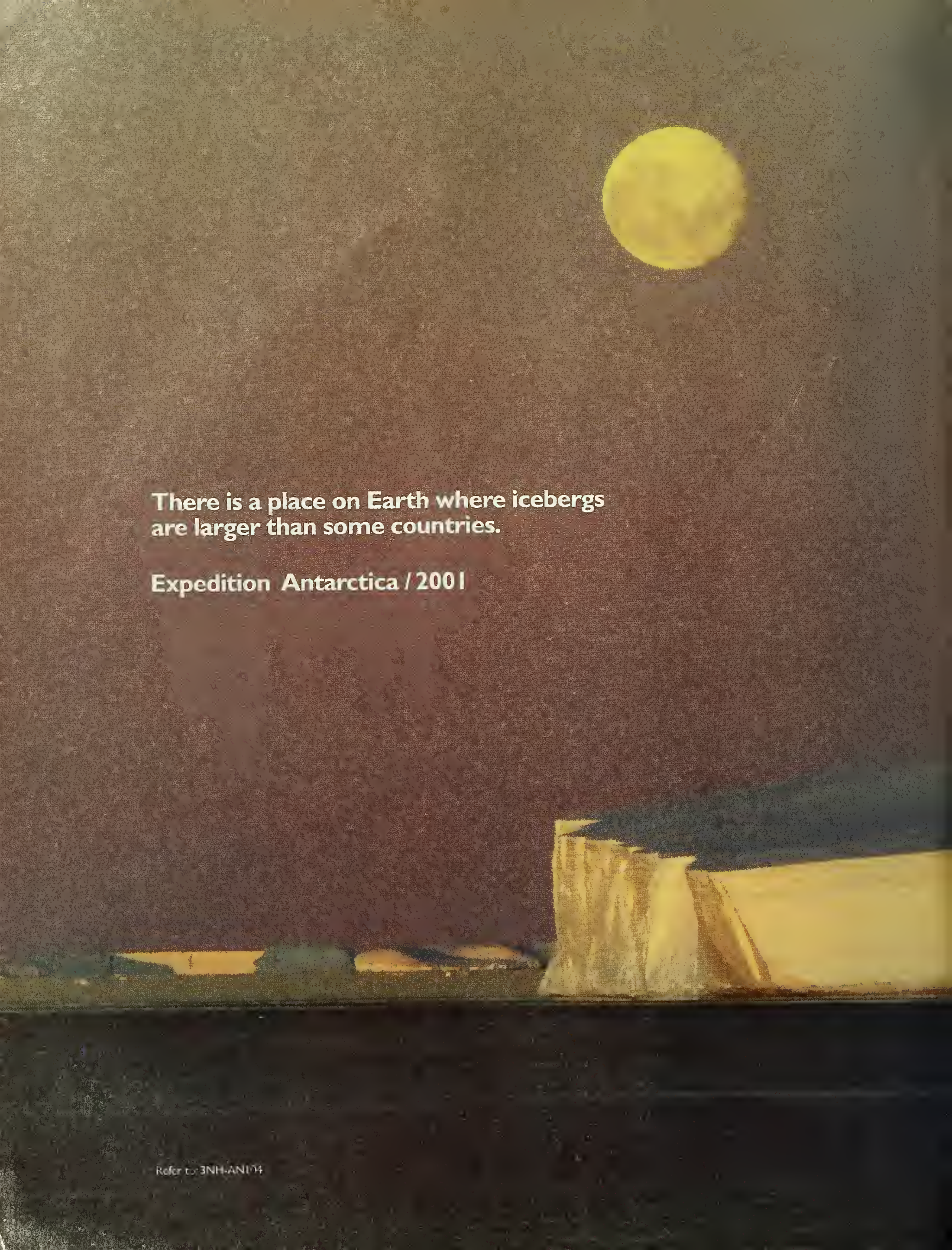
NATURAL HISTORY

4/01


Coming In For A Safe Landing.
Their wings may span six feet. Bringing bald eagles grace and majesty, but also danger. And that's because the place an eagle decides to land might be a high-voltage power line. So people working in Wyoming built special platforms on top of power poles. Helping this threatened species land safely. And soar to new heights.
Chevron
People Do.
www.peopledo.com
©2000 Chevron Corporation


There is a place on Earth where icebergs are larger than some countries.
Expedition Antarctica / 2001
Refer to: 3NH-AN104


Lindblad Expeditions
Expedition Travel. By The Family That Pioneered Expedition Travel.
See your travel agent or call: 1-800-EXPEDITION (397-3348) www.expeditions.com

Majestic humpback whales share coastal waters with 10,000 year-old icebergs.

Beyond the shore, there's a place where nature only comes in one size.

This is where the giants live. One, freed from an ancient glacier, sweeping southbound through Iceberg Alley. The other, gentle leviathan of the deep, a humpback moving north. Good fortune has their paths crossing just off our shores. Close enough to leave a very large impression.

NEWFOUNDLAND & LABRADOR
CANADA

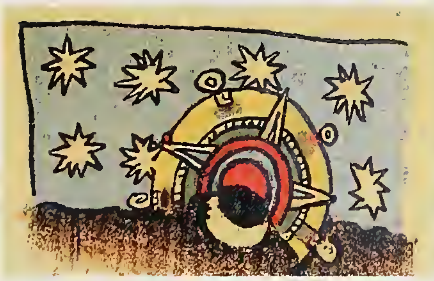
www.gov.nf.ca/tourism/

For your free travel guide or to make reservations, call Kelly at 1-800-563-NFLD

NATURAL HISTORY

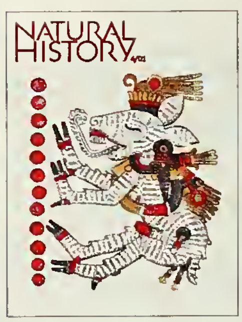
APRIL 2001 VOLUME 110 NUMBER 3

FEATURES



DEPARTMENTS

Visit our Web site at
www.naturalhistory.com



COVER A living deer depicted in the Codex Borgia, an Aztec document, represents half of a 260-day ritual calendar. (The other half is symbolized by a dead deer.)

STORY BEGINS ON PAGE 66

PHOTOGRAPH BY MEGAN CARLOUGH; AMNH

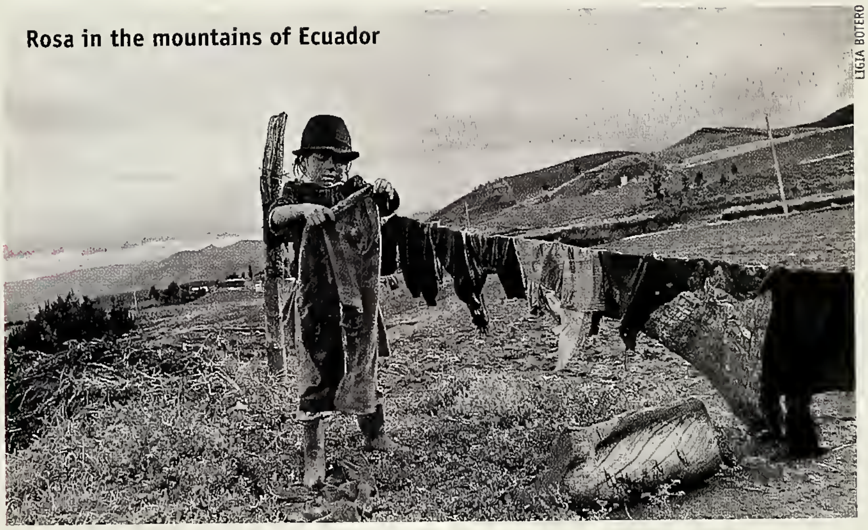

designer
architect
demolition expert
appropriately complex
Hennessy
Maison Fondée en 1765
VERY SPECIAL
COGNAC

UP FRONT

One Girl's Life

Surely it is difficult for any of us to understand how someone else experiences the world. Stuck in our own skins, limited to a given time and place in history, we are evolved to be healthily self-absorbed. To appreciate a life lived in another country (or next door, or even in the next room) requires empathic imagination and reason. We also need facts—as well as ideas to help us interpret those facts.

Textbooks, of course, have their limitations, which great works of art and literature help us transcend. Read *Anna Karenina,* and Tolstoy makes you learn—and feel—something of what happened to a woman if she stepped out of line in upper-class nineteenth-century Russian society. Read *The Autobiography of Malcolm X,* and you see the world through the prism of a forceful and specific individual mind, forged in a specific period of



Rosa in the mountains of Ecuador

LIGIA BOTERO

twentieth-century America. But the facts and truths of many other kinds of lives remain unexpressed, either in great novels or in autobiographies.

Enter Ligia Botero, a photographer who believed it was important to document the life of Rosa, an indigenous Ecuadorean girl. And enter Lynn A. Meisch, who, as a cultural anthropologist, can help us understand one another (and therefore ourselves) by teasing apart what is universal and what is particular in the innumerable lives being lived out on this planet.

In "Working Girl" (page 74), Botero and Meisch tell Rosa's story. Hers is the traditional life of any girl born poor in a poor country. But Rosa's life is also a very modern one, its broad contours shaped by global economic forces and its details modified by individual needs and personal enterprise.

Botero's beautiful, thought-provoking images and Meisch's seasoned observations allow us the privilege of traveling a short distance into the difficult life of Rosa—and, one hopes, into a more subtle understanding of the complex world we share with her.—*Ellen Goldensohn*

NATURAL HISTORY

THE MAGAZINE OF THE AMERICAN MUSEUM OF NATURAL HISTORY

ELLEN GOLDENSOHN *Editor in Chief*

Rebecca B. Finnell *Executive Editor*

Máire Crowe *Managing Editor*

Thomas Page *Designer*

Board of Editors

Jenny Lawrence, Vittorio Maestro, Richard Milner, Judy Rice, Kay Zakariasen (Pictures)

Michel DeMatteis, Avis Lang *Associate Managing Editors*

Thomas Rosinski *Assistant Designer*

Flora Rodriguez *Picture Coordinator*

Barbie Bischof *Research Editor*

Carol Barnette *Editorial Coordinator*

Merle Okada *Assistant to the Editor*

MARK A. FURLONG *Publisher*

Gale Page *Consumer Marketing Director*

Judy Lee-Buller *General Manager*

Denise Clappi *Director of Manufacturing*

Edgar L. Harrison *National Advertising Manager*

Sonia W. Waites *Senior Account Manager*

Jessica Mackin *Advertising Production Manager*

Ramon E. Alvarez *Circulation Manager*

Michael Shectman *Fulfillment Manager*

Jennifer Stagnari *Promotion Director*

Gladys Rivera *Assistant to the Publisher*

Monique Berkley *Advertising Coordinator*

Suzanne Kato *Circulation Assistant*

Advertising Sales Representatives
New York—Metrocorp Marketing (212) 972-1157
Chicago—Jerry Greco & Assoc. (847) 925-9300
Detroit—John Kennedy & Assoc. (313) 886-4399
West Coast—Robert Flahive Co. (415) 781-4583
Toronto—American Publishers Representatives Ltd. (416) 363-1388
Atlanta and Miami—Rickles and Co. (770) 664-4567
Northeast Direct Response—Nick Distasio (561) 748-1750

For subscription information, call (800) 234-5252 (within U.S.) or (515) 247-7631 (from outside U.S.). For advertising information, call (212) 769-5555.

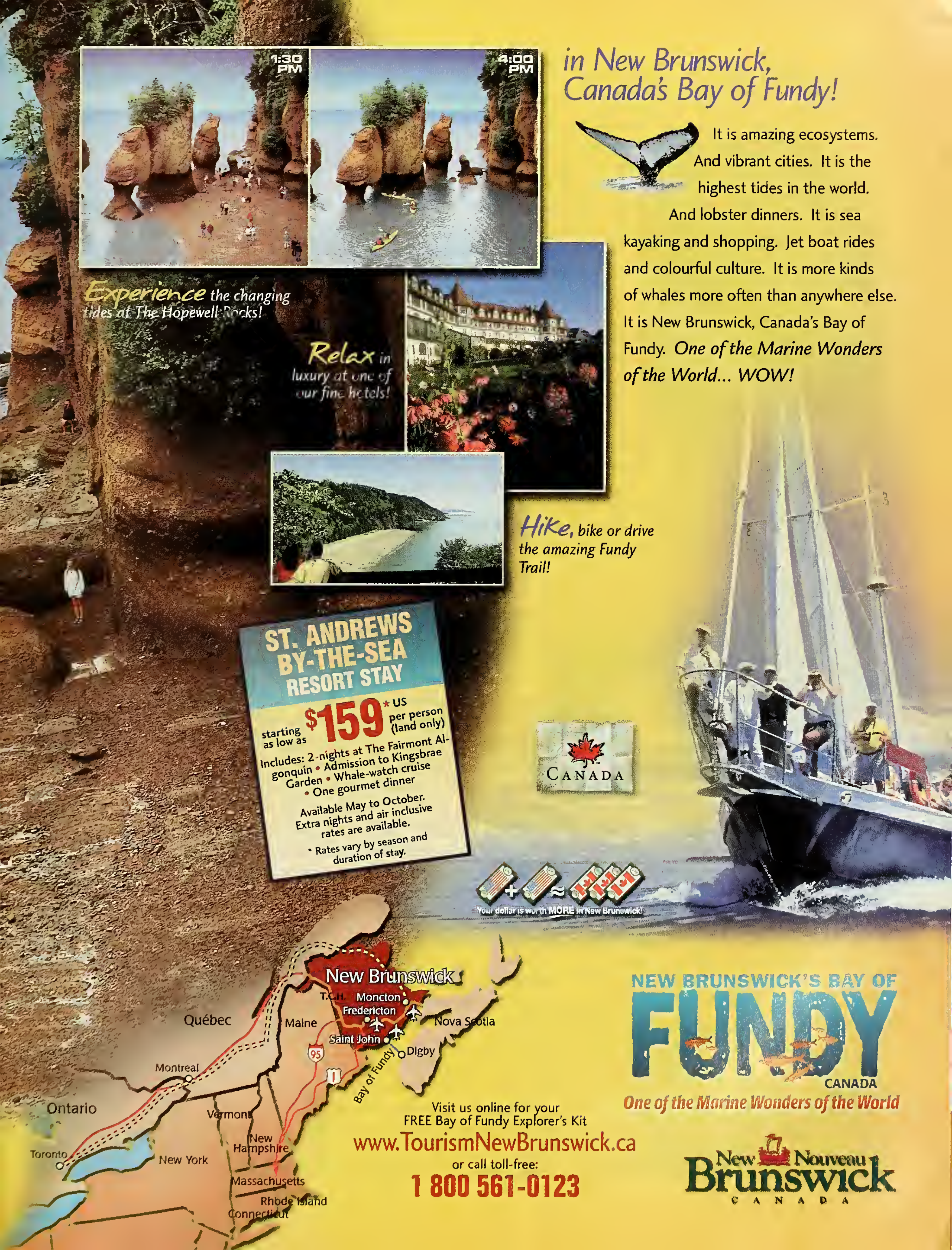
AMERICAN MUSEUM OF NATURAL HISTORY

AN INSTITUTION DEDICATED TO UNDERSTANDING AND PRESERVING BIOLOGICAL AND CULTURAL DIVERSITY

Lewis W. Bernard *Chairman, Board of Trustees*

Ellen V. Futter *President*

Natural History (ISSN 0028-0712) is published monthly, except for combined issues in July/August and December/January, by the American Museum of Natural History, Central Park West at 79th Street, New York, NY 10024 E-mail: nhmag@amnh.org Subscriptions: $30.00 a year; for Canada and all other countries: $40.00 a year. Periodicals postage paid at New York, N.Y., and at additional mailing offices. Send subscription orders and undeliverable copies to the address below. For subscription information, call (800) 234-5252 or, from outside U.S., (515) 247-7631. Postmaster: Send address changes to *Natural History*, P. O. Box 5000, Harlan, IA 51537-5000. Canadian GST Registration #128426574. Canadian Publications Agreement #1423274 Printed in the U.S.A.



1:30 PM
4:00 PM
in New Brunswick, Canada's Bay of Fundy!
It is amazing ecosystems. And vibrant cities. It is the highest tides in the world. And lobster dinners. It is sea kayaking and shopping. Jet boat rides and colourful culture. It is more kinds of whales more often than anywhere else. It is New Brunswick, Canada's Bay of Fundy. One of the Marine Wonders of the World… WOW!
Experience the changing tides at The Hopewell Rocks!
Relax in luxury at one of our fine hotels!
Hike, bike or drive the amazing Fundy Trail!
ST. ANDREWS BY-THE-SEA RESORT STAY
starting as low as $159* US per person (land only)
Includes: 2-nights at The Fairmont Algonquin • Admission to Kingsbrae Garden • Whale-watch cruise • One gourmet dinner
Available May to October. Extra nights and air inclusive rates are available.
* Rates vary by season and duration of stay.
CANADA
Your dollar is worth MORE in New Brunswick!
New Brunswick
T.C.H.
Moncton
Fredericton
Saint John
Digby
Nova Scotia
Québec
Maine
95
1
Bay of Fundy
Montreal
Ontario
Vermont
New Hampshire
Toronto
New York
Massachusetts
Rhode Island
Connecticut
Visit us online for your FREE Bay of Fundy Explorer's Kit
www.TourismNewBrunswick.ca
or call toll-free:
1 800 561-0123
NEW BRUNSWICK'S BAY OF FUNDY
CANADA
One of the Marine Wonders of the World
New Nouveau Brunswick
CANADA

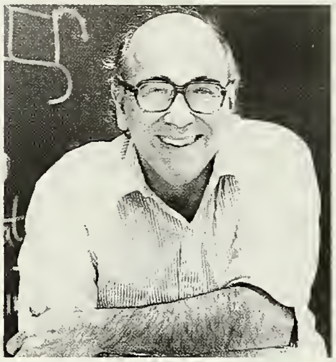
CONTRIBUTORS

A curator in the department of paleobiology at the Smithsonian National Museum of Natural History, **Scott L. Wing** ("Hot Times in the Bighorn Basin," page 48) first went to the Bighorn Basin in 1972, the summer after he finished high school. By the end of that first field season, he was a confirmed desert rat—captivated by the solitude and beauty of the badlands, intrigued by the information that could be extracted from their rocks, and addicted to the intermittent success that fossil hunting brings. His research interests and love of the country have taken him back to this part of Wyoming nearly every year since then. Wing, left, has also chased plant fossils in other parts of the western United States and in deserts in Egypt, Cameroon, China, Argentina, and Pakistan. For more on Wyoming geology and history, he recommends John McPhee's *Rising From the Plains* (Farrar, Straus and Giroux, 1986). **Kenneth D. Rose** ("Wyoming's Garden of Eden," page 55) established a fossil museum in his basement when he was in high school, and on occasion he exhibited his collection publicly. His love of paleontology was strengthened by visits to the American Museum of Natural History and particularly by a trip to the Smithsonian, where several curators helped him identify fossil bones he had found in Florida. Now a professor of anatomy at the Johns Hopkins University School of Medicine in Baltimore, Rose has collected mammal fossils in Wyoming's Bighorn Basin for the past twenty years. He is also a veteran of fieldwork in other parts of the western United States, as well as in Egypt, Pakistan, and, most recently, the Indian state of Rajasthan. Rose's avocation, collecting marine fossils, dates from his basement-museum days and has led him to comb the coasts of North America, Africa, Japan, and the Philippines. The work of **Utako Kikutani,** who illustrated both Bighorn Basin stories, bridges the realms of art and science. Born in Japan, Kikutani spent her childhood in Kenya and Tanzania, where she became fascinated by and began to draw African wildlife. Ten years later, as she was about to complete a doctorate in zoology at the University of Tokyo, Kikutani read an article about the Guild of Natural Science Illustrators in the United States and realized that, for her, the "ideal work" would combine her interests in biology and drawing. A year later, she enrolled in the scientific illustration program at the University of California, Santa Cruz. Now a freelance illustrator in the New York City area, Kikutani contributes frequently to *Natural History* and enjoys "having opportunities to work closely with scientists and to visualize their world."

When the brothers **Anup** and **Manoj Shah** ("Tête-à-Tête," page 60) were children in Kenya, one of their favorite activities was visiting Nairobi National Park, where they spent long days watching lions, elephants, zebras, and other animals. They were educated in England, but their attachment to Africa and its animals never lessened; as adults, they returned to Kenya and became self-taught wildlife photographers, specializing in large mammals. The Shahs have also photographed in India and the rainforests of Indonesia. In the nine years since deciding to work as a team, they have taken four or five field trips a year. In the field, Anup (left, with Manoj) may shoot from a distance, using a long lens, while Manoj goes in for close-ups. Both brothers have received awards in the BG Wildlife Photographer of the Year contest and the Nature's Best and Cemex International Photography competition.

Born during World War II in the Sudetenland region of Czechoslovakia, **Walter R. Tschinkel** ("Colonies in Space," page 64) grew up in Texas, Alabama, and Connecticut. After attending Wesleyan University, he earned his doctorate in biochemistry at the University of California, Berkeley, with a thesis on chemical communication in beetles. He enjoys digging holes and can excavate a hundred cubic feet of earth in about an hour—an avocation that suits his passion for casting ants' nests in plaster. Tschinkel is currently the Menzel Professor of Biological Science at Florida State University, where for thirty years he has conducted research on how ants manage to function as a superorganism. He has published more than sixty scientific papers on the social biology of ants.

Originally trained as an astronomer, **Anthony F. Aveni** ("Other Stars Than Ours," page 66) was attracted to indigenous New World calendars thirty years ago, when he took a group of undergraduates to Mexico to see the Mesoamerican pyramids. An early result of that interest was his book *Skywatchers of Ancient Mexico* (University of Texas Press, 1980), which helped establish the field of archaeoastronomy—the study of the astronomical practices, celestial lore, and cosmologies of ancient cultures. A revised and updated edition of this classic will be published later this year. Among the other books Aveni has authored is *Between the Lines: The Mystery of the Giant Ground Drawings of Ancient Nasca, Peru* (University of Texas Press, 2000). Honored in 1982 as U.S. Professor of the Year by the Council for Advancement and Support of Education, Aveni is the Russell B. Colgate Professor of Astronomy and Anthropology at Colgate University in Hamilton, New York.



Ligia Botero ("Working Girl," page 74) began photographing life in the hills of Ecuador's Chimborazo Province in 1994. Shortly afterward, she took her first photographs of Rosa, the subject of her and Lynn A. Meisch's story. Botero, left, says she continues to document Chimborazo's "communal way of living" in an attempt "to show the fears and hopes of these indigenous peasants at a very decisive moment—when so many of them are uprooting and migrating." The Colombian-born photographer lives in New York City. **Lynn A. Meisch** has conducted fieldwork in Colombia, Ecuador, Peru, and Bolivia since 1973 and has published extensively on Andean life and culture. Meisch (far right, with Marta Conterón and son Alex) has twenty-four godchildren in Ecuador; they—not only her research—draw her back to the Andes each year. Deciding that education is wasted on the young, Meisch returned to school in her forties, receiving her Ph.D. in cultural anthropology from Stanford University in 1997. She is an associate professor of anthropology at Saint Mary's College of California in Moraga.

Having graduated from the University of Hawaii with a degree in biology, **Mike Severns** ("The Natural Moment," page 94) has spent his adult life as a diver, explorer, and marine photographer. With his wife, Pauline, he operates a dive boat operation in Hawaii that offers visitors tours of underwater wildlife, including the opportunity to observe the seasonal mass spawning of corals off the islet of Molokini. Severns, who dives to great depths using a U.S. Navy rebreather, has discovered the longest underwater cave system in Hawaii, an ancient Hawaiian fishing site, fossils of thirty extinct and previously unknown Hawaiian birds, and several new species of fish. His latest book, *Hawaiian Seashells,* a photo guide to 360 species of shells, has just been published by Island Heritage.

LETTERS

Analyzing Freud

In "Nature's Infinite Book" (2/01), Jared Diamond undertakes to compare and contrast the legacies of Darwin and Freud while missing a fundamental difference between the two. Darwin developed a scientific theory susceptible to test and to disproof. What Freud developed was closer to a system of religious belief than it was to a testable scientific theory.

Leonard Sax, M.D., Ph.D.
via e-mail

My problem with Jared Diamond's nomination of Sigmund Freud for membership in the august club of those who have made a "major, lasting difference to the course of science" is that Freud's work was not scientific. There is no objective way of confirming Freud's hypotheses or of disproving any of his concepts, since they are all based on interpretation.

Ronald G. Good
Louisiana State University
Baton Rouge, Louisiana

To find Jared Diamond placing Freud on a par with Darwin and publicly acknowledging the value of personal psychotherapy is refreshing and tremendously welcome. The theories of Freud, and of all depth psychologies, will continue to come in for assault simply because they focus on the unconscious, which remains largely unrecognized and uncharted territory. Freud was not dealing with the mind but with the psyche, of which mind is merely a part.

Meredith Sabini, Ph.D.
Berkeley, California

Darwin and Freud are both interesting and deserving scientists for Jared Diamond to ponder, but his concerns about pills versus talk therapy, in my experience and opinion, are wrong. From 1962 until 1983, talk therapy was used on my chronically depressed wife by psychologists, family counselors, several psychiatrists, a psychotherapist, and clergymen. After tens of thousands of dollars and years of tears, our family doctor began prescribing psychotherapeutic drugs. After four failed attempts, my wife is now enjoying a normal life.

Doug Swanson
North Branch, Minnesota

Jared Diamond replies: I sympathize with Mrs. Swanson and with the many other people who were helped by psychotherapeutic drugs only after years of inappropriate talk therapy. However, I also sympathize with the growing number of people today who are inappropriately given drugs by clinicians lacking the patience, training, skill, or motivation to listen and to talk. As for the comments of Dr. Sax, Mr. Good, and other Freud-bashers, I say to them what I say to Darwin-bashers: There is substance to your critiques, but much more substance to Freud's and Darwin's achievements.

Alpha and Omega

On the matter of "last things" ("Universe," 2/01), readers and Neil de Grasse Tyson might enjoy a story attributed to Johannes Brahms and one of his friends. They were standing by the shore, and the friend was complaining that all the great music had already been written. "Look," said Brahms, pointing at the water, "here comes the last wave."

Roy Wagner
University of Virginia
Charlottesville, Virginia

Nisa Now

I read and enjoyed the book review in your 2/01 issue ("Long Live the !Kung"), but I have a question. As one of many anthropologists who has for years assigned the book *Nisa: The Life and Words of a !Kung Woman* in the courses I teach, I was under the impression that the cover photo was not that of Nisa, and I have discussed this point in the context of research ethics and protection of anonymity. However, that same photo appears in your review of the book's recent reprint with the caption "Nisa in 1971." Can you tell me if this is really the Nisa of the book?

Barrett P. Brenton, Ph.D.
St. John's University
Jamaica, New York

Mary Kate Maco of Harvard University Press replies: Indeed, *Natural History* wrongly captioned the photo on page 76. The late Marjorie Shostak, concerned with protecting the anonymity of her source, changed her subject's name to Nisa and did not publish a photograph of her in the original book. (A photograph of another woman was used, and this was what the magazine printed.) Shostak's sequel, *Return to Nisa,* was posthumously published. Harvard University Press, Shostak's husband (Mel Konner), and other anthropologists who knew the !Kung woman studied by Shostak decided to place a photo of the real "Nisa" on the cover and jacket flap of the second book. This decision was based on the knowledge that "Nisa" understood the success of the book and enjoyed knowing that her words would be published. The photo that appears in the *Natural History* review on page 77 is captioned correctly.

Erratum

In the 2/01 issue, we mistakenly identified the home institution of author Robert T. Mason ("Serpentine Cross-Dressers") as the University of Oregon. He is on the faculty of Oregon State University in Corvallis. We regret the error.

Natural History's e-mail address is nhmag@amnh.org.

IN SUM

FATAL ATTRACTION Rats have evolved a strong, innate aversion to the smells of their predators. Healthy rats—even those bred for hundreds of generations in the laboratory—show distinct anxiety around feline odors. When the amoebic parasite *Toxoplasma gondii* gets into their brains, however, many of the rodents seem to lose their fear.

Zoologist Manuel Berdoy, epidemiologist Joanne Webster, and colleagues at the University of Oxford have studied the life cycle of *T. gondii* to test the hypothesis that the parasite manipulates the behavior of its intermediate host, the rat, to reach its ultimate target, the cat. The researchers infected captive rats with oocysts of the parasite and then placed them in large outdoor pens containing both cat and rabbit urine. Uninfected rats tended to shun the cat-scented areas, while the parasitized rats became substantially less afraid. With their fear of felines diminished, parasitized rats may become uninhibited about approaching their arch predators, with the predictable result of ending up as dinner.

Although all mammals are susceptible to infection by *T. gondii*, the amoebas can reproduce only within members of the cat family. Once *T. gondii* has bred in the brain of a cat that has ingested an infected rat, the parasite's oocysts are expelled with the cat's feces. After being washed away by rain, these oocysts can remain infectious in moist soil for more than a year. They can be ingested by beetles and worms, which are readily eaten by rats.

While the parasite affects rats' fear of cats, it appears to leave other aspects of rat behavior intact and to leave cat behavior completely unchanged. The Oxford researchers believe that *T. gondii* has evolved to alter rat behavior in this specific way and that the reduction of fear is not simply a side effect of cerebral malfunction. ("Fatal Attraction in Rats Infected With *Toxoplasma gondii*," *Proceedings of the Royal Society of London* B 267, 2000)

FLOOD RELIEF Ants that nest in underground colonies have developed various strategies to cope with flooding, including the formation of living rafts and the sealing of nest entrances. To deal with rain, arboreal ants often build their nests of waterproof leaves.

But ants that nest in plant cavities, such as some of the eighty ant species that nest in and on Southeast Asian giant bamboos, have developed a unique strategy to bail out their colonies during heavy downpours.

Entomologists Ulrich Maschwitz and Joachim Moog, of Germany's Goethe-Universität, studied the reactions of the bamboo-nesting ant *Cataulacus muticus* to the flooding of its nest, both in a Malaysian rainforest and in the laboratory. These ants make their homes only inside the hollow segments of giant bamboo, where their colonies contain a queen, her brood, and as many as 2,000 workers.

When a nest became flooded, either by rain or artificially in the laboratory, the ants responded first by trying to keep the water out. Two or three workers blocked the nest entrances with their broad, flat heads. If that tactic proved ineffective, however, scores of workers came forward and drank as much water as they could. Each one then left the nest with a full abdomen and excreted water droplets on the outer surface of the bamboo's stem. According to the researchers, "This cooperative 'peeing' behavior is a new survival mechanism adaptive to the ants' nesting ecology." Experiments with two species of *Cataulacus* that do not live in hollow bamboo revealed no forms of water-bailing behavior. ("Communal Peeing: A New Mode of Flood Control in Ants," *Naturwissenschaften* 87, 2000)

CRABS: A LANDMARK STUDY Some crabs find their way back home the same way people do—by observing and memorizing landmarks. Biologist Stefano Cannicci, of the Department of Animal Biology and Genetics at the Università degli Studi di Firenze, and colleagues studied the homing behavior of *Thalamita crenata*, a crab found in large numbers on an intertidal mudflat north of Mombasa, Kenya. In one set of trials, the researchers left variously colored concrete bricks and tiles around the animals' underwater dens for a few days, until they became accustomed to the objects. The artificial landmarks were then repositioned in the same configuration some distance away, and the crabs were displaced from their dens. Continuing to use the old landmarks, the crustaceans aimed for a "false home," directed by the misleading information they were given. The researchers concluded that the crabs showed good spatial knowledge and cognitive memory, resulting in a much more flexible orienting mechanism than those of other crabs—"comparable to the route-based memory of honeybees." ("Homing in the Swimming Crab *Thalamita crenata*: A Mechanism Based on Underwater Landmark Memory," *Animal Behavior* 60, 2000)—*Richard Milner*

wonderful WEST VIRGINIA

NATURALLY WILD...SOMETIMES UNUSUAL

West Virginia has a reputation for awe-inspiring natural beauty, and for good reason. This scenic state offers visitors majestic mountains that show ever-changing scenery throughout all four seasons. The West Virginia that lies beneath the winter snow becomes a vision of pastel flora in the spring. And bright colors in the summer turn into rich shades of red, orange and gold in the fall.

Throughout the state, enclaves of natural wonder provide vacationers with examples of some of the most beautiful wilderness in the country. West Virginia has been making great strides in preserving its cherished wilderness, so visitors can discover this naturally wild and wonderful state.

For vacationers who are naturalists at heart, stop by the Cranberry Glades nestled in a remote valley within the mountains of Pocahontas County. It is unusual to find cranberry bogs in the southern United States, but West Virginia, with the highest mean altitude of any state east of the Mississippi River, has four bogs that cover more than 600 acres.

Cranberry Botanical Area, within Cranberry Glades, has a number of plants that many people wouldn't expect to find in this region of the country, including the serviceberry, bog rosemary, and two varieties of cranberries that give the wilderness its name. In addition, Cranberry Glades is home to white-tailed deer, beaver, and black bear, as well as ruffed grouse and great blue herons.

Two of the bogs are open to the public and a large boardwalk allows visitors to view these pristine areas without disturbing them. The rest of Cranberry Botanical Area is reserved for scientific and educational programs.

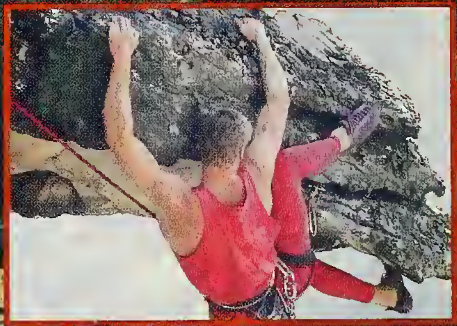
Farther south, vacationers can take advantage of the New River Gorge area, a smaller version of the Grand Canyon that cuts a path through the mountains, nourishing the woodlands and offering both a recreational and vast conservation area. With more than 63,000 acres, the New River Gorge area is an outdoor lover's paradise. Visitors can take a whitewater rafting trip, hike one of the many trails, horse-back ride, fish, and even take a llama trek.

West Virginia pays as much attention to preserving a way of life as to preserving its natural resources. Tamarack, with its crown-like roofline, is the only State collection of arts and crafts in the country. For a hand-made nineteenth-century pattern quilt, or a piece of heirloom glass, Tamarack is the place to go. Visit this state treasure to sample some native West Virginian cuisine, music and entertainment.

One of the arts most associated with West Virginia is glassmaking. There are no fewer than ten glass factories and stained glass creators in the state. Among them is Fenton Art Glass, located along the Ohio River in Williamstown, just north of Parkersburg. Started in 1905, the family-owned and operated Fenton Art Glass produces its wares the old-fashioned way, and visitors are invited to watch the process during daily tours.

One of the most obvious cultural distinctions that is quintessentially West Virginia is its hospitality. West Virginians are proud of their natural and artistic wonders and enjoy playing host to visitors. Call **1-888-call-wva** or visit **www.callwva.com** to discover why West Virginia is indeed both wild and wonderful. ■

This special editorial/advertising supplement was created by the Natural History Special Sections Department and did not involve the magazine's editorial staff. • **WRITER:** *Stephanie Fekety* • **DESIGN:** *Mindy Phelps Stanton*
PHOTOGRAPHY: *Courtesy of West Virginia Division of Tourism*



FOR MORE INFORMATION CALL 1-888-CALL-WVA
OR VISIT WWW.CALLWVA.COM

EXPLORING THE TREASURES OF WEST VIRGINIA

Pocahontas County

Visit Pocahontas County, WV. Experience the Village of Snowshoe Mountain and ride the Cass Scenic Railroad or visit the world's largest steerable telescope at the National Radio Astronomy Observatory.

SNOWSHOE MOUNTAIN

877 441 4FUN
www.pocahontascountywv.com

Glade Springs Resort

4,100 Acres of Pure Fun & Adventure

- Play one of WV's finest golf courses.
- Conference Center with 20+ meeting rooms.
- Outdoor Adventure: rafting, fly-fishing, hiking and more!
- Great American cuisine by Chef Robert Wong.

3 Day, 2 Night Bed & Breakfast Package:
From **$59.00**
Per person, per night based on double occupancy in a 2 room Presidential Suite.
Adults receive full breakfast each day. Children stay free.

Other Seasonal and Special Packages Available
Call 1-800-634-5233 for Reservations or Information. www.gladesprings.com

Where People & Nature Meet.

Taking a break from life's daily pressure is closer than you think. Get away to a West Virginia State Park. Call for a free brochure and travel information.

Wild and Wonderful West Virginia State Parks & Forests

1-800-CALL-WVA
www.wvparks.com

Comforts of the past.

Escape to the freedom...

The Historic River Cities invite you to visit the past at the historic Lafayette and Blennerhassett Hotels. Both are located near biking, golfing and the world-famous Fenton Art Glass and Lee Middleton Original Dolls factories and Holl's Swiss Chocolatier.

Escape to the freedom of the Historic River Cities.

West Virginia Wild and Wonderful — The Historic River Cities

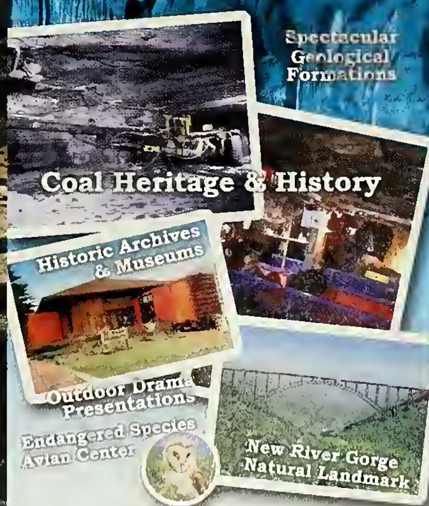
For a PastPort™ value pack call Toll Free: 1-877-669-6879 or visit: historicrivercities.com

SONGER WHITEWATER

Combine the history of the New River Gorge with the adventure of a lifetime!

1-800-356-7238 or SONGERWHITEWATER.COM

Southern West Virginia Historical Happenings



1-800-VISIT WV
www.visitwv.org or www.visitwv.com

West Virginia *Wild and Wonderful*

THIS LAND

The Rise of Phoenix

The capital of Arizona owes its birth to the handiwork of the ancient Hohokam.

By Samuel M. Wilson

In 1868, when the name "Phoenix" was chosen for what would become the capital city of Arizona, the reference to a creature reborn from its own ashes was not entirely a romantic notion. The Anglo- and Mexican Americans who began to settle the Phoenix basin in the mid-nineteenth century found the ruins of towns built by the Hohokam ("the people who have gone," as they were dubbed by later indigenous people). The Hohokam lived in this northern part of the Sonoran Desert from the last few centuries B.C. until A.D. 1450; toward the end of that period, as many as 80,000 people may have populated the basin. To feed their population, the Hohokam grew corn and other crops, which they irrigated with water from the Salt River by means of about 500 miles of canals. To a great extent, the modern city owes its very existence to those abandoned canals.

The city's rebirth began in 1867, when Jack Swilling, who had been employed variously as a Confederate soldier, a Union Army scout, and a miner, passed through the area and met John Y. T. Smith, one of the first settlers. Smith told him of "diggings" he thought might be mines, inland from the river, but on inspecting these channels Swilling quickly understood their real purpose:

> *By the end of my third afternoon there I was convinced that I had examined nothing less than an extensive system of canals and ditches whose function had once been to bring the water of the river to the farms of a country with rich soil but no rainfall to speak of.*

Artist's conception of the Pueblo Grande mound in prehistoric times

MICHAEL HAMPSHIRE; PUEBLO GRANDE MUSEUM AND ARCHAEOLOGICAL PARK, CITY OF PHOENIX

Jack Swilling began a new career as founder of the Swilling Irrigating and Canal Company, which cleaned out a few of the abandoned canals. "As long as we're following their lead," Swilling wrote, "we ought to walk in the same tracks." Soon the canals were watering a growing settlement, just as they had served Hohokam towns centuries before.

Like the core of modern Rome or Mexico City, central Phoenix has archaeological remains almost everywhere you look—and they turn up whenever a sewer line is dug, a foundation is excavated, or a road is built. More than 300 sites are known just within the city limits. One of them, La Ciudad ("the city," in Spanish), was once home to several hundred people. It included a platform mound—a rectangular construction of stone walls filled with dirt, often the result of periodic expansion and remodeling. This one was 150 feet long, 110 feet wide, and nearly 50 feet high. On and around it the Hohokam would have constructed houses of mud, stone, and cementlike caliche. La Ciudad is one of several similar large sites spread around the irrigated basin.

The large platform mound of La Ciudad has practically vanished following 150 years of urban development. (One early-twentieth-century landowner even charged daily admission to anyone wishing to dig up artifacts from the site.) But it's hard to erase some 30,000 cubic yards of material. Armed with a modern map and a map from 1868, photographer

David Ortiz and I spent a morning surveying some of the empty lots scattered through downtown Phoenix, and eventually we were able to identify a remnant of La Ciudad. It is now only about ten feet high and paved over by the parking lot of St. Luke's Medical Center at the corner of 18th and Van Buren Streets. No traces seem to remain of the canals that were once located near it.

We also poked around an undeveloped city lot, a leftover triangle enclosed by train tracks, a large concrete-lined irrigation canal, and huge highways. We saw evidence that in historic times this land was used for farming, grazing, and as a dump for stockyard manure. Piles of dirty blankets and old shirts showed that it now serves as a camping spot for the homeless. There were signs of the vanished Hohokam as well. Small, reddish brown pot shards dotted the ground, interspersed with worn-out or broken remains of stone hoes. And two ridges of earth that more or less paralleled the nearby bed of the Salt River—which in this spot is almost entirely dry—proved to be remnants of an eighty-foot-wide canal, large enough to have carried a fair portion of the river's water. It was once one of the main canals, extending more than ten miles to serve the agricultural plots of Hohokam villages.

Visitors to Phoenix who are reluctant to venture into empty lots can turn instead to the Pueblo Grande Museum and Archaeological Park, located north of the Salt River and east of the city's airport. The centerpiece is a rectangular platform mound as big as a football field and twenty to thirty feet high. Its construction was begun about A.D. 1150, with further expansion during the next 300 years. Hohokam houses were once scattered up to half a mile around the mound; the society's elite were housed on its top, where they probably had rooms designed for determining solstices and carrying out other rituals.The site may well have boasted one or more multistoried buildings akin to the Hohokam big house (*casa grande,* in Spanish) that may be seen at Casa Grande Ruins National Monument, fifty miles southeast of Phoenix.

North of the platform mound is one of the site's ball courts, now excavated and restored. A depression about forty feet wide by eighty feet long, the court was most likely used by teams who competed in a Southwestern version of the ball game played by many indigenous groups in the Americas and the Caribbean. Participants had to keep a ball in play without touching it with their hands or feet. Wherever this game was played, it was intertwined with religious ritual, intervillage rivalry and cooperation, trade, and good fun.

In addition to a paved trail that guides visitors to the top of the platform mound and around it to the ball field, the Pueblo Grande Museum maintains archaeological exhibits, interactive multimedia displays, and interpretive exhibits on the prehistory of the Southwest. The museum also houses the office of the city archaeologist—an unusual position in the United States but one that this city really needs. In fact, Phoenix had the first city archaeologist in the nation:

PHOTOGRAPHS COURTESY OF PUEBLO GRANDE MUSEUM AND ARCHAEOLOGICAL PARK, CITY OF PHOENIX

A bird motif decorates a Hohokam pottery shard, above. A fragment of a shell bracelet, above left, with a carving of a frog.

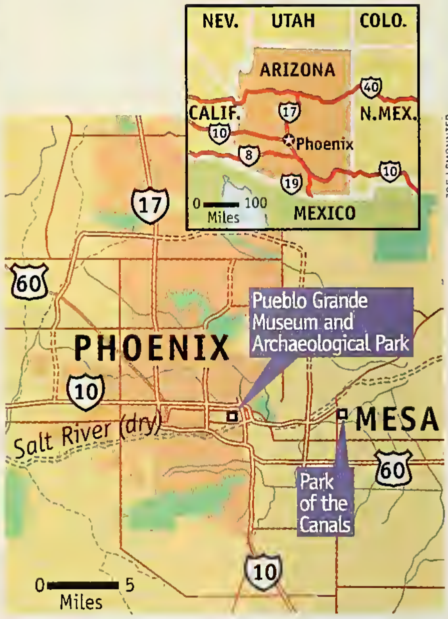
Odd Halseth, hired in 1929, who on a shoestring budget built the first museum at Pueblo Grande, using adobe, scrounged materials, and convict labor.

Today the position is filled by Todd Bostwick, who has written extensively about Pueblo Grande and the Hohokam canals. Bostwick often finds himself caught between the demands of Phoenix's explosive growth and the need to preserve and protect some of North America's most extraordinary heritage. It's a job that calls for political skill and the ability to make difficult choices, because the laws concerning archaeological remains are a rather porous combination of federal, state, and local measures. One of Bostwick's immediate goals is to save the last of the big canals—the ones in the triangular lot we inspected—and turn them into a public park.

South of the Salt River and a little way upstream, in the adjoining city of Mesa, the Park of the Canals offers a snapshot of three periods of canal use. Surrounded by suburban plots of irrigated greenery, the thirty-acre park looks at first like a forlorn patch of the Sonoran Desert. Creosote bushes grow head-high and lizards walk by on tiptoe, keeping their bellies off the scalding dirt and gravel. A closer look reveals shallow channels bordered by linear ridges. There is a Hohokam canal, somewhat eroded but still quite visible in the bare landscape. Branching off from it is one built by Mormon colonists in the late 1800s. It, in turn, is cut by a modern, concrete-lined canal that carries a stream of water. Why successive canal-builders chose to take slightly different routes is unclear, but pehaps irrigation eventually resulted in the salinization of tracts of farmland. The Salt River was given its name for good reason.

Samuel M. Wilson, an associate professor of anthropology at the University of Texas at Austin, is the author of The Emperor's Giraffe and Other Stories of Cultures in Contact *(Westview Press, 1999).*

DAVID ORTIZ



JOE LEMONNIER

Left: A parking lot sits atop remnants of the platform mound known as La Ciudad. Below left: A Hohokam irrigation canal in Mesa's Park of the Canals.

DAVID ORTIZ

For visitor information, contact:

Pueblo Grande Museum and Archaeological Park
4619 East Washington Street
Phoenix AZ 85034
(602) 495-0901
www.ci.phoenix.az.us/PARKS /pueblo.html

Park of the Canals
Mesa Convention and Visitors Bureau
120 North Center Street
Mesa, AZ 85201
(480) 827-4700

NOVA SCOTIA

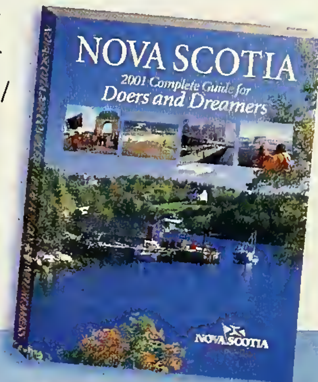
Your vacation begins as soon as you open this guide.

IN NOVA SCOTIA, you'll never be more than 35 minutes from the sea. Explore the world's highest tides in Nova Scotia's Bay of Fundy. Learn about rare seabirds and whales at our compelling museums. Or visit Halifax for the most vibrant urban experience in Atlantic Canada.

Get your FREE 400 page *Doers' and Dreamers' Guide* when you call 1-800-565-0000, op. 46 or visit our website at exploreNS.com/natural If you like, you can make reservations during your call or when you're online.

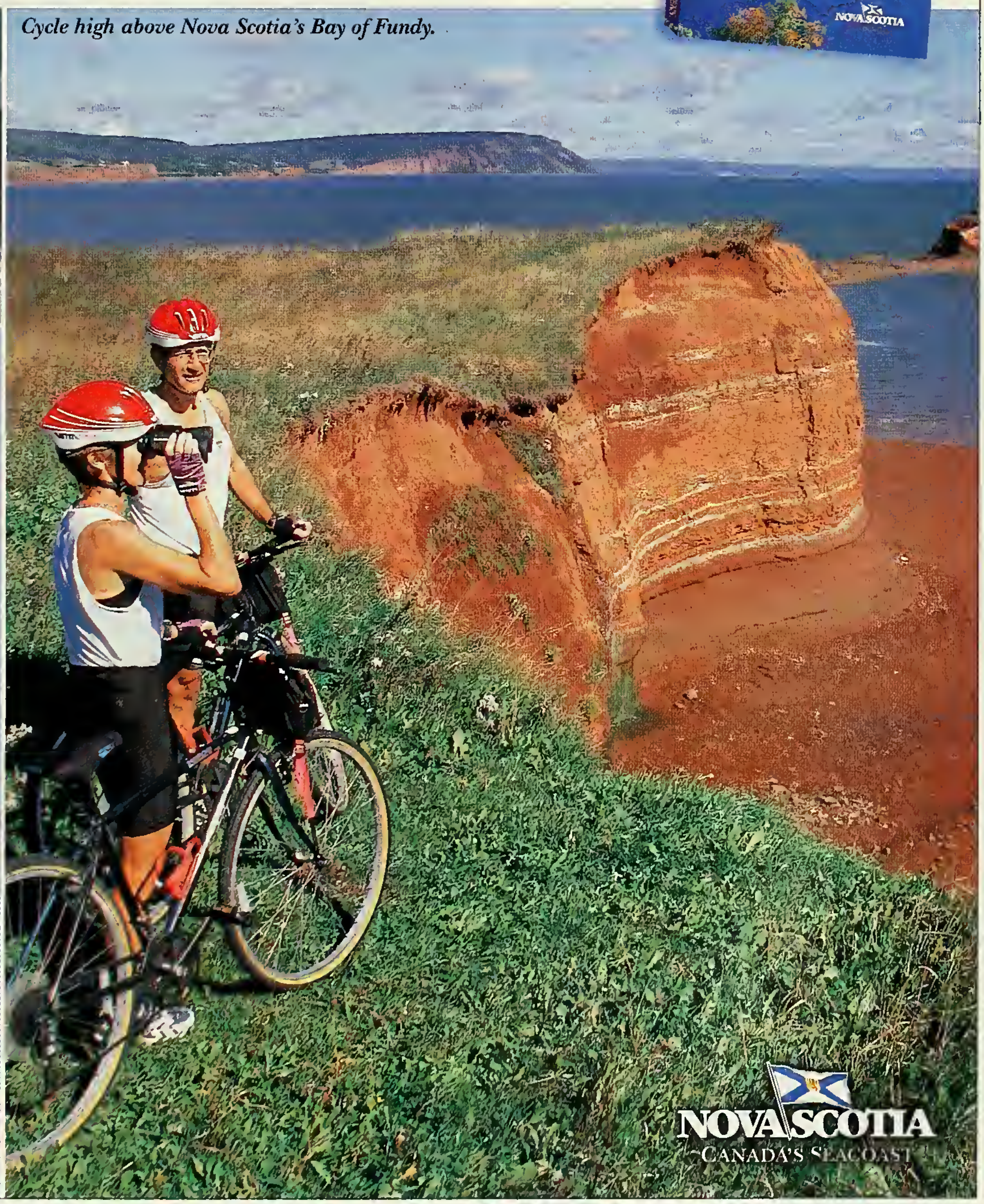
And remember, your money is worth more here.

Canada
Discover our true nature



See the world's most accurate Sei whale skeleton at the Museum of Natural History.

Journey to Halifax for great shopping, exquisite dining and exciting entertainment.



Cycle high above Nova Scotia's Bay of Fundy.

NOVA SCOTIA
CANADA'S SEACOAST

IN THE FIELD

Found Object

By Bernd Heinrich

Beautiful winged things come in small packages.

The snow on the steep, south-facing slope of Raven Ridge, near my house in Vermont, was melting quickly in the April sun. I was scrambling up toward the ravens' cliff nest to check on its progress. Climbing the hill up to the base of the cliff is a treat, because here is where I always find the first bare patches of ground after seeing only deep snow for almost six months. The sun reaching this slope cuts through the snow early, revealing a moist layer of fallen oak, maple, and ash leaves. On this day, the first hepatica buds were poking through the leaf mat, and some were opening into startlingly light-blue flowers.

As I searched for a secure footing on some protruding rock, a roundish object caught my eye. It was about the size and shape of a shelled hickory nut but had bits of dead maple leaf adhering to it, as though it had once been wrapped in a leaf that had then withered and partially peeled off. I had on rare occasions found such an object before, and I recognized this one. It was the cocoon of a Saturniidae silk moth, possibly a luna or a polyphemus moth. As adults, both of these moths are stunning aerial creatures, but I had seen them only after raising them from caterpillars and after attracting them to a light at night, when they are active.

Silk moth cocoons are made of a layer of silk that the caterpillar exudes from glands in its mouth. While the silk of Saturniidae moths is considered inferior to that of Asian silk moths, it is tough and durable. The caterpillar, or larva, lays down the silk in one continuous strand, endlessly weaving its head back and forth and frequently changing position. The strands glue themselves together into a resilient fabric that I cannot tear apart with my fingers. Once enshrouded in silk, the larva enters a new stage, that of the pupa. The energy stored in the pupa itself will last the insect the rest of its life: eight months of pupation and a few days of adulthood. (Adult moths have neither feeding mouthparts nor digestive tracts.) While rodents often succeed in opening cocoons and extracting the nutritious pupae, birds rarely invest the time and effort needed to pierce the silken armor. The moth itself can escape from the cocoon only by secreting an enzyme that dissolves some of the silk and creates an exit hole.

This cocoon had no exit. I shook it slightly and from its heft and rattle I knew that it contained a live pupa. I put it in my pocket and continued on to the ravens' nest, thinking that good things often come to one obliquely.

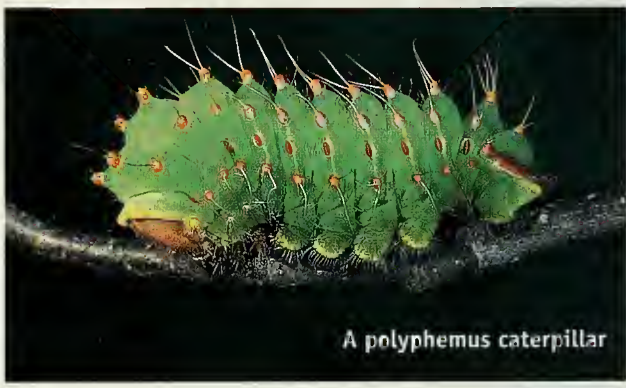
After coming home, I placed my find in a screened cage, which I left outside, on the back porch. The pupa had long been in a state of torpor, but shortly after receiving signals of warmth in spring, its biological clock would restart and its development toward adulthood would resume. If I had taken the cocoon into the house, the premature warmth would have disturbed the insect's timing. If a moth is to find a mate, as well as fresh leaves on which to deposit its eggs (if it is female), then it must emerge and live out its few adult days at the same time as the rest of its population. Up to now the insect's life had progressed at a leisurely pace; indeed, most of it had been spent in torpor. After emerging, though, life would take on urgency.

My moth emerged on the bright sunny afternoon of May 30. I saw it hanging from the ceiling of its cage; it cannot have been out for more than an hour. Its limp, still-soft wings of cream and various browns, with touches of pink, were folded over its thorax and abdomen, which were covered with a light down. This thin cloak acts as insulation when the moth begins to shiver and warm up in preparation for flight. This was a polyphemus moth (named for the Cyclops of Greek mythology); each hind wing bore a large blue-black "eye."


DWIGHT KUHN

Leaf-shrouded cocoon

The mission of this moth would be to lay eggs. It was a female, as evidenced by its plump, rounded abdomen and thin antennae. Males have broad, feathery antennae that provide ample space for millions of chemical sensors tuned to detect one kind of molecule: the scent of a female of its species. This fine-tuning of the senses provides the moth with a very narrow window on the world, but it is both sufficient and efficient.


DWIGHT KUHN

A polyphemus caterpillar

After the moth had dissolved her way out of the tough cocoon, she must have quickly crawled to where she could dangle her wings, pumping

E.R. DEGGINGER; COLOR-PIC, INC.

A female polyphemus moth and newly laid eggs

blood into them and expanding them to their full length of almost three inches. Over several hours, a hormone released into her blood would serve to harden her wings and the rest of her exoskeleton. Then she would be flight-ready.

I tied a thread around the moth's waist and then attached her loosely to a low branch of the oak tree next to my house. Oak is one of several food plants used by polyphemus caterpillars. As soon as I released my grip on her wings, she shivered, isometrically contracting her wing muscles to increase her thoracic temperature to about 97° F, sufficient for takeoff. Attempting to fly, she fluttered for three or four minutes before folding her wings over her back and coming to rest, pendent under a leaf.

The next dawn I eagerly checked on her. Not only was she still attached to the twig by the thread but she was also attached to a male. Literally. Belly to belly, with the tips of their abdomens joined, the motionless couple looked like dead leaves. This was a useful camouflage, as they were both cool, torpid, and temporarily unable to fly after their probably nightlong tryst. At midmorning the male disengaged, and after vibrating his wings for a minute or two to warm up, he flew off. He, possibly, would mate again. She would not. But neither had any time to lose.

By noon, the female had laid seven eggs, her total for the first day. Each egg was about the size of a peppercorn, somewhat flattened, and brown around the circumference. Yellow in the middle when first laid, the eggs quickly turned white. To me, the most amazing thing about the eggs was their adhesive property. The moth laid each one separately. She extended her otherwise round abdomen, acrobatically bending it into a C-shape, probed a leaf surface with its tip, and extruded an egg that instantly stuck fast, thanks to its coating of quick-drying, nontoxic superglue. The female's second night was devoted to egg laying; she deposited more than thirty eggs on the leaves and twigs around her. The following day and night, she laid just a few more. Had she not been tethered, the moth would have avoided laying all her eggs in one place. Flying to several sites to deposit eggs is a strategy used by all moths and butterflies whose caterpillars must hide from predators. Only adults whose caterpillars are noxious to birds lay their eggs in a single mass.

After three days the moth was spent, and dead. Most of her colorful scales had worn off; she was bald. I looked forward to seeing the eggs hatch in a few days' time and to watching the caterpillars grow on my oak tree throughout the summer. A luminescent, almost translucent green with red dots and small silver highlights, they blend artfully into the foliage and are almost invisible, despite being relatively large—about the size of my thumb. I would eventually watch some of them don a mantle of leaves and begin the process of weaving their own silk cocoons.

As to the spent female, I examined her slimmed-down abdomen and found four more eggs, partly developed. She had succeeded in laying nearly a full clutch. As an adult she had not lived long, but I granted her immortality by recycling her into a young raven.

Bernd Heinrich is a professor of biology at the University of Vermont, Burlington.

BIOMECHANICS

Prepared for the Past

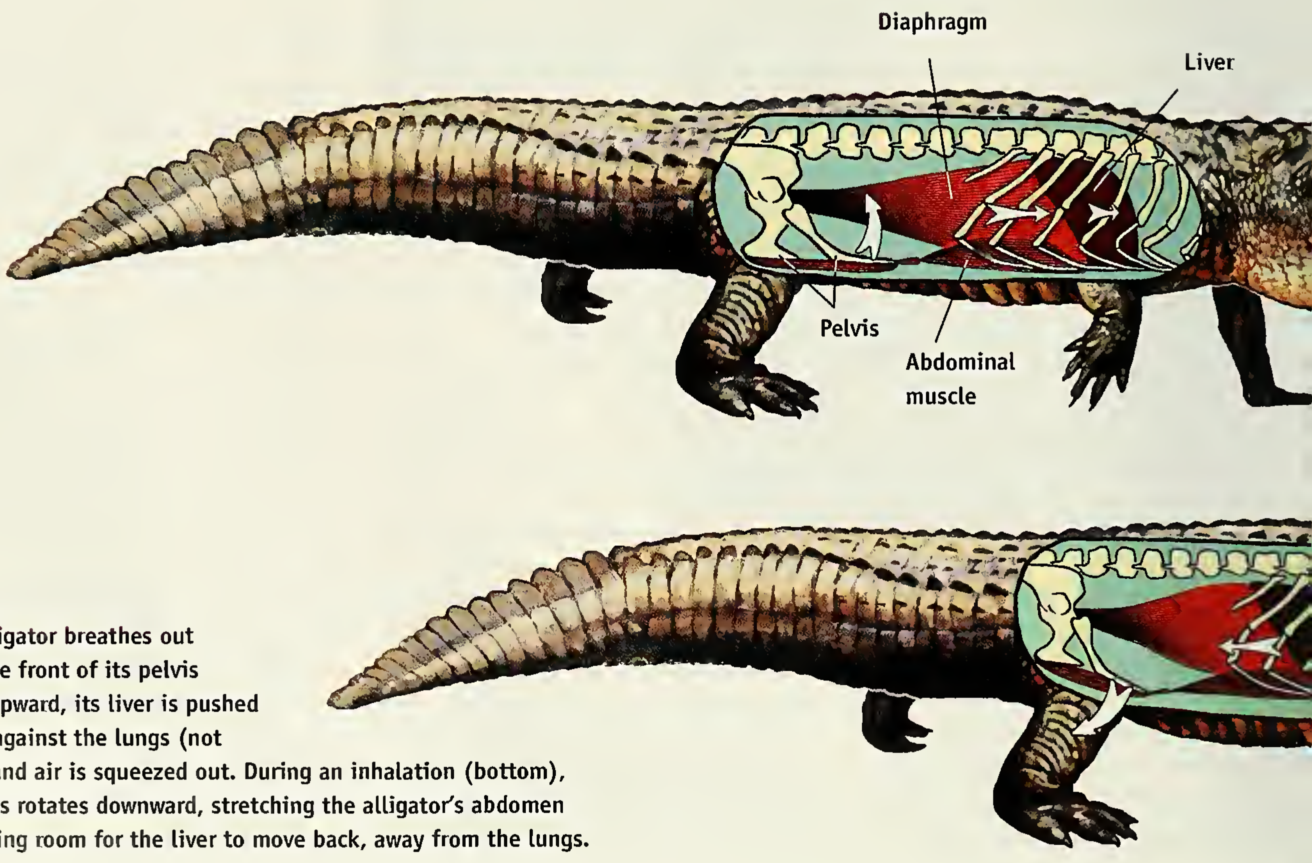
Thanks to their landlubber ancestors, alligators have more breathing power than they need.

Story by Carl Zimmer ~ Illustrated by Sally J. Bensusen

Most of the time, evolution hands out its gifts sparingly. Natural selection generally produces animals that are well designed for the lives they lead—but not *too* well designed. Some hawks have eyes sharp enough to see a mouse up to 300 feet away, but not 1,000 miles away. After all, everything in life has a cost. An owl with eyes the size of beach balls might be able to see quite far, but it would have a hard time flying (let alone pumping enough blood to its eyes to keep them working properly). Some animals, however, do seem to be overdesigned. One of these is the American alligator *(Alligator mississippiensis)*.

Recently, biologists Colleen Farmer and David Carrier, of the University of Utah, measured the breathing patterns of alligators. When an alligator is resting, it breathes intermittently, taking one breath per minute, much like other cold-blooded reptiles. To study alligators on the move, Farmer and Carrier trained them to do four-minute bouts on a treadmill. The scientists placed a mask over each alligator's nose to measure how much air the animals inhaled and exhaled.

Your typical reptile—an iguana, for instance—can't take deep breaths while walking. To exhale, an iguana uses some of its trunk muscles to squeeze its ribs, compressing the lungs and forcing



As an alligator breathes out (top), the front of its pelvis rotates upward, its liver is pushed forward against the lungs (not shown) and air is squeezed out. During an inhalation (bottom), the pelvis rotates downward, stretching the alligator's abdomen and making room for the liver to move back, away from the lungs.

out the air. As long as the animal is resting, this presents no problem. But when walking, it must use these same muscles to bend from side to side. The demands of walking and breathing thus come into conflict. Making matters worse, a walking iguana needs more oxygen than a motionless one. For iguanas and many other reptiles, the solution is to take quick, shallow breaths when they walk and never to walk very fast. (Some lizards can sprint, but they can't keep it up for more than a few minutes.) Modern lizard skeletons look a lot like the oldest reptile fossils, suggesting that reptiles are still constrained the same way they were some 300 million years ago.

But not alligators, as Farmer and Carrier discovered. As soon as these animals started moving on the treadmill, they began to breathe deeply at regular intervals (about thirteen times per minute). Their walking breaths were four times deeper than their resting breaths—in fact, relative to their weight, alligators take in more air per breath than has been reported for any other exercising animal.

Alligators manage such an unreptilian feat because they don't rely solely on rib muscles to breathe. When an exercising alligator exhales, its liver is pushed forward, ramming against its lungs and squeezing the air out. During an inhalation, a muscle attached to the pelvis pulls the liver back, creating negative pressure that draws air into the lungs.

Farmer and Carrier have discovered that the alligator's liver-pump system is even more sophisticated than previously thought. Every time the animal breathes in, muscles rotate the front of its pelvis downward. This hip rotation stretches the abdomen, making room for the liver and for the muscles that retract it. When the alligator exhales, the front of the pelvis rotates back up and the abdomen shrinks, forcing the liver forward again. None of the muscles that help move the liver are involved in bending an alligator's trunk from side to side, so there is no conflict between walking and breathing.

Impressive, yes, but given the gator's lifestyle, this biomechanical design seems over the top. Alligators spend most of their time lying around, and their hunting style involves lurking in the water, motionless, and then suddenly ambushing their prey. A lion or a wolf may sometimes need to breathe deeply for long periods while running after prey, but putting a liver pump in an alligator is a bit like hooking a jet engine to a hang glider.

To explain this apparent excess, Farmer and Carrier point out that today's alligators and crocodiles look very different from their ancestors. Those early reptiles, known as crocodylomorphs, date back about 240 million years and were the size and shape of a coyote with a heavy tail. They had long slender legs that fit under the body rather than sprawling out to the sides, and they ran on the balls of their feet. Farmer and Carrier speculate that the ancestors of crocodylomorphs evolved special breathing mechanisms for sustained locomotion on land—a liver pump complete with rotating hips, which would have allowed them to take the deep breaths needed to gallop. And indeed, the pelvis bones of fossil crocodylomorphs show features that could have played a role in driving air in and out of an animal's lungs.

Perhaps 100 million years after the first crocodylomorphs trotted across the land, their descendants shifted to an amphibious way of life. Their legs grew short, and their tails became stout—an adaptation for swimming. Yet they retained the powerful hip-driven system for breathing. Whatever the reason, today's alligators are biomechanically prepared for a way of life that vanished 140 million years ago.

AFTER C. FARMER AND D. CARRIER, *JOURNAL OF EXPERIMENTAL BIOLOGY* 203:11, 2000

Carl Zimmer's new column, "The Evolutionary Front," debuted in March and will appear bimonthly. Starting in June, "Biomechanics" will be written by Adam Summers, assistant professor of ecology and evolution at the University of California, Irvine.

NATURE'S INFINITE BOOK

Deaths of Languages

Six thousand languages are spoken today. By the end of the century, we may be down to two hundred.

By Jared Diamond

YVONNE BUCHANAN

In this magazine, the phrase "tragic loss of diversity" usually refers to the current disappearance of biodiversity, with its big, though indirect, consequences for humans. However, another tragic loss of diversity has been going on for a long time, and it has more direct consequences for us: the extinction of our languages.

Language is the most complex and distinctive product of the human mind. Possession of language is the most important trait distinguishing us from apes, and differences among languages constitute the most important distinctions among human groups. In addition to being the focus of each group's culture and the vehicle of its literature and songs, a language provides detailed clues to a people's history, just as do their bones, genes, and faces. Unfortunately, thousands of languages disappeared in recent millennia as their speakers were conquered or exterminated by dominant groups or assimilated into them. Farmers have overwhelmed hunter-gatherers, and strong states have overwhelmed weaker states and tribes. Whatever the original number of languages spoken in the world at the end of the Ice Age (I'd guess tens of thousands), we are down to about 6,000 today.

Most of those 6,000 languages are actually moribund, now spoken only by older people and being learned by few, if any, children. Moribund languages are being eliminated not so much through murder of their speakers (as in the past) as by a more insidious process: the use of a few dominant national languages in governments, schools, businesses, movies, videos, and on the Internet. At this rate, by the end of this century we shall have lost 97 percent of our remaining languages, and barely 200 will survive. That would be a gigantic intellectual and cultural loss for all of us.

This article is about the Ostrogothic and Frisian languages, two members of the Germanic language group—to which English, too, belongs. Ostrogothic disappeared about two centuries ago. Nothing is known of it except for

Îles de la Madeleine
Islands in the heart of Atlantic Canada
peaceful lively stunning
1-877-MAGGIES
extension 177
Canada
www.ilesdelamadeleine.com
Photos : Pascal Arseneau, J. Du Boisberranger, George Fischer
© GEMINI 3D

a list of 101 words obtained from one of its last speakers. With the extinction of the Ostrogothic language, the longest-surviving Gothic people finally disappeared from history. The other language, Frisian—the modern language closest to English—still hangs on as a minority language in the Netherlands, backed at the eleventh hour by the resources of the majority Dutch-speaking government and by the pride of the Frisian people. The story of Ostrogothic exemplifies what we have already lost; the story of Frisian exemplifies what we can still save.

Today, Germanic languages and peoples fall into two groups: North Germanic, alias Scandinavian (Swedish, Danish, Norwegian, Icelandic, and Faeroese), and West Germanic (German, English, and Frisian). Around the time of Christ, though, many East Germanic peoples lived on the coast of the Baltic Sea in what are now eastern Germany and Poland. These groups are collectively termed the Goths (and individually known as the Visigoths, Ostrogoths, Burgundians, and Vandals) and were prominent among the so-called barbarians who destroyed the Western Roman Empire. Early in the Christian era, the Goths migrated south to establish kingdoms in North Africa and much of Europe, such as the Ostrogothic kingdom in the Ukraine. But all of those Gothic kingdoms eventually succumbed in battle to assorted other peoples, the last to fall being Spain's Visigothic kingdom, conquered by Arabs in A.D. 711.

For most Gothic languages, our only information consists of a few words quoted by Roman authors. Our sole extensive Gothic text is a partially preserved translation of the Bible into Visigothic, made circa A.D. 340 by Bishop Wulfila, inventor of the twenty-seven-letter Gothic alphabet. The translation is doubly significant as the earliest extensive text preserved in any Germanic language. However, from the ninth century onward, travelers to the Crimean Peninsula (which projects from southern Ukraine into the Black Sea) reported encountering there, among other groups, people who had distinctive customs and spoke some obviously Germanic language. As time went on, such reports began mentioning that these people were becoming multilingual, using their own language less, and adopting the Islamic faith and Turkish dress. The last report of a Crimean Germanic language, in 1780, came from a visitor who described meeting some Turkish-looking people speaking a Germanic language among themselves without knowing that it was Germanic. Their assimilation appeared to be complete by 1794, when another visitor to the Crimea reported that he could find no trace of such a language.

All that remains of Ostrogothic is contained in a list of 101 words obtained from one of its last speakers.

What made these reports so intriguing was that the Crimea had once been part of the Ostrogothic kingdom. Could those Crimeans really have been the last Goths, continuing to speak Ostrogothic for more than a thousand years after their kingdom fell? Or were they relatively recent immigrants from the area of modern Germany? That is, was their language some type of German, or was it something more like the Visigothic of Wulfila's translated Bible? Alas, almost all those visitors to the Crimea failed to write down even a single word of the mysterious language they heard. The one exception was a Flemish diplomat and man of letters named Ogier Ghislain de Busbecq, who served as the Austrian ambassador to Istanbul from 1555 to 1562. Busbecq was very curious about whether those Crimeans were indeed the last Goths, and he begged his interpreters to be on the lookout for any who might be visiting Istanbul. Finally, two of the Crimeans showed up in Istanbul, and Busbecq's interpreters brought them to dinner. A highly educated man and an accomplished linguist familiar with at least nine languages, Busbecq quizzed them in detail for several hours, got them to pronounce 101 words, and carefully recorded the meanings of those words as explained through his interpreters. A letter describing the dinner, sent by Busbecq to a friend, contains everything we know of that vanished Crimean language.

Linguists nearly weep in frustration at the sequence of steps by which those words have come down to us. To begin with, Busbecq wrote that of his two visitors, one really was a "Goth" (Busbecq's term, which I shall adopt) who had completely forgotten his own language because it was already falling into disuse. The real informant was the other guest, not a Goth at all but a Greek who had learned Crimean "Gothic" (Busbecq's term again) while living in the Crimea and who presumably pronounced it with a Greek accent. Busbecq's interview procedure was evidently to have the Greek visitor carefully pronounce a Gothic word and then explain its meaning in Greek, which Busbecq understood only imperfectly—so his Greek interpreter translated the explanation into Italian, in which Busbecq was fluent. Busbecq then translated the Italian into Latin, the language in which he wrote the letter to his friend. Because the phonetic alphabet now used by professional linguists hadn't yet been invented, Busbecq used either German or Dutch spellings to transcribe the Greek visitor's pronunciation of the Gothic words, depending on how the word sounded to him. Ultimately, a copy of

Busbecq's handwritten letter in Latin fell into the hands of a French printer, who had difficulty reading Busbecq's handwriting but who published the letter anyway, without Busbecq's permission. The printer knew neither German nor Dutch and probably overlooked some typesetting mistakes.

Errors must have crept in at each stage of this process. Confronted with such complications, some linguists have thrown up their hands and despaired of reaching any conclusions about Crimean Gothic. But dozens of others have been struggling for more than four centuries to peel off the errors at each stage and to figure out what Crimean Goths really spoke. The following account is based on the most detailed study available (by the linguist MacDonald Stearns Jr., a former colleague of mine at the University of California, Los Angeles).

To give you a feeling for Crimean Gothic, the table at right lists some of Busbecq's transcriptions (as reconstructed by Stearns) and compares them with the modern German, English, and Frisian words having the same meaning. The first conclusion you'll reach is that Busbecq's informant was indeed speaking some Germanic language, because most of the transcribed words and grammatical endings are close to the corresponding German, English, or Frisian terms. A few Crimean words were evidently borrowed and modified from other languages, because the Crimea was such a linguistic melting pot over the centuries (for example, *telich* 'foolish', from the Turkish *telyq; sada* 'hundred', from the Iranian *sad; Menus* 'meat', from the Hungarian *mén-hús* 'horsemeat'). There is even a Crimean word derived from Latin: *Cadariou* 'soldier' is a legacy of the days when Goths were fighting for or against Roman centurions (*centurio* in Latin). Some of the Crimean words lack a recognizable cognate in any other language (for example, *Marzus* 'wedding').

Even though our sample of Crimean Gothic is so small, it suffices to demonstrate that the language was closer to Wulfila's Visigothic than to either old or modern German—so those Crimeans could not have been descendants of medieval German immigrants. This conclusion is also supported by the similarity of the Crimean and Visigothic words for the numerals '2' through '10'. Citing the Crimean first and the Visigothic second in each case, they are as follows: 2/*tua*/*twa*, 3/*tria*/*thria*, 4/*fyder*/*fidwor*, 5/*fynf*/*fymf*, 6/*seis*/*saihs*, 7/*seuene*/*sibun*, 8/*athe*/*ahtau*, 9/*nyne*/*niun*, 10/*thiine*/*taihun*.

Especially interesting is the Crimean Gothic word for 'egg'. Linguists have deduced that the proto-Germanic language, spoken around 500 B.C. and ancestral to all later Germanic languages, had a sound "jj" between two vowels, which became "gg" in North Germanic languages, "i" in West Germanic languages, and "d" in Visigothic. For instance, the proto-Germanic word meaning 'egg' would have been *ajjaz*, which became *egg* in Old Norse (spelled *ägg* in modern Swedish) but *Ei* in modern German and in Dutch. (We English speakers lost our original *Ei* and now say 'egg', as do Swedes and other North Germanic peoples, because that was one of the many words that our English ancestors borrowed from the Danish invaders who ruled much of medieval England for two centuries.) The surviving portions of Wulfila's translated Bible have nothing to say about eggs, so we can't be certain what a Visigoth said when ordering scrambled eggs for breakfast. However, Busbecq, God bless him, did ask his informant about eggs. Sure enough, the answer was *ada*!—demonstrating that Crimean Gothic had undergone the same "jj"-to-"d" sound shift attested by many Visigothic words. We would never know this if Busbecq had not written down that one word.

But the Crimean Goths were not speaking Visigothic, or even a dialect derived from Visigothic. Among the features of Crimean Gothic unparalleled not only in Visigothic but also in any other preserved Germanic language is the unique formation of the words for '12', '13', and so on (*thiinetua* meaning '10-2'; *thiinetria* '10-3'), as well as the unique formation of the words for '30', '40', and so on (*treithyen* meaning '3rd-10', *furdeitheien* '4th-10'). (Look at the Crimean numerals for '2', '3', '4', and '10' in the list two paragraphs back).

EXTINCT	MODERN		
Crimean Gothic	German	Frisian	English
Apel	Apfel	apel	apple
Boga	Bogen	bôge	bow
Bruder	Bruder	broer	brother
geen	gehen	gean	go
Goltz	Gold	goud	gold
Handa	Hand	hân	hand
lachen	lachen	laitsje	laugh
Oeghene	Augen	eagen	eyes
Rinck	Ring	ring	ring
Salt	Salz	sâlt	salt
schieten	schießen	sjitte	shoot
schlipen	schlafen	sliepe	sleep
Siluir	Silber	sulver	silver
Sune	Sonne	sinne	sun
tzo	Du	dij	thou
telich	närrisch	núver	foolish
sada	hundert	hûndert	hundred
Menus	Fleisch	fleis	meat
Cadariou	Soldat	soldaat	soldier
Marzus	Hochzeit	boaskerij	wedding

In short, in the course of one evening, Busbecq was able to learn enough about Crimean Gothic to convince future linguists that its speakers were not Germans but a distinct group of Goths related to the Visigoths. Almost surely, they were the direct descendants of the mighty Ostrogoths who settled in the Crimea about A.D. 250, battled the Huns, and conquered Italy. Incredible as it may seem, a few of their descendants were still speaking Ostrogothic some fifteen centuries later, in 1780, at the time of the American Revolution. But before George Washington could complete his second term as president, the few remaining Ostrogoths lost their language and cultural identity, leaving a host of linguistic questions forever unanswerable and extinguishing the last of the Gothic peoples, who had played such a major role in history.

Frisian, the other Germanic language I shall discuss, is of special interest to us speakers of English because it is the language closest to ours, even closer than are German and Dutch. The word for 'cheese', for example, has a familiar sound *(tsiis)* in Frisian but a less familiar sound in Dutch *(kaas)* and German *(Käse)*. (Look again at the table, opposite, for some other Frisian words.) About 2,000 years ago, the Frisians shared the coasts of what are now Denmark, Germany, and the Netherlands with the ancestors of the modern English—the Angles, the Saxons, and the Jutes—who invaded England in the fifth century. When I picked up a book in Frisian, the language struck me as much more reminiscent of the Old English of *Beowulf* than is modern English, because the English, but not the Frisian, language ultimately lost most of its inflectional endings.

After remaining politically independent until the sixteenth century, the Frisians finally became submerged within the Dutch state and German principalities. Today, Germany's remaining Frisian speakers (who live on the country's northwest coast) number only a few thousand individuals, and their two very different dialects (or separate languages) seem doomed to extinction. About 700,000 Dutch people still speak Frisian in the coastal Netherlands.

Many warning signs might suggest that even the large number of Frisian speakers in the Netherlands face the fate of the Goths. The writing of the Frisian language virtually disappeared several centuries ago and was not revived until recently. Since World War II, Frisians have been moving out of Friesland and have become scattered among the majority population, while the Dutch have been moving in. Within Friesland itself, the upper class, the townspeople, and professionals speak predominantly Dutch, while the lower class, the inhabitants of rural areas, and the agricultural population speak predominantly Frisian. The percentage of Frieslanders who speak or understand Frisian has been decreasing for decades, and those who do speak or understand it mostly can't write it (instead they write in Dutch). The Frisian language is becoming ever more "Dutchified" in its vocabulary, its grammar, and some aspects of its pronunciation.

Recently I found myself in Friesland without having planned the visit. While lecturing at the University of Groningen in the northeastern Netherlands, I was invited by three ornithologists to go for an afternoon's birdwatching. I discovered that Friesland is a distinct province of the Netherlands, with its boundary only fifteen miles west of Groningen. Of my three birdwatching companions, two were Dutch, but one, Theunis Piersma, a well-known authority on migratory shorebirds, was Frisian. Suddenly, there I was in Friesland with a Frisian.

I confess that upon realizing my situation, I felt both curiosity and a little trepidation. I had spent much time in parts of Europe where ethnic divisions provoke vicious conflict, especially Spain's Basque Country and the former Yugoslavia. Were my two Dutch companions welcome in Friesland? Was I entering a depressed area with high unemployment, alcoholism, and a dying language spoken only by old people? Worst of all, was Friesland home to a terrorist movement seeking independence?

Absolutely not. It was immediately obvious that Friesland is peaceful and flourishing, made prosperous by agriculture, industry, and tourism. Road signs are bilingual, in Frisian and Dutch. Everywhere, the Frisian flag flies beside the Dutch flag. Domestic architecture and boats are distinctively Frisian in style. I passed a Frisian wedding procession and visited a Frisian museum. To our two Dutch companions, Theunis spoke Dutch; to a pedestrian whom he asked for directions, he spoke Frisian, which our companions could not understand. The overwhelming sense I came away with was that the Frisians are proud of being Frisian *and* Dutch and are comfortable in their dual identity. Their outlook is reflected in the words of the Frisian national anthem: *It beste lân fan d'ierde!* (The best land on earth!)

How did this happy situation come to be? The key is that the Frisian language is neither outlawed nor merely tolerated as a necessary evil by the Dutch but instead is vigorously supported. As early as 1907, the government began making grants for Frisian lessons in primary schools. In 1955 the teaching of Frisian was permitted in all primary schools, and by 1980 it was required. The government of the Netherlands supports radio and TV broadcasts in Frisian. Frisian writing has been revived, with dozens of books for both children and adults being published in Frisian each year. Since the Bible was finally translated into Frisian in 1943, the number of people using the Frisian language for prayer has increased.

The visit left me feeling cautiously optimistic about the future of the Frisian language. The Netherlands' public policies seem good both for the Frisian people and for the Dutch state. Even a cynic with zero interest in linguistic diversity would have to admit it: at a relatively insignificant price, the Netherlands has spared itself the problems that many other multiethnic countries have.

I wish I could say the same for the rest of the world. In fact, the situation

About 1,000 languages are still spoken on the island of New Guinea. Of these, Baso, Kapori, and Mandar have 175, 60, and 20 speakers, respectively.

of most other minority languages is disastrous. For instance, of the 250 or so original Australian Aboriginal languages, fewer than 100 are still spoken or even remembered by anyone at all, and only half a dozen can boast more than 1,000 speakers. The highest density of languages in the world today is on the island of New Guinea, where approximately 1,000 different languages are still spoken. (Yes, they are really distinct languages, not just dialects, and they fall into dozens of language families, as different from one another as Athabascan languages are from Indo-European.) The median number of speakers per New Guinean language is only 2,000 people, and even the most widely used New Guinean language has only 200,000 speakers. On a recent trip to the island I encountered a North American missionary couple who are devoting their lives to studying the Elopi language and producing an Elopi translation of the Bible. When I asked why they had chosen that language, they explained, "It's because Elopi is such an important language: it has 600 speakers!" That makes Elopi a giant compared with its neighbors Baso, Kapori, and Mandar—spoken by 175, 60, and 20 people, respectively. To deal with this linguistic Babel, the government of Papua New Guinea (the eastern part of the island) adopted English and Pidgin as the national languages but has not promoted instruction in the indigenous languages, all of which face a bleak future.

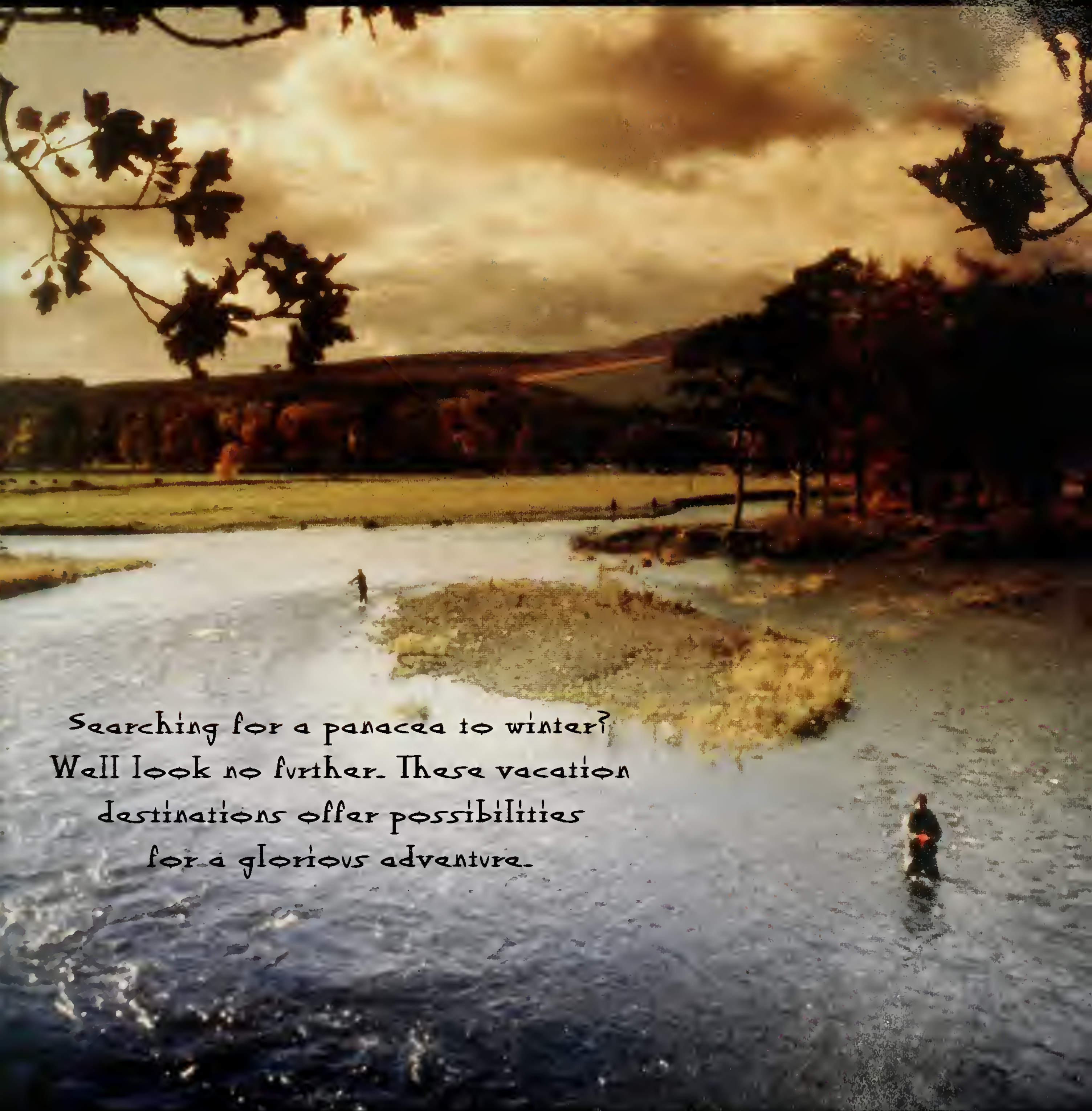
In North America, of the unknown number of native languages that were spoken when Europeans arrived, only about 200 survive. Most are on the verge of extinction, and many are now spoken by only one or two elderly people. Not one has a secure future. Even Navajo—by far the most widely spoken North American Indian language (with about 100,000 speakers) and one of only two heard in radio broadcasts—is at risk, because many or most Navajo children now speak only English.

How Indian languages were reduced to this condition is no secret. For most of the first three centuries after Europeans settled in North America, their main preoccupation was to kill, conquer, drive out, or acculturate Indians. Once the Indian population had been subdued, the U.S. government decided that the best way to "civilize" Indian children was to send them to boarding schools with instruction in English only and to punish severely any of them caught speaking their "barbarous" native tongues. Only in 1967 did our federal government reverse its complete ban on school instruction in any Indian language; not until 1990 did our government decide (in principle) to encourage Indian languages; and not until 1992 did the government appropriate funds for that purpose, in the form of $2,000,000 to foster Native American language studies (that's an average of $10,000 for each of 200 languages). By comparison, our government has spent nearly $20,000,000 to save one endangered North American bird species, the California condor. As an ornithologist, I would be the very last person to begrudge money for the condor; I would merely like to see money for human languages as well.

Why should anyone care about all these vanishing Indian languages? One consideration is their unique value for understanding the history and origins of Native Americans. Many extinct or vanishing Indian languages are the only evidence we have of the long migrations and complex histories of particular peoples. For example, the long-extinct Timucua language of northern Florida, known mainly from the writings of a Spanish missionary living among the Timucuans in the early 1700s, appears to be closest to Indian languages of coastal Venezuela and Colombia, suggesting an ancient back-migration of Indians from South America across the Caribbean to Florida. Our only evidence for a transcontinental migration of Gulf Indians from the area of the U.S. Southeast is the existence of the extinct or nearly extinct Yuki and Wappo languages of northern California (down to ten speakers and one speaker, respectively, a few decades ago), spoken 2,000 miles from the nearest Gulf languages (Choctaw, Creek, and others). With the vanishing of Yuki and Wappo, we are unlikely ever to learn more about them or to uncover the clues they held to great migrations rivaling those of the Goths.

The larger reason that anyone should care about these languages is related to the overall circumstances of Indians in the United States and Canada today—a serious issue for Indian minorities and non-Indian majorities alike. To put it mildly, the situation is not the happy one of Frisians in the Netherlands. Many Indians are caught up in poverty, alienation, health crises, and personal tragedy, which translate into social, political, and economic problems for American society as a whole. Both those Indians who remain poor and those who have achieved some affluence pose challenges to the rest of society, albeit in different ways. What is the role of language in all this? The answer is simple: for North America's 200 Indian language groups, as for every other language group in the world, their language is the vehicle of their culture. No one is demanding that English-speaking Americans be forced to learn Navajo, any more than anyone is demanding that the Dutch of Amsterdam learn Frisian. But all Americans would be much better off if Indians felt unalienated, and proudly and unambivalently Indian and American, just as the Frisians feel proud to be both Frisian and Dutch.

Jared Diamond is a professor of physiology at the UCLA School of Medicine and a research associate in ornithology at the American Museum of Natural History.



distinctive DESTINATIONS

distinctive DESTINATIONS

AMAZING THAILAND

The beauty of nature and the treasures of an ancient culture

THROUGHOUT 700 YEARS OF INDEPENDENCE, THE THAI kingdom has displayed an amazing continuity, underpinned by the people's adherence to Buddhism and the monarchy. Thailand contains a wealth of architecture, culture, cuisine, and traditions that are at once diverse and yet distinctly Thai. Located in the heart of Southeast Asia, Thailand has something for everyone. Geographically, Thailand is divided into four regions, and the landscape varies in each. The Central Plains, which include Bangkok, are flat and fertile. Forested mountains mark the north, while the high plateau of the northeast is relatively dry. The southern peninsula, flanked by the Gulf of Thailand to the east and the Andaman Sea to the west, has beaches and wetlands on either side of its lush central mountain range.

Daily direct flights from the United States fly into Bangkok, known as the City of Angels. The nation's capital since 1782, Bangkok is both a gateway and a principal destination for most travelers. When you fly into this huge city of approximately 10 million people, you'll be struck by the towering high-rise buildings. But once on the ground, the hidden treasures of this wondrous city are revealed. Among the small alleyways that run off the major thoroughfares and the maze of canals that criss-cross the city, Bangkok presents you with a way of life like you've never experienced. Don't miss the Grand Palace and the Temple of the Emerald Buddha, Bangkok's most impressive monument. And wake up at dawn one morning to get a glimpse of saffron-robed monks as they make their early morning alms rounds through the city.

Located on the lower edge of the northern region, some 427 kilometers from Bangkok, is the site of Sukhothai. Founded in the early fifteenth century, Sukhothai was Thailand's first capital. Numerous ruined temples of what was once a large and glorious city are today conserved in Sukhothai Historical Park, an UNESCO designated World Heritage Site. Not far from Sukhothai are the remains of its satellite towns, Si Satchanalai and Kamphaeng Phet. Both have monuments dating from the Sukhothai era, which help complete your understanding of this vital age in Thai history. A good base for exploring Sukhothai is the town of Phitsanulok, 55 kilometers to the east. It is served by regular flights from both Chiang Mai and Bangkok.

Farther north is a region of teak forests and jungle-covered peaks. Chiang Mai is a top destination with its lush forested-mountain landscape, fascinating high-altitude flora and fauna, and various ethnic hill tribes. Chiang Mai is a perfect base from which to explore the hill country of the north. Venture into the remote villages of the hill people by elephant to witness this dramatically beautiful region. Chiang Mai is also known for its handicrafts. Silverware, woodcarving, celadon pottery, lacquerware and paper umbrellas make this city a shopping experience not to be missed. •

distinctive
DESTINATIONS

BELIZE ADVENTURE

Belize is known for the warmth and hospitality of its population.

ONLY A TWO-HOUR PLANE RIDE FROM the United States, Belize lies directly south of Mexico's Yucatán Peninsula and borders the Caribbean Sea. Fly into Belize City and you're off on a wonderful adventure. One of the best shows in Belize happens every day of the year, and it's free. [illegible] stroll by the famous Swing Bridge [illegible] Creek. There [illegible] from the city gather to manually turn the bridge sideways to allow vessels to pass to or from the Caribbean Sea. Built in Liverpool, England, and installed in 1923, it may be the last manually operated bridge in service anywhere.

Natural and unspoiled, Belize is a haven for some of the world's most exotic and endangered species. It has become a recognized leader in preservation and conservation. Nature reserves abound, and a fascinating population of birds, beasts, and marine life reside here.

Twenty-seven miles outside of Belize City, the Community Baboon Sanctuary supports the only stable and healthy population of black howler monkeys in the world. The reserve provides a home to 1,[illegible] black howler monkeys as well as 250 species of birds, deer, [illegible], anteaters, peccaries, and iguana. The black howler, an endangered species, is found only in Guatemala, Mexico, and Belize.

Belize boasts four butterfly breeding farms: Chaa Creek Butterfly Center, San Ignacio; Shipstern Butterfly Breeding Center, Orange Walk; and Tropical Wings Nature Center, Cayo—all natural reserves; and Fallen Stones Butterfly Ranch in Toledo. Here Belize's colorful butterfly population is sustained, increased, and bred for export.

Belize is also known for its marine environment. Home to the Western Hemisphere's largest barrier reef, 70 types of hard corals, more than 400 species of fish, three major offshore atolls, seven aquatic World Heritage sites, nearly 200 offshore cayes, and an endless array of dive sites, Belize is an extraordinary experience for the beginner as well as the seasoned diving enthusiast.

If you want to experience Belize's wondrous history, a visit to the Maya ruins is a fascinating excursion to another time. Belize has the highest concentration of Maya sites among all Central American countries. Belize has joined with El Salvador, Guatemala, Honduras, and ▶


Catch the exhilaration of inland hideaways.
Discover streams, rivers and caves. Explore ancient Maya sites. And on the coast, dive the extraordinary Blue Hole. There is fabulous fly-fishing for tarpon, bone and permit. And at days end, you'll discover that the people are as warm and friendly as the climate. Experience the diversity of Belize, your English-speaking neighbor on the Caribbean coast, only 2 hours from the U.S.
Call 1-800-624-0686
or visit our website: www.travelbelize.org/nh
Catch the adventure
BELIZE
Mother Nature's best kept secret

distinctive DESTINATIONS

Some of Belize's more exotic inhabitants include toucans, scarlet macaws, jaguars, ocelots, pumas, and iguanas.

Nature observation requires the best performance and value optics.

Mexico to establish Mundo Maya, the World of the Maya, a program dedicated to the preservation of Maya culture. Most sites are readily accessible, with guided tours available.

The most extensively excavated ruin is Altun Ha, or Water of the Rock. Altun Ha was a major ceremonial and coastal trade center. The ruin consists of two main plazas with thirteen temple and residential structures. The Jade Head, representing the Sun God, Kinich Ha, was found here—the largest carved jade object in the whole Maya area. Caracol, or Snail, is the largest of Belize's Maya ruins, reached by a spectacular scenic drive through the Chiquibul Rainforest. Currently under excavation and restoration, Caracol's importance as a major ceremonial center has only recently been discovered. The largest pyramid in Caracol, "Caana" (Sky Place), rises 140 feet and is the tallest man-made structure in Belize. •

EAGLE OPTICS OFFERS A WIDE SELECTION of equipment from every major manufacturer of visual optics. They feature only those models that, in their experience, represent the best performance and value in various categories suitable for the outdoor enthusiast.

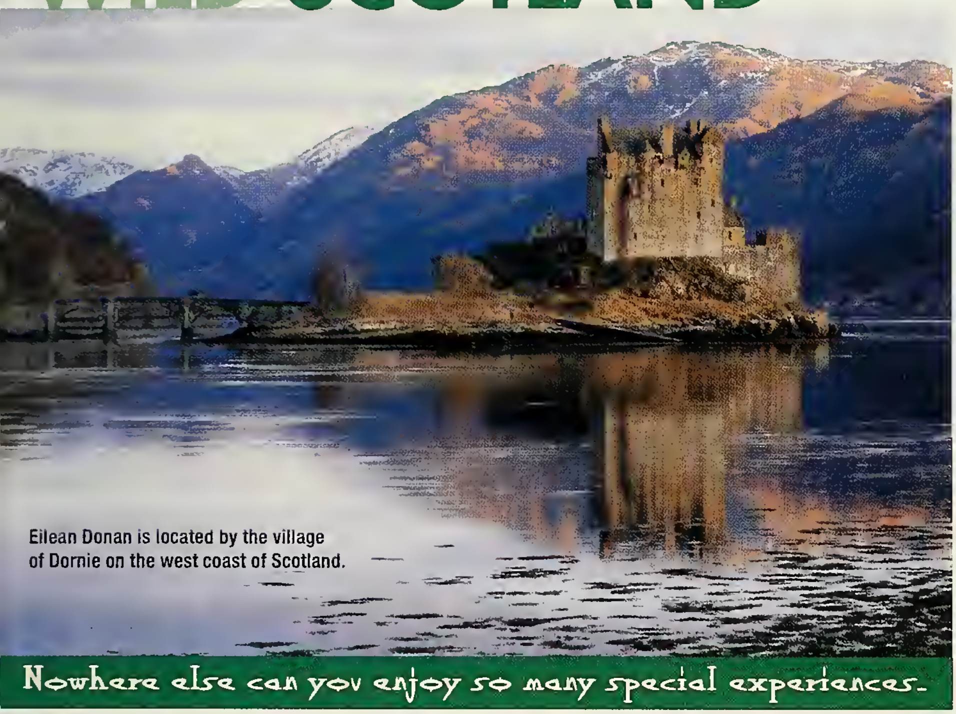
Fair, honest and knowledgeable service, extremely competitive prices, and customer satisfaction have made Eagle Optics the leader in supplying optic equipment to birdwatchers, amateur astronomers, and outdoor enthusiasts.

Since they are an authorized dealer of each manufacturer they represent, customers can be confident that their selection will include factory new equipment with all accessories supplied by the manufacturer, including an U.S. warranty. Most models listed in the price list are stock items, available for immediate shipment. And, purchases may be returned in their original condition for an exchange or refund. •

Belize has recorded over 500 species of birds within its borders.

The best equipment provides the best view.

WILD SCOTLAND



Eilean Donan is located by the village of Dornie on the west coast of Scotland.

SCOTLAND PROVIDES A WONDERFUL opportunity to enjoy wild and untamed scenery, fascinating history and culture, and friendly people who are waiting to show you their own special version of this treasure on the edge of Europe.

Scotland is a small country and traveling around is easy. Begin your vacation by flying directly into Glasgow Airport in the west of Scotland. Glasgow is particularly well served by transatlantic flights. Continental Airlines operates a year-round, non-stop service to Glasgow via Newark, and from May to October, American Airlines operates a daily direct service to Glasgow from Chicago O'Hare. Within Scotland you can fly to main airports in Edinburgh, Aberdeen, and Inverness.

Glasgow is one of Europe's great cultural destinations. Its museums and galleries, coupled with its architecture and culture, offer a veritable feast for visitors. Alexander Thomson designed some of the most original Victorian architecture in Glasgow. Discover his many buildings including the recently opened Holmwood House, or follow one of the heritage trails and self-guided walking tours available. Glasgow is also the headquarters of many cultural organizations, including Scottish Opera, Scottish Ballet, and the Royal Scottish National Orchestra, all of which have regular performances in venues around the city.

After thoroughly getting a feel for Glasgow and its environs, head toward the West Highlands and Islands, Loch Lomond, Stirling, and Trossachs. Here the lowlands meet the mountains of the north and west. Both the Trossachs and Loch Lomond have intrigued visitors since Sir Walter Scott's writings first made the area well known in the early nineteenth century.

IN THE OLDEN DAYS, ALL ROUTES LED to Stirling. Whoever held Stirling Castle controlled the entire Scottish nation. The Battle of Bannockburn in 1314, the last conflict of the Scottish Wars of Independence, was fought within sight of its walls. Led by King Robert I, the Scots defeated the English occupying forces and gained almost three centuries of independence. Close by is the National Wallace Monument, a tribute to Scotland's first freedom fighter, Sir William Wallace, whose struggle to free Scotland from England's occupation was portrayed in the movie *Braveheart*. •

distinctive
DESTINATIONS

GUIDED TOURS

IF YOU WANT TO TAKE PART IN A UNIQUE vacation, but don't want to plan, organize, arrange, or make reservations, leave your vacation planning and itinerary to the professionals.

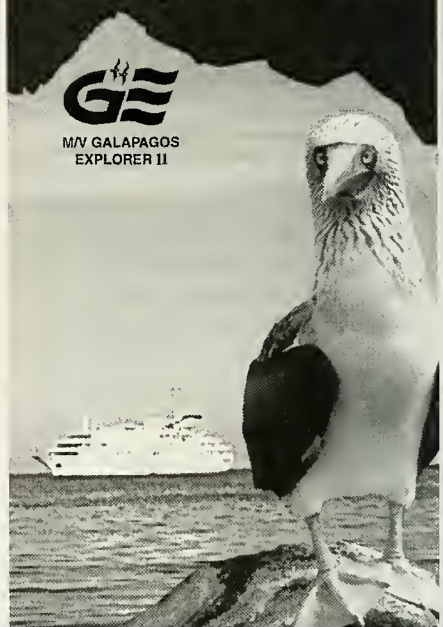
If a cruise is what you are looking for, **Swan Hellenic** offers an exciting blend of discovery and relaxation with plenty of time to swim, dine in authentic restaurants, and shop in such places as Copenhagen's famed Stroget and Istanbul's Grand Bazaar.

Norwegian Cruise Lines, **Holbrook Travel**, **Cross Cultural Adventures**, **KD River Cruises**, and **Galápagos EXPLORER II** also offer wonderful expeditions to exciting destinations.

In April 2001 you can escape to the Mediterranean for Easter and stay on in Athens to experience the colorful pageantry of the Orthodox festival. In the summer, Swan Hellenic offers a series of six short cruises, which explore the Atlantic isles and different areas of the Mediterranean. Other getaways include Corsica, Elba and Ischia; the Italian coast to Ravenna and Venice; the Dalmatian coastline from Venice to Dubrovnik and Corfu; and pretty Greek islands plus Istanbul.

If you would rather stay on land, Holbrook Travel brings an element of exploration and learning throughout all of their trips. Their programs are custom-designed to explore

Birding at Palenque



Take a cruise to the Greek Islands and visit their famous archaeological sites, museums and dramatic landscapes.

Too busy? Leave the planning to us.

lesser-known areas, and accommodations range from inns to camps to hotels, offering you a variety of experiences.

From April through December 2001, travel with Holbrook to Via Verde in Costa Rica. The Natural Highlights tour provides a nine-day overview of Costa Rica's best known natural areas. With an experienced naturalist guide, you will see an incredible diversity of wildlife, habitats and ecosystems. Hike through Costa Rica's lush lowland rainforests, observe eruptions of Arenal Volcano from the balcony of your lodge, and explore Monteverde Cloud Forest's canopy-shrouded trails, all during one wonderful vacation. •

This special editorial/advertising supplement was created by the Natural History Special Sections Department and did not involve the magazine's editorial staff. ☐ WRITER: Stephanie Fekety ☐ DESIGN: Mindy Phelps Stanton

practical INFORMATION
websites

Belize Tourism Board
800-624-0686 ■ www.travelbelize.org

Cross Cultural Adventures
703-237-0100

Dare County
252-473-1101 ■ www.co.dare.nc.us

Eagle Optics
800-289-1132 ■ www.eagleoptics.com

Galapagos Explorer II
888-368-9929
www.galapagosexplorer.com

Holbrook Travel
800-451-7111
www.holbrooktravel.com

Norwegian Coastal Voyage Inc.
800-205-3005 ■
www.coastalvoyage.com

Scottish Tourist Board
800 GO 2 BRITAIN
www.2001toscotland.com

Swan Hellenic
877-219-4239 ■ www.swanhellenic.com

Tourism Authority of Thailand
662-694-1222
www.tourismthailand.org

Hot Times in


Alnus (alder)
Glyptostrobus
Coryphodon
Salvinia
Lygodium
Sabalit

the Bighorn Basin

A modern desert provides clues to an ancient period of global warming.

Story by Scott L. Wing ~ Illustrations by Utako Kikutani

To most people who drive through, hurrying west to Yellowstone National Park, Wyoming's Bighorn Basin is nothing but a vast sagebrush plain crossed by two lanes of blacktop stretching away toward distant snowcapped peaks. Those with their eyes on the horizon may never notice badland hills striped with red and purple, and only those who leave the road will smell pungent, fresh-crushed sage, hear the total silence of the desert at midday, and feel dust as fine as powder between their fingers. Even those who experience the desert may not realize it is a country haunted by time travelers—paleontologists—who pull from the rocks not only fossils but an understanding of how the earth's climate has changed in the past and how plants and animals have responded to those changes. This part of Wyoming contains the world's best record of a period 55 million years ago, when the earth experienced an episode of global warming more rapid than any before, perhaps as rapid as the one we humans are about to cause and experience.

The Bighorn Basin is roughly 4,000 square miles (about 10,000 square kilometers) of badlands, sagebrush flats, and irrigated fields. Except for a narrow opening to the northwest, it is surrounded by mountains. Like other basins in the Rocky Mountains, the Bighorn Basin formed 60–50 million years ago, during the late Paleocene and early Eocene, as mountains were pushed up on all sides. Fast-moving streams eroded mud and sand from the rising mountains and, slowing as they reached flatter land, spread sediment across the bottom of the basin. Year after year, flood after flood, layers of sediment accumulated until in some areas the pile was more than six miles deep, burying—and preserving—the remains of countless organisms. In the past few million years, this part of the North American continent experienced renewed uplift, the climate became colder and drier, and the vast deposits began to erode rapidly, dissecting the soft rocks into strange and intricate shapes and littering the slopes

Fifty-five million years ago, parts of Wyoming's Bighorn Basin were lush and swampy. Here, a hippolike *Coryphodon* mother and her young feed on aquatic plants, while a pair of tapirlike *Homogalax* walk among the palmettos at the base of some dawn redwoods.

and flats with the fossils once contained inside.

Fossil riches first attracted paleontologists to the Bighorn Basin more than a century ago. Early scientists worked from horseback; photographs of their expeditions show U.S. Army cavalrymen, brought along to ensure safety. In photographs from the early twentieth century, field crews cluster around buckboard wagons or Model T Fords, replaced in more recent photos by weathered pickups and four-wheel-drive vehicles. Traveling in the badlands is still difficult and sometimes dangerous—anyone who has worked long in the basin has spent time digging a stuck vehicle out of a dry creek bed or walked miles to the nearest road to seek help. Stories of such experiences, retold around campfires, remind us of some constants in fieldwork—even if we now locate fossil sites with global positioning systems rather than with cairns and enter data into computers at night as well as into notebooks during the day.

Poplars growing in the basin's streamside forests had graceful pointed leaves and small hanging flowers, right, much like those of their living relatives.

The generations of effort have paid off handsomely. Hundreds of thousands of fossils—mammal bones, leaves, shells—fill the cabinets of museums around the country and even the world. There are fossil pollen grains by the millions. Each fossil reveals something about a once-living organism: a leaf may contain the fossilized trail of an insect larva that tunneled within it for food; the cusps and crests of a mammal tooth bear evidence of the food it was suited to chew; the bones of large land tortoises, soft-shelled aquatic turtles, and alligators show that the ancient climate was warm and that the rivers teemed with life.

Hundreds of thousands of fossils from the Bighorn Basin—mammal bones, leaves, shells—fill museum cabinets around the world.

Evidence of past conditions also comes from the Bighorn Basin rocks themselves. The varicolored bands running across the hills are fossilized soils. The bands' colors indicate such things as the wetness of the original soil, and their thickness provides evidence of the length of time over which they developed. The depth and sinuosity of sandstone deposits reveal the original dimensions and course of ancient river channels. Coal-dark deposits show where the floodplain was especially wet, inhibiting the decay of plant remains by the fungi, bacteria, and arthropods living in the soil. Veterans of fieldwork in the basin are familiar with the colors and shapes that indicate the likely presence of fossils. Bands of red, orange, purple, and light gray (evidence of well-drained soil) often contain fossil bones. Plant fossils occur in several types of rocks, including brown and dark gray layers—all that is left

of ancient swamps—and also coarse silt and fine sand layers deposited millions of years ago by overflowing rivers. Sediments containing fossil plants also typically contain the mineral gypsum, which forms large crystals as it weathers out of the rocks. The flashing of gypsum crystals in the desert sunlight can beckon a fossil hunter from miles away.

Taken together, all the evidence yields a picture of the environment and life of the basin during the late Paleocene and early Eocene. The streams—mostly small, slow moving, and gently meandering—were lined with low, natural levees on which grew a variety of trees, including relatives of sycamore, poplar, walnut, and hazelnut. The most common streamside tree was a relative of the katsura tree *(Cercidiphyllum),* a genus restricted today to two species in eastern Asia but once common across the mid and high latitudes of the northern continents. In the understory of these streamside woodlands lived several types of ferns still found in temperate forests, but the areas of open grassland that are so common today were absent. (Grasses had evolved by this time but had not yet become important forms of vegetation.) A variety of turtles lived in the rivers, along with gar, freshwater clams and snails, crayfish, and alligators. More than a hundred species of mammals roamed the forested floodplains, including some of the earliest primates, dawn horses, the earliest even-toed ungulates (the group that includes deer, pigs, and antelope), early true carnivores, and other mammals that have no extant close relatives (see "Wyoming's Garden of Eden," page 55). Among the birds was *Diatryma,* a six-foot-tall relative of today's cranes.

Plants of the lower, wetter floodplains included dawn redwood *(Metasequoia),* a Chinese relative of bald cypress *(Glyptostrobus),* alder, a relative of witch hazel, and more than a hundred less-common species. Also flourishing in these swamp forests were relatives of a number of living, mostly tropical or subtropical plant families, including palms, cycads, tree ferns, gingers, magnolias, laurels, and hibiscus.

My work in the Bighorn Basin has focused on the plant fossils and the story of climatic change that can be learned from them. Even after nearly thirty years of fieldwork in the area, I still find it exciting to collect fossils of subtropical plants in a high desert where winter temperatures sometimes drop to -40° F (-40° C). One indication that the global climate has cooled radically in the past 50 million years comes from the identification of fossil plants whose living descendants are restricted to relatively mild parts of the planet. But the shapes and sizes of leaves have their own story to tell. Today, for example, plants with smooth-margined leaves (such as magnolias) are more diverse in warmer climates; plants with toothed or jagged leaf margins (such as elms or birches) make up a larger proportion of the species in cooler areas. We don't fully understand the reasons for this difference, although we do know that the tissue in a leaf's marginal teeth matures more quickly and begins to photosynthesize earlier than its other parts—a developmental schedule that may be advantageous for plants in cool climates with short growing seasons. Water evaporates faster from the teeth, however, and in warmer, drier climates the cost of lost water may outweigh the benefit of a photosynthetic head start.

The size of a leaf, too, can inform us about past climatic conditions. The larger the leaf, the more quickly it heats up—and loses water. As a result, plants of drier climes tend to have smaller, more water-efficient leaves. Extrapolating from the relationships between leaf size and shape in living plants and contemporary levels of precipitation and temperature, scientists can use the sizes and shapes of fossil leaves to infer past levels of precipitation and temperature. The estimated mean annual temperature in the Bighorn Basin during the Paleocene and early Eocene varied from about 50 to 68° F (10–20° C). Winter frosts, if they occurred at all, were short-lived and mild. The ground never froze.

Other clues to past temperatures exist in the ratio of two oxygen isotopes: ^{16}O and ^{18}O. These isotopes occur in rainwater and therefore also in the surface water that animals drink and that helps form soil minerals. The warmer the climate, the warmer the rain and the higher the ratio of ^{16}O to ^{18}O. Knowing this, scientists can estimate the temperature of ancient rain from the ratio of isotopes trapped in fossil mammal teeth and soil minerals.

A common tree in Wyoming's ancient swamps was *Glyptostrobus,* in the bald cypress family. A fossil, below, shows a branch with scalelike leaves and a cone at the tip.

CHIP CLARK


KENNETH D. ROSE

A view of the Bighorn Basin. When looking for fossils, paleontologists are guided by the shapes and colors of the basin's rocks. Red and orange bands are fossil soils that often contain mammal bones.

The results of calculations using the isotopic method are generally in agreement with those based on studying leaves. Both show a complex pattern. Temperatures warmed fairly quickly during the last million or so years of the Paleocene (from about 56 to 55 million years ago). Then, about 55 million years ago—near the boundary of the Paleocene and the Eocene—they warmed even more, and very rapidly. Detailed analyses of cores taken from the ocean bottom suggest that this warming took place over about 10,000 to 20,000 years—very fast for such a large change. Over the course of the following 100,000 to 200,000 years, the moderate climate seen through much of the late Paleocene and early Eocene returned. Later in the early Eocene, temperatures cooled and then warmed once more (reaching the highest temperatures seen in the past 65 million years).

The release of enormous amounts of methane gas from the seafloor may have contributed to a period of rapid global warming 55 million years ago.

In the Bighorn Basin, evidence of the sharp warming near the time of the Paleocene-Eocene boundary can be found in several exceptionally thick, greatly weathered fossil soils. It is in these layers that fossils of odd-toed ungulates, even-toed ungulates, and primates first appear. These new mammals arrived simultaneously in Europe, and at the same time a number of hard-to-explain global events occurred: Single-celled seafloor organisms went extinct in record numbers. Warmth-loving plankton appeared in middle- and high-latitude oceans, such as the North Atlantic and the oceans surrounding Antarctica. Ocean surface waters at high latitudes warmed by as much as 14° F (about 8° C). The ratio of light to heavy carbon isotopes increased dramatically in rocks and fossils. (Like oxygen, carbon has two common stable isotopes: light, or ^{12}C, and heavy, or ^{13}C. Many organisms use ^{12}C preferentially in their metabolism, because it's more chemically reactive, so an increase in the amount of ^{12}C in rocks and fossils could indicate that something had caused the release of large amounts of carbon previously used by living things.)

What was responsible for the rapid warming 55 million years ago, and did it perhaps have anything to do with these other events? We can pretty much rule out one known cause of rapid climate change—the melting and growth of ice sheets—because polar ice caps and continental ice sheets probably didn't exist during the Paleocene and Eocene. Recently, however, scientists proposed a new theory to explain the Paleocene-Eocene climate change: the melting of methane ice on the seafloor.

Microbes that feed on organic material raining down to the ocean bottom produce methane gas as a by-product of their decay. When this gas combines with water under the high pressures and low temperatures found on the seafloor, it can form ice-like compounds called clathrates. According to the new theory, rising ocean temperatures, an earthquake beneath the seabed, or some as yet unknown mechanism triggered the release of enormous quantities of methane that had been locked up in clathrates. This would have led to further warming of the atmosphere and the ocean (methane is a powerful greenhouse gas), encouraging the additional release of seafloor methane in a potentially self-reinforcing process. The released methane would have reacted rapidly with oxygen, producing carbon dioxide and water vapor (both powerful greenhouse gases), and both of these would have made their own contributions to the warming.

Eventually, however, much of this carbon dioxide would have reacted with rocks during the process of chemical weathering or been used by plants in photosynthesis. Much of the water vapor produced by the methane-oxygen reaction would have rained out of the atmosphere. The result of these processes would have been a gradual return to the earlier atmosphere and climate.

The methane theory illuminates more than just the increase in temperature that occurred 55 million years ago. A by-product of decaying organic matter, methane has a high ratio of light to heavy carbon, which could explain why geochemists have found more ^{12}C in rocks from that period. In addition, carbon dioxide that formed when methane reacted with oxygen that was dissolved in seawater or contained in the atmosphere could have changed the chemistry of the deep-sea environment, making it more corrosive. This, plus the reduced amount of oxygen in the water, would help account for the extinction of bottom-dwelling microorganisms. Moreover, the temporarily increased rainfall and higher temperatures explain the highly weathered soils seen in the Bighorn Basin rocks of this time.

Warming probably also made high-latitude land bridges across what are now the Bering Strait and the North Atlantic Ocean more hospitable to mammals, enabling intercontinental migration and explaining the animals' sudden appearance in the basin. Unfortunately, we have found no fossil plants from the warmest period, but fossils from just after the Paleocene-Eocene boundary show that only a few new types of plants (including several ferns) appeared at this time. The modest change in vegeta-

CHIP CLARK

The lobes and veins of a fossilized *Macginitiea* leaf, above, show that it belongs to the sycamore family. An Eocene insect chewed a semicircular cut in the leaf's central lobe. Left: An artist's rendering of an intact *Macginitiea* leaf shows male and female flowers as well.

tion is curious, because plants are famously sensitive to climate change. Perhaps warm-climate (probably evergreen) species found it difficult to adapt to the polar nights on the high-latitude land connections. Or perhaps plants were slow to disperse because their seeds did not germinate and grow well in the shade of preexisting dense vegetation.

The warming that took place around the transition from the Paleocene to the Eocene demonstrates that greenhouse climates can come and go in

CHIP CLARK

Common in the Tropics today, *Salvinia* was also an abundant aquatic fern during the Eocene. Its small, hairy, oval leaves floated on the water's surface.

a geological blink and that lasting rearrangements of animal life may accompany the changes. Although the temperature increase reversed within a geological moment, the effects on the mammalian community were permanent. The lineages that appeared during this period went on to dominate faunas for millions of years, largely replacing those that had been important on the northern conti-

The fossils from the Bighorn Basin tell a story about how plants, animals, and whole ecosystems respond to long-term shifts in global climate.

nents for the previous 10 million years. Descendants of some of these immigrants, such as deer and pronghorns, are still dominant in this area today.

The lack of dramatic change in vegetation raises questions about how successfully plants can respond to warming climates, especially if they disperse slowly. Most of our knowledge about the issue has come from studying the recent geological past (the past 20,000 years), during which glaciers retreated from the northern continents. Plant populations altered their distributions very rapidly during this period, sometimes averaging more than half a mile (about one kilometer) a year. For those who hope this means plants will be able to cope with rapid climate change in the future, the message is not so simple. The difference between plant response to the Paelocene-Eocene warming and to the last deglaciation suggests that vegetation can't always respond quickly. (It may, for example, be easier for seeds to establish themselves on the new ground exposed by retreating glaciers.) Moreover, the past makes an imperfect predictor because of the complicated effects of human actions—including habitat fragmentation, introduction of nonnative species, and conservation efforts. These actions may skew the odds in favor of some plants and against others.

Much remains to be learned about climate change during the Paleocene and Eocene. Our current knowledge has come from the efforts of hundreds of scientists—paleontologists, geochemists, climate modelers, and oceanographers—working all over the globe. New methods of analyzing fossils and sediments allow us to ask new questions. For instance, we may soon have reliable estimates of the concentrations of carbon dioxide in the atmosphere during this time. As work continues in the Bighorn Basin and elsewhere, our static snapshots of individual reconstructed moments from the past are being transformed into a motion picture revealing the responses of ecosystems to long-term shifts in global climate and regional environments. In effect, scientists are discovering a movie about life during the last great warming.

This may be a movie worth watching. The past decade was by far the warmest since the beginning of good record keeping. Average global temperature is now higher than in any previous period for which written documentation exists. Present levels of atmospheric carbon dioxide are 30 percent higher than preindustrial levels and will continue to increase rapidly if current trends in the human generation of carbon dioxide continue.

Earth's future may well hold climates warmer than any experienced in the last several hundred thousand years. But we know from work in the Bighorn Basin and elsewhere that greenhouse climates are not without precedent in our planet's history. If our climatic future looks even a little like the greenhouse past, then the paleontological and geological work done in the Bighorn Basin is not just an exercise in intellectual curiosity. The horse-mounted paleontologists of the 1880s probably wouldn't have been surprised to learn that their successors 120 years later were still finding fossils in the basin, but they would likely have been astonished that our minds are as much on the future as on the past. □

Wyoming's Garden of Eden

The rich fossil record from the early Eocene Bighorn Basin includes the remains of the most ancient primates, hoofed animals, and carnivores.

Story by Kenneth D. Rose
Illustration by Utako Kikutani

Today Wyoming's Bighorn Basin, home to pronghorns and prairie dogs, coyotes and rattlesnakes, is nearly a desert. But close your eyes and imagine a scene in this same region 54 million years ago, after a time of rapid and dramatic warming. The ancient Bighorn is a subtropical lowland floodplain, lush with vegetation and teeming with animal life. Many of the mammals are new immigrants to the basin, and some look, if not modern, then strangely familiar. It is just after daybreak, and a group of primates forages peacefully among the trees bordering a pond. Resembling lemurs, they leap from branch to branch in search of fruit and nuts. Nearby, raccoonlike animals climb through the trees; occasionally one stops to groom itself, using its front teeth. On the forest floor, two rabbit-sized, hoofed animals hop through the low underbrush. Browsing on herbs and shoots, they are apparently oblivious to a herd of dawn horses, no bigger than beagles, running by. Suddenly the serenity is broken as a giant bird, recalling the mythological roc, barges through the brush, creating a momentary panic among the dawn horses. As they scatter, they are startled by a bear-sized *Pachyaena* with a monstrous head and threatening jaws. This time, however, the *Pachyaena* merely wants to scavenge a carcass. Some distance away, a pair of tapirlike animals ambles through a swamp while a hippolike *Coryphodon* and its baby stand in the still waters and feed on aquatic plants.

For those of us who study Eocene mammals of the Bighorn Basin, such scenarios are easy to envision, for the life and death of the region's ancient inhabitants are recorded in the fossils that abound in the badlands. Over the past 120 years, paleontologists working there have recovered remains of more than 200 species of mammals. These fossils not only tell us what early denizens of the basin looked like but also provide information about what they ate, how they moved, how they were related to one another, and what habitats they lived in. Tooth marks on bones reveal attacks or scavenging by ancient carnivores; some bones are even broken in ways that suggest an individual was killed by an owl. Bones that lay exposed long after the animals died often have characteristic gnaw marks left by rodents, or cracks due to drying.

Well-preserved, articulated, and nearly complete, a skeleton of *Chriacus*, below, indicates that this raccoonlike mammal was rapidly buried after its death.

NORMAN BARKER

Each summer for the past twenty years, often in collaboration with Tom Bown of the U.S. Geological Survey, I have led a group of students and associates to the Bighorn Basin to collect fossils of early Eocene vertebrates. Of particular importance to paleontologists, the early Eocene—from about 55 to 52 million years ago—is the interval when many of the modern orders of mammals, including our own, first appeared. The more than 50,000 specimens we have amassed from the 2,000- to 3,000-foot-thick sediments of the basin's Eocene outcrops now reside at the Smithsonian's National Museum of Natural History. Our collection, together with the others unearthed from the Bighorn Basin, con-

When Wyoming was warm: Ancient animal life abounds at an early Eocene pond and in surrounding woodland.

stitutes the world's richest and most diverse record of the vertebrate life that existed during the warmest climatic interval since the demise of the dinosaurs. These specimens also provide evidence—some of the most detailed in the entire vertebrate fossil record—of how certain animals evolved, in many cases showing a continuous, gradual transformation from one species to another through time.

Like most Eocene fossils, those in the Bighorn Basin are almost always fragmentary, consisting mainly of isolated bones, jaw fragments, and teeth. While teeth can tell us a lot, other parts of the skeleton are essential if we are to understand many other aspects of these mammals' lifestyles and relationships. One of the main goals of our expeditions has been to find mammal fossils other than teeth and jaws. By concentrating on ancient soils whose color and other sedimentary features indicate that they are likely to preserve skeletal material, we have been rewarded with hundreds of partial skeletons of nearly fifty kinds of mammals. These include the most ancient primates, hoofed animals (ungulates), carnivores, and rodents, as well as many extinct groups. We can now re-create the mammalian life of the Eocene in considerable detail.

Impressive numbers of the lemurlike *Cantius* inhabited the newly formed basins and ranges of the Rocky Mountain region during the early Eocene. Thousands of its jaws and hundreds of isolated bones have been found in the Bighorn Basin. So far, however, only three partial skeletons have been unearthed. From these we know that *Cantius* was one of the earliest of the primates, the group that now includes monkeys, apes, and humans. It was an agile climber, with long hind limbs for leaping, nails on its digits, and a grasping big toe. Compared with other early Eocene mammals, *Cantius* also had a large brain and relatively large eyes. In all these characteristics, *Cantius* resembles modern primates and differs from the so-called archaic primates that were common in the Paleocene, the 10-million-year period after the dinosaur extinction and just before the Eocene.

The change in mammal life was abrupt and profound: in the early Eocene, half the individuals in many Bighorn Basin animal communities were immigrant species.

Also adapted to life in the trees was *Chriacus,* a raccoonlike member of the arctocyonids, a now-extinct group that probably gave rise to the modern ungulates. In contrast to the feet of present-day hoofed mammals, which are specialized for ground locomotion, the foot structure of *Chriacus* shows that it could climb up and down trees with facility. By turning its feet around and gripping the tree trunk with sharp claws, it could descend headfirst,

NORMAN BARKER

***Diacodexis*, above, had long, slender hind limbs and joints specialized for running and hopping. Despite its rabbitlike features, *Diacodexis* is the oldest known member of the group that includes today's pigs, camels, and deer.**

in squirrel fashion. This creature was one of the first mammals we know to have had long, narrow lower incisor teeth arranged in the shape of a comb, similar to the tooth comb of modern lemurs. Microscopic grooves on these teeth confirm that *Chriacus* used them to groom its fur. Its molars indicate that it was an omnivore whose diet most likely included fruit, nuts, and even small animals, although it was probably no threat to the similar-sized *Cantius*. The primate and its young would have had more to fear from early tree-climbing carnivores known as miacids, from predators called creodonts, and from a variety of terrestrial meat-eaters.

While none of the true carnivores (those related to living dogs and cats, for example) got much larger than a coyote, some of the early Eocene creodonts were bigger than wolves. But even they were dwarfed by the formidable *Pachyaena*, a ground-dwelling cousin of the earliest whales, whose head reached the size of a Kodiak bear's. *Diatryma*, a six-

Unlike many of their hoofed descendants, none of the early Eocene ungulates was a grazer. Grassland habitats were not to become widespread for millions of years.

foot-tall flightless bird with a foot-and-a-half-long head, would have been equally intimidating. Both of these creatures, which are best known from the Bighorn Basin, appear to have been primarily carnivorous, although we cannot be certain if they were active predators or merely scavengers.

The bones of another Bighorn Basin mammal, *Diacodexis*, show it to be the oldest and most primitive of the even-toed ungulates. (We divide hoofed mammals into two main groups: the artiodactyls, having an even number of toes, and the perissodactyls, having an odd number of toes.) *Diacodexis* was thus the forerunner of all the living artiodactyls, a varied group that includes pigs, hippopotamuses, camels, giraffes, sheep, and deer. *Diacodexis* itself probably looked and moved something like the diminutive chevrotain, or mouse deer, of Asian forests. Its molars, which have low, rounded cusps, suggest a diverse herbivorous or omnivorous diet, but while its teeth are generalized, *Diacodexis*'s skeleton is strikingly specialized for its time. Its small size and elongated, slender legs—with the hind limbs markedly longer than the forelimbs—would have given the animal a somewhat rabbitlike appearance and way of moving, although it is not related to rabbits. Unlike the flexible joints of climbing mammals, *Diacodexis*'s joints restricted movement to a hinge motion in a fore/aft plane. The feet had four functional toes, the two central ones being larger and of equal size. A delicate hoof tipped each digit. These features would have made *Diacodexis* one of the swiftest runners of its day. But given its probable forest habitat, diet, and ability to hop over branches, *Diacodexis* may have used its speed only occasionally, to escape predators.

Remains of odd-toed ungulates are among the most common Eocene fossils found in the Bighorn Basin. Jaws of *Hyracotherium* (or *Eohippus*, the dawn horse) have emerged by the thousands, and its skeletons are more numerous than those of any other mammal. Less common, and found only recently, are skeletons of *Homogalax* and other ancient relatives of the present-day tapirs of South America and Asia. The tapiroids were generally larger than dawn horses, the biggest being sheep-sized. Both *Hyracotherium* and *Homogalax* were well adapted for running, but the tapiroid was more primitive in this regard, suggesting that it more closely resembled the ancestor of all odd-toed ungulates than does *Hyracotherium*. The hind feet of both animals bore just three toes; the front feet had three plus a greatly reduced fourth digit. All the toes were equipped with a small, broad hoof.

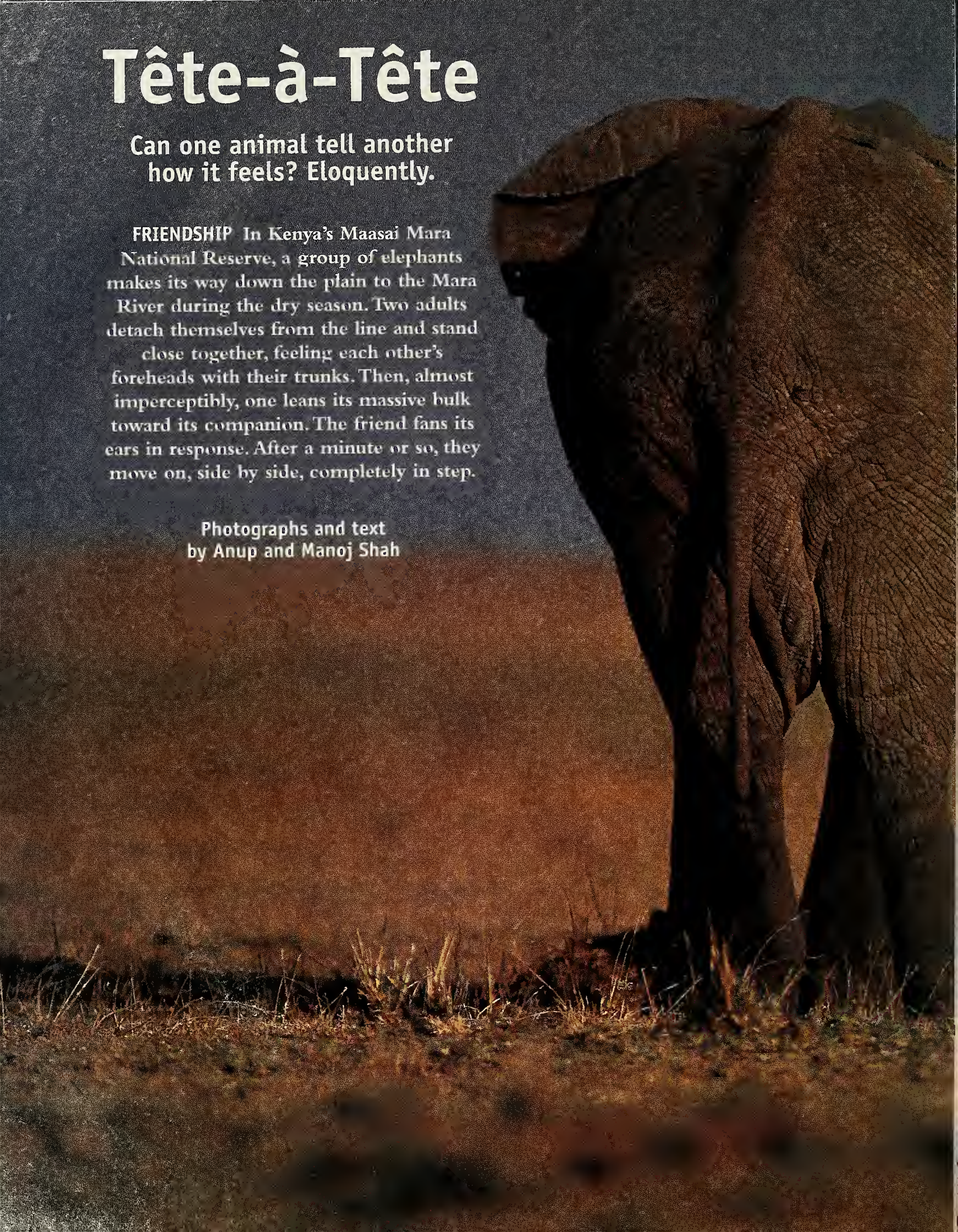
The molars of *Hyracotherium* and *Homogalax* were low-crowned, like those of *Diacodexis*, but had multiple shearing crests, a specialization for processing vegetation. Unlike many of their hoofed descendants, neither they nor any other early Eocene ungulate was a grazer. Grassland habitats were not to become widespread for millions of years. The teeth of early Eocene ungulates lacked the high crowns and elaborate chewing surfaces that allow grazers to grind grasses, which contain abrasive silica. These animals were probably browsers that fed on softer plant material, leaves, and shoots.

Not all the plant eaters in the Bighorn Basin Eocene mammal community were related to present-day ungulates. The most abundant large herbivore was *Coryphodon,* a ponderous, cow-sized member of an extinct group known as pantodonts. Like tapirs and pygmy hippopotamuses today, *Coryphodon* probably preferred wet forests or swamps, where it used its tusklike canines and broad, crested molars to feed on vegetation.

The newcomers that arrived in association with the warming at the end of the Paleocene—especially primates and ungulates—significantly altered the composition of the Bighorn Basin's mammal communities. Paleocene faunas were dominated by what we refer to as archaic mammals: condylarths (archaic ungulates), archaic primates, small rodent-like multituberculates, pantodonts, and others. While all these groups survived into the Eocene, most were substantially reduced in numbers and diversity. The change in mammal life was not only abrupt, it was profound: fossil evidence shows that in the early Eocene, half the individuals in many mammal communities belonged to immigrant species. This faunal turnover at about 55 million years ago took place not just in the Bighorn Basin but across all the northern continents. The results have been long lasting. Even- and odd-toed ungulates are the predominant large mammalian herbivores in most of the world today, and primates populate rainforests from South America to Africa and Asia. One thing seems clear: the immigrations were tied to global warming. But had we been there 55 million years ago, we could hardly have predicted the eventual ecological impact of that warming event. Only through paleontology have we gained the hindsight to appreciate the potential consequences of widespread climate change. ☐

In 1896 vertebrate paleontologist Walter Granger photographed the fossil-rich Wyoming badlands, below.

WALTER GRANGER; AMNH

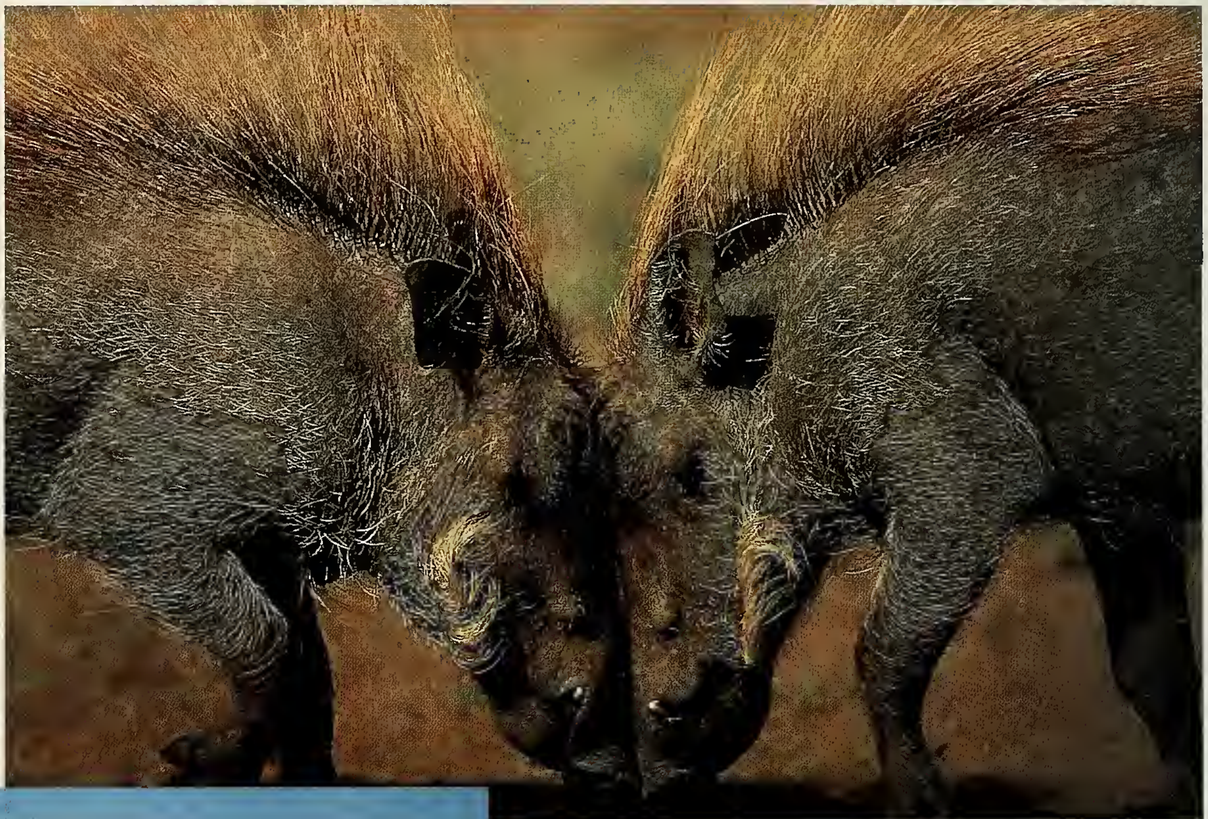


Tête-à-Tête

Can one animal tell another how it feels? Eloquently.

FRIENDSHIP In Kenya's Maasai Mara National Reserve, a group of elephants makes its way down the plain to the Mara River during the dry season. Two adults detach themselves from the line and stand close together, feeling each other's foreheads with their trunks. Then, almost imperceptibly, one leans its massive bulk toward its companion. The friend fans its ears in response. After a minute or so, they move on, side by side, completely in step.

Photographs and text
by Anup and Manoj Shah



RIVALRY At the Musiara swamp in the Maasai Mara, a mated pair of warthogs feed side by side. A solitary male forages nearby. Eventually the female leaves her mate to drink from a small pool of water. The lone boar follows her, but before he reaches the pool, the other male calmly trots over. The two size each other up, then butt heads in what seems like a highly formalized ritual rather than an angry battle. After a few knocks, the intruder turns and runs. A short distance away, he resumes feeding. There are no injuries and no spilled blood, but the female's consort is clearly the winner.

AVIAN AMOUR It is early morning on Paradise Plain in the Maasai Mara National Reserve. Atop a tall acacia tree, two saddle-billed storks begin a courtship ritual. The male spreads his wings and raises one leg. They touch beaks, and the female attempts to clasp the male's beak in hers. Spreading their wings while clasping beaks, they slowly circle each other again and again. Finally the male lands gently on the female's back. Crouching, with wings outstretched, the huge birds mate, then fly away together to a nearby glade.

DANCE OF DOMINANCE A small group of greater flamingoes stands in the shallows of Kenya's alkaline Lake Borgoria, in the Great Rift Valley. Straining the silt by holding their beaks upside down in the water, they feed on cyanobacteria. Suddenly one individual, its back feathers erect as porcupine quills, approaches a larger one to challenge its feeding spot. They go head-to-head in a flamingo flamenco, necks writhing in graceful curves. When the larger bird claims victory by decisively elevating its head above the challenger's, the smaller one concedes and returns to mining its own claim in the mud.

Colonies in Space

By Walter R. Tschinkel

As an entomologist interested in how ants live underground, I have long wished I could see into the earth and examine every detail of their nests and tunnels. The next best thing, I decided, would be to use their nests as a mold for casting these complex living spaces in plaster. To begin the process, I pour orthodontic plaster (which is stronger than plaster of paris) down the entrance burrows and let it penetrate into the farthest recesses of a colony's nest. Then follows the long, laborious process of progressive excavation and reassembly of the resulting casts. The finished and assembled model is like a positive print of a photographic negative, a record of the art that ants have practiced for millions of years. Collectively the diminutive insects create a giant structure, one sand grain or bit of earth at a time—the product of evolved behavioral programs within each tiny worker's brain.

Nest size varies enormously from species to species. Eastern woodlands *Aphaenogaster* ants make twenty-inch-deep nests occupied by a few hundred workers. New World tropical leafcutter ants create colossal underground metropolises, each housing several million workers that tend huge fungus gardens. Every ant species constructs a nest so distinctive that an entomologist can usually tell which one created it.

Florida's coastal plains are ideal for studying the ants' subterranean architecture: the deep, homogeneous sand is a congenial medium both for the ants and for the researcher seeking a permanent record of these ant cities. After practicing on examples of modest size, I decided to tackle the abandoned dwelling of a particularly ambitious nest-building species: the Florida harvester ant. The nest (pictured opposite) contains 135 chambers arranged along four vertical connecting tunnels that total thirty feet in length. Some of the chambers are specialized for food storage; this nest held about a quarter of a million seeds collected by workers for later consumption. The colony that had built and occupied this nest began with a queen that left her home and mated with another colony's male. After digging a narrow, twelve-inch-deep chamber, she sealed herself inside, laid her first few dozen eggs (a single mating provides the queen with a lifetime supply of sperm), and then reared the hatched larvae and pupae with nutrients stored in her body. These pupae emerged as workers, which then reared more workers, and as the colony grew, the ants deepened the nest and added more chambers. A large harvester ant nest may be as deep as ten feet and contain as many as 200 chambers.

Once or twice a year, the colony abandons its home and excavates a new one—a formidable task that in the case of the nest shown here was completed in four or five days by about 5,000 workers. Together they weighed a total of seven-tenths of an ounce and moved forty-four pounds of sand. Within such nests, the living inhabitants arrange themselves more or less according to their stage of life. Larvae and pupae live in the bottom third, where they grow into young adult workers that will care for the brood of eggs and larvae surrounding them. As the workers grow older, they gradually drift upward, changing their occupation from brood care to more general duties, such as transporting seeds and maintaining the food-storage chambers. Later they take up residence near the surface, where they become the colony's defenders and spend the last quarter of their one-to-two-year lives venturing outside to forage for seeds and insects.

In spring the colony breeds some winged males and unmated queens that will, in time, seek mates outside the colony. During their age-related upward migration, the workers become more and more active in excavating chambers to hold the growing population and its food supply, which is why the nest has a top-heavy shape. The ants' social organization helps shape the space in which they live, and the space in turn organizes the colony by providing separate areas and chambers for various activities and functions. Harvester ant colonies thus have four dimensions—the usual three dimensions of space and the vertical dimension of worker age. □

About 5,000 tiny worker ants excavated forty-four pounds of sand in five days.

The author stands next to his 8.5-foot-tall plaster cast of a Florida harvester ant colony's nest.

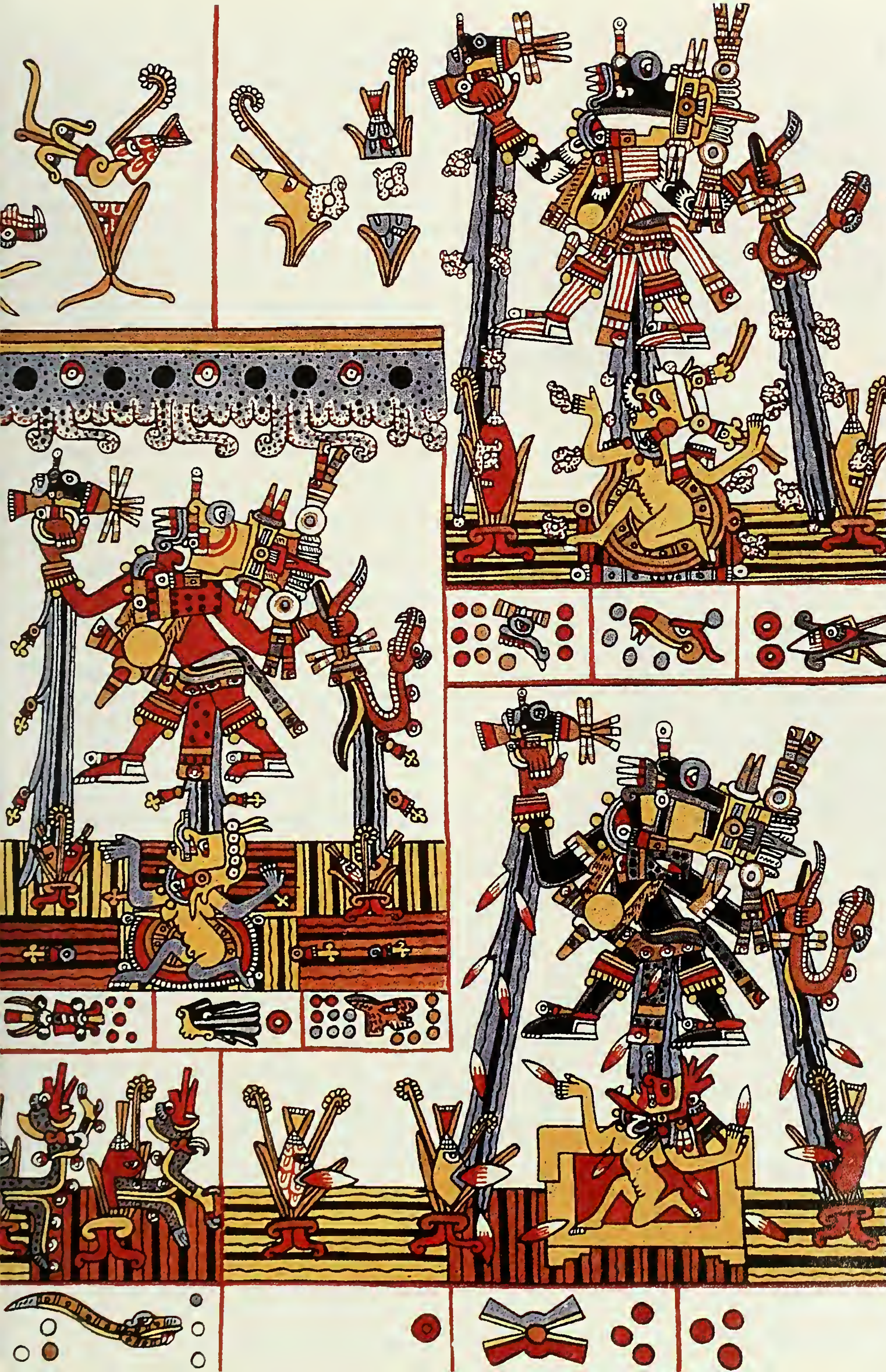
Other Stars Than Ours

Aztec astronomers had their own reasons for sky watching.

By Anthony F. Aveni

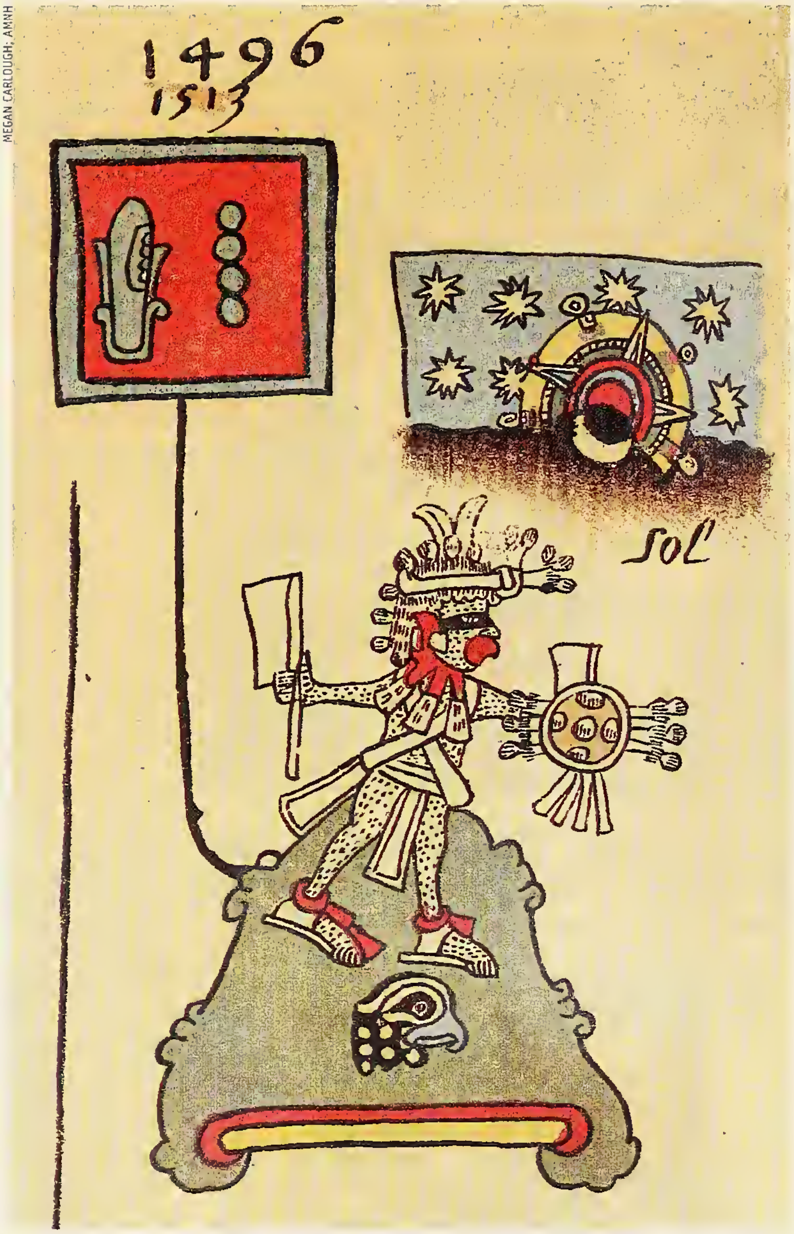
The Aztecs saw in the heavens the sustainers of life—the gods they sought to repay, with the blood of sacrifice, for bringing favorable rains, for keeping the earth from quaking, for spurring them on in battle. Among the gods was Black Tezcatlipoca, who ruled the night from his abode in the north, with its wheel (the Big Dipper). He presided over the cosmic ball court (Gemini) where the gods played a game to set the fate of humankind. He lit the fire sticks (Orion's belt) that brought warmth to the hearth. And at the end of every fifty-two-year calendrical cycle, Black Tezcatlipoca timed the rattlesnake's tail (the Pleiades) so that it passed overhead at midnight—a guarantee that the world would not come to an end but that humanity would be granted another epoch of life. The priests in Tenochtitlan, the Aztec capital, climbed to the top of their sky watchers' temple on the Hill of the Star to witness this auspicious sign. The Aztecs lived their sky, knowing that everything that happened on earth was the outcome of destiny. And they wrote it all down in their books.

Created in the late fifteenth century, the Codex Borgia, a seventy-six-page "screenfold" document of deerskin, is one of a handful of Aztec manuscripts that escaped the Spaniards' book burnings. "Paganism must be torn up by the roots from the hearts of these frail people!" wrote the Dominican friar Diego



Five images of Tlaloc, the god of rain and fertility, dominate the twenty-eighth page of an Aztec almanac known as the Codex Borgia. The old woman below Tlaloc in each panel personifies the maize crop, while the dots and icons along the bottom specify dates for the performance of rituals.

MEGAN CARLOUGH; AMNH



The total or near-total solar eclipse of August 8, 1496, is illustrated (upper right) in the early colonial Codex Telleriano-Remensis. The setting Sun is drawn as a crescent, very much as it may have appeared.

Durán, a sixteenth-century chronicler horrified by such documents, which often included graphic depictions of sacrifice and dismemberment. And in fact, some pages in the Codex Borgia do have illustrations of stabbing and blinding and of blood squirting from a torso with dangling intestines. But this random survivor from Mexico's past is also a mine of impressive information about Aztec astronomy.

Much of the first half of the codex prescribes the performance of "debt payment" rituals, as the sixteenth-century Franciscan priest Bernardino de Sahagún put it. These rituals were to be carried out with reference to a sacred calendar called the *tonalpohualli*, the "count of days." This round of time operated much like the Western calendar's cycling of seven named weekdays in tandem with each month's numbered days (Monday the 1st, Tuesday the 2nd, and so on), except that it cycled twenty signs (representing various animals, plants, and forces of nature) against thirteen numbers. This yielded a sequence of 260 uniquely named days (1 Crocodile, 2 Wind, 3 House, and so on), after which the sequence would begin again. The rest of the Codex Borgia is a pictorial narrative detailing the attributes of supernatural characters—probably patron gods of the ruling Aztec lineage for which the codex was prepared—and the world they inhabited prior to humanity's existence.

Recently I have been delving into certain pages in this little-understood codex—pages that resemble Mayan almanacs, which are well known for their precise prediction of astronomical events. My working hypothesis has been that the dates designated in the Codex Borgia for the performance of rituals were chosen by Aztec prognosticators, who calculated when the heavenly bodies would be in especially auspicious or dangerous positions. If we take just one page in the codex—page 28—as an example, we can begin to see how they put their astronomical expertise to use.

One of the brightest objects in the night sky, Venus commanded the attention of ancient sky watchers, just as it does today.

This page (reproduced at the opening of this article) depicts five similar figures, one for each of the cardinal directions (most likely starting with east at the lower right and running counterclockwise to north, west, and south), along with a central one representing the up-down axis, a standard dimension in Mesoamerican cosmology. The featured player is Tlaloc, the goggle-eyed, long-fanged god of rain and fertility, who appears at the top of each frame in a similar pose but with varied accoutrements. At lower right, for example, the rain he unleashes from each hand is studded with flint knives (hail); at upper right, it carries flowers; at lower left, it is accompanied by wind in the form of Quetzalcoatl, the Feathered Serpent. Absorbing the seasonal punishments and rewards doled out by the forces of nature is the maize crop. In each frame, the maize is personified as an aged female deity, who is shown in a field beneath Tlaloc, flanked by plants bearing ears of corn.

Tlaloc may be the star of the show in another way, because he has a link with Venus. A variety of recent studies of both Mayan and Aztec sculpture, carved inscriptions, and architecture have led to the discovery of a cult known to scholars as the Tlaloc-Venus-War complex, so called because of the imagery worn by its practitioners and the timing of its rites to coincide with particular stations of the planet Venus.

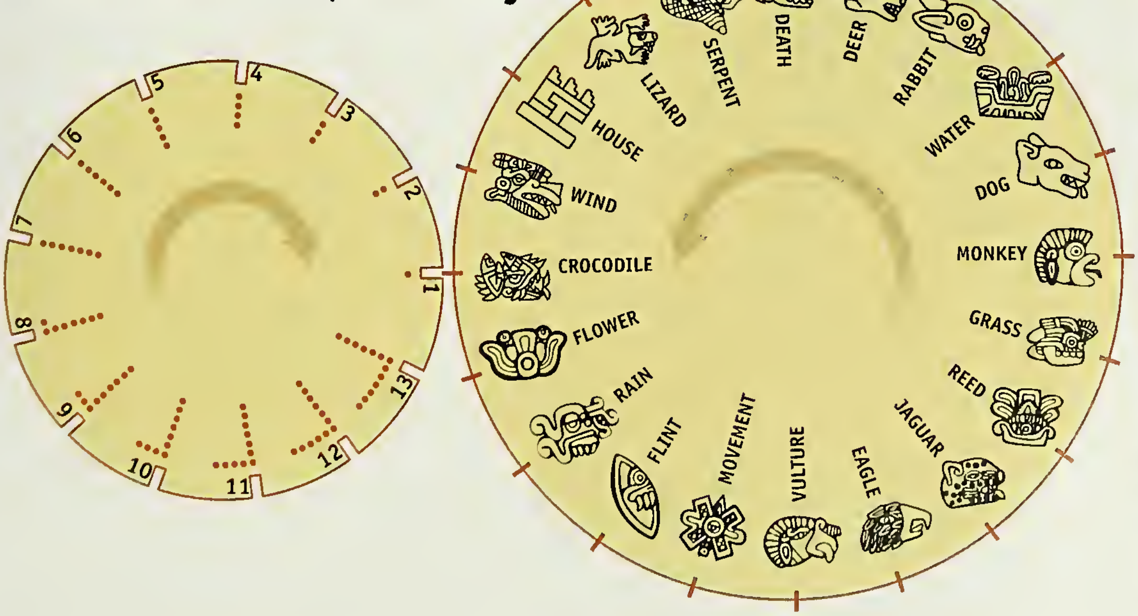
One of the brightest objects in the night sky, Venus commanded the attention of ancient sky watchers, just as it does today. Part of its fascination is that it periodically shifts from appearing as an evening star that sets shortly after sunset to appearing as a morning star that rises just before dawn. Between these manifestations, it disappears from the night sky altogether. All this is a consequence of the fact that the planet's orbit is closer to the Sun than ours is, so that from our point of view Venus seems to move back and forth across the Sun's position. (The reason we sometimes can't see Venus is that it gets so "close" to the Sun that it is lost in the daylight.)

Venus completes its entire appearing-disappearing-reappearing-disappearing act every 583.92 days. Coincidentally, Venus runs through five such cycles in the course of almost exactly eight solar years (a solar year is 365.2422 days). As a consequence, whatever we see Venus doing in the sky on a given date in our calendar, we can expect to see the planet do again, eight years later, on exactly or almost exactly the same day of the same month. For example, Venus begins to appear as a morning star around April 1, 2001, and around April 1, 2009, it will put on a repeat performance. The Aztecs, who had a 365-day calendar by which they measured the solar year, were well aware of this mathematical meshing, which added to Venus's attraction as an astronomical phenomenon.

At the turn of the twentieth century, the visionary German scholar Eduard Seler, who drew on his knowledge of Babylonian astronomical texts, suggested that page 28 in the Codex Borgia may have referred to events in the Venus cycle. He declared himself unable, however, "to discover a law for the days." He was referring to the dates, some of them effaced, that were written along the base of each of the five framed Tlalocs. Fortunately, not only has decipherment of these symbols improved since Seler's time, but high-speed computers now enable us to easily calculate the astronomical events to which ancient dates may correspond.

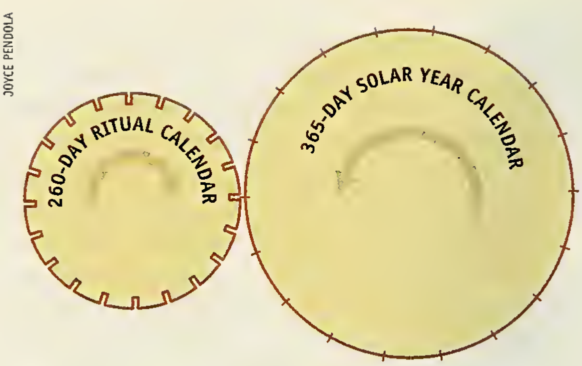
Within each frame, two *tonalpohualli* (ritual calendar) days are specified, as well as a third day that

How to Reckon Time, Aztec Style

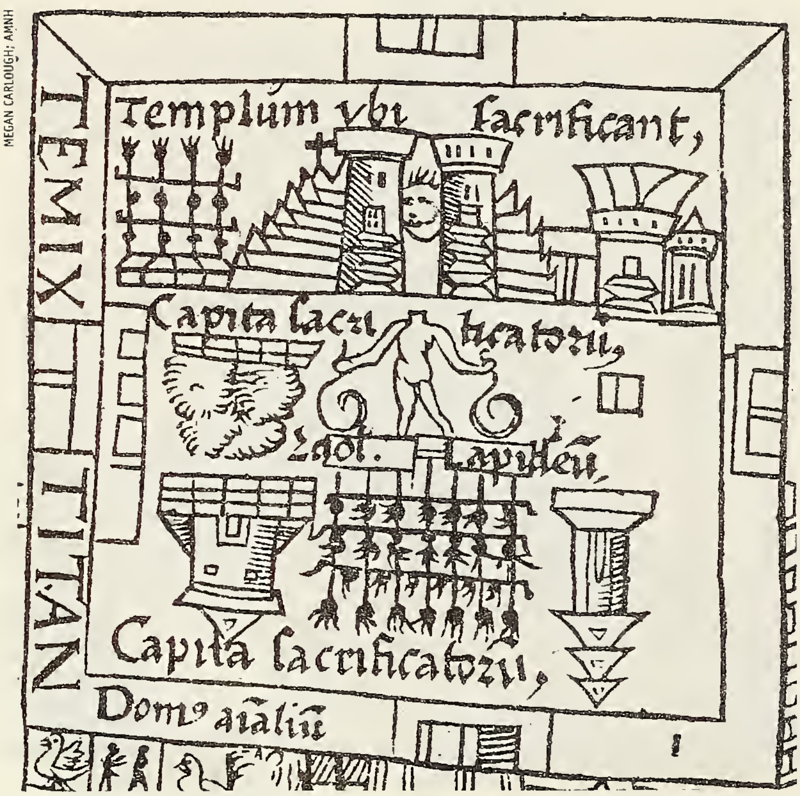


The Aztec ritual calendar consisted of 260 days, each uniquely named by combining a number (from 1 through 13) with one of twenty signs that represented animals or other natural phenomena. The full sequence can be generated by rotating the numbers and signs in the order shown, beginning with 1 Crocodile.

JOYCE PENDOLA



JOYCE PENDOLA



MEGAN CARLOUGH; AMNH

Right: By combining the 260 named days of their ritual calendar with a 365-day solar year calendar, the Aztecs generated a cycle of dates that did not repeat for fifty-two years. Below: A detail of an early-fifteenth-century map shows the Great Pyramid in Tenochtitlan, the Aztec capital city. The Sun is rising between the pyramid's twin temples—an event that marked the spring equinox.

identifies the particular 365-day year in which the two days fall. Inconveniently for us, however, central Mexican calendars provided no long-term running count for the years, as their Classic Mayan counterparts did. Instead they tell us only the sign and number for the 360th day of the year they are referring to. (It's as if we identified 2001 only as "the year Tuesday-the-25th" because in 2001, Christmas falls on a Tuesday.) But this shorthand presented no problem to the Aztecs, since the same *tonalpohualli* day did not coincide again with the 360th day of the year for a long while.

Indeed, exactly how long did it take for a year name to be repeated? One might guess 260 years, since there are that many distinct days in the *tonalpohualli* cycle, with its twenty day signs and thirteen numbers. But when the twenty day signs are rotated in order against 365-day solar years, only four signs happen to fall on the 360th day—Reed, Flint, House, and Rabbit, after which we come back to Reed. These four, cycled against the thirteen numbers, provide fifty-two unique names for years. Thus the year name in which a person was born would not recur before he or she reached the age of fifty-two.

In each frame on page 28 of the codex, one of the day names serves to refer to the year. We can distinguish it because the day sign is superimposed over a sort of trapezoidal symbol, which essentially translates as "this is the year." Deciphering the year names on this page, we get the following: upper right, 2 Flint; upper left, 3 House; center, 5 Reed. Although the year names for the bottom two Tlaloc figures are partly effaced, it's a good guess that we're dealing with a sequence of five consecutive years, beginning at the lower right panel, continuing counterclockwise, and ending at the center: 1 Reed, 2 Flint, 3 House, 4 Rabbit, 5 Reed.

Next we have to determine when this five-year

Using computers, modern astronomers can quickly calculate celestial events that were visible in specific places on particular dates.

sequence falls with respect to our own calendar. From its style alone, we can date the Codex Borgia to sometime between the mid-fifteenth and early sixteenth centuries. Thanks to documents concerning the Spaniards' siege of Tenochtitlan, we know that April 8, 1519, was the first day of an Aztec year and that the name of the year was 1 Reed. This matches the first year in our sequence, so conceivably we are looking at a five-year sequence that ran from April 1519 to April 1524. Or we could drop back one cycle, to March 26, 1467, when 1 Reed also gave its name to a year. Given the approximate dating based on the codex's style, we don't have to look any earlier or later than these two possibilities.

Taking the years and the day names provided for each year, we can identify specific corresponding dates in the Western calendar. Now comes the fun part: testing whether the creators of page 28 intended its colorful scenes to be connected with specific, observable celestial events. Checking for any significant astronomical events that would have fallen on or near the dates in question, I found that the earlier sequence (from late March 1467 to late March 1472) yielded the most candidates. Many of its celestial events involve Venus in some way, such as the planet's first appearance as an evening star or its alignment with other planets visible to the naked eye. Still, not every date provides a perfect match. Those that don't may have referred to celestial observations that the Aztecs deemed more important than we do and that may become apparent to us once we learn more. The Aztecs may even have sought to predict certain meteorological or geological phenomena—earthquakes, volcanic eruptions, hailstorms, or the rare snowfall—that we do not include in the category of astronomical event.

Page 28 of the Codex Borgia is, in effect, one page in an almanac produced by astronomer-calculators to suit a particular time and place of celestial observation. (The adjoining page 27 seems to be a master plan that embraces larger segments of time, suggesting that the almanac as a whole may cover a full fifty-two-year period, from 1467 to 1519.) Each of the dates on page 28 was apparently considered a prime time to schedule a suitable propitiation ritual to Tlaloc, the deity that dominates the images. An important purpose of such rituals seems to have been to bring on needed seasonal rains or to ward off calamities that could befall the maize crop. Four of the dates cluster around mid-May, when the rains begin, a crucial time in the agricultural cycle.

Given the connectedness, for the Aztecs, of fertility, warfare, and Venus, the meaning of this page may run much deeper. The rain-drought cycle in the biosphere, the cycle of kingship in the human sphere, and the periodic motions in the celestial sphere all undergo similar junctures: just as new maize germinates, so does the empire flourish in the presence of the newly "sprouted" ruler, whose conquest and acquisition of tributary states are

On June 6, 1468, sky watchers in Tenochtitlan would have witnessed an alignment of planets and the setting Sun, close to a constellation they called the ball court (Gemini). Aztec astronomers apparently foresaw this event, whose date is listed on page 28 of the Codex Borgia: the year 2 Flint, the day 10 Rain.

RON MILLER; HIEROGLYPHS REPRINTED FROM *THE CODEX BORGIA: A FULL-COLOR RESTORATION*, BY GISELE DÍAZ AND ALAN RODGERS sanctioned in heaven by the wandering of his patron star. These interconnections aren't really that exotic. We should not forget that Western astronomy before the Enlightenment was also driven largely by astrological and religious concerns (even the major Christian holidays were pegged to observable celestial events). Louis XIV proclaimed himself Sun King; more recently, an astrologer was thought to have played a role in Ronald Reagan's conduct of presidential affairs.

Ancient and indigenous peoples created elegant systems for making things comprehensible—not to us but to themselves.

While the Maya have long been credited with prowess in calendrical and astronomical matters, we are now seeing that the upstart Aztecs were also sophisticated in these realms. In fact, it appears that Mesoamerican cultures were much more interrelated than we once thought. The connections extended to their pantheons of gods, with those of the Maya and the Aztecs, like those of the Greeks and Romans, displaying many correspondences.

But perhaps the most important lesson we can derive from the study of Aztec astronomy is that these people simply were not concerned with what seems important to us now. Even the eclipses of the Sun they chose for temporal markers had to fall on special days of the *tonalpohualli;* whether or not these eclipses were spectacular by our criteria mattered less. But these astronomers were precise. For example, if we look at the early- to mid-sixteenth-century manuscript known as the Codex Telleriano-Remensis, we find that an eclipse that took place on the afternoon of August 8, 1496, is depicted just about as it happened, with the still partially eclipsed solar disk plunging into the mountainous horizon west of Tenochtitlan.

Caught up in the theory of progress, we tend to focus on whatever glimmers of modern science we find in ancient or indigenous ways of understanding nature. We see that a certain group discovered an herb containing a curative chemical or recorded the position of the rising Sun at the vernal equinox. And then we lament, Just think what they might have accomplished if they had taken the "right track" and pursued this knowledge more single-mindedly. But we would do better to study how and why these cultures built elegant systems for making the things they observed comprehensible—not to us but to themselves. Other peoples' motives for sky watching may tax our patience and require dredging up subjects that suit neither our tastes nor our prejudices. But our failure to understand these motives will always be our loss. □

Tenochtitlan is recreated in a mural, below, painted by Diego Rivera in 1945 for the National Palace in Mexico City. Opposite page: A mask representing the god Xolotl, possibly associated with the planet Venus as evening star.

SCHALKWIJK; ART RESOURCE, NY

SCALA; ART RESOURCE, NY

WORKING GIRL

For many young girls in Andean Ecuador, life involves labor. For Rosa, the tradition continues—with some adjustments.

Story by Lynn A. Meisch ~ Photographs by Ligia Botero

Above: As a seven-year-old, Rosa made breakfast for her family. Top of page: A drawing from a seventeenth-century volume by Felipe Guaman Poma de Ayala portrays the work expected of a teenage girl during Inca rule.

Rosa was another blessing and another pair of hands when she was born in 1988. Her home was an adobe-and-thatch structure with an attached cooking shed, set on a slope of Taita (Father) Chimborazo, the 20,702-foot snowcapped Andean volcano that dominates Ecuador's Chimborazo Province. Like most of the families living in small mountainside communities nearby, hers scratched a living from *allpa mama* (mother earth) through hard agricultural labor and the sale of surplus barley and potatoes at the weekly market in Riobamba, about fifteen miles away.

By the time Rosa turned five, she was rising at five A.M. to cook and clean for herself, her mother, and two younger brothers. After school she washed clothes; helped her mother plant, weed, and harvest potatoes and other crops; and found time to do homework and to play. She also cared for her youngest brother (the other was making himself useful in the fields). Within a few years, however, Rosa's life, although still governed by the tradition that young indigenous girls are expected to work and help their families, veered from its expected path.

In the Ecuadorean Andes, I have watched a four-year-old girl weed the garden with a baby sibling strapped to her back and I have held my breath as a two-year-old boy carried a knife across the room to his father. Children in these communities are given many responsibilities at an early age, and parents are confident in their sons' and daughters' ability to carry out what are, to us outsiders, dangerous and difficult tasks. Every family member is valuable. "Children bring joy," I've been told. They also contribute to the maintenance of the household.

The Andean concept of childhood as being useful and productive is not of recent origin. When the Inca conquered Ecuador in the fifteenth century, they introduced the Quechua language (which Rosa speaks at home) and imposed a tax system in which payments were made in human labor. *The First New Chronicle and Good Government,* a 1,200-page manuscript written and illustrated by the Andean writer Felipe Guaman Poma de Ayala, portrays life in the Inca empire before and after the

After school, Rosa helped her mother in the potato fields, washed clothes, and took care of her youngest brother.

Most rural schools are poorly equipped. Right: At Rosa's school, each child brought wood for the lunchtime cooking fire. (Rosa is second from left.)

Spanish conquest. Completed in about 1615, the book includes a description of the Inca's division of both males and females into ten categories, based on the capacity for work. Adults in the prime of life were the most important group, not only for reproduction but also for their labor. Adults might spin and weave for the state, maintain roads and bridges, or farm the lands set aside for the benefit of Inca rulers. Some adult males left home to serve in the Inca army or to work on construction projects for a specified time.

According to Inca dictates, girls between the ages of twelve and eighteen—called "short-haired girls"—owed help in many forms to their parents and communities. They were expected to spin and weave, pasture llamas and alpacas, work in the fields, gather firewood, make *chicha* (corn beer), cook, and clean the house. One of Guaman Poma's drawings shows a teenager carrying out three tasks at once: with a load of firewood strapped to her back, she spins while herding llamas (see page 74).

Girls between nine and eleven were called "girls who gather flowers" because they collected flowers and plants for dyeing yarn and also picked edible herbs and plants. They were assigned these tasks, Guaman Poma observed, "so they would not be lazy." Indeed, the Inca's three commandments were "Don't steal, don't lie, don't be lazy"—admonitions repeated in indigenous communities today.

The eighth category consisted of girls between five and nine. These children were called "girls who go about playing," perhaps a misnomer from our point of view, given how much work they did. According to Guaman Poma, "They served their mothers and fathers by bringing firewood and straw for thatching. They began to work, spinning delicate yarn, and collecting aquatic plants, and they helped make *chicha*, care for younger children, and carry infants on their backs." Rosa's early childhood resembled the Andean model in many respects, especially in terms of the amount and kinds of labor she did for her family and the reciprocal relationships of work and caring.

High school was not an option for Rosa. At the age of eleven, she became a maid's assistant in the city of Riobamba.

Anthropologists and historians have long noted that reciprocity, both between humans and between humans and supernatural beings, lies at the core of Andean values. Each summer when I arrive in Ecuador to conduct research, I bring gifts of clothing for my godchildren; they and their parents greet me with gifts of food. During Inca times, humans made offerings to the earth in return for a good harvest. Such offerings are still called "paying the earth." In exchange for their labor tax, communities received food from Inca storehouses in times of famine, and indigenous families whose adult males were away working or fighting for the Inca state were fed at public expense.

Following the Spanish conquest of the Andes, the equation became unbalanced. In 1532 the king of Spain gave Spanish overlords the right to collect labor and tribute from native Andeans in return for Christianizing them, but the Spaniards' obligations did not include feeding the families of those working in Spanish mines, sweatshops, and haciendas (large farms and ranches). Indigenous people in Chimborazo who were unable to meet their tribute or whose

land was expropriated eventually became tied to the region's haciendas in a system of debt servitude that lasted until an agrarian reform in 1964.

A quarter of a century later, only 25 percent of Ecuador's adults were employed full-time, and few of these shared Rosa's ethnic and class background. Rural community schools, where Quechua-speaking children are often taught by Spanish-speaking outsiders, generally impart little more than minimal numeracy and literacy. Because the government provides only the building and the teachers' tiny salaries, while parents must pay for books, school supplies, and uniforms, even primary schooling is out of reach for many families. High school was not an option for Rosa. In any event, she didn't like school.

If Rosa had followed the traditional rural pattern, she would eventually have married a young man from her own or a neighboring community and started a family. But Rosa's life took another direction. With the area where she was raised becoming increasingly impoverished, her mother sent her to work in the city; domestic service has long provided cash employment for some rural girls. In 1999, at the age of eleven, Rosa became a maid's assistant in Riobamba, the largest city in the province.

During the 1990s, a decade plagued by political, economic, and natural disasters, the trickle of people of all ages from the Ecuadorean countryside into the cities became a torrent. Hundreds of thousands of adults left home to look for work in large cities and abroad; tens of thousands of young people like

In 1999 Rosa's family, including her grandmother (second from left) and mother (far right), traveled to Riobamba for her first communion, then took Rosa home for a visit.

Rosa in Riobamba: She has few friends her own age and rarely leaves the house unchaperoned.

Rosa, children really, also migrated to find work. According to Ecuador's National Migration Service, of the country's 12.4 million people, 300,000 emigrated in just the last few months of 1999—many of them illegally. The United States, Italy, and Spain were—and still are—favorite destinations. A *coyote* (smuggler) charges between $5,000 and $10,000 to conduct emigrants on the dangerous overland journey to the United States. Many emigrants leave their children in Ecuador because of

From the pittance she earns, Rosa sends money home to her mother and saves some for herself.

the dangers of the journey. Most do not contemplate a return home until their debt is paid off and some money put aside. Successful migrants work for several years to pay off the debt, then save money to buy a taxicab or start a business if and when they return home, all the while sending remittances to their families. (The pattern of emigration and absentee parenting is so prevalent in Ecuador that the newspaper *Hoy* ran an article this past August on the psychological trauma suffered by children whose parents are abroad.)

In Riobamba, Rosa ended up helping an elderly woman, Mama Cata, to care for the two children of a couple who emigrated to New York City in 1992. These children, now about thirteen and fifteen, barely remember their parents. Mama Cata also has charge of the little girl her own daughter left behind when she emigrated to Spain.

Rosa helps Mama Cata cook, clean, wash clothes by hand, and do other household chores.

She also takes care of Mama Cata's granddaughter. Like the "short-haired girls" of Inca times, Rosa is accomplished and efficient in all the domestic arts. Typically, someone in her position is lucky to earn a dollar a day plus room and board for six and a half to seven days' labor, but *"algo es algo"* ("something is something"). From the pittance she earns, Rosa sends money home to her mother and saves some for herself.

Mama Cata is fond of Rosa, watches her carefully, and sees to her religious education. In 1999, in preparation for her first communion, Rosa attended catechism lessons in the afternoon; it was her only chance to go out unchaperoned. Rosa has no friends her own age and no opportunities to make them. But she hasn't been abandoned by her family. For her first communion, her mother and grandmother, along with some older siblings and other relatives, made the trip to Riobamba. Afterward, Rosa went home with them to the slopes of Taita Chimborazo to celebrate. She had grown so big that her cousins barely recognized her. ☐

Rosa assists with the household chores. She also takes care of Mama Cata's granddaughter.

23. Lindblad Expeditions
Expedition travel by the family that pioneered expedition travel. For information on our worldwide journeys call 1-800-EXPEDITION or www.expeditions.com.

24. Lodge on Little St. Simons Island
Exclusive 10,000-acre Georgia island paradise, private 7 mile pristine beach, natural history tours, birding and recreational activities galore, gourmet regional cuisine and gracious accommodations await just 30 guests.

25. Malta Tourism
English-speaking, hospitable Mediterranean jewel offering 6,000 years of civilization, the highest concentration of landmarks per square mile in the world. 212-695-9320 www.visitmalta.com.

26. Maryland Vacations
Beaches, mountains, big cities, small towns. Maryland has so much to do. Welcome. Call 800-984-9502 for a free Maryland Travel Kit - today!

27. Mexico Tourism
Discover the many moods of Mexico, with its majestic architecture, ancient temples, and flourishing culture. 800-44-MEXICO.

28. New Mexico Department of Tourism
Put yourself in a place where outlaws like Billy the Kid become legends. Put yourself in a State of Enchantment. Free vacation guide: 1-800-SEE NEWMEX (800-733-6396), ext. 1144. www.newmexico.org.

29. North Carolina Outer Banks
Pristine Beaches. History. Fishing. For travel information and Getaway Card good for seasonal values at over 150 business, log onto www.outerbanks.org, call toll-free 800-446-6262 or email visitorinfo@outerbanks.org.

30. Norwegian Coastal Voyage
A Voyage of Discovery. Cruise Norway's breathtaking 1,250-mile coastline - from its majestic fjords to its stunning Arctic landscapes - and explore the picturesque ports and quaint villages en route.

31. Nova Scotia Tourism
Your outdoor vacation begins when you open this guide. Get your FREE 400 page Doers' and Dreamers' Guide. 1-800-565-0000, Op. 46R or exploreNS.com/natural.

32. Pax World Fund Family
Pax World Fund Family, a socially responsible fund group, has offered investors the opportunity to achieve "performance with principles" for over 25 years. 800- 767-1729 www.paxfund.com.

33. Pequot Museum
The Pequot Museum, a tribally owned complex, brings to life the Native American and natural history of New England through extensive permanent exhibits and research libraries. For information call 1-800-411-9671. Located between Norwich & Mystic, CT. Exit 92 off I-95 or exit 79A off I-395.

34. Pocahontas County CVB
Big Mountain Country, Pocahontas County, WV. Home of Snowshoe Mountain, Cass Scenic Railroad and the Greenbrier River Trail. Biking, fishing, outdoor recreation. www.pocahontascountywv.com.

35. Saga Holidays
World leader in the 50+ travel market, providing domestic and international tours and cruises. Send for your free travel planner today.

36. Scottish Tourist Board
Scotland. See ancient castles reminiscent of our rich, tumultuous history. Grand old cities vibrant with culture. Visit us at www.ToScotland.com or call 1-800- 969-SCOT.

37. Songer Whitewater
Combine history, natural beauty and adventure! Raft the new river, the oldest river in the world, or challenge the rapids of the Gauley River.

38. Southern West Virginia CVB
Stay and play in our mountains of fun! America's Best Whitewater, New River Gorge Bridge, Historic sites and museums, caverns, Exhibition Coal Mine, outdoor dramas and more 1-800-VISIT WV. www.VISITWV.org or www.VISITWV.com.

39. Swan Hellenic Cruises
Ocean and sea cruises, expedition and river cruises all with the accent on discovery. Exotic destinations and distinguished guest speakers.

40. Swift Instruments
Quality in optics since 1926. Free brochure displays Swift's complete line of birding and compact binoculars, contains photographs and detailed descriptions with binoculars use chart. On the web at http://www.swift-optics.com.

41. Tamarack
The largest collection of West Virginia crafts, Tamarack offers world-class shopping, events, theater, art gallery and fine dining managed by The Greenbrier. 1-88-TAMARACK and www.tamarackwv.com.

42. TIAA-CREF
TIAA-CREF IRA's - Low expenses and management expertise from the company Morningstar says "sets the standard in the financial services industry" (1/31/01). Call 1-800-842-2776 or visit www.tiaa-cref.org/iras.

43. Tourism Authority of Thailand
For more information, contact your travel agent. Call 1-800-THAILAND or visit www.tourismthailand.org.

44. Tourism New Brunswick
Walk on the ocean floor in New Brunswick, Canada's Bay of Fundy! For your free Vacation Planning Kit visit us online: www.tourismnewbrunswick.ca or call 1-800-561-0123.

45. Tourism Newfoundland and Labrador
Newfoundland and Labrador. We offer our visitors the natural wonders of whales, icebergs and seabirds framed by our dramatic seascape and landscape and unique culture.

46. Toyota and the Environment
Find out about Toyota's environmental breakthroughs, including hybrid technology, electric vehicles and fuel cells.

47. West Virginia State Parks
Escape to the mountain at West Virginia State Parks. Come enjoy scenic splendor, outdoor adventures, historical sites and much more. For more information, call 1-800-CALL WVA or visit us at www.wvparks.com.

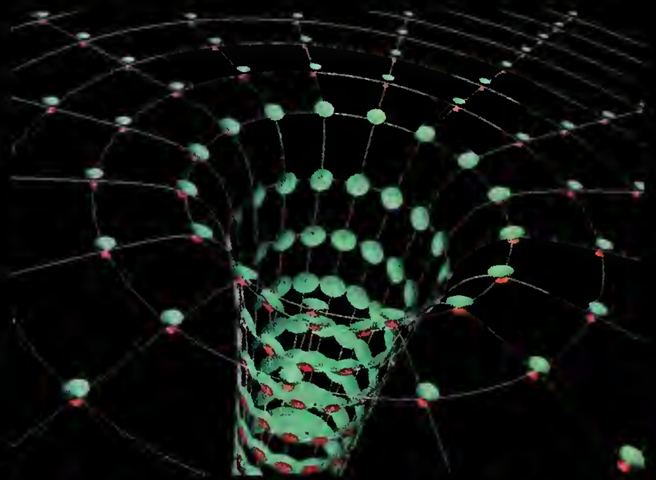
48. West Virginia Tourism
Get your free West Virginia Travel Guide and discover why some say it's Almost Heaven. Visit us at www.state.wv.us/tourism or call 1-800-CALL-WVA.

CELESTIAL EVENTS

Plenty of Nothing

And nothing is plenty for some sky watchers.

By Richard Panek



The gravitational forces in a Schwarzschild black hole are so strong that anything within its radius—even light—cannot escape. (The colored cones represent how light would respond to the intense gravity.)

Devoting a column that's supposed to be about what you can see in the night sky to something you can't see may seem to make no sense. But then, there's a lot about black holes that seems to make no sense—at first.

Although we tend to think of black holes as a purely post-Einsteinian conception, the credit for coming up with the idea belongs to eighteenth-century British geologist and astronomer John Michell, who used Newton's laws to deduce the possibility of what he called a "dark star"—a mass so substantial that not even light can escape its gravitational field. The idea first received widespread attention in French mathematician and astronomer Pierre-Simon de Laplace's wildly popular 1796 book *Exposition du système du monde*. But such speculation didn't begin to assume modern form until 1916, when the German astronomer Karl Schwarzschild seized upon the brand-new notion of relativity to produce his landmark paper "On the Gravitational Field of a Point Mass According to the Einsteinian Theory."

There the matter (or disappearance thereof) rested for the next half century: mathematically possible, even speculatively irresistible, but *real*? In 1967 U.S. physicist John Archibald Wheeler dubbed any such objects (should they exist) black holes, and throughout the 1960s and 1970s theorists worked out models for how these objects might reveal themselves. Since a black hole, by definition, emits no electromagnetic radiation, the only way to find one would be indirectly. This could be done by observing a signature gravitational effect on nearby visible objects or by monitoring through X-ray telescopes the "death scream" of gas that's been heated to millions of degrees as it plunges toward the event horizon—the black hole's ring of no return.

Still, observers remained understandably reluctant to come right out and say that something like Cygnus X-1—a binary star system consisting of one visible star rapidly orbiting one invisible companion that is radiating extraordinary levels of X rays—contained a black hole. As one astronomer said at a press conference on black holes just last summer, "It's taken us this long to convince ourselves they're real."

Not until May 6, 1994, did astronomers identify a black hole with relative certainty. It resided, they said, at the heart of M87, an elliptical galaxy 50 million light-years from Earth and previously best known for an unusual jet emanating from it, the first such extragalactic jet discovered (by American astronomer Heber Curtis in 1918). What convinced them of the existence of a black hole within M87 was the Hubble Space Telescope's detection of gas whipping around the core of the galaxy at 1.1 million miles per hour—meaning, according to their calculations, that whatever was driving this frenzy had to have a mass equivalent to 3 billion Suns. What's more, the mysterious jet, extending a distance of at least 5,000 light-years outside the galaxy, was probably fueled by that mass at M87's center. In the seven years since then, so many black holes have been detected that one astronomer, with only a little irony, has described identifying one as "even mundane."

Astronomers today no longer ask whether individual specimens might exist but how best to think about black holes collectively. A supermassive black hole—one with a mass equaling between 1 million and 3 billion Suns—may perhaps reside at the center of every large galaxy (including our own Milky Way, as observers demonstrated in 1998). Stellar-remnant black holes—those with a mass between three and thirty Suns—might number as many as 100 million per galaxy, including one situated only 1,600 light-years from Earth, as astronomers announced just last year. Stellar-remnant black holes are formed by the collapse of massive stars; as for supermassive black holes, nobody knows where they come from or why they seem to have a mass directly proportional to the size of their host galaxy.

But at least astronomers at long last are beginning to figure out what to ask about black holes, besides the obvious question of what happens to anything that goes into one (see "Universe," October 1995). So what's in all this for a sky watcher? Nothing, at least in terms of something to see. But in terms of something to think about—just as much the point for many amateurs studying the night sky—the answer is, Plenty. If the galaxies in the universe number 125 billion (according to the latest estimates, which are always subject to upward revision), and even if stellar-remnant black holes number "only" 50 million per galaxy, that would bring the universe's black hole population to well over 5 quintillion.

You can use binoculars or a telescope to find M87 in the Virgo cluster of galaxies, on the border between the Virgo and Coma Berenices constellations, which this month will be high in the southeastern sky after nightfall. And if, while you're staring up at the heavens, some neighborhood wit should ask the inevitable "What's up?" you can answer, "Nothing"—and then go on to explain just how much of it there is.

Richard Panek is the author of Seeing and Believing: How the Telescope Opened Our Eyes and Minds to the Heavens *(Penguin, 1999).*

THE SKY IN APRIL

By Joe Rao

Mercury is out of sight almost all month, reaching superior conjunction (and slipping behind the Sun) on April 23. But this quick little planet reappears a week later, just above the northwestern horizon at dusk.

Venus has a busy and interesting month. The brilliant planet was visible both after sunset and before sunrise for a few days beginning March 29, but for most of April, Venus becomes purely a planet of the dawn. It rises about thirty-five minutes before the Sun on the 1st, as seen from 40° north latitude, and by month's end it appears about one and a half hours before sunrise. Seen through a telescope on April 1, its large, thin crescent is 1/30 the apparent diameter of the full Moon but shrinks by nearly a third as the month progresses.

Mars rises within an hour of midnight local time during April. Due to its rapidly intensifying luminosity (magnitude -0.2 on the 1st, reaching -1.0 by the 30th) and its increasingly noticeable fiery color, it is becoming more prominent. This month Mars finally moves close enough to Earth to give observers a real shot at catching some surface features with at least a medium-sized telescope, plus very good viewing conditions, particularly when the planet is high in the southeastern sky toward dawn. Mars will appear above and to the right of the waning gibbous Moon during the morning hours of April 13.

Jupiter is the first "star" to come out at early dusk this month. Look for it in the western sky. It is soon followed by Sirius in the southwest at a similar altitude above the horizon (Jupiter's magnitude is -2.1; Sirius's is -1.4). As the giant planet nears the end of its yearlong apparition (it sinks into the sunset in May), it edges noticeably away from Saturn. By April 16, Jupiter's eastward motion carries it just over 5° north of the reddish giant star Aldebaran, completing a triple conjunction with this star that began last September. A very thin crescent Moon lies well below Jupiter on the evening of the 25th. The planet sets about three hours after twilight's end on April 1 but less than an hour after dusk on the 30th.

Saturn can be found at dusk as a yellowish, zero-magnitude "star" about 30° above the western horizon (the width of your fist held out at arm's length is roughly 10°) and 9° below and to the right of Jupiter at the beginning of April. During this time, the planet sets about three and a half hours after the Sun. But by the end of the month, Saturn stands only about 10° high in the northwestern sky at dusk, setting just ninety minutes after the Sun. A striking array awaits you as darkness falls on the evening of the 25th: the delicate sliver of a two-day-old Moon joins the eye-catching triangle of Jupiter, Saturn, and Aldebaran. Saturn lies several degrees below and to the right of the Moon.

The Moon is at first quarter on April 1 at 6:49 A.M. The full Moon occurs on April 7 at 11:22 P.M., last quarter on April 15 at 11:31 A.M., and the new Moon on April 23 at 11:26 A.M. The Moon returns to first quarter on April 30 at 1:08 P.M.

Unless otherwise noted, all times are given in Eastern Daylight Time.

REVIEW

Short Shrift to Long Life

Living to a very advanced age is unlikely, the authors argue. But are they right?

By Steven N. Austad

FROM *LOVE IN THE 90S: A GRANDDAUGHTER'S PORTRAIT*, BY KERI PICKETT

The Quest for Immortality: Science at the Frontiers of Aging, *by S. Jay Olshansky and Bruce A. Carnes (W. W. Norton, 2001; $25.95)*

Although the dangers of basing predictions of the future on short-term statistical trends are well known, they're sometimes conveniently forgotten. Johns Hopkins University biostatistician Raymond Pearl, one of the grand characters of twentieth-century science, spent much of his career examining the growth trajectories of fruit fly and mouse populations to determine whether there was a universal law of mortality—the logistic curve. Logistic population growth proceeds rapidly at first, then gradually slows to a stop as it comes up against a biological limit. Invoking this "law" in the early 1920s, Pearl predicted that the world's population would reach its limit of 2 billion in the year 2026. In fact, it reached the 6 billion mark in 1999.

Similarly, in their book *The Quest for Immortality: Science at the Frontiers of Aging,* demographers S. Jay Olshansky and Bruce A. Carnes cite another statistical law of mortality, the Gompertz function, which states that the chance of dying doubles every seven or so years after puberty. The authors project that maximum human life expectancy (currently between seventy-five and eighty years in the countries with the best health status) will not exceed eighty-five years anytime soon. They also think we should be glad it won't, because society might collapse under the collective expense of supporting the decrepit and demented elderly. To support this view, and to expose the long and continuing history of human folly in the pursuit of immortality, they have written a delightfully accessible, evolutionarily sensible, and often highly personal book on the history of prospects for human longevity.

Some demographers, believing that the Gompertz pattern has no discernible biological underpinnings, vehemently disagree with Olshansky and Carnes and assert that babies born today can expect to live as long as 100 years. Underlying these contending projections are very different visions of biology and the future of humanity. The Carnes-Olshansky vision is that our bodies are like race cars, exquisitely designed to perform well for a certain time but likely to collapse as the parts—engineered to last only so long—give out one by one at an accelerating rate. So many things go wrong late in life that improved success in treating individual problems doesn't affect average survival all that much. Carnes and Olshansky have calculated, for instance, that eliminating all cancers (responsible for about 25 percent of all U.S. deaths) would increase life expectancy by only about three years. In giving as clear an explanation of the relation between evolution and aging as I have ever come across, they assert the necessity of a collective collapse of parts. They also make an excellent case that given the current state of medical technology, the assumptions necessary to project a 100-year life expectancy defy biological rationality.

But the authors' concentration on the average age at which individuals die can be misleading. Life expectancy anywhere in the world before the past couple of centuries probably never exceeded twenty-five or thirty years. This doesn't mean that an adult was considered elderly at forty or that extreme ages weren't reached—only that infant mortality, which has a disproportionate effect on life expectancy, was very high.

The ancient Egyptians, for instance, understood old age in terms that are easily recognizable today. One pharaoh, Ramses II, probably lived into his nineties.

Aging is not a modern phenomenon. What is modern is the likelihood of living to a very old age. The probability in the United States of any given person's reaching eighty is now double what it was in 1940, but this means that more people than ever before will be leading lives of chronic disability. What we are now adding to our lives is what these authors call manufactured time—that is, life purchased by medical intervention but not necessarily high-quality life. Yet need it be so?

Prolongevists believe that aging and death can be modified right now. All we need to do is swallow supplements, follow a special dietary plan, inject hormones, use certain relaxation techniques. Such beliefs can be traced back at least to early Taoism, in the third century B.C., and their historical development is nicely documented here. One thing common among antiaging therapies, then and now, is the lack of any evidence that they work. My current favorite in this vein (so to speak) is the injection of human growth hormone, the virtues of which have been promoted by Hollywood celebrities and "medical experts." There does exist firm documentation that this hormone can increase muscle mass and decrease body fat (as do exercise and anabolic steroids). The popularity of such injections is particularly ironic, however, given that convincing evidence has accumulated over the past three to four years that in mice, at least, increased growth-hormone levels lead to a shorter life.

As much fun as it is to debunk so-called antiaging therapies, I think Carnes and Olshansky have allowed their delving into this long history of human silliness to make them unduly pessimistic about the capacity of new medical technologies to increase health and life span in the relatively near future. We have already been able to extend life as much as threefold in experimental animals such as the roundworm *Caenorhabditis elegans*. Nearly every month, researchers find new genetic manipulations and synthetic pharmaceuticals that extend life and health by 30 to 50 percent in fruit flies and mice. The cloning technology developed in mammals over the past few years also holds the promise of using our own cells for growing replacement cells, tissues, and even organs.

Taken together, these findings suggest to me that we will soon be making very real progress toward slowing the aging rate in humans. In fact, I believe this firmly enough to have made a bet with Olshansky on the matter. We each put $150 into a trust fund to be invested for the next 150 years. If at that time (2150), someone has lived to at least the age of 150, my heirs will get the accumulated cash. If not, his heirs will get it. That $300, invested today and returning 10 percent per year (about the stock market average for the past seventy years), will turn into almost $500 million. Compared with that miracle of compounding, the development of medical therapies to slow human aging seems almost child's play.

Steven N. Austad is a professor of zoology at the University of Idaho and the author of Why We Age: What Science Is Discovering About the Body's Journey Through Life *(John Wiley & Sons, 1997).*

nature.net

Gigalopolis

By Robert Anderson

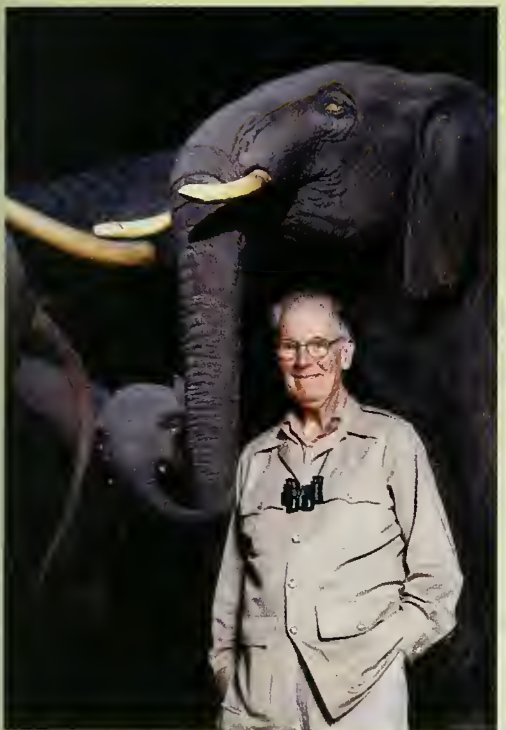
I have always enjoyed time-lapse photography—you know, flowers opening, seeds sprouting, clouds racing across the sky as the sun arcs toward the western horizon. By distorting time, these films seem magical, allowing us to see what before we could only imagine. And as a result, we often gain a new understanding. Project Gigalopolis, a joint effort of the University of California at Santa Barbara and the U.S. Geological Survey (www.ncgia.ucsb.edu/projects/gig/ncgia.html) is a prime example. It seeks to document the explosive growth of our cities in recent years. This is an important task, given the project's assertion that "urban settlements and their connectivity will be the dominant driver of global change during the twenty-first century."

To view some of the group's first efforts, click on "Urban Growth Animations." You can see cities and towns in San Francisco's Bay Area gobble up undeveloped land and merge, or you can watch Washington, D.C., spread far beyond the beltway and fuse with Baltimore. For decades, urban growth was slow and had little impact on the surrounding environment. Then suddenly in the 1950s, things began to accelerate—perhaps due to the combination of booming populations, a national campaign of highway building, faster cars, and cheap gasoline. Now cities and their suburbs are poised to consume rural lands that not long ago were considered well beyond their reach.

Project Gigalopolis plans to use its model to predict the expansion of the urban areas around New York City, Chicago-Milwaukee, Philadelphia-Wilmington, Portland-Vancouver, and elsewhere. Those of us who have grown up near any of these cities are well aware of the tremendous growth, but only this sort of time-lapse animation can give us a real sense of what we have lost and what the future may hold.

Robert Anderson is a freelance science writer living in Los Angeles.

Join The Museum Adventure and Provide for Your Retirement



World traveler Everett Hoffman's stories of his adventures are filled with curious children, roving wildlife, sultry afternoons and African dictator's cronies. These days his adventurous spirit has led him to the AMNH and the research expeditions of its scientists to every continent of the globe.

In fact, he is so impressed with this facet of the Museum's mission that he has established the Everett Hoffman Endowed Fund for Research Expeditions. He recently set up this fund with a Charitable Gift Annuity and will supplement it with a future bequest.

A Gift Annuity is a way to support the Museum and provide lifetime income to one or two people. When low-yield stock is used to fund the plan, capital gains tax is avoided.

Says Mr. Hoffman, *"Creating a Gift Annuity was easy, and since I don't travel myself anymore, the endowed fund is a way to send surrogate travelers in my place while helping the Museum's research mission. At the same time, I get a check every three months for my own use."*

Here are sample rates and benefits for one person with a $10,000 gift:

Age	Annuity Rate	Income Tax Deduction	Annuity Payment
65	7.0%	$3,721	$700
70	7.5%	$4,080	$750
75	8.2%	$4,460	$820
80	9.2%	$4,884	$920
85	10.5%	$5,334	$1,050
90	12.0%	$5,807	$1,200

For more information, please call (800) 453-5734 or reply by mail to: Office of Planned Giving, American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024-5192

Please send information on:

- ◯ Gifts that provide lifetime income.
- ◯ Bequests to the Museum in my will.
- ◯ I have already included a provision for the Museum in my estate plans.

American Museum of Natural History

Name:

Address:

Telephone Home: Office:

My (our) birth date(s) is (are):

Your reply is confidential and implies no obligation.

4/01

BOOKSHELF

The Universe Unveiled: Instruments and Images Through History, *edited by Bruce Stephenson, Marvin Bolt, and Anna Felicity Friedman (Adler Planetarium & Astronomy Museum/Cambridge University Press, 2000; $29.95)*
Since the late fifteenth century, humans have been devising elegant and innovative technologies for measuring and mapping Earth, navigating, keeping time, and observing the heavens.

The Little Ice Age: How Climate Made History 1300–1850, by Brian Fagan *(Basic Books/Perseus, 2001; $26)*
While documenting the rapid climate shift known as the little ice age, archaeologist Fagan traces its effects on history and human experience, from the demise of Viking colonies in Greenland to the Irish potato famine.

The Ghosts of Evolution: Nonsensical Fruit, Missing Partners, and Other Ecological Anachronisms, *by Connie Barlow (Basic Books/Perseus, 2001; $26)*
Barlow examines the idea of "missing partners" in nature, focusing on the many fruits that evolved their adaptive features during millions of years of association with the great mammals that fed on them. Most of these so-called megafauna went extinct 13,000 years ago, leaving the plants behind as anachronistic survivors in today's world.

No Apparent Danger: The True Story of Volcanic Disaster at Galeras and Nevado del Ruiz, *by Victoria Bruce (HarperCollins, 2001; $26)*
Surviving Galeras, *by Stanley Williams and Fen Montaigne (Houghton Mifflin, 2001; $25)*
Linking the disastrous events of two recent eruptions in southern Colombia, Bruce, a science reporter, describes the harrowing ordeal of those who experienced the disasters firsthand and survived. Williams, leader of a volcanological expedition to Galeras during the 1993 blowout, recounts his own close encounter with death. Both stories create a framework for exploring modern volcanology.

Birthplace of the Winds: Storming Alaska's Islands of Fire and Ice, *by Jon Bowermaster (National Geographic Books, 2001; $26)*
Bowermaster writes about a twenty-five-day kayaking expedition in the Aleutians (the island chain off Alaska designated a Biosphere Reserve by UNESCO) and produces an informative account of a largely unknown area, volcanically active and extraordinarily rich in fauna.

From Ellis Island to JFK: New York's Two Great Waves of Immigration, *by Nancy Foner (Yale University Press/Russell Sage Foundation, 2000; $29.95)*
By comparing factors such as race, gender, ties to the home country, and the role of education, anthropologist Foner contrasts New York City's immigrant experience at the beginning of the 1900s with the second influx at century's end. Today's immigrants from the Dominican Republic, Mexico, Jamaica, and China are again changing the face of the city.

On Fertile Ground: A Natural History of Human Reproduction, *by Peter T. Ellison (Harvard University Press, 2001; $27.95)*
As an anthropologist viewing human reproduction from multiple perspectives—anthropology, ecology, and evolutionary biology—Ellison answers such questions as why human birth is so difficult, why females menstruate, and why males mature later than females.

The books mentioned are usually available in the Museum Shop or via the Museum's Web site, www.amnh.org.

PHOTOGRAPHY

Places of Power: The Aesthetics of Technology, *by John Sexton (Ventana Editions, 2000; $60)*

EXPLORER GUIDE

AT THE MUSEUM

Mount Vesuvius, 1944

AP/WORLD WIDE PHOTOS

Upwardly Mobile

A Museum scientist analyzes what's inside volcanoes to predict how high they'll blow.

By Henry S. F. Cooper Jr.

In the Gottesman Hall of Planet Earth is a ten-foot, grayish black cube: a cast of part of a debris flow from Mount Vesuvius that helped bury Pompeii in A.D. 79. Pieces of real rocks that stuck to the latex mold provide the cast with an authentic veneer, and missing bits have been painted in. At the bottom are the remains of a brick column crushed by the weight of the volcanic material.

DENIS FINNIN; AMNH

James Webster with the Museum's cast of a Vesuvius debris flow

"It's the stuff that buried the bodies found at Pompeii," says James Webster, a geochemist interested in volcanoes and a curator of earth and planetary sciences in the Museum's Division of Physical Sciences. "The level where the pillar is, is the same layer where the bodies were found. The interpretation is that the eruption, which had been going on for several hours, seemed to calm down, and the people who had left returned to their homes to collect their belongings. Then flow upon flow of pyroclastic [violently ejected] material came pouring down the side of Vesuvius."

Webster collected many of the volcanic rocks displayed in the Hall of Planet Earth. His research may lead to ways of predicting which of the world's 500 to 600 active volcanoes will produce the most explosive eruptions. Clearly the citizens of Pompeii would have appreciated some advance warning of these catastrophic events. So would the neighbors of Indonesia's Mount Tambora in 1815 and Krakatoa in 1883 and those of the Philippines' Mount Pinatubo in 1991, as well as the more than 20,000 Colombians killed by a lahar (a mudflow of hot volcanic material) when Colombia's Mount Ruiz erupted in 1985.

In his laboratory on the Museum's fourth floor, Webster shows me a large blue vessel capable of reproducing the temperatures and pressures corresponding to depths inside Earth where magmas form in the crust and upper mantle. The two-week experiment going on behind the tightly closed hatch has just started. It involves heating and squeezing powdered rock from a lava flow; gauges on the wall indicate that the current pressure is 30,000 pounds per square inch (equivalent to the pressure four and a half miles down) and that the temperature is about 1,000° C. Webster is trying to remelt the rock particles to measure the concentration of one of the flow's volatiles, sulfur. Volatiles—the water and dissolved gases in magma—are what drive eruptions, propelling the molten material upward and eventually out.

Despite the miniature volcano seething inside the pressure vessel, the laboratory is a quiet place for a talk. Some geologists, Webster tells me, are attempting to predict eruptions by measuring seismic waves (a method that has achieved some success, particularly at Kilauea in Hawaii), while others measure the volatiles released from volcanoes. Webster tries to measure volatiles in the magma *before* an eruption. The most common ones—and those that provide the most explosive force—are water and carbon dioxide. Depending on the composition of the magmas, however, smaller quantities of sulfur, chlorine, and fluorine, as well as traces of nitrogen, hydrogen, and carbon monoxide, may also be involved.

The deeper the magma, the greater the pressure and the greater the quantity of volatiles that will be dissolved in it. As magma rises, the pressure decreases and the volatiles increasingly turn to vapor, pushing the magma onward and upward with ever increasing force. The richer the magma is in dissolved volatiles, the faster they are released as gases and the more explosive the eruption. The problem with looking for volatiles in the original melt is that by the time magmas reach the surface, cool into solid lava flows, and find their way into Webster's machine, the rocks have lost their volatiles. It's a little like looking for carbon dioxide in flat ginger ale. As the lava cools and crystallizes, however, crystals that measure between half a millimeter and tens of millimeters in diameter can retain droplets of "melt," or still-molten volcanic glass. The melt hardens as glass inclusions in the lava, trapping the volatiles inside what amount to tiny enclosed bottles and providing the scientists who open them with a measurable source.

One result of discovering this source has been to allow geochemists to take a closer look at the role of some of the less abundant volatiles. "We used to look at the rocks, and when we saw they didn't have much chlorine, we assumed that chlorine was not important," says Webster. "But over the last decade, looking at the melt inclusions, we find higher abundances of chlorine in many cases. One of the things we've been doing at the Museum in the last ten years is looking at the behavior of chlorine-rich magmas, and we've been focusing on volcanoes around the world that have higher chlorine contents."

What drives a volcano's explosive force? Ordinary water and carbon dioxide, with a touch of sulfur and chlorine.

In particular, Webster and Museum colleague Federica Raia, together with Benedetto DeVivo, of the University of Naples, have been looking at lavas from Somma-Vesuvius (Mount Somma is an older cone that forms a summit and ridge partly encircling Vesuvius). Over the past 25,000 years, Somma-Vesuvius has erupted dozens of times, but only seven or eight of these eruptions have been as catastrophic as the one that buried Pompeii. "We have been looking at melt inclusions in these magmas that date from 3,500 to 14,000 years ago, which is when we believe the break between Somma and Vesuvius occurred," Webster says. "What we have found is that the most highly explosive eruptions—the ones that bury communities and cause the greatest loss of life—show very different ratios of sulfur to chlorine in their melt inclusions and therefore in the magma." He is quick to add that other factors, such as the strength of the rock surrounding the magma, are important too.

Every volcano is different, of course. But Webster and his associates continue to gather data suggesting that an increase of sulfur relative to chlorine in the inclusions could well indicate that an explosive eruption might be in the works at Vesuvius—and possibly elsewhere. Why the ratio of chlorine to sulfur is a factor, however, is not understood.

Another feature of volatiles in magma is that they attach themselves to a number of metals, determining which metals a particular magma will carry along and deposit in underground pipes, veins, and cracks. "So in studying how these hot gases drive volcanic eruptions, one can also see how they concentrate metals like gold and silver and tin and molybdenum," Webster says. In fact, when he first joined the staff of the Museum in 1990, two years after receiving his doctorate from Arizona State University, his research focused on ore and mineral deposits and their transport underground via the same volatiles that make magmas upwardly mobile.

As Webster tells it, "My grandfather, my father's father, was a miner, so whenever we went to visit him in Georgia—and later in Dutchess County, New York—I would go off with Grandpa to the marble or limestone quarries. What was really neat was that in pockets in the rock I could find crystals. He got me started with rocks and minerals, and I've been hooked ever since."

Henry S. F. Cooper Jr., a former staff writer for the New Yorker, *has been visiting the Museum since he was four years old, when his father sat him in a cavity of the Willamette meteorite.*

MUSEUM EVENTS

APRIL 2

John Burroughs Association literary awards luncheon. Winner of this year's book award: *Swampwalker's Journal: A Wetlands Year,* by David M. Carroll (Houghton Mifflin, 1999). 12:00 noon. For information and reservations, call (212) 769-5169.

Lecture: "Supermassive Black Holes, Quasars, and Their Galaxy Hosts" (Frontiers in Astrophysics series). Astronomer Richard Green. 7:30 P.M., Space Theater, Hayden Planetarium.

APRIL 3

Lecture: "Dinosaur Imagery: The Science of Lost Worlds and Jurassic Art." Collector John Lanzendorf. 7:00 P.M., Kaufmann Theater.

APRIL 4, 5, AND 6

Symposium: "Conservation Genetics in the Age of Genomics." Keynote address by author and activist Jeremy Rifkin, April 4, 7:00 P.M. Scientific presentations April 5–6, 9:00 A.M.–5:30 P.M. Sponsored by the Museum's Center for Biodiversity and Conservation and the Bronx Zoo–based Wildlife Conservation Society. Call (212) 769-5200 or visit research.amnh.org/biodiversity/.

APRIL 12

Lecture: "Redwood Logs, Rubber Ducks, and Loggerheads: What Can Sea Turtles Teach Us About the Ocean?" (Earthwatch at the Museum series). Herpetologist Wallace Nichols. 7:00 P.M., Kaufmann Theater.

APRIL 17

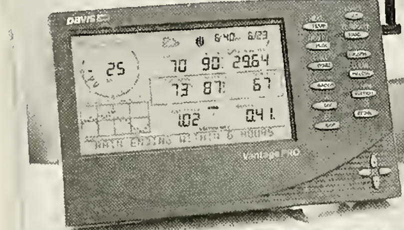
Lecture: "Avoiding a Planet of Weeds: Environmentalism and Democracy in the Twenty-First Century." Journalist Mark Dowie and environmental lawyer William Shutkin. 7:00 P.M., Kaufmann Theater.

APRIL 19

Lecture: "Putting Species Back Into Human Evolution: Why Should Our Evolution Be Different From Other

GIRAUD FOSTER AND NORMAN BARKER

Ammonite fossil, from "Ancient Microworlds," an exhibition of fifty photographs by Giraud Foster and Norman Barker. Akeley Gallery, April 28–September 9.




Animals'?" Physical anthropologist and Museum research associate Jeffrey H. Schwartz. 7:00 P.M., Kaufmann Theater.

APRIL 19 AND 26

Two lectures: "Along the Silk Road," Karen Kane, manager of Museum teaching and learning, April 19; "Ocean Life: A Changing Ecology," senior Museum instructor Lisa Breslof, April 26 (Thursday Afternoons at the Museum series). 3:00 P.M., Linder Theater.

APRIL 23

Lecture: "Atom: An Odyssey From the Big Bang to Life on Earth and Beyond" (Distinguished Authors in Astronomy series). Physicist Lawrence Krauss. 7:30 P.M., Space Theater, Hayden Planetarium.

DURING APRIL

Asian Pacific American Heritage celebration. Free weekend programs (except April 14–15), including films, lectures, performances, and workshops. 1:00–5:00 P.M., Leonhardt People Center. Call (212) 769-5315.

For the Hayden Planetarium course schedule, call (212) 769-5200. For information on field trips and workshops for adults and children, inside and outside the Museum, call (212) 769-5200.

Films at the IMAX Theater: *Shackleton's Antarctic Adventure* (the dramatic story of the 1914–17 British Imperial Trans-Antarctic Expedition) and *Ocean Oasis* (the biodiversity of the Baja California peninsula).

The American Museum of Natural History is located at Central Park West and 79th Street in New York City. For listings of events, exhibitions, and hours, call (212) 769-5100 or visit the Museum's Web site at www.amnh.org. Space Show tickets, retail products, and Museum memberships are also available online.

THE NATURAL MOMENT

Photograph by Mike Severns

Coral Stables

Horses are sometimes confined to corrals, but Bargibant's, or pygmy, seahorses are confined to corals—in fact, to a particular genus of gorgonian coral called *Muricella,* found in Southeast Asia, Indonesia, and Australia. A relative of the pipefish, this tiny seahorse *(Hippocampus bargibanti),* when full grown, is the size of a pinky fingernail. It spends its adult life with its tail wrapped around the coral's branches, waiting to ambush tiny crustaceans and larvae that drift near enough to be sucked up. With its numerous pink and red tubercles, the pygmy seahorse blends so perfectly with its host that the species was not discovered until 1970, when a zoologist noticed that several were clinging to a *Muricella* in an aquarium.

Like most seahorse species, *H. bargibanti* is monogamous, and couples spend most of their time together. When they mate, they lock together face-to-face, and the female transfers her eggs into the male's abdominal pouch. Within a few weeks, the male grows visibly pregnant. (This pair, with pregnant father at right, was photographed at a depth of 140 feet, off the coast of Indonesia's Komodo Island.) The embryos hatch in his pouch and are brooded there. While male seahorses of larger species may brood as many as a thousand embryos in their pouches, the male pygmy seahorse carries only one or two. As soon as they are expelled from the pouch, the young are on their own.

—*Richard Milner*

actual size

ENDPAPER

What We Do Best

By Vaclav Smil

What makes us human? A large brain, an upright stride, coherent speech, shared cultures? All of these, of course, and something else. Something that does not command as much admiration as high encephalization, bipedal locomotion, symbolic language, or intergenerational transmission of mores and taboos. The trait that I have in mind is something most people would not even think about listing as truly special, yet we do it better than any organism alive. And having just moved, temporarily, from Canada to tropical China, I have to rely on it heavily to make it through a day. I'm talking about sweat.


Simon Karori, Kenyan long-distance runner

YANN ARTHUS-BERTRAND; CORBIS

I perspire a great deal. Since I dislike air conditioners, I have to depend on my internal thermostat, which tries to keep the body's core temperature from rising as the outside air climbs above 86° F. As long as I sit still, my body's initial thermoregulatory adjustment consists of dilating peripheral blood vessels and shifting additional blood from internal to superficial veins. But as I climb up a steep hill to my apartment—although it seems to me I am crawling, compared with my usual Canadian pace—and as my skin temperature approaches 95° F, I begin to sweat. Not a great deal at first, because I haven't been here long enough to be fully acclimatized. But if I keep climbing, I will lose water at a rate of more than fourteen ounces per square yard of skin (that is, about a cup every twenty minutes). Per unit of skin area, this is about four times more than a horse and nearly twice as much as a camel, two of the most profuse perspirers among mammals.

But even such a rate of cooling, corresponding to a power input of about 500 watts, is not always enough to cool me. During strenuous activity, most fit people will consume energy at ten to fifteen times the rate they do while resting, and they may need to dispose of 600 to 800 watts of heat. For topflight athletes, the rate of energy consumption during exercise can increase up to twenty-five-fold. To avoid overheating, these individuals must dispose of heat at rates exceeding 1,300 watts, and they will perspire about two quarts of water every hour. Fortunately, such high water losses do not require instant replenishment: healthy individuals are not harmed if they can make up their water deficit within the next twelve to twenty-four hours.

Our genes have conserved the sweating capacity we acquired on the seared grasslands of Africa, but for those of us coming from northern climes, it takes a while to turn the flow fully on. Even a fit Englishman trying to run farther than six miles the day after flying from London to Singapore is flirting with dangerously high core temperatures and with heartbeats approaching normally tolerable maxima. But if he keeps exercising moderately, he may start matching the sweating rates of acclimatized locals in just ten days. That, of course, is how all those Scottish laddies, who grew up never enduring a hot day, could sail away and build an immense tropical empire for the Queen.

Many centuries ago, the Tarahumara of northern Mexico took turns running down deer in the middle of the day. Unable to match the Indians' enviable capacity for keeping themselves cool, the animals died of heat prostration. The Kalahari's Basarwa hunted duikers, gemsbok, and zebras the same way, and perhaps some Australian Aborigines simply "thermoshocked" kangaroos. After a week's adjustment, I plan to deploy my sweating capacity in running a sixty-two-mile trail in several segments. As the trail shifts from sea level to more than 3,000 feet, and then down and up again, I will find myself having to use that very human, and truly lifesaving, ability to outsweat every other species.

Vaclav Smil teaches at the University of Manitoba's geography department. His most recent books, both published by MIT Press, are Energies: An Illustrated Guide to the Biosphere and Civilization *(2000) and* Feeding the World: A Challenge for the Twenty-First Century *(2000).*

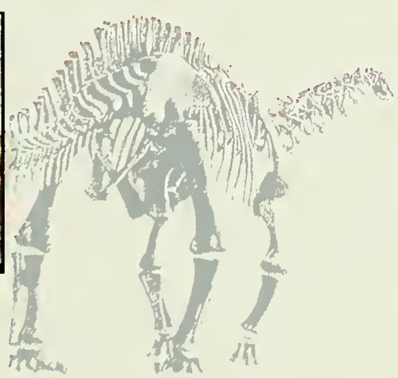
AMERICAN MUSEUM OF NATURAL HISTORY

EXPEDITIONS THROUGHOUT THE WORLD WITH DISTINGUISHED SCIENTISTS AND EDUCATORS

2001 FAMILY PROGRAMS

Discovery Tour's Family Programs were created to engage, enrich, and delight an audience of parents, grandparents, and children. Traveling in the company of Museum scientists and special lecturers, participants of every age learn firsthand about the natural history, cultures, and even the prehistory of the regions we visit. Throughout these itineraries, however, the focus remains the family...experiencing together the excitement of shared discovery and understanding in places of great beauty, antiquity, and scientific importance.

EXPLORE THE WORLD ON A Discovery TOUR



Visit our website at www.discoverytour.org

JUNE 2001

China for Families: Beijing, Xi'an, Yangtze River, and Shanghai
JUNE 19 – JULY 3, 2001
$5,990 – $6,390** Includes int'l airfare from selected cities.

Wildlife of the Galapagos Islands: A Family Adventure Aboard the Santa Cruz
JUNE 30 – JULY 10, 2001
$3,280 – $5,790

JULY 2001

Family Dinosaur Discovery: In the Grand Valley of the Colorado River
JULY 7 – 13, 2001
$1,745 – $2,650

Voyage to the Lands of Gods and Heroes: A Journey to the Ancient Mediterranean Aboard the Clelia II
JULY 23 – AUGUST 4, 2001
$3,745 – $10,645

AUGUST 2001

Tuscany: A Summer Family Adventure
AUGUST 10 – 18, 2001
$3,750 – $5,290

Family Alaska Expedition: Aboard the Wilderness Adventurer
AUGUST 14 – 21, 2001
$2,790 – $4,890

Family Dinosaur Discovery: In the Grand Valley of the Colorado River
AUGUST 18 – 24, 2001
$1,745 – $2,650

DECEMBER 2001

Nepal: A Himalayan Family Adventure
DECEMBER 20, 2001 – JANUARY 3, 2002
$4,490 – $4,690

To request our 2001 catalog call: 800-462-8687 or 212-769-5700 fax: 212-769-5755
Please mention ad code **NHF0501**