CORAL IN THE RED • VISIONARY SHRIMP • POSSUM VS. POLAR BEAR


ONE GIANT BABY STEP FOR SCIENCE
The most perfectly preserved mammoth ever found reveals new information about life during the ice age.
WAKING THE BABY MAMMOTH
PREMIERES SUNDAY
APRIL 26 9P E P
NATIONAL GEOGRAPHIC CHANNEL

NATURAL HISTORY

APRIL 2009 VOLUME 118 NUMBER 3
www.naturalhistorymag.com

FEATURES

DEPARTMENTS

ON THE COVER: Grandmother and granddaughter in Litang, Sichuan Province, China.
Image by Adam Wong / Corbis

THE NATURAL MOMENT

VIPERIZED

Photograph by Solvin Zankl

WORD EXCHANGE

Natural History Subscribers
Subscription Scam Alert!

Unauthorized renewal notices have been sent to some of our subscribers. *Natural History* does not authorize third parties to send out renewals. We are concerned that your order may not be forwarded to us.

When your subscription is ready for renewal, our circulation department will notify you and include a return envelope pre-addressed as follows:

Natural History
P.O. Box 3030
Harlan, IA 51593-0091

If you receive a renewal notice that did not come directly from *Natural History*, please contact us immediately:
Email: nhmag@nhmag.com
Phone: 646-356-6508
Mail: Natural History Magazine, Inc.
36 West 25th Street, Fifth Floor
New York, NY 10010

Word Exchange continued on page 42

nature.net by robert anderson

ALLERGIC REACTION

I count myself lucky: my immune system doesn't overreact to pollen, animal hair, peanuts, or anything else. But both my wife and daughter are sensitive to cats and dogs (as is about a tenth of the U.S. population). And, while it is not a true allergy, my daughter has celiac disease, which requires strict adherence to a gluten-free diet, because that protein—found in wheat and other grains—triggers a destructive autoimmune response. According to the American College of Allergy, Asthma & Immunology, some 50 million Americans suffer from exposure to one allergen or another. The college's "Advice from Your Allergist" page (www.acaai.org/public/azallergytopics.htm) offers guidance on a host of such conditions. For my guide to Web sites exploring allergies, please visit the magazine online (www.naturalhistorymag.com).

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

NATURAL HISTORY

VITTORIO MAESTRO *Editor in Chief*
Steven R. Black *Art Director*
Erin Espelie *Executive Editor*

Senior Editors
Rebecca Kessler, Dolly Setton

Melisa Beveridge *Assistant Art Director*
Annie Gottlieb *Copy Chief*
Graciela Flores *Editor-at-Large*
Florence Brauner *Volunteer*

Contributing Editors
Robert Anderson, Olivia Judson, Avis Lang, Charles Liu, Laurence A. Marschall, Richard Milner, Robert H. Mohlenbrock, Joe Rao, Stéphan Reebs, Judy A. Rice, Adam Summers, Neil deGrasse Tyson

CHARLES E. HARRIS *Publisher*
Edgar L. Harrison *Advertising Director*
Maria Volpe *Promotion Director*
Sonia W. Paratore *National Advertising Manager*
Adam Cohen *Advertising Manager*
Meredith Miller *Production Manager*
Joe Sharkey *Manager, Publishing Services*

For advertising information call 646-356-6508

Advertising Sales Representatives
Detroit—Barron Media Sales, LLC, 313-268-3996
Chicago—Robert Purdy & Associates, 312-726-7800
West Coast—On Course Media Sales, 310-710-7414
Toronto—American Publishers Representatives Ltd., 416-363-1388
Atlanta and Miami—Rickles and Co., 770-664-4567
South America—Netcorp Media, Ltd., 51-1-222-8038
National Direct Response—Smyth Media Group, 914-693-8700
Market Classified—Media Options, 800-442-6441

TODD HAPPER *Vice President, Science Education*

Educational Advisory Board
David Chesebrough *COSI Columbus*
Stephanie Ratcliffe *Natural History Museum of the Adirondacks*
Ronen Mir *MadaTech–Israel National Museum of Science*
Carol Valenta *Saint Louis Science Center*

NATURAL HISTORY MAGAZINE, INC.
Charles E. Harris *President, Chief Executive Officer*
Judy Buller *General Manager*
Cecile Washington *General Manager*
Charles Rodin *Publishing Advisor*
Jim Van Abbema *Webmaster*

To contact us regarding your subscription, to order a new subscription, or to change your address, please visit our Web site www.naturalhistorymag.com or write to us at

Natural History
P.O. Box 5000, Harlan, IA 51593-0257.

Natural History (ISSN 0028-0712) is published monthly, except for combined issues in July/August and December/January, by Natural History Magazine, Inc., in affiliation with the American Museum of Natural History, Central Park West at 79th Street, New York, NY 10024. E-mail: nhmag@naturalhistorymag.com. Natural History Magazine, Inc., is solely responsible for editorial content and publishing practices. Subscriptions: $30.00 a year; for Canada and all other countries: $40.00 a year. Periodicals postage paid at New York, NY, and at additional mailing offices. Canada Publications Mail No. 40030827.

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.

Natural Resources

Lars Jonsson's Birds

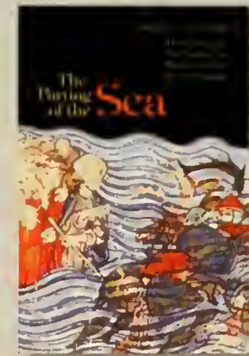
Paintings from a Near Horizon

Lars Jonsson

"Everything that Lars applies to paper or canvas is accurate. The work may be loose or precise, but it always reflects an intimate knowledge of the subject and its situation."
—John Sill, wildlife artist

Cloth $55.00 978-0-691-14151-0

Not for sale in the Commonwealth (except Canada) & the European Union



The Parting of the Sea

How Volcanoes, Earthquakes, and Plagues Shaped the Story of Exodus

Barbara J. Sivertsen

"With an arresting topic, great storytelling, superb scholarship, and a command of diverse sources, Sivertsen makes an important contribution to a significant historic and scientific puzzle."
—Adrienne Mayor, author of *The First Fossil Hunters*

Cloth $29.95 978-0-691 13770-4

The Princeton Encyclopedia of Birds

Edited by Christopher Perrins

"[This encyclopedia] captures the full display of the birds of the world with wonderful illustrations and engaging prose. From the lavish birds-of-paradise to the stately seriemas, Christopher Perrins and his distinguished colleagues distill their expertise into a powerful work."
—Frank B. Gill, author of *Ornithology*

Paper $35.00 978-0-691-14070-4

For sale only in the United States and Canada

Margaret Mead

The Making of an American Icon

Nancy C. Lutkehaus

"This is an absorbing, expertly researched, and much-needed treatment of Margaret Mead. It is the definitive book about Mead's fame and her complicities in creating it."
—George E. Marcus, University of California, Irvine

Cloth $29.95 978-0-691-00941-4

The Princeton Dictionary of Ancient Egypt

Ian Shaw & Paul Nicholson

For more than a decade, Ian Shaw and Paul Nicholson's *Dictionary of Ancient Egypt* has been the most informative and useful dictionary of ancient Egypt available. Now fully revised and updated, this new edition covers the most important discoveries and scholarship in the field since 1995.

Published in association with the British Museum

Cloth $49.50 978-0-691-13762-9

For sale only in North America & the Philippines

The Princeton Encyclopedia of Mammals

Edited by David W. Macdonald

"*The Princeton Encyclopedia of Mammals* is a rare treasure that combines spectacular photographs and authoritative, easily accessible text describing the world's mammals, from aardvarks to zebras and everything in between."
—Don E. Wilson, National Museum of Natural History

Paper $45.00 978-0-691-14069-8

For sale only in the United States and Canada

Birds of East Asia

China, Taiwan, Korea, Japan, and Russia

Mark Brazil

"Well-written and well-organized, this excellent book will be widely applauded by the professional and amateur birding community."—Susan Myers, Victor Emanuel Nature Tours

Princeton Field Guides

Paper $39.95 978-0-691-13926-5

Cloth $79.50 978-0-691-13925-8

Not for sale in the Commonwealth (except Canada) & the European Union

Mammals of India

Vivek Menon

"This handsome volume is ideal for naturalists and sufficiently thorough to be valuable to professional mammalogists. With superior visuals, informative text, and sound scholarship throughout, *Mammals of India* is beyond compare. This is an exceptional little book."—Andrew T. Smith, coeditor of *A Guide to the Mammals of China*

Princeton Field Guides

Paper $35.00 978-0-691-14067-4

Not for sale in the Commonwealth (except Canada) & the European Union

PRINCETON UNIVERSITY PRESS   800.777.4726 nathist.press.princeton.edu

Order today and Save $100s!

Rare Hoard of 100-Year-Old U.S. Gold Coins Released to Public

HISTORIC U.S. GOLD ON SALE

Just discovered hoard of U.S. $10 Gold Liberty Coins Now Available

Our buyers just discovered one of the most significant European Bank hoards of U.S. gold in years. They secured 1,769 magnificent U.S. gold coins guaranteed to be over 100 years old. The vintage coins in this hoard represent dates ranging from 1866 through 1907 that uniquely represent the history of our nation in fine gold.

Uncirculated Gold Coins from the Past are Timeless Treasures

Each of these $10 Gold Liberty coins is certified in Uncirculated Condition. As gold values have soared with unpredictable oil prices and the falling dollar, you may never again have the opportunity to own these gold coins at this price. With the falling dollar, demand for these coins continues to escalate as collectors and investors scramble to scoop up U.S. gold coins for their pure gold content and scarcity.

Certified genuine uncirculated U.S. gold coins have historical and numismatic value that bullion gold cannot match, making these coins even more attractive.

As low as $749 ea.

Shown larger than actual size of 27 mm in diameter

Don't Miss This Opportunity: Order Now!

Consider that the number of U.S. coin collectors has sharply risen to over 50 million today, you may never get a second chance to take advantage of this opportunity. Order now while our limited supplies last. Buy more and save! Due to our limited supply of these coins, we must issue a strict limit of 5 coins per customer. Why pay $849 or more for similar coins? Prices and orders subject to availability, so call today. Your satisfaction is assured by our 30-day money-back guarantee.

Order More & Save

	$ per coin	shipping	total
1 Liberty Coin	$795	$15 S&H	$810
3 Liberty Coins	$779	FREE!	$2,337
5 Liberty Coins (max)	$749	FREE!	$3,745

Call Toll-Free:

1-800-642-9160 ext. 2280

New York Mint, 5577 W 78th St., Edina, MN 55439

Not affiliated with the U.S. Government

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL

FIRST-CLASS MAIL PERMIT NO. 55 HARLAN IA 51593-2091

POSTAGE WILL BE PAID BY ADDRESSEE

NATURAL HISTORY
P.O. BOX 3030
HARLAN, IA 51593-2091

Sow, Shine, and Reap

One way to slow down global warming is to reflect more sunlight back into space. We could all close our eyes and wish for bright clouds to become more abundant, but that's a rather passive approach. More enterprising—not to mention cumbersome, time-consuming, and expensive—would be to deploy giant sunshades in space. And then there's the comparatively simple suggestion of Andy Ridgwell and his colleagues at the University of Bristol in England.

Using a computer climate model, the team calculated what would happen to global temperatures if croplands were covered with extra-reflective plants. They found that a 20 percent increase in reflectivity would lower summertime temperatures by almost 2 Fahrenheit degrees over much of North America and Eurasia. Elsewhere, cropland is less extensive so the effect would be greatly reduced. The temperature savings would roughly equal one-fifth of the regional warming expected by around 2100—no small chunk.

High crop reflectivity could be achieved by developing cultivars with waxier or better-angled leaves. Another method, already known to boost reflectivity by 30 percent or more, is to spray water mixed with kaolinite (a non-toxic clay) onto leaves.

The trick will be to ensure that photosynthesis and crop yield aren't unduly compromised—obstacles Ridgwell thinks can be overcome. (*Current Biology*)

—*S.R.*

Sorghum

Out of Sync with Science

Polls show that fewer than 60 percent of Americans think people are responsible for global warming, and fewer than 50 percent think scientists agree on that point. But according to Peter T. Doran of the University of Illinois at Chicago and his former graduate student Maggie Kendall Zimmerman, citizens are not on the same wavelength as scientists.

In an online survey, the two researchers invited 10,257 Earth scientists to anonymously answer the question "Do you think human activity is a significant contributing factor in changing mean global temperatures?" In all, 3,146 scientists replied, and 85 percent of them answered in the affirmative. (Fewer than 5 percent said no, the rest opting for "I'm not sure.") Among well-published climate experts, more than 97 percent said yes, a near consensus of those in the know. Agreement with the logical precursor—that the globe is warming—was also overwhelming.

The replies being voluntary, the survey sample wasn't truly random, but anonymity should have alleviated skew toward believers or skeptics. What's more, any bias should apply equally to scientists and laypeople, and is contradicted by the large gap between the two. Doran and Zimmerman recommend a two-part cure: scientists need to better disseminate their views, and the media need to report the scientific consensus accurately, despite the noble impulse to present both sides of a story. (*Eos*)

—*S.R.*

A Pardon for Plants

We're all counting on plants to help fight global warming by absorbing carbon dioxide. So it was disheartening to hear in 2006 that plants actually *make* another greenhouse gas, methane [*see "How Does the Greenhouse Grow?" March 2006*]. That report was surprising because only bacteria had been known to produce methane, and only in anaerobic (oxygen-free) conditions. A new study sets the record straight. Plants aren't making the stuff after all; they're just passing it along.

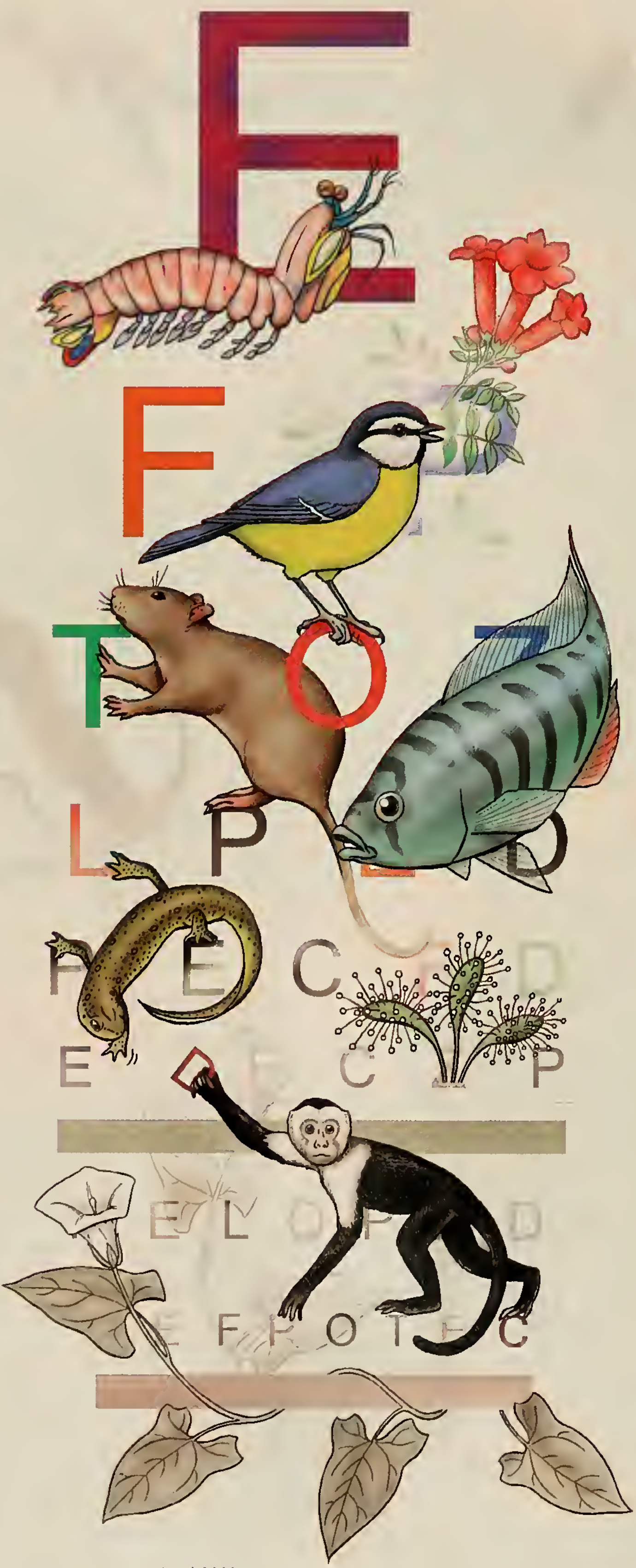
A team of biochemists headed by Ellen R. Nisbet, now at the University of South Australia in Adelaide, searched in plant genomes for genes similar to the ones bacteria use in methane-making—but couldn't find any. Next the team grew plants with either distilled water or methane-containing water. Only plants grown with methane released the stuff into the air. The team showed that methane, produced in nature by soil-dwelling bacteria, journeys with the water as it is absorbed through plants' roots and then is released by transpiration through the stomata of their leaves.

Only small amounts of gas are let go, but the 2006 study had also mentioned satellites detecting a great deal of methane over tropical forests. Now it appears clouds may have biased those readings. All in all, Nisbet thinks plant transpiration contributes at least an order of magnitude less methane than had been feared in 2006. (*Proceedings of the Royal Society* B)

—*S.R.*

Seeing the Light

We humans pride ourselves on our color vision. Yet compared with many other animals, we are visual pipsqueaks.



In my mind's eye, I'm sitting in front of a row of magic helmets. Like motorcycle helmets, they cover the head and face; each is labeled with the name of a different animal. Here's one that says "yellow swallowtail butterfly." Another has the name of that small songbird known as the blue tit. And look, this one is for an animal so exotic that it's usually known by its Latin name: *Odontodactylus cultrifer.* That is a particular species of mantis shrimp, or stomatopod—a voracious little predator that looks like a cross between a lobster and a praying mantis, and lives on the seafloor.

The point of the helmets is that they will let me see light as those other creatures do. When wearing the "blue tit" helmet, I will see a dazzling range of colors: other birds will shimmer and sparkle, their feathers richer and more beautiful than anything I have known. When I put on the mantis shrimp helmet—well, I'll be speechless. Mantis shrimp have more complex color vision than any other creature we know about. And it's not just their color vision that is amazing. They can distinguish differences in how light is polarized as well. As a result, when I don the helmet, plants and animals that before seemed transparent, and thus almost invisible, will suddenly become as obvious as sparklers.

Just as people cannot smell the variety and richness that a dog can smell, or hear the high squeaks of a bat or the low rumblings of an elephant, we cannot see light as other animals see it. But, increasingly, researchers are finding ways to infer the visual capabilities of other animals.

Given the presence of light, the ability to see depends on two elements: what the eye detects, and what the brain does with the information it receives. The first is measured by looking at eyes and how they respond to light; the second, by how an animal behaves under different light regimes. I shall focus on the first, for this is the subject we know more about. Moreover, it is

JOHN NORTON

where the process begins: if the eye itself cannot detect light of different colors, no amount of brain hardware can alter that fact.

Vertebrate eyes contain two types of light-sensitive cells: rods and cones. In humans, rods are mostly used for seeing when light levels are low. Cones, on the other hand, are involved in color vision. Unlike rods, they contain a range of visual pigments that enable perception of a wide spectrum of wavelengths of light. Cones also have a faster response time than rods, permitting the perception of rapid movements and fine details.

In humans, any given cone cell contains only one of three types of pigment; in other vertebrates, a single cone cell can hold multiple pigments. Visual pigments have two components: a chromophore and an opsin. The chromophore, a light-absorbing molecule, sits in a pocket inside the opsin, a protein. Which wavelength a pigment responds most strongly to depends on how the chromophore and the opsin interact. That, in turn, depends principally on the opsin. The reason is that chromophores vary little from one species to the next—in mammals and birds, for instance, they are always a form of vitamin A known as retinal. Opsins, instead, vary a lot. Mutations to the genes that encode the opsin proteins can, therefore, alter the wavelengths that an animal can see.

That said, amphibians, fish, and reptiles have a second possibility for a chromophore: a form of vitamin A known as 3-dehydroretinal. If the opsin remains the same but the chromophore changes, the pigment will alter its sensitivity to light. The effect is especially pronounced for long wavelengths. For instance, suppose you have a retinal-based pigment that responds maximally to light at a wavelength of 565 nanometers (what humans perceive as yellow-green light). Replacing retinal with 3-dehydroretinal will create a pigment that responds maximally to light at 615 nanometers (orange). Such swaps are employed by fish such as lampreys as they migrate from oceans into rivers; each environment favors the ability to detect different wavelengths of light. Similarly, some tadpoles change their chromophores when they turn into frogs. (Certain fish—tilapia, for instance—also see differently as juveniles and adults, but here the effect is mediated by opsin genes being turned on and off.)

In a sense, visual pigments in the eye are like paint on an artist's palette. Just as a painter with only one color of paint can only create monochromatic pictures, so too an animal that can detect light of only one wavelength sees the world in monochrome. (In other words the world appears in shades of one color, according to the intensity of light. I'd say shades of gray—but it might just as well be orange or green.) Having different kinds of visual pigments thus allows the eye to mix light and make colors as a painter mixes paints.

Normal human eyes contain four kinds of visual pigments. One of them is found only in rods; the others are found in cone cells and are thus responsible for color vision. Because humans have three kinds of visual pigment for seeing color, we are known as *trichromats*. The pigments in our three kinds of cones (commonly called the "blue," "green," and "red" cones) respond maximally to violet, green, and yellow-green light, respectively. That is, each has a peak of reaction at a particular wavelength—a relatively short one in the case of a blue cone, a medium one in the case of a green cone, and a longer one for a red cone. But each reacts to a lesser degree over a range of wavelengths, and those ranges overlap considerably. Almost any wavelength of visible light activates at least two and sometimes all three pigments in different proportions—giving us the power to see well over a million shades of color.

That, for a mammal, is pretty good. Most mammals—dogs and elephants, for instance—have cones with only two kinds of pigments, for short and long wavelengths of light. Such *dichromats* can see at most 10,000 colors. Humans with certain kinds of color-blindness are restricted to this far smaller number. But even that is vibrant luxury compared with vision in creatures such as whales and seals, which have just one kind of

visual pigment in their cone cells and see only shades of one color.

A poor sense of color is thought to be a legacy from the time our mammalian ancestors coexisted with the dinosaurs. The idea is that while the dinosaurs were tramping about, our forebears were small animals that mostly went out at night. Elaborate color vision wasn't useful, and so there was no evolutionary pressure to keep it: animals without it were no worse off than animals that had it, and so it began to decay. Instead, mammalian eyes evolved to be good at seeing in low levels of light.

After the dinosaurs went extinct, those nocturnal ancestors evolved into a broad diversity of forms, many of which come out in the daytime. However, in general, mammalian color vision has remained quite poor. Primates are the exception. Among primates, improved color vision has evolved at least twice, once in the lineage leading to Old World monkeys and apes, and again, independently, in some of the New World monkeys, such as capuchins. The reason primates evolved better color vision than other mammals isn't clear; the most popular theory is that it's related to diet, and that trichromatic individuals find it easier to spot ripe fruits and young, edible leaves.

Yet compared with most other vertebrates and many invertebrates, even primates are colorfully challenged. The eyes of many amphibians, birds, fish, reptiles, and insects contain an additional kind of visual pigment—one that typically detects light that to us is entirely invisible: ultraviolet. A yellow swallowtail butterfly or a bird such as a blue tit is, therefore, a tetrachromat, and has a visual palette far more complex than our own. After all, what color is made from green, red, and ultraviolet?

Indeed, to us, the male and female blue tit look similar. Yet some of their plumage reflects in the UV range—especially the "blue" cap that the male wears on his head—a feature that affects mate choice. A blue tit looking at the world with a magic helmet labeled "human" would find the world almost as drab as we find black and white. That is, a "*normal* human" helmet. Tantalizing evidence suggests that certain rare women—mothers whose sons have a particular type of colorblindness—may be tetrachromats of a sort, though they still wouldn't see what a bird sees, as they can't see UV.

What sort of color vision would dinosaurs have had? Obviously, that question is hard to answer, but we can make some general inferences. The two living groups most closely related to dinosaurs are birds and crocodiles. Indeed, to be strict about it, birds are dinosaurs: they are descended from a dinosaur lineage, and are more closely related to *Tyrannosaurus rex* and friends than they are to any living organisms. Birds, of course, are tetrachromats, and some species of crocodiles, such as the Mississippi alligator, probably are too. (I say "probably," because they have four visual pigments in their cones, but their behavior hasn't been studied to confirm how they see.) All this suggests that many dinosaurs may have had complex, tetrachromatic color vision.

But even a blue tit's vision seems boring when compared with what goes on in the stalked eye of the mantis shrimp. Those animals don't merely have four, five, or six kinds of visual pigment in their eyes. Some have sixteen. What that does for their view of the world is unclear, however, partly because it's impossible for humans to guess what it's like to have eyes on stalks that move independently and continuously.

It is clear that mantis shrimp can see color, and that their range covers the whole of the spectrum visible to humans and extends into both the ultraviolet and the infrared; but scientists don't know whether they see many more shades of color than a bird does. For like insects and other crustaceans, mantis shrimp have compound eyes, which work rather differently from vertebrate eyes. One idea is that each pigment in a mantis-shrimp eye signals the presence of a single color in the same way that a hair cell in the cochlea of a human ear responds to a single frequency of sound. In that case, a large range of pigments would be essential for seeing many colors. Lacking a big brain, such animals may be unable to mix a vast range of colors from just a few kinds of inputs, as we are able to do.

As I mentioned, mantis shrimp can also detect how light waves are polarized—marshaled into a single plane of oscillation—which is independent of the wavelength of light. That ability is found in a panoply of other animals, including some spiders, insects, and migratory birds, for whom it may be part of their navigational tool kit.

Mantis shrimp, however, can not only distinguish linearly polarized light, some of them can also detect circularly polarized light—with its plane of oscillation spiraling like a screw either to the left or to the right. That enables them to respond to tiny shifts in the polarization of the light that reaches them. Not only do potential mantis-shrimp mates have circularly polarized light reflected off parts of their carapaces—like secret come-hither jewelry—but much of the stomatopods' transparent-looking prey is filled with sugar molecules that polarize light.

Woe betide any such prey that crosses the path of one of these animals. Forget the eye of a hawk: it's the eye of the mantis shrimp that should be legendary.

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

Distinctive Destinations

It's time to explore something old and discover something new. Compare dinosaurs and birds in Delaware. Visit ancient ruins and modern masterpieces of architecture in Arizona. And in Asia, voyage into an exotic world and enjoy timely comforts amid timeless beauty.

Clockwise from above: Taliesin West, Frank Lloyd Wright's desert masterpiece; the ghostly White House ruins in Canyon de Chelly National Monument; Mission San Xavier del Bac, the White Dove of the Desert

Feasts for Body and Soul in ARIZONA

IN ARIZONA, dramatic landscapes and diverse cultures offer an endless feast for the eyes and an abundant variety of food to satisfy body and soul. Whether you're interested in art, theater, architecture or casual fine dining, you'll find memorable destinations to choose from.

Arizona has inspired architects and builders, ancient and modern, through the centuries. Architectural marvels can be found tucked into mountainsides, clinging to canyon walls and burgeoning from the desert floor. From timeless Navajoland to bustling cities, you can span the ages, traveling from the ancient cliff dwellings of Canyon de Chelly and the mission architecture of San Xavier del Bac to the modern masterpiece of Taliesin West in Scottsdale.

Past and present come together dramatically in the Canyon de Chelly National Monument. The Navajo people still have a mystical bond to this redstone canyon, home to several periods of Native American culture. Canyon cliffs ranging to more than 1,000 feet provide a spectacular backdrop for hundreds of Anasazi ruins as well as modern Navajo homes and farms.

Dramatic in a different way is the Mission San Xavier del Bac, the "White Dove of the Desert," located south of Tucson. The mission rises like a brilliant white dove from the desert floor, framed in the warm browns of the surrounding hills and violet shadows of more distant mountains. San Xavier, which blends Moorish, Byzantine and late Mexican Renaissance architecture, has been acclaimed as the country's finest example of mission architecture.

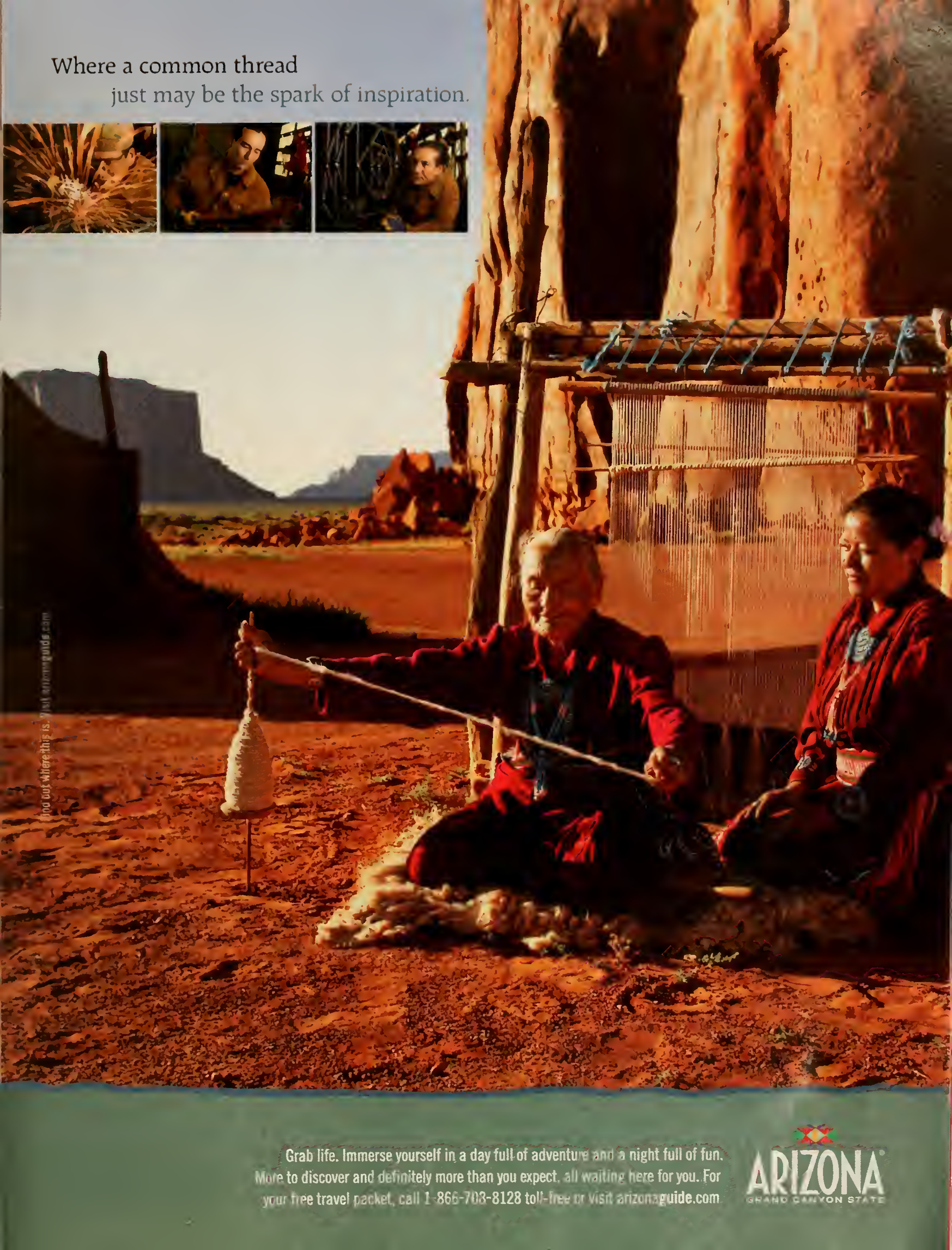
Also rising like an apparition from the desert floor is Taliesin West, built by Frank Lloyd Wright and his apprentices in the 1930s. Wright, whose spirit and influence linger strongly in Arizona, created Taliesin West out of the desert by gathering rocks from the desert floor and sand from the washes to keep the design in balance with the surrounding environment. The site is considered one of Wright's greatest masterpieces.

To accompany the visual feast, you'll find some great food near these remarkable sites. In Scottsdale, haute cuisine meets haute couture in a fusion of food and fashion at Canal, located beside the tranquil waters of the Scottsdale Waterfront. In Tucson, if you're craving old Mexican favorites, you'll find the oldest family-run Mexican restaurant in the country: El Charro Café. El Charro, with its blend of Sonoran ingredients, is a delicious lesson in Tucson's culinary history. For Navajo food, you'll find local favorites such as Navajo tacos, mutton stews, and frybread in most restaurants on the Navajo Nation. Two popular options not far from Canyon de Chelly are Junction Restaurant and Garcia's Restaurant.

With its storied past reaching back thousands of years, and its vibrant blends of old and new, Arizona offers something for everyone. Wherever you go, and whatever your taste, you'll find unforgettable landscapes, culture and food to savor.

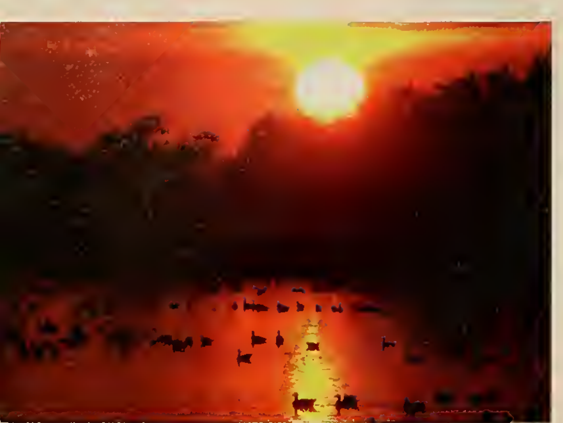
For your free travel packet, call 1-866-708-8128 toll-free or visit arizonaguide.com.

ARIZONA®
GRAND CANYON STATE



Where a common thread
just may be the spark of inspiration.
Find out where this is. Visit arizonaguide.com
Grab life. Immerse yourself in a day full of adventure and a night full of fun. More to discover and definitely more than you expect, all waiting here for you. For your free travel packet, call 1-866-708-8128 toll-free or visit arizonaguide.com
ARIZONA
GRAND CANYON STATE

DELAWARE



Above: Sunset at Bombay Hook National Wildlife Refuge; below: Slaughter Beach horseshoe crabs

DELAWARE is brimming with history and natural wonders to explore, indoors and out. From dinosaur exhibits to prime bird-watching spots, you'll find compelling reasons to stop, learn, and discover something new.

You can jump-start your adventure at the Delaware Museum of Natural History, where you'll encounter life-sized dinosaurs, take a look under the oceans, come face to face with a jaguar, linger at an African watering hole, and marvel at the diversity of birds and shells from around the world.

For some great birding and sightseeing, drive Delaware's Coastal Heritage Scenic Byway Route 9, which traverses 50 miles of the state's carefully preserved shore, unparalleled on the East Coast. The green way that runs north and south along the Delaware River and Bay was the first designated reserve in the Western Hemisphere Shorebird Reserve Network, and you'll see some of the region's best birding spots here. The route's generous stretches of unspoiled marshland include the Thousand Acre Marsh, the largest freshwater tidal wetland in northern Delaware. You'll find easy access to the Bombay Hook National Wildlife Refuge, with its handy observation towers, and to the adjacent Little Creek Wildlife Area.

For sightings of horseshoe crabs, which put on an incredible display in May and June, stop at Slaughter Beach. Further south, the waters within Prime Hook National Refuge are open for canoeing and boating, and hiking trails include a boardwalk over the marshes. Continue to Cape Henlopen State Park, which offers different environments from which to view wildlife and shorebirds.

Visit www.visitdelaware.com for more information.

Special Advertising Section

Alluring Asia Inviting Indian Ocean & Africa

Escape to the Orient

Port by port the Orient unfolds its treasures as you sail aboard mv *Discovery* from **Singapore** to the tranquil beaches of **Thailand**. **Vietnam** offers green rice fields and ancient temples. **Hong Kong's** bustling streets bring some of the best shopping in the world. Forests in **Borneo** reveal orangutans. In **Brunei**, museums display the Sultan's royal regalia. Behind the modern skyscrapers, Singapore and **Kuala Lumpur** retain the magic of the old Orient.

Sun-swept isles

Ahead lie simple pleasures: African Mortia dances in the **Seychelles** and lemurs in **Madagascar**. Fort Adelaide dominates historic **Port Louis** with its Colonial architecture. The Indian Ocean islands offer some of the most stunning beaches anywhere!

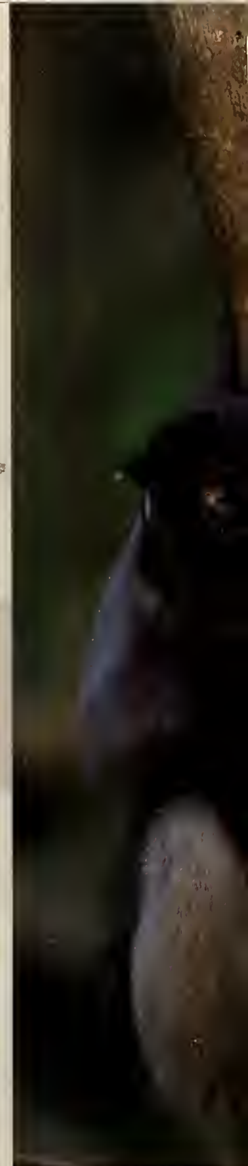
From the tip of Peninsular **Malaysia**, *Discovery* heads to the Cape of Good Hope. En route, you'll acquire a taste for a thousand spices – creamy coconut curries laced with cumin, cloves and aniseed, stalls stacked with the fruit of mangosteens. Shop in **Cape Town** on the V&A Waterfront. Head from Dutch legacies to veldts still home to Zulu ways outside **Richard's Bay**. Sample peri-peri prawns in **Mozambique**, dance in **Mayotte** and explore **Zanzibar**. In **Mombasa** take day safaris to Amboseli and Tsavo.

Camels and Kings

Upper **Egypt** takes you back to a time of Pharaoh dynasties. Mystical **Petra** captures your imagination. Our passage through the **Suez Canal** brings Saladin castles and Seljuk walls unfurl along **Turkey's** Turquoise Coast in **Latakia** and **Antalya**. After visiting the ruins of **Ephesus** head to bustling, Byzantine **Istanbul**.

To book these exciting cruise adventures, contact your cruise professional or Voyages of Discovery at 1-866-623-2689. Visit www.voyagesofdiscovery.com.

Meet the Alloparents



Shared child care may be the secret of human evolutionary success.

BY SARAH BLAFFER HRDY

We cram our bodies into the plane's narrow seats, elbow-to-elbow, making eye contact with nods and resigned smiles as we yield to latecomers pushing past. Most ignore the crying baby, or pretend to. A few of us even signal the mother with a sideways nod and a wry smile. We want her to know that we know how she feels, and that the disturbance she thinks her baby is causing is not nearly as annoying as she imagines—even though we can tell (as can she) that the young man beside her, eyes determinedly glued to the screen of his laptop, does indeed mind every bit as much as she fears.

Thus does every frequent flier employ our species' peculiarly empathetic aptitude for intuiting the mental states and intentions of other people. Cognitive scientists and philosophers have long called this awareness of others' inner life "theory of mind," but many psychologists now refer to it as "intersubjectivity," a broader concept that roots our sophisticated skill at mind reading in the capacity to share in the emotional states and experiences of others. Whatever we call it, this ability to divine and care about the mental experiences of others makes humans more adept at cooperating than other apes are.

Imagine what would happen if one were traveling with a planeload of chimpanzees. We would be lucky to disembark with all our fingers, testicles, and toes attached, and with the baby still breathing and unmaimed. But human passengers fill some 2 billion airline seats every year and submit to being compressed and manhandled, with no dismemberments reported yet! Along with our 1,350-cubic-centimeter brains and capacity for language, such unusually well-developed impulses to cooperate have helped propel our success as a species. But *why* did humans become such "other-regarding" apes?

Although the genus *Homo* arose before the beginning of the Pleistocene epoch (1.8 million to 12,000 years ago), *H. sapiens*—anatomically modern humans with upright bodies and big brains—evolved only within the last 200,000 years. And *behaviorally* modern humans, capable of symbolic thought and language, emerged more recently still, within the last 80,000 years. Most evolutionists have assumed that our unusually sophisticated capacities for attributing mental states and feelings to others coincided with those late-Pleistocene behavioral transformations, and corresponded with the need for members of one group to get along so as to outcompete and defend themselves against other groups.

But there are difficulties with that scenario. There is abundant archaeological evidence for early warfare, but none dates back much before 12,000 years ago, when people began to settle down and live in more complex societies with property to protect. Moreover, genetic evidence suggests that our foraging ancestors in the Pleistocene lived at low densities. Although individuals no doubt fought and sometimes killed one another, there is no evidence that whole groups fought. More to the point, if the drive to outcompete members of opposing groups was the source of our hypersocial tendencies, why didn't selection favor even greater and more Machiavellian intelligence,

Female dusky leaf monkey tries to take a newborn from its mother. In all primates, babies are a source of interest, most often to subadult females. Distinctive juvenile traits, such as this baby's golden hair, help induce non-parents to take care of an infant.

better mind reading, and better capacities to cooperate against hostile neighbors among the ancestors of today's chimpanzees? Chimpanzees are competitive, dominance-oriented, aggressive, and reflexively xenophobic: wouldn't they have benefited just as much, or more, from being able to cooperate to wipe out competing groups?

Consider, however, an alternative explanation, the possibility that our empathetic impulses grew out of the peculiar way that children in the genus *Homo* were reared. I believe that at an early stage in human evolution, our bipedal ape ancestors were increasingly cared for and provisioned not just by parents but also by other group members, known as *alloparents*.

In my view, cooperative breeding (as sociobiologists term the reproductive strategy in which alloparents help both care for and provision young) came before big brains. I believe it first emerged among upright apes that were only beginning to look like us, and further evolved during the Pleistocene in African *H. erectus* (also called *H. ergaster*)—creatures that did not think or use language to communicate the way we do. Alloparental care and provisioning set the stage for children to grow up slowly and remain dependent on others for many years, paving the way for the evolution of anatomically modern people with even bigger brains. It was not the other way around: bigger brains required care more than caring required big brains.

Comparisons across cooperatively breeding species show how nonessential a sapient mentality is for shared care, and provide our best hope for understanding what selection pressures induce individuals to help rear someone else's young. Insights from such comparisons help explain why mothers among highly social apes living in Africa about 1.8 million years ago might have begun to abandon mother-only care, setting our ancestors on the road to emotional modernity.

Although at first caring for and provisioning someone else's offspring seems to defy evolutionary logic, coop-

Golden lion tamarins often live in groups containing several adult males and one breeding female. The mother relies on the males for shared infant care as well as extensive provisioning, and males carry the infants most of the time. Any males the mother mated with, older offspring, and even unrelated "immigrants" may spontaneously offer beetles and other prey to infants around the time of weaning.

SALLY LANDRY

erative breeding has evolved many times in a taxonomically diverse array of arthropod, avian, and mammalian species. It occurs in 9 percent of the 10,000 living species of birds and in perhaps 3 percent of mammals. The advantages for parents are well documented, with significant demographic consequences.

Mothers able to confidently entrust helpless offspring to groupmates' care conserve energy, stay better nourished, and remain safer from predators and other hazards, leading longer lives with greater reproductive success. Because mammal mothers that have aid also wean babies sooner, many reproduce again sooner, and so give birth to a greater number of young over their lifetimes. More important, the extra help ensures the young have a better chance of survival. Certain species therefore spread successfully thanks to cooperative breeding and, with it, a faster pace of reproduction and the flexibility permitting young to survive in a wide range of habitats.

But how could natural selection ever favor caring for someone else's young? Why would young magpie jays in Costa Rica, ones that have never reproduced, bring back beakful after beakful of food to begging fledglings? Those allomothers often provide more food than the chicks' own parents do. Ornithologists J. David Ligon of the University of New Mexico and D. Brent Burt of Stephen F. Austin State University in Texas propose a two-step process for such development. Start with a species with particularly helpless, slow-maturing young, in which selection will favor high sensitivity to the cues emitted by needy babies as a parental trait. Then add some special benefit that encourages maturing individuals to linger in their natal place, such as defensible and heritable resources. As a result, group members will be exposed to sensory cues from chicks (or pups) and will be primed to respond. This "misplaced parental care" hypothesis helps explain why cooperative breeding is three times more likely to evolve in taxa that produce altricial (helpless) young rather than precocial young (those that are soon able to survive on their own).

Not all such caretaking is as self-sacrificing as it may appear. Often, alloparents only babysit when no more self-serving option is available. They may proffer food only when they do not actually need it themselves. They may volunteer only when they have energy to spare, or when they are still too young or lack the opportunity to reproduce themselves. Or if two cohabiting mothers are reproducing, as occurs among lions, ruffed lemurs, bush babies, and some mice, they may take turns as alloparents. One mother may suckle the other's offspring while the other mother is "at work" foraging. And where practice is critical for learning how to parent, as is the case for many primates, babysitters derive valuable experience by first caring for another's young.

In other cases, however, helping is more of a one-way street—and by no means entirely voluntary. Subordinate meerkat, wild dog, and wolf females that have never conceived (and may never do so) sometimes undergo a "pseudopregnancy," developing a swollen belly and mammary glands. Then, once the alpha female's pups are born, the nonmothers secrete milk for the alpha's pups. By becoming a wet-nurse, a subordinate may increase her chances of being tolerated in the group. Had she given birth herself, her young might have been killed by the alpha female.

Of course, it makes good evolutionary sense for individuals to enhance the reproductive success of relatives with whom they share genes. But helpers are not always kin, and even kin can be less than kind: some meerkat and marmoset alphas eliminate their own daughters' offspring—the grandmothers from hell.

In roughly half the 300-odd species of living primates, including all four great apes and many of the best-known species of Old World monkeys, such as rhesus macaques and savanna baboons, mothers alone care for their infants. A chimpanzee, gorilla, or orangutan mother will be literally "in touch" with her infant for almost every moment during its first six months of life, and the orangutan nurses her baby for up to seven years. Such continuous maternal care cannot be attributed to lack of interest from would-be babysitters, however. In all primates, babies are a source of attraction, most often to subadult females. The mother's possessiveness is the determining factor. A wild ape mother is adamant that others will not hold or carry her baby.

Elsewhere in the primate order, mothers are more tolerant of allomaternal overtures. Shared care with at least minimal provisioning (often no more than one female allowing another female's infant to briefly nurse) is found in some 20 percent of primate genera. But only among marmosets and tamarins, members of the family Callitrichidae, do we find shared infant care combined with extensive alloparental provisioning, such as we also see in humans. In that respect, those tiny-brained South American monkeys, which last shared a common ancestor with humans more than 35 million years ago, may provide more insights into the early evolution of human family life than do more closely related species such as chimpanzees.

Marmoset and tamarin mothers tend to produce twins (together weighing up to 20 percent of the mother's body weight) as often as twice a year. But the social arrangements lighten the load. Usually, only the group's most dominant female breeds, although groups with two breeding females sometimes occur. Fathers and alloparents of both sexes are unusually eager to help mothers rear their young. Babies are carried throughout most of the day by one or more adult males, which expend so much energy doing so that they actually lose weight. Other helpers, typically but not exclusively kin, voluntarily deliver even prized animal prey to youngsters.

Group members are also unusually tolerant of one another during foraging. Observing moustached tamarins in the wild, University of Illinois primatologist Paul A. Garber recorded only one aggressive act for every fifty-two cooperative ones he saw, such as collaborating to gnaw open hard fruits. When tested in the lab, cotton-top tamarins studied by psychologist Marc D. Hauser's team at Harvard, and marmosets studied by evolutionary anthropologists Judith M. Burkart and Carel P. van Schaik at the University of Zurich, turn out to be unusually attentive to the needs of others. They are far more willing to deliver food to individuals (including nonrelatives) in an adjacent cage than are chimpanzees in comparable experiments. Marmosets go out of their way to provide food to others, and tamarins even keep track of and reciprocate generosity. Burkart argues that the combined mutual tolerance and spontaneous generosity of cooperative breeders are conducive to social learning, in particular to the ability of youngsters to glean information from and about their caretakers.

In every human hunting-and-gathering society about which we have information, mothers allow others to hold newborns. But how could selfish apes ever make the transition from mother-only care to such cooperative breeding? At some point in the emergence of the genus *Homo*, mothers must have become more relaxed about handing even quite young infants over to others to temporarily hold and carry. No infant is more costly than a human one, and a growing body of evidence from traditional societies makes clear that wherever rates of child mortality were high, children with alloparental provisioning were more likely to survive. I believe that was the case among our ancestors in the Pleistocene.

Yellow warbler, a species that produces helpless young, is primed to respond when a cowbird egg laid in its nest hatches a big, begging chick. A propensity that leads to such misplaced parental care can also be conducive to cooperative breeding within a species.

Among ethnographically recorded hunter-gatherers, provisioning by allomothers starts early and goes on for years, beginning with "kiss-feeding" of unweaned infants with saliva sweetened by honey or with premasticated mouthfuls of other food. That encourages infants to pay attention to others, including their own mothers, with whom they are eager to maintain visual and vocal contact. An infant temporarily out of its mother's arms will spend more time monitoring her whereabouts and looking at her face. Youngsters also have a big incentive to learn who else might be available and willing to care, and children with several trusted attachment figures learn to integrate multiple perspectives. In the words of pioneering child psychologists Ted Ruffman of the University of Otago and Josef Perner of the University of Salzberg, "theory of mind is contagious"—you catch it from older siblings and other caretakers.

Among our Pleistocene ancestors, infants with multiple caretakers would have been challenged in ways that no ape had ever been before. The needy youngster would have had to decipher not only its mother's commitment but also the moods and intentions of others who might be seduced into helping. How best to attract care in varied circumstances? Through crying? With smiles, funny faces, gurgling, or babbling? The youngster best at mind reading would be best cared for and best fed. Such novel (for an ape) selection pressures favored a very different type of ape—one that we might call emotionally modern.

Almost all primates live in social groups, and it is generally advantageous for a mother to be in a group that includes close kin. Their help is especially critical when an inexperienced young female first gives birth. In most social mammals, and in the majority of monkeys, females remain with the group where they are born, and maturing males strike out to make their fortunes. But among our nearest living relatives, the great apes, only a tiny minority of new mother apes ever have matrilineal kin nearby. Evolutionary biologists have taken for granted that, like other apes, our female ancestors must have left their natal groups to breed in another community. There they would have encountered unrelated females, possibly competing mothers, who might be not only unsupportive but actually infanticidal.

Until recently, in fact, evolutionary biologists assumed hunter-gatherers followed a similar pattern of female dispersal. But in 2004, in an exhaustive review of ethnographic studies, University of Utah anthropologist Helen Alvarez concluded that mothers living in hunting-and-gathering groups were likely to have their mothers and other kin nearby when they gave birth.

For example, Stanford University anthropologists Brooke A. Scelza and Rebecca Bliege Bird found that among the traditionally polygamous Mardu hunter-gatherers of Australia's Western Desert, older mothers would relocate to be near daughters of childbearing age, especially if the daughter lacked an older cowife to advise and help her. Mothers were also eager to join a daughter if she was married to the same man as her sister. In consequence, half of married Mardu women between the ages of fourteen and forty had a mother in the same group, while many had sisters or cousins as well, often as cowives. On average, female group members had an 11 percent chance of sharing a gene by common descent—just as do females of some of the nonhuman primate species that practice infant-sharing.

Artist's rendering of Homo erectus, *ancestral humans who lived in Africa in small groups as early as 1.8 million years ago: The woman in the center is cracking open nuts, while parents and other group members (so-called alloparents) help take care of infants. Shared care coevolved with empathetic awareness; mothers and infants benefited from intuiting who would help and who would hurt.*

PATRICIA J. WYNNE

Something happened in the line leading to *H. sapiens* that encouraged female relatives to stick together. The impetus, I believe, had to do with food.

By 1.8 million years ago *H. erectus* had new ways of finding, processing, and digesting food needed to support both larger bodies and energetically more expensive, larger brains. The most plausible scenario, set forth by anthropologists James F. O'Connell and Kristen Hawkes of the University of Utah, is that long-term trends toward a cooler, drier climate leading up to the Pleistocene pressured the precursors of *H. erectus* to supplement a diet that had consisted mostly of fruit and occasionally meat. Game was increasingly important, but its availability unpredictable. A division of labor emerged between male hunters and female gatherers, and social bonds ensuring that men and women shared became increasingly essential.

O'Connell and others suggest that when other foods were scarce, our ancestors relied on the large underground tubers that plants in dry areas use to stockpile carbohydrates. Those storage organs occur throughout the savanna, but are protected by a deep layer of sunbaked earth. Savanna-dwelling baboons dig up rhizomes and undergound stems called corms, both found nearer the surface, and at least one unusual population of savanna-dwelling chimpanzees is known to use sticks to dig out the shallower tubers, suggesting that early bipedal apes may have done so as well. But it takes special knowledge and equipment to dig out the deeply situated larger tubers.

Tubers are not only hard to extract. They are fibrous and difficult to digest, hardly ideal food for children. Like nuts, they need skilled processing. To eat them, weaned juveniles would have to depend on capable providers. Nevertheless, evidence is increasing that starchy tubers were an important fallback food for African hunter-gatherers. A 2007 report in *Nature Genetics* revealed that people like the Hadza of Tanzania, who rely on roots and tubers, have accumulated extra copies of a gene that makes an enzyme useful in the digestion of starch, salivary amylase. While we can't test the saliva or sequence the genes of African *H. erectus*, isotopic analysis of their tooth enamel yields results consistent with a diet substantially reliant on underground roots. Once *H. erectus* developed the use

Hunter-gatherers still living in small, tight-knit communities, such as these members of a clan of Kua Bushmen in the Kalahari desert in Botswana, are the best proxy we have for how early humans kept children alive in the Pleistocene. During the day, Kua women look for edible tubers in the surrounding Kalahari bush. Some anthropologists believe that H. erectus grandmothers helped in the communal raising of children by finding and processing tubers when other sources of food, such as game, were scarce.

of fire, perhaps as early as 800,000 years ago, roasting tough, fibrous tubers would have rendered them more digestible, and more useful still.

Even before cooking, the addition of tubers to nuts and other plant foods gathered and processed by women would have provided new incentives for food sharing between hunters and gatherers, as well as new opportunities for postreproductive women motivated to share. In their "grandmother hypothesis," Hawkes and O'Connell propose that Darwinian selection would have favored experienced, hardworking women who live on for decades after menopause, not just for a few more years, as in other primates. Such women could help provision younger kin, without the distraction of infants of their own.

Across traditional societies, where it is not unusual for 40 percent or more of individuals to die prior to maturity, mortality rates depend a lot on family composition. Not surprisingly, presence of the mother matters most. The father's impact varies from being vitally important to having no detectable impact, depending on local conditions and who else is around to help. When it comes to alloparents, older siblings and grandmothers, especially maternal grandmothers, have the most reliably beneficial impact. Under some circumstances, their presence cuts the chance of dying during childhood in half.

In purely practical terms, we can envision a sequence that begins with hunters and gatherers sharing the fruits (and tubers) of foraging and then moving toward cooperative breeding. That would have allowed our Pleistocene ancestors to produce young that depended on many caretakers for a long time. No ape produces such big babies that mature so slowly, yet not only did our ancestors manage to survive, but our species eventually expanded beyond Africa and around the globe.

In terms of cognition and emotions, the transformations wrought by shared care and provisioning were even more profound. Our bipedal ape ancestors were surely as clever and manipulative as are living chimpanzees, able to manufacture and use tools; they must have been at least as empathetic in some circumstances, and endowed with a rudimentary theory of mind. But when they adopted what was, for an ape, a novel mode of rearing young, one that produced individuals more mutually tolerant and other-regarding than other apes, they laid the foundations for ever higher levels of empathy and cooperation. In such modest beginnings we can identify the groundwork for spectacular later developments.

This article was adapted from *Mothers and Others: The Evolutionary Origins of Mutual Understanding*, by Sarah Blaffer Hrdy, ©2009, published by Harvard University Press. On sale in bookstores in April.

Sarah Blaffer Hrdy, an anthropologist and mother, is a professor emerita at the University of California, Davis. Her book *The Woman That Never Evolved* (1981) was selected by the *New York Times* as one of the Notable Books of that year, and *Mother Nature* was chosen by both *Publishers Weekly* and *Library Journal* as one of the best books of 1999. Hrdy is a frequent contributor to *Natural History*; "Meet the Alloparents" is her ninth article for the magazine.

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

Jewel of the Deep

Are the modern incarnations of age-old traditions—coral diving and craftsmanship—selling Mediterranean red coral out?

BY GEORGIOS TSOUNIS

We sink into cool, dusky water along the island's rocky foundation. A strong current hinders our swimming and washes in organic particles that cloud the view through our diving masks. The particles are food for coral, but there's no coral in sight as we descend past 100, then 120 feet. Finally, 160 feet down, first one red coral, then another and another, each as large as a man's palm, appears in the beam of our flashlights. They're the biggest ones I've ever seen, and my partners and I holler into our scuba mouthpieces in excitement. We stop to watch the coral polyps' myriad transparent little tentacles waving gently in the current, and we know we've found precious treasure. Visiting this dark and hidden underwater forest feels like a privilege.

For safety in the murky waters, we stick close together. We are three: two fellow marine ecologists, Sergio Rossi of the Autonomous University of Barcelona and Lorenzo Bramanti of the University of Pisa, have joined forces with me to study the health of Mediterranean red coral (*Corallium rubrum*) along the Costa Brava, Spain's northeast shore in the region of Catalonia and the hub of the Spanish coral fishery. Finding some of Spain's oldest red corals is an important part of our research, but it isn't easy. The depth, current, and poor visibility that make this location hard to dive provide a favorable habitat for the coral. For unknown reasons, the species shuns light and prefers to grow in deepwater cave entrances, crevices, and overhangs.

Artisans have crafted jewelry and artwork from Mediterranean red coral for millennia. Its color symbolizing the blood of Christ, *Corallium rubrum* is often used in Catholic art, as in this sixteenth-century sculpture of the Virgin Mary, made of eight ingeniously joined coral pieces (shown approximately actual size).

LEFT: ALINARI/SEAT/ART RESOURCE, NY; OPPOSITE PAGE: © WOLFGANG PÖLZER/ALAMY

Colony of Mediterranean red coral, at most fifteen years old. Each white cluster is an individual animal, a coral polyp. Much bigger, 100-year-old colonies could be found without great difficulty well into the twentieth century. Recent overfishing has reduced the average age of populations, however, so that rare old corals persist only at great depth.

The corals we admire—huge by today's standards, but small by those of a century ago—owe their size to their location, deep underwater in the Medas Islands, a protected marine reserve off-limits to fishermen. The species has been harvested for centuries to make jewelry and artwork, and today, with its stocks declining and its population structure shifting, it has many biologists and conservationists concerned about its future.

Corallium rubrum lives only in the Mediterranean Sea and along neighboring Atlantic shores. It grows mainly at depths of 90 to 600 feet, but occasionally its habitat can be as shallow as 20 feet or as deep as 1,000 feet. Despite its genus name, *Corallium*, it is not one of the "stony," reef-building organisms people typically think of first when they hear the word "coral." Those are members of the taxonomic order Scleractinia, whereas red coral belongs to the related order Gorgonacea, the soft corals. Both stony and soft corals are colonies of invertebrate animals called cnidarians, a group that includes jellyfish and sea anemones. In both orders, mature colonies act as ecosystem engineers: they and their remains provide three-dimensional habitat and shelter for fish, crustaceans, and other organisms, enhancing biodiversity. There are thirty-one species in the genus *Corallium*, of which seven are harvested for jewelry and crafts. *C. rubrum*'s typical intense-vermilion skeleton—which can vary to orange, pinkish, and in rare cases, white—makes it the jewel supreme.

The skeleton, of calcium carbonate, is produced by individual cnidarian polyps *[see photograph above]*. The polyps take shelter under a crust of tissue covering the entire colony; they protrude through it to feed, and they exchange nutrients via passages in it. (Jewelers remove the tissue before working the skeleton.) Each polyp is little more than a digestive sac with tentacles that catch plankton and organic particles. Colonies are composed entirely of either male or female polyps. In early summer the males liberate sperm sacs, which wash over to fertilize eggs inside female polyps situated, at most, a few hundred yards away. A month later, each female polyp releases between one and five larvae. Swept along by currents, a larva has only limited motility to help it locate a suitable home: a patch of rock free from competitive algae with dim lighting and a moderate current. There it attaches itself and metamorphoses into a polyp that might found a new colony by reproducing asexually—"budding" new polyps that themselves bud.

After about seven years, colonies are unbranched sticks less than an inch tall by a quarter inch in diameter. After a century, they grow to a height of one and a half feet and have many branches. They look like little

Investigators examine coral confiscated by police in 2007 from a poacher on the Spanish Costa Brava. Most of the coral was below the legal size limit, and the case went into legal proceedings.

red bonsai trees extending their white, flowerlike polyps into the watery breezes.

My colleagues and I spent 2002 and 2003 intensively counting, measuring, filming, and photographing *C. rubrum* all over the Costa Brava. We developed a nondestructive photographic sampling method to measure the size of 7,600 coral colonies. Our results showed that the seven-year-old, inch-tall sticks are average for the region. The oldest corals, like the ones we saw deep in the Medas reserve, were no bigger than our palms, probably about thirty years old. Where were the 100-year-old, foot-and-a-half-tall "bonsais," which local divers in the 1940s described as common?

The populations seemed to be unnaturally, perhaps unhealthily, youthful, and we wondered why. Red coral has no predators, but it does have a parasite: a sponge that perforates colony bases. Yet if either elevated parasitism or a disease were responsible for the skewed populations, dead corals would remain as evidence, and we'd seen few. We knew that Mediterranean red coral is generally thought to be overharvested; in fact, Catalonia's fisheries department had commissioned our project to help guide an update of its coral-fishing regulations. But just nine legal coral divers work along the Costa Brava; it seemed unlikely that so few fishermen could distort the populations, though we had yet to learn the extent of poaching.

The traditions of red-coral fishing and craftsmanship are indeed old ones. Coral amulets some 7,000 years old have turned up around Europe. For millennia, red-coral branches were probably collected on Mediterranean shores, having washed up after storms. People used red coral decoratively and traded it as far away as India. About 5,000 years ago, people began harvesting live corals. Working from boats or while swimming, they used iron hooks, probably affixed to wooden poles, to dislodge colonies from shallow outcrops. Then, by the first century B.C., someone, possibly a Greek, invented a coral dredge that was used for centuries throughout the Mediterranean, with many variations. The dredge consisted of two crossed wooden beams with nets attached at the four ends; the nets entangled corals, breaking them off the substrate [*see illustration on opposite page*].

Over time, red coral acquired tremendous cultural and religious importance. In Greek myth, the first red coral appeared when blood from Medusa's severed head petrified seaweed. To Greeks, red coral's magical powers included overcoming evil and protecting ships against lightning. Romans ingested it powdered to counteract poison, sorcery, seizures, and other ills. Later, Christians considered it protective against Satan, its color symbolizing the blood of Christ. *C. rubrum* was often used in rosaries, and necklaces and branches of it appear in many works of Catholic religious art.

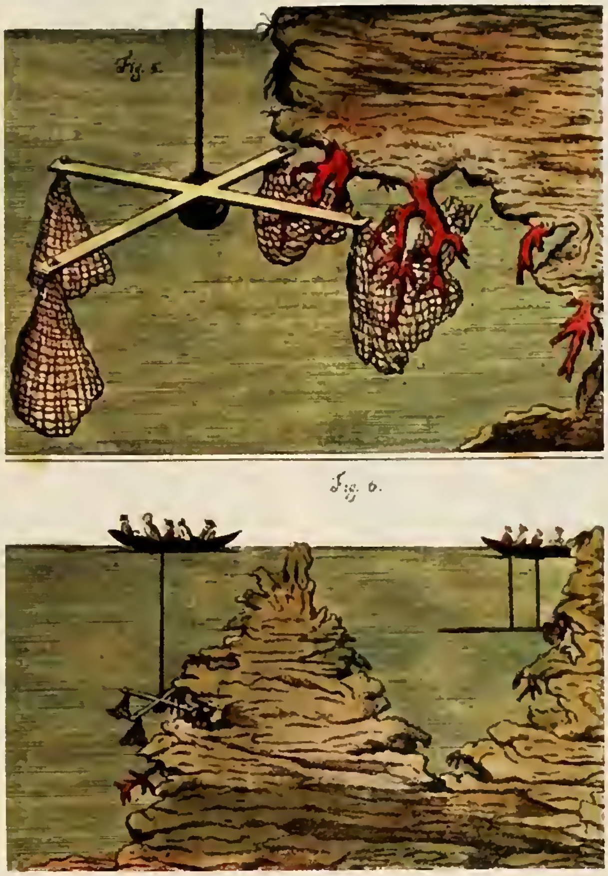
In 1943, the invention of the Aqua-Lung, a pressurized-air delivery system, initiated modern scuba diving. Swimming and breathing freely, coral divers could selectively collect large colonies in caves and crevices, where dredges were useless. Dredging recovers only 40 percent of the coral it dislocates and destroys most marine life in its path; in 1994, the European Union banned it because of the devastation it causes. By that point, however, diving had largely replaced dredging anyway, and it remains the only harvesting method used today.

Diving is much less damaging to other marine life than dredging is. Ideally, divers leave colonies smaller than the

THIS PAGE: FUNDACIÓ PER A LA CONSERVACIÓ I RECUPERACIÓ D'ANIMALS MARINS (CRAM); FACING PAGE: COURTESY OF MARIO GALASSO, CENTRO STUDI CORALLO legal size—in Spain, a quarter-inch in basal diameter—and cut larger colonies off just above the base so they have a chance to regrow, rather than rip out the entire colony. Not all divers are so responsible, however. Some, particularly poachers, will completely wipe out the red corals at a site. Red-coral larvae don't travel far from their parent colonies; indeed, recent studies indicate that distinct populations are fairly isolated genetically. That, combined with the species' low growth rate and late fecundity, makes clear-cutting unusually devastating, and leaves red-coral populations vulnerable to local extinction.

The practice of removing every little scrap of coral from a site became profitable a few decades ago, when the industry developed a method of using epoxy to reconstitute coral from shards or powder. Before that, small branches were practically worthless, because only larger pieces could be worked. Now coral of any size is salable, and a recent rise in the market value of illegally small branches—to a high of about $180 per pound—indicates the scarcity of large colonies in the Mediterranean. (Large-diameter, high-quality coral goes for nearly $700 per pound, and a finished bead necklace can retail for $25,000.) Even legal fishermen admit they frequently harvest undersize colonies to stay in business.

Several locales have dominated the trade in Mediterranean red coral through time, but the most powerful has been Naples and its vicinity. The region rose to prominence for coral production in the sixteenth century; at its peak in the mid-nineteenth century, it employed several hundred boats and thousands of fishermen and jewelers. Today, Torre del Greco near Naples remains the world's main center for precious-coral jewelry manufacture. It processes more than 90 percent of harvested Mediterranean red coral and much of the world harvest of other *Corallium* species. It generates approximately $230 million annually. Several thousand citizens are employed in the craft. The harvesting is decentralized, however; dozens of independent divers operate off Spain, France, the Italian islands of Corsica, Sardinia, and Sicily, and to a lesser degree off North Africa.



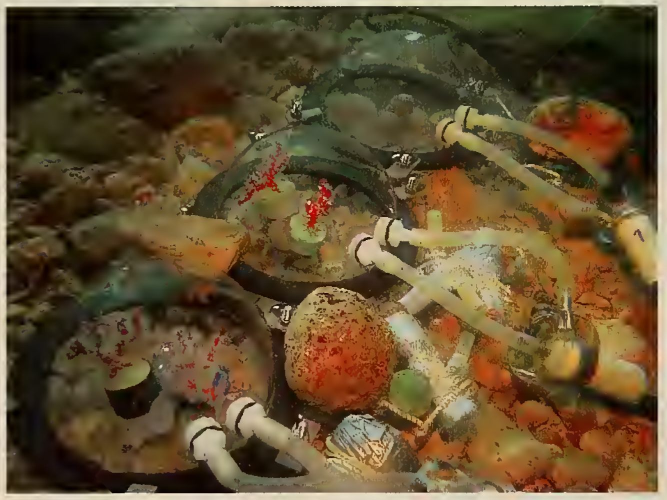
Eighteenth-century engravings depict coral fishing with a St. Andrew's cross, a dredge used in the Mediterranean from the first century B.C. or earlier until its prohibition in 1994. The cross's four nets entangled coral, destroying "forests" of mature colonies that had sheltered other sea life.

The best way to reveal the effects of a fishery is to compare harvested with untouched populations, and my colleagues and I set out to do so. Finding a harvested population was no problem, obviously, but we knew of no undisturbed populations of *C. rubrum* along the Costa Brava. (Indeed there are few anywhere.) Our two best options were the Medas Islands marine reserve, and deep populations—260 feet below the surface—that we could best examine using remotely operated vehicles (ROVs). Fishing was banned in the reserve only in 1991, and though the deep populations are beyond the reach of most divers now, they were dredged until 1994. Even so, our photographic survey showed a difference in demographics: deep or protected populations had significantly older, bigger, more-branched corals than harvested populations did. (And of the two kinds of semipristine populations, protected ones had scantier coral, probably because poachers can access their shallow sectors.) Harvesting essentially transforms an underwater forest landscape into a grass plain.

To learn how the populations had become so distorted, we turned to the fishermen themselves, a wary lot. The Costa Brava's nine legal fishermen are between forty-five and fifty-five years old. They live in little villages, and keep in close touch with one another. Slowly, Sergio Rossi established contact. He met first one, then another, and was given introductions only after thorough scrutiny. Good fishing grounds have always been kept secret, passed on from father to son—and licenses are granted according to a rather subjective system of merit and family tradition. The legal fishermen often complain that on most days, poachers outnumber them in the water. Rossi interviewed several of the license holders, and eventually they allowed him to accompany them during their work and to take samples from their fishing grounds. Never before had anyone monitored his work so attentively.

"Come on, you've made some coral as well, haven't you?" asked one fisherman. To "make coral" means to make money selling harvested coral. Only when they saw Rossi preserve tiny coral fragments in liquid nitrogen did the fishermen begin to relax. Eventually, a rare partnership between fishermen and marine biologists developed. Once, after guiding Rossi and me to a closely held population of valuable large corals, the youngest fisherman said, "For God's sake, take all the samples you need and do study the corals!" Fishermen and biologists both want red coral to be preserved.

So do poachers. But, as one Spanish coast guard officer told Rossi, the poachers feel entitled to harvest the corals on their coast, which leads to stubborn and violent behavior. The officer's car had been set on fire after he made some arrests. I've spoken with a Spanish fisheries officer and a biologist at the Medas reserve who were both threatened by poachers. Local part-time professionals, poachers know exactly how to avoid patrols while diving for coral. Some are well known, but ordinary coastal residents aren't inclined to object—only coral divers, biologists, and the poachers themselves seem to be aware that the species is overharvested.



Pumps circulate water through experimental chambers holding Mediterranean red coral. By sampling the water periodically, the author studied the corals' feeding rate.

In stark contrast, coral jewelers profess faith in the endless bounty of the sea. Basilio Liverino, a legendary jeweler in Torre del Greco, declared in 1983, "It is true that we lack the raw material, but I am convinced that it still exists. It is only necessary to find and harvest it." That position may have been tenable twenty-five years ago, but many Italian coral jewelers still cling to it today, even in the face of annual *C. rubrum* catches that have declined to 40 percent of their historic levels, and that include ever-younger specimens.

Six years and several hundred dives after we began our project, Rossi, Bramanti, and I started piecing together the results of our population studies with similar findings from smaller-scale studies by other teams, along with the insider knowledge of the fishermen and historical data. Unfortunately, *C. rubrum*'s story is a classic fish tale: over the centuries, fishermen have become increasingly adept at finding and depleting populations. Throughout the Mediterranean, red-coral fisheries have long followed a boom-and-bust cycle, tapping out one rich bank and then moving on to the next. Red-coral populations living in shallow water are at the greatest risk, because, in addition to overharvesting and poaching, they're vulnerable to a combination of climate change and disease. Computer simulations by Giovanni Santangelo, a coral biologist at the University of Pisa, show that mass die-offs of unknown origin, which have occurred during recent exceptionally warm summers, can eliminate shallow-water populations already stressed by overharvesting. Healthy populations will probably recover from such setbacks, but overharvested ones may not.

Even so, it is not the species' ecological extinction that is at stake—at least, not yet. Its economic extinction is a real possibility, however, and that would end the centuries-old crafts of coral fishing and jewelry making. Torre del Greco's jewelers already make only about half—or perhaps less—of their jewelry from Mediterranean red coral; for the rest they rely on other troubled *Corallium* species imported primarily from Japan and Taiwan. Attempts at coral aquaculture have failed, and the prospect of finding many new *C. rubrum* stocks seems remote. Most remaining unknown populations are probably located beyond the depth limit of scuba diving technology. Some coral divers now use ROVs to locate a few scattered large colonies, then perform logistically and economically demanding deep dives to harvest them. And I have heard of one team that targets underwater seamounts, in international waters where they don't need licenses, to harvest large colonies that can sell for $65,000 apiece.

The next step would be to do the actual harvesting with ROVs or manned submersibles, but for the moment those technologies remain impractical. As with other endangered species, however, the scarcer the corals are, the more they're worth, so the more incentive there is to track down the very last ones. Unfortunately, it's the large, mature corals that are the most fecund. Exposing deep populations of mature colonies to heavy harvesting could indeed send the species into extinction.

There are lessons to be learned from other precious-coral fisheries. Several red and pink *Corallium* species have been harvested by dredge in the Pacific Ocean for 200 years, and today the stocks are devastated. Black corals of the genus *Antipathes*, harvested in Hawaii since the 1960s, provide a counterpoint. Besides being Hawaii's official state gem, black coral shelters fish communities that support endangered Hawaiian monk seals. A man-

THIS PAGE: GEORGIOS TSOUNIS; OPPOSITE PAGE: KURT AMSLER/ARDEA.COM agement program developed by Richard W. Grigg, a coral biologist at the University of Hawaii at Manoa, and implemented in the 1970s has made it the world's only sustainable precious-coral fishery. Black coral is protected under Appendix II of the Convention on International Trade in Endangered Species (CITES), which ensures that only licensed businesses can ship and sell it.

Licensed diver harvests typically small Mediterranean red coral.

In 2007, the same was proposed for the entire *Corallium* genus, which has no international protection. CITES' expert panel at first accepted the proposal. Then it made the unorthodox move of voting again by secret ballot after the meeting's scheduled close, when some delegates had departed. Under pressure from the jewelry industry and North African coral-exporting nations, the panel rejected the proposal, citing a lack of sufficient population data. (This was despite having included both black coral and blue coral, *Heliopora coerulea*, in Appendix II. Both are less well-known biologically and also of lesser economic importance than *Corallium*.) But the panel did acknowledge the need to conserve the genus, and committed to study how CITES can contribute. To that end, the first of two promising workshops convening international experts was scheduled for this March (after press time) in China. The National Oceanic and Atmospheric Administration was to host the meeting, in recognition of the United States' responsibility as one of the largest importers of precious coral.

Experts agree that *Corallium* species are overharvested, though how best to manage them is subject to debate. Even "sustainable" management allows target species to be fished after their population structure changes drastically, as long as the stocks don't collapse. But because of corals' importance in structuring their habitats and sheltering other organisms, the mere survival of populations and species is insufficient: they must be healthy to fulfill their ecological role. Conserving seamounts in deep, international waters—perhaps the last reservoirs of virgin populations—is therefore as important as protecting overharvested stocks.

Realizing that precious corals were in trouble, leading jewelry manufacturer Tiffany & Co. stopped using them in 2002. They and other fashion and jewelry businesses joined a campaign, launched last year by the U.S. conservation group SeaWeb, to conserve precious corals. Those are bold moves, but not ones realistically possible for Italian companies specializing in coral jewelry. Their future lies in scaling back their business to align with a sustainable coral harvest, a change that will probably require international as well as local regulation to achieve. Finding a solution is an enormous challenge, but the rewards will be great: ensuring the survival of red corals and the species that depend upon them, as well as preserving the fascinating and ancient traditions of coral diving and craftsmanship.

Gone forever are the innocent days old divers remember, when corals were so abundant they could pick a colony, like a bouquet, for their girlfriends. Nevertheless, with proper management and plenty of time, the rich red-coral forests of the past can come to life again. Then the northern Catalan coast will again live up to its colloquial name: *Costa Vermell*—the Vermilion Coast.

Georgios Tsounis studied marine biology in Germany, Hawaii, and the United Kingdom before earning his doctorate in 2005 from the University of Bremen, Germany, for research on the ecology of Mediterranean red coral. He is a postdoctoral researcher at the Institute of Marine Sciences in Barcelona, Spain, where he studies precious-coral fishery management and deep-coral ecology. He is also involved in documentary filmmaking on environmental topics.

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

THIS LAND BY ROBERT H. MOHLENBROCK

A Bibb County glade

The Magic Rock Garden

A rare dolomite plays host to Alabama rarities.

Exploring parts of the future state of Alabama in 1775, William Bartram was one of the first prominent naturalists to record some of the native vegetation. In the ensuing years, many professional and amateur enthusiasts scoured the region to add to his list of plants. Some—such as Charles T. Mohr in the latter part of the nineteenth century, Roland M. Harper in the early 1900s, and Robert K. Godfrey and Robert Kral during the latter half of the twentieth century—made significant discoveries. As a result, two hundred years after Bartram's visit, Alabama could boast one of the largest documented floras in the United States. So it's all the more remarkable that an area about fifty miles south of Birmingham, harboring many new or rare species, went undiscovered until only twenty years ago.

Georgia botanist James R. Allison had been contracted by the United States Fish and Wildlife Service in 1989 to conduct a survey of Nevius's stonecrop, a candidate for the federal list of endangered and threatened species. Since the plant was known to grow on rocky bluffs along the Little Cahaba River in Bibb County, Alabama, Allison decided a canoe trip down the river might be a way to spot new populations. His hunch was correct, and the newly identified populations were a factor in *not* deeming the species endangered or threatened. In 1992 Allison fulfilled a similar mission, this time looking for Georgia rockcress. In the process he and his companions on the canoe trip collected some plants they couldn't identify. From that and subsequent visits, it became evident that several rocky, relatively treeless slopes above the river deserved careful exploration.

Although many of the plants growing in those rather open areas, known as glades, were commonplace, Allison eventually tallied five species and three varieties new to science (and still known only from Bibb County). He also documented populations of two species on the federal list of endangered and threatened species (and of two more that are candidates); eight other species never recorded before in Alabama; and another fifty-six species or varieties already known in the state but considered rare by the Alabama Natural Heritage Program.

Glades occur here and there in the eastern United States. Among the most familiar to naturalists are the cedar glades of northwestern Alabama, northwestern Georgia, central Kentucky, and central Tennessee; the shale

HABITATS

Ketona dolomite glade Little bluestem is the dominant grass; other predictable glade plants include false garlic, glade sandwort, and grooved flax—all spring bloomers—and the summer- and autumn-blooming elm-leaved goldenrod, fringed bluestar, and green milkweed. Expected woody species are chinquapin oak and eastern red cedar; unusual for glades are longleaf pine and the shrubs Alabama croton, dwarf palmetto, and maidenbush. Unique to the Bibb County glades are Alabama gentian-pinkroot, Cahaba daisy fleabane, Cahaba paintbrush, Cahaba prairie clover, Cahaba torch, deceptive marbleseed, Ketona tickseed, and sticky rosinweed. Mohr's Barbara's-buttons and Tennessee yellow-eyed grass are federally listed endangered or threatened plants growing in the glades, and Georgia aster and Georgia rockcress are candidates. The eight plants never found before in Alabama are blue wild indigo, Catesby's false bindweed, dwarf Carolina horsenettle (not seen anywhere since 1837), hybrid cloak fern, needle beaksedge, shining ladies'-tresses (a kind of

Cahaba lily

FRANK EMORY

barrens of Maryland, Pennsylvania, Virginia, and West Virginia; and others in southern Illinois, Missouri, and elsewhere. But except for eastern red cedar and chinquapin oak, the scattering of woody plants that grow in the Bibb County glades are atypical, including longleaf pine and shrub-size dwarf palmetto, Alabama croton, and maidenbush. That difference, as well as the presence of so many rare species, can be attributed to the local rock, called Ketona dolomite, found nowhere else in the world.

A dark gray sedimentary rock, Ketona dolomite contains carbonates

Cahaba torch

BERNARD GARLAND

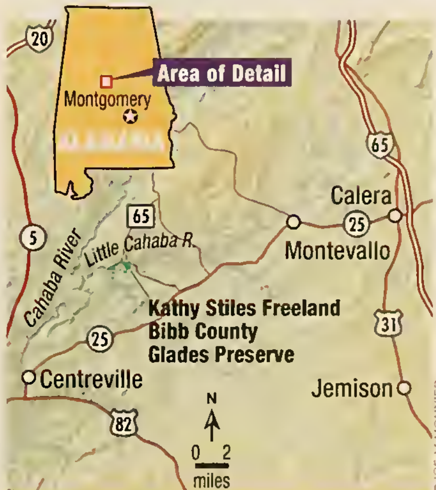
of calcium and magnesium without the usual impurities, including silica, that most other dolomites contain. The soil derived from the rock is particularly rich in magnesium, an element essential to plant growth, but one that in high concentrations proves toxic to many species. That probably explains the conspicuous absence of several plants that usually grow in dolomite glades.

About forty Ketona dolomite glades lie within an area about eleven miles long and one-half mile wide, forging openings within the surrounding dry forest. Some are only a quarter acre in size, while others cover as much as twelve acres. Along with thin soil containing rock particles of dolomite, they feature boulders and occasionally expanses of exposed bedrock. The soil deepens where glade meets forest, and species from the two habitats intermix in a transition zone.

In 1996 the Nature Conservancy moved to protect the unique glade habitat by purchasing land. The Conservancy now oversees a 370-acre preserve and is working in partnership with local landowners to protect additional acreage. The preserve is adjacent to the Cahaba River National Wildlife Refuge, established in 2002 with plans to encompass some 7,300 acres of land near the confluence of the Little Cahaba and Cahaba rivers.

The Cahaba River is itself noteworthy. For one thing, it is the only major river in Alabama that has been left essentially undammed. According to the U.S. Fish and Wildlife Service, its waters harbor 131 species of fishes and 75 species of snails and mussels, some found nowhere else in the world.

Robert H. Mohlenbrock is a distinguished professor emeritus of plant biology at Southern Illinois University Carbondale.



©JOE LEMONNIER

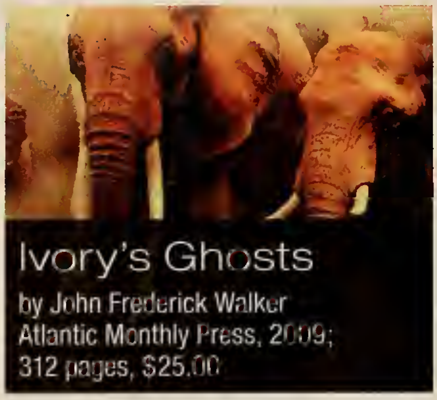
VISITOR INFORMATION
Kathy Stiles Freeland Bibb County Glades Preserve
The Nature Conservancy of Alabama
2100 First Avenue North, Suite 500
Birmingham, AL 35203
205-251-1155
www.nature.org/wherewework/northamerica/states/alabama/preserves/art902.html

orchid), Thorne's beaksedge, and Virginia nailwort. Other relatively rare species include Alabama phlox, Boykin's milkwort, eastern white-flower beardtongue, Great Plains ladies'-tresses, Michaux's gladecress, pinnate-lobe black-eyed Susan, and Tennessee gladecress.

Glade and forest transition Woody species include Carolina buckthorn, chalk maple, dwarf hackberry, loblolly pine, longleaf pine, sand hickory, and shortleaf pine. Among the wildflowers are cross-vine, eastern purple coneflower, false sunflower, hoary puccoon, and whorled milkweed.

Dry forest American hornbeam, chinquapin oak, flowering dogwood, loblolly pine, longleaf pine, red buckeye, and winged elm are the principal trees. Other common plants are muscadine grape, poison ivy, rusty blackhaw, shrubby St. John's-wort, and Virginia creeper.

Riverbank Trees along the river include hazel alder, river birch, sycamore, and Virginia sweetspire. Among the shrubs are false indigo bush and stiff dogwood, while Cahaba lily, northern sea oats, Philadelphia fleabane, and savanna sneezeweed are among the wildflowers.



In 1889, Henry Drummond of Scotland's Free Church College wrote that "the only thing of value the interior of Africa produces at present in any quantity is ivory." And such quantities! After the turn of the nineteenth century, traditional hand carving of ivory was dwarfed by its machining for industrial use. Throughout the Victorian era, streams of slaves, staggering under unwieldy loads of tusks, carried the white gold to the coasts of Africa, where it was loaded on to ships bound for Europe, America, and the Far East. Britain alone imported about 500 tons annually between 1850 and 1910, mostly for the manufacture of brush and cutlery handles. Even more went to the United States, to feed production lines of piano keys and billiard balls. In 1922, estimating that at least 4,000 elephants died each year to supply the ball factories, a U.S. billiard enthusiast remarked that "some thin-skinned person might question the killing of this large number of elephants to provide . . . recreation, but on second thought. . . . All animals have been created for man's special use, and for his good, and this includes the elephant and his ivory."

No longer does public opinion support such brutal exploitation of native labor or such self-serving slaughter of wildlife. Over the past century, plastic has gradually replaced ivory for most industrial uses, and the elephant has come to be valued more for what it is—a remarkable and intelligent beast—than for its precious dentition. A growing world conservation movement has led to campaigns for the elephant's protection (some species are endangered), and in January 1990, all international trade in ivory was banned.

Still the lust for ivory persists, virtually undiminished. John Frederick Walker, who has written extensively about African wildlife in the past, quotes estimates of between 5,000 and 12,000 elephants illegally killed each year to supply the black market for ivory, and notes that valuable stocks of tusks, harvested legally from natural deaths in national parks, have been piling up in government warehouses because they are too valuable to trash. Despite the wonders of chemistry, ivory still has its charms; and despite the best efforts of conservationists, elephants are still being shot

Walker provides a sensitive and insightful analysis of all this ivory mischief, past and present. It's not, in his view, a case of greedy capitalists versus sensitive eco-warriors. Ivory, he acknowledges, is as wondrous as the creatures that produce it, and if there were abuses in the way it was harvested and sold in the 1800s, it makes no more sense to shun it now than to eschew cotton because it was once harvested by slaves. Ivory remains an ideal medium for carving and sculpture, sensuous in texture and subtle in coloration, with traditional uses that go back to the dawn of civilization. And on the other side, elephants cannot be preserved by simply ignoring them. They compete with humans—and other animals—for scarce resources, and while they may delight urban tourists on safari, they can also terrorize rural populations.

Walker sees the future of elephants not in an absolute ban on all ivory, but in a system of sustainable harvesting and wildlife management. It's a difficult balancing act, to be sure, but ivory, he proposes, can transcend its bloody past "long stained with the slaughter of elephant herds and human misery" to become a self-renewing resource which can fund national parks, stabilize local economies, and preserve the impressive creatures that make it.

Sometime in the first century B.C., a heavily laden sailing vessel struck a rock off the small island now called Antikythera, just south of the Greek mainland, and went straight to the bottom. It lay there, timbers rotting away, until the autumn of 1900, when itinerant sponge divers noticed shapes of humans and horses emerging from the mud. Over the next year, with the encouragement of Greek authorities, those diver's salvaged all that remained, an exquisite cargo of marble and bronze statues, jars, and gold jewelry, which today occupy a major portion of the National Archaeological Museum in Athens. Price was an expert in ancient scientific instruments, and he had come to Athens because he realized that an analysis of the operation of such an odd device "must entail a complete reestimation of ancient Greek technology." Dazzled by the glory of those artworks, archaeologists of the time scarcely noted a remarkable yet humble-looking item in one of the wooden boxes: a few lumps of corroded metal—the remains of an elaborate assembly of interlocking gearwheels and inscribed metal plates.

Finding a geared mechanism in a wreck of such antiquity was "eerie and otherworldly," writes science journalist Jo Marchant, "like finding a steam engine on the ancient, pitted surface of the Moon." Although there were a few descriptions of simple screw-and-gear lifting devices in surviving classical texts, elaborate clockworks did not appear in Europe until the late Middle Ages, and mechanical calculators not until even later. The purpose of the Antikythera mechanism was unknown, though a few decipherable words on the oxide-encrusted disks hinted that it was an astronomical device. But whatever it was supposed to do, it seemed to be 1,500 years ahead of its time.

Fast forward to 1958, when a young historian of science, Derek de Solla Price of Cambridge University, first examined the Antikythera fragments at the Athens museum. Even though the device resisted understanding, Price remained obsessed by it, and in the 1970s, now a historian of science at Yale, he applied newly advanced X-ray and gamma-ray imaging technology to see what naked-eye inspection could not.

By counting the number of teeth on the interlocking gears, Price was gradually able to get an inkling of how the machine might have functioned as a mechanical calculator of positions of the Sun and Moon (the five known planets, too, as London Science Museum curator Michael Wright would figure out twenty years after Price's death). It embodied a knowledge of astronomical cycles well known to have been passed down to the Greeks by the Babylonians, but the technology was far in advance of anything historians had believed the Greeks capable of.

Price died of a heart attack in 1983, but subsequent researchers, using increasingly sophisticated imaging techniques, have verified the basic thrust of his work. They continue to elaborate on the operation of the complex mechanism, scrutinizing inscriptions previously obscured by two millennia of corrosion, building real and virtual models, filling in gaps, and correcting misapprehensions. We now know, for instance, that one use of the device was to predict eclipses. Nowadays you can go on the Web and watch the ancient Greek clockwork come to life in numerous animated diagrams and modern replicas. As Marchant points out, we are still unsure who made the original, nor do we know if there were others like it. Whether it was an isolated curiosity or the lineal ancestor of the Rolex, however, the device was a work of genius—and art—to rival anything Greek culture produced in bronze, gold, or marble.

Why do we love our cats and dogs so much? If you think it is just that they are cute, clever, and affectionate, well, that's only part of the story. And if you think they are fond of us only because we fill their food bowls, rest assured that animals really do love us—truly, madly, and deeply. Meg Daley Olmert, who produces natural history documentaries for TV, has investigated the scientific and historical background of the bond between humans and their domestic animals, finding that it's as socially complex and as biologically mediated as the love we humans have for each other.

We are, Olmert reminds us, social animals, and as such we naturally seek the company, not only of others of our species, but of all sorts of other animals. E.O. Wilson called this trait *biophilia*, and though not everyone shares his fascination with ants, we all seem to enjoy watching creatures as they go about their daily business. Zoos, nature films, and TV documentaries all cater to this interest, which Olmert traces back to the adaptive advantage our ancestors gained when they observed wolves and lions to become their pupils in predation, rather than their prey. By copying the strengths and second-guessing the weaknesses of coevolving animals, Stone Age hunters could assure ample meals for their families. Over several million years it was a natural progression from there to bringing the animals into the family: a domesticated wolf could help with the hunting in return for a secure share of the catch and the added protection of living with wily humans.

Interspecies bonds are more than just a marriage of convenience. According to Olmert, they are cemented by a hormonal mediator known as oxytocin. In new mothers, it's what produces labor contractions and stimulates lactation; released during courting, cuddling, and sex, it promotes intimacy and pair-bonding. In mammals in general, it functions as a sort of "anti-stress" hormone, lowering heart rate, reducing blood pressure, and producing a general feeling of contentment, peacefulness, and attachment. Oxytocin is produced—in both humans and animals—when we touch each other, and also when we are touched. We may not be able to talk with the animals like Dr. Doolittle, but on a chemical level, apparently, we all speak the same language.

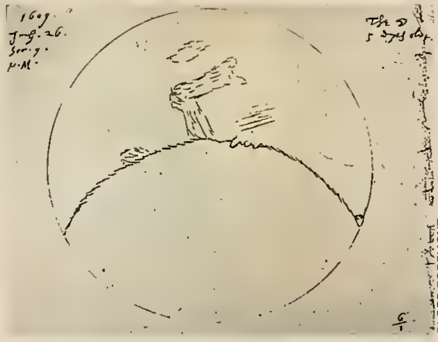
Although mediated by a single chemical, the social manifestations of the human-animal bond take many forms. Horse whisperers have discovered a spot on the back of the horse's neck that seems to stimulate oxytocin-induced feelings of sympathy. Cows and their milkers have been known to go into a mutual meditative state during the milking process. However it is manifest, Olmert believes, the oxytocin boost we get from pets not only makes us love our animal buddies, but can make us "smarter, calmer, friendlier, healthier, even more attractive." Good pets, as animal lovers have long known, make us good people.

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

SKYLOG BY JOE RAO

In a joint initiative of the International Astronomical Union and UNESCO, this year has been designated the International Year of Astronomy—IYA2009. The celebration coincides with the 400th anniversary of Galileo Galilei's historic astronomical observations with a telescope. A cornerstone project of IYA2009 is "100 Hours of Astronomy," beginning 12 noon Greenwich Mean Time on April 1. One aim of this worldwide event is to coax as many people as possible to look at celestial objects through a telescope. (Visit www.astronomy2009.org and www.100hoursofastronomy.org for details on the activities.)

Another public occasion is Astronomy Day, which was started in 1973 by amateur astronomer Douglas Berger. His intent was to set up telescopes in busy urban locations to captivate passersby. Since then the annual event has expanded, and it is now sponsored by a number of organizations. This year there will be two Astronomy Days. The first will be observed on May 2 (go to www.astroleague.org/al/astroday/astroday.html for more information); a second is planned for October 24. Or just organize your own 400th-anniversary celebration. For those who live in large cities, this is a good year to schedule an excursion to the countryside to become reacquainted with the night sky.



©LORD EGREMONT

A drawing of the Moon by Thomas Harriot, dated July 26, 1609, is the first record of the astronomical use of a telescope. The narrow field of view includes several dark lunar features and the line of the Moon's shadow.

Although Galileo has generally received credit for being the first to train a telescope on the heavens, new evidence shows that an Englishman, Thomas Harriot, made a drawing of the Moon, viewed through a telescope, on July 26, 1609—several months before Galileo's first astronomical observations with the device.

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

APRIL NIGHTS OUT

1 Saturn lies on the meridian around 11:30 P.M. local time. Visible through a telescope, the planet's brightest satellite, Titan, lies west of the ring edge, about five "ring-widths" away.

2 The Moon waxes to first quarter at 10:34 A.M. eastern daylight time (EDT).

9 The Moon is full at 10:56 A.M. EDT.

13 Mercury's best evening apparitions of the year (for mid-northern latitudes) begin tonight and continue until May 3. Look for the little planet about forty-five minutes after sunset.

17 The Moon wanes to last quarter at 9:36 A.M. EDT.

19 During the predawn hours, Jupiter is about 4 degrees to the lower left of the crescent Moon.

22 Venus rises before dawn just a couple of degrees to the lower left of a slender crescent Moon. Viewers near and along the West Coast of the U.S. and Canada can watch the Moon occult Venus. (For viewing details see this "Skylog" column at www.naturalhistorymag.com.)

24 Mars and Venus are in conjunction this morning. Venus, 4.1 degrees above the Red Planet, outshines it almost 200-fold. The Moon becomes new at 11:23 P.M. EDT.

26 Mercury is at its greatest eastern elongation this evening, 20 degrees above the Sun, thus able to linger as twilight fades. With binoculars look for the Pleiades and a two-day-old crescent Moon hovering about 3 degrees above the speedy little planet.

WORD EXCHANGE

Continued from page 6

Not Dead Yet

In his article about the revival of Hebrew ["Flowers Have No Names," 2/09], Benjamin Harshav correctly identifies the importance of language to smaller nations that seek to define themselves in the absence of political sovereignty. To my surprise, however, he then states that "To that end, immense efforts were invested in reviving old, 'dead' languages, such as Irish, Welsh, and Breton, but none of them became the base language of a nation." Irish is the first official language of Ireland, and there are an estimated 275,000 speakers of Breton and 575,000 speakers of Welsh who use those languages on an everyday basis. Globalization and the late granting of a public place for Welsh and Breton threaten their survival, but there are people working ardently to see that they remain alive and well.

Lois Kuter
U.S. Branch, International Committee for the Defense of the Breton Language
Jenkintown, Pennsylvania

Illogic

In "Onboard Computer" ["Samplings," 2/09], Stéphan Reebs describes a cell designed to signal "when one particular drug is present but the other absent" as performing a NAND function. But NAND would signal that only one drug or neither is present—that is, any condition except both being present. It is the opposite of AND.

Ed Schoch
Los Angeles, California

THE EDITORS RESPOND: The scientists in question designed a NAND function, BUT we characterized it incorrectly.

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

EXPLORER GUIDE

A Place Apart

AMNH/K. HOLMES

The Palmyra Atoll coral reef

The coral reefs of Palmyra Atoll in the Pacific Ocean have long been prized by scientists as a relatively untouched ecosystem. Despite dredging and other alterations to ease the movement of military supplies in World War II, near-pristine conditions still exist for the sharks, sea turtles, coral, sea birds, and other fauna there—and will now continue to exist because of the persistence of scientists and a rare presidential gesture that brought the string of islets into one of three new marine national monuments.

Through an executive order issued in the waning days of the Bush Administration, under the same law—the Antiquities Act of 1906—used by President Theodore Roosevelt to set aside such national treasures as the Petrified Forest and the Grand Canyon, oil and gas exploration are prohibited, and commercial fishing will be phased out over the next five years over a total area of 195,280 square miles in the central and western Pacific. The protected areas are Rose Atoll in American Samoa; the three northernmost islands of the Marianas chain, including the Mariana Trench, the deepest canyon on Earth; and a set of seven other remote Pacific Islands that includes Palmyra Atoll, a small circular chain of some 50 uninhabited islets and sand flats surrounded by more than 15,000 acres of coral reef systems and lagoons.

"These are 'gem' ecosystems in the Pacific," says Dan Brumbaugh, Senior Conservation Scientist at the American Museum of Natural History's Center for Biodiversity and Conservation (CBC), who has been studying coral reefs in Palmyra Atoll and The Bahamas with Kate Holmes, CBC Marine Biodiversity Specialist, and other scientists. "The great thing about Palmyra is that it's relatively untouched. We have more opportunity there than in most any other place to understand how an intact reef ecosystem works."

The inclusion of Palmyra Atoll in the new protection measures stems in part from a unique public-private partnership between the Palmyra Atoll Research Consortium, a consortium of eight universities and cultural institutions; The Nature Conservancy; and the US Fish and Wildlife Service. CBC Director Dr. Eleanor J. Sterling was named Chair of the Consortium in 2006. The Consortium was created to undertake basic and applied research at the field station on Palmyra Atoll and has played a strong advisory role in the conservation activities of The Nature Conservancy and the Fish and Wildlife Service at Palmyra. Through their combined work, on December 23, 2008, Palmyra Atoll was designated a Ramsar Wetland of International Importance. This designation places Palmyra within a framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.

Working with Brumbaugh and Holmes in the Palmyra study are Douglas McCauley and Hillary Young of Stanford University and Robert Steneck and Suzanne Arnold of the University of Maine. Funding for this research is from the National Science Foundation, the National Oceanic and Atmospheric Administration, and the Jaffe Family Foundation. The goal of the current research is to establish a baseline of what constitutes a healthy ecosystem and use that to determine steps needed to restore damaged ones.

"People tend to think of the ocean as this enormous entity that can absorb pollutants and disperse them, that we can throw whatever we want into the water and it will disappear," says Dr. Sterling. "We also have, in the past, thought of the oceans as a massive resource for fish that just show up on our plates. And yet ocean studies show, more and more, the extended harmful effects of our overfishing and our adding pollutants and trash to the oceans."

These new marine national monuments expand on the 2006 creation of Papahanaumokuakea Marine National Monument, which covers 139,797 square miles in the Northwestern Hawai'ian Islands. Together, these rare and valuable resources offer scientists a chance to learn more about a rapidly deteriorating environment—and serve as powerful symbols of the importance of understanding and sustaining healthy ocean ecosystems.

Creatures Great and Small

How do you replicate an animal that no one has ever seen? That was one of the central challenges of mounting the exhibition *Extreme Mammals: The Biggest, Smallest, and Most Amazing Mammals of All Time,* which opens on May 23 at the American Museum of Natural History.

Along with examples of familiar living mammals with unusual adaptations—flying squirrels or the duck-bill platypus—the exhibition will include models of such mysterious extinct creatures as *Ambulocetus,* a whale with legs and feet; *Indricotherium,* the largest known land mammal ever, standing 15 feet tall at the shoulder; and *Batodonoides vanhouteni,* a shrew-like mammal so tiny it could fit on the tip of a pencil (if there were pencils, that is, when it lived about 50 million years ago!).

Following in a long tradition of marrying art and science, a dozen or more staff artists have worked with curators to fashion the models that will enliven the exhibition. Their studio, on the fifth floor of a Museum building called the Powerhouse, looks like a combination factory and artist's atelier. Here, the signs of craftsmanship and creative expression are everywhere: a sculptor patiently applies clay to a fossil jaw of the knobby-headed, saber-toothed *Uintatherium;* a nearly finished model of a pint-sized tapir is held aloft by a metal-rod "leg" secured in a vise; and a heavy-wire "skeleton" is covered in foam in the humpless-camel shape of a long-nosed *Macrauchenia.*

AMNH/R. MICKENS

AMNH/R. MICKENS

Preparator Rebecca Meah meticulously recreates a massive *Macrauchenia.*

The typical process of creating a model starts with the sculpting of a soft clay likeness of whatever fossils or fossil fragments are available. (The diminutive *Batodonoides vanhouteni,* for example, was built up from a single, very small jaw.) When the clay model is completed to the finest detail, from feathered fur strokes to taxidermy marble eyes, it's covered in liquid rubber that sets to form a pliable mold. The mold is peeled away from the clay cast and filled with resin, which hardens into a realistic cast that requires only the restoration of the marble eyes and the painting of finishing touches. Larger models may use the first process for the head and then depend on a complex, jerry-rigged structure of wires, wood frames, foam blocks, and spray-on foam, sculpted into shape for the body.

The realization of this painstaking yet—to see the artists at work—pleasurable process continues to have value beyond its use in the current exhibition. After the exhibition finishes its run, the molds are archived, like scientific specimens, for future reference and possible use for generations to come.

Rx for a Greener World

Ten years ago, a cutting-edge film opened with a women telling her therapist she couldn't stop thinking about garbage. "I've gotten real concerned about what's going to happen with all the garbage," she says. "I mean, we've got so much of it, you know?" The garbage represents a problem over which she has no control—and a feeling of helplessness many of us may share about looming environmental crises. But a remedy is at hand in the Environmental Health Clinic coming to the Museum on Thursday, April 23.

An Art/Sci Collision program scheduled in conjunction with the current exhibition *Climate Change: The Threat to Life and A New Energy Future,* the clinic invites people to express their fears about global warming and other environmental threats. Then, Natalie Jeremijenko, director of the xDesign Environmental Health Clinic at New York University and an artist with a background in biochemistry, physics, neuroscience, and precision engineering, will write a "prescription." (Tellingly, Jeremijenko calls participants her "impatients"—an indication of frustration with the slow pace of change in public policy.) You might be directed to participate in a community project, cultivate plants that improve the air quality in your home, or learn more about how consumer products are made—all voluntary, but designed to create a sense of empowerment. "My hope," says Jeremijenko, "is to engage the wonder, observational skills, and intelligence of people. This is the real and powerful and renewable resource required to address the climate crisis."

For more information, visit www.amnh.org/programs.

Save the Date: Yo-Yo Ma and Friends at AMNH

Join us on Sunday, May 3, when music, art, and science come together in the world premiere of a musical composition about the evolution of mind. Visit www.amnh.org/programs for tickets and more information about this exciting event.

At the Museum

AMERICAN MUSEUM ō NATURAL HISTORY

www.amnh.org

EXHIBITIONS

Climate Change: The Threat to Life and A New Energy Future
Through August 16, 2009
This timely exhibition explores the science, history, and impact of climate change on a global scale.

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

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

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

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

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

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

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

On Feathered Wings
Through August 30, 2009
See the work of renowned wildlife photographers who showcase 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.

GLOBAL WEEKENDS

Pacific Island Heritage Day Celebrating Our Pacific: People, Ocean, Land, Sky, and Stars
Sunday, 4/26, 1–5 pm
Celebrate Pacific Island cultures with Susana Lei'ataua, artist-in-residence at New York University, and others.

Co-sponsored with the Asian/Pacific/American Institute, New York University

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

MILSTEIN SCIENCE SERIES

Center for Biodiversity and Conservation Milstein Science Symposium: Exploring the Dynamic Relationship Between Health and the Environment
Thursday–Friday, 4/2–4/3, 8:30 am–5 pm
symposia.cbc.amnh.org
This two-day conference will present a diversity of viewpoints and experiences spanning the natural, medical, and social sciences, as well as policy planning.

Proudly sponsored by the Paul and Irma Milstein Family. Additional support is provided by a grant from the Defense Advanced Research Projects Agency of the United States Department of Defense (DARPA), and by the Mack Lipkin Man and Nature Series.

LECTURES

Mack Lipkin Man and Nature Series Panel Discussion: It Takes a Planet: Connecting the Health of People and Nature
Thursday, 4/2, 7 pm
Julie Burstein, WNYC and Public Radio International, leads a discussion with **Dr. Julie Gerberding,** Director of the Centers for Disease Control and Prevention; **Peter Daszak**, Executive Director of the Consortium for Conservation Medicine; and **Peggy Shepard**, Executive Director and Co-founder, West Harlem Environmental Action, Inc. (WE ACT).

The Wilderness Warrior: Theodore Roosevelt's Crusade for America
Tuesday, 4/28, 6:30 pm
Author Douglas Brinkley, Rice University, examines President Theodore Roosevelt's pioneering environmental policies. A book signing follows.

Women of Discovery
Wednesday, 4/29, 4 pm
Meet the extraordinary women recipients of the 2009 Wings WorldQuest Women of Discovery Awards.

Art/Sci Collision Environmental Health Clinic
Thursday, 4/23, 6:30 pm
Natalie Jeremijenko, Director of the xDesign Environmental Health Clinic at New York University, creates actionable prescriptions for participants' environmental worries.

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

FIELD TRIPS AND WORKSHOPS

Spring Bird Walks in Central Park
Tuesdays, 4/7–5/26, 7–9 am
Wednesdays, 4/8–5/27, 7–9 am
Thursdays, 4/9–5/28, 7–9 am
Thursdays, 4/9–5/28, 9–11 am
Observe the spring activity of birds in Central Park with naturalists Stephen C. Quinn, Joseph DiConstanzo, and Harold Fienberg.

FAMILY AND CHILDREN'S PROGRAMS

Wild, Wild World: Predators
Saturday, 4/4, 12–1 pm or 2–3 pm
Learn more about predators in this special live-animal presentation with wildlife expert Andrew Simmons.

Dr. Nebula's Super Cold Adventure
Sunday, 4/19, 2–3 pm
Explore the properties of cold and learn how temperature affects different states of matter in Dr. Nebula's lab.

Robots in Space II (Intermediate)
Tuesday–Thursday, 4/28–4/30, 4–5:30 pm
Hone your skills as an expert robot designer. (Ages 8–10)

AMNH Adventures: Spring Camps
Monday–Friday, 4/13–4/17, 9 am–4 pm
Fossils and DNA
Take an exciting journey through human evolution. (Grades 2 and 3)

Mission Earth: Our Changing Planet
Examine the elements of

climate change and its impact on Earth. (Grades 4 and 5)

Robotics Camp
Design, build, and program your own robot to explore an unknown planet. (Grades 6 and 7)

After-School Programs
Courses in the Sciences
Session V, 4/20–5/29 (once or twice per week), 4:30–6:30 pm
amnh.org/education/highschool
New York City high school students interested in science can choose from a diverse range of scientific topics.

Support for the After-School Programs is provided by the Goldman Sachs Foundation.

A Night at the Museum Sleepovers
Saturday, 4/4
Friday, 4/24 (Girl Scouts)
amnh.org/sleepovers

MEMBERS' PROGRAMS

Coal Mining in Pennsylvania
Thursday, 4/23, 6:30 pm, 7 pm, and 7:30 pm
Join geologist Joe Boesenberg to explore Pennsylvania's Llewellyn Formation and visit the Anthracite Heritage Museum.

BEHIND THE SCENES TOURS

Behind the Scenes in Herpetology
Thursday, 4/23, 6:30 pm, 7 pm, and 7:30 pm
Join Curatorial Associate David Kizirian, Biodiversity Specialist Raoul Bain, Biodiversity Scientist Richard Pearson, and colleagues to visit the Department of Herpetology research collections.

WALKING TOURS

Who Was Who in Old New Amsterdam
Saturday, 4/18, 10 am–12 pm and 1–3 pm
A walking tour with geologist Sidney Horenstein.

HAYDEN PLANETARIUM PROGRAMS

TUESDAYS IN THE DOME

Virtual Universe
What's Hot in the Universe
Tuesday, 4/7, 6:30 pm

Celestial Highlights
The Lord of the Rings Resides in the Realm of the King
Tuesday, 3/31, 6:30 pm.

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

LECTURES

Death from the Skies! with Phil Plait
Monday, 4/20, 7:30 pm
Astronomer and author Phil Plait discusses possible cosmic catastrophes and what we can do to protect ourselves.

Cosmic Collisions
Journey into space to explore the impacts that formed our universe. Narrated by Robert Redford.

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

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

IMAX MOVIES

Wild Ocean
Experience the massive annual feeding frenzy in the oceans of South Africa as billions of fish migrate up the KwaZulu Natal Wild Coast.

Dinosaurs Alive!
This stunning film tracks AMNH scientists past and present search for dinosaurs in New Mexico and Mongolia.

LATE NIGHT DANCE PARTY

One Step Beyond
Friday, April 17
Visit amnh.org/onestepbeyond for details.

INFORMATION

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

TICKETS AND REGISTRATION

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

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

Become a Member of the American Museum of Natural History

You'll enjoy many valuable benefits, including unlimited free general admission, discounts on programs and in shops, subscriptions to *Natural History* magazine and *Rotunda*, our Members' newsletter, and much more!

For further information, call 212-769-5606 or visit www.amnh.org/join.

ENDPAPER

Possum on the Rostrum

By William F. Laurance

When we ponder the perils of global warming, the polar bear pops into many people's minds before any other threatened creature. But a different icon may be needed. Undoubtedly the bear is seeing its habitat melt away; yet the Arctic harbors only limited biodiversity. Plant and animal species at the Earth's equator vastly outnumber those at the poles—and may be even more vulnerable to temperature changes.

Polar bears and others living near the poles have adapted to seasonal swings of temperature, whereas tropical-zone species are thermal specialists, adapted to a narrow, stable temperature range. For every 1,000-foot rise in tropical-mountain elevation, temperatures drop by about 3.5 Fahrenheit degrees. Accordingly, local species adapted to relatively cool, cloudy upland conditions, often find the sweltering lowlands unbearable. Their montane populations become geographically isolated, allowing them to evolve and diversify—spawning kaleidoscopes of unique, locally endemic species.

Those montane endemics may be among the most vulnerable species on Earth. "As the world gets hotter, these creatures have nowhere to go," says rainforest ecologist Stephen E. Williams of James Cook University in Queensland, Australia. Williams has attempted to predict the responses to global warming of every endemic bird, mammal, frog, and reptile species in the rainforests of northern Queensland. His conclusions are jolting. If average temperatures rise by more than 4 degrees—which could easily happen this century—his studies suggest that extinctions will spike dramatically.

For Williams, the poster child for global warming should not be the polar bear, but the white lemuroid ringtail possum, a rare color morph of the species *Hemibelideus lemuroides* [*see photograph above*]. As photogenic as any polar bear, that marsupial is restricted to a single mountaintop in tropical Queensland, and it hasn't been seen by anyone in four years. Its death knell may have been a heat wave that hit the region in late 2005, when dead possums of several species were found in the forest. With their white brethren gone, lemuroid ringtail possums that sport the species' more common brown fur may not be far behind.

Tropical lowland species could be just as vulnerable as their mountain-dwelling cousins. On Barro Colorado Island in Panama, where I sometimes work, research suggests that many species—such as silky anteaters, insects, and iguanas—are living dangerously close to their thermal maximum. "If you heat an anolis lizard just a few degrees above its preferred foraging temperature, you risk killing it," says evolutionary physiologist Raymond B. Huey of the University of Washington in Seattle. Mass die-offs of tropical animals during heat waves seem to confirm this view.

White form of Australia's lemuroid ringtail possum

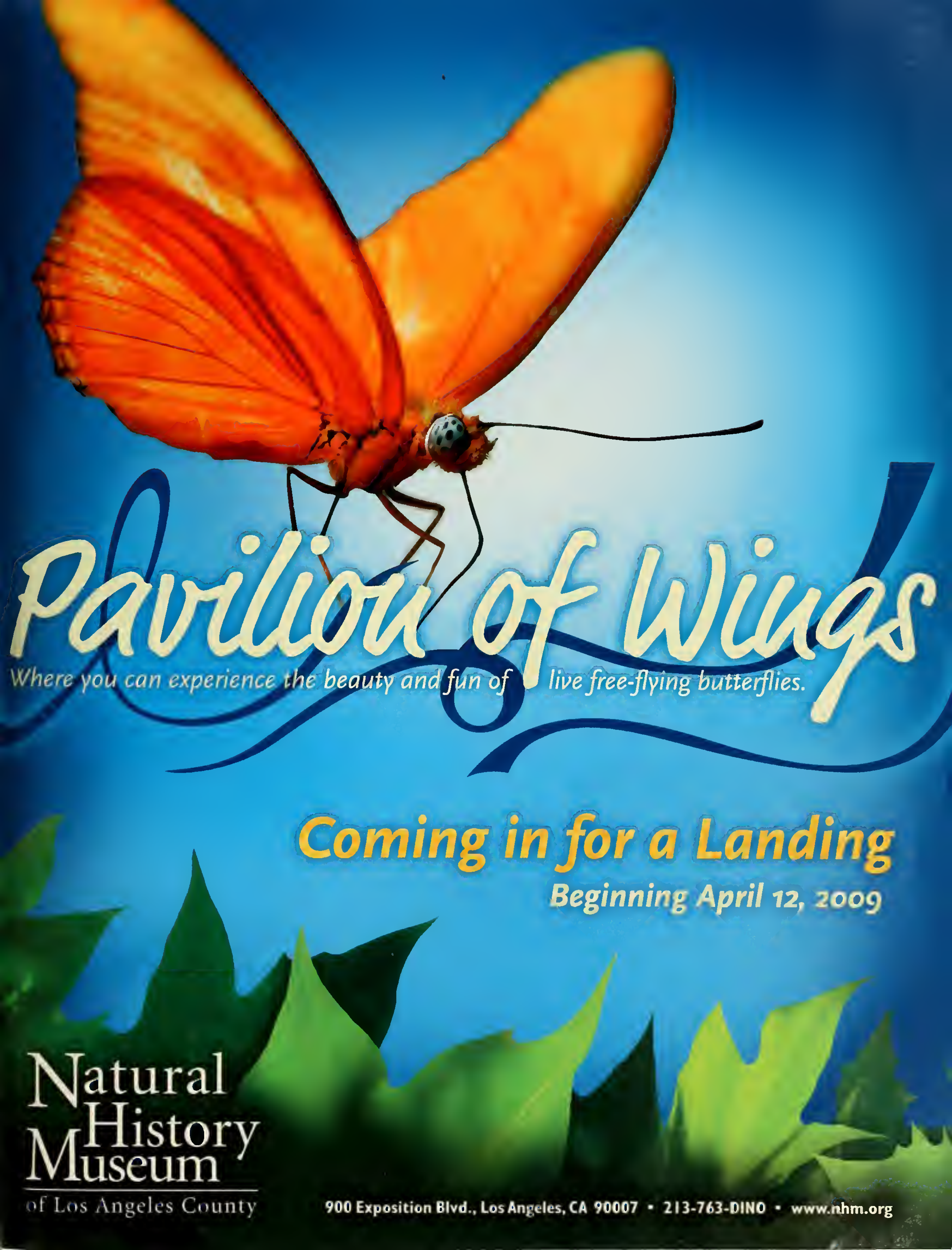
Many biologists now believe that global warming could rival habitat destruction as a threat to tropical biodiversity, endangering possibly a thousand times more species than those imperiled by warming near the poles. With an expanse of rainforest the size of fifty football fields going up in smoke every minute, that says a lot. At the very least, the two threats will conspire synergistically. Increasing habitat loss and fragmentation are likely to trap forest species, preventing them from shifting to more favorable climates or elevations. The small populations that remain could then be battered by heat waves, droughts, storms, and other manifestations of global warming, perhaps disappearing forever.

This alarming scenario has tropical biologists, myself included, wondering which battle to fight first—habitat destruction or global warming. I believe that slowing habitat loss is the higher priority, in part because the rapid destruction of tropical forests produces about a fifth of all greenhouse gas emissions today. Hence, saving rainforests is also a very effective way to combat global warming.

I, for one, will be keeping the white rainforest possum in mind as temperatures rise.

Young green iguana on Barro Colorado Island, Panama

William F. Laurance is a biologist with the Smithsonian Tropical Research Institute in Panama.


Pavilion of Wings
Where you can experience the beauty and fun of live free-flying butterflies.
Coming in for a Landing
Beginning April 12, 2009
Natural History Museum of Los Angeles County
900 Exposition Blvd., Los Angeles, CA 90007 • 213-763-DINO • www.nhm.org


ROLEX
SUBMARINER