

NATIONAL GEOGRAPHIC



Our Coasts in Crisis 60

Rome's Basement 88

Dance Across America 104

The Downside of Upright 126

Blackbeard's Shipwreck 146

Panda, Inc.



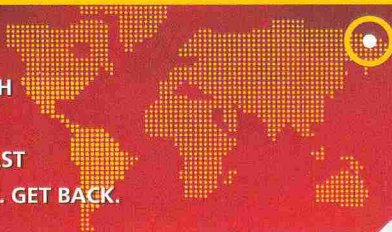
It's people like Evgeniy Darovskikh and the more than 285,000 employees worldwide who give DHL unrivaled local knowledge. Our fleet of 76,000 land, air and sea vehicles in over 220 countries and territories makes it possible to cover the globe and meet deadlines every day. It's the spirit of can do and the experience of know how. It's the people who go all the way to get the job done. www.dhl.com

>> EVGENIY DAROVSKIKH

>> DHL COURIER

REGION: RUSSIAN FAR EAST

ASSIGNMENT: GET THERE. GET BACK.



OUR PEOPLE GO TO THE ENDS OF THE EARTH FOR YOU.
EVGENIY DAROVSKIKH GOES THREE TIMES A WEEK.



ALL THE WAY **DHL**

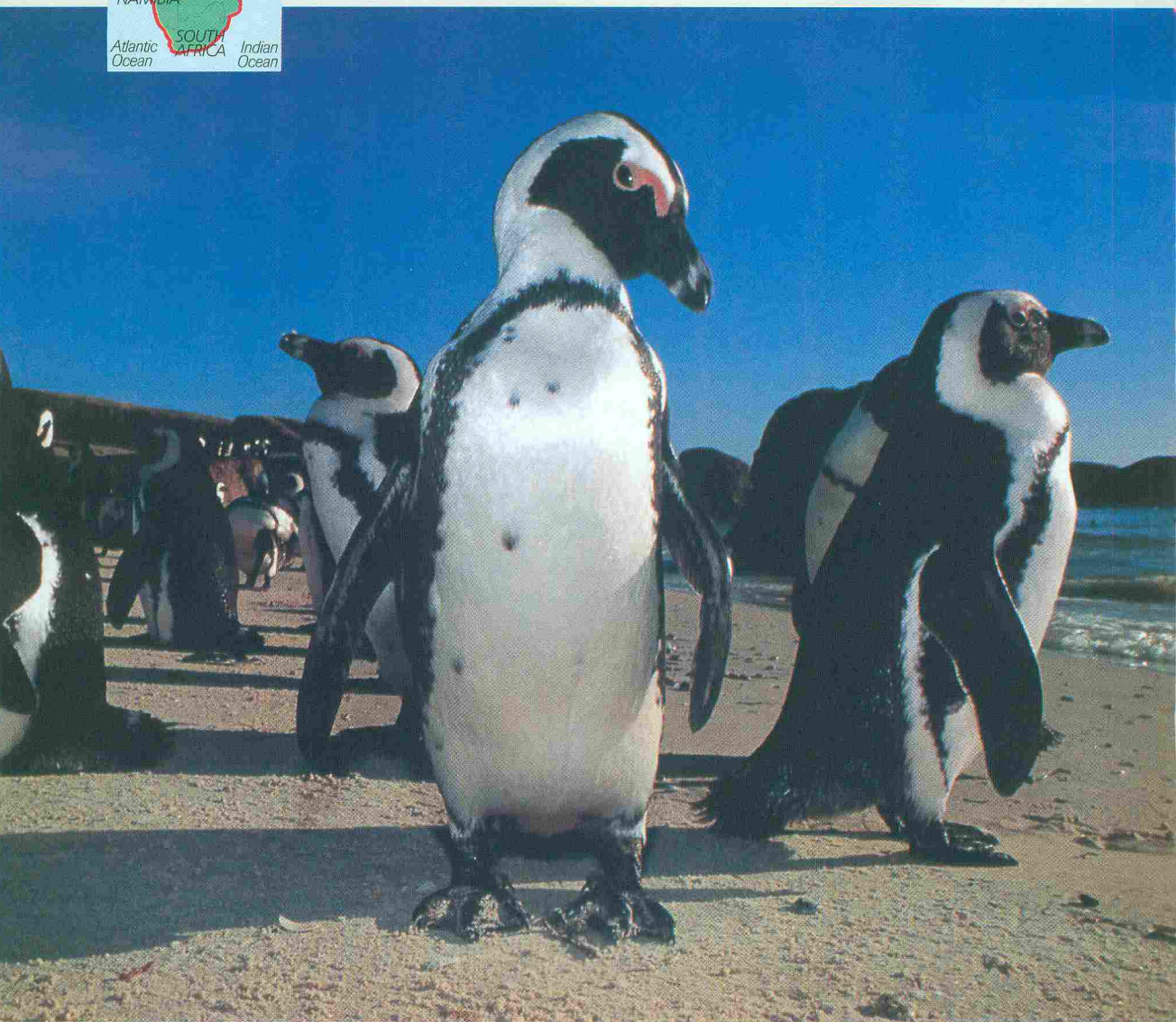




African Penguin (*Spheniscus demersus*)

Size: Length, 60-70 cm **Weight:** 2.1-3.7 kg **Habitat:** Breeds at 24 islands and three mainland sites between Hollamsbird Island, Namibia, and Bird Island, South Africa

Surviving number: Estimated at 180,000



Photographed by Nigel J. Dennis

WILDLIFE AS CANON SEES IT

Sun, sand...and penguins? The African penguin has adapted to warm weather and even, in some cases, the proximity of beach-loving humans. It beats the heat by confining activities to dawn and dusk and spending the hottest hours in the water. This isn't always possible when incubating eggs or caring for vulnerable young, so families take shelter from the sun in nests. Historically, these nests were burrows dug into a cap of guano built up over many generations; but these

droppings are also prized by humans, mainly as fertilizer, and much has been removed. The paucity of adequate shelter, food shortages and predation are all problems for the fast-dwindling bird.

As an active, committed global corporation, we join worldwide efforts to promote awareness of endangered species. Just one way we are working to make the world a better place—today and tomorrow. Visit ngm.com/canonwildlife to find out more.

Canon

NATIONAL GEOGRAPHIC

JULY 2006 • VOL. 210 • NO. 1

Prelude to the Dance

San Francisco ballerina Laurel Keen, a member of Alonzo King's LINES Ballet, stretches deeply during a rehearsal.



BRIAN LANKER

Features

- Panda, Inc.** 42 What's black and white and adored all over—and can cost a zoo more than three million dollars a year?

BY LYNNE WARREN

PHOTOGRAPHS BY MICHAEL NICHOLS AND FRITZ HOFFMANN

- Land on the Edge** 60 America's coastlines are in danger of being loved to death.
BY JOEL K. BOURNE, JR. PHOTOGRAPHS BY TYRONE TURNER

- Rome's Basement** 88 Sloshing through sewers and crawling down long-lost passages, urban adventurers investigate the mysteries of an ancient city.
BY PAUL BENNETT PHOTOGRAPHS BY STEPHEN L. ALVAREZ

- Dance Across America** 104 From ballet to break-dance, from the hora to hip-hop, this country stays moving on the dance floor.
BY CATHY NEWMAN PHOTOGRAPHS BY BRIAN LANKER

- Downside of Upright** 126 All those aching backs may be trying to tell us something: It's part of the price we pay for walking on two legs.
BY JENNIFER ACKERMAN PHOTOGRAPHS BY CARY WOLINSKY

- Blackbeard's Shipwreck** 146 Archaeologists search a North Carolina wreck for clues to the ruthless man behind the heartless pirate.
BY JOEL K. BOURNE, JR. PHOTOGRAPHS BY ROBERT CLARK

COVER Panda mother Mei Xiang cuddles her baby, Tai Shan, at the National Zoo in Washington, D.C. **PHOTO BY MICHAEL NICHOLS**

© Cover printed on recycled-content paper



VISIONS OF EARTH

WILDLIFE

FAMILY OF MAN

EXPEDITIONS

GEOGRAPHY

SPACE

FOSSILS

SCIENCE

VOICES

Departments

Namib Desert, Namibia
Crystal River, Florida
Manhattan, New York

Vanishing Hedgehogs

Wrestlers

Hunt for the Tallest Tree

World's Travelers

Africa's New Eye on the Sky

Butterfly Jewels

Suspended Animation

BY JOEL ACHENBACH

Remembering Peter Benchley

BY DAVID DOUBILET

Miscellany

EDITOR'S NOTE

LETTERS

YOUR SHOT

PHOTO JOURNAL

INSIDE GEOGRAPHIC

FLASHBACK

On the Web

ngm.com/0607

Blackbeard's Shipwreck

Manipulate a 360-degree view of a cannon from this fearsome pirate's ship, zoom in on a photomosaic of the wreck site, and browse an online-only photo gallery with tips from photographer Robert Clark.

Dance Across America

Experience some of the sights and sounds of U.S. dance halls and studios in a multimedia show.

Fun Stuff

Visit Fun Stuff to find free panda wallpaper and postcards. Then vote on your favorite image for the August cover of NATIONAL GEOGRAPHIC in Match Wits.

Member Services

Subscriptions

To order a subscription to NATIONAL GEOGRAPHIC magazine, give a gift membership, or change address, contact Customer Service online at ngmservice.com, or call 1-800-NGS-LINE (647-5463). Hearing-impaired TDD users may call 1-800-548-9797. Outside the U.S. and Canada call +1-813-979-6845.

Customer Service

Write to:
National Geographic
PO Box 63001
Tampa, FL 33663-3001

Online Index

For an online index of all National Geographic publications go to: nationalgeographic.com/publications.

Shopping

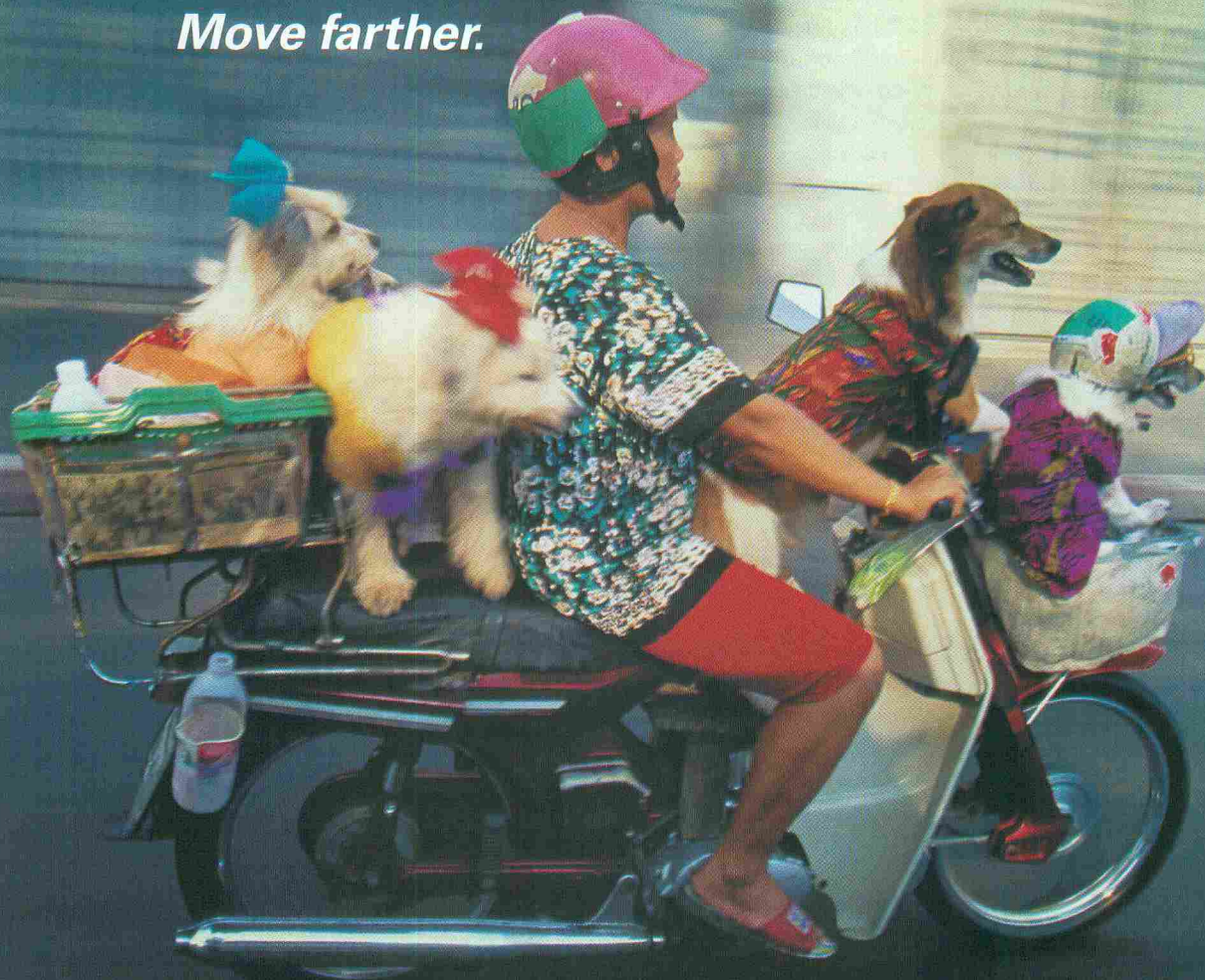
For National Geographic products go to: shopng.com or call 1-888-225-5647.

Mailing List

We occasionally make a mailing list available to carefully screened companies whose services may be of interest to National Geographic Society members. To remove your

name from this list, email ngsline@customersvc.com. U.S. and Canadian customers call 1-800-NGS-LINE (647-5463). International customers call +1-813-979-6845. Or write: National Geographic Society, PO Box 63005, Tampa, FL 33663-3005. Please include address label from the magazine wrapper.

Move farther.



New experiences keep us young and maintain our sense of wonder. Only by travelling can we explore the many cultures and people that make up the world we live in. Move farther with Cathay Pacific to over 90 destinations worldwide. You never know what you'll see until you're there.



Asia Miles



Airline of the Year 2006

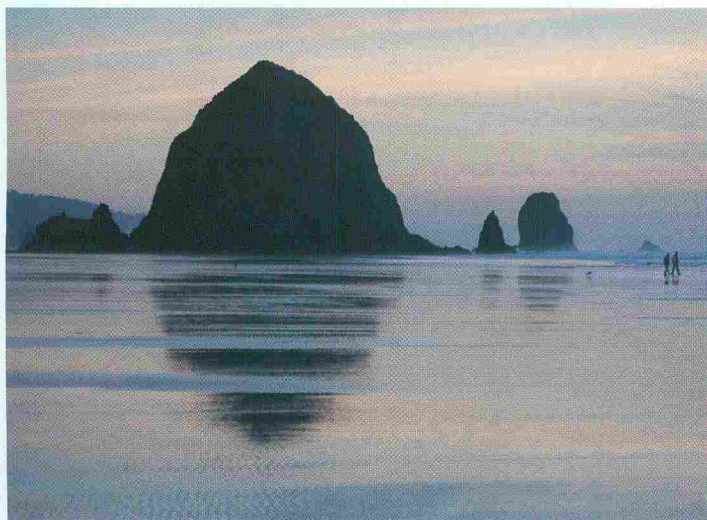


CATHAY PACIFIC

Now you're really flying

"Airline of the Year 2006" awarded by Air Transport World, the leading global aviation journal.

My special place has the magic of a fairy tale. A road winds through a tulip field and turns west through a forest of twisted evergreens. Wind whistles through fir needles, sculpting trees, bushes, and everything else in its path. The forest smells damp and mossy. In a clearing, a cabin perches on a high bluff overlooking the Pacific. The view is as spectacular as the weather is unpredictable; it changes from fog to sunshine to rain in minutes. A rickety stairway twists down to a beach scattered with driftwood. The water is freezing, but compelling. My mother yells,



Sunset on the Oregon coast.

"Don't go out too far, you'll be swept out to sea." My cousin Harold and I ignore her. We are running free.

This story does not have a happy ending. To my family's dismay, my grandfather sold our southern Oregon beach retreat. Heartbroken, I stayed away from the spot. Ten years later, I returned. The special place had been discovered by others. The tulip field had become a trailer park; the dark forest of fir trees had been replaced by an opulent, sprawling house. I took a long walk on the same stretch of sand where I'd played as a kid. The wind howled. Fog rolled in. I kicked off my shoes, ran through the icy water, and faced the fact that I am not the only one drawn to the beach. As this month's article reports, we are loving our coasts to death.

PHOTO: TYRONE TURNER

CHRIS JOHNS, *Editor in Chief*

Victoria Pope, *Managing Editor*

Dennis R. Dimick, *Executive Editor*

Bill Marr, *Executive Editor*

Carolyn White, *Executive Editor*

Robert L. Booth, *Associate Editor*

SENIOR EDITORS

Tim Appenzeller, *Science*

Don Belt, *Geography & World Affairs*

Bill Douthitt, *Story Development*

John A. Echave, *Research Grants*

Ken Geiger, *Technology*

David Griffin, *Photography*

Valerie A. May, *New Media*

Peter Miller, *Expeditions*

Kathy Moran, *Natural History*

Oliver Payne, *Manuscripts*

Lesley B. Rogers, *Research*

Christopher P. Sloan, *Graphics*

David C. Whitmore, *Design & Typography*

Margaret G. Zackowitz, *Departments*

TEXT

Assistant Editors: Alan Mairson, Peter L. Porteous,

Jane Vessels. **Text Editors:** Lynn Addison, Karen M.

Kostyal, Glenn Oeland, Barbara Paulsen, Jennifer

Reek. **Senior Writers:** Joel K. Bourne, Jr., John L. Eliot,

Jennifer S. Holland, Karen E. Lange, Cathy Newman,

Tom O'Neill, Cliff Tarpy, A. R. Williams. **Writers:** Chris

Carroll, Peter Gwin, Carol Kaufmann, Michael Klesius,

Cate Lineberry, Neil Shea, Lynne Warren. **Departments:**

Whitney Dangerfield, Siobhan Roth. **New Media:**

Cassandra Franklin-Barbajosa, *Senior Writer*

PHOTOGRAPHY

Susan A. Smith, *Deputy Director. Photo Editors:*

Bert L. Fox, Todd James, Elizabeth Krist, Sarah Leen,

Kurt F. Mutchler, Sadie Quarrier, Susan Welchman.

Photographers: William Albert Allard, Jodi Cobb,

Michael Nichols, Mark Thiessen. **Photo Engineering:**

Lawrence B. Maurer, Joseph S. Stancampiano

DESIGN AND GRAPHICS

Design Editors: Robert Gray, *Deputy Director;*

Elaine H. Bradley, Beth L. Rakouskas. **Designers:**

Betty Clayman-DeAtley, Joanna Foucheux, Oliver R.

Uberti; Cinde Reichard, *Production. Maps:* William E.

McNulty, *Director. Art:* Jeffrey L. Osborn, *Deputy*

Director; Charles L. Floyd, Christopher A. Klein,

Joshua Korenblat. **Infographics:** Brenna Maloney,

Juan Velasco. **Art Research:** Patricia B. Kellogg,

Director; Ellie Boettinger, Ann R. Perry

RESEARCH

David Brindley, *Deputy Director;* Abigail A. Tipton,

Asst. Director. Research Editors: Victoria C. Ducheneaux,

Alice J. Dunn, Kathy B. Maher, Mary McPeak, Heidi

Schultz, David W. Wooddell, Barbara L. Wyckoff.

Senior Researchers: Nora Gallagher, Mary Jennings

Luger, Marisa J. Larson, Elizabeth Snodgrass, Christy

Ullrich. **Researchers:** Karen C. Courtneage, Emily

Krieger, Nancie Majkowski, David A. O'Connor, Taryn

Salinas, Brad Scriber, Shelley Sperry

EDITORIAL SERVICES

Administration: Marisa Domeyko, *Staff;* Mark

Feldman, *Finance;* Carol Dumont Kerby, *Scheduling;*

Brian E. Strauss, *Electronic Publishing;* Karen Dufort

Sligh, *Asst. to the Editor in Chief;* Sandra M. Dane,

Ewart Ignacio, Caroline Wallinger. **Communications:**

Mary Jeanne Jacobsen, *Vice President;* Barbara S.

Moffet, Heather Riley. **Correspondence:** Joseph M.

Blanton, Jr., *Director;* Carol Stroud, Lisa Walker.

Image Collection: Maura A. Mulvihill, *Vice President;*

William D. Perry, *Sales;* Carolyn J. Harrison, John A.

Rutter. **Libraries and Information Services:** Susan Fifer

Canby, *Vice President;* Renee Braden, Ellen D. Briscoe,

Barbara P. Ferry, Anne Marie Houppert, Ann E. Hubbs,

Karen Huffman. **New Media:** Lisa Hungness, *General*

Manager. Travel: Cristine E. Ghilani, *Director*

PRODUCTION SERVICES

Hans H. Wegner, *Vice President. Digital Imaging:*

Thomas J. Craig, *Director;* Clayton R. Burneston,

Phillip E. Plude, Bernard G. Quarick. **Distribution:**

Michael Swarr, *Director. Engraving:* George Bounelis,

Director; William D. Reicherts. **Printing:** Joseph M.

Anderson, Luz Garcia, Edward J. Holland. **Quality:**

Ronald E. Williamson, *Director*

MAGAZINE PUBLISHING

Advertising: Stephen P. Giannetti, *Vice President*

and Group Publisher; Claudia Malley, *Vice President*

and U.S. Publisher. International: Declan Moore,

National Advertising Directors: Jerry Brennan,

Western; John Patten, *Eastern. Directors:* Ron

Bottomff, *West Coast Sales;* Suzanne McKeon,

Marketing; Margaret Robertson, *Business and*

Operations. Managers: Bob Amberg, *Southeast;*

John Iavarone, *Detroit. Circulation:* Terry Day,

Vice President. Directors: Elizabeth M. Safford,

North America; John A. Seeley, *International.*

Member Services: Christina C. Alberghini, *Director*



At the heart of the image

LAUNCHED



Armed with remarkable image processing technology, and brilliantly balanced with an easy-to-use interface. The new D200, loaded with 10 megapixel power and superior shooting capabilities, will precisely execute your every command.

The D200's professional list of features include a 10 effective megapixel DX Format CCD for high quality images, a newly developed 11-area AF system for exceptional sharpness, our Creative Lighting System providing the ultimate in lighting control, Ultra-High speed 5fps continuous shooting to capture fleeting moments, and a magnesium alloy body for the perfect blend of durability, weight, and feel.

NIKON HONG KONG LTD.
Website: www.nikon.com.hk
Tel: (852) 2882-3536 Fax: (852) 2504-5689

NIKON SINGAPORE PTE LTD.
Website: www.nikon.com.sg
Tel: (65) 6559-3618 Fax: (65) 6559-3671

NIKON (MALAYSIA) SDN BHD (Co. No. 531447-K)
Website: www.nikonmalaysia.com.my
Tel: (603) 7876-3887 Fax: (603) 7876-3387

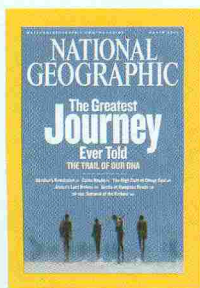
NIKON IMAGING (CHINA) SALES CO., LTD.
Website: www.nikon.com.cn
Tel: (86) 21 6340-5188 Fax: (86) 21 6340-5066

DIGITAL SLR CAMERA

D200

<http://nikonimaging.com>

LETTERS



March 2006 *One story in each issue usually draws the most letters. This month, however, comments were spread among four: "Human Journey," "Celtic Realm," "The High Cost of Cheap Coal," and the ZIP USA story on Houston, Texas. Some readers made connections between stories, such as noting the economic disparity between West Virginia and Houston.*

✦ Voice opinions about July stories at ngm.com.

Human Journey

The perspective that our genes give us on how humans came to populate the world is, no doubt, one of the great perks of living now. How cool that, as products of this 200,000-year-long story, we are the first to see a global outline of the plot! There's a real gift of wonder that comes from being reminded that we are part of this great human story.

GRANT YOUNG
Washington, D.C.

In the article, three boys represent three countries: one a Brazilian Indian, Brazil's indigenous inhabitants; another a boy depicting traits associated with Mongolia. The third boy does not represent the indigenous population of the United States. Shouldn't an American Indian boy be depicted?

MARIA PAULA FERREIRA
Lisbon, Portugal

The photos were meant to illustrate the diversity of people around the world, not indigenous populations.

The Genographic Project is very important, and I am glad National Geographic is sponsoring it. Personally I was fascinated by the report I received about my origin based on the DNA cheek swab. It confirmed many family stories.

JOHN DAVIS
Richardson, Texas

Celtic Realm

So much of worldwide culture has been enriched by the Celts, through music, writing, a sense of egalitarianism, and an emphasis on justice. It is thrilling to see those characteristics being lifted up from the dust of history!

M. VINCE TURNER
Boston, Massachusetts

Perhaps the greatest legacy of Celtic culture lies in North America. Between 1700 and 1800, one of the largest immigrant groups coming to America was the Scotch-Irish. Indeed these peoples formed the frontier culture, which became the foundation of folk culture in the South and in portions of the Midwest and the far West.

MIKE MAFFETT
Atlanta, Georgia

The naked revelers in your article do not represent the Celtic tradition of these islands. They are followers of the New Age movement, who have hijacked Celtic customs and created their own identity that has more in common with the hippies of the 1960s. True Celtic traditions, by contrast, are kept alive by many ordinary people who retain the music, stories, and languages of their ancestors despite the pressures of the modern world.

MICHAEL SHERLOCK
Limerick, Ireland

It is one thing to portray partially clad people of a remote tribe in the midst of their daily routine. It's quite another to show us nearly naked people who normally wear complete outfits. Even if those folks happen to be painted red, why do we need to see them nude?

ANDREA J. GLADSTONE
Roseville, California

How delightfully appropriate—and convincing—to follow your article on our common genetic beginnings with a photo of the modern Celtic primitives with torches celebrating the pagan arrival of summer.

WILSON STRAND
Centerville, South Dakota

High Cost of Cheap Coal

Coal isn't so cheap when you factor in the devastating strip-mining, dangerous coal mines, leveled mountains, air and water pollution, and global warming. Too few are talking about conservation as a low-cost alternative. Compact fluorescent lights, energy-efficient appliances, and common sense behaviors like turning off computers when we're not using

Write, email, fax

Write

National Geographic Magazine
PO Box 98199
Washington, DC 20090-8199

Email

ngsforum@nationalgeographic.com

Fax

202-828-5460

Include name, address, and daytime telephone. Letters may be edited for clarity and length.

them will help us kick the coal habit. If we don't get sustainable soon, we're likely to go the way of the dinosaurs found in the very coal we're burning.

RICH THOMPSON TUCKER
Dorset, Vermont

Your stories reflect a doomsday mentality. Wouldn't it be better if the states involved come up with a comprehensive plan that also provides for the welfare of those impacted by the mining operations? I know the region well enough to know that when the coal is gone, there is nothing left but a cinder region of poverty and discomfort. If the people could see viable and comfortable futures, then possibly the resistance now exhibited would go away.

ROBERT GIBSON
Aurora, Illinois

Recent mine accidents, not only in this country but worldwide, demonstrate the cost in human life of this vocation. Unfortunately, it has been passed down from one generation to the next, ensuring, for the most part, poverty, poor health, and a shorter life span.

NELSON MARANS
Silver Spring, Maryland

Were I not a proud member of the coal mining industry, I would have skipped these lopsided articles altogether. Fact: Coal was, is, and will continue to be fundamentally necessary in the production and mass distribution of this magazine. John Mitchell hopefully realized that his readers rely on ample coal-powered electricity in every facet of daily living.

STEVEN R. LEWIS
Cedaredge, Colorado

As an underground coal miner, I know firsthand the company approach on environment and safety. The scheme is that there will always be a fresh line of employees because of good pay and benefits coupled with the lack of alternative jobs. The plan for the environment is that whatever happens, the company can stonewall the wreckage under "act of God" with litigation that will last longer than the population. The attitude has not varied after numerous deaths underground and aboveground through the air that we breathe.

FRED ROCK PRIESTER
Farmington, West Virginia

We in West Virginia who make our living from coal have seen the generosity of the coal companies. Why don't you ask Kanawha County residents about the Friends of Coal soccer complex, or students who work in or around the mines and earn money to go to college? Dig a little deeper into what coal does for West Virginia. Do some research on the hard-working coal miner who gets up before daylight and puts in ten- to twelve-hour days to provide energy for America.

TIM BELLAMY
Beckley, West Virginia

ZIP USA: Houston, Texas

While it is hypocritical to condemn coal mining while enjoying the benefits of the power it creates, I cannot help but wonder: If the residents of zip 77019 had to float their gondolas in the "toxic soup" (page 111) that the children of Rawl, West Virginia, drink, how quickly things would change.

DARREN WARD
Salt Lake City, Utah



"FOR THE INCREASE AND
DIFFUSION OF GEOGRAPHIC
KNOWLEDGE"

The National Geographic Society is chartered in Washington, D.C., as a nonprofit scientific and educational organization. Since 1888 the Society has supported more than 8,000 explorations and research projects, adding to knowledge of earth, sea, and sky.

JOHN M. FAHEY, JR., *President and CEO*

EXECUTIVE VICE PRESIDENTS

Terrence B. Adamson
Linda Berkeley, *President, Enterprises*
Terry D. Garcia, *Mission Programs*
John Q. Griffin, *President, Magazine Group*
Nina D. Hoffman, *President, Books and School Publishing Group*
Christopher A. Liedel, *CEO*

BOARD OF TRUSTEES

Gilbert M. Grosvenor, *Chairman*
Reg Murphy, *Vice Chairman*
Joan Abrahamson, Michael R. Bonsignore, Martha E. Church, Roger A. Enrico, John M. Fahey, Jr., Daniel S. Goldin, John Jay Iselin, James C. Kautz, J. Willard Marriott, Jr., Floretta Dukes McKenzie, George Muñoz, Patrick F. Noonan, Nathaniel P. Reed, Rozanne L. Ridgway, James R. Sasser, B. Francis Saul II, Gerd Schulte-Hillen

TRUSTEES EMERITUS

Joe L. Allbritton, William L. Allen, Thomas E. Bolger, Frank Borman, Lewis M. Branscomb, Robert L. Breeden, Michael Collins, Lloyd H. Elliott, George M. Elsey, Mrs. Lyndon B. Johnson, William K. Reilly, Robert C. Seamans, Jr.

COUNCIL OF ADVISORS

Roger A. Enrico, *Chairman*
Darlene T. Anderson, Michael R. Bonsignore, Howard G. Buffett, Craig D. Campbell, Jean N. Case, Juliet C. Folger, Robert B. Haas, Robert A. Hefner III, David H. Koch, Bruce L. Ludwig, Sally Engelhard Pingree, W. Russell Ramsey, Catherine B. Reynolds, Edward P. Roski, Jr., Victoria P. Sant, B. Francis Saul II, Michele Sofisti, Ted Waitt, Garry A. Weber, Tracy R. Wolstencroft

RESEARCH AND EXPLORATION COMMITTEE

Peter H. Raven, *Chairman*
John M. Francis, *Vice Chairman*
Martha E. Church, Steven M. Colman, Scott V. Edwards, Philip Gingerich, William L. Graf, Nancy Knowlton, Dan M. Martin, Scott E. Miller, Jan Nijman, Stuart L. Pimm, Elsa M. Redmond, Bruce D. Smith, Patricia C. Wright, Melinda A. Zeder

EXPLORERS-IN-RESIDENCE

Robert Ballard, Wade Davis, Jared Diamond, Sylvia Earle, J. Michael Fay, Zahi Hawass, Beverly Joubert, Derek Joubert, Louise Leakey, Meave Leakey, Johan Reinhard, Paul Sereno, Spencer Wells

MISSION PROGRAMS

Vice Presidents:
Barbara A. Chow, *Education Foundation*
John M. Francis, *Research, Conservation, and Exploration*
Jacqueline M. Hollister, *Development*
Sarah Laskin, *Public Programs*
Exhibits: Susan S. Norton
Expeditions Council: Rebecca Martin
Geography Bee: Mary Lee Elden
Lectures: P. Andrew van Duym, Gregory A. McGruder

Communications: Betty Hudson, *Sr. Vice President*
Human Resources: Thomas A. Sabló, *Sr. Vice President*
International: Robert W. Hernández, *Sr. Vice President*
Treasurer: H. Gregory Platts, *Sr. Vice President*

NATIONAL GEOGRAPHIC VENTURES

Dennis R. Patrick, *Chairman*
Timothy T. Kelly, *President and CEO*
Edward M. Prince, Jr., *COO*
National Geographic Channel: David Haslingden, *President, International*; Lauren Ong, *President, U.S.*
Digital Media: Chris McAndrews, *President*
National Geographic Maps: Frances A. Marshall, *President*; Allen Carroll, *Chief Cartographer*
Television: Michael Rosenfeld, *Executive Vice President*

Contributions to the National Geographic Society are tax deductible under Section 501(c)(3) of the U.S. tax code.

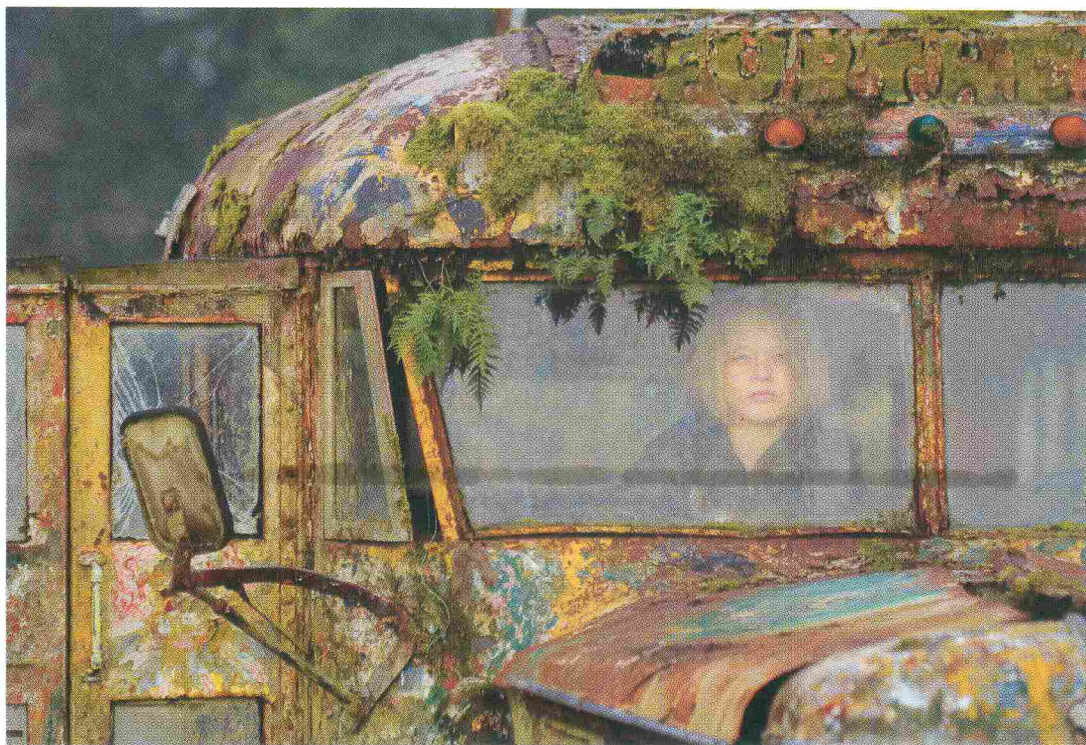
Copyright © 2006 National Geographic Society. All rights reserved. National Geographic and Yellow Border: Registered Trademarks © Marcas Registradas. National Geographic assumes no responsibility for unsolicited materials. Printed in U.S.A.

'Lunar landscape or
South Australian outback?'

Ask an expert



For more information go to www.nationalgeographic.com/travelaustralia



Ken Kesey's grandson Caleb peers through the window of the bus called *Further*, a psychedelic icon of the 1960s.

Brian Lanker is a Pulitzer Prize-winning photographer, writer, documentary film director, and baby boomer. He lives in Eugene, Oregon.

On the Bus Since 1969, when it returned from Woodstock, this old International Harvester school bus has rested in a swampy, forested area on the Oregon farm of the late writer—and my friend—Ken Kesey. Named *Further* by Kesey and his band of Merry Pranksters, the bus once journeyed across the country in pursuit of what was called an “experiment in the arts.” The brilliant paint that was its hallmark has long faded and peeled. Mother Nature and rust have been racing to reclaim it.

Kesey's bus strikes me as a metaphor for the baby boomer generation. Upon close examination, we find emerging life: Mosses and sword fern spores have nestled into the rusty crevices to bring new color and life to *Further*. Maybe this is not so different from the soon-to-be seniors who bring their wisdom and perspective to our lives. It's easy to find beauty in youth. I'm just as moved by the personality found in aging.

A favorite saying of Kesey and friends was, “You're either on the bus or you're off the bus.” Boomers are off the bus now. But Kesey's son Zane and others are raising funds to refurbish *Further*. Restoration of the old vehicle might seem to some like plastic surgery on a face that's past its prime. I see it as paving the way for a new generation's ideas and dreams.



Ken Kesey's grandson Caleb peers through the window of the bus called *Further*, a psychedelic icon of the 1960s.

Brian Lanker is a Pulitzer Prize-winning photographer, writer, documentary film director, and baby boomer. He lives in Eugene, Oregon.

On the Bus Since 1969, when it returned from Woodstock, this old International Harvester school bus has rested in a swampy, forested area on the Oregon farm of the late writer—and my friend—Ken Kesey. Named *Further* by Kesey and his band of Merry Pranksters, the bus once journeyed across the country in pursuit of what was called an “experiment in the arts.” The brilliant paint that was its hallmark has long faded and peeled. Mother Nature and rust have been racing to reclaim it.

Kesey's bus strikes me as a metaphor for the baby boomer generation. Upon close examination, we find emerging life: Mosses and sword fern spores have nestled into the rusty crevices to bring new color and life to *Further*. Maybe this is not so different from the soon-to-be seniors who bring their wisdom and perspective to our lives. It's easy to find beauty in youth. I'm just as moved by the personality found in aging.

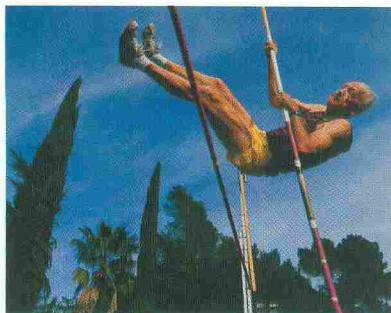
A favorite saying of Kesey and friends was, “You're either on the bus or you're off the bus.” Boomers are off the bus now. But Kesey's son Zane and others are raising funds to refurbish *Further*. Restoration of the old vehicle might seem to some like plastic surgery on a face that's past its prime. I see it as paving the way for a new generation's ideas and dreams.

We all speak one language.

Fly Emirates to five continents where football is spoken.
Keep discovering.



V I E W P O I N T : *medicine*



"Is medicine a pill? An herb? Acupuncture? Massage? Exercise? I've seen it interpreted many ways all around the world. The Hawaiian healer I photographed places a leaf on a patient's head to emphasize the powerful connection between health and a good mental outlook. For one 86-year-old the best medicine was pole-vaulting every day. Treatments abound, but the desire is the same—not only to live long, but to live well."

—Karen Kasmauski



 **NATIONAL
GEOGRAPHIC**
Mission Programs

KAREN KASMAUSKI NATIONAL GEOGRAPHIC PHOTOJOURNALIST



Issued by HSBC Holdings plc.

There's no point pretending we all agree.

But at the heart of most arguments, we find an amazing amount of agreement.

For example, people have different views about the methods but we all want to be healthy.

At HSBC we take part in this constant conversation with 100 million customers all over the world.

And we feel all the better for a little healthy debate.

yourpointofview.com

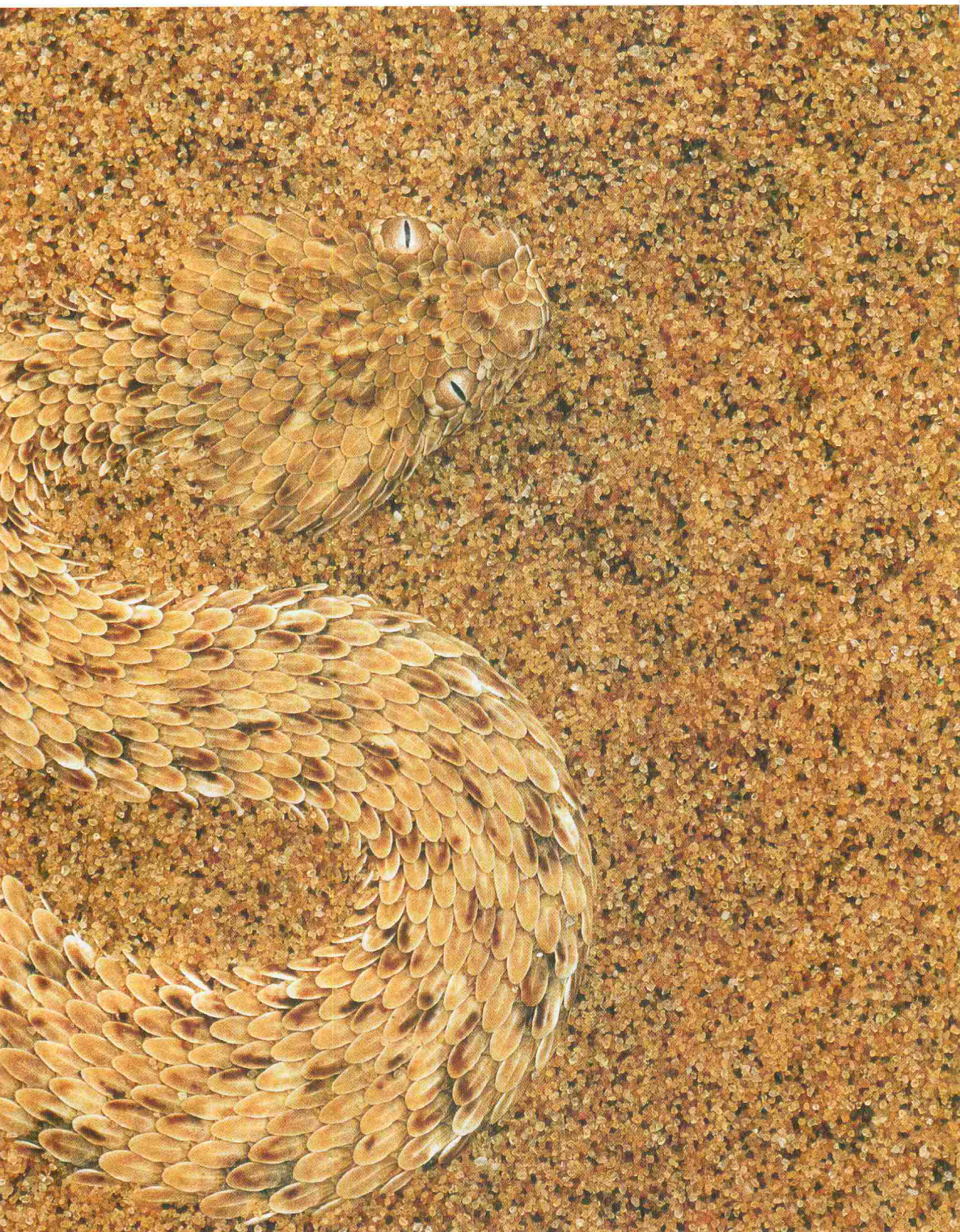
HSBC 
The world's local bank

VISIONS OF EARTH



Namib Desert, Namibia Camouflaged by sand and scales, a Péringuey's adder hunts in almost total stillness, twitching only its black tail to attract prey. When it does move, this viper slips sideways across the dunes.

PHOTO: THOMAS DRESSLER



Crystal River, Florida Bubba, a smooth fox terrier, cools his heels during a game of swimming-pool fetch. Light shining into the pool creates a mirror on the underside of the water's surface, giving the dog his all-legs look.

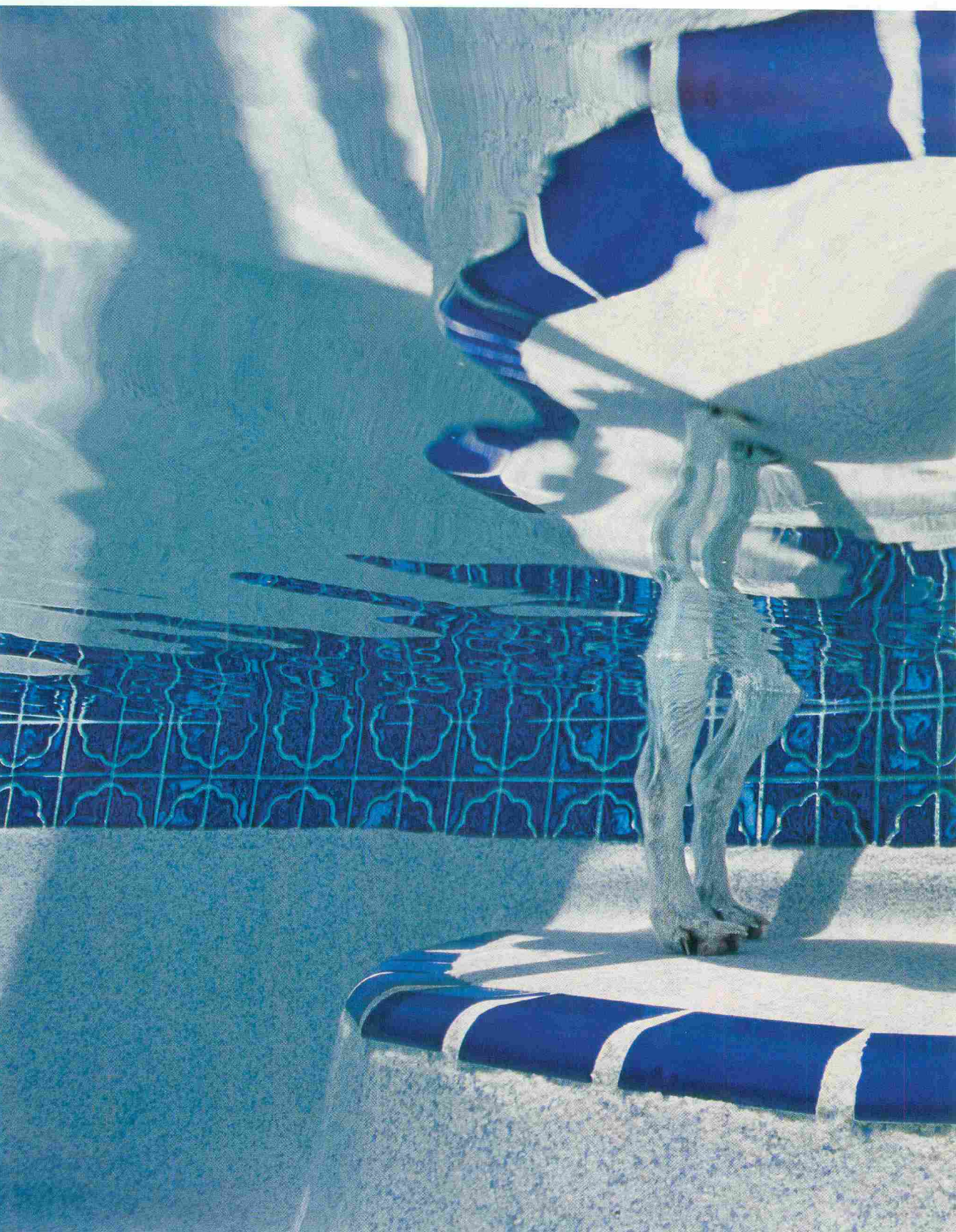


PHOTO: ALEX KIRKBRIDE

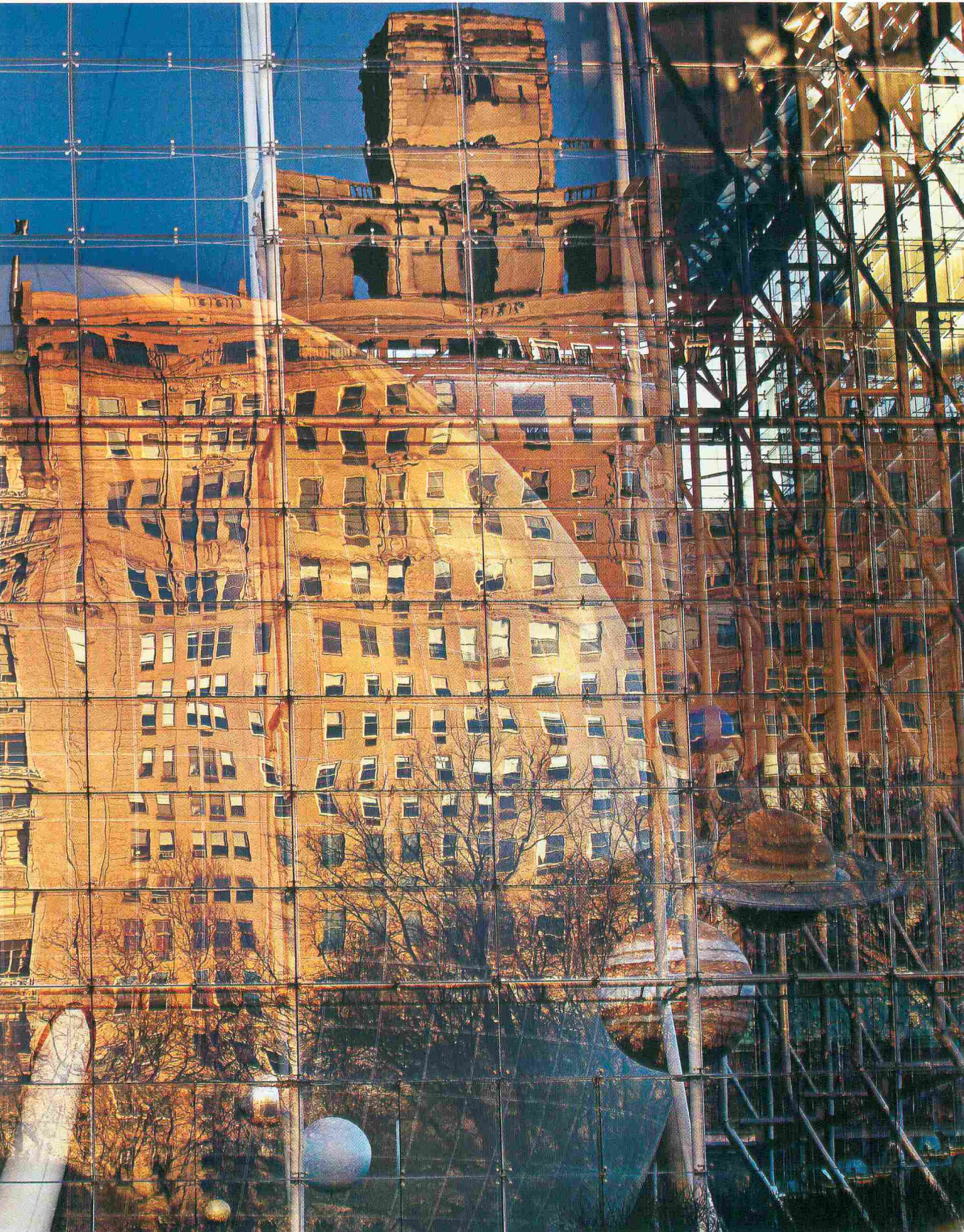


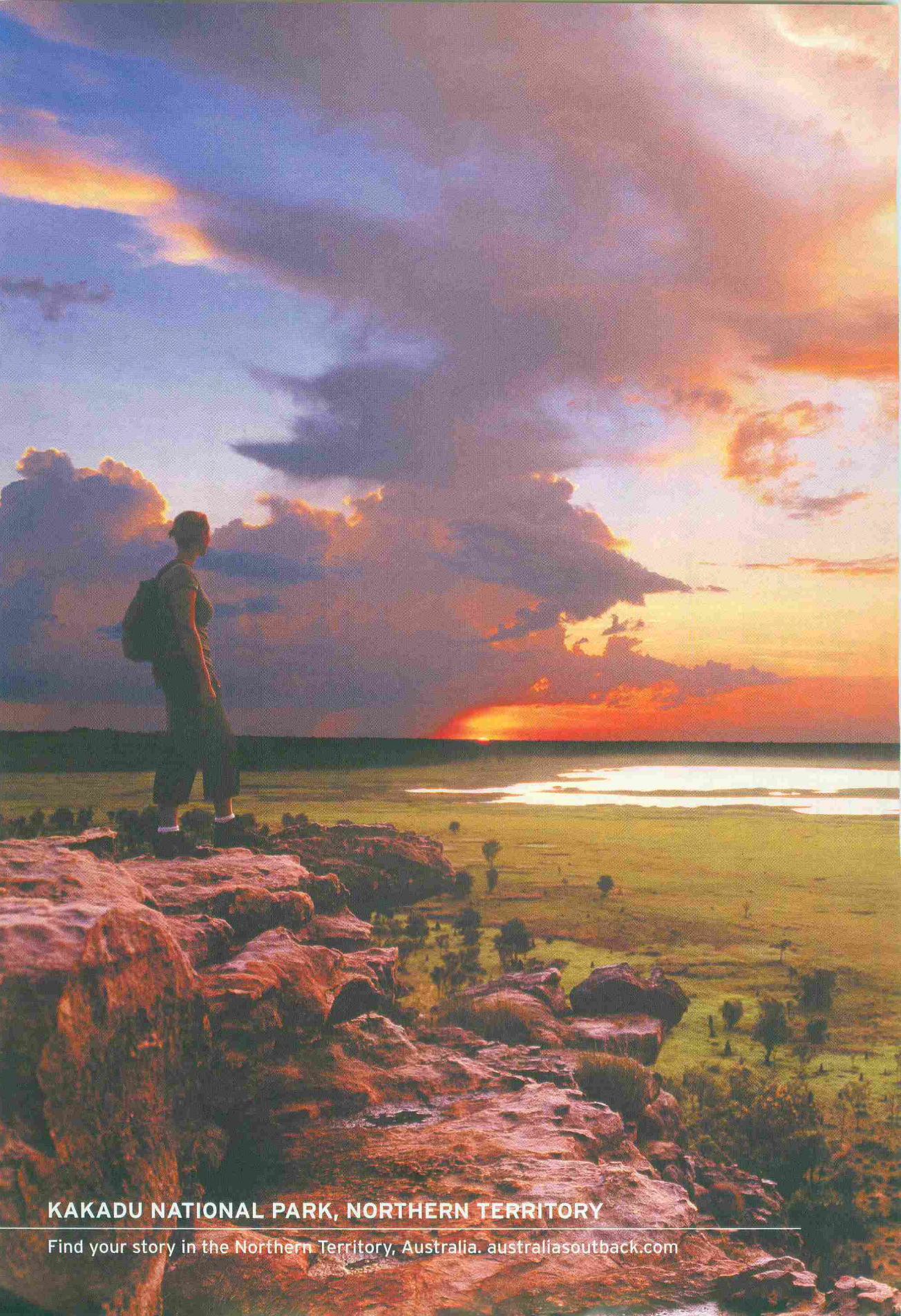
Manhattan, New York The solar system meets West 81st Street in the reflective skin of the Rose Center for Earth and Space. Behind the glass, steel beams resembling fingers hold up a model of the sun, orbited by its planets.



➤ Decorate your desktop with Visions of Earth images in Fun Stuff at ngm.com/0607.

PHOTO: JEFFREY AARONSON, STILL MEDIA





KAKADU NATIONAL PARK, NORTHERN TERRITORY

Find your story in the Northern Territory, Australia. australiasoutback.com

"Our land has big story.

Sometimes we tell a little bit at a time.

Come and hear our stories, see our land.

A little bit might stay in your hearts."

Jacob Nayinggul, Traditional Land Owner, 7.03pm

ENCHANTED

share our story



AUSTRALIA'S OUTBACK
NORTHERN TERRITORY



A hedgehog hides out in the underbrush.

A Garden Lover's Last Stand England's hedgehogs are in trouble. The timid insectivores, which favor the privacy of unkempt shrubs and roll into spiny balls when threatened, are disappearing at a rate that could render them extinct in the English countryside by 2025. The biggest hurdle to saving the creatures: No one knows what's killing them. Pesticides could be the culprit, but scientists haven't confirmed a direct link. Recent evidence suggests the animals fare better in leafy suburbs than in open farmland. Until more is known to formulate a comprehensive strategy, conservationists are urging gardeners to be more welcoming to nesting hedgehogs by leaving their yards somewhat messy—a tough sell in a garden-conscious country. —*Siobhan Roth*

Beastly News

Female mice like a "ladies man."

A new study reveals that female mice prefer mates that carry the scent of other females. When exposed to the odor of a solo male mouse or the combined odors of a male and female, female mice consistently chose the latter. They even rejected the odor of a healthy solo mouse in favor of the male-plus-female odor tainted by scientists with *the scent of an infectious parasite*. Peer influence in choosing

mates is known in birds and fish; this study offers the first evidence of it in mammals.

The southern house mosquito, a ubiquitous tropical species, has long been thought to be a single strain. New research indicates that this mosquito has several variations around the world. The differences may explain why mosquito-borne diseases such as West Nile virus occur only in specific regions.

Donkeys should be seen and not hurt, says the group Donkey Welfare of Namibia. It is estimated that more than a quarter of road accidents in the country involve collisions with donkeys—often because the dark-coated animals lie down to sleep on the warm pavement at night. To prevent such accidents, the group is working with the Namibian government to outfit donkeys with reflective ear tags. Some 500 donkeys have been tagged so far.



**SPEND EVEN MORE TIME
TOGETHER WITH A \$100
COUPON FOR NEXT TIME.**

When you stay with us, romance is awakened whether you leave the room or not. Sleep late in our new beds with soothing, cotton linen and big downy soft pillows. Watch the sun settle into the horizon as you lounge around the pool. Or enjoy a romantic dinner after another amazing afternoon. Contact us to plan your next rendezvous so the only thing you have to think about is each other.

IT'S THE MARRIOTT WAY.SM

Stay For BreakfastSM

Breakfast is included, plus pay with your Visa card to receive a Bonus coupon valued at up to \$100 for your next stay.

Marriott.
HOTELS & RESORTS



JW MARRIOTT.
HOTELS & RESORTS



RENAISSANCE.
HOTELS & RESORTS

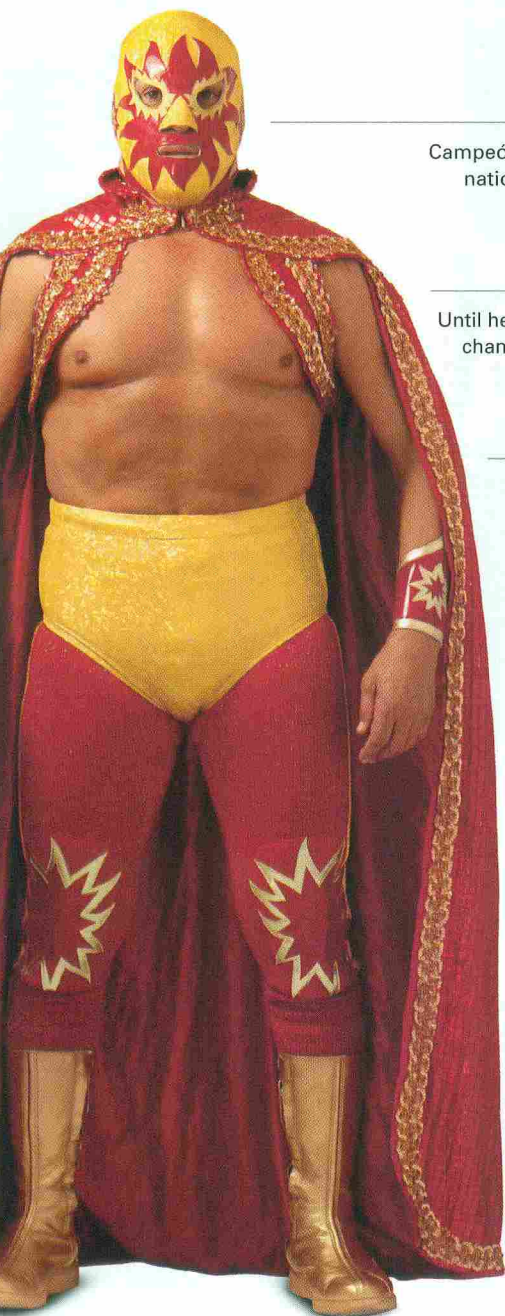


Call any Marriott Global Reservations Office or contact your travel professional. Alternatively, book online at Marriott.com or reach us by email at hkres@marriott.com. Please remember to quote ratecode OTP.

VISA
PROUD PARTNER

Offer valid on Stay For BreakfastSM only, for stays from 1 May through 3 September 2006 at participating Marriott, JW Marriott, Renaissance and Courtyard Hotels & Resorts outside the US and Canada. Must stay over a Friday or Saturday night to get the breakfast rate. Offer may be made available seven days a week at select locations. Rate includes breakfast in hotel restaurant for up to two adults and children age 12 and under. Offer not applicable to groups of 10 or more. A limited number of rooms are available and blackout dates may apply. Payment must be made with a valid Visa card in order to receive one Bonus Bucks / Extra Euros / Premium Pounds / Australian dollars coupon valid for six months on a future consecutive two-night paid stay. One coupon issued per room, per stay. A stay is defined as consecutive nights spent at the same hotel, regardless of check-in/check-out activity. All Visa programme terms and conditions apply. See complete terms and conditions on Marriott.com. ©2006 Marriott International, Inc.

Wrestlers



SOLAR
Lucha Libre wrestler
Mexico



ASASHORYU
Sumo wrestler
Japan

Highest rank

Campeón Nacional, or national champion	Yokozuna, or grand champion
--	-----------------------------

How long they hold the title

Until he loses his next championship fight	Until retirement
--	------------------

Symbol of their status

Championship belt	Tsuna, or belt
-------------------	----------------

Age

Closely guarded	25
-----------------	----

Weight

196 pounds	322 pounds
------------	------------

Height

5 feet, 6 inches	6 feet
------------------	--------

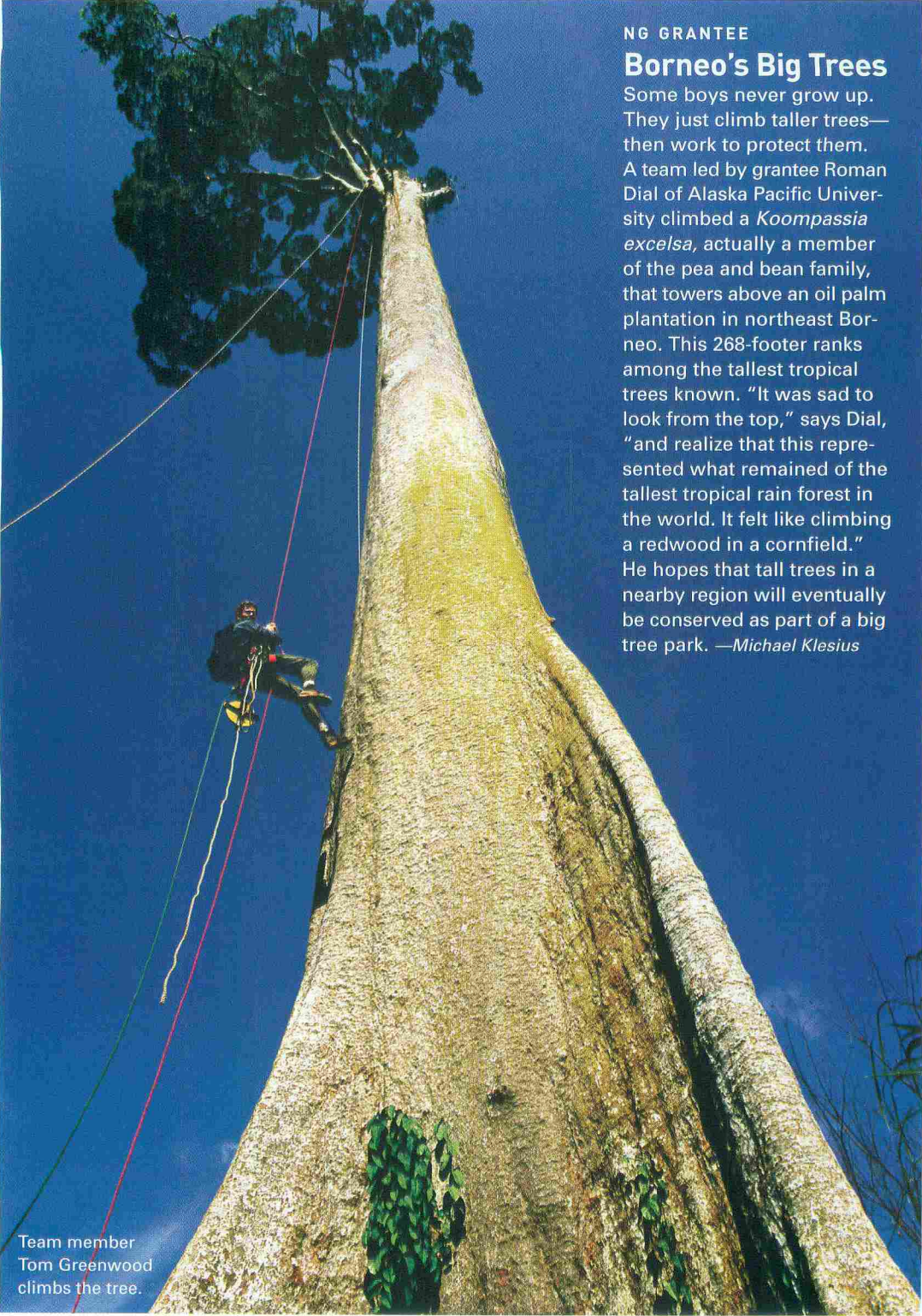
What's on their heads

A mask concealing his identity	A topknot, which takes 20 minutes to tie and marks elite status
--------------------------------	---

NG GRANTEE

Borneo's Big Trees

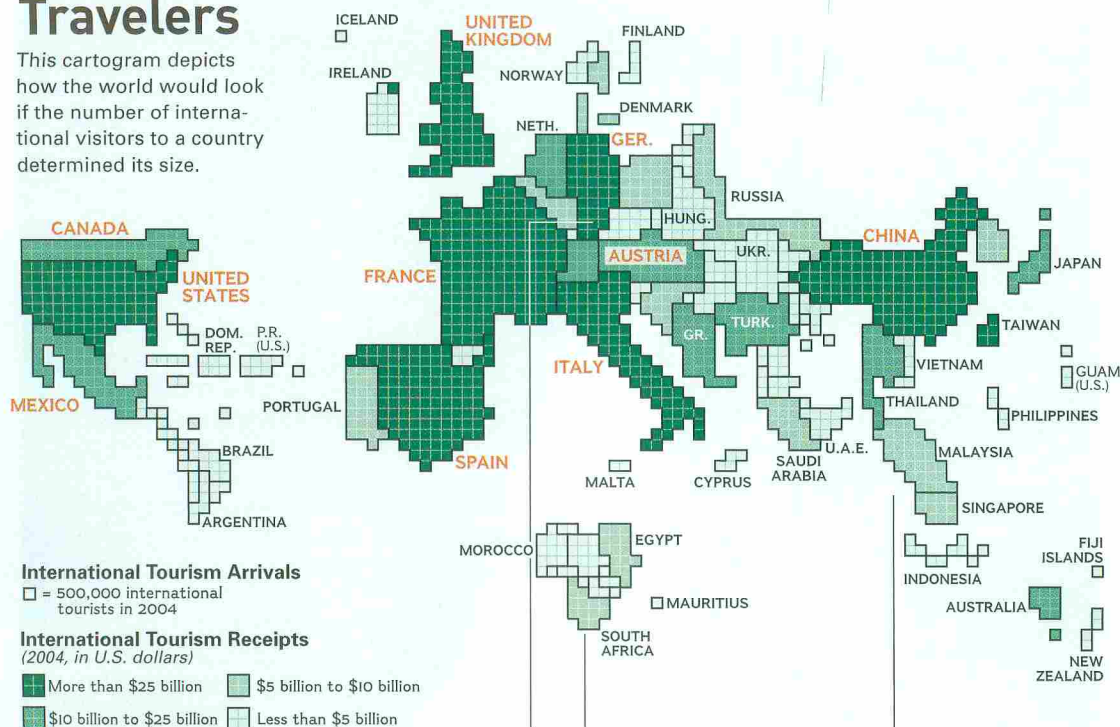
Some boys never grow up. They just climb taller trees—then work to protect them. A team led by grantee Roman Dial of Alaska Pacific University climbed a *Koompassia excelsa*, actually a member of the pea and bean family, that towers above an oil palm plantation in northeast Borneo. This 268-footer ranks among the tallest tropical trees known. "It was sad to look from the top," says Dial, "and realize that this represented what remained of the tallest tropical rain forest in the world. It felt like climbing a redwood in a cornfield." He hopes that tall trees in a nearby region will eventually be conserved as part of a big tree park. —Michael Klesius



Team member
Tom Greenwood
climbs the tree.

World's Travelers

This cartogram depicts how the world would look if the number of international visitors to a country determined its size.



TOP TEN COUNTRIES

Arrivals in millions, 2004

1	France	75.1
2	China	66.8
3	Spain	53.6
4	United States	46.1
5	Italy	37.1
6	United Kingdom	27.8
7	Mexico	20.6
8	Germany	20.1
9	Austria	19.4
10	Canada	19.2

WHO'S SPENDING?

Germans spent the most on travel: 71 billion dollars, or \$861 a person. Most EU countries mandate at least 20 vacation days each year. Germans receive 24.

WHERE'S AFRICA?

The entire continent received 41 million visitors, 20 million of whom headed to sub-Saharan Africa. Conflicts in Sudan and elsewhere kept tourists away.

WHAT'S NEW?

Asia's tourism industry has thrived despite one hurdle after another: SARS in 2003; the tsunami on December 26, 2004; and now, fear of the avian flu.

People are traveling far from home more than ever before in human history. International tourist arrivals—arrivals in one country from another—jumped from about 540 million in 1995 to 763 million in 2004, and the numbers continue to rise. Last year, international arrivals worldwide topped 808 million. The extended hurricane season that blasted the Caribbean in 2004, rioting in France, terrorist attacks in Turkey and the Middle East, and the devastating Indian Ocean tsunami caused rates to tumble only briefly. The desire to travel apparently trumps fear of natural or man-made dangers. Softer borders between countries in the European Union have boosted crossings by auto, bus, and train. Low-cost airline flights are also stoking the trend. One carrier recently offered round-trip tickets from London to Brest, in France, for less than two dollars. —Siobhan Roth



SALT glimpsed the young stars of the Lagoon Nebula some 3,800 light-years away.

Africa's New Eye on the Sky A huge telescope has begun to peer into the austral night: the Southern African Large Telescope (SALT), rising from a hilltop near the little town of Sutherland, South Africa. With a mirror more than 30 feet across composed of 91 hexagonal pieces, the telescope captures the title not only of the largest in Africa but in the entire Southern Hemisphere. This new tool gathers ultraviolet, visible, and infrared light from distant stars, galaxies, and quasars a billionth as bright as celestial objects visible to the naked eye; it has the power to spy a candle flame on the surface of the moon. The SALT officially began operation November 10, 2005, in a ceremony attended by South African President Thabo Mbeki. Says project scientist David Buckley, "The SALT has become an iconic symbol for what can be achieved in science and technology in the new South Africa." —*Michael Klesius*

F O S S I L S

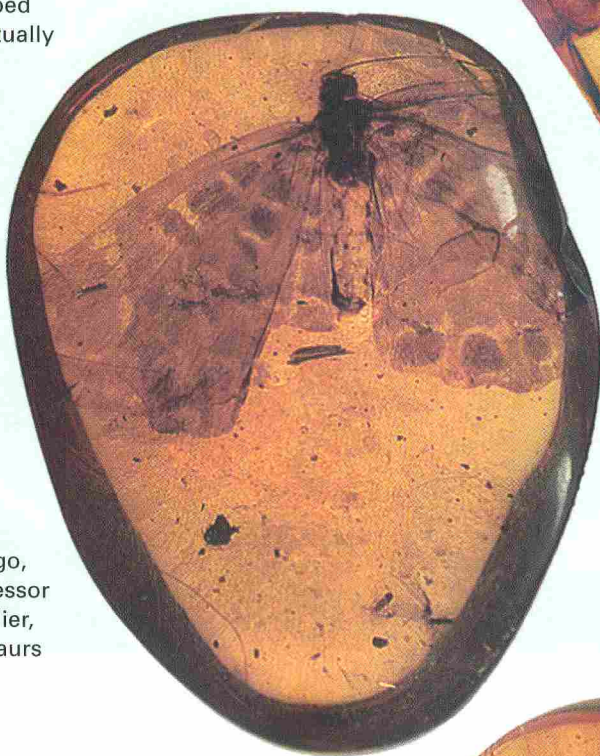
Butterfly Jewels

A bad day for some extinct metalmark butterflies was a lucky break for scientists, who say that these beautifully preserved specimens could help extend the range of butterfly history. About 20 million years ago in what is now the Dominican Republic, the butterflies laid their eggs on plants clinging to resinous trees. Oozing resin trapped the butterflies and eventually hardened into amber.

Jason P. W. Hall of the National Museum of Natural History studied five of the amber-trapped specimens bought from collectors. He says they are a sister species to a living metalmark butterfly—which means both had an earlier common ancestor.

"The sister species diverged about 40 to 50 million years ago," says Hall. That's about as far back as butterfly fossils go, but Hall says the predecessor may have lived even earlier, "possibly with the dinosaurs 65 million years ago."

—John L. Eliot



Amber has preserved these butterflies for 20 million years.

PHOTOS: CHIP CLARKE, E. MORONE, AND JASON P. W. HALL

Fresh Dirt

A dino campus is in the works for the University of Pittsburgh. Rancher Alan Cook donated a 4,700-acre Wyoming tract rich in late Jurassic and Cretaceous remains. The University of Wyoming and the Carnegie Museum of Natural History will team up to help administer the land.

The oldest insect ever found lived in what is now Scotland about 410 million years ago. The rice-grain-size find is 30 million years older than any other insect fossil.



Taking a Metabolic Time-Out

In science fiction, astronauts go into suspended animation to kill time crossing interstellar space. Now everyday people are getting interested in suspended animation. The *Wall Street Journal* recently reported that rich folks are making special funeral arrangements: They name themselves as their own heirs, get frozen, and hope to thaw out sometime in the future to reclaim their millions (plus interest).

It's not a workable idea yet. People, like certain kinds of pasta and salad, don't freeze well. Just for starters, ice crystals in your tissues produce a horrible case of freezer burn.

There are, however, some workable plans in nature. "Metabolic flexibility" allows a sort of suspended animation throughout the animal kingdom: sharks that can survive out of water, seemingly dead but merely quiescent; squirrels that hibernate at temperatures just below freezing, breathing only a few times a minute.

Oxygen is fundamental in helping animal cells turn food into energy. But it's also volatile. Being alive is a bit like being on fire. Oxygen-based metabolism creates radical oxygen species, sometimes called free radicals: molecules that batter your cells and play a key role in aging. A mouse placed in an enclosure with an atmosphere of pure oxygen will be dead in three to four days.

Premature babies can suffer damage from oxygen-rich air delivered by ventilators.

Mark Roth, a biologist with the Fred Hutchinson Cancer Research Center in Seattle, compares oxygen to rocket fuel: "It can take you to the moon, but too much too fast, and you burn out."

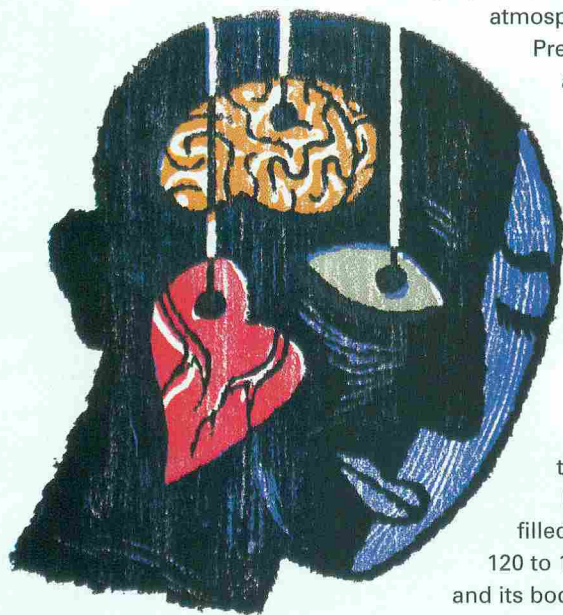
Roth has come up with a strategy for neutralizing oxygen burn in cells. Our bodies make hydrogen sulfide, which, he hypothesizes, helps keep oxygen in check by occupying cellular spaces that the oxygen would normally inhabit. The hydrogen sulfide, Roth says, acts like a "chemical warfare agent in our bodies to regulate the degree to which we burn."

He experimented by putting a mouse in a chamber filled with hydrogen sulfide. Its respiration dropped from 120 to 10 breaths a minute, it used ten times less oxygen, and its body temperature dropped 40 degrees. Six hours later, exposed to fresh air, it warmed up and was back to normal.

"We turned it into a reptile and made it come back," Roth said.

Where will this research lead? Maybe it will keep donated organs alive longer before surgery. Soldiers wounded on the battlefield or victims in traffic accidents might stay alive longer while awaiting transport to a hospital. But no one knows exactly where science will take us. Someday, hibernation might become fashionable in certain social circles.

Many of us do need to slow down.



Joel Achenbach is a staff writer for the *Washington Post*.



Peter Benchley was a frequent contributor to NATIONAL GEOGRAPHIC.



Remembering Peter Benchley

BY DAVID DOUBILET

Writer Peter Benchley died in February of lung disease. He was 65 years old. Though best known for writing the undersea thrillers Jaws, The Deep, and others, Benchley also worked as what he called “the youngest and least qualified” speechwriter for President Lyndon B. Johnson, a newspaper reporter, a screenwriter, and the author of 15 articles for National Geographic publications. Photographer David Doubilet worked with Benchley on eight of those stories. These are David’s memories of his friend.

The best conversations I ever had were conducted in complete silence—wordless moments shared with Peter Benchley in the sea. Underwater communication is, at best, wildly frustrating, but I could always see Peter’s eyes through his clear, yellow 1980s face mask. His signature piece of equipment, it was comfortable, and it was his window into the sea. He always seemed to look out with a calm and measured gaze he referred to as his “peaceful pocket of detached observation.”

Over the years, Peter and I shared many journeys across the world as friends, colleagues, and in special partnership as author and photographer. Once, in the tumbling world of a shark cage, he and I waited for great white sharks to materialize out of the blue void in front of us. Their shadows in the distance drew closer, and they appeared to be swimming through a curtain of light. I remember watching Peter: He raised an eyebrow, cocked his head, and absorbed the scene playing out in front of us with greater detail and emotion than I could ever hope to create with my camera.

The son of the novelist Nathaniel Benchley and the grandson of celebrated humorist Robert Benchley, Peter was raised in a world of words. He grew up spending summers on Nantucket, and after earning a degree in English from Harvard, Peter returned to the island. One summer night, he met Wendy Wesson at the Jared Coffin House, an inn that was the social center of Nantucket. Two weeks later they decided to get married. Wendy, their three children, Tracy, Clayton, and Christopher, and their five grandchildren all shared Peter’s enthusiasm for the ocean, how it works, and how to protect it. Members of the family often joined him on assignment. The love of the sea flowed through the Benchley family. He depended on their shared vision.

The idea of a shark story had been rattling around in Peter’s mind for a while as he scrabbled for work as a freelance journalist. Tom Congdon, an editor at Doubleday, saw Peter’s June 1970 GEOGRAPHIC article on Nantucket and liked it. He invited Peter for lunch. Later that afternoon, back at Doubleday, Peter borrowed

Our first good look at the movie's shark did not occur for more than an hour. Then, in a single horrifying moment, the enormous beast emerged out of a chum slick, clacking its jaws. I kicked the row in front of me to get away.

Tom's typewriter and wrote a proposal for the book in 15 minutes; an advance for four chapters of a shark story soon followed. This was one time when Peter's sense of humor didn't help the situation. The chapters arrived, and Tom had to tell Peter, "Gore and funny don't mix." Peter went back to rewrite. The book was still without a title half an hour before it went to press. *Jaws* was published in the spring of 1974.

About a month before the movie *Jaws* was to be released in 1975, a private screening was held for those of us known as the "shark people." Steven Spielberg and Universal Pictures wanted to know how the film would be received by a knowledgeable audience. They had assembled a tough crowd. I was seated next to Al Giddings, an underwater photographer who once literally pulled another photographer from the jaws of a great white. Peter was at the screening, too. Although he had co-written the screenplay, Wendy told me, he had never seen so much as a rough cut before we sat down in the theater that night. Our first good look at the movie's shark did not occur for more than an hour. Then, in a single horrifying moment, the enormous beast emerged out of a chum slick, clacking its jaws. I kicked the row in front of me to get away. Al, a seamount of a man, levitated out of his seat, and Peter, the shark's own creator, jolted backward. Of course, the film made history.

Jaws brought the Benchley family financial security, but what Wendy always lightly referred to as "the fish book" also gave Peter the freedom to follow his heart to the sea. It was a place where he found like minds and made enduring friendships. Two such friends were Teddy Tucker, a wreck diver, naturalist, and maritime historian, and pioneering underwater filmmaker Stan Waterman.

It was Stan who introduced me to Peter—and Stan who introduced Peter to the world of nonfictional great white sharks during a trip to Australia for *The American Sportsman* television show. On that journey Stan offered Peter this sound advice, "The first law of sharks is: Forget all the laws about sharks." In Stan, Peter had a neighbor, tennis partner, and friend who shared his passion for the sea. He was someone Peter declared he could trust with his life.

Teddy and Peter first met in 1970 while Peter was writing a story on Bermuda, his second assignment for the GEOGRAPHIC. That encounter fostered an unshakable bond between the two men and their families. They shared adventures searching for centuries-old wrecks, wandering through the arcane and bizarre corners of 17th-century maritime history. Peter once described another series of their adventures as going "over the horizon, and over the edge, into the blue water beyond Bermuda's reefs, fishing for the elusive giant squid."

Peter and I began our own partnership with the sea during an assignment to cover the Cayman Islands for NATIONAL GEOGRAPHIC. As author and photographer—and friends—we would go on to collaborate on eight articles.

Peter could instantly get to the spine of a story. He brought with

Peter's teenage daughter, Tracy, calmly embraced a seven-foot green moray eel. Peter quietly noted that the giant fish rivaled the fictional eel that unkindly separated the villain's head from his body in his novel *The Deep*.

him an attitude of steady calm accented with wry humor. His jokes were delivered with perfect timing, sometimes at my expense (and often deservedly so). I came to find his presence on a story like a ship's ballast, balancing out the frenetic pace and pressures of the field. His curiosity knew no borders. Peter was an avid collector of artifacts that ranged from the historically priceless to the incredibly bizarre. One such item was his antique skull gibbet—an iron cage meant to hold severed heads for public viewing. It came complete with the skull of some ancient criminal; Wendy banned the thing from the kitchen.

I know that my travels with Peter were journeys in search of fact, but they also had the soul and joy of good fiction. On our first assignment in the Cayman Islands, we explored coral reefs and sheer walls dropping into the abyss. His family came along, too. Once I watched as Peter's teenage daughter, Tracy, calmly embraced a seven-foot green moray eel. It returned her affection by gently mouthing her ankle like a Labrador puppy. Peter quietly noted that the giant fish rivaled the fictional eel that unkindly separated the villain's head from his body in his novel *The Deep*.

Peter and I shared a mild obsession with World War II history, so we were given the green light to journey to the South Pacific for an assignment called "The Ghosts of War." We swam around a sunken B-25 bomber off New Guinea's north coast. I'll always remember Peter reaching into the cockpit to grasp the control wheel overgrown with a red encrusting sponge. A few days later, Peter, Wendy, and I dived on the Whirlwind Reefs in the dark velvet Bismarck Sea. We saw schools of silvery jacks catch and reflect the slanting rays of the sun like a wall of mirrors. Suddenly, a squadron of dogtooth tunas rose from the depths and attacked the jacks. Catching us by surprise, the fish moved as one, making an unforgettable sound like the ripping of a great canvas sail.

For their 40th wedding anniversary, Peter took Wendy on an expedition to Isla Guadalupe, Mexico, where they celebrated their love and their life together in a shark cage surrounded by great whites.

Peter decided in 1999 it was finally time for a GEOGRAPHIC story about great white sharks. Its publication would coincide with the 25th anniversary of the movie *Jaws*. It would be a chance for Peter to reintroduce the shark to the public, to assemble the facts and destroy the myths that had accumulated over the past quarter century. My challenge was to make images worthy of this majestic creature. We traveled to South Australia and South Africa. When he wrote the book back in 1973, armed with the best scientific knowledge of the day (and a dash of artistic license), Peter famously described a violent attack on an unsuspecting swimmer. On a gray morning in June 1999, just offshore from Seal Island in False Bay, South Africa, Peter, his son Clayton, and I watched a 2,000-pound great white shark burst through the surface like a Polaris missile, grab our seal decoy in its teeth, carry it into the air, and then smash down upon it. Moments later, an even larger shark launched into the air and *snatched a real*

Lion. King?



RELENTLESS ENEMIES, part of Predator Week CHECK LOCAL LISTINGS

As Tsaro Lions take on Cape Buffalo, both sides develop their own deadly tactics and strategies for survival. Watch the action unfold.



Think again.

During the past decade, a powerful and driving theme began to emerge from Peter's work: conservation.

seal less than 50 yards away from us, repeating the same grisly beating. Staring at the disappearing pool of red—all that was left of the seal—Peter mumbled only this, “Ultra-violence.”

Peter described sharks as perfect predators. They are examples of a biological design that has not changed in millions of years. But now it is humans who perpetrate ultra-violence against sharks. Shark fishing, the brutal practice of amputating fins for shark-fin soup, and accidental bycatch are all factors contributing to their demise. The presence of sharks is considered to be a bio-indicator of a healthy and stable marine ecosystem. One shark conservation group estimates that more than a hundred million of these animals are taken from the seas each year. As slow-growing, apex predators, sharks cannot survive that level of harvest.

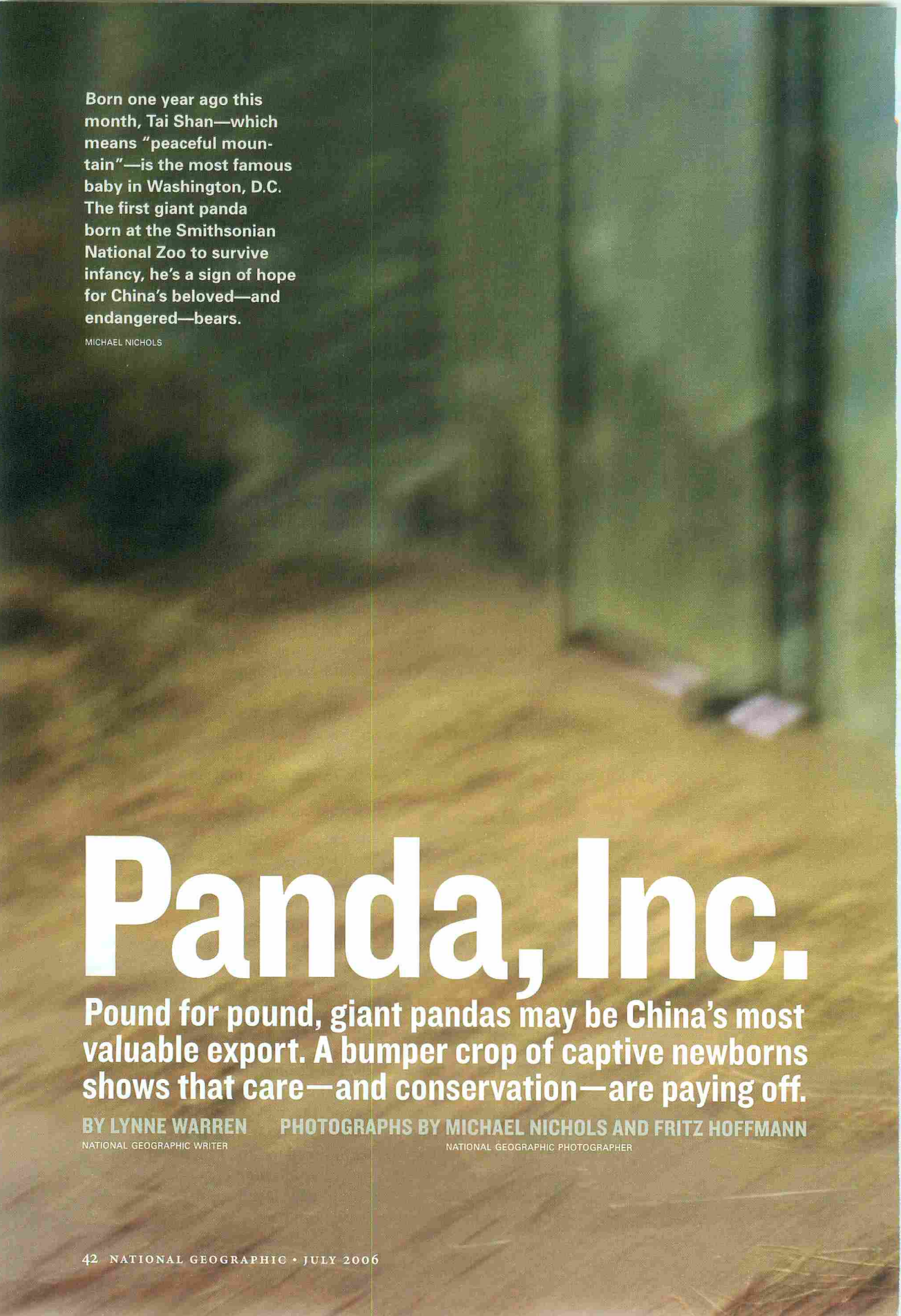
It occurs to me now that all the assignments I had with Peter were really about vanishing ocean Edens. For our February 2002 story, “Cuba Reefs,” we rolled off a dive boat into the sea off southern Cuba—and fell into the past. The reef there was teeming with fish species, all in schools of a thousand or more. Peter called the experience “time out of joint.” We were swimming in a living memory of a Caribbean Sea from the late 1950s, the time when each of us first discovered diving. It turns out this “peaceable kingdom” was the product of the last gasp of the Cold War. Offshore fishing during the Castro regime is largely forbidden for fear that the fishermen might instead take a one-way trip to Florida.

The sea has always been an important theme in literature. But Homer, Herman Melville, Joseph Conrad, and even Jules Verne never saw beneath the ocean's surface. That vision is less than 60 years old; its truths are far stranger than fiction. Peter was a voice for this vision. I've always thought that the real power of his writing was its believability. His novels, so grounded in reality, recorded the feeling of a time and a place in the sea. His monsters—the shark, the squid, the moray—were not mythical beasts. They were real, yet they were not malevolent. Peter's creatures were governed by hardwired instinct. He well understood biologist E. O. Wilson's statement that “in a deeply tribal sense we love our monsters.”

During the past decade, a powerful and driving theme began to emerge from Peter's work: conservation. Armed with a real understanding of the oceans, he reached out across the globe to friends and colleagues to build a network of knowledge, and the returning flood tide of information became the foundation for his writing. Peter was a powerful advocate. His message was clear: “We have, in fact, no choice, for we cannot survive without healthy seas.”

The day that Peter died I was on assignment on a distant reef in a far corner of the world. The sun had made a long-hoped-for appearance over a glass-calm sea. I slipped into the water and swam silently into a group of 30 manta rays. The rays surrounded me and kept me in their center. It was one of the most profound moments I have had in the sea. It was a dive Peter would have loved.

Once again our silent conversations begin. □



Born one year ago this month, Tai Shan—which means “peaceful mountain”—is the most famous baby in Washington, D.C. The first giant panda born at the Smithsonian National Zoo to survive infancy, he’s a sign of hope for China’s beloved—and endangered—bears.

MICHAEL NICHOLS

Panda, Inc.

Pound for pound, giant pandas may be China’s most valuable export. A bumper crop of captive newborns shows that care—and conservation—are paying off.

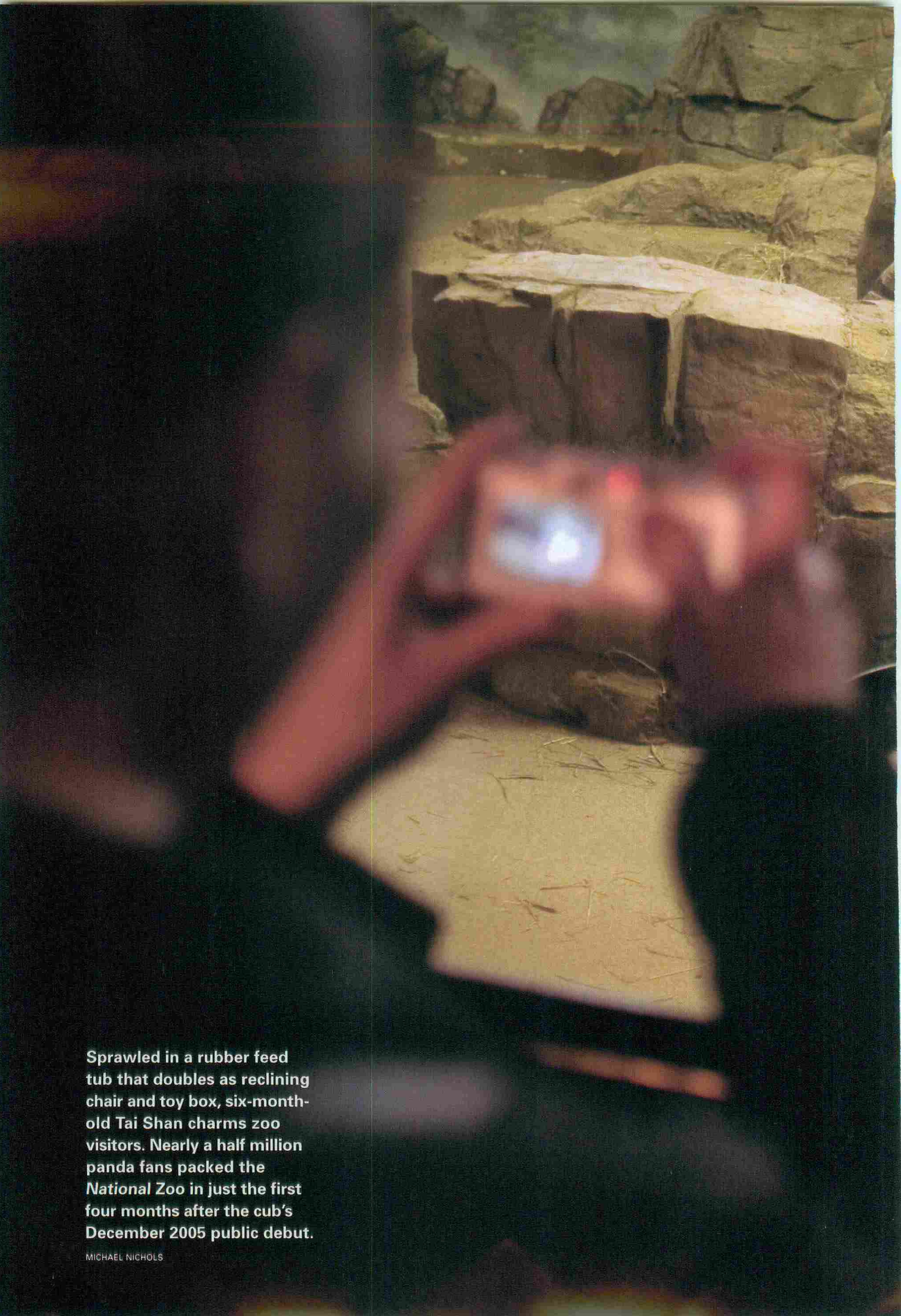
BY LYNNE WARREN

NATIONAL GEOGRAPHIC WRITER

PHOTOGRAPHS BY MICHAEL NICHOLS AND FRITZ HOFFMANN

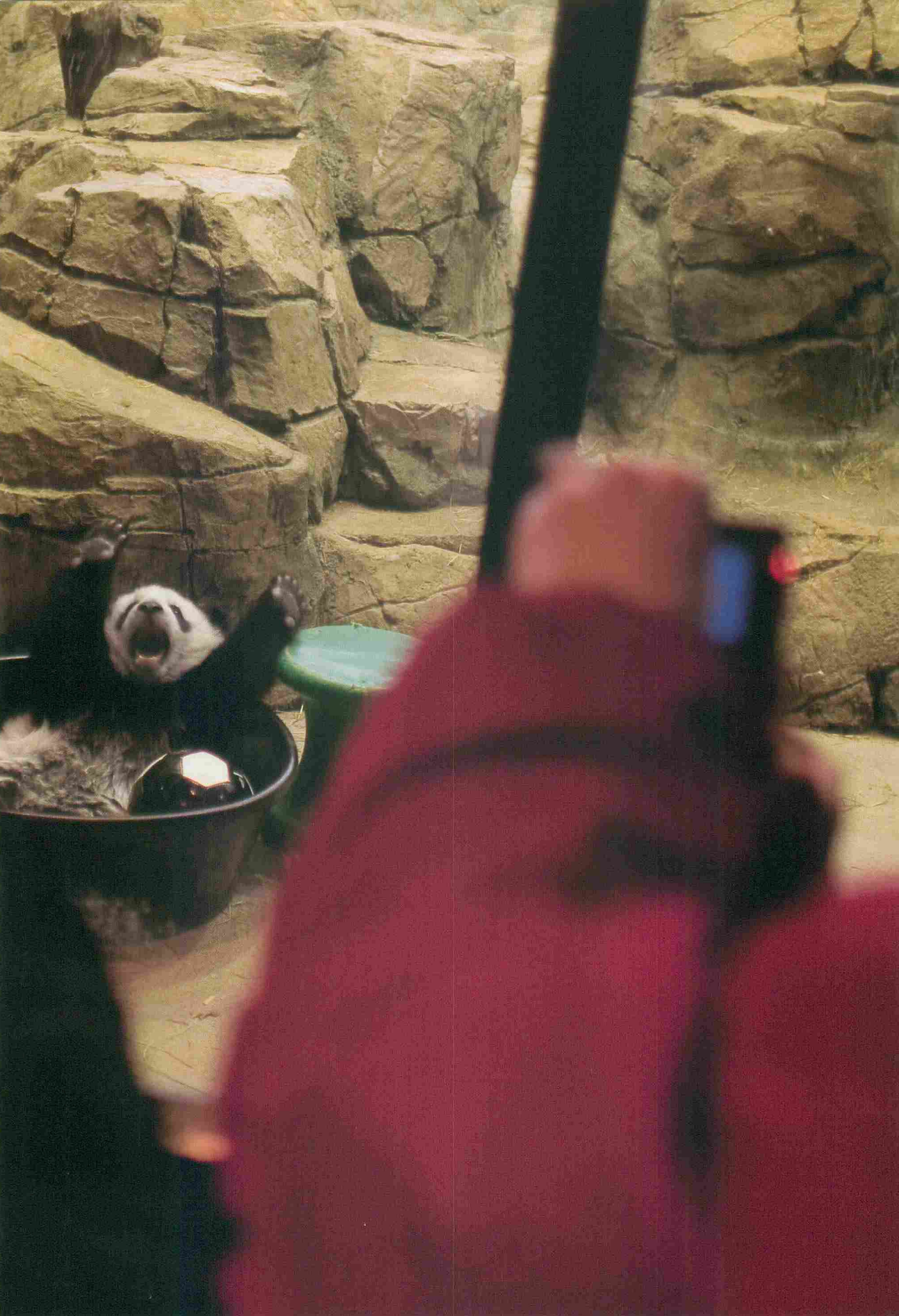
NATIONAL GEOGRAPHIC PHOTOGRAPHER





Sprawled in a rubber feed tub that doubles as reclining chair and toy box, six-month-old Tai Shan charms zoo visitors. Nearly a half million panda fans packed the National Zoo in just the first four months after the cub's December 2005 public debut.

MICHAEL NICHOLS



A photograph of a forest floor. On the left, a large, weathered log with a rough, textured bark lies diagonally. To its right is a dark, shallow, circular bowl or basket. Inside the bowl, a piece of light-colored, coarse fabric is draped. The ground is covered with dry, brown leaves and some green grass. The lighting is natural, suggesting an outdoor setting.

Cradling 28 pounds of dozing bear, Mei Xiang has proved an adept mother. Tai Shan is her first cub, conceived by artificial insemination in 2005. Mei Xiang and Tian Tian—Tai Shan's father—came to Washington in 2000, on a ten-year loan from the Chinese government.

MICHAEL NICHOLS





He's got chubby cheeks. He naps a lot. He eats with his hands. He lives with his mother. Not exactly the kind of character you'd expect to find at the center of high finance, international diplomacy, fan frenzy, government scrutiny, and scientific fascination. But Tai Shan is a giant panda cub, and that makes him, well, not your average bear.

Born at 3:41 a.m. on Saturday, July 9, 2005, at the Smithsonian National Zoological Park in Washington, D.C., Tai Shan is the first offspring of Tian Tian

and Mei Xiang, male and female giant pandas shipped from China to Washington in December 2000. There are only eight other pandas in the United States: two at Zoo Atlanta in Georgia, two at the Memphis Zoo in Tennessee, and four at southern California's San Diego Zoo, where Bai Yun has had three healthy cubs in the past seven years. Together these 11 animals represent an extraordinary investment of scientific resources—and cash.

Hosting giant pandas costs each zoo an average of 2.6 million dollars a year, and that's if no babies arrive. Add a cub, and the budget tops three million dollars. Add two cubs (nearly half of panda pregnancies produce twins), and the tab approaches four million dollars. "Nobody," says David Wildt, head of the National Zoo's reproductive sciences program, "would ever commit this kind of money to any other species."

What makes pandas so special? Could be sheer cuteness. Giant pandas possess the charisma that politicians and movie stars dream of—and people crave a glimpse. The National Zoo's Internet panda cams, which follow the daily activities of Tai Shan and his mom, draw an average of two million online visits a month. In the first three months that Tai Shan was on public display, visits to the zoo jumped by as

much as 50 percent over prior years. Adoring fans pack the railing at the Giant Panda Habitat shoulder to shoulder. Fingers point, voices coo, faces crease in blissful grins. So many cameras click at once that you'd think you were on the red carpet on Oscar night.

Scarcity also boosts the bears' cachet. Giant pandas are excruciatingly rare. Even other famously endangered mammals—tigers, gorillas, black rhinos, Asian elephants—outnumber them, both in the wild and in captivity. China's most recent national giant panda survey reported that 1,590 of the black-and-white bears survive in the rugged hills of Sichuan, Shaanxi, and Gansu Provinces. Such a precise figure is questionable, especially for a hard-to-spot species that occupies isolated and often virtually impassable mountain forests. Wildlife biologists put the free-ranging population somewhere between 1,000 and 2,000 individuals. In captivity, there were only 188 pandas worldwide at the end of 2005: the 11 U.S. residents, a handful of others in Mexico, Japan, Thailand, Germany, and Austria, and all the rest in zoos and research centers in their native China.

At any zoo the arrival of newly loaned pandas or the birth of cubs brings surges in attendance. But crowds don't translate into profits. Even with aggressive "save the pandas" membership



A cub born in captivity in China's Shaanxi Province shows the vulnerability of newborns. There were 188 captive pandas worldwide at the end of 2005, most in China's zoos and research centers. All belong to a tightly managed gene pool, their breeding coordinated to preserve genetic diversity—and to ensure the species' survival even if disaster strikes their wild kin. Wherever they're born, all are officially Chinese. Tai Shan will stay at the National Zoo with his mother (facing page) until he's at least two years old. Any time after that, he can be called home.

campaigns and gift shops hawking panda-themed mugs, T-shirts, puzzles, and plush toys, no zoo has collected enough additional revenue to offset panda costs—not by a long shot.

Why are pandas so expensive? Maybe they're just the tiniest bit spoiled. At U.S. zoos these high-profile animals get the best of everything: state-of-the-art habitats with 24-hour video monitoring, the services of devoted keepers and

veterinarians, and abundant supplies of fresh bamboo to eat, supplemented with carrots, yams, and vitamin-and-mineral-packed biscuits cooked up especially for leaf-eaters. Keepers even add chunks of fruit to juice and water, then freeze the mix into big "fruitsicles" as treats for their charges. Under the serious-sounding heading of "enrichment items," keepers give pandas a constantly changing assortment of



Last summer 16 baby pandas—six single cubs and five pairs of twins—were born to 11 captive females at the Wolong Nature Reserve’s giant panda research center. A decade ago at least half of the twins and many of the single cubs would have died in infancy, but recent studies have led to new care and feeding techniques that have dramatically improved infant survival rates. All of Wolong’s 2005 cubs have flourished.





Wolong panda keeper Hu Haiping totes a four-month-old cub back to its mother after a checkup. Habituating captives to human contact makes routine care less stressful for keepers and animals, but may interfere with the development of normal panda behaviors.

plastic tubs, burlap bags, balls, and other toys to crush, wrestle, toss, and roll. This caliber of care runs hundreds of thousands of dollars a year.

Itemizing the rest of the bill gets a little more complicated. Giant pandas are protected by both the United Nations Convention on International Trade in Endangered Species (CITES) and the U.S. Endangered Species Act. "CITES forbids exchanges of animals for 'primarily commercial purposes,'" says Ken Stansell of the U.S. Fish and Wildlife Service (FWS). "Our Endangered Species Act goes even further and says that if we're going to issue a permit for a zoo to import an endangered animal, that import has to actually enhance the survival of the species."

Panda loans haven't always worked that way. In the 1980s and early '90s, some short-term loans from China to U.S. zoos seemed to be more about China's rental fees and zoos' admissions income than conservation. Sexually mature animals were shipped to institutions that couldn't offer breeding opportunities. Some critics even accused the Chinese of capturing wild pandas just to build up their rental stock. The controversy pushed the Fish and Wildlife Service to declare

a moratorium on panda loans of any kind until it worked out a new set of giant panda import regulations. "We had to step back," Stansell says, "and find a way to use our permit process as a conservation tool."

In 1998 the FWS declared a bold new policy: If U.S. zoos wanted pandas, they would have to become partners with China in giant panda conservation. China needed the help. Its conservation agencies needed information—basic science about panda diseases, hormones, social skills, and needs for space and privacy. In China's zoos and breeding centers, caretakers needed training to help pandas having trouble with mating, to combat parasites and infections, to bring up babies, and to make sure pandas were getting optimal chow. China's cash-strapped central government needed money to help pay for expanding and improving its network of nature reserves, and for the enforcement essential to transforming a reserve from an outline on a map into a genuine haven for wildlife. Today, to qualify for a panda import permit, a U.S. zoo has to design a research program that benefits wild pandas, and it must

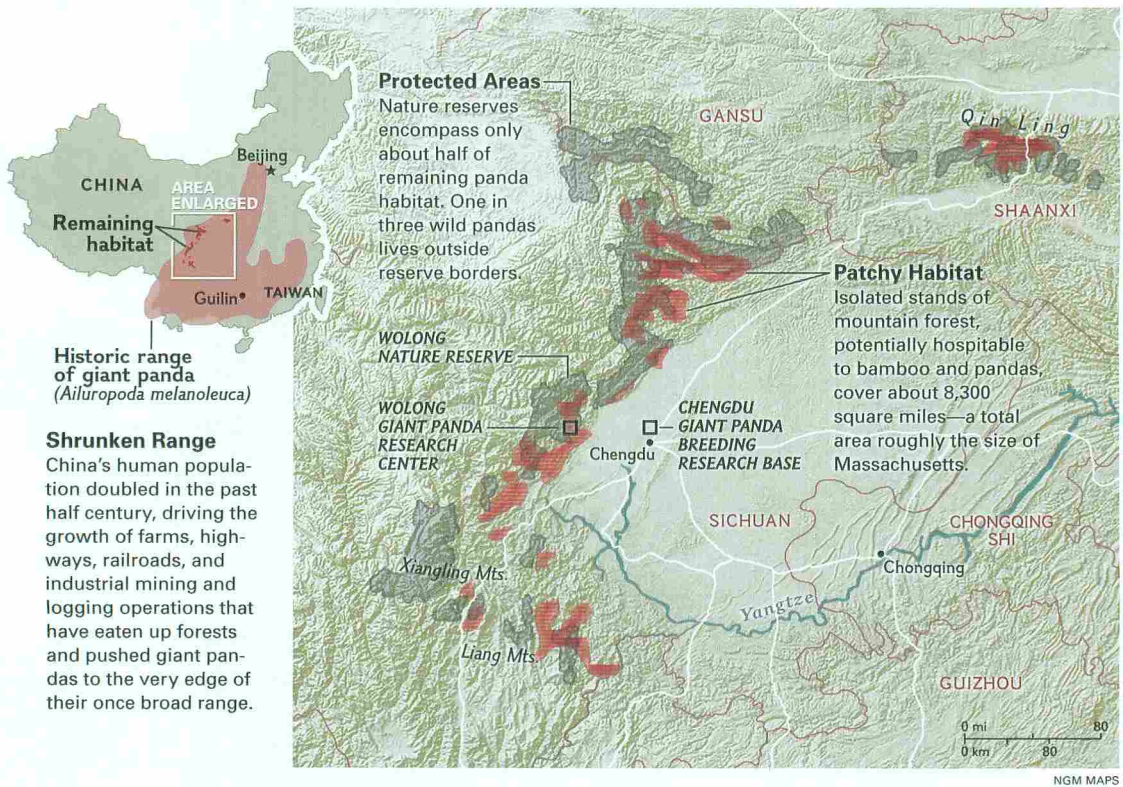
(Continued on page 58)

Protecting Pandas in the Wild

INVESTING IN HABITAT

The Chinese are the world's biggest panda fans, according to Tom Dillon of the World Wildlife Fund (WWF). But caring isn't enough: Pandas need intact habitat to support stable populations. WWF has worked to protect pandas for 25 years, and there's been progress, Dillon says. China has banned logging in natural forests, started a ten-billion-dollar reforestation project, and announced plans to invest a billion dollars a year over 30 years to expand protected areas.

Multimillion-dollar contributions from U.S. zoos to China's reserves and breeding centers have produced valuable results, but they pay just a fraction of the total cost of panda conservation. And the bears' habitat remains at risk. China's hundred-billion-dollar Western Development Initiative promises economic growth in the country's poorest areas—and threatens to supercharge construction, industry, and tourism cutting into the heart of panda country.



No Profits on Pandas

Pandas have giant appeal, but for U.S. zoos their price tag is even bigger. Zoo Atlanta compiled budgets from each of the four host zoos. Financial details vary, but an average panda ledger in a year with a new cub (graph, right) shows far more expense than revenue.

Average annual expenses \$3,204,000

Zoo domestic costs \$990,000 (31% of expenses)


\$314,000	\$676,000
Panda care	Operations and management

Funds supporting panda conservation in China \$2,214,000 (69% of expenses)

\$1,000,000	\$600,000	\$614,000
Loan fee for two pandas (Annual fee to China)	Payment for panda cub (Onetime fee to China)	Research, staff training, and other programs

Average annual revenue \$966,000

\$966,000	Admissions, concessions, fund-raising, public programs
-----------	--

A close-up photograph of a young giant panda, identified as a male from Wolong, eating bamboo. The panda's head is in the lower right, with its mouth open, holding a piece of bamboo. Its thick, dark fur is visible. In the upper left, there are several cut bamboo stalks. The background is a soft-focus view of a mountain range under a clear sky. The lighting suggests it is late afternoon.

Soaking up afternoon sun, a young Wolong male munches bamboo provided by keepers. He may soon join other captives being trained to be more self-sufficient. China's long-term goal: to boost wild panda numbers by releasing captive-bred animals into reserves. The first release occurred in April. Many scientists call the plan premature. "We don't know if there's a need for reintroduction," says National Zoo biologist David Wildt. "There may be as many wild pandas out there now as the habitat can support."

FRITZ HOFFMANN





Zhang Ka, an adult female, occupies a favorite perch in her private yard at Wolong. To encourage natural behavior—including mating—China recently spent half a million dollars to upgrade Wolong's panda facilities.

FRITZ HOFFMANN



also help China pay for its own panda projects.

Starting in the late 1990s, U.S. zoos have committed research firepower and fund-raising clout to long-term scientific loans. China sends captive-bred giant pandas to the United States. Zoo staff here study the smallest details of their pandas' mating activity, food habits, exercise preferences, sleep rhythms, and other traits, and share results with their Chinese counterparts.

By David Wildt's latest count, workshops presented by U.S. and Chinese experts in China have trained nearly 1,300 of that country's conservation professionals. Another hundred-plus have spent time at American zoos, working side by side with U.S. counterparts, then going home to share their new knowledge and skills. Each zoo's average annual investment in panda science and education programs: \$614,000.

Every year each zoo also sends China a million dollars for the protection of pandas and their remaining habitat. China uses these funds, for instance, to install communications networks in reserves, create environmental education programs for schools near protected areas, analyze the impact of habitat fragmentation on genetic diversity, and develop plans to restore degraded bamboo forests.

There's plenty of bureaucracy involved. Funds for projects in nature reserves in Sichuan Province typically pass from the contributing zoo to the China Wildlife Conservation Association, to the central government's State Forestry Administration, to the Wildlife Division of the Sichuan Provincial Forestry Department, to the district government where the reserve is located, and only then to the reserve itself. But the support for fieldwork is crucial, says Peking University researcher Wang Dajun. "Captive numbers are up, but pandas in the wild still face very serious problems," especially the loss of habitat.

"Getting as much information as we'd like to have on how the money is being spent has been challenging," David Wildt says. Zoos must account to the Fish and Wildlife Service for the impact of their funds, but China is a sovereign nation, and no donor organization is likely to have much luck ordering the Chinese to open their books to public scrutiny. The large sums of money zoos spend on their panda loan agreements "create some tension," Ken Stansell acknowledges. "But China's spending a lot of its own money too, and investing twice as much in

conservation in the wild as it was a decade ago."

Loan agreements also provide that a surviving cub can ring up an additional \$600,000 obligation for the breeding zoo. All in all, the financial burden is tremendous, Stansell says, leaving him still puzzled about "why a zoo would want to get into the panda business."

Don Lindburg, head of the San Diego Zoo's giant panda program, has an answer. Hosting pandas isn't about boosting revenues, or institutional prestige, or visitor numbers, he says. "Our pandas are valuable because they create a reason for a relationship with China. They open doors and give us access to what's happening with pandas in the field."

Lindburg's mightiest ambassador has probably been Hua Mei, oldest daughter of San Diego panda matriarch, Bai Yun. Born in 1999, Hua Mei was the first surviving panda cub bred in the U.S. In 2004 she was recalled by China to her mother's birthplace—the giant panda research center in Sichuan Province's Wolong Nature Reserve—where she promptly got pregnant and delivered twins. Hua Mei produced a second pair of baby pandas in 2005. And she wasn't alone.

Last summer Wolong was at the center of an unprecedented captive-panda population explosion: 11 females there (including Hua Mei) gave birth to 16 cubs. More stunning than the number of births was the survival rate, even of the twins: 100 percent.

"Ten years ago the infant *mortality* rate for babies hand-reared in Wolong's nursery was 100 percent," Don Lindburg says. When a wild female panda gives birth to twins, she typically cares for one and abandons the other to die. For twins born in captivity, human caretakers would try to save the rejected newborn, but almost always failed. "Those cubs were getting a dog-milk formula," Lindburg says, until a San Diego Zoo nutritionist came up with a replacement formula that more closely mimics the high-fat milk nursing pandas get from their mothers.

Wolong staff also boosted their survival rate by "twin swapping," which alternates babies between mother's care and nursery tending. Even though pandas don't usually raise two offspring at once, new mothers seem willing to accept both cubs—with a little help from human nannies.

Conservation International biologist Lü Zhi says the popular notion that giant pandas are naturally poor breeders is just wrong. Recent



Mourners lined up to say goodbye with flowers and gentle touches when 36-year-old Mei Mei, China's oldest captive panda, died at the Guilin City Zoo last July. The loss of any panda, says National Zoo curator Lisa Stevens, "is as devastating as losing a close friend."

studies show that wild pandas reproduce about as robustly as North American brown bears: On average, a wild female will have a cub every other year for some 15 years, adding five to six new pandas to the population over her lifetime.

Years of frustrating captive-breeding failures turn out to be mostly the result of human mismanagement, zoo staff acknowledge—making 2005's successes even more gratifying. Two cubs born in the U.S. boosted the year's total count, as did a surviving baby in Japan, and cubs produced at breeding centers in China's Sichuan and Shaanxi Provinces.

All those cubs pushed the captive population closer to a magic number: 300. With that many pandas, says population biologist Jon Ballou, "we can have a self-sustaining captive population, and maintain 90 percent of known giant panda genetic variation for a century." A member of the Conservation Breeding Specialist Group, Ballou compiles a list every year that rates the genetic desirability of potential

matings between all the captive adult pandas in the world.

So cuddly, funny, rambunctious, adorable Tai Shan turns out to be more than just the fulfillment of the National Zoo's decades-long dream of raising a healthy giant panda cub, more than a crowd-pleasing, four-legged rock star in a black-and-white bear suit. He stands for the possibility of genuine international cooperation on behalf of endangered animals, for the powers of science to turn substantial, long-term funding into real progress on tough conservation challenges. And like every one of the cubs that swelled the giant panda ranks last year, he moves his species one step closer to a self-sustaining captive population, and one step back from the brink of extinction. Pretty heady stuff for a one-year-old. Happy birthday, Tai Shan. □

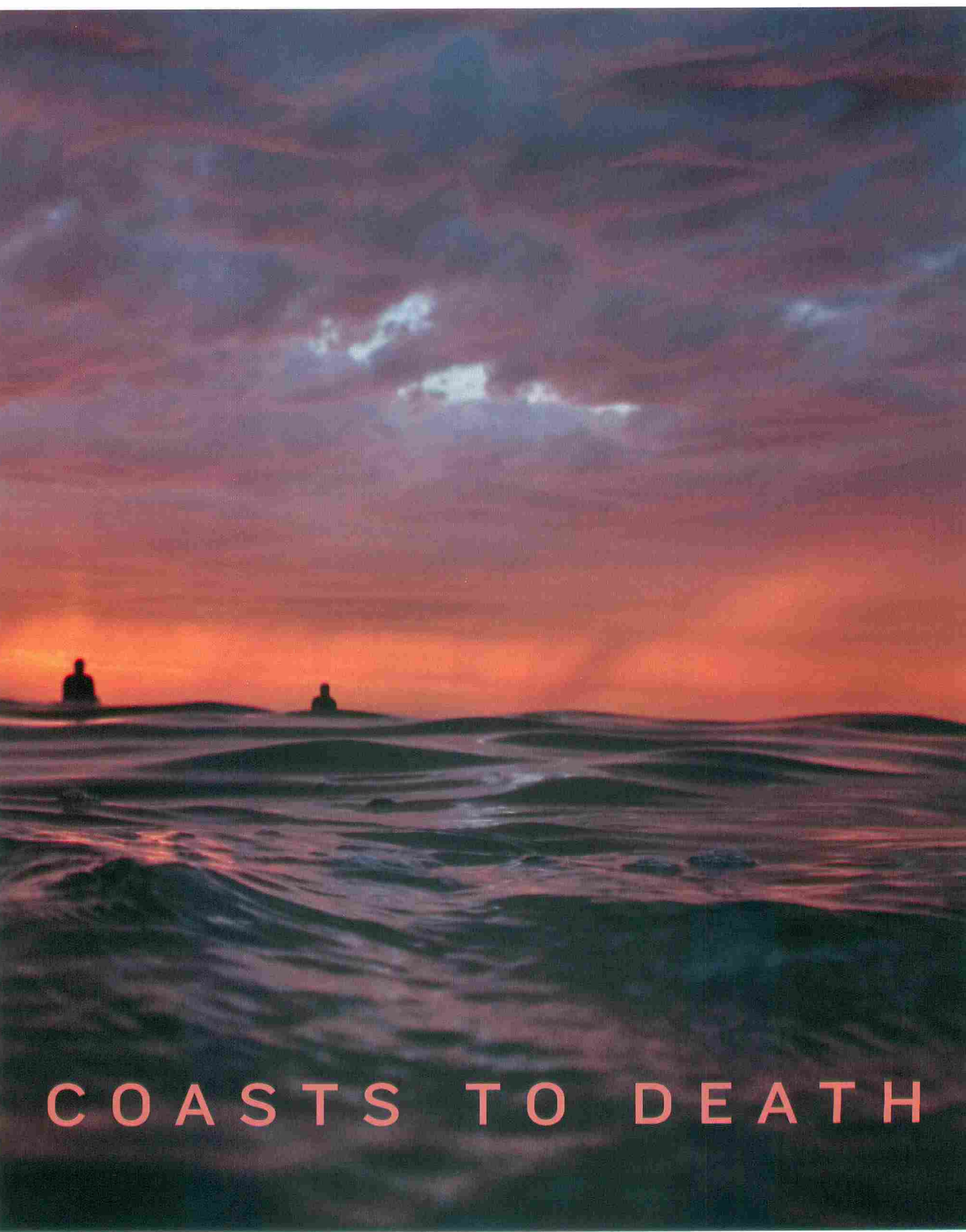
➤ **Pandamania** Decorate your desktop with pics from our online photo gallery; then meet panda baby Tai Shan in a video at ngm.com/0607.



LA JOLLA, CALIFORNIA

The sun sets as surfers await a perfect wave. People have forever been drawn to the sea for reasons both mystical and workaday. But now coastal ecosystems are under strain as never before.

LOVING OUR



COASTS TO DEATH



MIAMI BEACH, FLORIDA

As space to spread out gets scarce, developers look skyward. More than half of Americans already live



in coastal counties, and the rush to water continues: Over 20 million more will join them within a decade.

BY JOEL K. BOURNE, JR. NATIONAL GEOGRAPHIC SENIOR WRITER

PHOTOGRAPHS BY TYRONE TURNER

On a gorgeous San Diego afternoon, 64-year-old surfing legend Skip Frye strokes his longboard into a towering blue wall of water hurtling toward the aptly named Sunset Cliffs. He fades left to discourage a half dozen teenagers from dropping in, then smoothly carves a fat bottom turn to the right, climbing the wave, cross-walking to the nose, gliding like a gull across the wave's wind-brushed face. On the surface, it's a quintessential California day.

Under the surface, it's a murkier story. Surfers know the popular break as "North Garbage." Just a few miles down the beach, the Point Loma Water Treatment plant spews 180 million gallons a day of partially treated sewage into a pipe that carries it 4.5 miles out into the ocean. Until it was extended in 1993, the 12-foot-diameter pipe was only two miles long, and its brown plume often ended up in the surf zone. Storm drains flush car-drippings such as oil, gas, and brake dust, along with a raft of coffee cups, soda bottles, and pet excrement, straight into San Diego's surf breaks every time it rains. Frye and his fellow surfers now routinely suffer a laundry list of waterborne ailments, from sinus and ear infections to more serious illnesses like hepatitis.

"There will be a time when the sea's dead," says Frye, who once predicted San Diego's waves would be too toxic to surf by 2000. "We're kind of like the Dutch boy with his finger in the dike."

And yet, still the masses come, lured by surf, sand, and laid-back lifestyles. Call it the Jimmy Buffett syndrome. Every week more than 3,300 new residents land in southern California, while another 4,800 hit Florida's shores. Every day 1,500 new homes rise along the U.S. coastline. More than half the nation's population now lives in coastal counties, which amount to only 17

percent of the land in the lower 48. In 2003 coastal watersheds generated over six trillion dollars, more than half the national economy, making them among our most valuable assets. Yet two blue-ribbon bipartisan panels—the Pew Oceans Commission and the U.S. Commission on Ocean Policy, convened by the Pew Trusts and the U.S. Congress, respectively—recently issued disturbing reports that found the coasts are being battered by an array of pollution and population pressures. Former Secretary of Energy





Adm. James D. Watkins—not exactly a wild-eyed environmentalist—chaired the U.S. commission and laid it out for Congress:

“Our failure to properly manage the human activities that affect the nation’s oceans, coasts, and Great Lakes is compromising their ecological integrity . . . threatening human health, and putting our future at risk.”

What follows are stories of people with salt water in their veins, who, in ways large and small, are having an impact on our shores.

SAN CLEMENTE, CALIFORNIA

A board-toting surfer weaves through a throng of thousands who have come to Trestles Beach—a popular surf break in a state park—for a pro surfing event. Despite occasional crowds, it’s one of the most unspoiled places to catch a wave in southern California. Environmentalists are fighting a proposed toll-road expansion nearby that they say could increase runoff, pollute the ocean, and ruin the surfing.

I. SURFING'S DYNAMIC DUO

In which a surfer and his wife ride a wave of clean water populism into San Diego's city hall

In the tattooed, slash-and-burn circus that passes for surf culture these days, Harry Richard "Skip" Frye is the sport's Fred Astaire, a quiet, God-fearing surfer and surfboard shaper, whose unmistakable style on and off the water speaks louder than his words. At a time in his life when many of his contemporaries are contemplating bypass surgery, Frye spent his 64th birthday surfing for hours in head-high surf, riding everything from monster 12-foot longboards to short high-speed "fish" designs that he helped immortalize in the 1960s. To anyone who has ever tried to sit on a surfboard, much less paddle one in big surf, the feat was impressive. But what truly impressed the lifeguards, who let him in to San Onofre State Park early, was the hour he spent forgoing the fantastic waves to pick up trash along the beach.

"In Genesis, God lays it out," says Frye as he

Harrys' back in 1990. "People kept coming into the surf shop with a variety of ailments," she recalls. "First I was skeptical. 'Oh, the swell's up, sure you're sick!'" But then in September 1995, Skip came in from surfing in water unusually brown and murky. Normally healthy as a sea-horse, Skip felt dizzy and short of breath, and was so weak he couldn't drive home. "I did some research and found out that nearly all the popular surf spots were in front of storm drains or river mouths," Donna says. "We actually mapped them and tried to find out what was in them."

Donna explains all this in her husky Lauren Bacall voice. Her deep tan, straight blond hair, and ready smile give her a surfer-girl facade, but that quickly fades when she starts reeling off TMDLs, BMPs, and other arcane nuances of clean water regulations. What they found in 19 storm drains along some of San Diego's most popular surfing beaches was disgusting: Total coliform bacteria counts—which should be below 1,000 organisms per 100 milliliters of

**"There will be a time when the sea's dead,"
says Frye. "We're like the Dutch boy
with his finger in the dike."**

dusts off his latest creation—an alabaster fish with so many subtle curves da Vinci could appreciate its potential for flight. "We're in charge of Earth, but we have a responsibility to take care of it."

It's a responsibility Frye has been taking seriously for years, going back to the days when he used to pick up garbage around Harrys', the old-school surf shop that he and friend Harry "Hank" Warner ran for years just off the boardwalk at Pacific Beach. The strip of beach shops and bars serves as party central for much of San Diego, hitting a peak on the Fourth of July. July 5 is now officially dubbed by local beach activists the "morning after mess." Says Frye: "It's like they took the landfill, backed it up, and dumped it on the beach. It's the sickest thing you can imagine. I used to get very down on the human race."

Those are the kinds of thoughts that Skip's wife, Donna—who has more faith in people's ability to clean up their own messes—tries to temper. While Skip has evolved into a quiet role model for many surfers, Donna—loud, proud, and a veteran activist—became galvanized by the clean water issue after she and Skip opened

water for safe swimming—as high as 1.6 million organisms; counts of sewage-loving fecal coliform—which should be below 200 organisms for safe swimming—as high as 240,000. Armed with hard data, Donna launched a tireless campaign to get warning signs posted by the storm drains, fix leaking sewer pipes, require more stringent beach-water monitoring, and divert the worst offending drains into the sewer system.

Her activism eventually catapulted her onto the city council in 2001, one of the few Democrats to win a seat in the largely Republican town. Such is the power of her clean water message that Donna has twice nearly won the mayor's seat, losing by 8 percent last November to a former police chief. With city hall wracked with scandals and mountains of debt from the previous administration, San Diegans chose the conservative cop over the radical clean water activist.

Donna takes it all in stride. Since she began her campaign in the mid-1990s, the city has experienced 70 percent fewer sewage spills and 60 percent fewer beach closures. The beaches are better, she says, but there's much more to be



done, like restoring the San Diego River and upgrading the Point Loma wastewater plant to secondary treatment.

“One of the jabs against me was, ‘She may know clean water, but what’s she know about running a city?’” Donna says with that husky laugh. “Let me tell you, dirty water, dirty politics, it all comes from the same source.”

II. THE CONCERNED SCIENTIST

In which a marine scholar uses science and charm to sound the alarm about the state of the coasts

Far from the beaches of San Diego, a dozen or so young men and women in foul-weather gear and fleece scramble over a rocky Oregon headland on a low-tide scientific quest. Some collect bright orange pot scrubbers and gray squares of Plexiglas bolted amid a carpet of brown mussels. Others filter seawater through a sieve or measure the location of floppy sea palms with a transit. One student even scours the tide pools for sea urchin tube feet for something she calls the Urchin Genome Project.

Amid the blitzkrieg of data collection, a woman with short reddish brown hair, green Wellies, and gold sea star earrings hops from rock to rock, passing out organic chocolate, lending a hand or a word of advice when needed. Jane Lubchenco and her husband and colleague,

REHOBOTH BEACH, DELAWARE

Beachgoers dig into a funnel cake while workers carry out a sand-replacement project called beach replenishment. Towns that live on tourism must fight the ocean’s natural tendency to move sand from one place to another. It’s an ongoing battle, with this project slated to continue for 50 years at a total cost of 120 million dollars.

Bruce Menge, both of Oregon State University, have tried to understand this salty world for the past 28 years—and with that gain a greater understanding of the fundamental ecological principles that govern all life on Earth.

“The rocky intertidal area is incredibly good for studying the interactions between land and oceans,” says Lubchenco, a past president of the American Association for the Advancement of Science and a member of the Pew Oceans Commission. “We’re trying to understand the linkages and how they’re affected by human activity. Nutrient pollution, global warming, fishing, a whole number of things are all coming together right along the littoral zone.”

Today, however, the two scientists are trying to wrap their brains around one of the knottiest problems in marine biology: recruitment, or how many young of a (Continued on page 78)

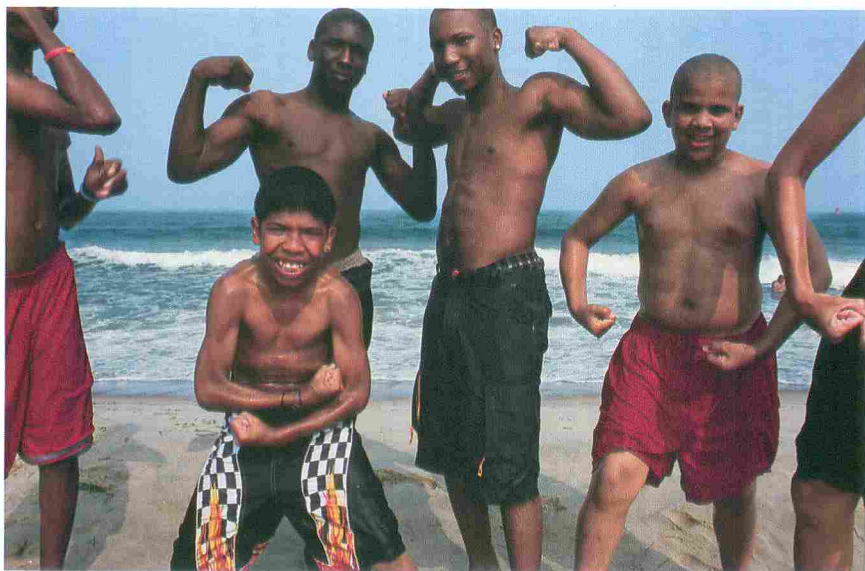




CAPE HATTERAS, NORTH CAROLINA



CLEARWATER BEACH, FLORIDA



OCEAN CITY, MARYLAND

At the seaside, people renew old ties and forge new ones. A group of old friends (left) separated by distance and family responsibilities meets each year on the Outer Banks. "When the fish are biting, you're shoulder to shoulder—about the most social kind of fishing you can do," says Scott Jacocks, in plaid. Several young cousins (above), some of whom are visiting a beach for the first time, strike muscle poses as waves crash behind them. On a Florida shore (top) a couple says vows and begins a new life. "I always dreamed of a beach wedding," says bride Randi Myers-Homem.



INDIAN ROCKS BEACH, FLORIDA



PADRE ISLAND, TEXAS

Municipal workers (right) scoop up a river of L.A. trash in Ballona Creek. A net keeps up to 200 cubic yards of junk a year out of Santa Monica Bay, but plenty gets through. At Padre Island National Seashore (above), the Gulf oil industry's detritus regularly washes up for hazmat crews to handle. In Florida a threatened loggerhead sea turtle (top) succumbed to red tide, an algal bloom. Fertilizer from development may have spurred the state's 2005 red tide. "It was like nuclear winter underwater," says marine veterinarian Janine Cianciolo. "Everything was dead."

HEALTH OF THE COASTS

More than half the nation's population lives in coastal areas—now the most developed regions of the country. Runoff, agriculture, sewage spills, construction, and overfishing are degrading the same resources that make the coasts desirable.

KEY

Primary land use

- Population (darker = higher density)
- Agriculture
- Other

Area rated poor by the EPA because of water quality, sediments, contaminated fish, or the health of benthic organisms. Sampling estimates the percentage of estuarine area in good, fair, or poor condition. Additional sampling needed to confirm conditions at specific points. In some areas more sampling was conducted than in others.

Overall condition is based on a 5-point EPA rating system, where 1 is poor and 5 is good.

West

OVERALL CONDITION

2.0

Rapid population growth on the West coast will increase pressure on coastal resources.

PUGET SOUND

Dredging and filling have removed or destroyed nearshore habitats. Shoreline armoring—such as bulkheads—has caused increased erosion.

PORTLAND

Raw sewage—nearly 1.2 million gallons—overflowed last year in the Willamette and Columbia Rivers.

OREGON COAST

Dead zone events in 2002, 2004, and 2005 killed a wide range of fish, crabs, and other marine species.

SAN FRANCISCO BAY

Multiple sources pollute the estuary, including municipal sewage treatment plants, industry, urban and agricultural runoff, oil spills, and atmospheric fallout.

SAN DIEGO

Urban runoff is a significant source of contamination in San Diego Bay, creating toxic hot spots at the mouths of Switzer, Paleta, and Chollas Creeks, and at the discharge points of urban storm drains.

Northeast

OVERALL CONDITION

1.8

The Northeast coast is the most densely populated coastal region in the U.S. It is also in the poorest health.

NEW YORK HARBOR

Despite significant cleanups, 30 years of insoluble toxic chemicals continue to pollute the harbor.

CHESAPEAKE BAY

Nutrient runoff such as phosphorus and nitrogen fuel dead zones, where most aquatic life cannot survive. Disease and overfishing caused oyster harvests to drop from 25 million pounds to a million in the past three decades.

Southeast

3.8

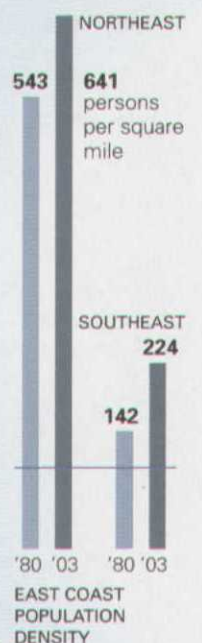
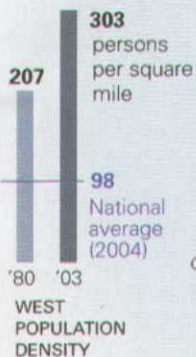
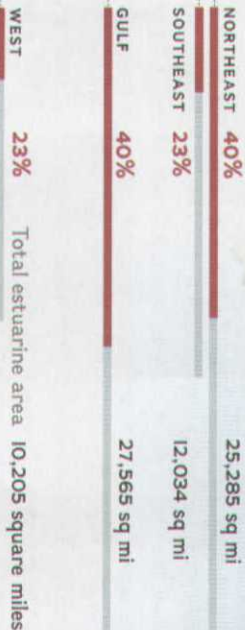
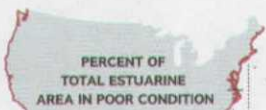
Despite a population growth of 160 percent from 1960 to 2000, the Southeast coast is the healthiest of all the nation's coasts.

NORTH CAROLINA COAST

The growth of industrial hog farms and their wastes in the 1990s has polluted rivers and sounds, contributing to harmful algal blooms.

SOUTH CAROLINA COAST

Urban runoff and municipal discharges are leading sources of pollution in rivers and streams.



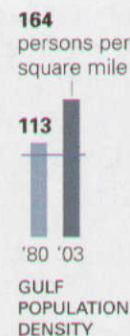
0 mi 100
0 km 100
NGM MAPS

53%

of the U.S. population lives within 50 miles of the marine coastline

Gulf 2.4

Gulf Coast estuaries are among the most productive ecological systems, producing more food per acre than the most fertile midwestern farmland. Population in coastal counties has steadily increased over the past 40 years—more than 100 percent from 1960 to 2000.



THE HUMAN IMPACT

1,500+

Number of new homes permitted for construction along the coast every day

25 million

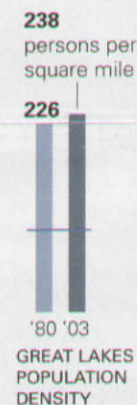
Increase in number of vehicles in coastal counties from 1980 to 2000—a rise of 43 percent

2,000

Acres of farmland lost each day in coastal counties to development

Great Lakes 2.2

The Great Lakes make up more than 80 percent of North America's surface fresh water and about 20 percent of the world's. Under the terms of the Great Lakes Water Quality Agreement, the U.S. and Canada have identified 43 "areas of concern" damaged by pollution and habitat degradation.



20,000

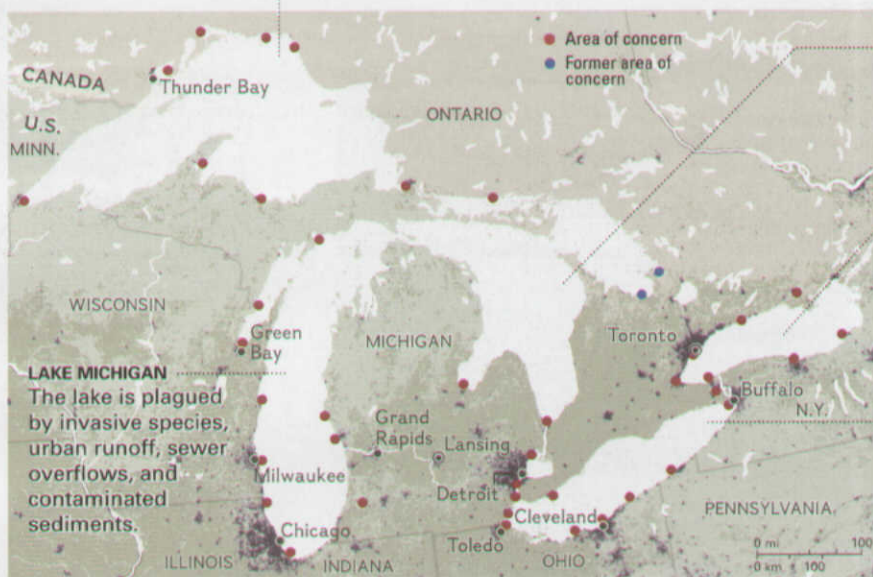
Days of beach closings and advisories at ocean, bay, and fresh-water beaches in 2004

33%

Projected increase in population in coastal areas from 1980 to 2008

LAKE SUPERIOR

Superior is the deepest and cleanest of the Great Lakes. Since 1990, sources of toxic chemicals have been cut in half. Environmental stressors include development and habitat loss.



LAKE MICHIGAN

The lake is plagued by invasive species, urban runoff, sewer overflows, and contaminated sediments.

LAKE HURON

Huron has the largest drainage basin of the lakes, making it most susceptible to pollution from runoff.

LAKE ONTARIO

The Great Lake farthest downstream is affected by pollutants from the upstream lakes as well as from the lingering impacts of old toxic discharges in the Niagara Falls area.

LAKE ERIE

Erie has the most productive fishery of the Great Lakes. It is also the shallowest and most stressed by urbanization, industrialization, and agriculture.

PREDICTED GROWTH

In 2003, an estimated 153 million people lived near the coastline. This coastal population is increasing by an average of 3,600 people a day. At that rate, it is projected to increase by nearly seven million people by 2008.

SOURCES: "NATIONAL COASTAL CONDITIONS REPORT II," ENVIRONMENTAL PROTECTION AGENCY, AVAILABLE ONLINE AT [HTTP://WWW.EPA.GOV/OWOW/OCEANS/NCCR/](http://www.epa.gov/owow/oceans/nccr/); GREAT LAKES NATIONAL PROGRAM OFFICE; "POPULATION TRENDS ALONG THE COASTAL UNITED STATES: 1980-2008," NATIONAL OCEAN SERVICE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION; U.S. CENSUS BUREAU; WOODS & POOLE ECONOMICS, INC.

BRENNA MALONEY (REPORTING) AND JUAN VELASCO (DESIGN), NGM ART



WEST COAST
expected to
increase by 2.2
million people.

GREAT LAKES
+650,000

NORTHEAST COAST
+1.7 million

SOUTHEAST COAST
+1.1 million

GULF COAST
+1.2 million

COASTAL COUNTIES*
WITH ABOVE AVERAGE**
POPULATION GROWTH,
2003-2008

4-11% 12-22%

* Within 50 miles of the coast
** National average = 3%



LOS ANGELES, CALIFORNIA



(Continued from page 67) species come into a system each year. Unlike land animals, in which the young stay within a population, ocean species tend to spread their little guys to the currents, while receiving others from afar, making it impossible for fisheries managers to know how much of a stock fishermen can sustainably catch each year. After years of trial and error, Menge discovered that plastic pot scrubbers are the perfect media for catching baby mussels, while Plexiglas squares coated with scratchy nonslip paint are the perfect landing spots for baby barnacles. And baby mussels and barnacles act much like baby rockfish and Dungeness crabs, two species worth millions to West Coast fishermen each year.

"It looks clean, and compared with other parts of the world it is," Lubchenco says. "That doesn't mean it's not under threat. Development is rampant here, as is overfishing. One of the largest restricted fishing areas in the world is right off our coast—8,000 square miles to protect six rockfish species that were overfished."

Such a concept was unthinkable back in 1969 when Congress appointed the Stratton Commission to prepare the first report on the U.S. coastal zone, which subsequently laid the foundation for current coastal policies. The Stratton commissioners saw the ocean as a source of endless bounty, encouraging the federal government to build up U.S. fishing fleets and drill for oil and gas offshore. Some 40 years later, says Lubchenco, it has become painfully obvious just how finite marine resources are and how great a bite humans have taken out of them: 90 percent of the world's large pelagic fishes, like tuna, marlin, and sharks, gone; three-quarters of the world's major fisheries exploited, overfished, or depleted; and enough oil spilling out of U.S. cars to equal an *Exxon Valdez*-size spill every eight months. Nearly 150 dead zones now occur around the world, including one off the Oregon coast that first appeared in 2002 and that has recurred twice since. Most ominous of all, Lubchenco says, is that the oceans absorb fully half of all the CO₂ released by humans—perhaps one of the greatest services the seas provide. But the vast amount of CO₂ entering the oceans today is making them more acidic, which, combined with rising sea temperature, could have devastating consequences for anything with a shell or skeleton, essentially making them slower, thinner, and more susceptible to predation.

The good news is that marine systems can recover to a surprising degree if given the chance. Lubchenco and many of her colleagues are increasingly convinced that a network of marine reserves where sea creatures and habitats are permanently protected would be a powerful tool in restoring fisheries along the U.S. coasts. Studies of reserves in Merritt Island, Florida, and in California's Channel Islands have shown that such havens give female fish time to grow, and big fat females are the key. "The number of young a fish produces is a product of its volume," Lubchenco explains. "A vermilion rockfish this big"—she spreads her hands apart 14 inches—"produces 150,000 babies. One this big"—she moves her hands apart 24 inches—"produces 1.7 million. Ten of the little girls can't produce what one of the big girls can. It's true for invertebrates as well."

But the time to act, she says, is now. "There are more bizarre things happening in the ocean than we've ever seen before," including the first known failure of the spring northerly winds to blow off the Pacific Northwest coast, in 2005. The normally predictable winds drive a nutrient-rich upwelling just offshore; without the upwelling there was no food for the phytoplankton at the base of the food chain. The result was a mass die-off of cormorants, murre, and auklets, and extremely low fish catches all the way to Point Conception, California.

The alternative no one wants to consider is another fundamental ecological principle learned in the rocky intertidal zone: altered stable states. "That's when you tweak a system to such an extent it may not recover," says Lubchenco, leading to more harmful algal blooms, more dead zones, more fisheries collapse, more invasive species, and, oddly enough, massive blooms of jellyfish.

III. THE BIG DEVELOPER

In which Florida's largest private landholder decides to grow boomer communities instead of pine trees along a vast swath of the panhandle

The first baby boomers turned 60 last January, the cutting edge of what will soon be the wealthiest, healthiest, and largest group of retirees the nation has ever seen, some 78 million strong. Imagine a tidal wave of fit, tanned, sixties-somethings crashing on the nation's shores every year.

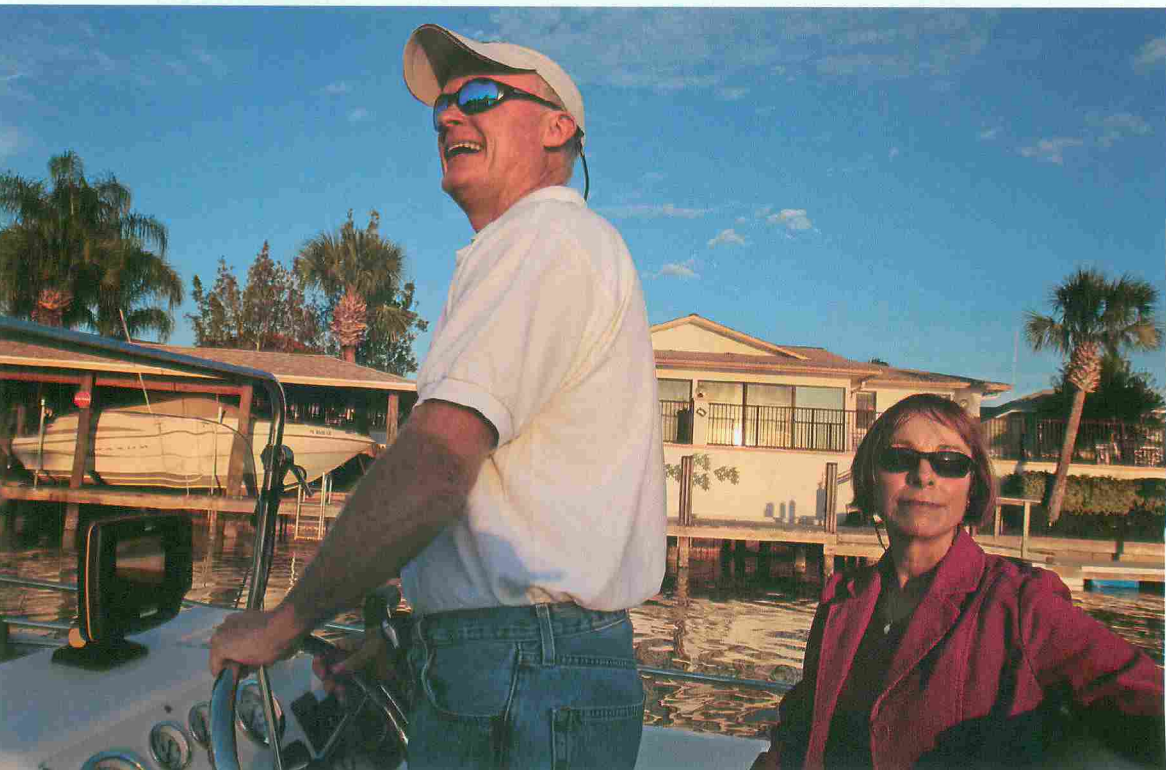
That suits Peter Rummell just fine. The former real estate guru for Disney now calls the shots at



MANTEO, NORTH CAROLINA

A life of sun and sea gets in your blood, says Rick Taylor (below), cruising with his wife, Paula, on a canal through his shoreline subdivision. "People here are a little more relaxed and friendly," he says. "Maybe it's because you feel like you're always on vacation." But coastal living can have unintended ecological effects. The dream homes of Pirate's Cove (above) are built on earth dredged from a marsh—feeding ground for waterfowl and shorebirds. Such development has contributed to the loss of more than half the lower 48's original wetlands.

PALM COAST, FLORIDA





DAUPHIN ISLAND, ALABAMA

A seaside paradise can quickly turn hellish. Hurricane Ivan battered Dauphin Island in 2004. In 2005



Katrina washed away part of the island, destroyed many homes, and left others standing in the ocean.

the St. Joe Company, Florida's former paper-and-timber giant that he has transformed into one of the largest coastal developers in the nation. Rummell beat the boomers to the big 6-0 by a couple of months. Tanned, fit, and with a wreath of short-cropped gray hair, he could be George C. Scott's laid-back younger brother. "We think there are enormous numbers of people getting to my age who have flexibility in their lifestyles," Rummell says. "They're not staying in Cincinnati 12 months of the year. They're looking for warmer climates, particularly Florida. It's a proven track record for 75 years."

In fact, quips Jerry Ray, St. Joe's VP for corporate communications, the entire state of Pennsylvania—that's 12 million people—will be moving to Florida in the next 25 years, according to census projections. To meet that demand, Rummell and his team are turning vast tracts of pines into tony resort developments, aimed at feeding the hearts and minds of wealthy, nature-loving second-home buyers.

The good news is that marine systems can recover to a surprising degree if given the chance.

So how do you squeeze all those people into a backwater chunk of Florida, once dubbed "the forgotten coast," without destroying the natural beauty that draws people to the area in the first place? The trick is planning, Rummell says, master planning, to be exact. At their showplace resort of WaterColor, about 40 miles west of Panama City, Jerry Ray proudly pointed out how far back the houses and the trademark WaterColor Inn—which looks like a large, tastefully done lifeguard station—are set behind the sugary dunes. Natural areas full of native Florida species, such as sand pines, saw palmettos, and sweet bay magnolias, are laced with biking and hiking trails that sweep around a natural coastal lake, forming a buffer zone. The houses, built like quaint bomb shelters, are designed in what the company calls Cracker Modern, or where red-neck Florida meets rich, tasteful Nantucket. While it's more spread out than the groundbreaking New Urbanism development of Seaside—the idyllic backdrop for *The Truman Show* just next door—many of the concepts are the same: Make it walkable with everything one could need

within a ten-minute stroll, protect natural areas like the beach and lake and make them community amenities, get people to park their cars and leave them idle for their entire stay.

Such concepts were reinforced after Rummell took a tour of Mississippi beach towns devastated by Hurricanes Katrina and Rita last year. Rummell was surprised to see newer gas stations and grocery stores relatively unscathed while the older homes and cottages got hammered. "It was apparent that the quality of construction makes an enormous difference," he says.

With more than 300,000 acres in the coastal zone, a market capitalization of 4.5 billion dollars, and plenty of political clout, St. Joe can do what other developers only dream about. In one section of Gulf County, the company is moving 13 miles of U.S. Highway 98, which currently runs through Joe lands right along the Gulf, a few miles inland. The public gets a new flood-protected four lane and the longest shoreside bike trail in the state, while St. Joe gets miles of secluded

beachfront acreage. In Bay County, the company has donated 4,000 acres to build a controversial regional airport to service its future homeowners, while setting aside almost 10,000 acres as a conservation buffer zone around nearby West Bay, important habitat for migratory songbirds such as scarlet tanagers and Kentucky warblers.

Not everyone is thrilled with St. Joe's vision. Environmental groups recently won a temporary injunction against the U.S. Army Corps of Engineers for granting the company an unprecedented permit to develop nearly 50,000 acres on the shores of three coastal bays that would destroy 1,500 acres of wetlands, even though the company had promised to mitigate that loss by creating or enhancing more wetlands elsewhere.

"Wetlands are not widgets," says Melanie Shephardson, staff attorney for the Natural Resources Defense Council, one of the groups that filed the suit. "They serve different functions. Just setting aside some acreage and buffers might sound good, but at the end of the day you have to make sure that these bays, with all their species diversity, are not going to be harmed."



The injunction, which halted some work on one of the company's developments, makes Rummell fume. "There are still people scared of growth," he says. "But it gets back to our vision of what the world is going to look like in thirty years. I want this part of Florida to be a better version of itself. It would be a shame if it got high-rised to death. I would declare success if ten years from now someone says this looks like it should be here. In the real estate world, that's hard to do."

In the aquatic world, that's hard to do too.

IV. THE SHELLFISH GUYS

In which a group of small-town locals, armed with good data, grant money, and a taste for clams, learns it takes a village to tackle runoff

It's a balmy day in January by New England standards—48 degrees air temperature, 38 degrees water temperature—as Greg Sawyer, a big, good-natured shellfish biologist for the Massachusetts Division of Marine Fisheries, and shellfish constable Garry Buckminster pull their Boston Whaler alongside a clammer's workboat for a chat. Tommy Caradimos, who has spent the past 20 of his 50 years as a commercial shell fisherman, rests his bull rake on the gunnel to show the rewards of an hour's worth of hard labor: a smattering of purplish gray clams ranging from biscuit-size chowders down to littlenecks.

NEW BEDFORD, MASSACHUSETTS

Better stewardship of coastal waters means kids can gleefully break the rules and dive off a city pier without the worry of landing in raw sewage. New Bedford has spent nearly 200 million dollars to upgrade its sewage collection and treatment facilities, and now shellfish—and swimmers—are making a comeback.

"He's one of the hard core," Sawyer says, as he samples the waters of Wareham, Massachusetts. "He'll be out there five hours when it's 30 degrees and blowing. You don't want to arm-wrestle these guys, trust me."

Any region that has five commercial sizes for a clam takes its shellfish seriously, and the Wareham area leads the pack. Unlike a brand-new development in Florida, here 54 miles of serpentine beaches along Buzzards Bay have been attracting visitors since Grover Cleveland moved his summer White House to the bay back in 1893. The population of roughly 20,000 doubles in the summer months, clogging the roads with cars, the rivers with boats, and the small cottages that pack the shores with clam-loving people.

Back in the early 1990s, however, the thick beds of quahogs and soft-shells in the town's Broad Marsh River were closed to shellfishing



BANDON BEACH, OREGON

Though the rugged islands and sea stacks of the Oregon coast are protected by federal statute, menacing



signs have been appearing in the water in recent years, including several oxygen-starved dead zones.

DEERFIELD BEACH, FLORIDA

Waves and the morning sun wash over German tourists in South Florida. Ever larger crowds are gathering at America's shores, threatening the very resource that has attracted them.

for years, thanks to high fecal coliform counts from runoff that poured off the streets directly into the river. That prompted Sawyer, who also samples the waters of five nearby villages, to dangle a carrot in front of town officials: Remediate the runoff, get the bacteria counts down, and he might be able to open 65 acres of shellfish area.

Mark Gifford, head of the town's public works department, took the bait, and with help from the Buzzards Bay National Estuary Project, and a few state and federal grants, he began tearing up the old roads along the river and installing sand galleys—big perforated concrete boxes that work like septic tanks for the roads. It wasn't easy. He had to stick the things down between old gas, water, and sewer lines, and deal with a whole new wad of paperwork to get the grants. But the galleys worked. By 1998 the entire river was open to shellfishing.

"All you need to do is get that first inch of water into the sand galleys," Sawyer says, "because that contains the most contaminants and fecal coliform. You get that filtered out, you're ahead of the game."

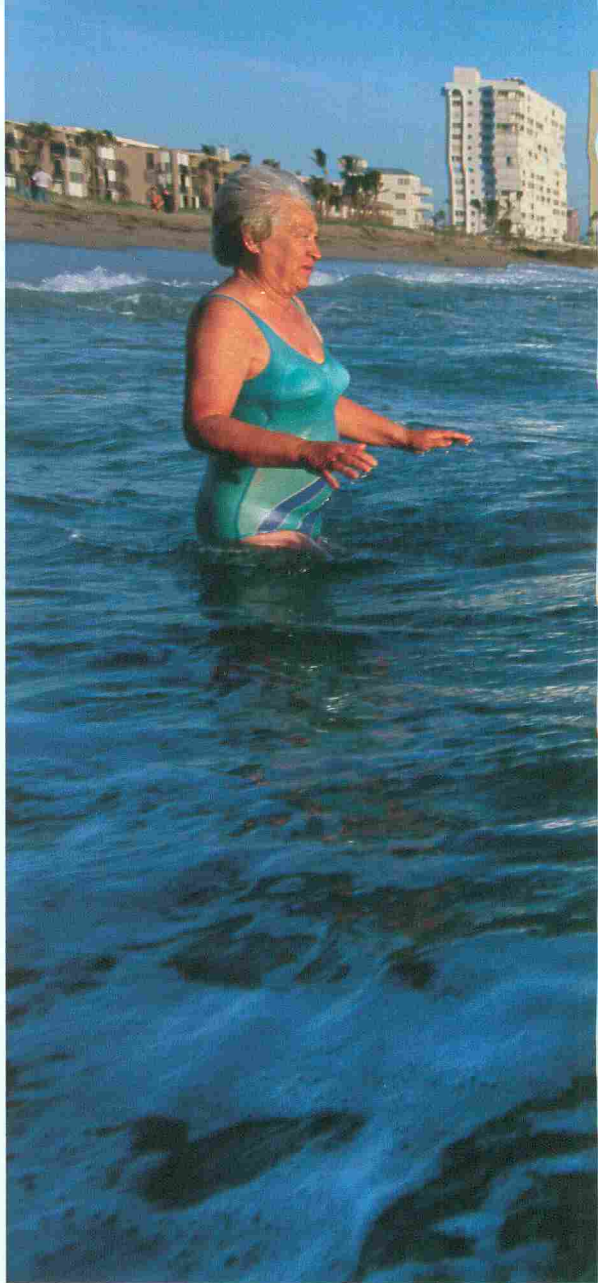
After that it became something of an addiction. Gifford has installed hundreds of the galleys in Wareham, with the neighboring town of Bourne following suit. Such galleys didn't work for the heavier soils of nearby Marion, so that town put in a man-made wetland instead, with the help of hundreds of volunteers. What used to be a ditch that routinely had fecal coliform levels in the thousands is now a meandering stream full of rushes and boulders, where counts are barely detectable at the outfall. The water is so clean you can eat the clams at the end of pipe.

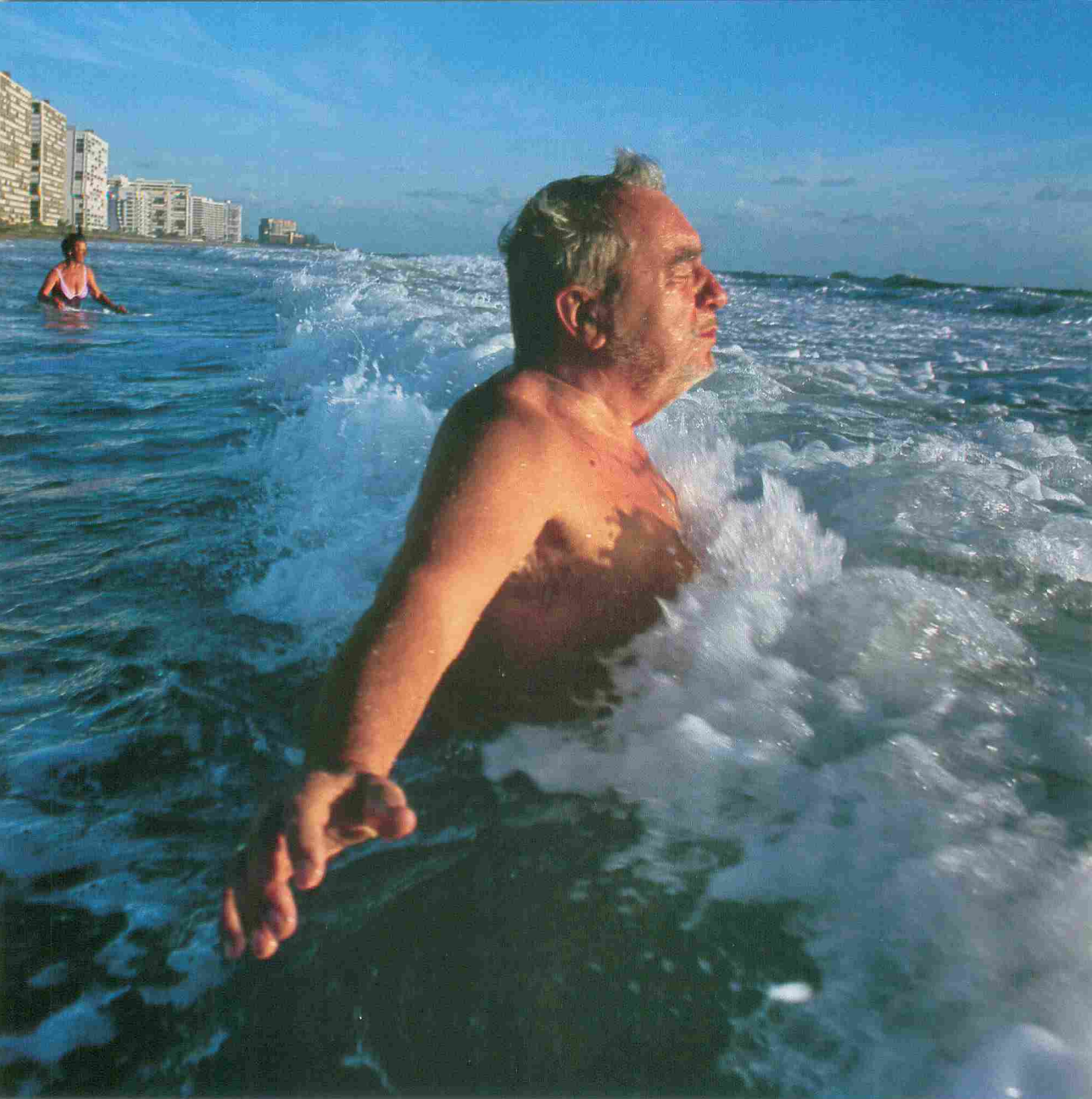
Just last year, Wareham bit a big bullet and spent more than 20 million dollars to upgrade its sewer treatment plant to reduce nitrogen and phosphorus levels entering the watershed, the prime drivers behind algal blooms. Though sewer bills almost doubled, the town now has the cleanest wastewater treatment facility in the state.

"We're picking away at it," Gifford says. "We couldn't have done it without state and

federal grants, or the help of guys like Greg."

It's a never ending process, especially as the population grows. Last year New England suffered its worst red tide outbreak in decades, prompting the closure of nearly 80 percent of the Massachusetts coast to shellfishing. It was the first ever occurrence of red tide in Buzzards Bay. Though a natural phenomenon, the algal bloom was exacerbated by last year's heavy spring runoff. But Sawyer believes that there is a growing public awareness in the area about the importance of protecting aquatic resources. Recently a Boston multimillionaire bought a McMansion in a nearby town and filled in a





small marsh so his manicured lawn could run down to his tennis court. He wanted to donate \$400,000 to the town as mitigation money to go build another salt marsh elsewhere. “The town said no, you will put back that marsh exactly where it was,” Sawyer says with a chuckle.

And perhaps that’s the ultimate lesson of the U.S. and Pew oceans commissions. Aside from a slew of ocean policy reforms recommended by the two commissions, ultimately if we want safe beaches, abundant wildlife, stable fisheries, healthy seafood, and vibrant coastal communities, says Oregon State’s Jane Lubchenco, we’re going to need a new ocean ethic.

“There’s no single silver bullet that’s going to fix the problem,” Lubchenco says. “The problems are complex and come from things we’ve been doing on land for a long time that are coming back to haunt us. But we need to understand that oceans are both valuable and vulnerable, and they are finite. It’s important that we restore them not just because it helps us, but because it’s the right thing to do.” □

📌 **On the Edge** Share your thoughts about the threats to our coasts in our forum. Then pan across a 180° image of Oregon’s Bandon Beach at ngm.com/0607.

In Rome's



Basement

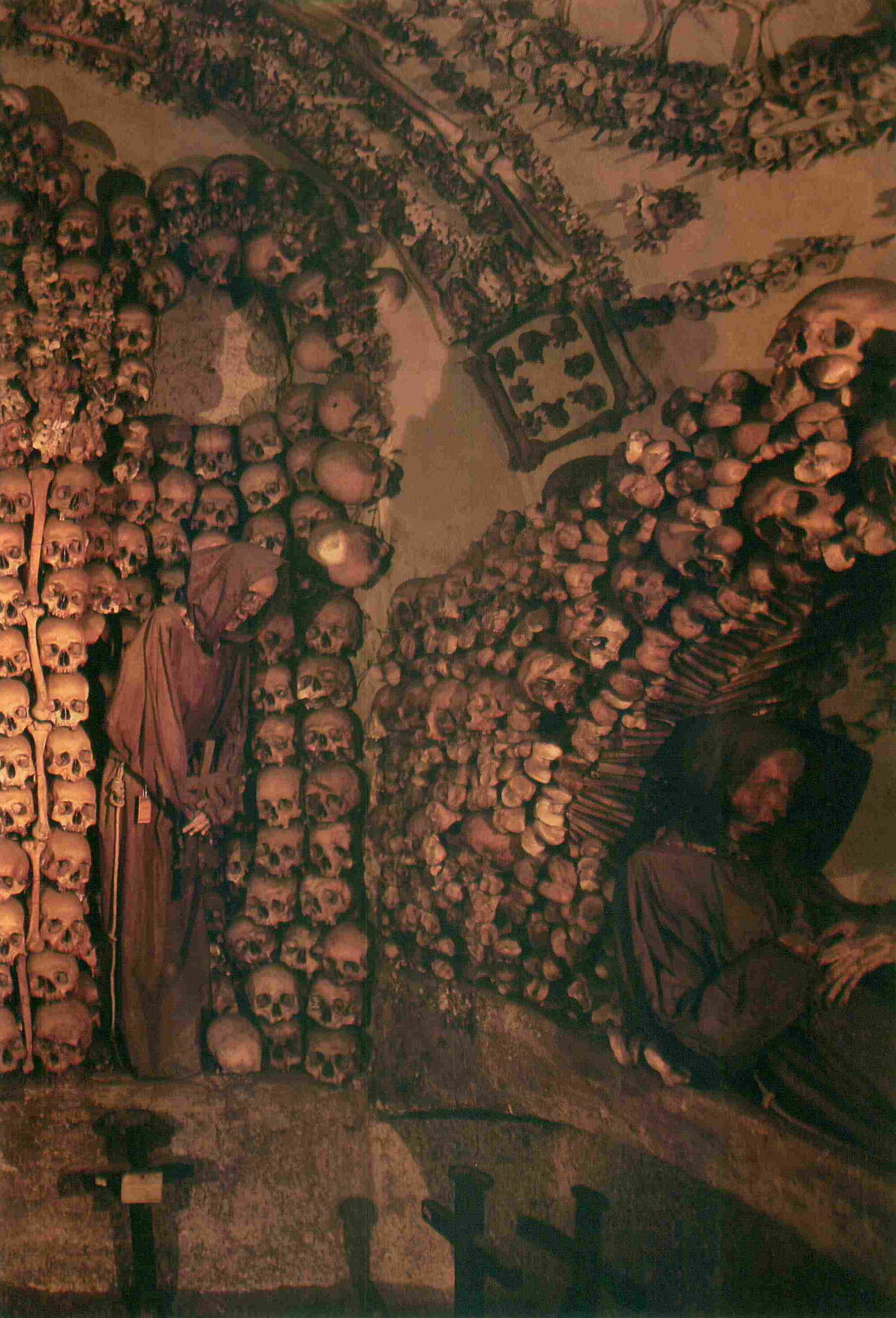
Below the city lies the world's
largest undiscovered museum



Dangling two stories below a historic Roman hillside, urban speleologist Adriano Morabito basks in the glow of a beautifully preserved 2,000-year-old mosaic depicting a grape harvest. Only a handful of people have seen it since it was buried in antiquity.



Skulls and bones of Capuchin monks, some of whom died nearly five centuries ago, adorn a crypt beneath the church of Santa Maria della Concezione.



BY PAUL BENNETT

PHOTOGRAPHS BY STEPHEN L. ALVAREZ

Luca pushes his head into the sewer, inhales, and grins. “It doesn’t smell so bad in the cloaca today,” he says, dropping himself feetfirst into a dark hole in the middle of the Forum of Nerva. Despite his optimism, the blackness emits a sickening aroma: a *mélange* of urine, diesel, mud, and rotting rat carcasses. In short, it smells just as you’d expect a 2,500-year-old continuously used sewer to smell. Below in the dark, tuff-vaulted cavern itself, things aren’t much better. As Luca wades through water the color of army fatigues, stepping over fragments of temples and discarded travertine washed down over the ages, a diorama of modern life floats past: cigarette butts, plastic bags, plastic lighters, a baby pacifier, and a disturbingly large amount of stringy, gray stuff that looks like toilet paper, although raw sewage isn’t supposed to be flowing through here. At one turn, Luca points out a broken amphora, perhaps 2,000 years old, lying in the mud next to a broken Peroni beer bottle, perhaps a week old. Together, they provide a striking testament to how long people have been throwing their garbage into the gutter of this city.

Luca Antognoli, 49, works for Roma Sotterranea, a group of urban speleologists commissioned by the city to explore Rome’s subterranean spaces—an amazing array of temples, roads, houses, and aqueducts buried by history since the fall of the Roman Empire. According to tradition, the Cloaca Maxima (“great drain”), which runs beneath the Roman Forum, was built in the sixth century B.C., making it one of the city’s oldest—if not the oldest—surviving structures. So it is surprising to learn, as Luca winds his way through the sludge-filled passage under Via Cavour, that the cloaca has never been fully explored and mapped.

In real life Luca Antognoli is a surgeon, and he has warned us to be careful not to expose our skin to the water, a potent mix of street runoff and raw sewage. Earnest and wide-eyed, he has taken the danger seriously, covering every inch of his body with gloves, boots, hooded wind suit, and mask—all hermetically sealed with duct tape. He motions sharply at a conduit disgorging a surge of ocher liquid into the cavern that aerosolizes into a mist, sending members of the group into a frenzy fitting masks over their faces.

He points out other conduits, some dumping clean water into the sewer from underground springs, some releasing dirty water. At one point, we pass through a sloping section down which brown sludge purls. Beyond this dangerous obstacle lies a deep hole where, sometime during



the past 2,000 years, the floor has washed out, forcing everyone to inch along an unseen precipice in chest-high, scum-covered water. A joker in the group observes that it looks like *schiuma*, the cocoa-like foam on Italian espresso.

At a pile of rubble—bones, pottery sherds, and caked mud that nearly fill the entire space of the cloaca—the adventure comes to a halt. The sewer’s barrel vault clearly reaches into the darkness beyond—one wonders how far.

Roma Sotterranea plans to send a remote-controlled robot to probe beyond the barrier; Luca expects to confirm that the great drain reaches the Baths of Diocletian, nearly a mile

northeast. Who knows what treasures lie along the way, he says, noting that archaeologists had recently pulled a colossal head of Emperor Constantine from a sewer just like this, prompting speculation that the first Christian emperor may have been the victim of *damnatio memoriae*, as the practice of obliterating the memory of despised emperors was known in ancient Rome.

For Luca Antognoli, subterranean spaces like the Cloaca Maxima offer clues about how this city grew to rule an empire from the edge of Scotland to Baghdad, leaving its imprint indelibly on Western history.

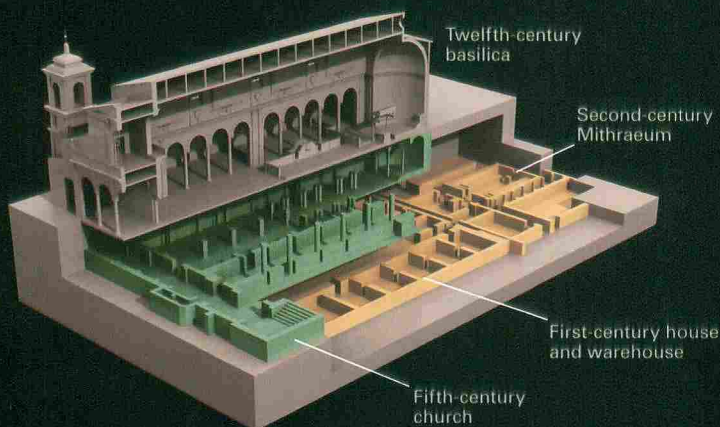
COLLIDING WORLDS

A modern billboard looms near an ancient sports stadium, built by A.D. 86 and paved over in the 15th century to create Piazza Navona. With a lost world of cultural treasures lying beneath city streets, construction workers and home remodelers stumble onto new finds almost daily.



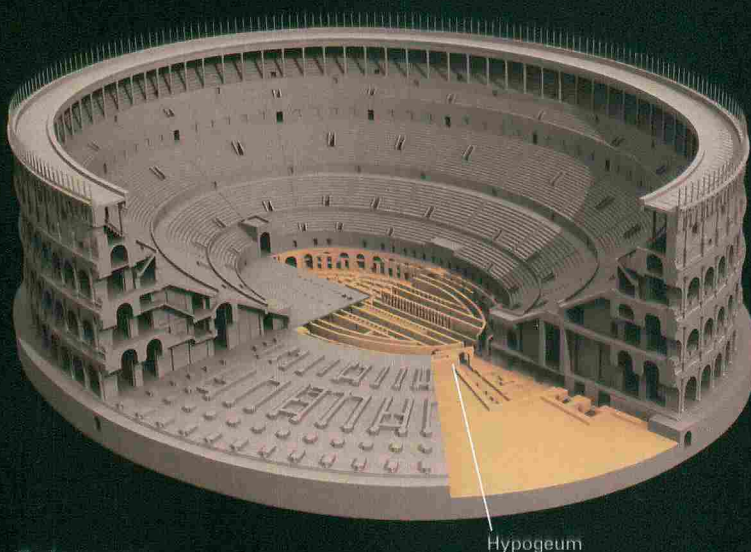
THE ETERNAL CITY: A RECORD IN STONE

With a 3,000-year past attesting to its stamina, Rome today retains imprints of the ancient city (model, bottom right). Because Romans built new structures on top of old ones, many relics still lie buried under layers of sediment and history.



San Clemente

Early structures, including a shrine to the god Mithras, were covered by a home where Christians met in the fourth century, and later by a church. After the Normans sacked Rome in 1084, the church was replaced with today's basilica.



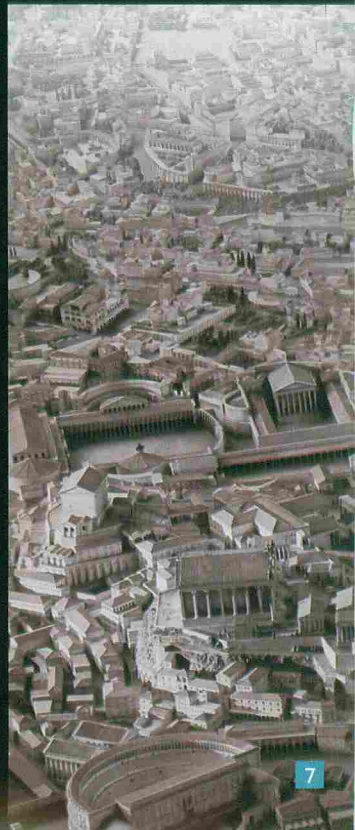
Colosseum

Excavations of the ancient amphitheater in the early 19th century revealed the hypogeum, an underground complex of rooms, lifts, and tunnels where gladiators and wild animals waited before fighting deadly battles.



2006

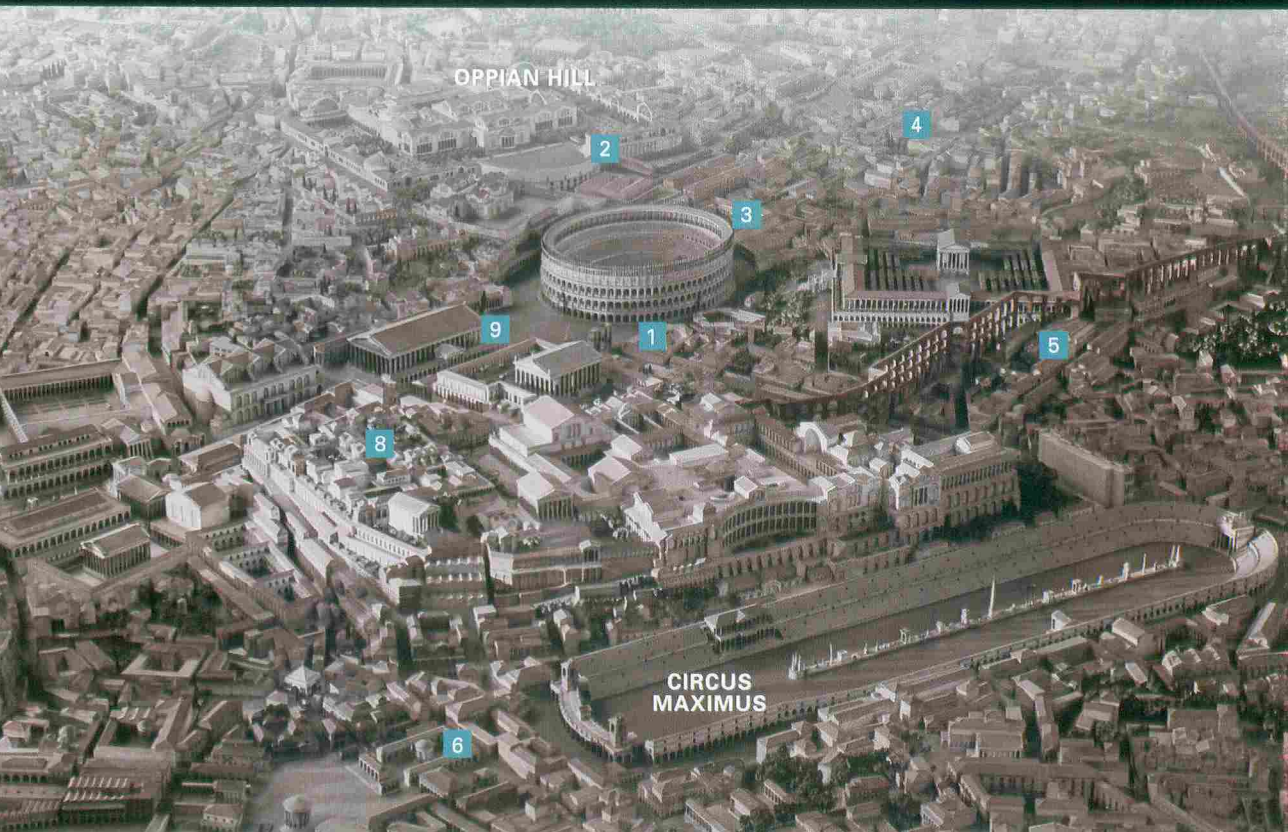
ca A.D. 300

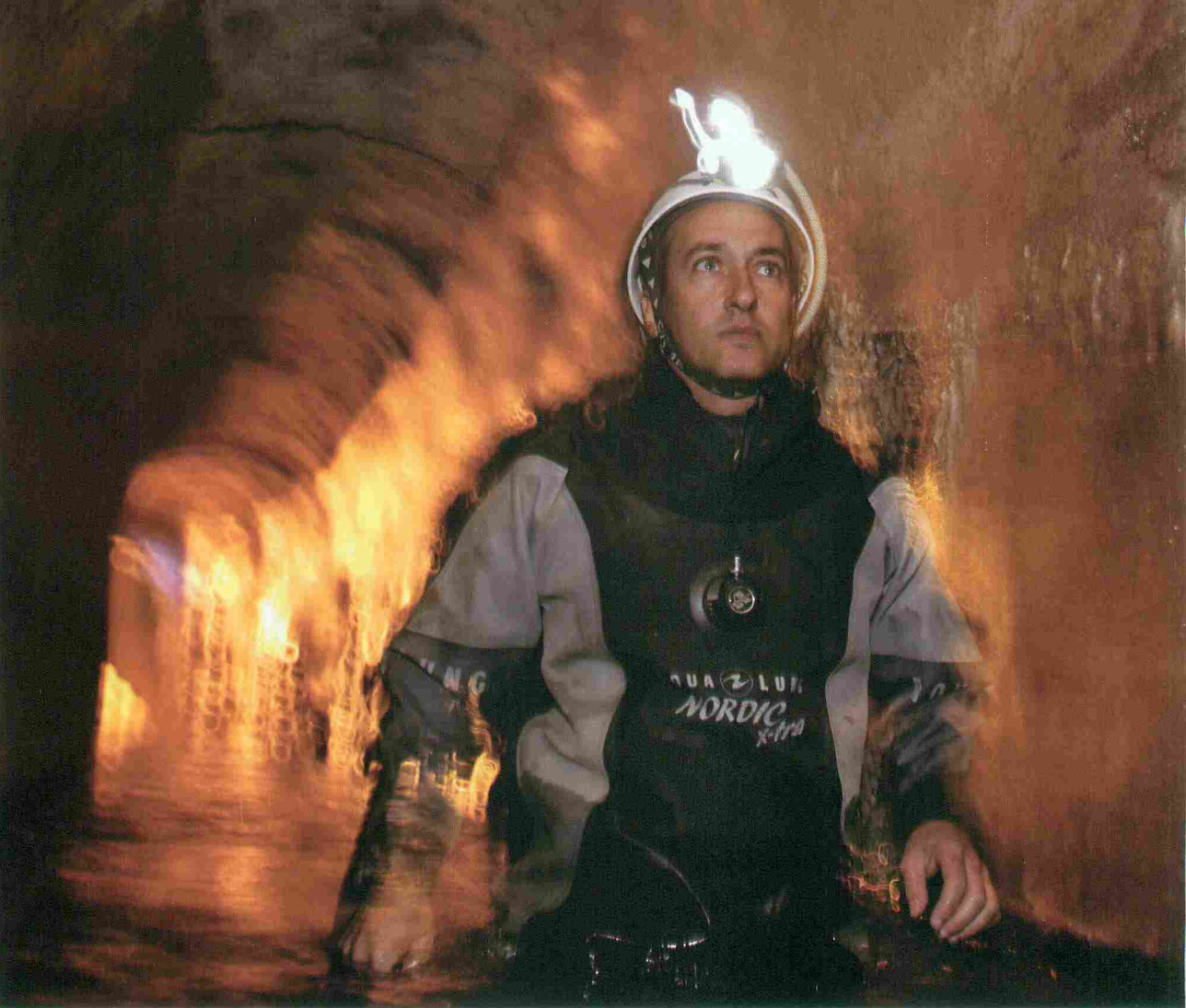




Accessible Underground Sites of Rome

- | | | |
|--|---|----------------------------|
| 1 Colosseum | 4 Warehouse
(later San Clemente complex) | 6 Circus Maximus Mithraeum |
| 2 Domus Aurea
(under the Baths of Trajan) | 5 House (later Saints John
and Paul complex) | 7 Forum Holitorium temples |
| 3 Ludus Magnus | | 8 Domus Tiberiana |
| | | 9 Temple of Venus and Rome |





A rivulet coming from the darkness flows down the rubble. Someone asks if it's dirty or clean. "It's very dirty," Luca says, eyeing the opening beyond, "but very important."

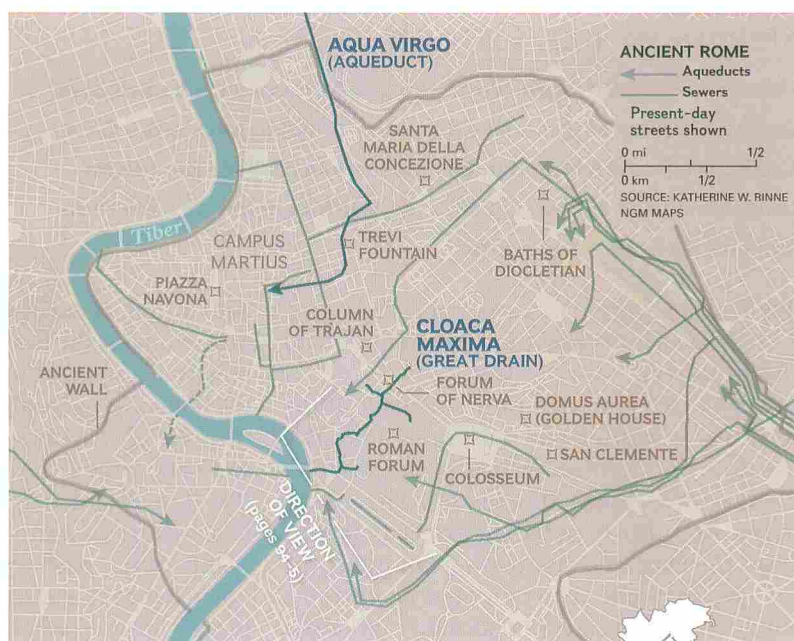
The cloaca, originally an open drain, was intentionally buried during the time of the Roman Republic, but most of what underlies Rome is there accidentally, buried by two millennia of sedimentation and urban growth.

"Rome has been rising for 3,000 years," says Darius Arya, an archaeologist and director of the American Institute for Roman Culture. Much of Rome is situated in a floodplain, including the modern city center, known in antiquity as Campus Martius, at a bend of the Tiber River. Although the Romans put up levees, the city still flooded periodically, so they built upward, laying new structures and streets on earlier ones. "It was cost-effective, and it worked," Arya says.

"We see the Romans jacking their city up two meters at a time, raising themselves above the water but also burying their past."

Today the city sits on layers of history 45 feet deep in places. But ironically, while the beguiling truth of Rome is that you can dig a hole anywhere within the 12-mile ring of walls that once enclosed the ancient city and find something of interest, comparatively little of this buried city has been excavated.

"I don't imagine more than 10 percent has been documented," Robert Coates-Stevens says. An archaeology fellow with the British School at Rome, Coates-Stevens has been trying for a decade to piece together the topography of ancient Rome. During the 1800s, the Roman Forum was dug out—work that continues—but most ancient structures are still trapped under the traffic-clogged streets and office buildings of the contemporary city. "It's a heady feeling,"



TRAVERSING ANCIENT ROME

Marco Placidi (left) marches past the timeworn walls of the Aqua Virgo, the only aqueduct in Rome still in use after 20 centuries. A founder of the urban speleological group Roma Sotterranea, Placidi inspects new finds and underground sites, including ancient waterworks that run through the urban center (above). "Most of underground Rome remains unexplored, waiting to be discovered," he says.

Coates-Stevens says, "to think that all this still lies beneath our feet awaiting discovery."

In the 1920s and '30s, seized with this kind of excitement, Benito Mussolini razed sections of Rome's historic center, where medieval and Renaissance houses stood, to reveal the layers below—specifically anything dating back to the time of Emperor Augustus. (Mussolini liked to compare himself to Augustus and equated fascism with Pax Romana, the time of peace ushered in by Augustus.) By the 1980s this big-hole approach to archaeology had fallen out of favor, in part because of the financial challenge of protecting the ruins Mussolini had exposed from acid rain, smog, and vandalism. But curiosity about Rome is eternal, and so the vanguard of archaeology has shifted: Archaeologists, and the speleologists they employ, are exploring ancient spaces from below, leaving the surface undisturbed.

Cristiano Ranieri pulls a dry suit over his head and fixes a full-face respirator in place. Above, the hum of tourist traffic bounces off the travertine and brick surfaces of the Colosseum. But down here, among the maze of passages where gladiators would have waited and lifts would have raised lions, bears, and other exotic animals up to the action, the sound is muffled. Ranieri becomes visibly excited as he describes scuba diving beneath the Colosseum, explaining that this space, inside the 40-foot-deep "doughnut" foundation that holds up the rest of the structure, isn't even the bottom. He removes a steel plate from the floor to reveal a still body of dark gray water several yards below: the underbelly of the underbelly of the Colosseum.

Ranieri is scouting a new access point into the drain system for a future measuring project. In particular, he wants to know whether he will be able to carry a full underwater lighting rig into

SPIRITS IN THE CELLAR

The blood of a bull sacrificed to the god Mithras once spilled over the marble floor of this second-century building beside the Circus Maximus—Rome's famed public racecourse. Built to mimic the caves often used as worship sites by devotees of Mithras, the room remains almost perfectly intact.

this hole or be forced to use portable flashlights. A well-lit swim below the Colosseum could change history.

Until three years ago only a quarter of the conduits—the driest and most easily accessible—below the Colosseum had been explored. These simple drains, designed to whisk away storm water, date from the late first century A.D., when the Flavian emperors were building the Colosseum. Some ancient writers claimed the building was deliberately flooded for mock naval battles. But there was no evidence of the large waterworks needed to bring in the water.

Then, in October 2003, Ranieri, an archaeologist and speleologist with the superintendency of archaeology, made a startling discovery. Below the simple drains (and predating the Colosseum) were large conduits constructed by Emperor Nero to charge an artificial lake in his gardens. The conduits had obviously been reused by the architects of the Colosseum, most likely to pipe quantities of water in and out. For the first few years of its history, at least, the Colosseum, like many other theaters, was capable of being flooded.

Far more common than planned expeditions to reveal Rome's hidden secrets are the chance discoveries: A work crew digs a hole in the street and cracks into a hollow underground space. Speleologists are called in, and yet another astounding find alters the picture. Such was the case on the Oppian Hill two winters ago when, after a period of intense rain, a hole spontaneously opened near a tree, exposing a matrix of underground rooms.

Marco Placidi, a coolheaded speleologist and a founder of Roma Sotterranea, was called in. Using ropes and harnesses, Placidi lowered himself into a dark, 40-foot-high room, which archaeologists believe was built sometime after Nero's nearby Domus Aurea ("golden house"), dating from A.D. 65, and sometime before the Baths of Trajan (circa A.D. 109), located above both of these structures.

This room, it turned out, is one of the best preserved features from the Roman world, with meticulously flat brickwork and large arches. But for Placidi, the heart-thumping moment came halfway down, when, hanging in midair, he aimed his headlamp at the wall: On it was a mosaic, in perfect condition, showing a group of naked men harvesting and stamping grapes. The "Vendemmia" ("Grape Harvest"), as it was called, is some ten feet long and made of minuscule, vividly colored bits of marble and other stone. "When I dropped down into this hole, I never imagined I'd see something like this," Placidi says. "It was an immense joy."

To an outsider, the randomness of such discoveries is shocking. But for Romans, it is quotidian. In the course of going about his business, someone somewhere bumps up against an artifact that hasn't seen the light of day for hundreds—or thousands—of years. Every year, the city authorizes 13,000 requests for building permits, each of which requires archaeological evaluation. Construction of roads and sewers in Rome's ever expanding suburbs is years behind because the overwhelming number of finds stops work and throws budgets into disarray.

The city of Rome has been trying hard to extend a sewer to the Appian area in the southeast for the past three years but has made little progress, according to Davide Mancini and Sergio Fontana. They run a cooperative of archaeology





graduate students called Parsifal, contracted by the city's cash-strapped archaeology office to monitor the work of dozens of construction crews. At any time, Parsifal may be overseeing up to 20 worksites, looking out for artifacts, reporting back to the government, and, if necessary, halting work to analyze finds. Traditional archaeology is painstakingly slow, but Parsifal's experts must be able to spot a precious object and assess its value in the seconds before the shovel plunges in.

On a typical day at the site, as Mancini and Fontana watch, a backhoe has to stop four times in a single half hour. A harried graduate student jumps into the muddy pit and tosses up treasure: a lamp, several plates and bowls, small terra-cotta sculptures, and countless fragments of amphorae—much of which might date from the third or fourth century B.C.

"This zone is a mess," Davide says. He explains that work began here in June 2003, expecting

the project would take a few months. But completion is still nowhere in sight.

A few minutes later, the backhoe stops again. The student hops into the hole and sends up several very large pieces of amphorae, one of which has a glob of something stuck to it. Brightening, Sergio sniffs it. He says that it might be resin used to seal the amphora, a rare find. Davide disagrees. He thinks it might be incense, maybe from the amphora's reuse in medieval times. Regardless, the fragment goes into a plastic bag, which goes into a box next to dozens of other boxes that wait for the truck to take them to a warehouse. Meanwhile, the backhoe driver finishes his cigarette and asks permission to continue digging.

Interruptions such as these cannot be planned for in advance, in part because it is impossible to know what the underground has in store. (Ground-penetrating radar, which works *well* in



A centuries-old spiral staircase fitted with modern lighting leads to the Aqua Virgo, which brought ancient Rome drinking water and still supplies some of its famed fountains.



PORTAL TO THE PAST

Masked against stench and germs, Luca Antognoli enters a fetid passage of the Cloaca Maxima at the Forum of Nerva to inspect the 2,500-year-old sewer. Still used today, the “great drain” holds fragments of ancient sculpture along with yesterday’s trash. Says Antognoli, “Every time you turn around, you see vestiges of the past.”

rural settings, has difficulty differentiating complex, debris-filled soils in continuously inhabited places.) Beyond that, the length of any delay depends very much on the value assigned to what is found. Some things, like amphorae sherds, can be quickly dismissed. Others, like buildings, may need to be sketched, measured, and otherwise documented. And occasionally, if something is unique, the Italian state may mandate that it be made accessible to the public.

This troubles many Romans. “No one wants the Beni Culturali knocking on their door,” Robert Coates-Stevens says, referring to the state ministry that oversees archaeology. Traditionally, private property owners have been loath to report that errant column in the basement. But this could change as people come to think of having a piece of ancient history as an asset rather than a liability.

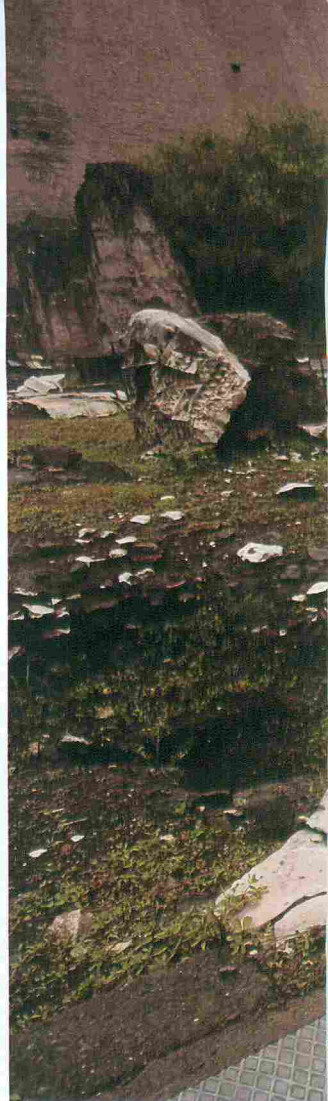
Five years ago Alda Fendi, scion of the Fendi fashion empire, bought a section of a Renaissance palace in central Rome just yards from the Column of Trajan. Her interior designer gutted the space for an art gallery, but in the course of the work, laborers digging in the basement discovered architectural footings of the Basilica Ulpia, a law court built by Emperor Trajan in A.D. 112 and attached to his forum. After a brief excavation and documentation, the state archaeologists recommended that part of the paving be restored and left visible. Fendi understood the importance of the find and envisioned incorporating the basilica into her gallery. She got permission to finance continued digging through the foundation of the palace and out under the piazza in front. The work eventually revealed a large section of the Basilica Ulpia, including several columns along with well-preserved flooring made of green and yellow marble and purple Phrygian marble.

“The marbles were an emotional find,” Fendi says. “They are beautiful, and I knew immediately that, if possible, I wanted to use them in our gallery.”

Urban speleologists like to joke about their work, poking fun at each other as they slog through sewers scaring each other with tales of rats the size of dogs and other nonsense. But as Marco Placidi and Adriano Morabito slip into their dry suits and descend the spiral staircase called La Chiocciola (“snail shell”) in central Rome, they get very quiet and very serious. To them, this is sacred space. At the bottom, the steps drop off into the Aqua Virgo, an underground aqueduct carved through solid rock by Emperor Augustus’ right-hand man, Marcus Agrippa, in 19 B.C. It travels more than ten miles from a spring in Salone, source of the most constant pure water supply Romans have ever enjoyed. The aqueduct is still in use, feeding the Trevi Fountain and Gian Lorenzo Bernini’s Fountain of the Four Rivers in Piazza Navona.

Roma Sotterranea surveyed the Aqua Virgo for the city’s water utility several years ago, fixing its position with lasers, compasses, and the occasional pop to the surface for a GPS reality check. This day the group has returned to double-check earlier work and to float in dry suits through the conduit.

The water, at cheek level, comes directly from the spring and is pretty cold. The walls of the Aqua Virgo, though cut from solid stone, are remarkably regular, recalling the rectilinear blocks of the Cloaca Maxima. But the two spaces couldn’t be more different. One brings pure, life-giving





water, while the other takes away putrid effluent. If the key to ancient Rome is water, then these two systems form the anchors of a critical continuum.

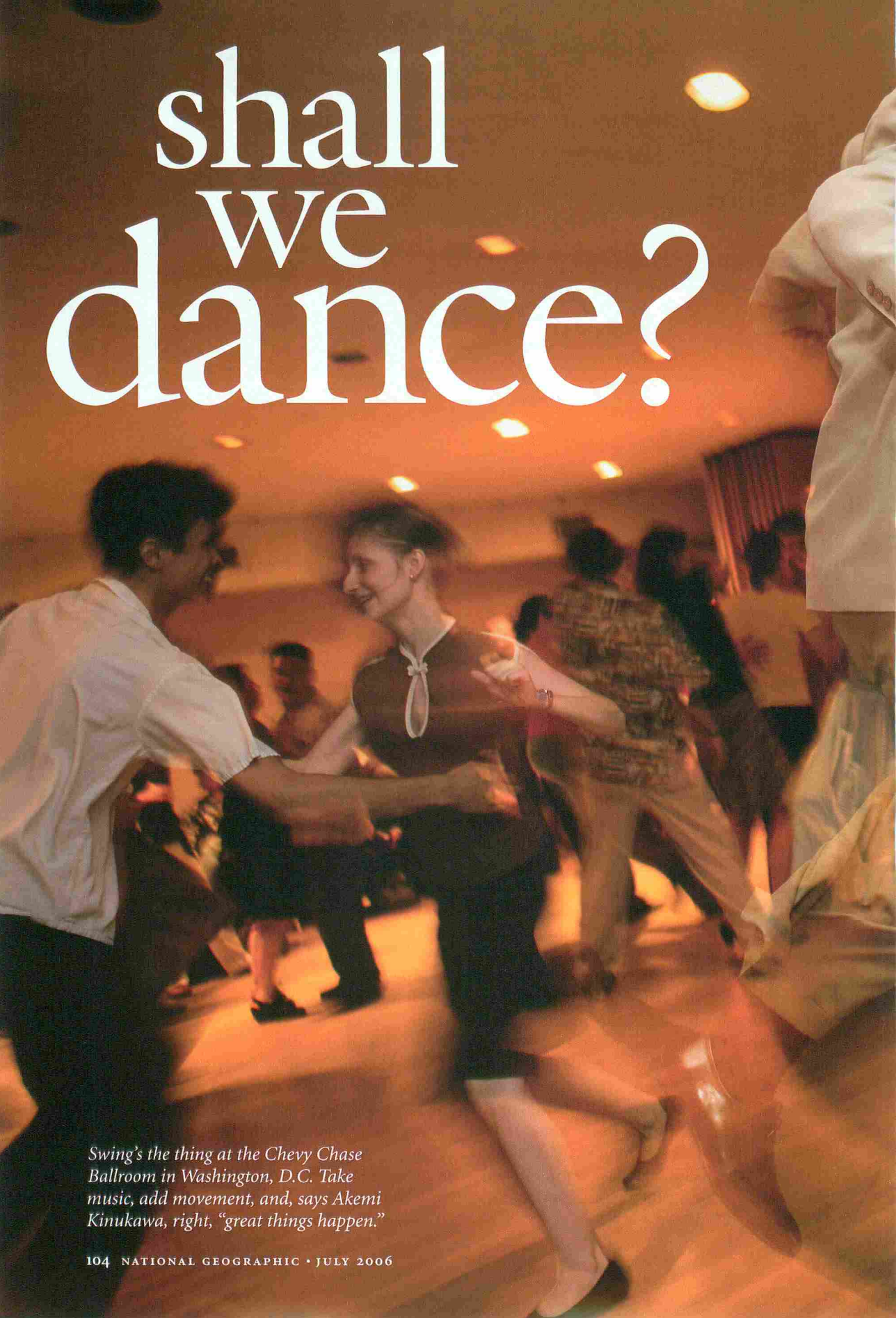
As the group presses on toward the Trevi Fountain, Nick De Pace, a teacher of architecture at the Rhode Island School of Design on a Fulbright fellowship studying Rome's underground structures, points out the curved lines where excavators scratched their way through the solid tuff 2,000 years ago. He describes a work crew using hand tools to chisel, by torchlight, a smooth, sloping conduit that looks, to modern eyes, as if it had been made by machine. For him, Rome's aqueducts and sewers are emblematic of the can-do spirit of Roman civilization. "Nobody thinks the sewers are that important," he says, examining a stalactite where calcium-rich groundwater is seeping into the aqueduct. "But for me they explain how and why Rome existed."

The exploring party comes to a wall of modern concrete where the original conduit has been truncated and its water diverted into a modern pipe. The pipe takes the flow downhill to the Trevi Fountain and beyond. What might it lead to? A new branch veering off to feed some buried ancient building whose discovery would bring the infrastructure of Rome into sharper focus?

"Rome is the biggest open-air museum in the world," says Darius Arya of the American Institute for Roman Culture. "There's so much to explore. I find it funny that people talk about diving to the bottom of the sea or climbing far-away peaks. Here's Rome, where we still don't know what's underneath." □

➤ **In Rome's Basement** Trace the ruins with a high-resolution map. Then get tales from the field and a Web-exclusive photo gallery at ngm.com/0607.

shall we dance?



Swing's the thing at the Chevy Chase Ballroom in Washington, D.C. Take music, add movement, and, says Akemi Kinukawa, right, "great things happen."



By Cathy Newman NATIONAL GEOGRAPHIC SENIOR WRITER

Photographs by Brian Lanker

planets **spin.** — lightning leaps. atoms dance. and so do we.

From the first kick of a baby's foot to the last "Anniversary Waltz," we dance—to internal rhythms and external sounds. Before the written word, humans spoke the language of dance. It's as ancient as the 3,400-year-old image of a man with a lute, dancing on a clay plaque discovered in northern Israel.

We dance, not just with our bodies, but from the heart. "Dance is bodies sounding off," says Judith Lynne Hanna, an anthropologist at the University of Maryland. We pour out love and hate, joy and sorrow; appeal to the spirits, gods, and nature; flirt, seduce, court; celebrate birth, death, and everything in between. We even presume to reorder the world, as if, in the Shaker song, by "turning, turning we come round right." Dance is so profane, some religions ban it; so sacred, others claim it.

Dance in America can hardly contain itself. We dance—from Florida to Alaska, from horizon to horizon and sea to sea, in the ballrooms of big cities and whistle-stop bars, in Great Plains Grange halls, underground kivas, church basements, barrio nightclubs, and high school auditoriums. We do the beguine, polka, waltz, fox-trot, tarantella, jitterbug, samba, salsa, rumba, mambo, tango, bomba, cha-cha, merengue, mazurka, conga, cakewalk, Charleston, two-step, jerk, swim, Watusi, twist, frug, monkey, electric slide, Harlem shake, shim sham shimmy, cabbage patch, fandango, garba, gourd dance, corn dance, hora, hopak—as if our lives depended on it. Some believed just that: A medieval superstition averred that dancing in front of Saint Vitus's statue ensured a year of good health.

We dance out of anguish, to attain solace, and, sometimes, in an attempt to heal. "I remember a couple," says Lester Hillier, owner of a dance studio in Davenport, Iowa. The husband was a retired farmer. His wife, a housewife, wore flat shoes and a floral housedress. "One of their sons had been killed," Hillier recalls. "He'd been in a love triangle and was shot in a club. The devastated parents had a dance lesson booked the day after it happened. They insisted on coming anyway."

They practiced the steps they'd learned—the rumba, the fox-trot, the

exuberant movements of swing. As the hour drifted to a close, the couple asked for one last dance. They wanted a waltz. And when it ended, she rested her head on his chest; he wrapped his arms around her shoulders. Then they stood still, clinging to one another.

"If we just sat at home, what would we do?" he said quietly.

Dance, like the rhythm of a beating heart, is life. It is, also, the space between heartbeats. It is, said choreographer Alwin Nikolais, what happens between here and there, between the time you start and the time you stop. "It is," says Judith Jamison, artistic director of the Alvin Ailey American Dance Theater, "as close to God as you are going to get without words."

To dance is human. To dance is divine.



Skirts bloom at a square dance in Albany, Oregon. "It's friendship set to music," says Marilyn Schmit, who met her husband on a square dance date 16 years ago.





Flight of fancy: Dancers improvise on the roof of OfficeOps, a factory converted into an arts performance center and studio space in Brooklyn. Dance embraces the breadth and depth of what it means to be human. "A dancer's world is the heart of man," said choreographer Martha Graham.

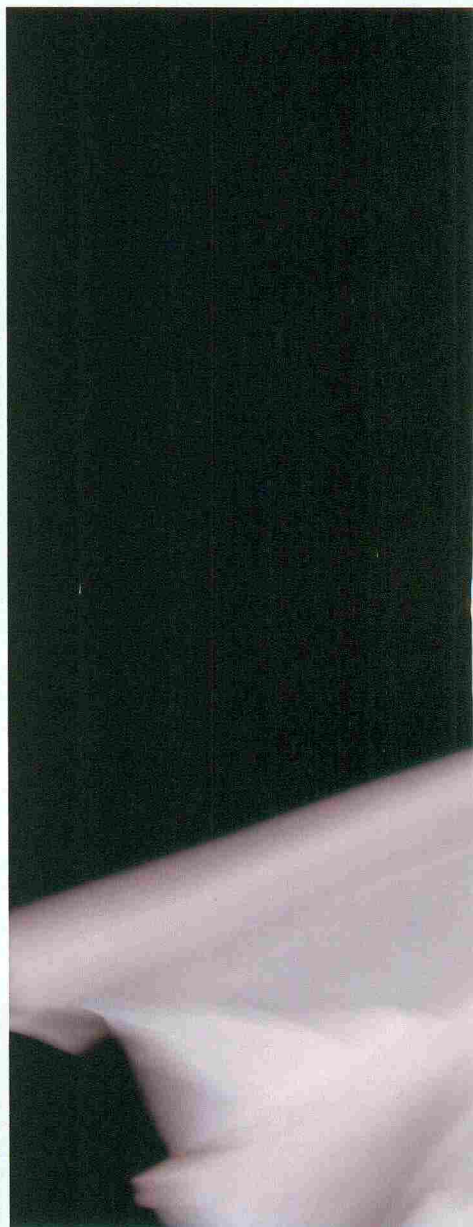
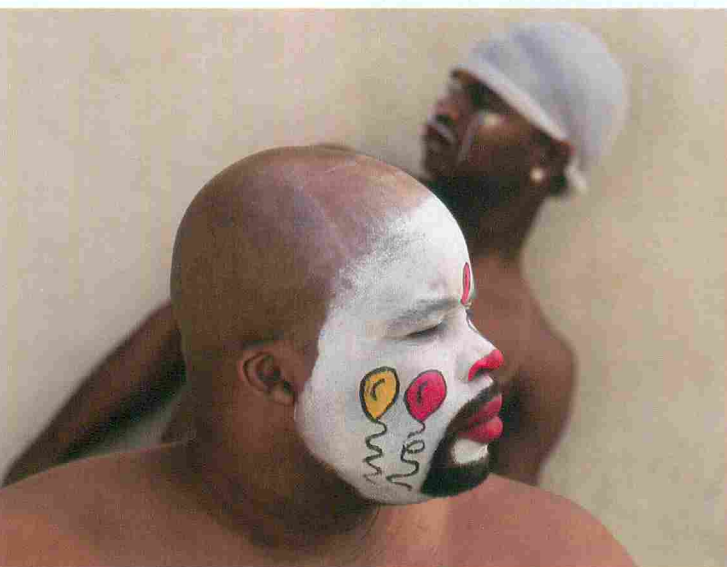
“I created the Battle Zone competition.
You still want to be better than this person.
You’re happy because you just shot this
dude down with dance moves.”

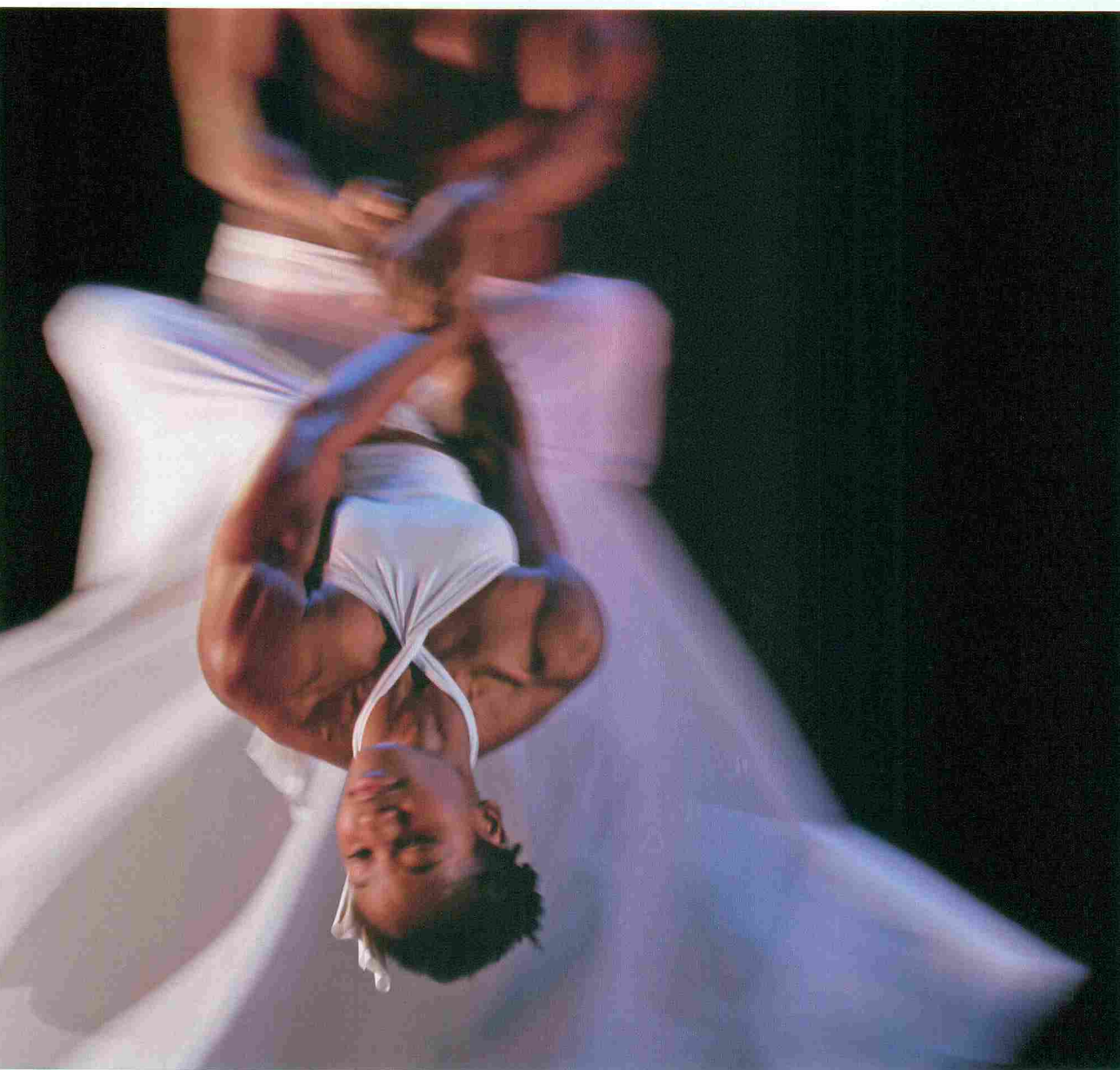
THOMAS JOHNSON

“Tommy the Hip-Hop Clown”

South Central Los Angeles

A fast life dealing drugs landed him in jail, but now Thomas Johnson does good in the 'hood as Tommy the Hip-Hop Clown. “I could have been dead, but I got it together,” he says. As part of his mission, he spreads the word it’s cool to krump—a don’t-mess-with-me set of torso and hip-snapping moves that generates more rpms than rush hour on a Los Angeles freeway. “Krumping is a creative alternative to gang fighting,” Tommy says. “It’s how you take out aggressions without violence.”





Modern, Cuban, and African dance styles interweave in "A Piece of White Cloth," danced by Patricia West Sotelo of the Alayo Dance Company in San Francisco.





From generation to generation, Jewish weddings, such as the marriage of Jason van Winkle to Candy Kühl in Los Angeles, have celebrated the tradition of hoisting the new couple on chairs while guests dance in a circle to honor them as one would a king and queen.



“A big part of the fun is creating something that is yours. Sometimes the dog ad-libs and throws in something extra. It’s more of a team effort.”

DIANE KOWALSKI AND WES

Canine Freestyle Dancing

Tyrone, Pennsylvania

In the dogma of canine freestyle competition, dog and handler are judged on artistic impression and technical merit in the execution of a choreographed routine. Champions Diane Kowalski and Wes have danced to Michael Jackson’s “Bad” and the Beatles. “We look for music that matches the dog’s natural rhythm. With the right piece, the dog lights up, its tail wags harder,” says Alison Jaskiewicz, who writes about and judges the sport.

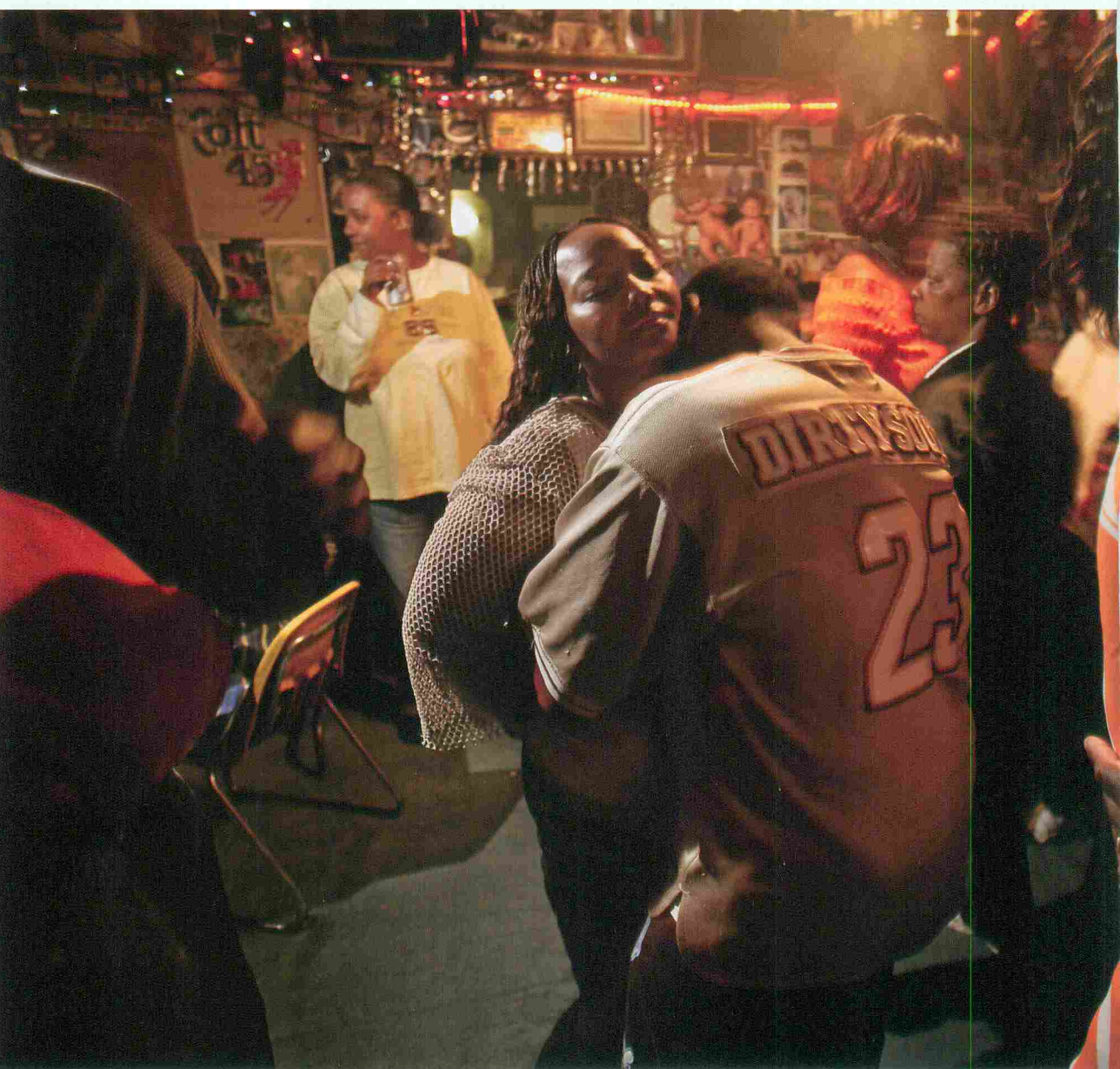


As if stepping on air, Yuan Yuan Tan of the San Francisco Ballet dances Juliet in Prokofiev’s Romeo and Juliet. Ballet originated in European courts of the Renaissance.





Saturdays, from June through September, the plaza by Shakespeare's statue in Central Park turns into a tango club for dancers such as Emma Gorelik and Mehdi Ghadimi. "I don't know if tango breaks or heals hearts," says Lucille Krasne, a founder of the event. "But it is about making a connection."



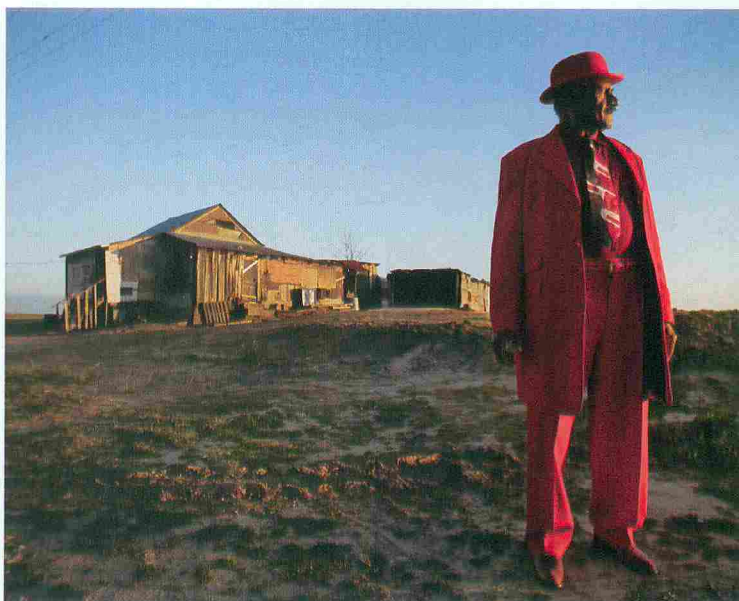
“The only thing we play here is nothing but the blues...no rap music. That bump, bump music, half the time you can’t hear what they’re saying...no way.”

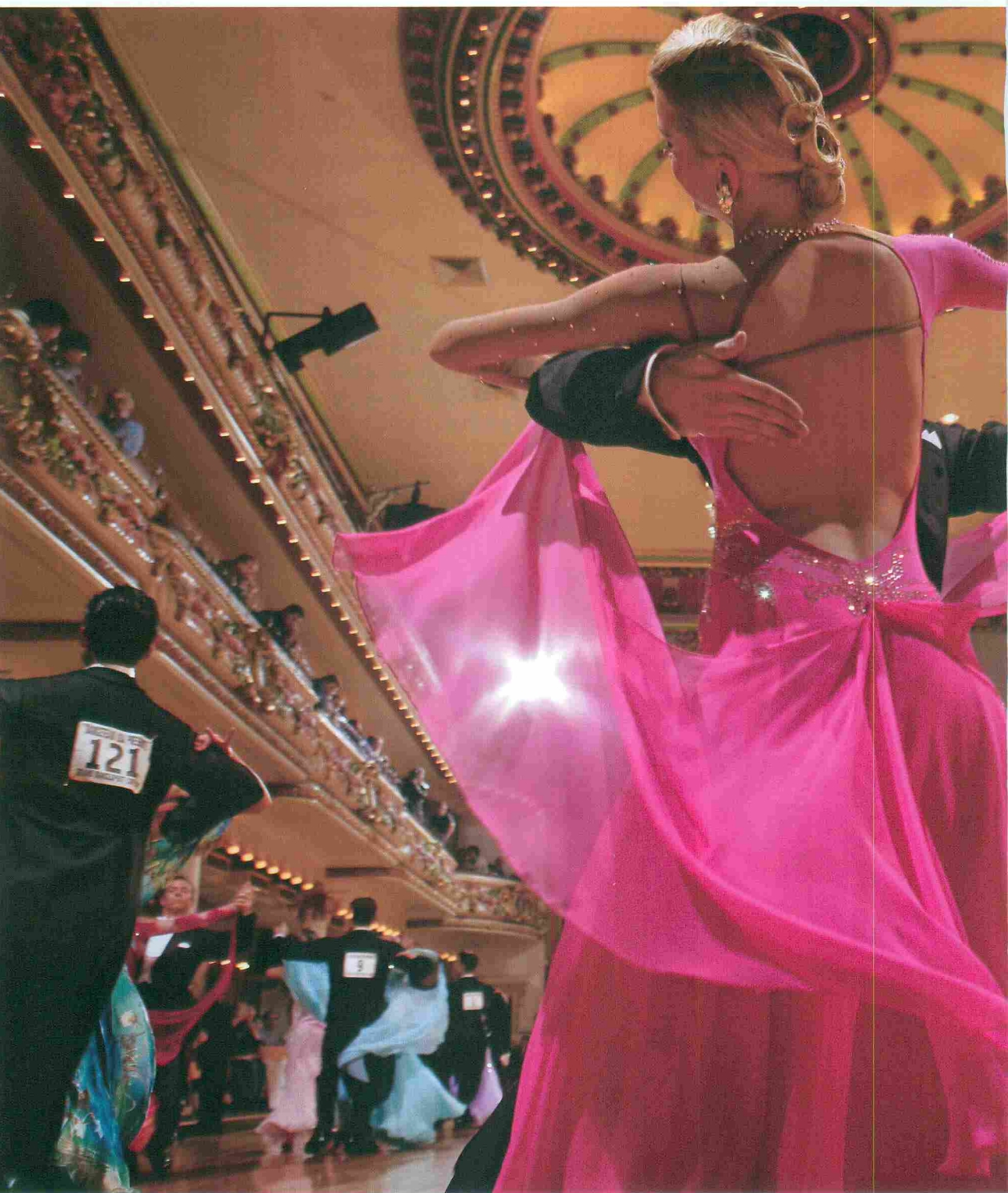
WILLIE “PO’ MONKEY” SEABERRY

Juke joint owner

Merigold, Mississippi

To get to Po’ Monkey’s Lounge, head south along U.S. Highway 61 through Hushpuckena and Mound Bayou, turn off at Merigold, and listen for the sound of blues in the night. Inside a worn clapboard shack at the end of a thin dirt road, you’ll find a scene as sultry as a Delta summer night. “This is called a juke house,” says owner Willie Seaberry (below). “When I was growing up, there was a bunch of them around, but they all gone bye-bye. We’re about the last one out this way.”







Elegance moves in three-quarter time as contestants waltz at the Grand DanceSport Cup competition held at the Grand Prospect Hall in Brooklyn. "This is Fred Astaire and Ginger Rogers style dancing and beyond," says Aleksandr Chmerkovskiy, who organizes the event.

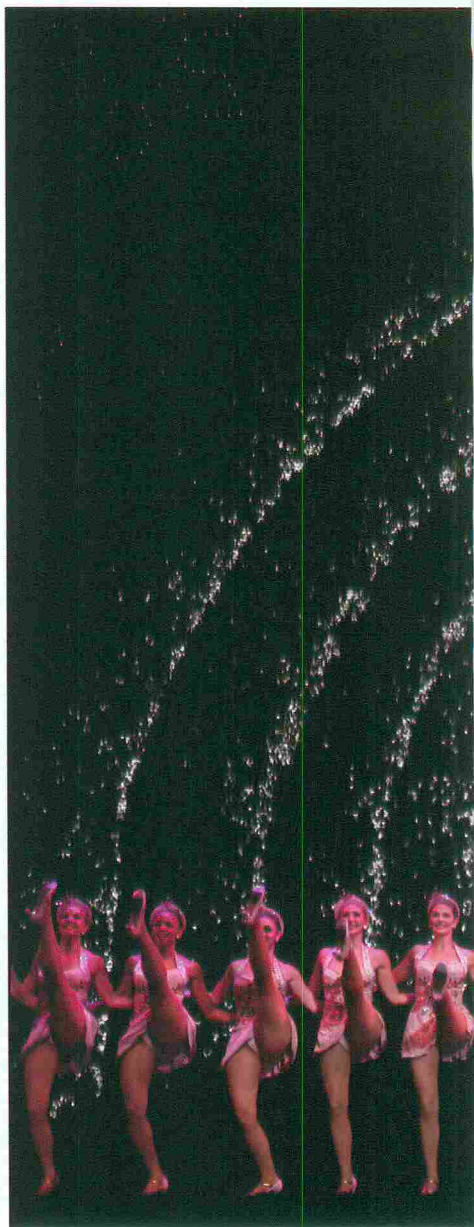
“When I went to the New Amsterdam Theatre at 14 and joined the chorus, I didn’t expect to be the very, very last of the Ziegfeld girls, but here I am.”

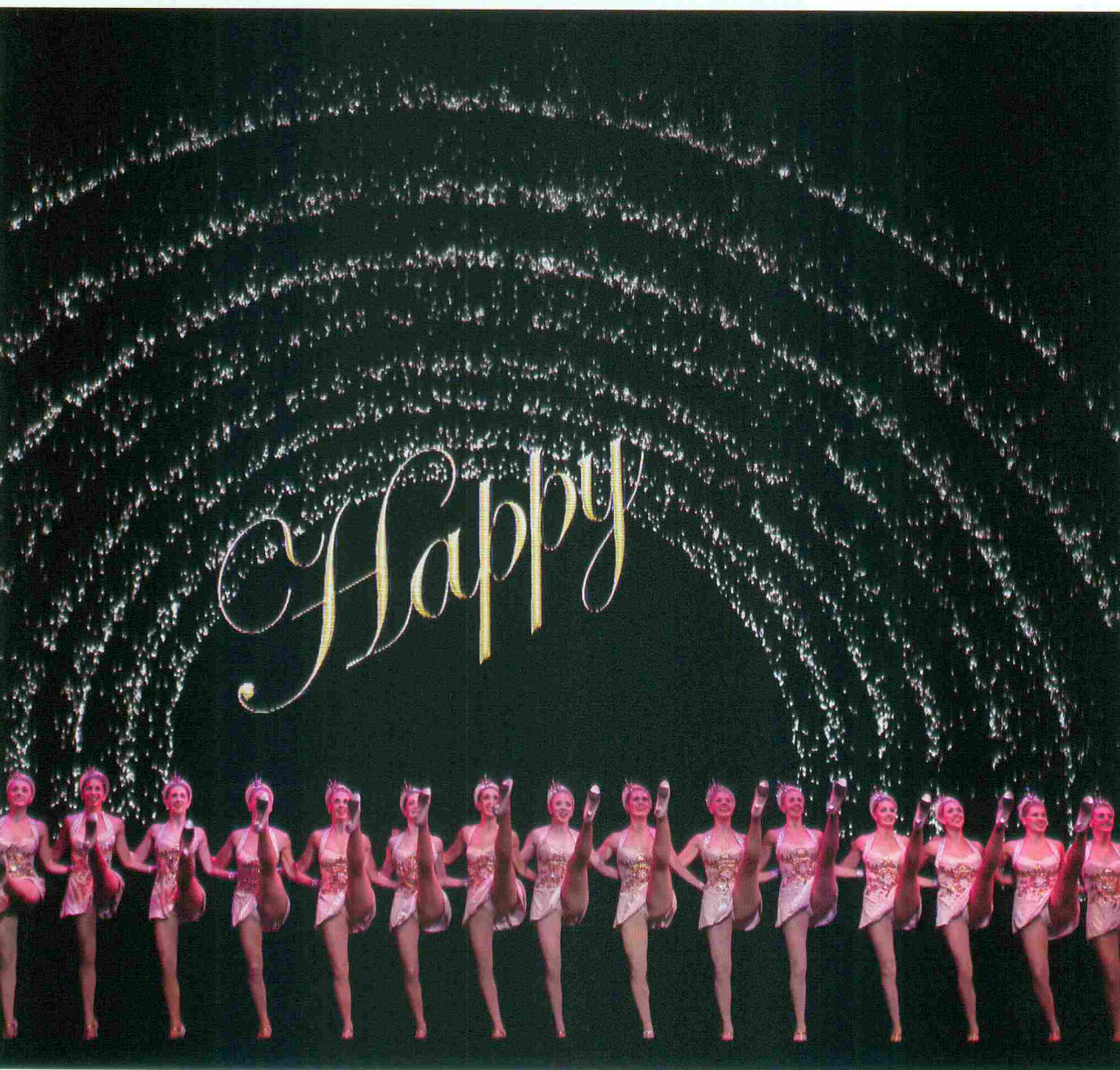
DORIS EATON TRAVIS

102-year-old former Ziegfeld Follies dancer

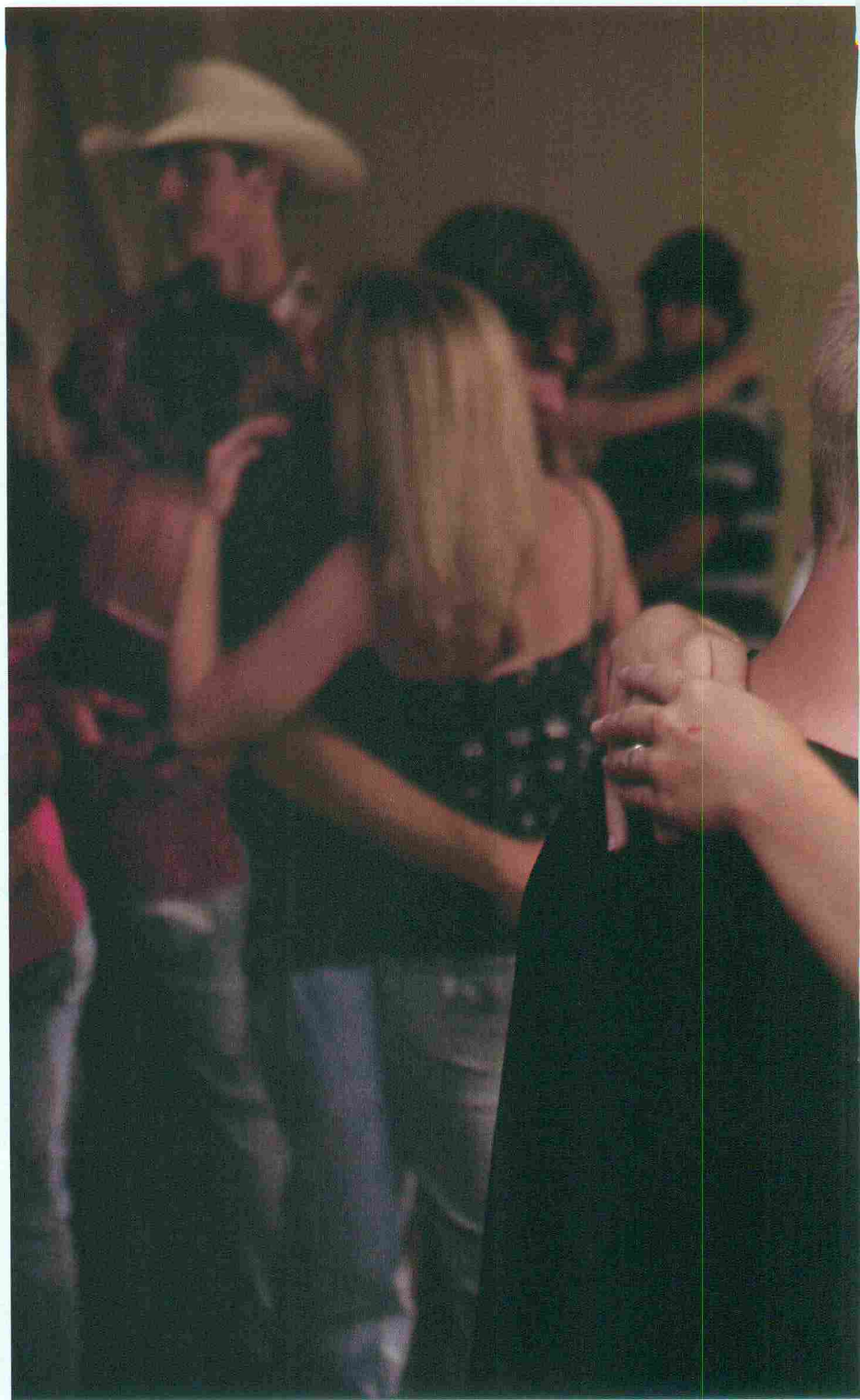
Norman, Oklahoma

The dancing has never stopped for Doris Eaton Travis, pictured in front of her younger self as a Ziegfeld Follies girl in 1919. “Mr. Ziegfeld had what you might call a sensuous touch,” she says. “The costumes were scant sometimes, but they were beautiful, and you were never offended by them.” In 1938, she left New York and ran a chain of dance studios in Michigan. Today she lives on a horse ranch in Norman, Oklahoma, and still goes dancing. “I don’t do cartwheels and splits and things, but I can do the fox-trot, waltz, and samba. It just takes a little more breath these days.”





The ultimate chorus line, the Rockettes, kick up their heels in front of more than 2.1 million people each year at Radio City Music Hall in New York.



"I'm always the first one on the dance floor," says Lacey Persell, with boyfriend, Tanner Dawson, at the Hope High School homecoming in Hope, Kansas. Dance is passion and consolation. "It gets deep down in your heart. When I'm in a bad mood, I go out in my garage and dance, and everything goes away." □



👉 **American Dance** Take a turn through America's dance halls and studios in a special multimedia show at ngm.com/0607.



the downside of upright



The agility and brainpower we've gained since our ancestors stood up on two feet haven't come without evolutionary trade-offs: a plethora of aches and pains that make it hard to be human.

Homely but highly dexterous, a chimp's flat feet have strong, thumblike opposable toes that allow for climbing, grasping, and fingering a berry—or a beautiful but impractical shoe. Our bipedal ancestors gave up all this in favor of rigid, arched, hyper-specialized feet prone to many ills.

by jennifer ackerman
photographs by cary wolinsky

We humans are odd creatures: tailless bipeds with sinuous spines, long limbs, arched feet, agile hands, and enormous brains. Our bodies are a mosaic of features shaped by natural selection over vast periods of time—both exquisitely capable and deeply flawed. We can stand, walk, and run with grace and endurance, but we suffer aching feet and knee injuries; we can twist and torque our spines, and yet most of us are plagued by back trouble at some point in our lives; we can give birth to babies with big brains, but only through great pain and risk. Scientists have long sought to answer the question of how our bodies came to be the way they are. Now, using new methods from a variety of disciplines, they are discovering that many of the flaws in our “design” have a common theme: They arise primarily from evolutionary compromises that came about when our ancestors stood upright—the first step in the long path to becoming human.



[A TIGHT SQUEEZE]

In Karen Rosenberg's laboratory at the University of Delaware, a room packed with the casts of skulls and bones of chimpanzees, gibbons, and other primates, one model stands out: It's a life-size replica of a human female pelvic skeleton mounted on a platform. There is also a fetal skull with a flexible gooseneck wire. The idea is to simulate the human birth process by manually moving the fetal head through the pelvis.

It looks easy enough.

"Go ahead, try it," Rosenberg says.

Turn the little oval skull face-forward, and it drops neatly into the pelvic brim, the beginning of the birth canal. But then it jams against the protrusions of the ischial bones (those that bear the burden during a long car ride). More shoving and rotating, and it's quickly apparent that the skull must traverse a passage that seems smaller than itself, cramped not only by the ischial bones but also by the coccyx, the bottom of the tailbone, which pokes into the lower pelvic cavity. Only by maneuvering the skull to face sideways in the middle of the canal and then giving it a firm push, does it move a centimeter or two—before it gets hung up again. Twist it, jostle it: The thing won't budge. Rosenberg guides my hand to turn the skull around to face backward, and then, with a hard shove, the stubborn cranium finally exits the birth canal.

"Navigating the birth canal is probably the most gymnastic maneuver most of us will ever make in life," says Rosenberg, chair of the university's department of anthropology. It's a trick all right, especially if there's no guiding hand to twirl and ram the skull. And the neat two-piece model doesn't even include the broad, rigid shoulders of the human infant, a legacy from our apelike ancestors who, some 20 million years ago, evolved wide clavicles that allowed them to hang suspended from branches and feed on fruit. To follow the head, a baby's

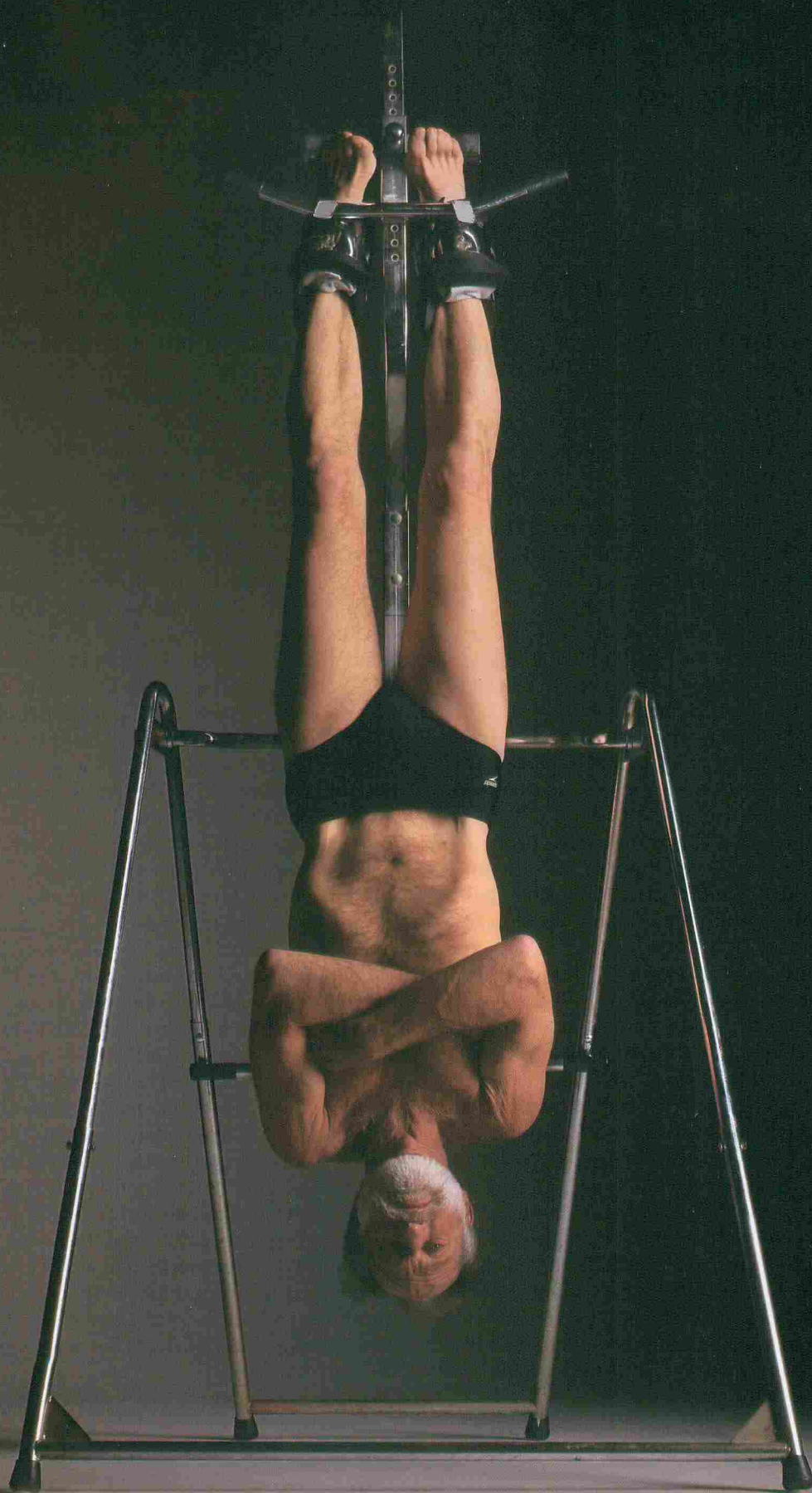
shoulders must also rotate two times to work through the birth canal; they sometimes get stuck, causing injury to part of the spinal nerves that control the arms.

Suddenly I understand as never before why it took 36 hours, two doctors, and three shifts of nurses to safely deliver my firstborn.

Birth is an ordeal for women everywhere, according to a review of birthing patterns in nearly 300 cultures around the world by Rosenberg and colleague Wenda Trevathan, an anthropologist at New Mexico State University. "Not only is labor difficult," Rosenberg says, "but because of the design of the female pelvis, infants exit the birth canal with the back of their heads against the pubic bones, facing in the opposite direction from the mother. This makes it tough for her to reach down and guide the baby as it emerges without damaging its spine—and also inhibits her ability to clear the baby's breathing passage or to remove the umbilical cord from around its neck. That's why women everywhere seek assistance during labor and delivery."

Compared with humans, most primates have an easier time, Rosenberg says. A baby chimpanzee, for instance, is born quickly: entering, passing through, and leaving its mother's pelvis in a straight shot and emerging faceup so that its mother can pull it forward and lift it toward her breast. In chimps and other primates, the oval birth canal is oriented the same way from beginning to end. In humans, it's a flattened oval one way and then it shifts orientation 90 degrees so that it's flattened the other way. To get through, the infant's head and shoulders have to align with that shifting oval. It's this changing cross-sectional shape of the passageway that makes human birth difficult and risky, Rosenberg says, not just for babies but also for mothers. A hundred years ago, childbirth was a leading cause of death for women of childbearing age.

Why do we possess a birth canal of such



backache

Marvin Lipschutz, a 63-year-old physician who suffered from a herniated, or slipped, vertebral disk, hangs on an inversion table designed to relieve back pain and pressure, a technique dating back to Hippocrates in 400 B.C. Today, roughly 80 percent of adults experience back problems sometime in their lives—a consequence of our upright posture. Humans have likely suffered this way since our ancestors first stood up, transforming our backbone from a bridge or arch to a column that must bear the full weight of the upper body. Especially vulnerable is the lower, or lumbar, region of the column, where pressure on the disks that separate our vertebrae can cause them to bulge or herniate.

Byzantine design? “The human female pelvis is a classic example of evolutionary compromise,” Rosenberg answers. Its design reflects a trade-off between the demand for a skeletal structure that allows for habitual walking on two feet and one that permits the passage of a baby with a big brain and wide shoulders. Its unique features didn’t come about all at once, but at different times in our evolutionary history, in response to different selective pressures. “The result of these different pressures is a jerry-rigged, unsatisfactory structure,” Rosenberg says. “It works, but only marginally. It’s definitely not the type of system you would invent if you were designing it. But evolution is clearly a tinkerer, not an engineer; it has to work with yesterday’s model.”

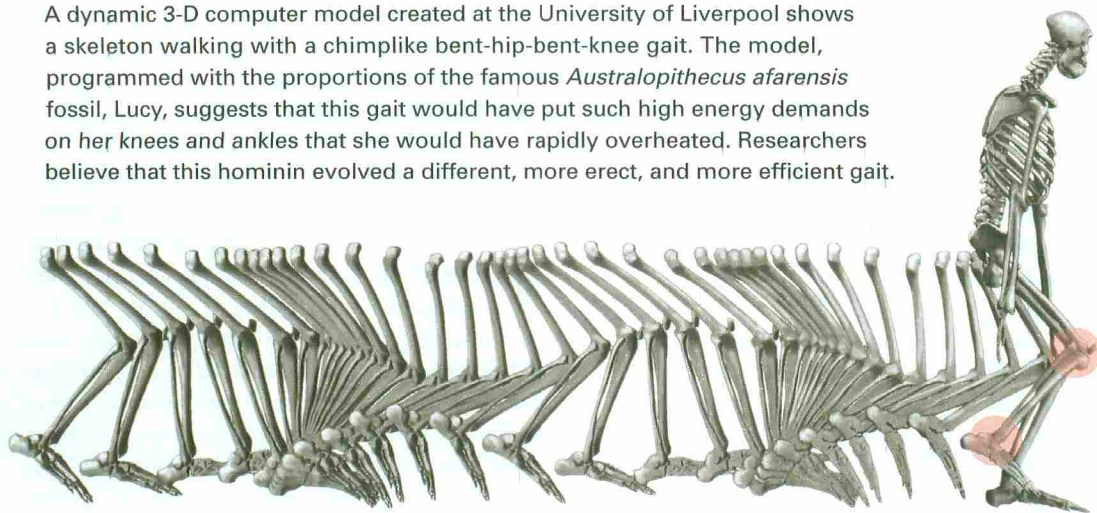
[YESTERDAY’S MODEL]

Humans come from a long line of ancestors, from reptile to mammal to ape, whose skeletons were built to carry their weight on all fours. Our ape ancestors probably evolved around 20 million years ago from small primates that carried themselves horizontally. Over the next several million years, some apes grew larger and began to use their arms to hold overhead branches and, perhaps, to reach for fruit. Then, six or seven million years ago, our ancestors stood up and began to move about on their hind legs. By the time the famous Lucy (*Australopithecus afarensis*) appeared in East Africa 3.2 million years ago, they had adopted walking as their chief mode of getting around.

It was a radical shift. “Bipedalism is a unique and bizarre form of locomotion,” says Craig Stanford, an anthropologist at the University of Southern California. “Of more than 250 species of primates, only one goes around on two legs.” Stanford and many other scientists consider bipedalism the key defining feature of being human. “Some may think it’s our big brain,”

ancestral gait

A dynamic 3-D computer model created at the University of Liverpool shows a skeleton walking with a chimplike bent-hip-bent-knee gait. The model, programmed with the proportions of the famous *Australopithecus afarensis* fossil, Lucy, suggests that this gait would have put such high energy demands on her knees and ankles that she would have rapidly overheated. Researchers believe that this hominin evolved a different, more erect, and more efficient gait.



Stanford says, “but the rapid expansion of the human brain didn’t begin until less than two million years ago, millions of years after we got upright and began using tools. Bipedalism was the initial adaptation that paved the way for others.”

Evolutionary biologists agree that shifts in behavior often drive changes in anatomy. Standing upright launched a cascade of anatomical alterations. The biomechanics of upright walking is so drastically different from quadrupedal locomotion that bones from the neck down had to change. The skull and spine were realigned, bringing the head and torso into a vertical line over the hips and feet. To support the body’s weight and absorb the forces of upright locomotion, joints in limbs and the spine enlarged and the foot evolved an arch. As for the pelvis: It morphed from the ape’s long, thin paddle into a wide, flat saddle shape, which thrust the weight of the trunk down through the legs and accommodated the attachment of large muscles. This improved the stability of the body and the efficiency of walking upright but severely constricted the birth canal.

All of these architectural changes, seen clearly in the fossil record, did not happen overnight. They came gradually, over many generations and over long periods of time, in small steps favored by natural selection.

[UPRIGHT CITIZENS]

Consider the simple human act of walking or running. At his laboratory in the anthropology department at Harvard University, Dan Lieberman does just that, using biomechanical studies to see how we use our body parts in various aspects of movement. As a volunteer subject in one of his experiments last fall, I was wired up and put through paces on a treadmill. On my feet were pressure sensors to show my heel and toe strikes. Electromyographic sensors revealed the firing of my muscles, and accelerometers and rate gyros on my head detected its pitching, rolling, and yawing movements. Small silver foam balls attached to my joints—ankle, knee, hip, elbow, shoulder—acted as reflectors for three infrared cameras mapping in three-dimensional space the location of my limb segments.

These biomechanical windows on walking and running illuminate just how astonishing a feat of balance, coordination, and efficiency is upright locomotion. The legs on a walking human body act not unlike inverted pendulums. Using a stiff leg as a point of support, the body swings up and over it in an arc, so that the potential energy gained in the rise roughly equals the kinetic energy generated in the descent. By this trick the body stores and recovers so much of

the energy used with each stride that it reduces its own workload by as much as 65 percent.

The key lies in our human features: the ability to fully extend our knees; the way our lower back curves forward and our thighbone slopes inward from hip to knee so that our feet straddle our center of gravity; and the action of the gluteal abductors, the muscles attached to the pelvis that contract to prevent us from toppling over sideways mid-stride when our weight is on a single foot.

In running, we shift from this swinging pendulum mode to a bouncy pogo-stick mode, using the tendons in our legs as elastic springs. Lieberman's recent studies with Dennis Bramble of the University of Utah suggest that

"Bipedalism is a unique and bizarre form of locomotion. Of more than 250 species of primates, only one goes around on two legs."

running—which our ancestors mastered some two million years ago—was instrumental in the evolution of several features, including our extra leg tendons, our relatively hairless skin and copious sweat glands (which facilitate cooling), and our enlarged gluteus maximus, the biggest muscle in the body, which wraps the rear end and acts to stabilize the trunk, preventing us from pitching forward. Now Lieberman is studying the role in upright locomotion of a tiny slip of muscle in the neck called the cleidocranial trapezius—all that remains of a massive shoulder muscle in chimps and other apes—which steadies our head during running, preventing it from bobbling.

Watching the graphs from the experiment on a computer screen, one can't help but marvel

at the effectiveness of the system, the little cleidocranial portion of the trapezius steadying the head; the regular pumping action of arms and shoulders stabilizing the body; the consistent springlike rhythms of our long-legged stride.

"Compare this with the chimp," Lieberman says. "Chimps pay a hefty price in energy for being built the way they are. They can't extend their knees and lock their legs straight, as humans can. Instead, they have to use muscle power to support their body weight when they're walking upright, and they waste energy rocking back and forth."

Chimps are our closest living evolutionary relatives and, as such, are especially well suited to teach us about ourselves. Almost every bone in a chimp's body correlates with a bone in a human body. Whatever skeletal distinctions exist are primarily related to the human pattern of walking upright—hence the keen interest in parsing these distinctions among those who study the origins of human bipedalism.

Two-legged walking in a chimp is an occasional, transitory behavior. In humans, it is a way of life, one that carries with it myriad benefits, perhaps chief among them, freed hands. But upright posture and locomotion come with a host of uniquely human maladies.

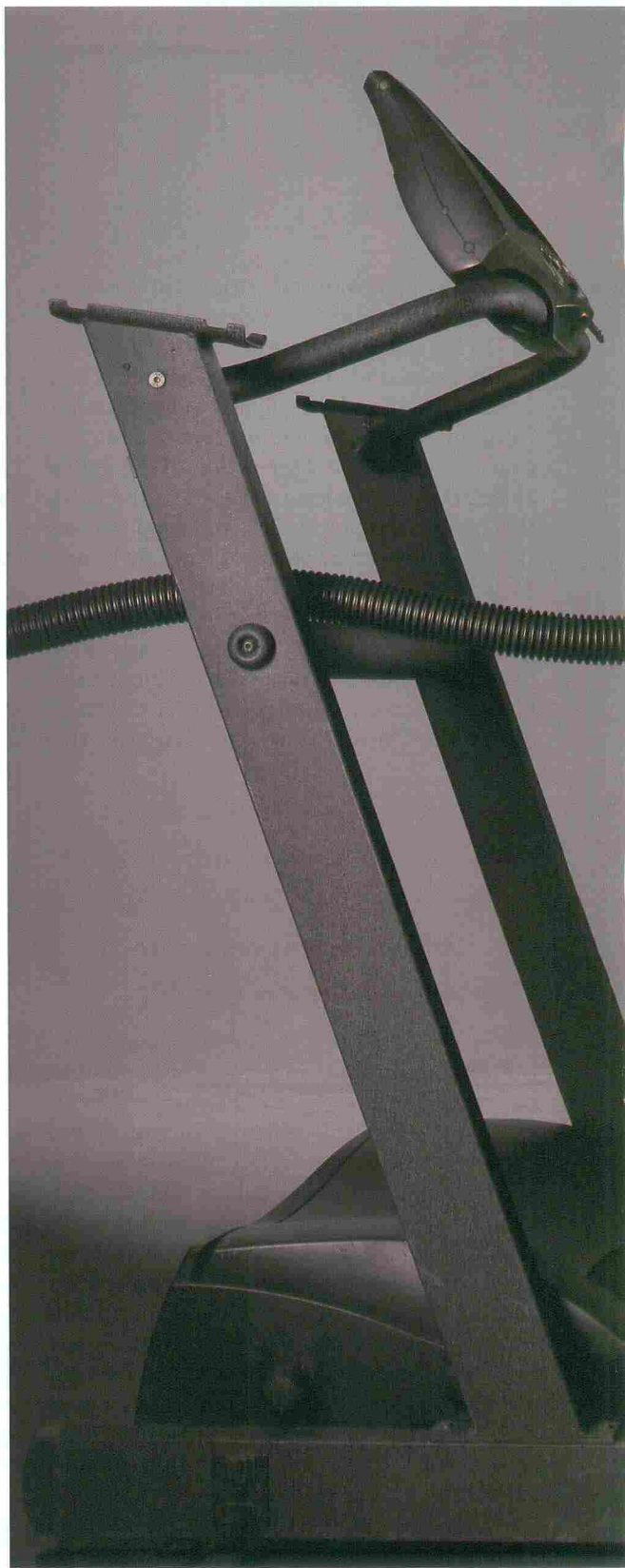
[ACHILLES' BACK]

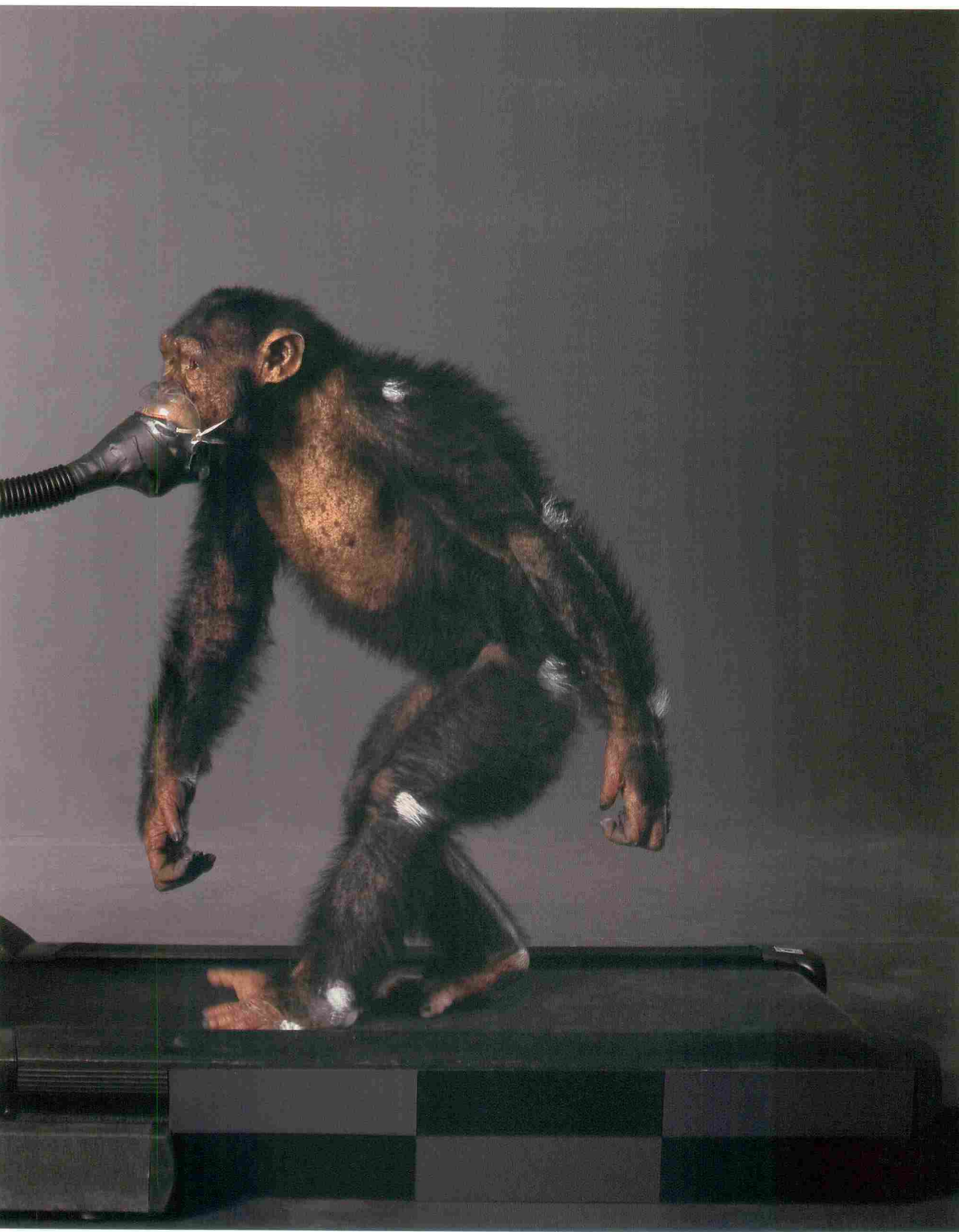
An old friend of mine, a former politician from West Virginia, has difficulty remembering names. He saves himself from embarrassment with a simple trick: He delivers a hearty handshake and asks, "So how's your back?" Four times out of five he strikes gold. Names become unnecessary when the acquaintance, flattered by the personal inquiry, launches into a saga of lumbar pain, slipped disk, or mild scoliosis.

Back pain is one of the most common health complaints, accounting for more than 15 million doctor visits each year. That most of us

energetics

Was walking on two legs an energy-saving measure for our ancestors? To help scientists fathom the answer, a trained, ten-year-old chimpanzee named Louie ambles willingly on a treadmill, first on two legs, and then on all four, his more usual “knuckle-walking” gait. The loose-fitting flow-through mask captures his exhalations, which scientists analyze to measure energy expenditure. White dots on his joints convey to cameras the location and movement of his limbs in space. By revealing the amount of energy Louie expends with each step and how it’s used, such experiments may shed light on the energetics of our chimplike forebears—and whether energy economy was a likely catalyst for their shift to bipedalism several million years ago.





will experience debilitating back pain at some point in our lives raises the question of the spine's design.

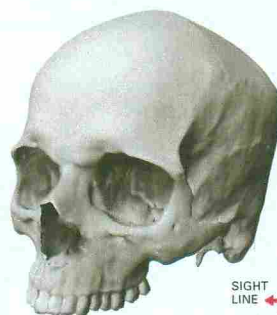
"The problem is that the vertebral column was originally designed to act as an arch," explains Carol Ward, an anthropologist and anatomist at the University of Missouri in Columbia. "When we became upright, it had to function as a weight-bearing column." To support our head and balance our weight directly over our hip joints and lower limbs, the spine evolved a series of S curves—a deep forward curve, or lordosis, in the lower back, and a backward curve, or kyphosis, in the upper back.

This change took place at least four million years ago, probably much earlier. Ward and her colleague Bruce Latimer, director of the Cleveland Museum of Natural History, recently analyzed the vertebral column of Lucy, along with two *Australopithecus africanus* skeletons from more than two million years ago. They found that the spines of all three possess the same S curves present in the human spine, confirming that *Australopithecus* walked on two legs.

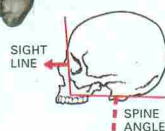
"This system of S curves is energetically efficient and effective for maintaining our balance and for bipedal locomotion," Ward says. "But the lower region of the column suffers from the excessive pressure and oblique force exerted on its curved structure by our upright posture."

Lean back, arching your spine. You're the only mammal in the world capable of this sort of backbend. Feel a cringing tightness in your lower back? That's the vertical joints between your vertebrae pressing against one another as their compressive load increases. The curvature in your lower spine requires that its building blocks take the shape of a wedge, with the thick part in the front and the thin part in the back. The wedge-shaped vertebrae are linked by vertical joints that prevent them from slipping out from one another.

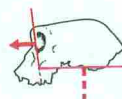
"These joints are delicate structures and very



Homo sapiens
Living bipedal hominin



Sahelanthropus tchadensis
First possible bipedal hominin



Chimpanzee
Quadrupedal ape



6-7 MILLION YEARS AGO

heads up

A hole in the head offers a clue to the beginnings of bipedalism. In modern humans the intersection of the plane of the foramen magnum—the hole where the spine enters the skull—and the plane associated with the eye sockets forms nearly a right angle. In chimps the angle is more acute. The *Sahelanthropus tchadensis* fossil was crushed when found, but a computer reconstruction shows an angle close to perpendicular, suggesting to some scientists that the species, perhaps the oldest hominin, stood upright.

complex,” Ward says. “They allow our spines to move with great flexibility, to twist and bend and flex, pivoting on the disks between the vertebrae.”

But in the lower back region, where the load is heaviest and the wedging most dramatic, strains such as heavy lifting or hyperextension (say, from doing the butterfly stroke or cleaning the gutters) can cause your lowest vertebrae to slip or squish together. When the vertebrae are pressured in this way, the disks between them may herniate, or bulge out, impinging on spinal nerves and causing pain. Or the pressure may pinch the delicate structures at the back of the vertebrae, causing a fracture called spondylolysis, a problem for about one in twenty Americans.

No other primate experiences such back problems—except, Ward and Latimer say, our immediate ancestors. The two scientists have found fossil evidence that back trouble likely plagued our bipedal forebears. The bones of the Nariokotome boy, a young *Homo erectus*

**“The rapid expansion of
the human brain didn’t begin
until less than two million
years ago, millions of years
after we got upright.”**

(a species preceding our own *Homo sapiens*) who lived some 1.5 million years ago, reveal that the youth suffered from scoliosis, a potentially devastating lateral curvature of the spine.

The cause of most scoliosis cases remains a mystery, Latimer says, but like spondylolysis, it appears linked to the spinal features associated with upright posture, particularly lordosis, the deep forward curvature and flexibility of our lower spine. “Because scoliosis occurs only in

humans and our immediate bipedal ancestors, it appears likely that upright walking is at least partially to blame,” he says.

Considering the pressures of natural selection, why are such seriously debilitating diseases still prevalent? Latimer suspects the answer lies in the importance of lordosis for upright walking: “Selection for bipedality must have been so strong in our early ancestors that a permanent lordosis developed despite the risk it carries for spondylolysis and other back disorders.”

[DISJOINTED]

Liz Scarpelli’s postural orientation is at the moment horizontal. Her leg is elevated in a surgical sling as Scott Dye, an orthopedic surgeon at California Pacific Medical Center, examines her knee with an arthroscope. The ghostly image of the joint—femur, tibia, and patella—appear magnified on a flat screen above the gurney. An athletic woman of 51, a former gymnast and skier, Scarpelli is a physical therapist who works with patients to rehabilitate their joints after surgery. While demonstrating to one patient a technique for leg-strengthening knee squats, Scarpelli blew out her own knee for the third time. Dye’s arthroscopic camera shows healthy bone and ligaments, but large chunks of cartilage float about like icebergs in the fluid spaces around the joint. Dye expertly scrapes up the pieces and sucks them out before sewing up the holes and moving on to the next five surgeries scheduled for the day.

To hear Scott Dye speak of it, the knee joint is among the greatest of nature’s inventions, “a 360-million-year-old structure beautifully designed to do its job of transferring load between limbs.” But it is also among the most easily injured joints in the human body; medical procedures involving knees total a million a year in the United States.

“In standing upright, we have imposed



dexterity

Among the benefits of being upright is “perfect freedom of the hands from all part in locomotion,” said Alfred Russel Wallace, the great English naturalist. Our forelimbs are a legacy from our earliest mammal ancestors. But only after our ape forebears left the trees and stood up did their fingers lose their curvature and shorten relative to the thumb. This allowed fingertips to meet easily in myriad precision grip positions. Humans gained the fine manipulative skills that are a hallmark of our species, but the unique arrangement of the wrist joint leaves us vulnerable to such ailments as carpal tunnel syndrome.

unprecedented forces on the knee, ankle, and foot,” Bruce Latimer says. When we walk quickly or run, the forces absorbed by our lower limbs may approach several multiples of our own body weight. Moreover, our pelvic anatomy exerts so-called lateral pressure on our lower joints. Because of the breadth of our pelvis, our thighbone is angled inward toward the knee, rather than straight up and down, as it is in the chimp and other apes. This carrying angle ensures that the knee is brought well under the body to make us more stable.

“But nothing is free in evolution,” Latimer says. “This peculiar angle means that there are forces on the knee threatening to destabilize it. In women, the angle is greater because of their wider pelvis, which explains why they are slower runners—the increased angle means that they’re wasting maybe ten percent of their energy—and also why they tend to suffer more knee injuries.”

[UNLIKELY FEAT]

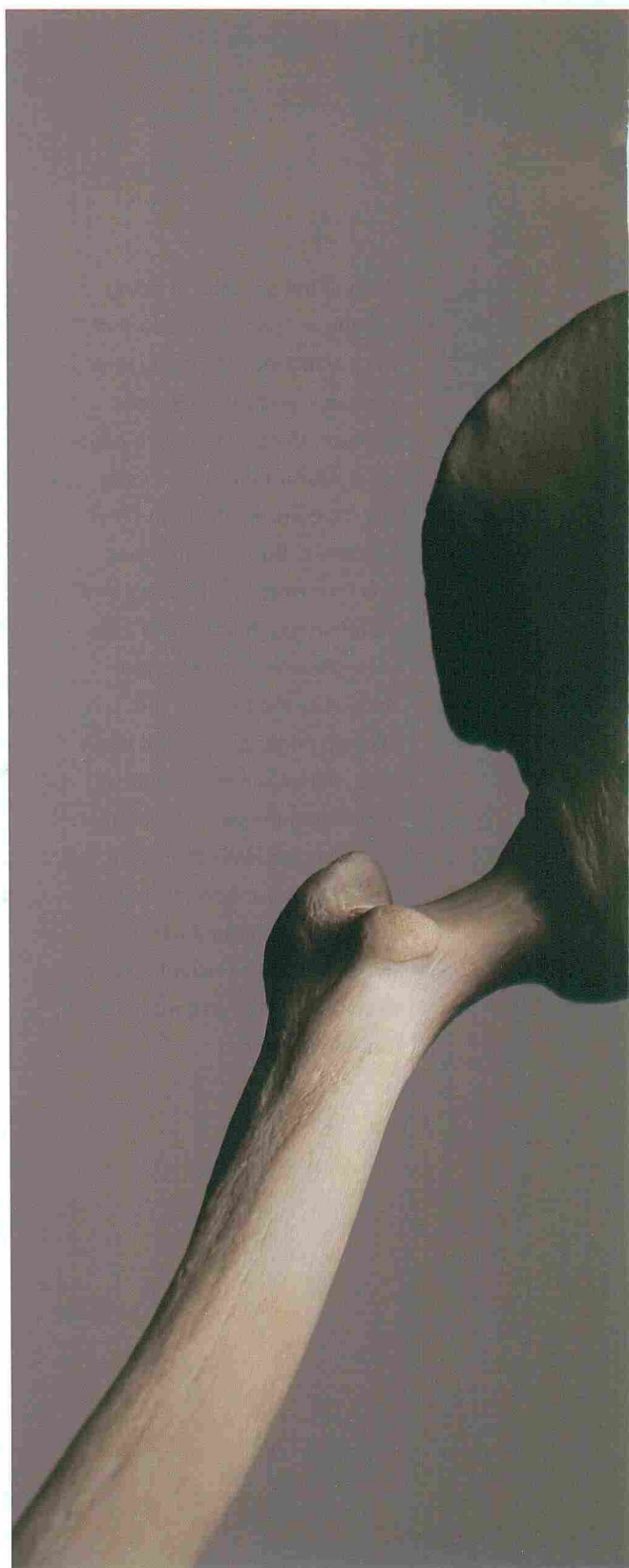
And where does the buck finally stop? What finally bears the full weight of our upright body? Two ridiculously tiny platforms.

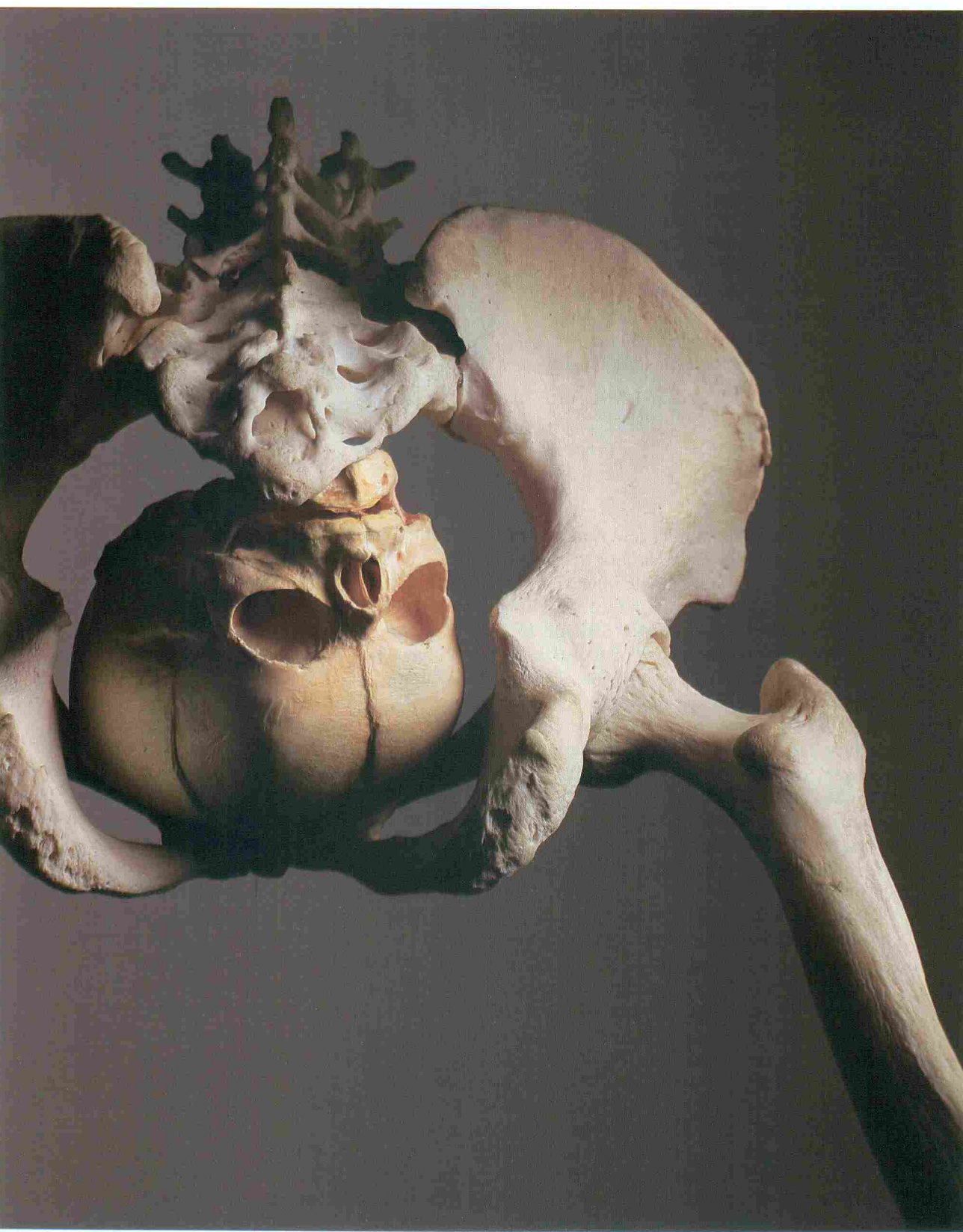
“The human foot has rightfully been called the most characteristic peculiarity in the human body,” says Will Harcourt-Smith, a paleontologist at the American Museum of Natural History. “For one thing, it has no thumblike opposable toe. We’re the only primate to give up the foot as a grasping organ.”

This was a huge sacrifice. The chimp’s foot is a brilliantly useful and versatile feature, essential to tree climbing and capable of as much motion and manipulation as its hand. The human foot, by contrast, is a hyper-specialized organ, designed to do just two things, propel the body forward and absorb the shock of doing so. Bipedality may have freed the hands, but it also yoked the feet.

childbirth

Upside-down and ready to deliver, a human fetal skull facing rear—in position for birth—points out perhaps the greatest downside of being upright: a difficult passage through the bony canal of a female pelvis. So tight is the fit that the human fetus must rotate as it moves down the canal; in some cases its cranial bones must squeeze together and overlap, compressing the skull a few millimeters so the infant can exit. The challenging nature of human birth reflects a history of compromise between the demands of bipedalism and a big brain. As our pelvis narrowed and our brain expanded, more than doubling in size from two million years to 100,000 years ago, the fit grew even tighter. The solution: Humans are born with their brains only a quarter of adult size.



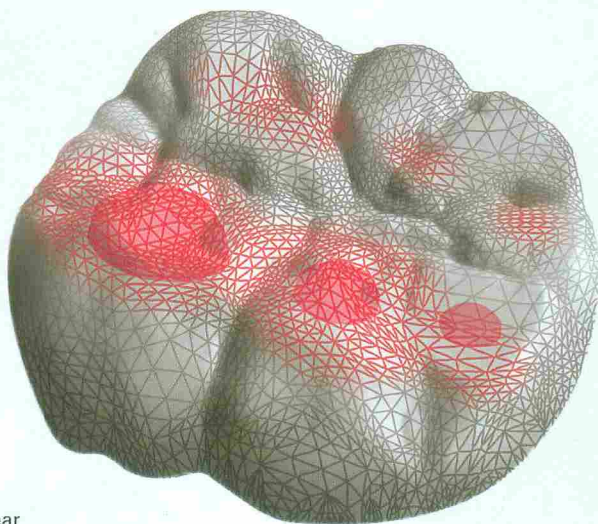


food for thought

Technology that analyzes the contours of the Earth's surface can be applied to the peaks and valleys of fossil teeth. The slopes and angles allow scientists to infer diet, whether or not the tooth is worn by age. This *Homo erectus* tooth reveals that its owner could have eaten tough, elastic foods such as animal flesh. Bipedalism presumably allowed *Homo* to forage intensively for meat, a rich source of fat and protein that helped fuel our dramatic brain expansion.



Projected areas of wear
● EARLY ADULTHOOD
■ OLD AGE



Harcourt-Smith studies foot bones of early hominins with the new technique of geometric morphometrics—measuring objects in three dimensions. The variations in foot structure he has discovered in *Australopithecus* and *Homo habilis* (a species that lived 2.5 to 1.6 million years ago) suggest that these early hominins may have walked in different ways.

“We have a desire to see the story of bipedalism as a linear, progressive thing,” he says, “one model improving on another, all evolving toward perfection in *Homo sapiens*. But evolution doesn’t evolve toward anything; it’s a messy affair, full of diversity and dead ends. There were probably lots of ways of getting around on two feet.”

Still, in all the fossil feet Harcourt-Smith studies, some type of basic human pattern is clearly present: a big toe aligned with the long axis of the foot, or a well-developed longitudinal arch, or in some cases a humanlike ankle joint—all ingenious adaptations but fraught with potential problems. “Because the foot is so specialized in its design,” Harcourt-Smith says, “it has a very narrow window for working correctly. If it’s a bit too flat or too arched, or if it turns in or out too much, you get the host of complications that has spurred the industry of podiatry.” In people with a reduced arch, fatigue fractures often develop. In those with

a pronounced arch, the ligaments that support the arch sometimes become inflamed, causing plantar fasciitis and heel spurs. When the carrying angle of the leg forces the big toe out of alignment, bunions may form—more of a problem for women than men because of their wider hips.

And that’s not all.

“One of the really remarkable aspects of the human foot, compared with the chimp and other apes, is the relatively large size of its bones, particularly the heel bone,” Bruce Latimer notes. “A 350-pound male gorilla has a smaller heel bone than does a 100-pound human female—however, the gorilla bone is a lot more dense.” While the ape heel is solid with thick cortical bone, the human heel is puffed up and covered with only a paper-thin layer of cortical bone; the rest is thin latticelike cancellous bone. This enlargement of cancellous bone is pronounced not just in the heel, but in all the main joints of our lower limbs—hip, ankle, knee—and has likely marked the skeleton of our ancestors since they first got upright; it has been found in the joints of 3.5-million-year-old hominin fossils from Ethiopia.

“The greater volume of bone is an advantage for dissipating the stresses delivered by normal bipedal gait,” Latimer says. However, it’s not without cost: “The redistribution in our bones

from cortical to cancellous means that humans have much more surface exposure of their skeletal tissue. This results in an accelerated rate of bone mineral loss—or osteopenia—as we age, which may eventually lead to osteoporosis and hip and vertebral fractures.”

[WHAT DO WE STAND FOR?]

We humans gave up stability and speed. We gave up the foot as a grasping tool. We gained spongy bones and fragile joints and vulnerable spines and difficult, risky births that led to the deaths of countless babies and mothers. Given the trade-offs, the aches and pains and severe draw-backs associated with bipedalism, why get upright in the first place?

A couple of chimps named Jack and Louie may offer some insights. The chimps are part of an experiment by a team of scientists to explore the origin of bipedalism in our hominin ancestors.

Theories about why we got upright have run the gamut from freeing the arms of our ancestors to carry babies and food to reaching hitherto inaccessible fruits. “But,” says Mike Sockol of the University of California, Davis, “one factor had to play a part in every scenario: the amount of energy required to move from point to point. If you can save energy while gathering your food supply, that energy can go into growth and reproduction.”

Paleogeographical studies suggest that at the time our ancestors first stood upright, perhaps six to eight million years ago, their food supplies were becoming more widely dispersed. “Rainfall in equatorial East Africa was declining,” Sockol says, “and the forest was changing from dense and closed to more open, with more distance between food resources. If our ape ancestors had to roam farther to find adequate food, and doing so on two legs saved energy, then those individuals who moved across

the ground more economically gained an advantage.”

To test the theory that the shift to two feet among our ancestors may have been spurred by energy savings, Sockol and his colleagues are looking at the energy cost of locomotion in the chimp. The chimp is a good model, Sockol says, not just because it’s similar to us in body size and skeletal features and can walk both bipedally and quadrupedally, but also because the majority of evidence suggests that the last common ancestor of chimps and humans who first stood upright was chimplike. By understanding how a chimp moves, and whether it expends more or less energy in walking upright or on all fours (knuckle-walking), the scientists hope to gain insight into our ancestors’ radical change in posture.

Jack and Louie and several other young adult chimps have been trained by skillful professional handlers to walk and run on a treadmill, both on two legs and on four. One morning, Jack sits patiently in his trainer’s lap while Sockol’s collaborators, Dave Raichlen and Herman Pontzer of Harvard University, paint small white patches

“It’s definitely not the type of system you would invent if you were designing it. But evolution is clearly a tinkerer, not an engineer.”

on his joints—the equivalent of those silver balls I wore on Dan Lieberman’s treadmill. Only occasionally does Jack steal a surreptitious lick of the sweet white stuff. Once he’s marked, he jumps on the treadmill and runs along on two legs for a few minutes, then drops to four. Every so often, his trainer hands him a fruit snack, which Jack balances on his lower lip,



first steps

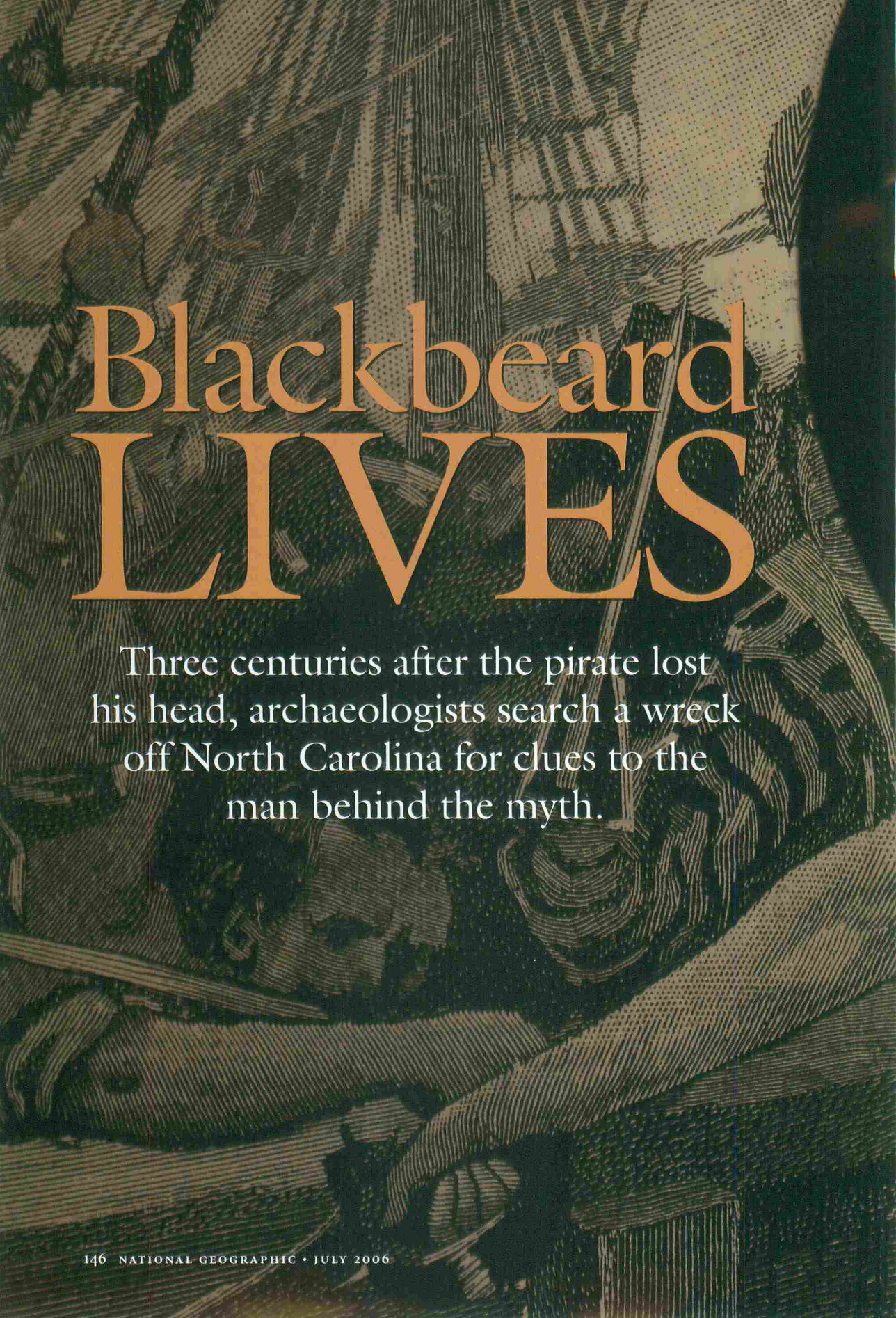
An infant's bowed legs and first toddling steps look more like those of its ape ancestors than its human parents. But once we're up on two feet, stresses on the thighbone promote more growth on one side of the bone than the other, forming the carrying angle that distinguishes our species. By age six or seven, we possess the stable leg-swinging gait that allows our kind to carry tools, meat, and babies. We gained efficient upright locomotion, but it came with a plague of problems in hips, knees, and feet.

thrust out as far as it will go, before rolling the fruit forward and flicking it into his mouth. For a set time, Jack breathes into a small mask connected to equipment that gathers information on how much oxygen he consumes—a measure of energy expenditure—while the movements of his limbs (marked by those white dots) are monitored with cameras to help the scientists understand how the energy is being used.

Once the scientists have refined their model for how things work in the chimp—for what limb movements are used in the two types of locomotion and how each consumes energy—they hope to apply this model to the fossils of our ancestors. “We use the biomechanical data to determine the types of anatomical changes that would have reduced energy expenditure,” Raichlen explains. “Then we look at the fossil record and ask, Do we see these changes? If we do, that’s a pretty good clue that we’re looking at selection for reduced energy costs in our ancestors who became bipedal. That’s the dream.”

Scientists are the first to admit that much work needs to be done before we fully understand the origins of bipedalism. But whatever drove human ancestors to get upright in the first place—reaching for fruit or traveling farther in search of it, scanning the horizon for predators or transporting food to family—the habit stuck. They eventually evolved the ability to walk and run long distances. They learned to hunt and scavenge meat. They created and manipulated a diverse array of tools. These were all essential steps in evolving a big brain and a human intelligence, one that could make poetry and music and mathematics, assist in difficult childbirth, develop sophisticated technology, and consider the roots of its own quirky and imperfect upright being. □

👉 **Of Chimps and Humans** Watch video of photographer Cary Wolinsky's session with a chimpanzee, and find Web-exclusive images at ngm.com/0607.



Blackbeard LIVES

Three centuries after the pirate lost his head, archaeologists search a wreck off North Carolina for clues to the man behind the myth.



A 19th-century engraving shows Blackbeard attacking an English sloop at the battle of Ocracoke, North Carolina, in 1718. His fierce look—and reputation—magnified the terror he struck in many hearts.

ENGRAVING FROM *THE STORY OF THE SEA*, EDITED BY
SIR ARTHUR THOMAS GILLER COUGH, PHOTOGRAPHED AT
THE MARINERS' MUSEUM, NEWPORT NEWS, VIRGINIA



On a sweltering June afternoon on the Hampton, Virginia, waterfront, a crowd gathers around a makeshift surgery where a hapless sailor dressed in 18th-century rags is about to get his leg sawed off. Held down by four brawny mates, he screams and squirms to the onlookers' delight until the offending limb is gone and a neat wooden peg is strapped in its place. Suddenly all eyes turn to a big man with a blood-red sash and wild black beard boldly sauntering across the lawn. His bulging eyes lock on a young mother with a stroller, and one bushy eyebrow rises to the sky. "Arrrh, what a cute one!" he bellows in a voice like a cannon shot. "And the kid ain't bad, either!"

Once again, Blackbeard is the man of the hour at the annual festival in his honor, a celebration of pirate life and times with mock battles, swordplay, and the odd removal of limbs. Thought to be the inspiration for the fictional Captain Hook and Long John Silver, the great bearded one's image is as popular today as ever, from Johnny Depp's



dashing plaits in *Pirates of the Caribbean*, to Ben Cherry's swaggering impersonation at the Hampton festival.

In nearby North Carolina, where Blackbeard met his grisly end, archaeologists are probing a shipwreck for new clues to his life. Although he struck terror from Pennsylvania to the Caribbean, it was along this coast that he found a welcome that lingers to this day, his memory saluted in trinket shops, inns, and bars. An audacious rascal, he came out of nowhere, never surrendered, and went down in a hail of musket balls. Even after his corpse was tossed overboard, some said it circled the boat three times before sinking. Like the pirate himself, the legend just won't die.



The schooner *Windfall* (above) sails past Ocracoke Inlet, where Blackbeard, born Edward Teach, was beheaded. His legacy lives on in reenactors like Ben Cherry (left), outfitted in swashbuckling finery. "Blackbeard wore the best clothes that money could steal," he says.

No one knows where the man named Edward Teach,

or Tache, or Thatch, called home. Capt. Charles Johnson (who some believe was Daniel Defoe) claimed he came from Bristol in his 1724 tome, *A General History of the Robberies and Murders of the Most Notorious Pirates*, the primary source of most Blackbeard legends. Others trace him to a prominent family on Jamaica, or to the Carolinas. Like thousands of other English tars, he was thought to have turned to piracy after sailing on privateers during the War of the Spanish Succession from 1702 to 1713. And no wonder: A single prize could be worth 20,000 pounds sterling, and a pirate's share worth many times what an honest seaman would earn in a lifetime.

Teach sailed onto the stage in late 1716 in charge of a sloop stolen by Capt. Benjamin Hornigold, one of the most successful freebooters of the age. With Hornigold as his mentor, young Teach had risen through the ranks showing "uncommon boldness and personal Courage," according to Johnson. Teach soon joined forces with Maj. Stede Bonnet, a wealthy planter from Barbados who'd taken to pirating, it was said, to escape a shrewish wife. With Teach calling the shots, the two captured 11 ships from Havana to Delaware Bay.

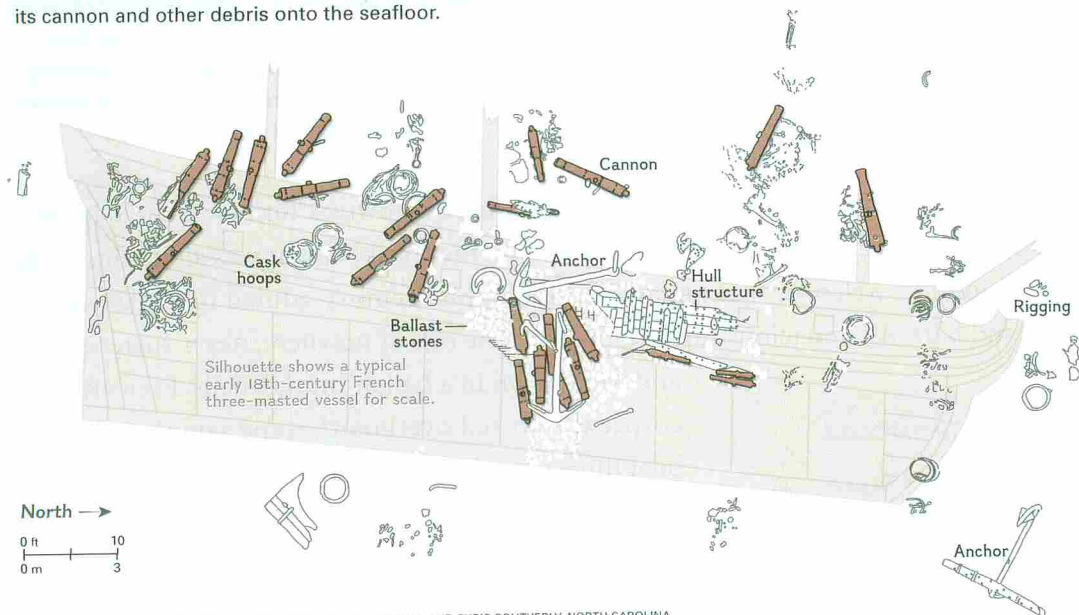
Partly freed from concretions, a 4.5-foot-long cast-iron cannon hangs in the shipwreck project's conservation lab at East Carolina University. Some guns still contain small antipersonnel shot.

Near the island of St. Vincent, Teach chased down *La Concorde*, a French slaver limping along with a crew decimated by scurvy and dysentery. After a brief skirmish, the French captain surrendered, and Teach dumped most of the crew and slaves on the tiny island of Bequia, leaving them a small sloop and a few tons of beans. He refitted the big slaver with 40 cannon and renamed her *Queen Anne's Revenge*. With one of the largest and most powerful pirate vessels ever to sail the Spanish Main, he sallied forth for a long season of plundering that the world would never forget.

Three centuries later, David Moore, curator of nautical archaeology for the North Carolina Maritime Museum in Beaufort, methodically dons his diving gear aboard a research vessel about a mile off Atlantic Beach. A pulse of clear green ocean

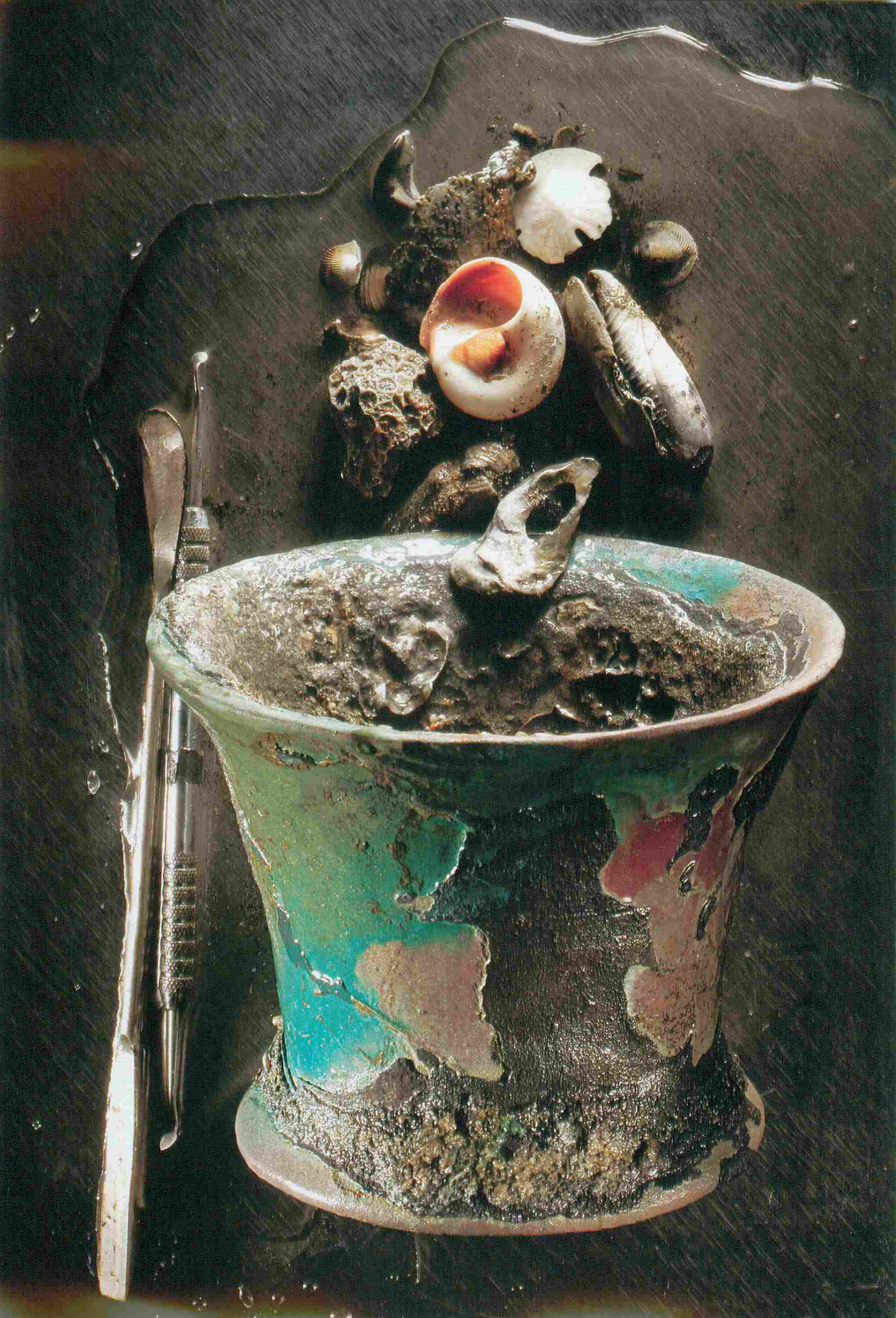
A Trove of Loaded Cannon

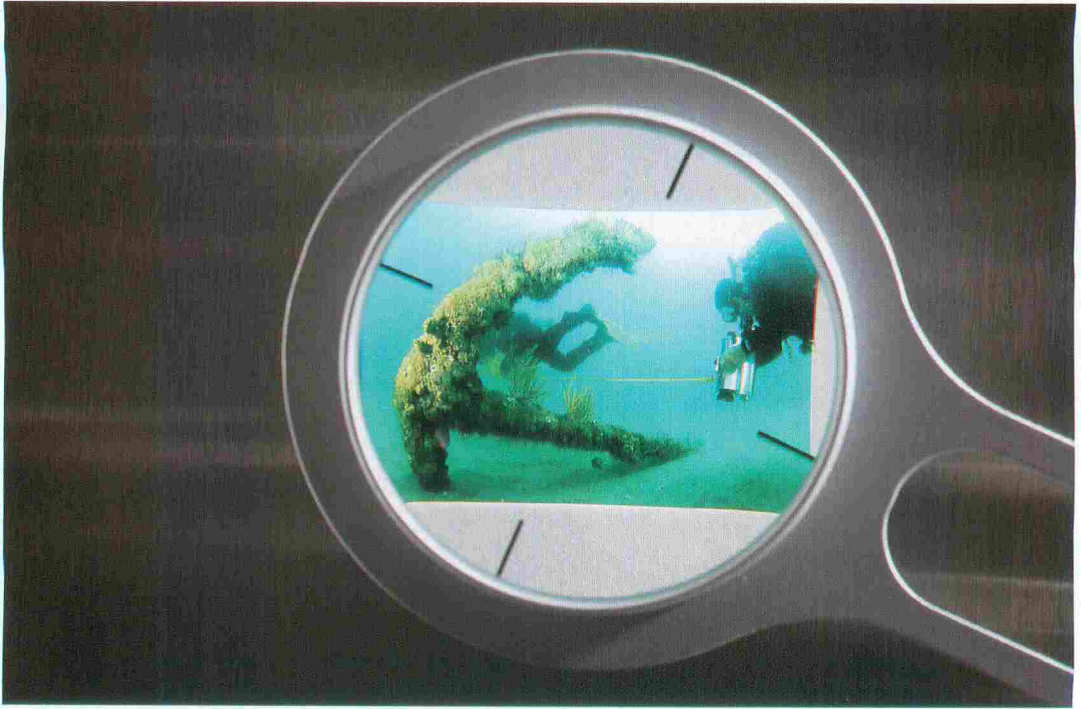
Archaeologists have found 24 guns so far at the wreck site at Beaufort Inlet, North Carolina, shown in this site plan, adding weight to the notion that the vessel was a pirate ship, since merchant vessels were not as heavily armed. Historical accounts say that *Queen Anne's Revenge* carried 40 cannon and measured close to a hundred feet long. Scientists speculate that the wreck listed to port and spilled its cannon and other debris onto the seafloor.



MAP SOURCES: DAVID MOORE, NORTH CAROLINA MARITIME MUSEUM, AND CHRIS SOUTHERLY, NORTH CAROLINA UNDERWATER ARCHAEOLOGY BRANCH. NGA MAPS. CANNON (OPPOSITE) AND OTHER ARTIFACTS PHOTOGRAPHED AT THE QUEEN ANNE'S REVENGE ARCHAEOLOGICAL CONSERVATION LABORATORY







water has raised the underwater visibility from its normal murky stew to nearly six feet, making Moore and the crew of marine archaeologists almost giddy. Just 22 feet below, partially buried in the shifting sands, lie the remains of what he and his colleagues believe is Blackbeard's flagship. Discovered by treasure hunters in 1996 to great media fanfare, the wreck was subsequently turned over to the state. Ever since, a dedicated team of archaeologists and conservators has been slowly recovering artifacts that ultimately will reside in the maritime museum. After years of shoestring budgets and numerous hurricanes, this is the project's first large archaeological expedition to the site in nearly five years.

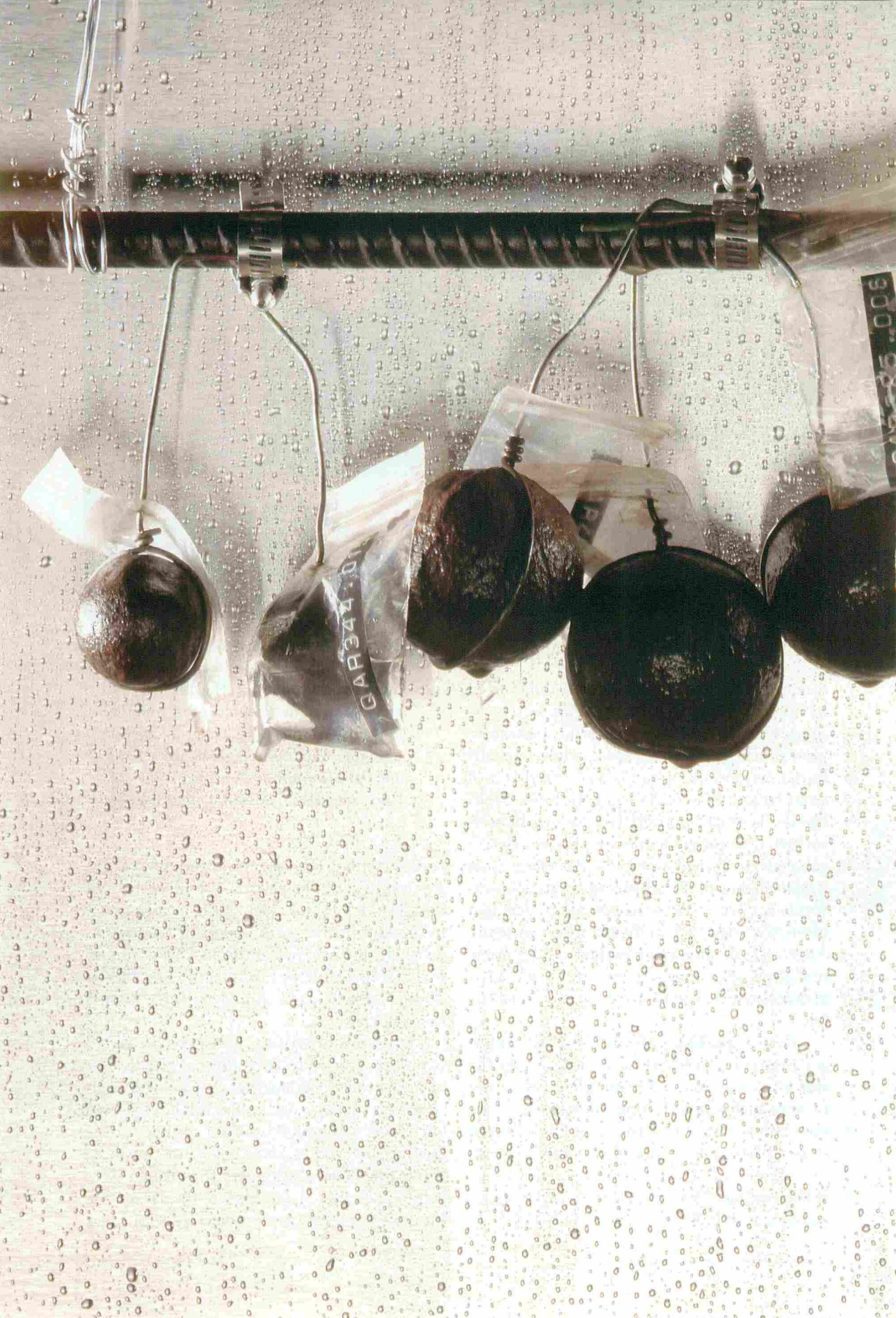
"This is amazing," Moore says. "We might get 20 days a year like this." We splash over the side and once on the bottom are greeted by a massive anchor fluke jutting defiantly out of the sand. Moore swims toward a large pile of ballast stones, parts of cannon, and two huge anchors

Blackbeard may have seized a mortar for grinding medicine (left) when he blockaded Charleston Harbor in 1718 and took on medical stores. A magnifying glass frames divers near an anchor (above). "We found Blackbeard's 'head,'" says photographer Courtney Platt—a lead "pissdale," or urinal, near the stern.

covered with green anemones. Stopping to fan a patch of sand, he reveals a small section of dark wooden hull. I reach out to steady myself in the current and grasp a perfectly shaped cascabel, the big iron ball at the back of a cannon. It was impossible not to imagine Blackbeard doing the same as he aimed the big gun on a fleeing prize.

Thousands of artifacts have been recovered from the wreck site, including a roughly cast Spanish bronze bell, a pewter charger big enough to serve a suckling pig, an English blunderbuss barrel, even a French urethral syringe for the treatment of syphilis. Some critics, not convinced this is Blackbeard's ship, say such things were common on merchant vessels of the day. But it's the guns, says shipwreck project director Mark

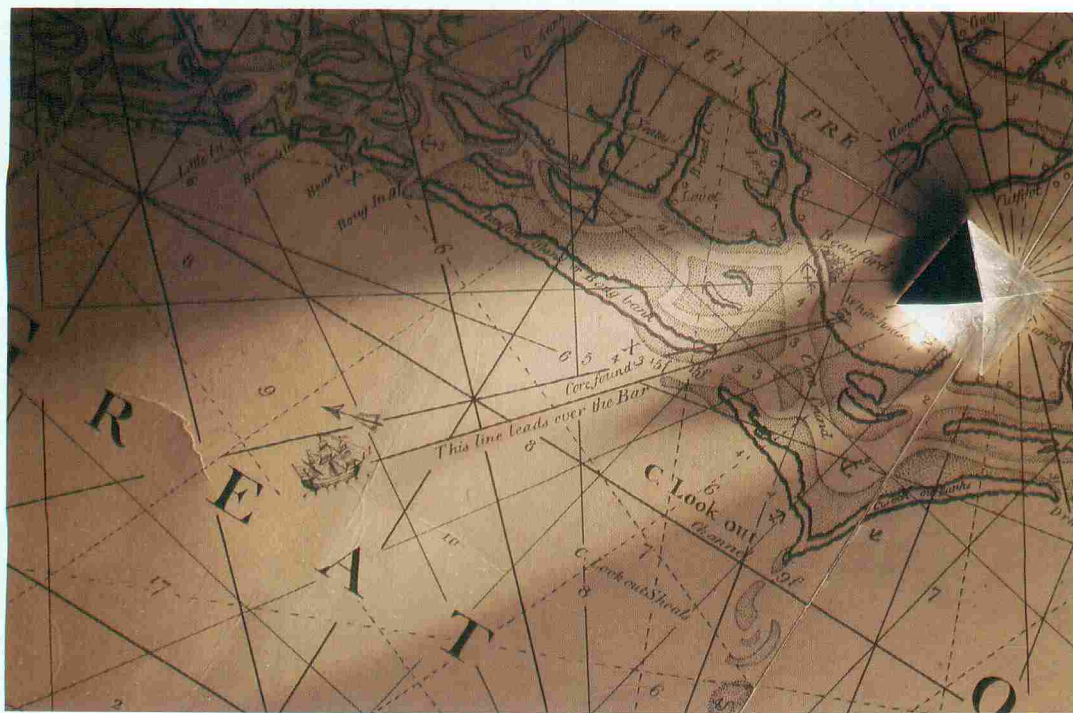
■ **Society Grant** This Expeditions Council project was supported by your Society membership.





Like pirates on a gallows, cannonballs hang above a desalination tank in the conservation lab. To prevent corrosion of iron artifacts such as these, an electric current is run through them while they are immersed in water containing a small amount of sodium carbonate, which removes salts. The conservation process can take one to four years.





A prism illuminates a chart drawn in 1738 of North Carolina's Beaufort Inlet, where Blackbeard grounded *Queen Anne's Revenge* 20 years earlier. This map helped salvors find the wreck in shifting sandbars. A British wineglass stem (left), made after 1713, helped to date the ship.

Wilde-Ramsing, along with a few crude hand grenades, that tip the scales toward pirates.

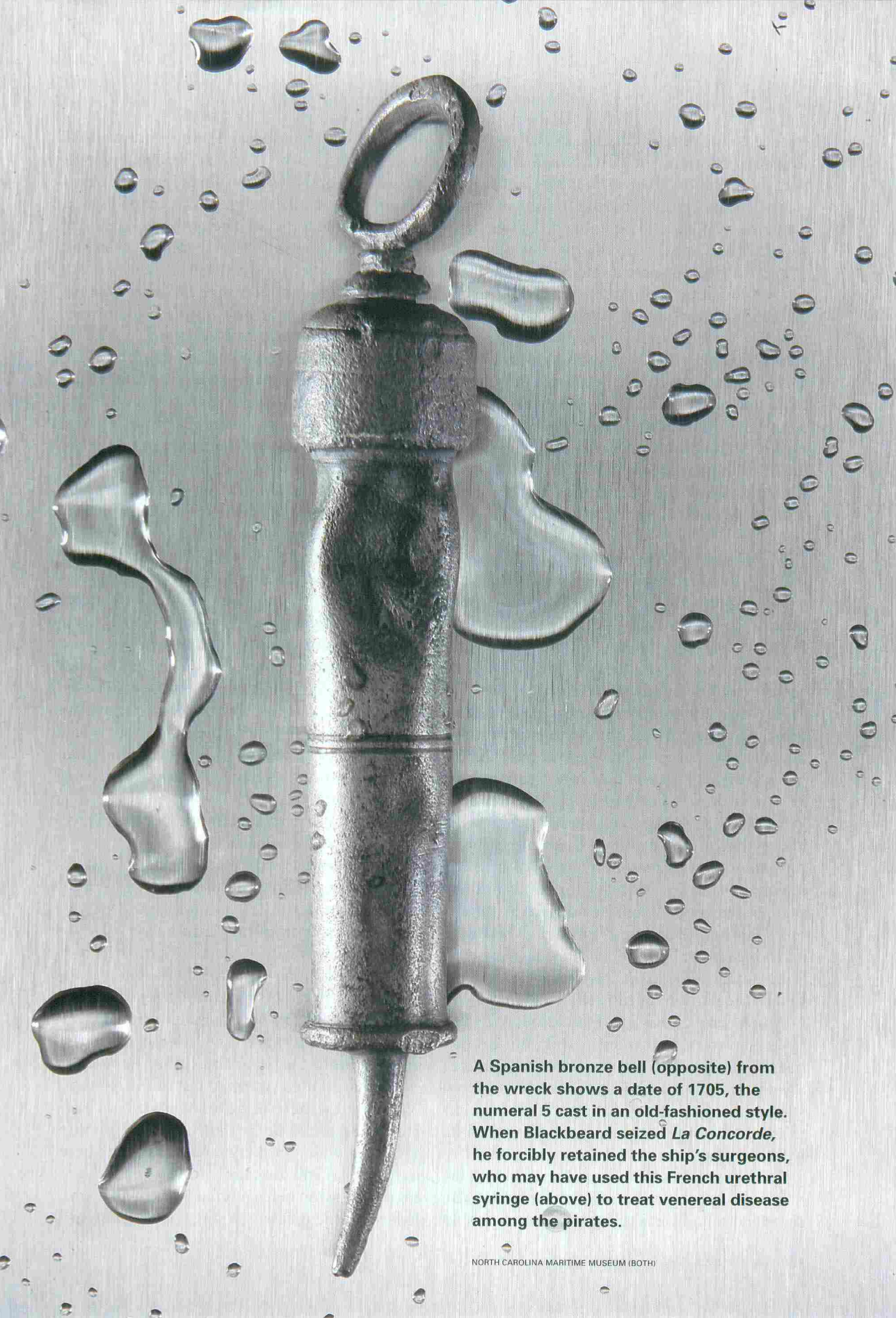
"We've found 24 cannon, and there may be more buried on the site," says Wilde-Ramsing—far more than carried by typical military or merchant ships known to ply these waters. The remaining cannon were probably small, easily removable rail guns. Several of the cannon have been recovered and restored, a hodgepodge of sizes and makes from Europe. Many were still loaded with typical pirate shot: bolts, nails, bar-shot, and spikes—ammo designed to shred sails or rigging, or rake the decks of ships before boarding. Pirates, after all, wanted to capture a rich prize, not to sink it. Such homemade grape-shot, along with a recovered lead touchhole cover that kept the gunpowder dry and crude hand grenades, are virtually identical to those found on *Whydah Galley*, a pirate ship discovered off Cape Cod in 1984. They've even found pieces of square "case" bottles that Blackbeard was said to have filled with powder to make early Molotov cocktails.

After capturing several prizes in the Caribbean, Blackbeard sailed north in the spring of

1718 in command of a pirate flotilla of four vessels with more than 60 guns and as many as 400 brethren of the coast. When he reached Charleston, South Carolina, one of the wealthiest towns in the Colonies at the time, he sprang his boldest plan yet—a blockade of the entire city. Within a week, he seized and plundered nine vessels attempting to enter or leave the port, taking 1,500 pounds sterling and numerous hostages, including a member of the governor's ruling council. Oddly enough, with the town at his mercy, Blackbeard's sole demand was a chest of medicines—items in great demand among pirates. The governor fretted and fumed for days, but eventually caved in.

"Up until then, he's just another little rogue," says Mike Daniel, the former treasure hunter who





A Spanish bronze bell (opposite) from the wreck shows a date of 1705, the numeral 5 cast in an old-fashioned style. When Blackbeard seized *La Concorde*, he forcibly retained the ship's surgeons, who may have used this French urethral syringe (above) to treat venereal disease among the pirates.

discovered the wreck. "Charleston Harbor, that's like the twin towers. You don't do something like that without the whole world taking notice."

And Blackbeard, according to Johnson, was someone who liked to be noticed. A huge man with fiery eyes and a booming voice, he was fond of a scarlet cloak, and went into battle with lighted, slow-burning cannon fuses tucked into his hair, and six pistols slung across his chest. Some said he was fond of pouring gunpowder into his rum and setting it ablaze before downing it. In a famous Blackbeard tale, while drinking in his cabin one evening with a few of his crew, he suddenly blew out the candle, drew two pistols, and fired them randomly beneath the table, wounding his sailing master Israel Hands in the knee. If he didn't kill one of them now and then, he said, "they would forget who he was."

Few ever forgot or forgave him. Days after the Charleston blockade, Blackbeard ran *Queen Anne's Revenge* aground—some say intentionally—entering what is now Beaufort Inlet. He ordered another pirate vessel, *Adventure*, to pull him off, and soon both vessels grounded and were lost.

The time for treachery was at hand. Blackbeard convinced Stede Bonnet to take some of his men and sail to Bath, where North Carolina's governor had a plantation, to accept the King's pardon, which had just been extended. While he was gone, Blackbeard gathered 40 loyal pirates and 60 captured slaves and stripped *Adventure* and *Queen Anne's Revenge* of anything of value—cheating his fellow brigands of their share of the booty. When David Herriot, *Adventure's* captain, demanded restitution, Blackbeard marooned him and 16 others on a barrier island "a league from the main." He then sailed to Bath to take the pardon for himself.

North Carolina was a perfect hideout. Wracked by Indian wars, yellow fever, and political upheaval, the poor colony could barely muster a weak militia and had no jails. Its shallow sounds and barrier islands were ideal for light pirate craft to prey on merchant ships from its wealthier neighbors.

Teach's retirement was short. He was soon back to his old ways, plundering local vessels in the rivers and sounds, and seizing a French sugar ship

off Bermuda. At one point he even rendezvoused with pirate Charles Vane at Teach's favorite honey-hole on North Carolina's remote barrier island of Ocracoke. Some say as many as 200 pirates partied for a week before Vane sailed off.

It was all too much for Virginia's Governor Alexander Spotswood to bear. When rumors reached him that pirates were building a fort at Ocracoke, Spotswood sent both a land and sea expedition to hunt down Blackbeard.

Near sunset on November 21, Lt. Robert Maynard, commanding two sloops and 60 men, found Teach anchored at Ocracoke. With the King's pardon in hand and only 20 pirates aboard, Blackbeard showed little concern, drinking heavily with a local trader deep into the night. His crew, sensing trouble, asked him where the booty was buried. Only the devil and he knew where it was, he reportedly barked, "and the longest Liver should take all." Despite 300 years of hunting, no treasure has ever been found.

At sunrise Maynard sailed right for him, Union Jacks flying, and the pirate's blood began to boil. "Damn you for villains, who are you? And from whence come you?" he is said to have bellowed at Maynard, who supposedly coolly replied: "You may see by our colors we are no pirates!" Blackbeard then raised his drink, called them "cowardly puppies," and swore his final oath: "Damnation seize my Soul if I give you Quarters, or take any from you!"

"I expect no quarter from you, nor shall I give any!" Maynard shot back.

No one knows what actually happened in the melee that followed. But according to published accounts, Blackbeard unleashed a crippling broadside from his cannon that killed or wounded nearly half of Maynard's men. Knowing he had no hope of capturing the pirate ship, Maynard ordered his remaining men below to lure the pirates on board. Blackbeard fell for the ruse. He and his crew hurled homemade grenades onto the sloop and rushed aboard.

Maynard's men swarmed out of the hatches. Blackbeard went straight for Maynard, the two men firing pistols at the same time. The pirate's shot rang wide, but Maynard hit Teach square in the chest. Still, the pirate fought on, landing a cutlass blow so fierce it broke Maynard's sword. Just then, the pirate was staggered by a sword



The skull and crossbones flies above Wayne Tankard's property in Bath, North Carolina. "I've been a Blackbeard buff all my life," he says. "Growing up, we were all pirate fanatics. Blackbeard was always lurking around every corner."

blow to his neck from behind. He pulled his last pistol but was too weak to fire. Blackbeard collapsed on deck, in the end having been shot five times and stabbed more than 20.

Maynard cut off Blackbeard's head, hung it from his bowsprit, and tossed the corpse into the water, where locals say it can be seen to this day on certain moonlit nights, searching for its head. That head, which Johnson wrote "frightened America more than any Comet," Maynard took back to his base at Hampton and stuck on a pike there. Thus the town's modern festival.

And that, of course, was the pirate's evil genius, enabling him to capture so many ships with so little trouble. "Blackbeard's image was so horrific it made his job easier," says historian Lindley Butler. "Pirates would much rather take a prize without a fight, and there were enough psychopaths around at that time to make merchantmen believe the image was true." It was this same image that finally caught up with him, Butler says. Spotswood was not going to let the fiercest pirate in the world retire in his backyard.

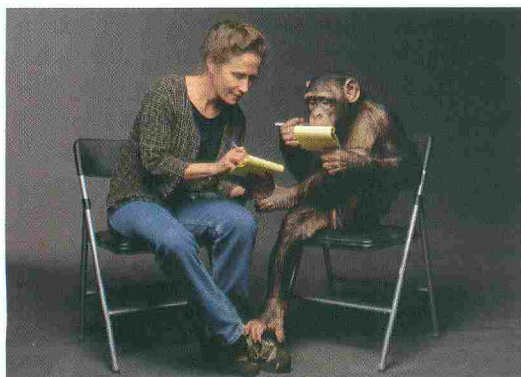
"He was probably a better actor than I am," admits Ben Cherry, taking a break in a waterfront watering hole. "And I'm pretty damned good!" He slaps his hand on the table, and that booming laugh echoes around the bar.

There's another theory about Blackbeard's legacy here and in North Carolina. Of the pirates who sailed with him into Beaufort Inlet back in 1718, some 200 were never captured, never tried, never heard from again. To this day, echoes of their voices are heard in bait shops and marinas on nearby Harkers Island or Ocracoke, where locals chatter with a distinctive Elizabethan patois. Don't be surprised during your next visit if they take your silver, and feed you full of beans. □

➤ **Cannon graveyard** Zoom in on a photomosaic of the shipwreck site, then listen to poet Rob Temple bring Blackbeard back to life at ngm.com/0607.

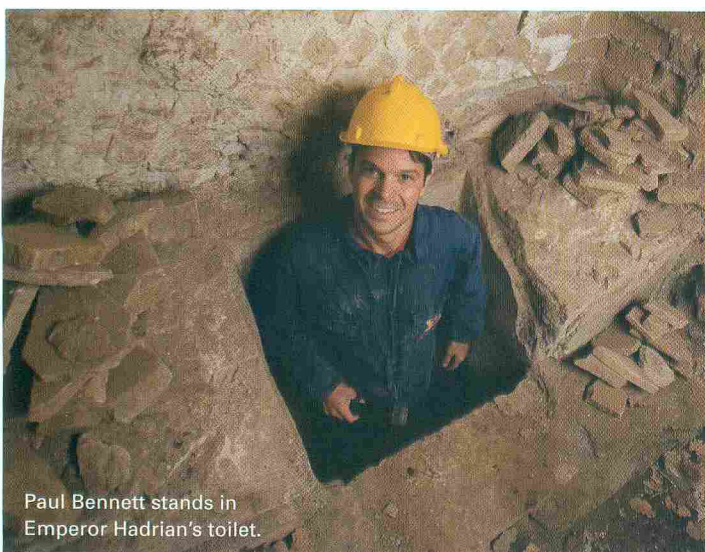


UPDATE Markha's Story In 1995, Markha Mitalipova lost her legs and her mother in a Russian-led attack on her village. There have been times when the girl, prosthetic limbs outgrown, was forced to walk the war-torn streets of Grozny, Chechnya, on her knees. "When we had to move very fast from the bombs," her aunt told photographer Heidi Bradner, "I would grab her and run with her in my arms." The GEOGRAPHIC published Bradner's picture of the child (left) in the July 2005 article "Chechnya: How Did It Come to This?" Now Markha is 12 years old. Today she has prosthetics that fit, but her story, like that of many Chechen children, has no happy ending, says Bradner. With poor living conditions and little access to schooling and health care, "Markha represents so much about the past 11 years in Chechnya. She hasn't gotten what she needs." To learn more, go to chechenchildren.org.



ON ASSIGNMENT

Comparing Notes "Being interviewed by Jack was a real highlight in my GEOGRAPHIC experience," says author Jennifer Ackerman. One of several chimps photographed for Ackerman's story, "The Downside of Upright," six-year-old Jack sat down with the writer for nearly 45 minutes while Cary Wolinsky snapped pictures. Trained for work in films, Jack "loves to write," says Ackerman. "He would scribble on his pad, and I would look over and comment admiringly. Then he would make this expression like, 'I can't believe you just said that.'"



Paul Bennett stands in Emperor Hadrian's toilet.

ON ASSIGNMENT

In Deep Living part-time in Rome, writer Paul Bennett appreciates the city's underground treasures. But for "In Rome's Basement," his first story for the *GEOGRAPHIC*, he descended into some unsavory places, including the toilet of the second-century Roman emperor Hadrian. Photographer Stephen Alvarez had urged Bennett to crawl into the hole to explore. "Judging from Stephen's mischievous grin when I emerged," Bennett says of the photo, "I'm convinced he had ulterior motives."

Contributors



Cathy Newman

During 27 years at the *GEOGRAPHIC*, Cathy Newman has reported on subjects from pollen to Lewis Carroll, trout to obesity. But for "Shall We Dance?" her field time started "at age eight in Beatrice LaVerne's dance studio." A keen observer even as a child, she says, "I immediately understood that I'd be better off in another career."

Brian Lanker

Pulitzer Prize-winning photojournalist Brian Lanker found his inspiration for this issue's dance story in Washington State. "My wife and I happened upon a small powwow," he says. "It made me think just how important dance is to human culture." It wasn't until he got to Davenport, Iowa, that Lanker was lured from behind the camera; a dance instructor he was photographing persuaded him, Lanker recalls. "Lester Hillier said, 'OK, I want you and your assistants out on

the floor. I'm going to teach you the samba.'"

Lynne Warren

It was easy for staff writer Lynne Warren to get excited about "Panda, Inc." She's had experience. A native of Washington, D.C., she was 12 years old when the first two pandas arrived at the city's National Zoo. Yet that pair's celebrity can't compare with the attention now showered on the zoo's first surviving cub, Tai Shan. "He's a rock star," Warren says. "He's bigger than his measurements."



Tyrone Turner

While photographing San Diego surfers for "Loving Our Coasts to Death," Tyrone Turner didn't quite hang ten. "Surfing is the perfect intersection between people and water," he explains. But surf photography is a specialized skill. Equipped with a wet suit, fins, boogie board, and camera, Turner—

accompanied by writer Joel Bourne and surfing legend Skip Frye (page 64)—started the half-mile swim to the reef. Two huge swells rushed into the channel, knocking Turner off his board and the heavy camera into his face. Seven stitches later, though, he returned to capture the image on the story's first pages.



Joel Bourne

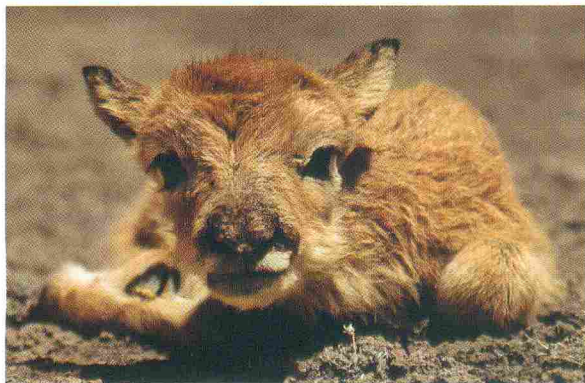
Pulling double duty this month, staff writer Joel Bourne authored stories on America's coasts and Blackbeard.

"When I was a kid in North Carolina, Blackbeard was one of my heroes, villain that he was," Bourne admits. "I spent a lot of time digging for his treasure." Bourne's hunt may be over: In lieu of pirate booty, he now has memories to treasure of diving on the shipwreck.

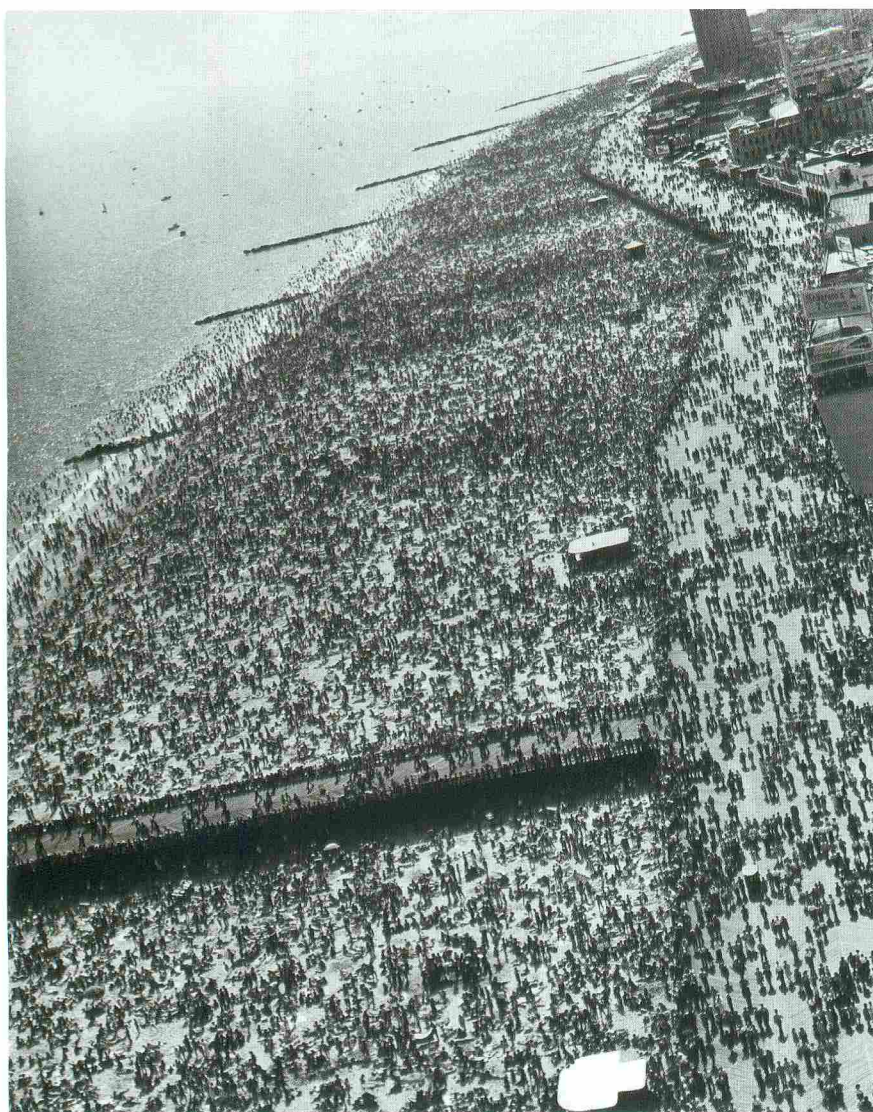
► **Tales From the Field** Find the best, worst, and quirkiest stories from our contributors in Features at ngm.com/0607.



The antipoaching force (above) meets in a scene from the film *Mountain Patrol*. Ultrafine wool from a Tibetan antelope, the chiru (below), is illegally used to make shawls.



NG FILM Mountain Patrol In the 1990s, a ragtag group of local men voluntarily took to the Tibetan Plateau's Kekexili, a place of snow-covered mountains and sweeping grassland, in search of poachers. Their self-appointed mission: to protect the chiru, or Tibetan antelope. Once a million strong, the chiru population had dropped to as low as 75,000 because entire herds were illegally being killed and skinned for their wool. The film *Mountain Patrol: Kekexili* dramatizes the life-and-death struggles the patrolmen faced to save the animal. "This story shocked the whole nation of China," says director Lu Chuan, who first heard reports about the group's battle against poaching in 1999. It wasn't until he got to the 17,000-square-mile Kekexili reserve that he fully understood how dangerous life was there. At an average altitude of 15,000 feet, "the air is very thin." Conditions were so harsh that half his crew fell ill or abandoned the project, and Lu himself was rushed to a hospital with altitude sickness. "I thought I would die there," he remembers. But he found inspiration in members of the original mountain patrol who worked on the film. "They were my teachers," he says.

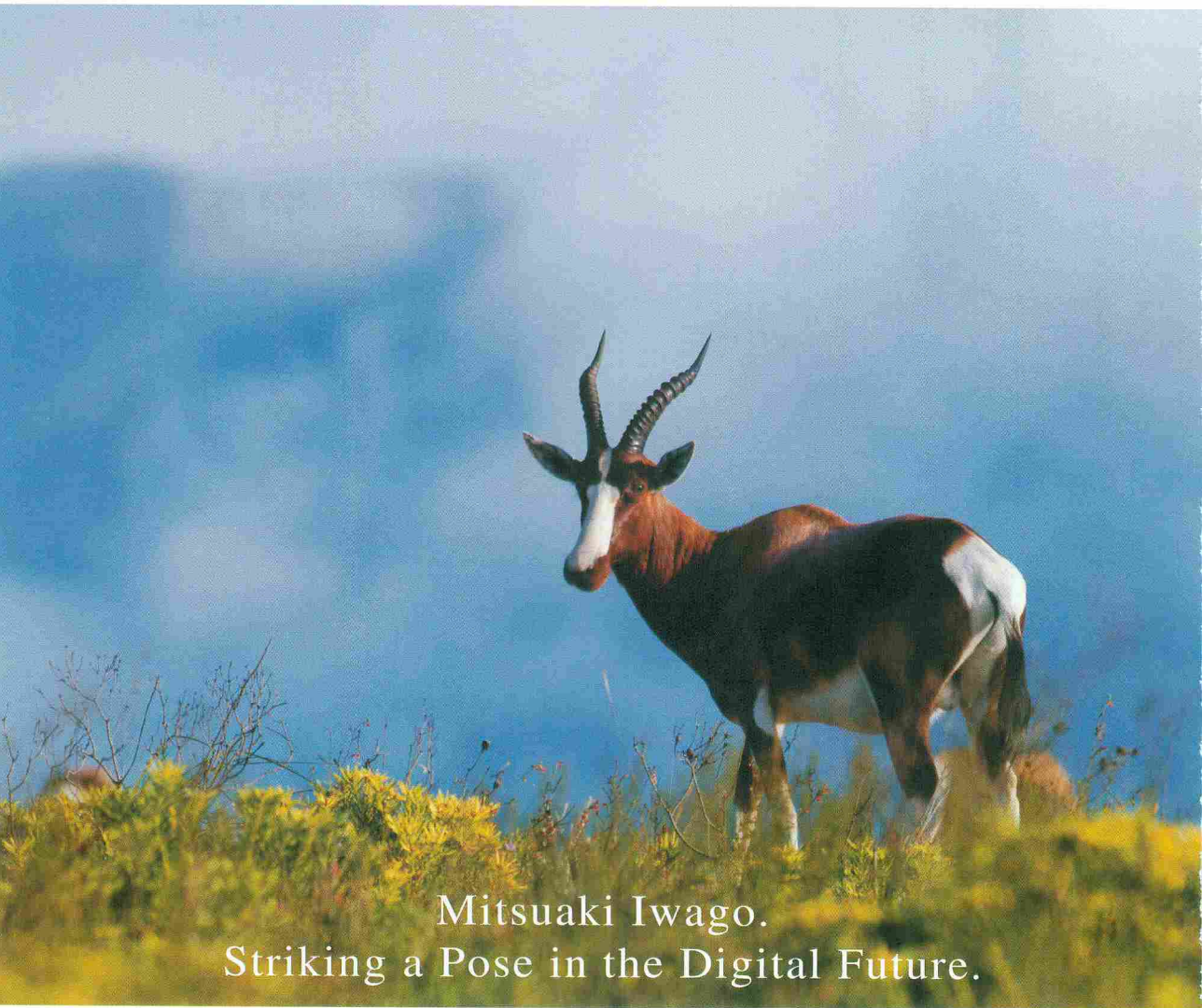


A Shore Thing Coney Island had been luring hot, weather-weary New Yorkers for more than a century when this photograph appeared in the March 1951 *GEOGRAPHIC*; the picture's caption claimed a count of 1.3 million bathers. Not actually an island at all (decades ago, silt filled the shallow creek that separated it from the rest of Brooklyn), Coney is said to have been named for wild crowds of a different sort: In the mid-1600s, Dutch sailors observing the frolics along its dunes knew it as Conyne Eylandt, or "rabbit island." —Margaret G. Zackowitz

🐾 **Flashback Archive** All the photos plus e-greetings, in Fun Stuff at ngm.com/0607.

PHOTO: PIX INC./TIME & LIFE PICTURES/GETTY IMAGES

NATIONAL GEOGRAPHIC (ISSN 0027-9358) IS PUBLISHED MONTHLY BY THE NATIONAL GEOGRAPHIC SOCIETY, 1145 17TH ST. NW, WASHINGTON, DC 20036-4688. \$34.00 A YEAR FOR U.S. DELIVERY, \$6.00 PER SINGLE COPY (INCLUDES POSTAGE AND HANDLING). IN CANADA, AGREEMENT NUMBER 40063649, RETURN UNDELIVERABLE CANADIAN ADDRESSES TO NATIONAL GEOGRAPHIC, PO BOX 4412 STN. A, TORONTO, ONTARIO M5W 3W2. UNITED KINGDOM NEWSSTAND COVER PRICE £3.75. PERIODICALS POSTAGE PAID AT WASHINGTON, DC, AND AT ADDITIONAL MAILING OFFICES. POSTMASTER: SEND ADDRESS CHANGES TO NATIONAL GEOGRAPHIC, PO BOX 63002, TAMPA, FL 33663-3002. MEMBERS: IF THE POSTAL SERVICE ALERTS US THAT YOUR MAGAZINE IS UNDELIVERABLE, WE HAVE NO FURTHER OBLIGATION UNLESS WE RECEIVE A CORRECTED ADDRESS WITHIN TWO YEARS.



Mitsuaki Iwago. Striking a Pose in the Digital Future.



Even in Africa, the effects of global warming are being felt. In the past three decades, the glacier atop Kilimanjaro has shrunk by almost half. Glaciers play an important role as a natural reservoir.

If the glaciers disappear, the natural consequence is a water shortage for humans and wildlife alike.

If the climate changes due to global warming, many species will be forced to move out of their present habitats.

For species whose habitats are already shrinking, finding a new sanctuary can be exceptionally difficult.

A bontebok stands tall on the crest of a small hill, proudly displaying its magnificent horns. Both males and females boast comparable horns, making it difficult to tell them apart. Judging by the way this one was showing off, photographer Mitsuaki Iwago was pretty sure it was a male. Once driven to the very brink of extinction by hunters in pursuit of their horns, these rare antelopes are now found only in South Africa. Iwago was especially impressed by the sharp contrast between the white markings and the reddish-brown coloring of the upper body. Thanks to Olympus digital technology, such striking moments as this can now be preserved forever.

Shot in Bontebok National Park in South Africa, on September 2, 2004, at 8:24 a.m., with the Olympus E-1, Zuiko Digital ED300mm, f4.0, 1/800 sec.

Digital SLR
Camera
OLYMPUS E-1



**An Olympus website about
global warming is coming soon.**

OLYMPUS CORPORATION Shinjuku Monolith, 3-1 Nishi-Shinjuku
2-chome, Shinjuku-ku, Tokyo 163-0914, Japan <http://www.olympus.com/>