

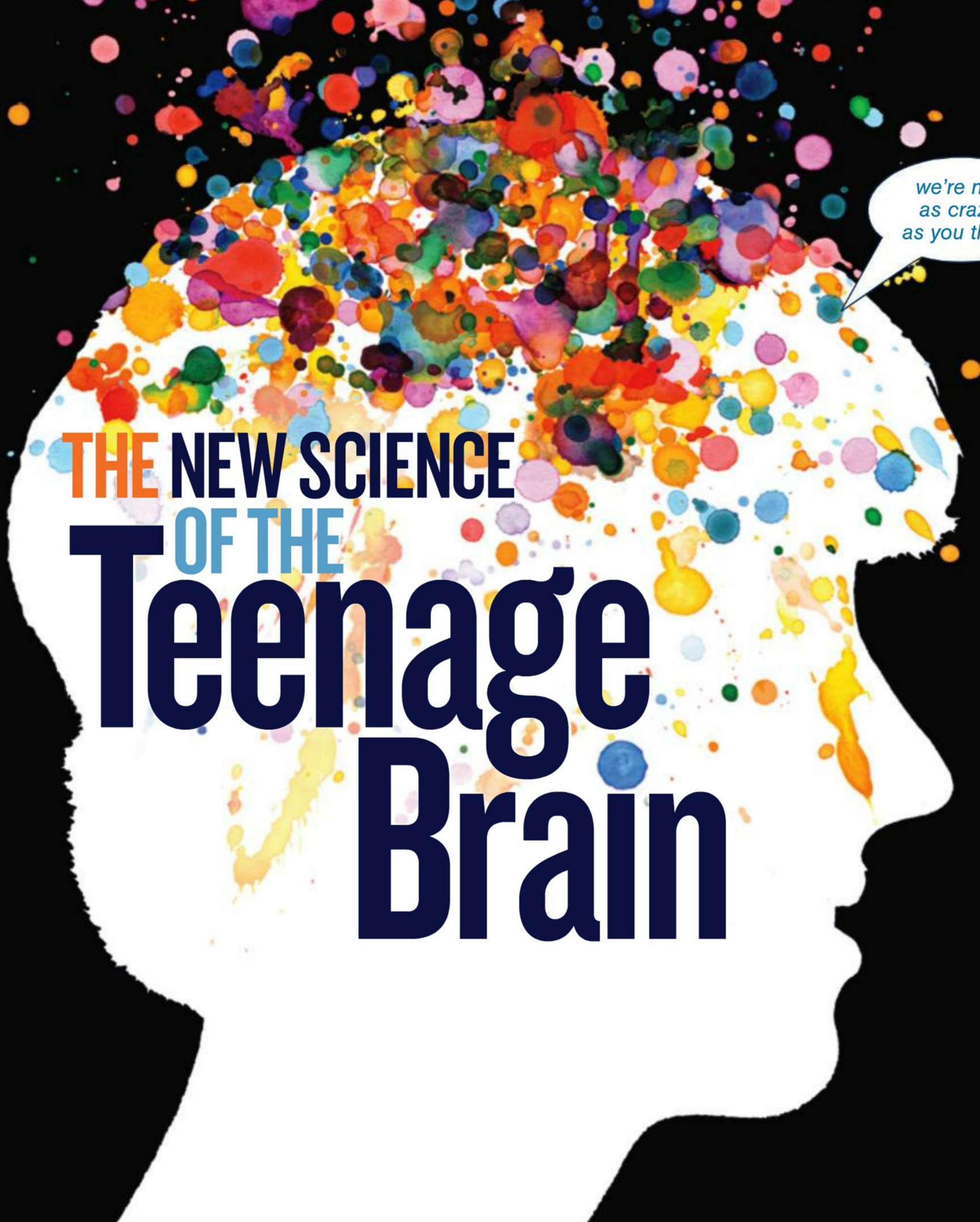
THE NO-ICE AGE
Earth's Tropical Past

SLOT CANYONS
Aussies Love to Drop In

ANSEL ADAMS
Views That Inspired Him

NGM.COM OCTOBER 2011

NATIONAL GEOGRAPHIC



we're not
as crazy
as you think

THE NEW SCIENCE
OF THE
Teenage
Brain

LIVE FOR

HE WORKS WITH THE MOUNTAIN, NOT AGAINST IT. THAT MAY EXPLAIN HOW HE'S CONQUERED 14 OF THE WORLD'S TALLEST PEAKS. ALL WITHOUT SUPPLEMENTAL OXYGEN. BUT CLIMBING ALSO COMES WITH RESPONSIBILITY. AS HE SAYS: "GETTING TO THE TOP IS OPTIONAL. GETTING DOWN, MANDATORY."

ED VIESTURS

GREATNESS



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VOL. 220 • NO. 4

NATIONAL GEOGRAPHIC

*Swimming in the Arctic would have
been like swimming today on the
mid-Atlantic seaboard.*
page 105

The Minarets of California's Ansel Adams Wilderness area are reflected in a pond near Cecile Lake.
Story on page 128.

PETER ESSICK

October 2011

36 Beautiful Teenage Brains

Impulsive, moody, maddening—that's a typical teen. Yet viewed through the eyes of evolution, adolescent behavior makes sense. Like, totally!

By David Dobbs Photographs by Kitra Cahana

60 Lost in Slot Canyons

Aussies love dropping into these drenched, narrow passages. Getting stuck is part of the fun.

By Mark Jenkins Photographs by Carsten Peter

82 A Whale of a Shark

Generally a gentle giant, the biggest fish is a beggar and a thief off the shores of Indonesia.

By Jennifer S. Holland Photographs by Michael Aw

90 World Without Ice

A mysterious surge of carbon sent temperatures soaring. Life changed forever. Welcome to Earth, 56 million years ago.

By Robert Kunzig Photographs by Ira Block

110 Genghis Khan's Urban Clan

Nomads were never meant to live in big-city boxes. But there they are, in Mongolia's capital.

By Don Belt Photographs by Mark Leong

128 An Homage to Ansel Adams

In the Sierra Nevada an unconfident young photographer became a lens master.

By Robert M. Poole Photographs by Peter Essick

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A pair of blue-eyed shags and their colony.

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Go ashore on Petermann Island and you'll be greeted by thousands of **gentoo penguins**, recognizable by a distinctive white stripe that spans the top of their heads.

VISIT

Port Lockroy, on Goudier Island, is considered a "living museum," and also features the Antarctic Peninsula's only public post office.

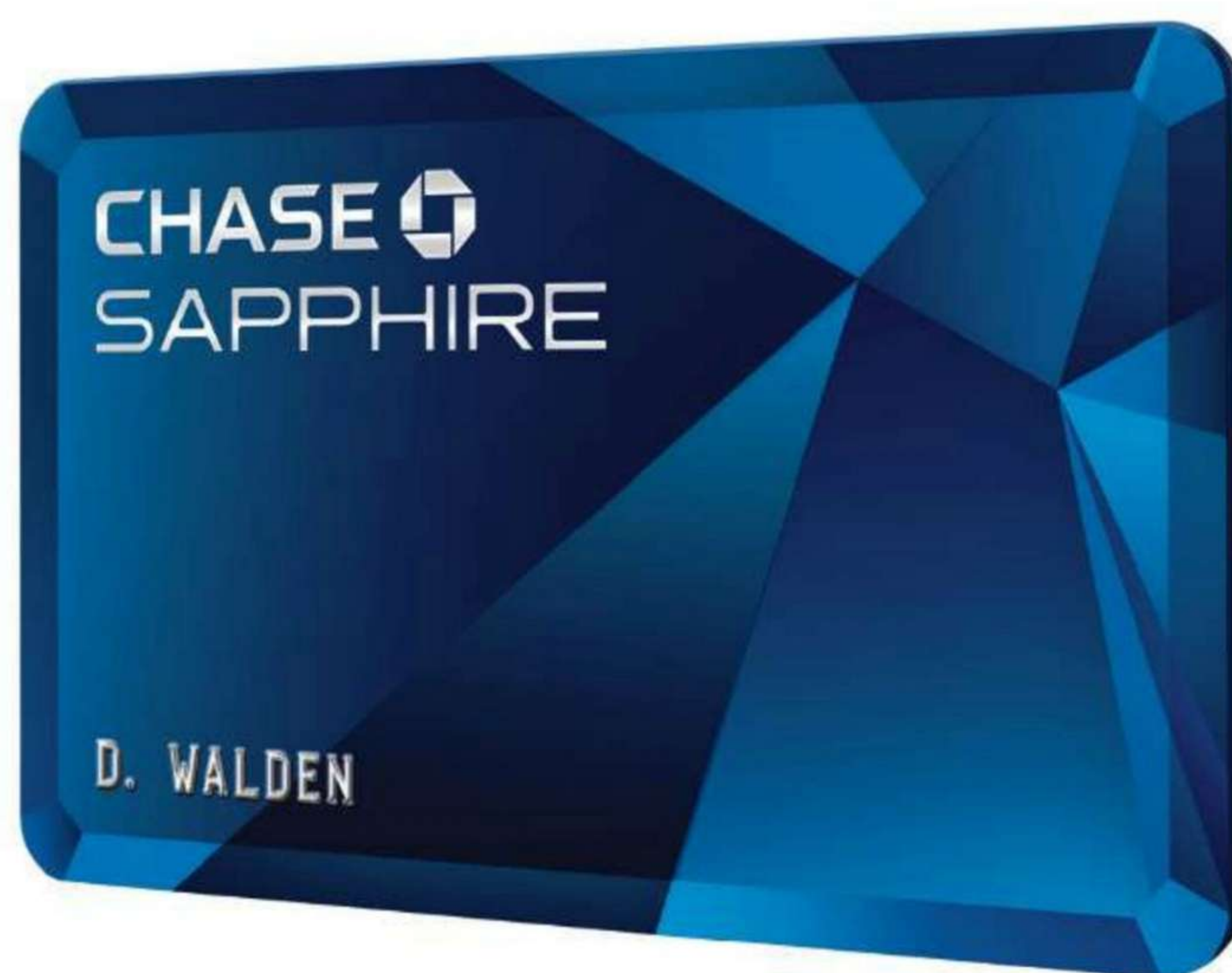


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October 2011

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Africa's elusive okapi looks like a mashup of familiar beasts.

Lethal Greens ▶

Beware of certain plants.

When Cancer Strikes

Habits, diet, and health care determine the death rate.

30 **NEXT****Meltdown-Proof Nukes** ▶

A different kind of technology could be a boon for safety.

Building Up Buddha ▶

The shattered Afghan statues could rise, thanks to 3-D modeling.

Pushy Jellyfish

They mix up ocean water as much as the wind and tides do.



- 144 **NG Connect**
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Flashback

E-GEOGRAPHIC

Here are the coolest extras in our electronic editions.

Teen Posers

Photographer Kitra Cahana tells how she entered the world of her teenage subjects for this month's cover story.

ngm.com + iPad

X Marks the Slot

Watch an Aussie descend into a narrow canyon.

ngm.com + iPad

Daily Dozen

Every weekday our editors pick a fresh selection of the best reader-submitted photographs for a Your Shot gallery.

ngm.com + iPad

**On the Cover**

To capture the "vibrant and alive and messy" nature of teen brains, our artist spent a day splattering watercolor paint on sheets of paper.

Art by Sam Hundley

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EDITOR'S NOTE

Chilling With Teens (Not!)

I'm so frustrated with my 14-year-old son, I am about to explode. I'm raising my voice. No, let's be honest, I'm yelling. I hate yelling. We are late. I hate being late. My 19-year-old daughter looks up from her phone, takes a break from texting and says, "Hey, Dad. Chill!" I hate being told to chill. My son sits in front of the television watching English Premier League soccer. Somehow he has discovered how to unblock satellite TV. I hate that. I cannot even figure out how to turn on the TV. To add insult to anger, he has figured out the password to my iPhone and is sitting on the couch texting the "mystery girl." My blood pressure skyrockets. He has not done his chores. His room is a mess. He cannot find his soccer jersey. We are going to miss his soccer game. Why do teenagers act this way?

To help us cope and, we hope, understand, we've made "Beautiful Brains," which is this month's cover story. We sent a talented photographer, Kitra Cahana, just a few years removed from her own teenage years, to Austin, Texas, to document life in and around high school. Her revealing photographs elicit fond and not so fond memories of our teenage years. David Dobbs writes about teenage behavior through the lens of evolution; he discovers there is actually a reason for their moody and maddening behavior.

Back to my frustrating morning: We finally get to the soccer game. My son plays with reckless abandon, scores a goal, and leaps into the arms of his teammates. Now that I love.



His room is a mess. Why do teenagers act this way?

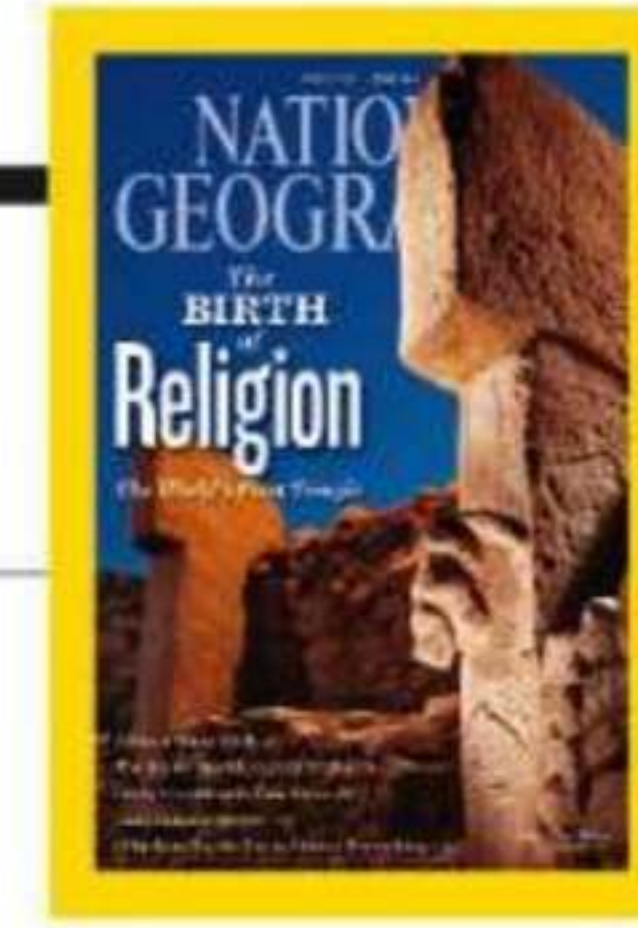
PAPER because

memories are more fond on paper.



LETTERS

June 2011



Birth of Religion

Author Charles C. Mann observes that the people at Göbekli Tepe “got steadily worse at temple building,” and their construction became smaller, simpler, and perhaps lost its

- ▶ charm over time. I wonder if he applies the same thought when comparing the awe-inspiring cathedrals of Christianity with our modern warehouse-like big-box churches.

STARR LUTERI
Goodyear, Arizona

It is understandable that a researcher would want to associate his life’s work with the dawn of civilization, but I am afraid Klaus Schmidt has gone a bit too far. He envisions a group of people building a religious center who suddenly develop agriculture to feed themselves. Sorry, but religion and food satisfy different types of hunger. It is not cause and effect. It is like saying football gave rise to beer and hot dogs because so many people consume them while watching that game.

ROBERT JEFFERS
North Billerica, Massachusetts

The animal carvings on the columns are similar to what

we know as the zodiac. To call Göbekli Tepe a temple is a leap of faith. It could also be seen as a celestial observatory.

ARNE SMITH
Meadows of Dan, Virginia

The supposition that 11,600 years ago this advanced group of artisans could be produced by a society of hunter-gatherers makes no sense. We need to consider the possibility that an advanced civilization existed at that time.

FREDERICK SCHAEFER
Mastic Beach, New York

The article highlights the theory that the urge to worship sparked civilization. However,

there’s an alternative theory: Civilization started because people found that by working together, they could make beer.

ROBERT G. SCHREIB, JR.
Toms River, New Jersey

When I look at the drawings of the temple of Göbekli Tepe on pages 44-5, it seems that the structure was meant to be looked down upon from the tops of the walls. From this perspective the entire temple can be seen to represent a womb. Such a temple would likely be used for mating rituals or fertility rites.

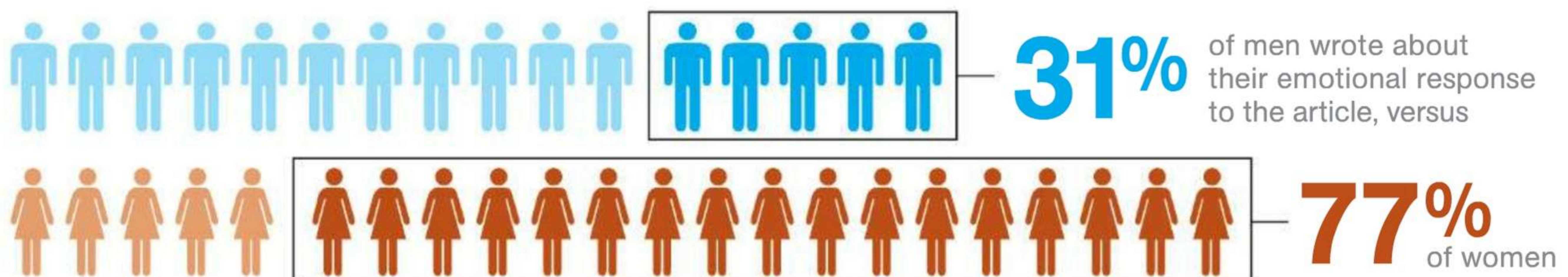
WILLIAM MORENO
Calabasas, California

Too Young to Wed

Rarely have I read a story with a mixture of emotions that can be described as simultaneous curiosity and nausea. I am a big believer in respecting different cultures, but I would challenge anyone to describe the good that comes with wedding children to adults. This is nothing short of child abuse.

BARDYA KAHROBAIE
San Ramon, California

FEEDBACK More women than men wrote us about “Too Young to Wed.” Each figure below represents two letters received.



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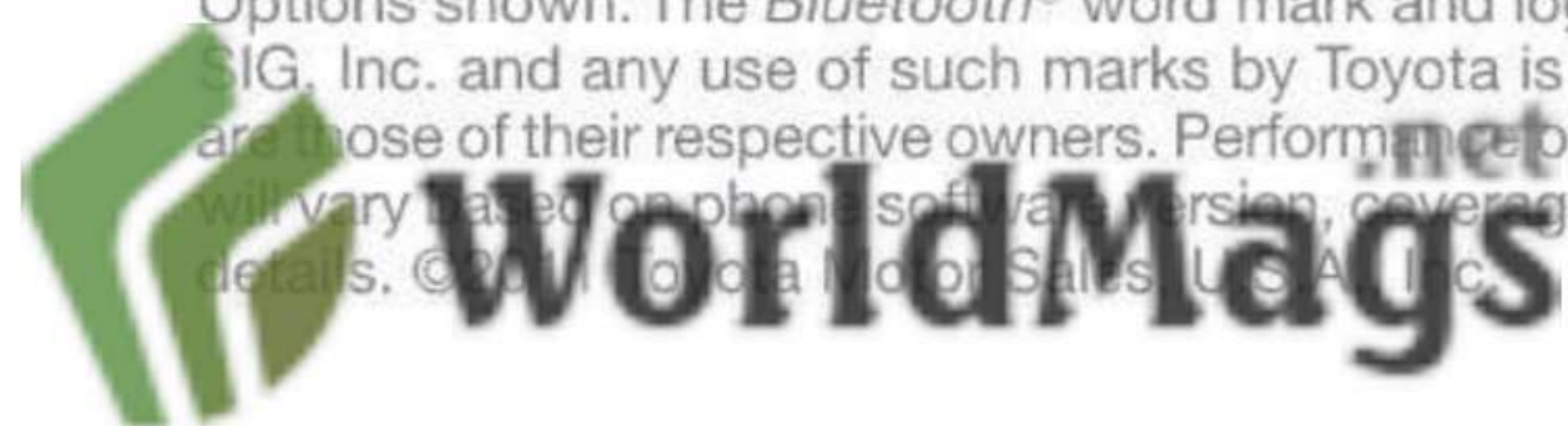
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HAVEN'T CALLED IN
OVER A WEEK. EVEN
THOUGH I KNOW
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LETTERS

“Too Young to Wed: The Secret World of Child Brides” has left me so angry that I am shaking as I write this. I cried for hours after reading it. I am a mother to two young daughters, and there simply aren’t words for the emotions this article invoked. I am left with one overwhelming feeling: I need to do something! Is there an organization that provides tangible help to these girls? Is there anything I can do to make a difference?

KRISTELLE CSERE
Walla Walla, Washington

Here are some groups that work to delay girls’ marriages and improve their lives.

International Center for Research on Women icrw.org

Equality Now equalitynow.org

The Veerni Project veerni.org

Tostan tostan.org

Elsa, Sifirash & Friends
viassociation.org

It was horrifying to read that a woman of 26 had already given birth to ten children.

It seems that the atrocities brought about by many of these countries just keep going on unchecked. The people who try to right the wrongs done to these young girls are met with indifference. I can’t imagine what must be going through the children’s minds when a man old enough to be their father rapes them and forces them to bear children. It was horrifying

to read that a woman of 26 had already given birth to ten children. If these women could only receive the education they need and the aid to stand up to these insane practices. If they have no safe havens, the practices will continue. I hope that someday this will be stopped, and those children can actually be children.

DEBBIE SIRONEN
Bend, Oregon

The incidence of suicide among child brides is not the only fatal result of this disturbing custom. In some cases mothers commit infanticide because the baby is female. Often, a cultural preference for sons is the driving force, but some of the mothers have said that they killed their little daughters out of pity for them, lest they be forced into the kind of miserable life they themselves endure. Early forced marriage to total strangers who then have absolute control of their wives is one of the features of such societies that make the lives of many women so intolerable that they feel it is kinder to kill their girl babies than to let them live.

HELEN F. STANBRO
Falmouth, Maine

My mother was a child bride at 13. I am the ninth of her eleven children, ten of whom survived to adulthood. My mother was a third-grade dropout who could read and write only at that level. But she devoured books from our local library—as if she did not have enough to occupy her time, with

milking cows, churning butter, milling grains, and so many other chores. She did not have any say in how she raised or married off her first five children. My paternal grandfather ruled with an iron fist. But after my grandfather’s demise, she established herself as a matriarch for her last five children. My father was supportive. All five children went to college and hold degrees. One decided not to marry, one chose not to have children, one married and holds multiple degrees. Education was her dowry to us.

CHARU GANDHI
Hoffman Estates, Illinois

Some may claim that people are uneducated and don’t know any better. Having “marriage” ceremonies in the middle of the night because of fear of arrest tells me that these people know exactly what they are doing.

N. FEHR
Calgary, Alberta

I would love to see an article about treatment and views of women in more developed societies where women are still not equal to men, such as Kuwait or Saudi Arabia.

KELLY M. POPTANYCZ
Venice, California

The implication of this article is that you have to go to some exotic developing country to find child brides. Not true. The practice derives from a conservative, patriarchal society and is not limited to one country or religion.

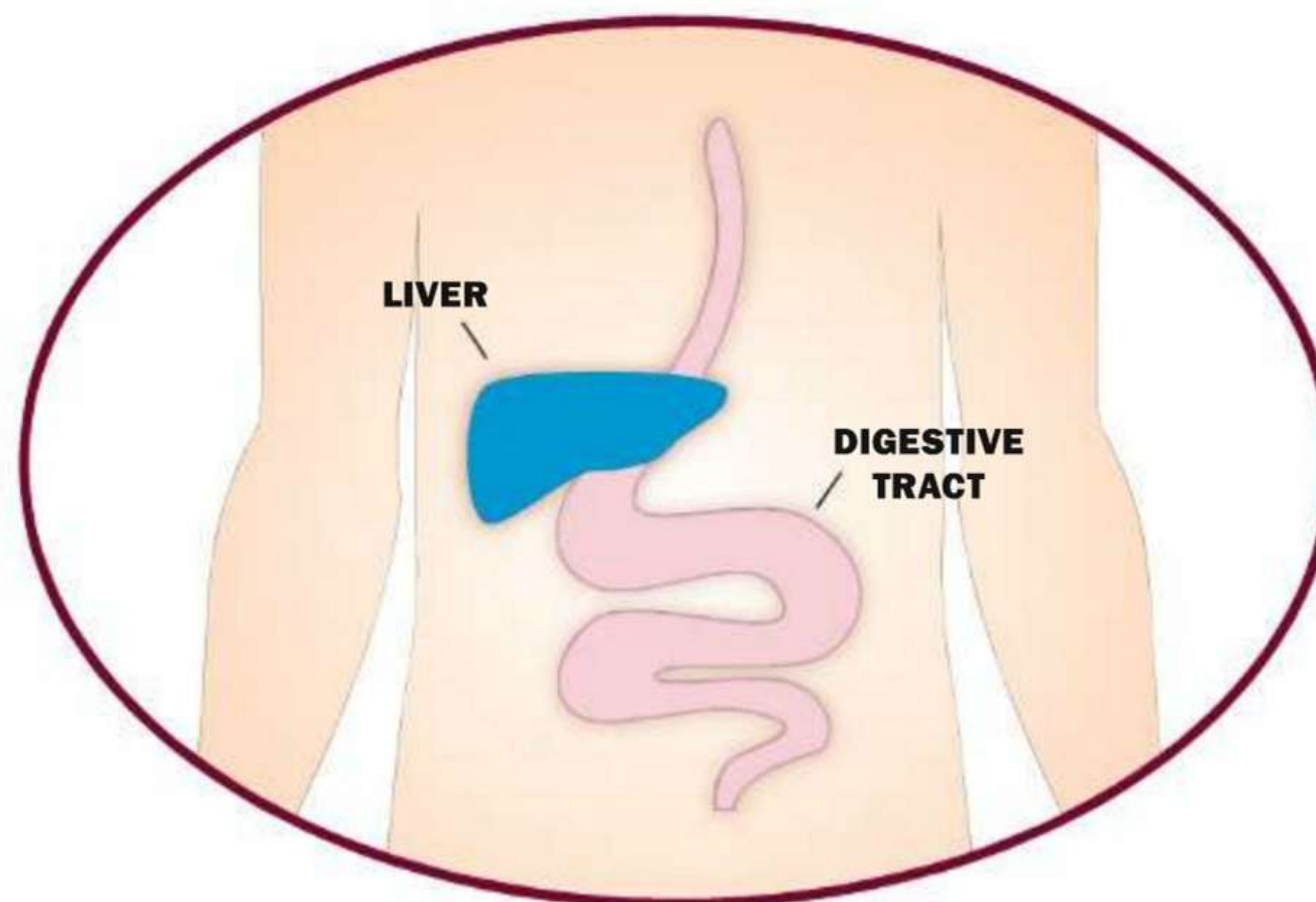
FRANK WEIGERT
Wilmington, Delaware

If you diet and take a statin, ZETIA can
help lower

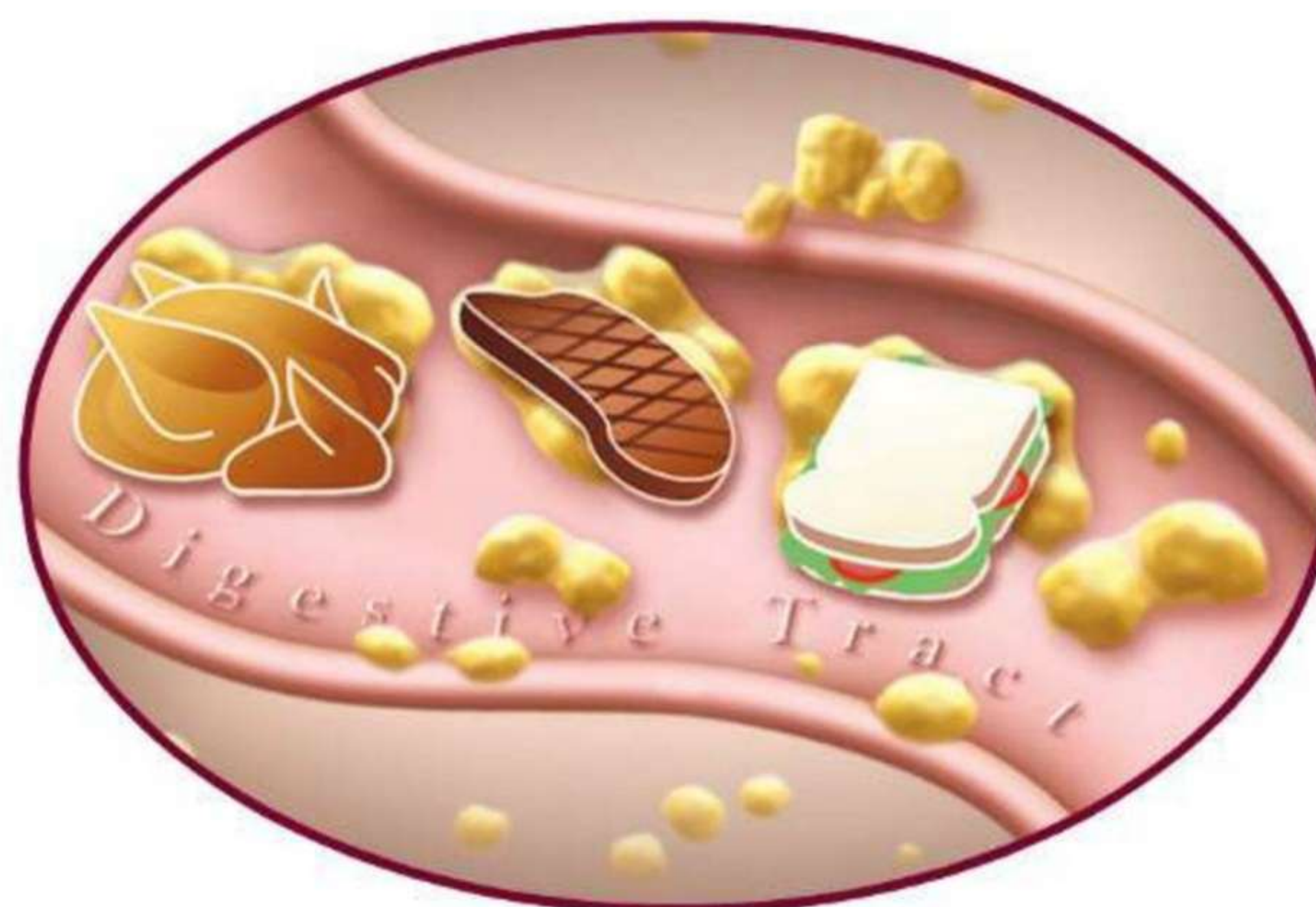
LDL (bad) cholesterol even more.

Statins, a good option, work mainly with the liver.

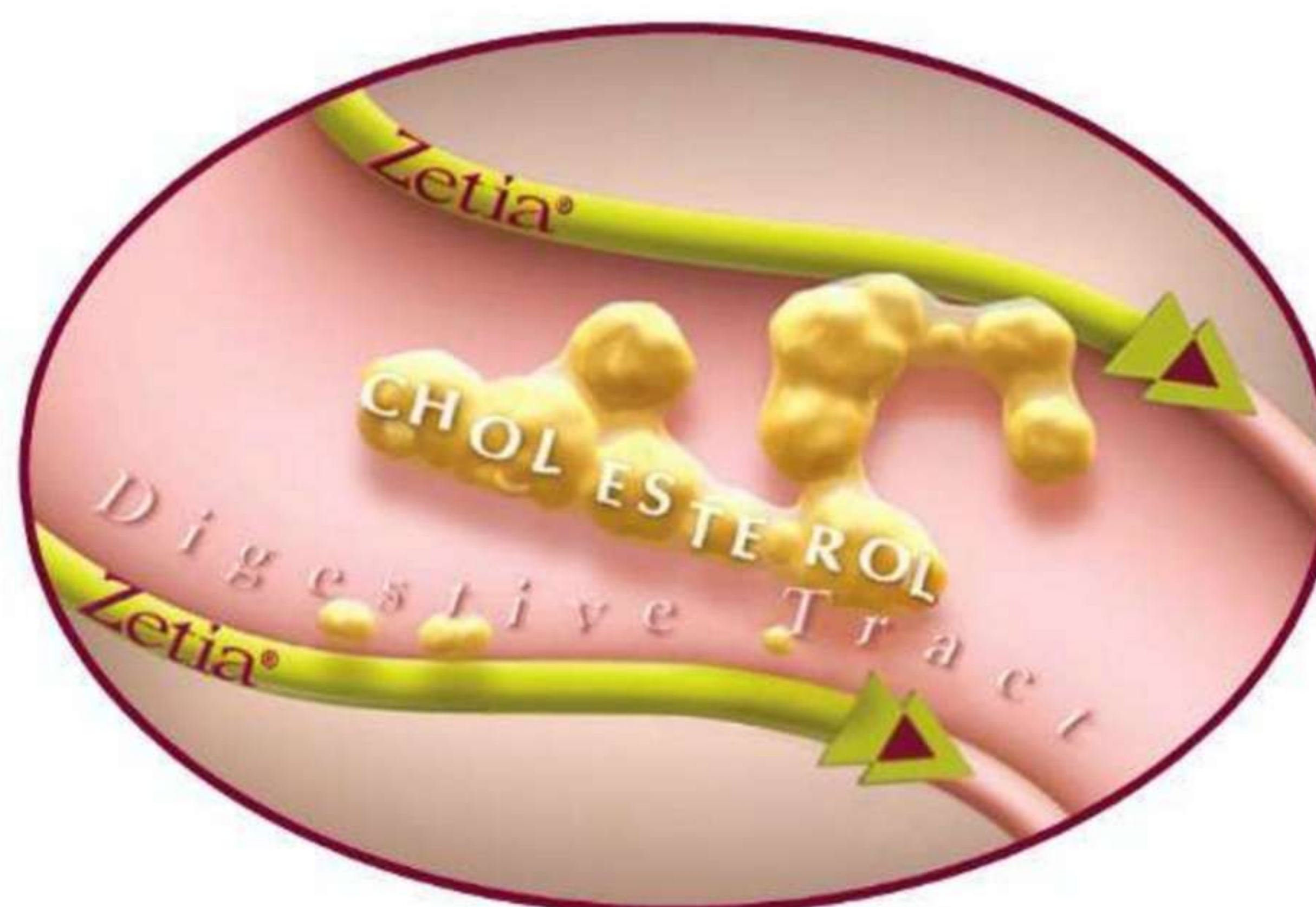
ZETIA works in the digestive tract, as do some other cholesterol-lowering medicines.



Cholesterol from food is absorbed when it enters the digestive tract.



ZETIA is unique in the way it helps block the absorption of cholesterol that comes from food. **Unlike some statins, ZETIA has not been shown to prevent heart disease or heart attacks.**



To learn about a free 30-day trial supply* offer for ZETIA, visit zetia.com.

*Not all patients are eligible. No purchase necessary. Restrictions apply. See Terms and Conditions.

Ask your doctor if adding **ZETIA** is right for you.

A healthy diet and exercise are important, but sometimes they're not enough to get your cholesterol where it needs to be. If you're also taking a statin, ZETIA can help lower your LDL (bad) cholesterol even further. In a clinical study, people who added ZETIA to their statin medication reduced their bad cholesterol on average by an additional 25% compared with 4% in people who added a placebo (a pill with no medication). Individual results vary.

Important Risk Information About ZETIA: ZETIA is a prescription medicine and should not be taken by people who are allergic to any of its ingredients. ZETIA can be taken alone or with a statin. Statins should not be taken by women who are nursing or pregnant or who may become pregnant, or by anyone with liver problems. If you have ever had liver problems or are pregnant or nursing, your doctor will decide if ZETIA alone is right for you. Your doctor may do blood tests to check your liver before you start taking ZETIA with a statin and during treatment.

Unexplained muscle pain or weakness could be a sign of a rare but serious side effect and should be reported to your doctor right away. In clinical studies, patients reported few side effects while taking ZETIA. These included diarrhea, joint pains, and tiredness.

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch, or call 1-800-FDA-1088.

Please read the more detailed information about ZETIA on the adjacent page.

For more information, call **1-800-98-ZETIA** or visit zetia.com.

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PATIENT INFORMATION ABOUT ZETIA (zēt'-ē-ā)

Generic name: ezetimibe (ē-zēt'-ē-mīb)

Read this information carefully before you start taking ZETIA and each time you get more ZETIA. There may be new information. This information does not take the place of talking with your doctor about your medical condition or your treatment. If you have any questions about ZETIA, ask your doctor. Only your doctor can determine if ZETIA is right for you.

WHAT IS ZETIA?

ZETIA is a medicine used to lower levels of total cholesterol and LDL (bad) cholesterol in the blood. ZETIA is for patients who cannot control their cholesterol levels by diet and exercise alone. It can be used by itself or with other medicines to treat high cholesterol. You should stay on a cholesterol-lowering diet while taking this medicine.

ZETIA works to reduce the amount of cholesterol your body absorbs. ZETIA does not help you lose weight. ZETIA has not been shown to prevent heart disease or heart attacks.

For more information about cholesterol, see the "What should I know about high cholesterol?" section that follows.

WHO SHOULD NOT TAKE ZETIA?

- Do not take ZETIA if you are allergic to ezetimibe, the active ingredient in ZETIA, or to the inactive ingredients. For a list of inactive ingredients, see the "Inactive ingredients" section that follows.
- If you have active liver disease, do not take ZETIA while taking cholesterol-lowering medicines called statins.
- If you are pregnant or breast-feeding, do not take ZETIA while taking a statin.
- If you are a woman of childbearing age, you should use an effective method of birth control to prevent pregnancy while using ZETIA added to statin therapy.

ZETIA has not been studied in children under age 10.

WHAT SHOULD I TELL MY DOCTOR BEFORE AND WHILE TAKING ZETIA?

Tell your doctor about any prescription and non-prescription medicines you are taking or plan to take, including natural or herbal remedies.

Tell your doctor about all your medical conditions including allergies.

Tell your doctor if you:

- ever had liver problems. ZETIA may not be right for you.
- are pregnant or plan to become pregnant. Your doctor will discuss with you whether ZETIA is right for you.
- are breast-feeding. We do not know if ZETIA can pass to your baby through your milk. Your doctor will discuss with you whether ZETIA is right for you.
- experience unexplained muscle pain, tenderness, or weakness.

HOW SHOULD I TAKE ZETIA?

- Take ZETIA once a day, with or without food. It may be easier to remember to take your dose if you do it at the same time every day, such as with breakfast, dinner, or at bedtime. If you also take another medicine to reduce your cholesterol, ask your doctor if you can take them at the same time.
- If you forget to take ZETIA, take it as soon as you remember. However, do not take more than one dose of ZETIA a day.
- Continue to follow a cholesterol-lowering diet while taking ZETIA. Ask your doctor if you need diet information.
- Keep taking ZETIA unless your doctor tells you to stop. It is important that you keep taking ZETIA even if you do not feel sick.

See your doctor regularly to check your cholesterol level and to check for side effects. Your doctor may do blood tests to check your liver before you start taking ZETIA with a statin and during treatment.

WHAT ARE THE POSSIBLE SIDE EFFECTS OF ZETIA® (EZETIMIBE)?

In clinical studies patients reported few side effects while taking ZETIA. These included diarrhea, joint pains, and feeling tired.

Patients have experienced severe muscle problems while taking ZETIA, usually when ZETIA was added to a statin drug. If you experience unexplained muscle pain, tenderness, or weakness while taking ZETIA, contact your doctor immediately. You need to do this promptly, because on rare occasions, these muscle problems can be serious, with muscle breakdown resulting in kidney damage.

Additionally, the following side effects have been reported in general use: allergic reactions (which may require treatment right away) including swelling of the face, lips, tongue, and/or throat that may cause difficulty in breathing or swallowing, rash, and hives; raised red rash, sometimes with target-shaped lesions; joint pain; muscle aches; alterations in some laboratory blood tests; liver problems; stomach pain; inflammation of the pancreas; nausea; dizziness; tingling sensation; depression; headache; gallstones; inflammation of the gallbladder.

Tell your doctor if you are having these or any other medical problems while on ZETIA. For a complete list of side effects, ask your doctor or pharmacist.

WHAT SHOULD I KNOW ABOUT HIGH CHOLESTEROL?

Cholesterol is a type of fat found in your blood. Your total cholesterol is made up of LDL and HDL cholesterol.

LDL cholesterol is called "bad" cholesterol because it can build up in the wall of your arteries and form plaque. Over time, plaque build-up can cause a narrowing of the arteries. This narrowing can slow or block blood flow to your heart, brain, and other organs. High LDL cholesterol is a major cause of heart disease and one of the causes for stroke.

HDL cholesterol is called "good" cholesterol because it keeps the bad cholesterol from building up in the arteries.

Triglycerides also are fats found in your blood.

GENERAL INFORMATION ABOUT ZETIA

Medicines are sometimes prescribed for conditions that are not mentioned in patient information leaflets. Do not use ZETIA for a condition for which it was not prescribed. Do not give ZETIA to other people, even if they have the same condition you have. It may harm them.

This summarizes the most important information about ZETIA. If you would like more information, talk with your doctor. You can ask your pharmacist or doctor for information about ZETIA that is written for health professionals.

Inactive ingredients:

Croscarmellose sodium, lactose monohydrate, magnesium stearate, microcrystalline cellulose, povidone, and sodium lauryl sulfate.

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REV 21

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Get one IMMEDIATELY."
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pieces of jewelry I own.
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THIS MONTH

Rocket City Rednecks

In Huntsville, Alabama, Charles "Daddy" Taylor and his son Travis are busy building lasers. Self-proclaimed rednecks, the Taylors also happen to be experts at rocket-propulsion engineering. In fact, Daddy helped build the Saturn V rocket in the fledgling days of America's space program. Get in on the action as these good ol' boys invent homespun solutions to some of science's biggest problems in this new series, *Rocket City Rednecks*. The backwoods good times begin this month on the National Geographic Channel.



NATIONAL GEOGRAPHIC CHANNEL

Brain Games

Get inside your head with scientists and psychologists as they explore the brain in this new three-part special.



NAT GEO WILD

Night Stalkers

Revolutionary camera technology illuminates the dark world of African hyenas on the hunt at night.

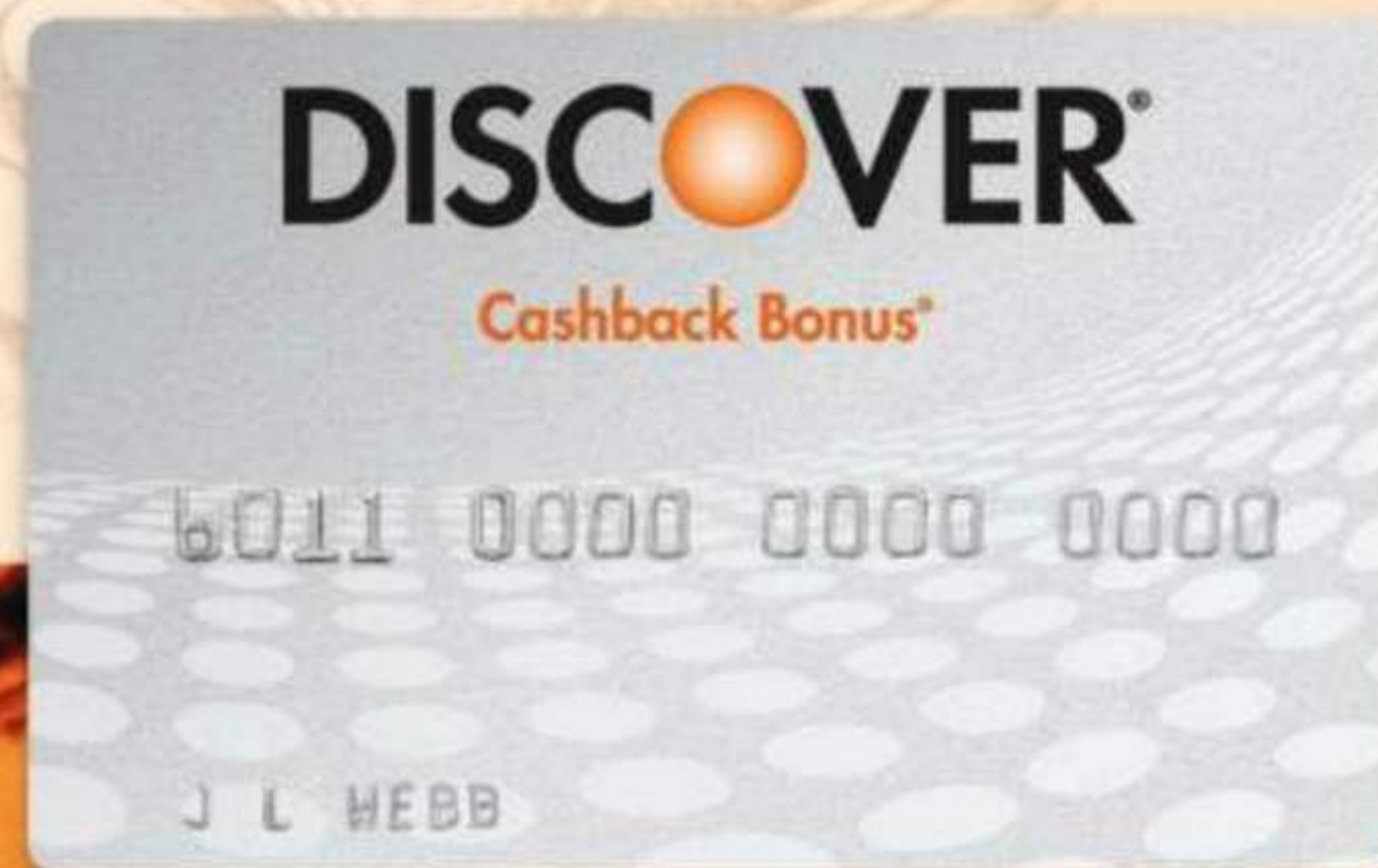
For listings go to natgeotv.com and natgeowild.com.

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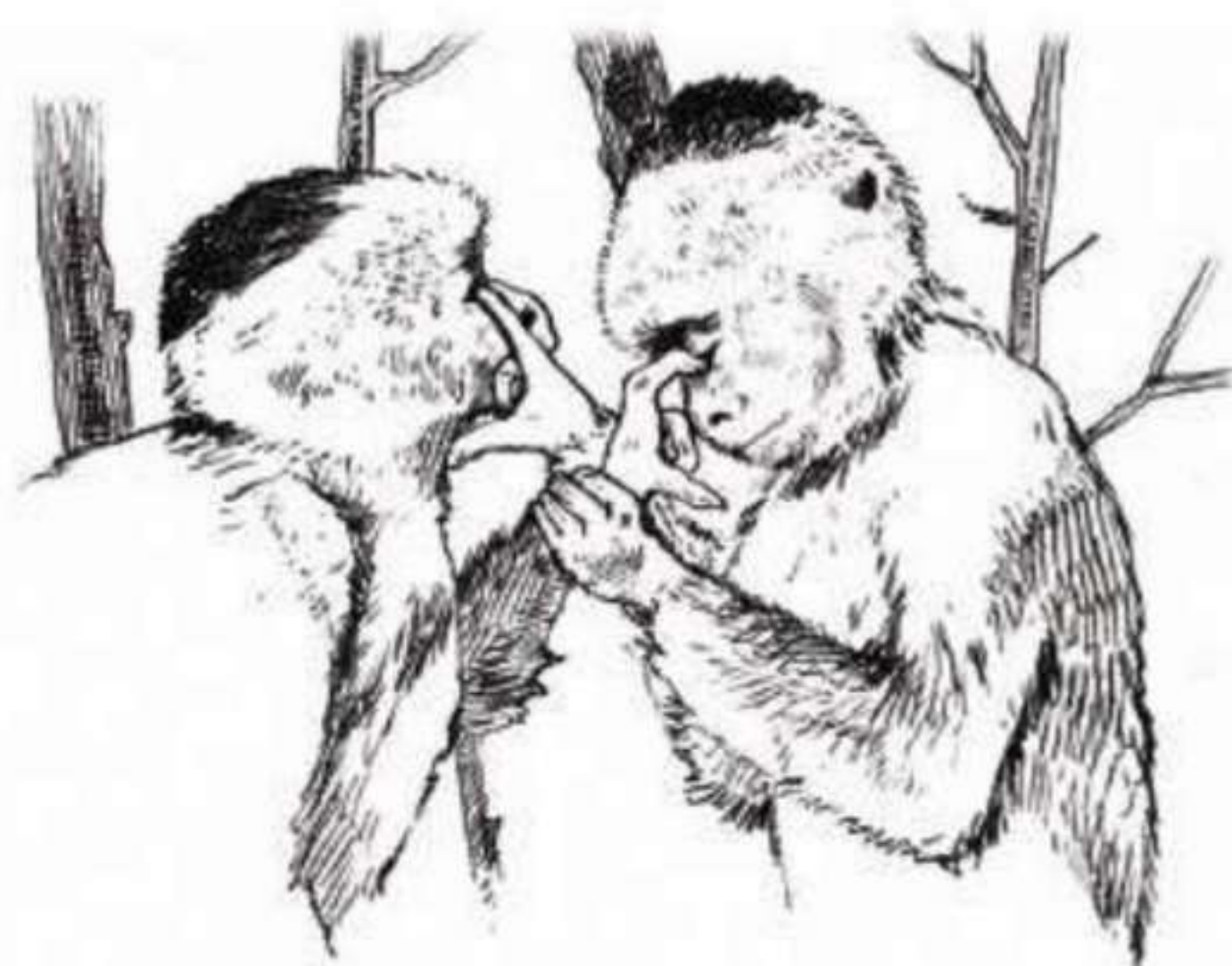
Patagonian Wetlands

In the temperate grasslands of southern Argentina, the wet meadows known as *mallines* support livestock and a host of native wildlife. But overgrazing threatens to dry out the lush landscape. Biologist-photographer **Anand Varma** spent 11 weeks documenting the region, on the ground and overhead—including a paragliding stint (right) that took him above Nahuel Huapí Lake. “A gaucho told me, ‘The *mallín* is our life,’” he says. Varma’s work will help conservationists protect critical areas.

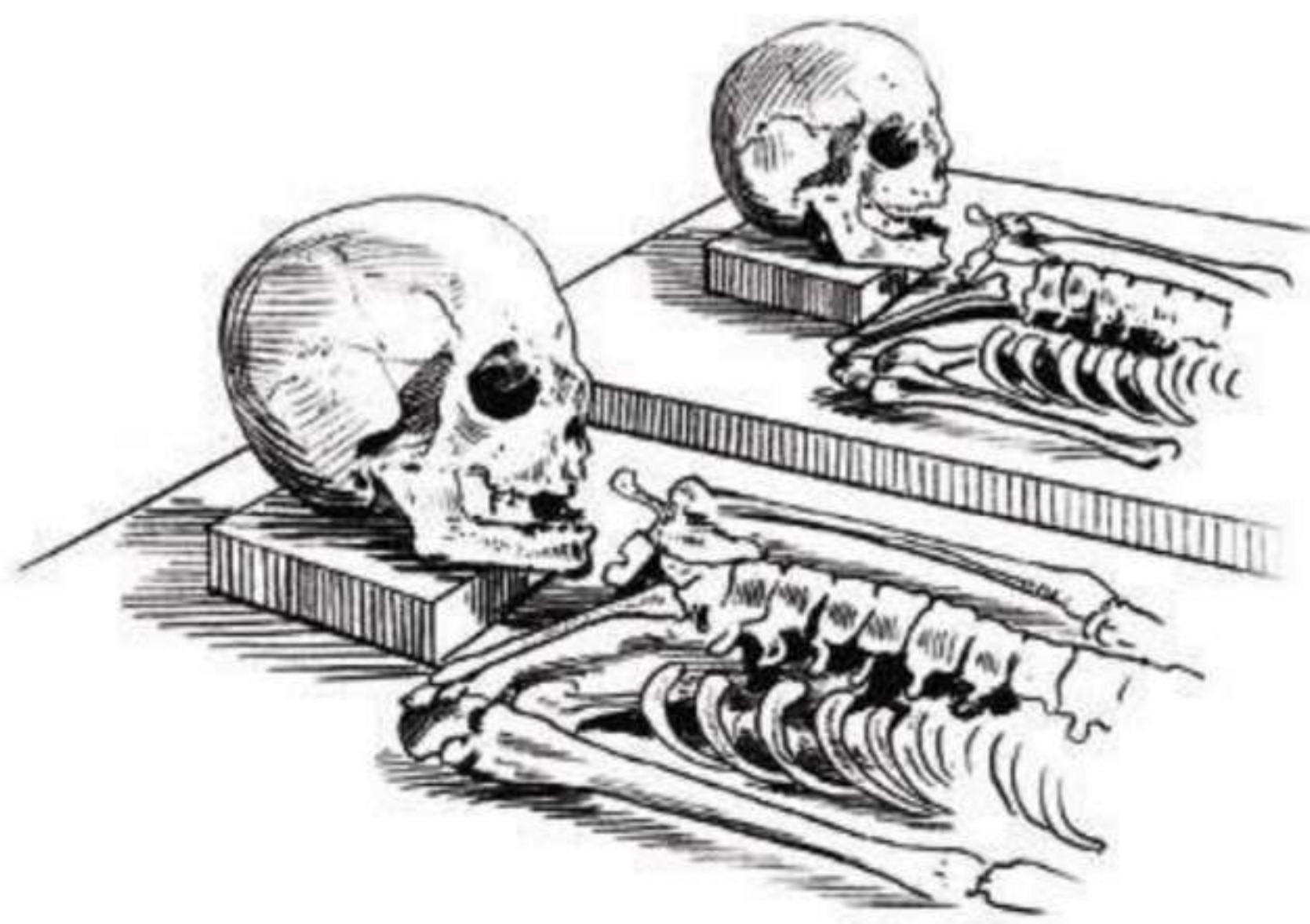
Founded in 1888, the National Geographic Society has supported more than 9,000 explorations and research projects, adding to our knowledge of earth, sea, and sky.



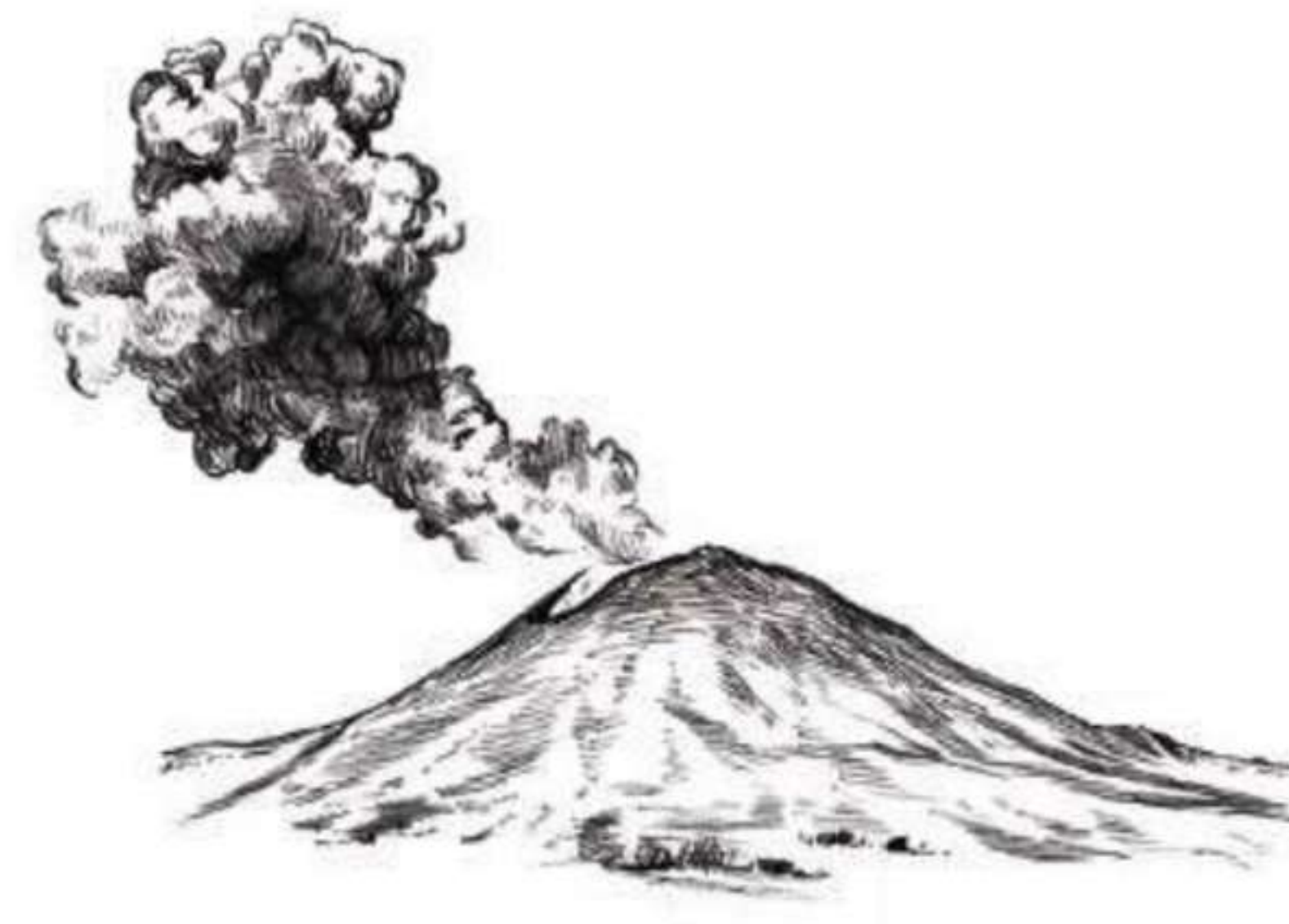
FIELD NOTES



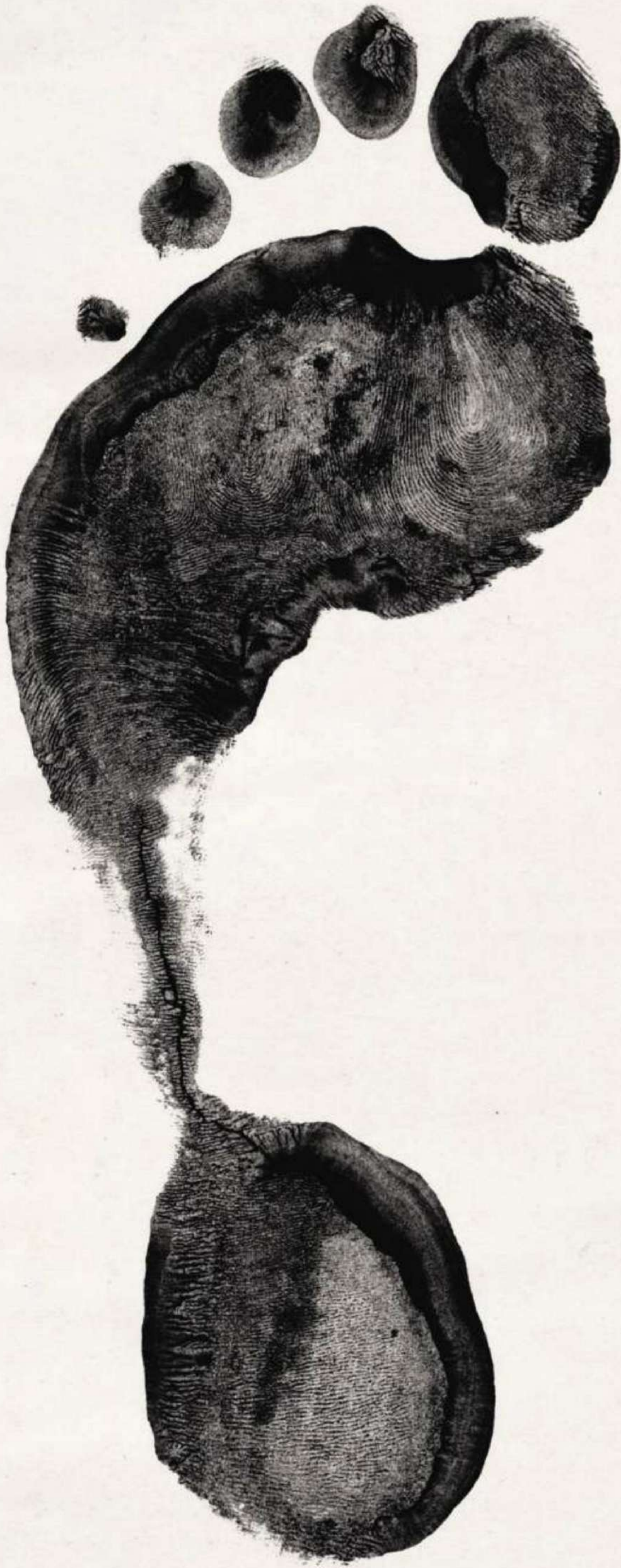
MONKEY WATCHER Capuchin monkeys, says anthropologist **Susan Perry**, are “high-drama animals.” She should know—she’s studied them in Costa Rica for the past 21 years. Among her findings: Capuchins like to push their fingers up to the first knuckle into each other’s eyes, a likely signal of trust.



SAINT SEEKER When Italy’s Reggio Emilia Cathedral was renovated in 2008, workers recovered bones making up two nearly complete skeletons. Paleopathologist **Ezio Fulcheri** believes they are the remains of third-century Christian saints Daria and Chrysanthus, killed by the Romans for proselytizing.



VOLCANO WHISPERER Geophysicist **Jeffrey Johnson** listens to rumbles for clues to volcanic behavior. Most signals he’s studied measure below 20 hertz, inaudible to the human ear but not to infrasound sensors that are used to examine volcanic processes to help anticipate future eruptions.



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VISIONS



United States

In windswept Iowa, ears of mature corn dry ahead of the autumn harvest. Last year the state yielded nearly 62 million tons of the crop—vital for livestock feed and ethanol production—making it the top U.S. grower of golden kernels.

PHOTO: JIM LO SCALZO





Indonesia

A tender moment transpires between mother and infant orangutans in Borneo's Tanjung Puting National Park. The arboreal species has one of the longest intervals between births among mammals, typically around eight years.

PHOTO: JAMI TARRIS, CORBIS



United States

Burning hot on a winter's day, a brush fire consumes a patch of dried marsh, drawing spectators at a golf course in Denver, Colorado. Fueled by wind and low humidity, the blaze charred dozens of acres.

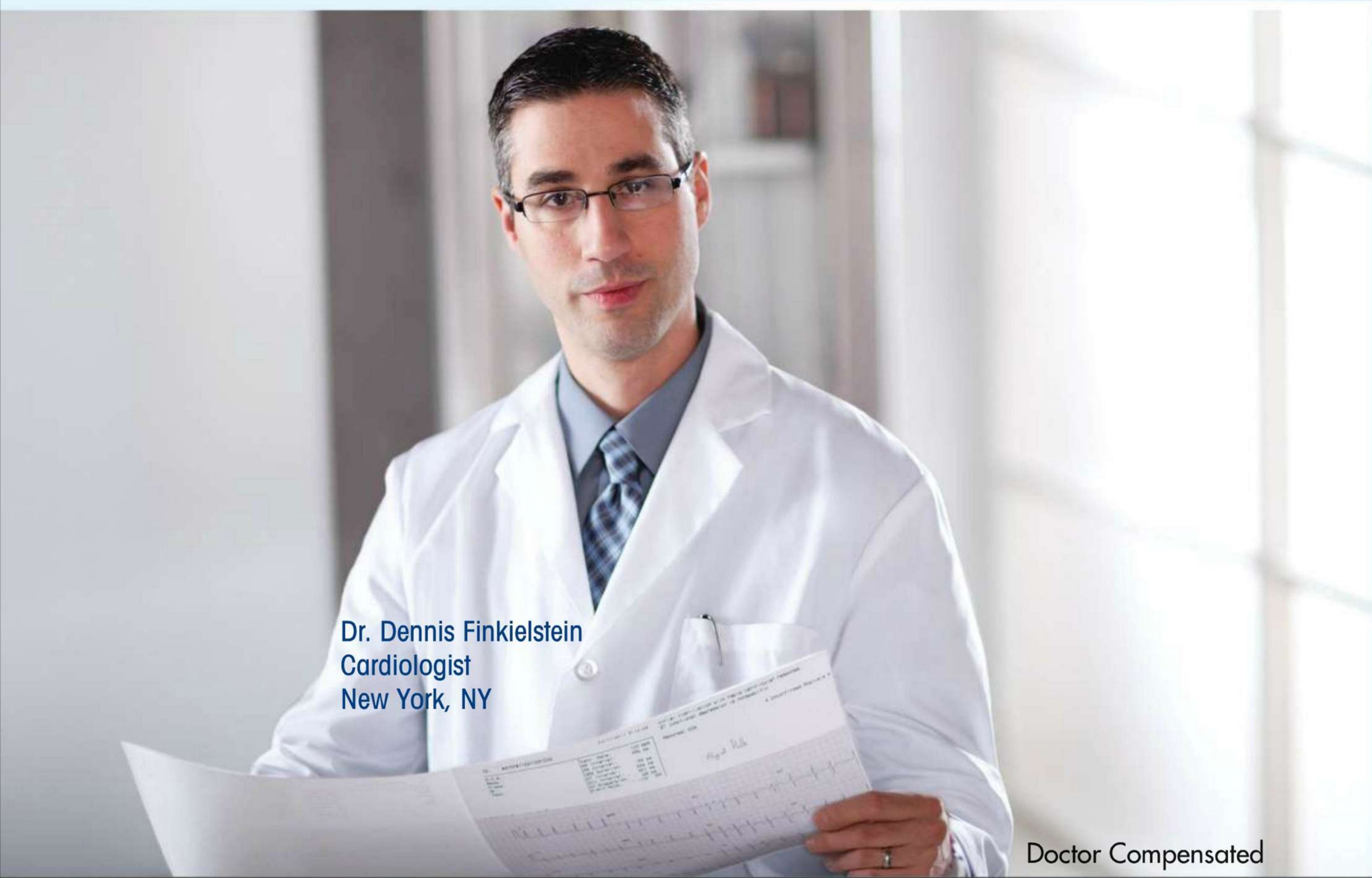
PHOTO: MATTHEW SLABY, LUCEO

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*Do you have an irregular heartbeat called **atrial fibrillation** not caused by a heart valve problem?*

And do you take warfarin, or Coumadin[®], to reduce your stroke risk?



Dr. Dennis Finkelstein
Cardiologist
New York, NY

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Here's why you should ask your doctor about **PRADAXA**.

- In a clinical trial, PRADAXA 150 mg **reduced stroke risk 35% more than warfarin.**
Risk reduction was greatest when compared to patients on warfarin whose blood tests showed lower levels of control.
- **Unlike warfarin, no regular blood tests.**

PRADAXA is a prescription blood-thinning medicine used to reduce the risk of stroke and blood clots in people with atrial fibrillation not caused by a heart valve problem. With atrial fibrillation, part of the heart does not beat the way it should. This can cause blood clots to form, increasing your risk of a stroke. PRADAXA lowers the chance of blood clots forming in your body.

IMPORTANT SAFETY INFORMATION ABOUT PRADAXA

PRADAXA can cause bleeding which can be serious and sometimes lead to death. Don't take PRADAXA if you currently have abnormal bleeding or if you have ever had an allergic reaction to it. **Your risk of bleeding with PRADAXA may be higher if you:** are 75 years old or older, have kidney problems, have stomach or intestine bleeding that is recent or keeps coming back or you have a stomach ulcer, take other medicines that increase your risk of bleeding, like aspirin products, non-steroidal anti-inflammatory drugs (NSAIDs) and blood thinners.

Call your doctor or seek immediate medical care if you have any of the following signs or symptoms of bleeding: any unexpected, severe, or uncontrollable bleeding; or bleeding that lasts a long time, unusual or unexpected bruising,

coughing up or vomiting blood; or vomit that looks like coffee grounds, pink or brown urine; red or black stools (looks like tar), unexpected pain, swelling, or joint pain, headaches and feeling dizzy or weak.

It is important to tell your doctor about all medicines, vitamins and supplements you take. Some of your other medicines may affect the way PRADAXA works.

Take PRADAXA exactly as prescribed by your doctor. Don't stop taking PRADAXA without talking to your doctor as your risk of stroke may increase.

Tell your doctor if you are planning to have **any** surgery, or medical or dental procedure, because you may have to stop taking PRADAXA for a short time. PRADAXA can cause indigestion, stomach upset or burning, and stomach pain.

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch or call 1-800-FDA-1088.

Please see more detailed Medication Guide on next page.

Reduce your risk of a stroke caused by a clot that starts in the heart.

Pradaxa[®]
dabigatran etexilate
CAPSULES



Read this Medication Guide before you start taking PRADAXA and each time you get a refill. There may be new information. This Medication Guide does not take the place of talking with your doctor about your medical condition or your treatment.

What is the most important information I should know about PRADAXA?

- PRADAXA can cause bleeding which can be serious, and sometimes lead to death. This is because PRADAXA is a blood thinner medicine that lowers the chance of blood clots forming in your body.
- **You may have a higher risk of bleeding if you take PRADAXA and:**
 - Are over 75 years old
 - Have kidney problems
 - Have stomach or intestine bleeding that is recent or keeps coming back, or you have a stomach ulcer
 - Take other medicines that increase your risk of bleeding, including:
 - aspirin or aspirin containing products
 - long-term (chronic) use of non-steroidal anti-inflammatory drugs (NSAIDs)
 - warfarin sodium (Coumadin®, Jantoven®)
 - a medicine that contains heparin
 - clopidogrel (Plavix®)
 - prasugrel (Effient®)

Tell your doctor if you take any of these medicines. Ask your doctor or pharmacist if you are not sure if your medicine is one listed above.

- PRADAXA can increase your risk of bleeding because it lessens the ability of your blood to clot. While you take PRADAXA:
 - You may bruise more easily
 - It may take longer for any bleeding to stop

Call your doctor or get medical help right away if you have any of these signs or symptoms of bleeding:

- Unexpected bleeding or bleeding that lasts a long time, such as:
 - unusual bleeding from the gums
 - nose bleeds that happen often
 - menstrual bleeding or vaginal bleeding that is heavier than normal
- Bleeding that is severe or you cannot control
- Pink or brown urine
- Red or black stools (looks like tar)
- Bruises that happen without a known cause or get larger
- Cough up blood or blood clots
- Vomit blood or your vomit looks like “coffee grounds”

MEDICATION GUIDE

PRADAXA (pra dax' a)
(dabigatran etexilate mesylate)
capsules

- Unexpected pain, swelling, or joint pain
- Headaches, feeling dizzy or weak

Take PRADAXA exactly as prescribed. Do not stop taking PRADAXA without first talking to the doctor who prescribes it for you. Stopping PRADAXA may increase your risk of a stroke.

PRADAXA may need to be stopped, if possible, for one or more days before any surgery, or medical or dental procedure. If you need to stop taking PRADAXA for **any reason**, talk to the doctor who prescribed PRADAXA for you to find out when you should stop taking it. Your doctor will tell you when to start taking PRADAXA again after your surgery or procedure.

See “What are the possible side effects of PRADAXA?” for more information about side effects.

What is PRADAXA?

PRADAXA is a prescription medicine used to reduce the risk of stroke and blood clots in people who have a medical condition called atrial fibrillation. With atrial fibrillation, part of the heart does not beat the way it should. This can lead to blood clots forming and increase your risk of a stroke. PRADAXA is a blood thinner medicine that lowers the chance of blood clots forming in your body.

It is not known if PRADAXA is safe and works in children.

Who should not take PRADAXA?

Do not take PRADAXA if you:

- Currently have certain types of abnormal bleeding. Talk to your doctor, before taking PRADAXA if you currently have unusual bleeding.
- Have had a serious allergic reaction to PRADAXA. Ask your doctor if you are not sure.

What should I tell my doctor before taking PRADAXA?

Before you take PRADAXA, tell your doctor if you:

- Have kidney problems
- Have ever had bleeding problems
- Have ever had stomach ulcers
- Have any other medical condition
- Are pregnant or plan to become pregnant. It is not known if PRADAXA will harm your unborn baby.
- Are breastfeeding or plan to breastfeed. It is not known if PRADAXA passes into your breast milk.

Tell all of your doctors and dentists that you are taking PRADAXA. They should talk to the doctor who prescribed PRADAXA for you, before you have **any** surgery, or medical or dental procedure.

Tell your doctor about all the medicines you take, including prescription and non-prescription medicines, vitamins, and herbal supplements. Some of your other medicines may affect the way PRADAXA works. Certain medicines may increase your risk of bleeding. See **“What is the most important information I should know about PRADAXA?”**

Especially tell your doctor if you take:

- rifampin (Rifater, Rifamate, Rimactane, Rifadin)

Know the medicines you take. Keep a list of them and show it to your doctor and pharmacist when you get a new medicine.

How should I take PRADAXA?

- **Take PRADAXA exactly as prescribed by your doctor.**
- Do not take PRADAXA more often than your doctor tells you to.
- You can take PRADAXA with or without food.
- Swallow PRADAXA capsules whole. Do not break, chew, or empty the pellets from the capsule.
- If you miss a dose of PRADAXA, take it as soon as you remember. If your next dose is less than 6 hours away, skip the missed dose. Do not take two doses of PRADAXA at the same time.
- Your doctor will decide how long you should take PRADAXA. **Do not stop taking PRADAXA without first talking with your doctor. Stopping PRADAXA may increase your risk of stroke.**
- Do not run out of PRADAXA. Refill your prescription before you run out. If you plan to have surgery, or a medical or a dental procedure, tell your doctor and dentist that you are taking PRADAXA. You may have to stop taking PRADAXA for a short time. See “What is the most important information I should know about PRADAXA?”
- If you take too much PRADAXA, go to the nearest hospital emergency room or call your doctor or the Poison Control Center right away.

What are the possible side effects of PRADAXA?

PRADAXA can cause serious side effects.

- See “What is the most important information I should know about PRADAXA?”
- Allergic Reactions. In some people, PRADAXA can cause symptoms of an allergic reaction, including hives, rash, and itching. Tell your doctor or get medical help right away if you get any of the following symptoms of a serious allergic reaction with PRADAXA:
 - chest pain or chest tightness
 - swelling of your face or tongue
 - trouble breathing or wheezing
 - feeling dizzy or faint

Common side effects of PRADAXA include:

- indigestion, upset stomach, or burning
- stomach pain

Tell your doctor if you have any side effect that bothers you or that does not go away.

These are not all of the possible side effects of PRADAXA. For more information, ask your doctor or pharmacist.

Call your doctor for medical advice about side effects. You may report side effects to FDA at 1-800-FDA-1088.

How should I store PRADAXA?

- Store PRADAXA at room temperature between 59°F to 86°F (15°C to 30°C). After opening the bottle, use PRADAXA within 30 days. Safely throw away any unused PRADAXA after 30 days.
- Store PRADAXA in the original package to keep it dry. Keep the bottle tightly closed.

Keep PRADAXA and all medicines out of the reach of children.

General information about PRADAXA

Medicines are sometimes prescribed for purposes other than those listed in a Medication Guide. Do not use PRADAXA for a condition for which it was not prescribed. Do not give your PRADAXA to other people, even if they have the same symptoms. It may harm them.

This Medication Guide summarizes the most important information about PRADAXA. If you would like more information, talk with your doctor. You can ask your pharmacist or doctor for information about PRADAXA that is written for health professionals.

For more information, go to www.PRADAXA.com or call 1-800-542-6257 or (TTY) 1-800-459-9906.

What are the ingredients in PRADAXA?

Active ingredient: dabigatran etexilate mesylate

Inactive ingredients: acacia, dimethicone, hypromellose, hydroxypropyl cellulose, talc, and tartaric acid. The capsule shell is composed of carrageenan, FD&C Blue No. 2, FD&C Yellow No. 6, hypromellose, potassium chloride, titanium dioxide, and black edible ink.

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VISIONS | YOUR SHOT

This page features two photographs: one chosen by our editors and one chosen by our readers via online voting. For more information, go to ngm.com/yourshot.



READERS' CHOICE **Ron Gravelle** Kitchener, Ontario

"When I left Santa Fe," says Gravelle, 46, a part-time storm chaser vacationing in New Mexico, "I was sure there'd be a tornado near Springfield, Colorado." He was right. This twister "stayed in the open country, away from people or buildings, rotating at 120 mph but only moving at 5 mph."



EDITORS' CHOICE

Brian Sing

Mount Dandenong, Australia

On a solo bike trip from Argentina to Ecuador, Sing, 36, met two companions in southern Bolivia. One was Carl-David Granback, whom he photographed (using Granback's camera) at this crossroads. After deliberation, the cyclists went left.

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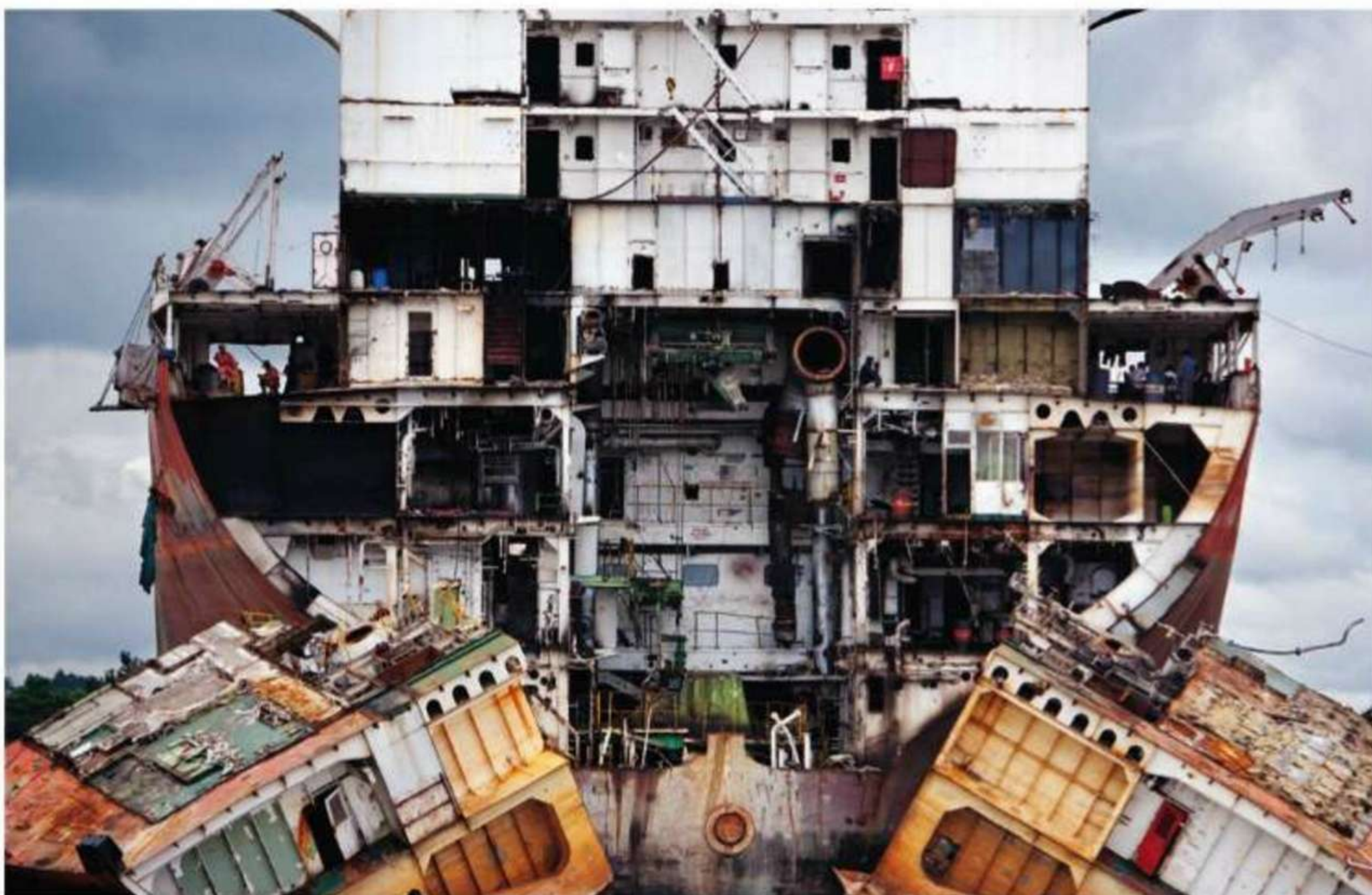
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PEOPLE **Chan Kwok Hung**
Hong Kong, China

Cattle race through rice fields in West Sumatra. The farmer holds on by the animals' tails.

PLACES **Jana Ašenbrennerová**
San Francisco, California

In Chittagong, Bangladesh, workers take apart a freighter so the parts can be sold for scrap.

NATURE AND GRAND-PRIZE WINNER
Aaron Lim Boon Teck
Singapore

Trekkers peer from the crater's rim at the Rinjani volcano in Lombok, Indonesia.



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If you had \$50,000 in the bank and you transferred it into Gold at today's prices, you would now have an opportunity to gain as much as 5 times its value—a quarter of a million dollars. That's because when you convert money to Gold, you haven't spent your money, but have transferred its value from a declining paper currency to a precious metal that is rising in both market and numismatic value. Gold can protect your money in today's very volatile market. The collapse of the housing market, major bank failures, continued worldwide volatility and the U.S. debt topping a whopping \$14 trillion are just a few reasons to move paper assets into Gold. Catastrophic debt and floundering economies have proven to be the perfect breeding ground that sends Gold through the roof. With prices reaching over \$1,800 per ounce in August 2011, it is crucial that individuals move now because as soon as tomorrow, Gold could start its predicted steep rise to \$5,000 per ounce. Do not miss out on this opportunity.

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Wherever Bess traveled throughout the land, she fueled kids' imaginations.

Inspired by sharing books as a child with her Nana Bess, Jennifer has dedicated herself to giving away free books to kids. With her Bess the Book Bus, she travels around the country handing out books to children who might otherwise not have access to them. Through the CITGO Fueling Good program, Jennifer was awarded with one year of gas, which helped her give away more than 50,000 books last year. Now there's a happy ending.

Fueling Good



Jennifer Bess the Book Bus founder

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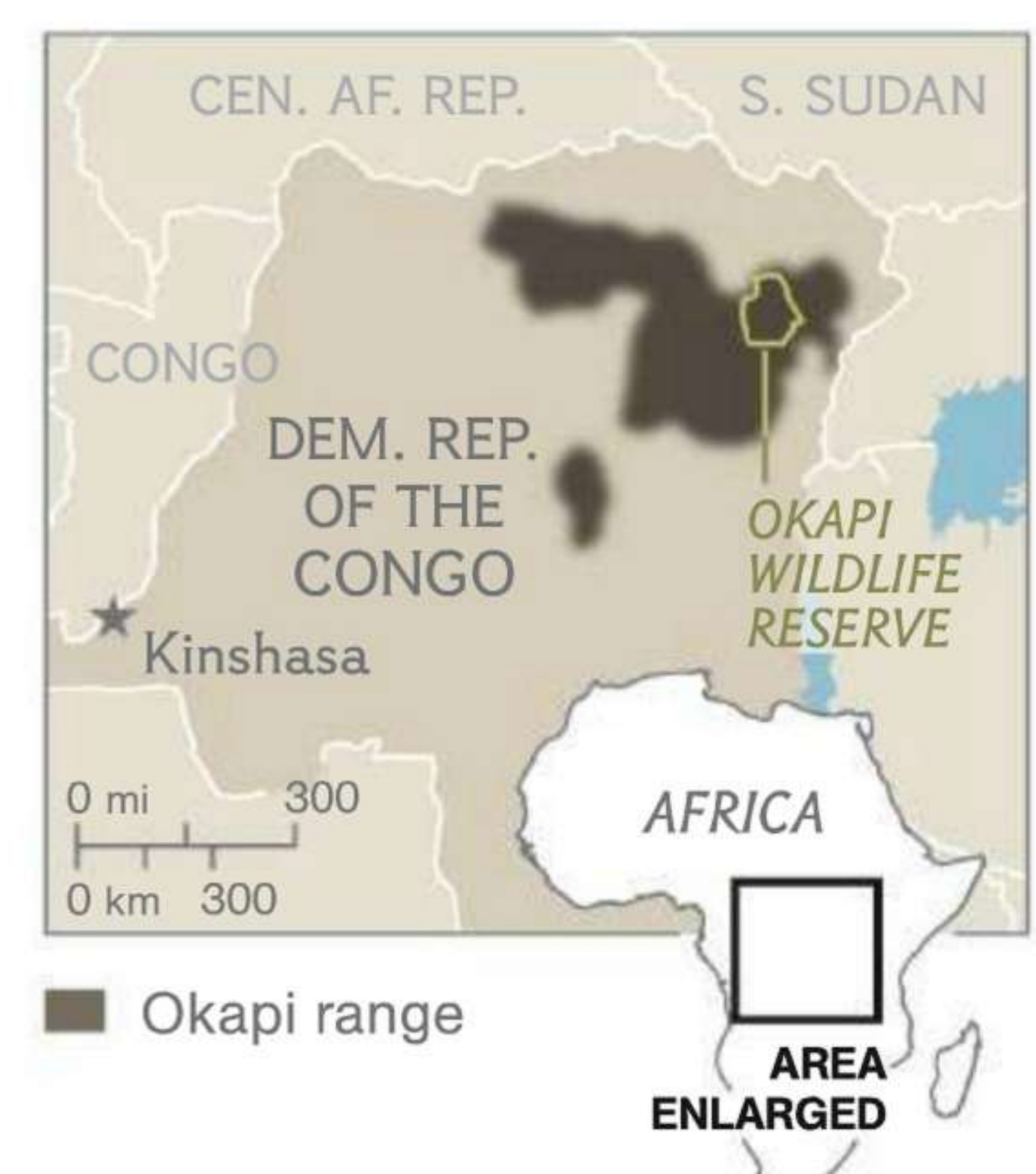
Overhead this month
in parts of the world

October 21
Orionids meteor shower

October 29
Look for Jupiter



The Elusive Okapi What has a head like a giraffe, a body like a horse, stripes like a zebra, and a blue tongue long enough to clean its own ears? This shy African herbivore (above) kept the world guessing until 1901, when it was identified as a new genus of giraffe: *Okapia johnstoni*. Today roughly 15,000 are believed to roam the wild, but they're famously hard to spot in the forest's sun-dappled undergrowth. "We still don't know that much about them," says Steve Shurter of the White Oak Conservation Center, which runs an okapi breeding facility in Florida and helps manage the Okapi Wildlife Reserve in the Democratic Republic of the Congo. Mining and human migration there threaten critical habitat for the okapis, but for now, they persist in quiet mystery. —Amanda Fiegl



NOW

Wicked Beauty

Curses, convulsions, poisonous peashooters—as much as some plants inspire poetry, others evoke the dark arts. The human-looking roots of mandrakes, source of legendary shrieks and dark spells, terrify budding wizards in the *Harry Potter* series. Greek mythology tells of monkshood toxin in the saliva of the three-headed hound Cerberus. And in the Middle Ages deadly nightshade was believed to help witches fly.

When it comes to sinister species, parsing fact from fiction can be spellbinding.

“Most people are amazed that so many common plants have toxins and can even kill you,” says Trevor Jones, who tends an educational “poison garden” near England’s Alnwick Castle, aka Hogwarts in the *Potter* films. Kids who shoot peas through the hollow stems of **giant hogweed** (right), for instance, risk sprouting painful blisters. Adding to the menace: Some species thought to have medicinal properties are also toxic; others get mistaken for edible plants. Nightshade berries in particular have enticed—at times to lethal effect. —Luna Shyr

PHOTO: JASON LARKIN

A Few to Beware

Heracleum mantegazzianum

Giant Hogweed

Contact with its sap can bring on blisters in the sun due to phototoxic chemicals.

Atropa belladonna

Deadly Nightshade

Its black berries contain a toxin that attacks the nervous system.

Arum maculatum

Cuckoopint

Also known as bloody man’s finger, this species may cause the tongue to swell.

Aconitum napellus

Monkshood

Ingesting any part of this plant can lead to heart failure.

Defy Pain, Defy Aging, Defy Fatigue

Scientifically Engineered to **Defy Gravity!**

This is my story

I used to be more active. I used to run, play basketball, tennis, football... I was more than a weekend warrior. I woke up every day filled with life! But now, in my late 30's, I spend most of my day in the office or sacked out in front of the TV. I rarely get to the gym – not that I don't like working out, it's the nagging pain in my knees and ankles. Low energy and laziness has got me down. My energy has fizzled and I'm embarrassed to admit that I've grown a spare tire (I'm sure it's hurting my love life). Nowadays I rarely walk. For some reason it's just harder now. Gravity has done a job on me.



Wear them and you'll know

That's what my doctor recommended. He said, "Gravity Defyer shoes are pain-relieving shoes." He promised they would change my life—like they were a fountain of youth! "They ease the force of gravity, relieving stress on your heels, ankles, knees and back. They boost your energy by propelling you forward." The longer he talked, the more sense it made. He was even wearing a pair himself!

Excitement swept through my body

I received my package from GravityDefyer.com and rushed to tear it open like a kid at Christmas. Inside I found the most amazing shoes I had ever seen – different than most running shoes. Sturdy construction. Cool colors. Nice lines... I was holding a miracle of technology. This was the real thing.

GDefy Benefits

- Relieve pain
- Ease joint & spinal pressure
- Reduce fatigue & tiredness
- Be more active
- Have more energy
- Appear taller
- Jump higher, walk and run faster
- Have instant comfort
- Cool your feet & reduce foot odor
- Elevate your performance

I put them on and all I could say was, "WOW!" In minutes I was out the door. I was invincible; tireless in my new Gravity Defyer shoes. It was as if my legs had been replaced with super-powered bionics. What the doctor promised was all correct. No more knee pain. I started to lose weight. At last, I was pain free and filled with energy! I was back in the game. Gravity had no power over me!

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So, my friend, get back on your feet like I did. Try Gravity Defyer for yourself. You have nothing to lose but your pain.



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Reduce fatigue. Be more active

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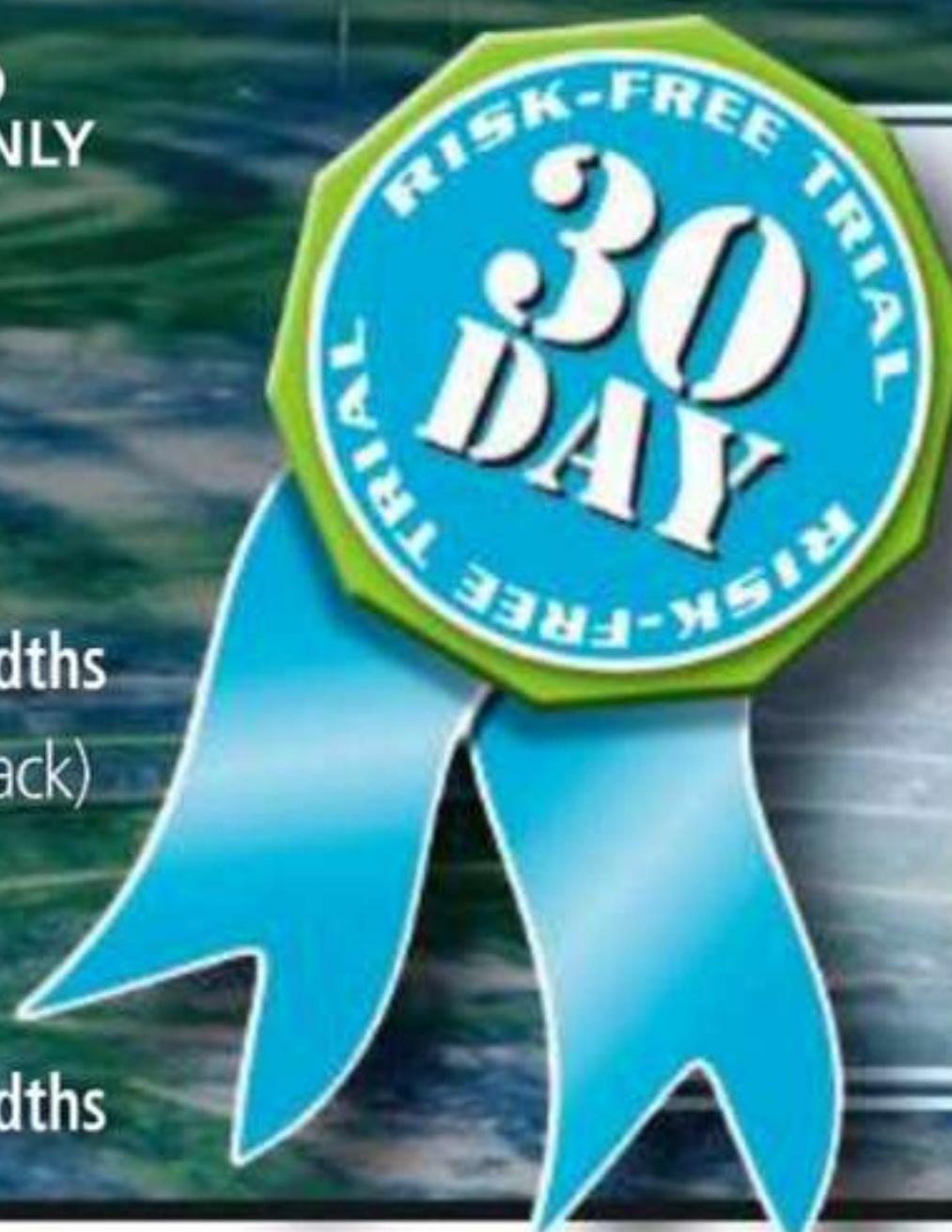
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NOW

Death rates are down for many cancers in the U.S. But globally the disease is rising.

FORTY YEARS AGO the U.S. government declared war on cancer by announcing a major push to boost federal funding and coordinate research through the National Cancer Institute (NCI). For the first two decades progress was slow, but since the early 1990s, better screening tests for colorectal, prostate, and breast cancer have led to early detection and contributed to better survival rates. The latest NCI statistics, in fact, show that U.S. mortality rates for 14 of the 19 most deadly cancers declined from 2003 to 2007. Lung cancer is among them; after years of falling death rates in men, women are registering lower numbers for the first time.

Along with the good news come more sobering statistics. Cancers without reliable screening tests—such as pancreatic, liver, and uterine—or effective treatments still have rising death rates. The five-year survival rate for pancreatic cancer patients is 6 percent, compared to over 90 percent for some forms of breast and prostate cancer. Other factors, from the way a tumor grows to the amount of diseased tissue available for research, can affect the outcome of a particular type of cancer, says NCI deputy director James Doroshow.

About a third of U.S. cancer deaths are still linked to tobacco, although the number of smokers in the country is down. (People who never smoked are susceptible too, often due to secondhand smoke.) Higher taxes on tobacco products have been key, along with public smoking restrictions and awareness campaigns, says NCI physician Michele Bloch. She notes that larger, graphic cigarette (Continued)

Number of people living in U.S. with current or prior case, as of December 31, 2007

LUNG

Women: 200,100
Men: 173,400

PROSTATE
Men: 2,355,000

The Top Five Killers

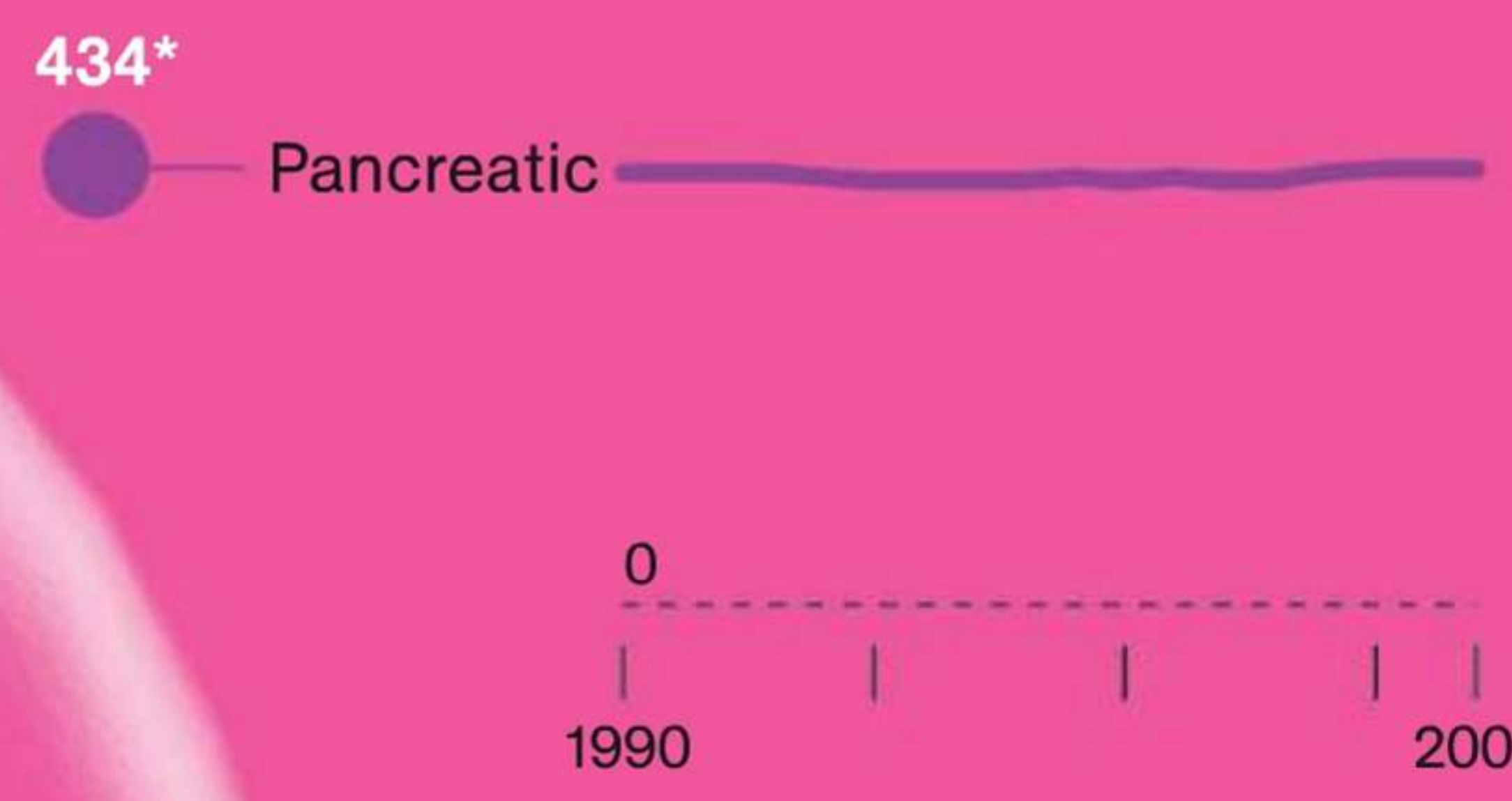
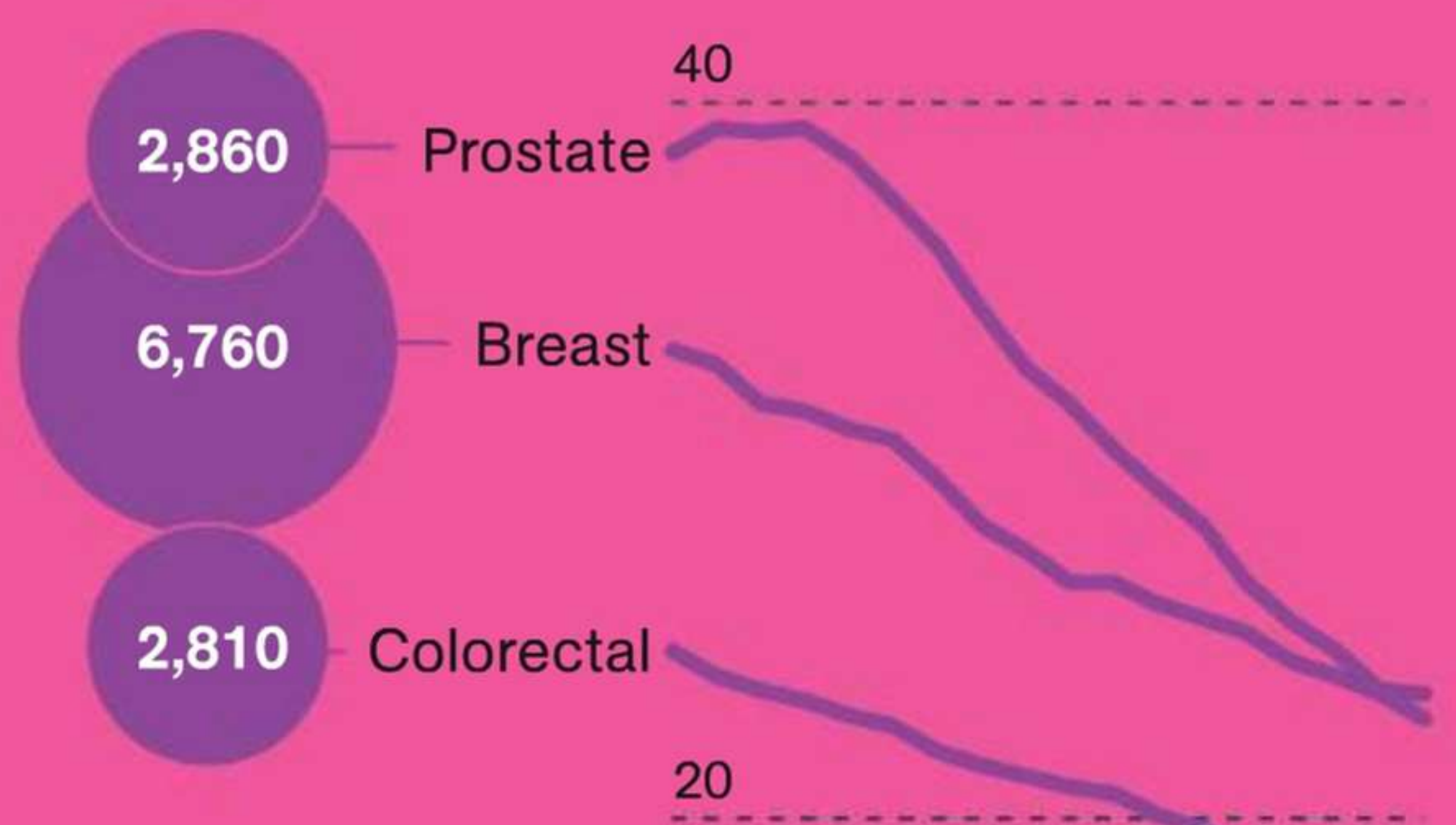
U.S. death rates for four of the five cancers with the highest mortality (left) have fallen as new screenings and treatments arise. Total federal funding through the National Cancer Institute topped \$5 billion in fiscal 2011.

**U.S. cancer deaths and research funding
1990 - 2007**

PANCREATIC
Women: 17,850
Men: 16,810

BREAST
Women: 2,632,000
Men: 13,620

COLORECTAL
Women: 567,900
Men: 542,100



*FUNDING FOR PANCREATIC CANCER FROM 1996 TO 2007 ONLY

ART: BRYAN CHRISTIE
GRAPHIC: OLIVER UBERTI, NGM STAFF
SOURCE: NATIONAL CANCER INSTITUTE

NOW

warning labels mandated earlier this year help bring the U.S. in line with 30 other nations' antitobacco policies. Still, lung cancer remains the leading cancer killer worldwide, with 1.4 million deaths each year.

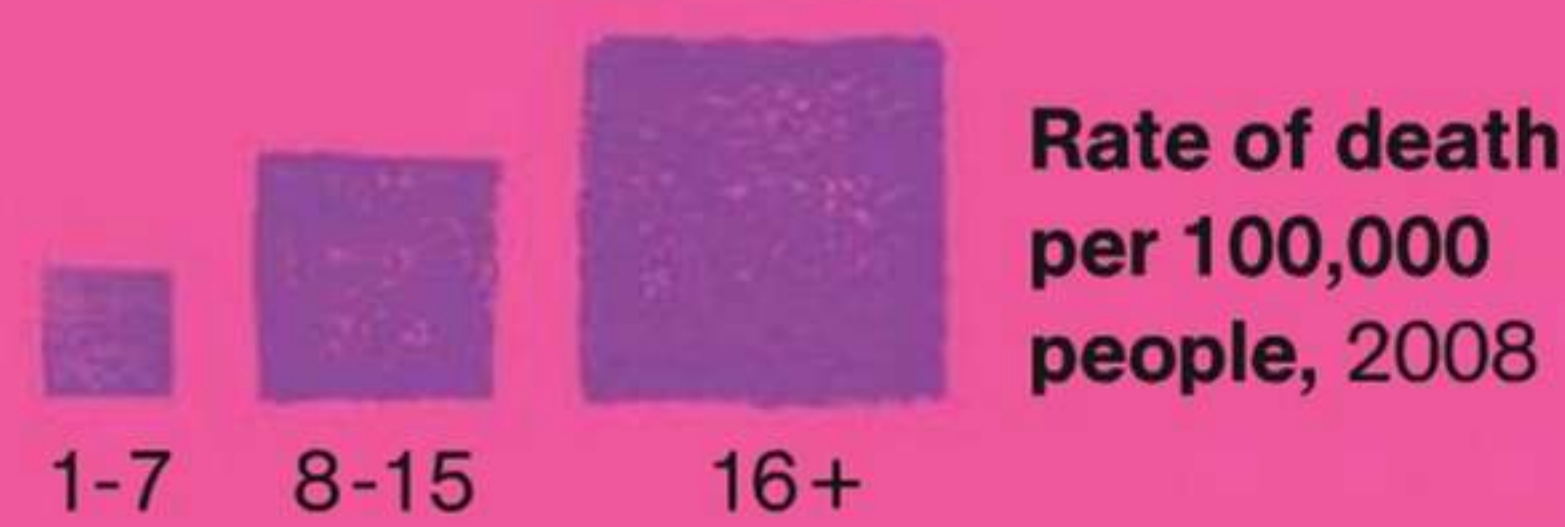
In the next few decades, says David Forman of the International Agency for Research on Cancer, growing and aging populations will make cancer more common. Changes that come with economic growth, such as diet and less physical activity, will also play a role. This fall the United Nations convened a summit on cancer and other chronic diseases—only the second such meeting in the UN's history. Says Forman: "We already have the knowledge to prevent many deaths. We just need the resources to implement it." —Shelley Sperry

Around the world, nearly 13 million people were diagnosed with cancer in 2008.



Where is cancer deadliest?

The answer depends on regional differences in lifestyle, diet, and health care. Worldwide, lung cancer claims the most lives.



| | Lung | Breast | Colorectal | Prostate | Cervical | Liver | Stomach |
|-------------------------|------|--------|------------|----------|----------|-------|---------|
| 1 Western Pacific | 26 | | | | | 21 | 19 |
| 2 Europe | | 17 | 13 | | | | |
| 3 Americas | | | | | | | |
| 4 Africa | | | | 15 | 22 | | |
| 5 Eastern Mediterranean | | | | | | | |
| 6 Southeast Asia | | | | | | | |

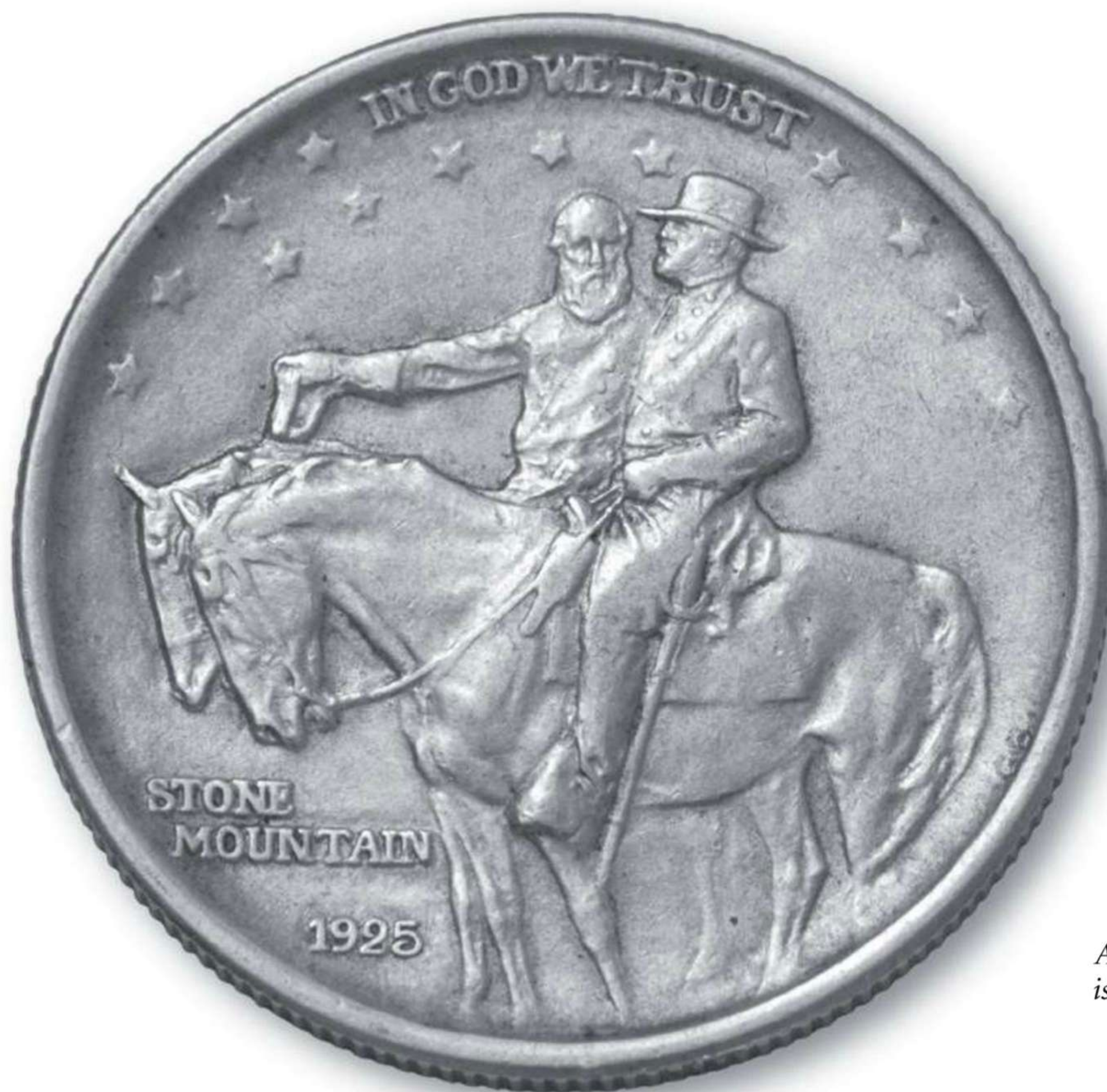
Regional Patterns

Breast cancer rates are higher in richer nations, where women give birth later in life and have fewer children.

Colorectal cancer, linked to diets with more meat and processed foods in affluent nations, is less deadly when caught early.

Cervical cancer kills more women in countries where the human papillomavirus is common and screening rare.

Liver cancer is linked to the hepatitis B and C viruses, more prevalent in nations like China, South Korea, and Mongolia.



Actual size
is 30.6 mm

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NEXT

MELTDOWN-PROOF NUKES

Water-cooled nuclear power plants aren't the only option.

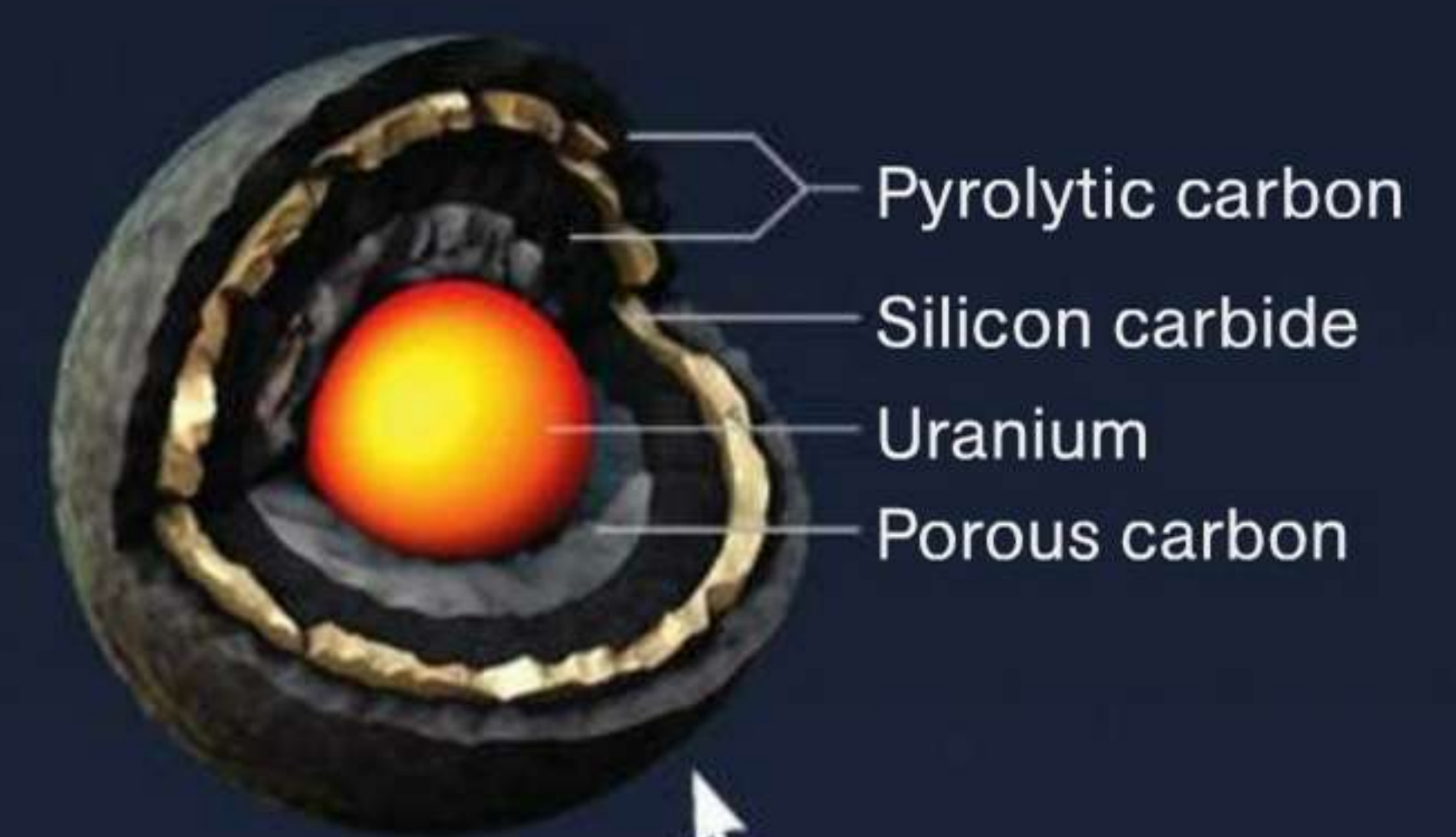
The next generation of nuclear plants may be cooled by gas—helium gas. Such reactors were proposed in the 1960s but rarely pursued; only a few have ever been built. But that could change. Though issues such as fuel storage are a potential concern, gas reactors—which can't melt down—may be a way forward in the wake of Japan's nuclear disaster.

Using helium as a coolant has at least a couple of advantages. For one thing, it's inert, so it can't become radioactive like the water in water-cooled plants. For another, gas reactors are more efficient at generating electricity than water-cooled ones, because they run much hotter. That heat, produced carbon free, has gotten the attention of chemical, fertilizer, and oil companies. Though it's still in the developmental stage, "this technology could be a real game changer," says Fred Moore of Dow Chemical.

At the core of the reactor's safety is a clever fuel design. Instead of the uranium fuel rods used in water reactors, gas-reactor fuel takes the form of uranium bits scattered among graphite "pebbles." Graphite is a great moderator, slowing down the neutrons and keeping their reaction in the proper temperature range.

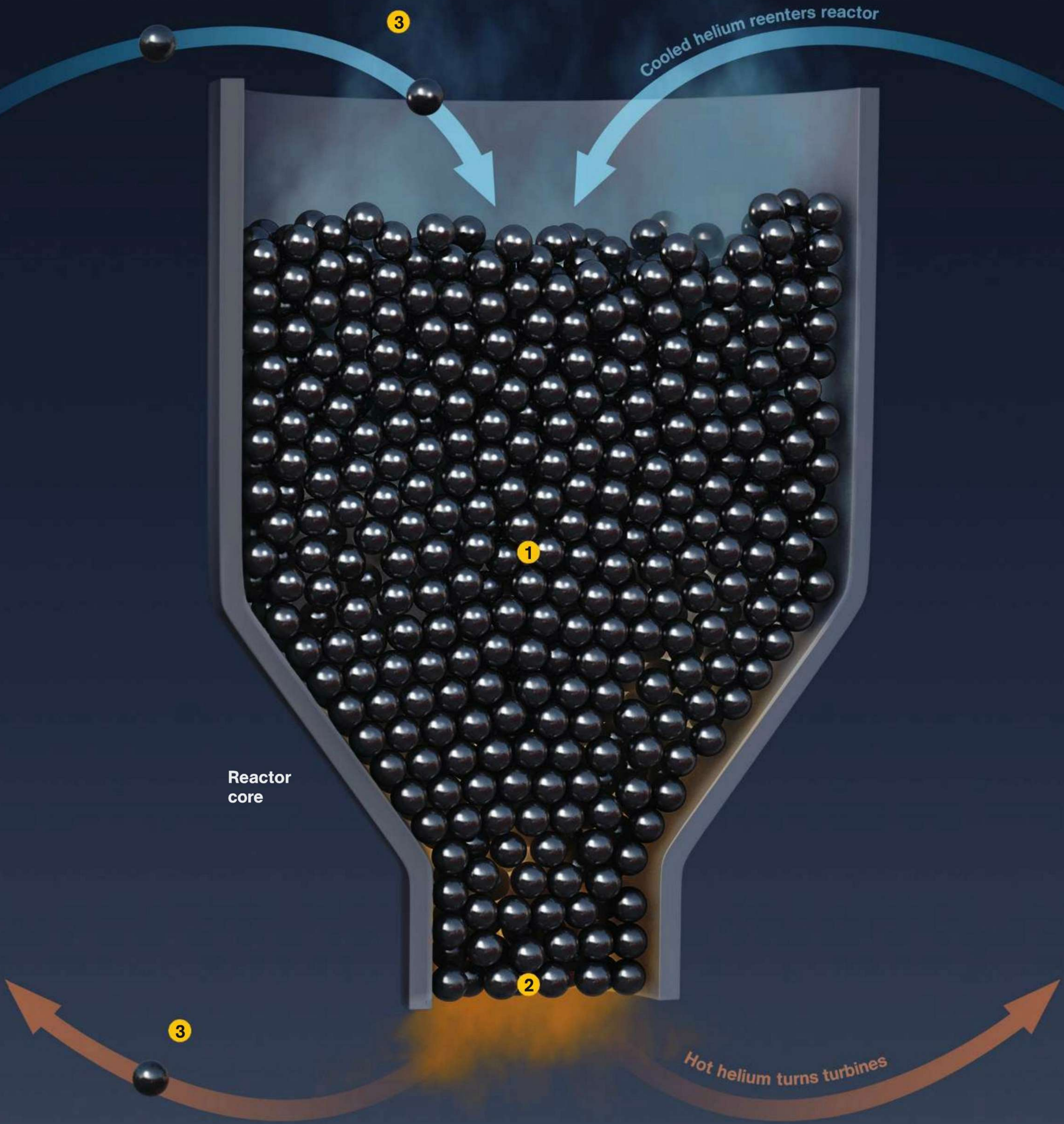
Andrew Kadak of MIT, who visited a small prototype pebble-bed reactor in China four years ago, watched engineers turn off the cooling system. "It naturally shut down," he says. "It was incredible. Especially in light of Fukushima, this is a reactor that doesn't melt down." —*Juli Berwald*

At the center of each poppy seed-size fuel particle is a uranium kernel. Layers of carbon and silicon carbide contain the radioactive material.



What's Inside a Pebble?

Each "pebble" in a pebble-bed gas reactor is a graphite fuel sphere the size of a tennis ball. Nine grams of uranium are dispersed among some 15,000 tiny particles within the graphite. During a recent three-year test at Idaho National Lab, 300,000 fuel particles were heated to 2300°F and bombarded with neutrons. Not a single particle leaked radioactive material—strong evidence of the fuel's safety.



Reactor core

Cooled helium reenters reactor

Hot helium turns turbines

How It Works

A pebble-bed reactor is made up of about 400,000 pebbles. Heat from the fuel spheres is picked up by helium and can then be used to generate electricity—or to drive industrial processes such as oil refining and desalination.

1 Blowers move helium gas through the reactor and over the pebbles, where nuclear fission releases large amounts of energy, heating up the helium.

2 About 5,000 spheres move through the reactor each day, like gum balls through a vending machine. The constant circulation means no refueling interruptions.

3 If a pebble taken from the bottom can produce more power, it goes back in the top. If it's spent, it's stored as waste, and a new pebble is added.

NEXT

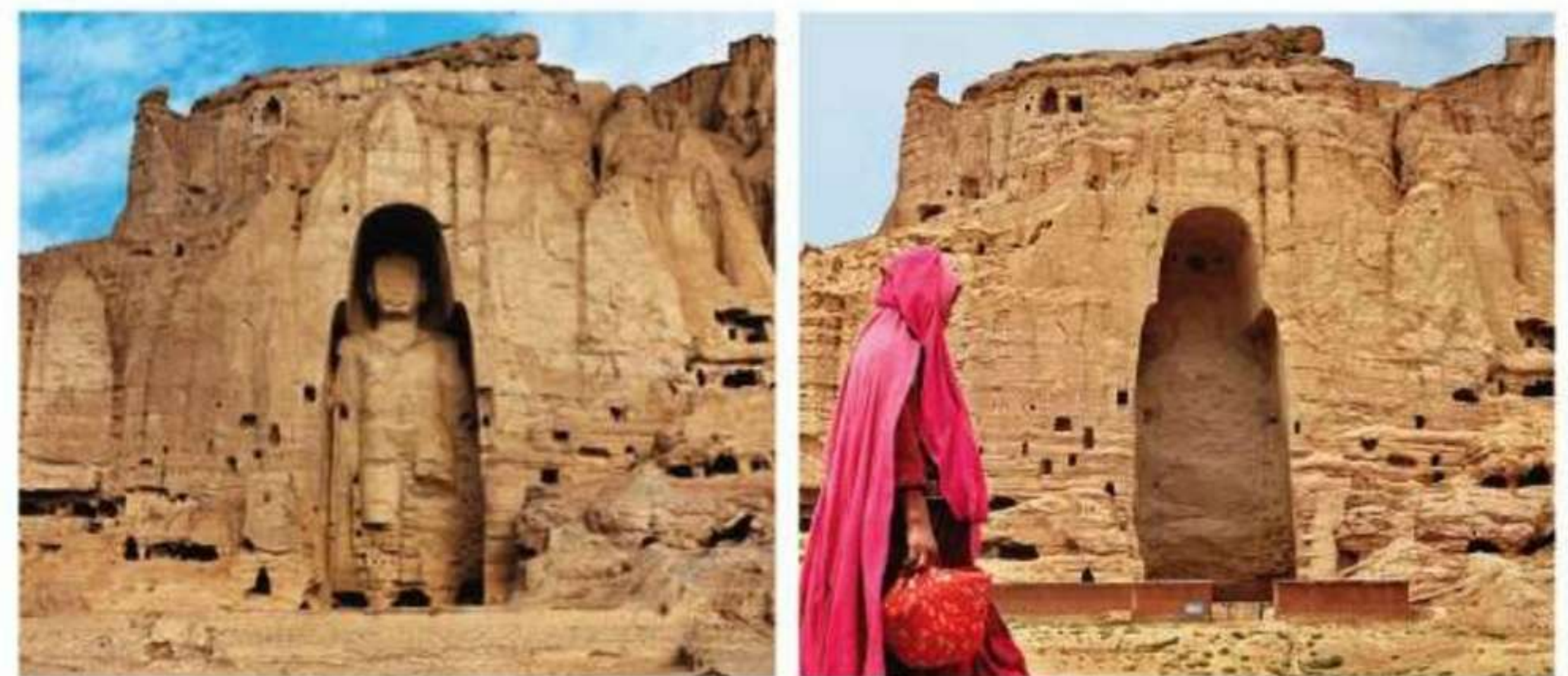


Rebuilding Buddhas

In Afghanistan's Bamian Valley, the shattered remains of two majestic Buddhas destroyed by the Taliban in March 2001 lie carefully preserved. The thousands of fragments, ranging from bits of clay plaster to nearly 80-ton chunks of rock, represent about 90 percent of the original statues. As experts debate the feasibility of reconstruction, a team at Germany's RWTH Aachen University is testing 3-D technology that allows researchers to reassemble pieces of the former giants—virtually.

Matching sediment patterns in the fragments with those in the hollow niches where the Buddhas once stood offers key clues to the pieces' original position. Scanning and matching the rocks' magnetic signatures, which require more funds to complete, are the crucial complement. Meantime, work at the site will focus on stabilizing the fragile niche rock to further salvage history. —Luna Shyr

Clay fragment from the larger Buddha
This remnant retains goat hairs that were added to prevent cracking when the clay dried.



Shelters at the base of the larger Buddha's empty niche (right) house fragments of the 180-foot-tall, seventh-century statue (left). Its sixth-century companion rose 125 feet.

“During my many years as a jeweler, examining an astonishing 20 ctw emerald necklace certainly is a rare treat. The Stauer Emerald in Gold Necklace is as good as it gets.”

**— JAMES T. FENT, Stauer
GIA Graduate Gemologist**

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It happened on our last trip to South America. After visiting the “Lost City” of Machu Picchu in Peru, we ventured through the mountains and down the Amazon into Brazil. In an old village we met a merchant with an impressive collection of spectacular, iridescent emeralds. Each gem was tumbled smooth and glistened like a perfect rain forest dew drop. But the price was so unbelievable, I was sure our interpreter had made a mistake.

But there was no mistake. And after returning home, I had 20 carats of these exquisite emeralds strung up in 14k gold and wrapped as a gift for my wife’s birthday. That’s when my trouble began. She loved it. Absolutely adored it. In fact, she rarely goes anywhere without the necklace and has basked in compliments from total strangers for months now.

So what’s the problem? I’m never going to find an emerald deal this good again. In giving her such a perfect gift, I’ve made it impossible to top myself.

To make matters worse, my wife’s become obsessed with emeralds. She can’t stop sharing stories about how Cleopatra cherished the green gem above all others and how emeralds were worshiped by the Incas and Mayans and prized by Spanish conquistadors and Indian maharajahs. She’s even buying into ancient beliefs that emeralds bring intelligence, well-being and good luck to anyone who wears them. I don’t have the heart to tell her that I’m never going to find another deal this lucky.



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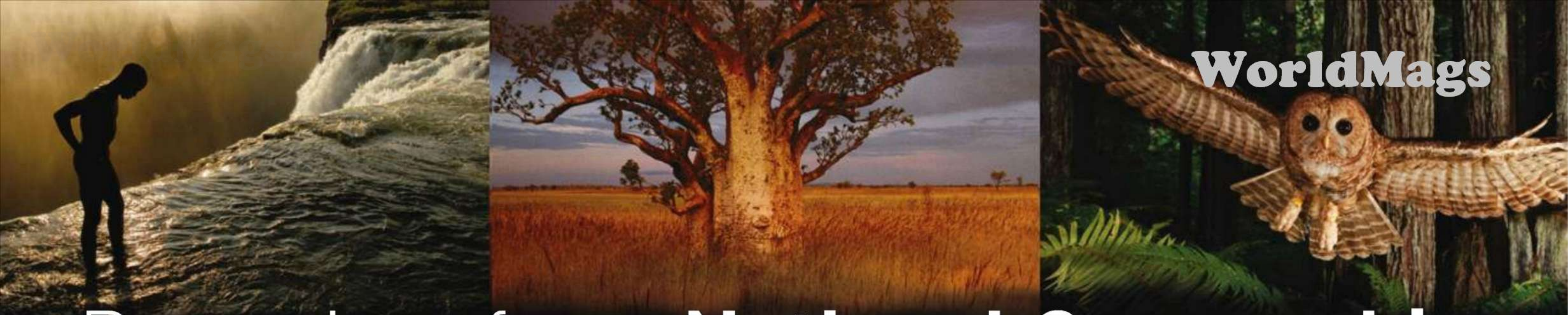
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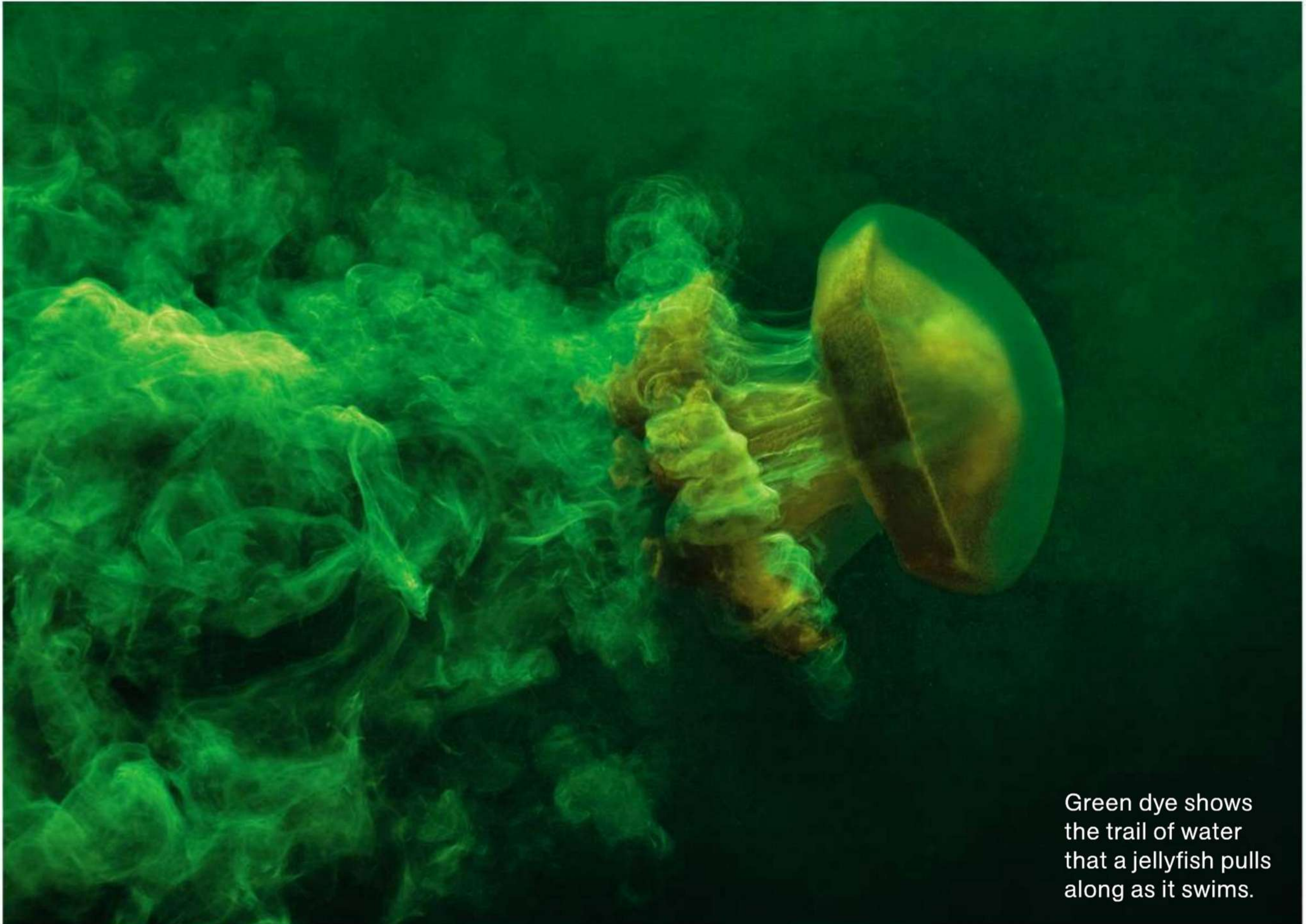
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In one day your kidneys can filter 33 times the total volume of blood in your body.



Green dye shows the trail of water that a jellyfish pulls along as it swims.

Jellyfish Currents Ethereal jellies have been stirring up the world's waters for at least 550 million years now. So what Caltech researcher John Dabiri wanted to know was whether all that pushing around added up to something big. To figure that out, he and his team squirted green dye in front of jellyfish to make the movement of water around them visible. The creatures swim by contracting a ring of muscles to collapse their umbrella-like bodies and expel water. As the fluid is forced backward, the jellies are thrust forward.

The dye revealed that much of the water pushed

away is then sucked up again and sticks around as the jellies make their next stroke. This means that as they head hundreds of feet up to the surface to feed each day, they're dragging along cold, nutrient-rich waters from the ocean deep, then pulling warmer streams back down. With the ability of jellyfish to mix water now proved, Dabiri's team is focusing on krill and other tiny crustaceans that number in the trillions. Collectively, he believes, these bits of marine life could rival the force of the winds and tides in ocean circulation. —Vikki Valentine

ET CETERA

NASA will launch an **ASTEROID MISSION** in 2016, when a robotic craft heads out to collect samples of carbon-rich rock. ▪ A Scripps Institution of Oceanography team estimates fish ingest thousands of tons of **PLASTIC DEBRIS** each year from the "great Pacific garbage patch." ▪ Scientists from the University of London aim to see if **HUMAN FACIAL EXPRESSIONS** register with robots. ▪ UC Riverside researchers have ID'd **ODOR MOLECULES** that could inhibit mosquitoes from finding people to bite.

BEAUTIFUL

BY DAVID DOBBS PHOTOGRAPHS BY KITRA CAHANA



BRAINS

Moody. Impulsive.
Maddening. Why do
TEENAGERS
act the way they do?

Viewed through the
eyes of evolution, their
most exasperating
traits may be
the key to success
as adults.

Caught in the mirror
of her parents'
truck, 12th grader
Amy "Dandilion"
Olsen waits at a
light in downtown
Austin, Texas.

STANDING ON THE SPRAINED ANKLE that kept him in rehab for weeks, Trojans running back and team co-captain Connor Sheehan had a choice: risk another injury or sit out what could be the first play-off victory in the history of Anderson High School in Austin—the city where *National Geographic* followed the lives of teens last fall. He chose to play and he reinjured his ankle. Research suggests that, compared with adults, teens value rewards more than consequences. The Trojans won the game, and Sheehan hopes to play at Harvard this fall.





THE CONCERT WAS UNLIKE ANY Austin Brown (center) had attended—a dance party called Dayglow where blasts of fluorescent paint rained down on crowds in downtown Austin. Black light made them shine. “If you weren’t dancing, you were just standing there covered in paint,” Brown said. “That doesn’t sound like fun.” The hunt for novelty can go awry when teens try to top each new kick with another, more intense one. But it also helps them find their path. A concertgoer since high school, Brown now studies lighting design in college.





During lunch break, a teen shows off leaping skills in the urban sport of parkour.

Although you know your teenager takes some chances, it can be a shock to hear about them.

One fine May morning not long ago my oldest son, 17 at the time, phoned to tell me that he had just spent a couple hours at the state police barracks. Apparently he had been driving “a little fast.” What, I asked, was “a little fast”? Turns out this product of my genes and loving care, the boy-man I had swaddled, coddled, cooed at, and then pushed and pulled to the brink of manhood, had been flying down the highway at 113 miles an hour.

“That’s more than a little fast,” I said.

He agreed. In fact, he sounded somber and contrite. He did not object when I told him he’d have to pay the fines and probably for a lawyer. He did not argue when I pointed out that if anything happens at that speed—a dog in the road, a blown tire, a sneeze—he dies. He was in fact almost irritatingly reasonable. He even proffered that the cop did the right thing in stopping him, for, as he put it, “We can’t all go around doing 113.”

He did, however, object to one thing. He didn’t like it that one of the several citations he received was for reckless driving.

“Well,” I huffed, sensing an opportunity to finally yell at him, “what would you call it?”

“It’s just not accurate,” he said calmly. “Reckless’ sounds like you’re not paying attention. But I was. I made a deliberate point of doing this on an empty stretch of dry interstate, in broad daylight, with good sight lines and no traffic. I mean, I wasn’t just gunning the thing. I was driving.

“I guess that’s what I want you to know. If it makes you feel any better, I was really focused.”

Actually, it did make me feel better. That bothered me, for I didn’t understand why. Now I do.

MY SON’S HIGH-SPEED adventure raised the question long asked by people who have pondered the class of humans we call teenagers: What on Earth was he doing? Parents often phrase this question more colorfully. Scientists put it more coolly. They ask, What can explain this behavior? But even that is just another way of wondering, What is wrong with these kids? Why do they act this way? The question passes judgment even as it inquires.

Through the ages, most answers have cited dark forces that uniquely affect the teen. Aristotle concluded more than 2,300 years ago that “the young are heated by Nature as drunken men by wine.” A shepherd in William Shakespeare’s *The Winter’s Tale* wishes “there were no age between sixteen and three-and-twenty, or that youth would sleep out the rest; for there is nothing in the between but getting wenches with child, wronging the ancientry, stealing, fighting.” His lament colors most modern scientific inquiries as well. G. Stanley Hall, who formalized adolescent studies with his 1904 *Adolescence: Its Psychology and Its Relations to Physiology, Anthropology, Sociology, Sex, Crime, Religion and Education*, believed this period of “storm and stress” replicated earlier, less civilized stages of human development. Freud saw adolescence as an expression of torturous psychosexual conflict; Erik Erikson, as the most tumultuous of life’s several identity crises. Adolescence: always a problem.

Such thinking carried into the late 20th century, when researchers developed brain-imaging technology that enabled them to see the teen brain in enough detail to track both its physical development and its patterns of activity. These imaging tools offered a new way to ask the same question—What’s wrong with these kids?—and revealed an answer that surprised almost everyone. Our brains, it turned out, take much longer to develop than we had thought. This revelation suggested both a simplistic, unflattering explanation for teens’ maddening behavior—and a more complex, affirmative explanation as well.

THE FIRST FULL SERIES of scans of the developing adolescent brain—a National Institutes of Health (NIH) project that studied over a hundred young people as they grew up during the 1990s—showed that our brains undergo a massive reorganization between our 12th and 25th years. The brain doesn’t actually grow very much during this period. It has already reached 90 percent of its full size by the time a person is six, and a thickening skull accounts for

most head growth afterward. But as we move through adolescence, the brain undergoes extensive remodeling, resembling a network and wiring upgrade.

For starters, the brain’s axons—the long nerve fibers that neurons use to send signals to other neurons—become gradually more insulated with a fatty substance called myelin (the brain’s white matter), eventually boosting the axons’ transmission speed up to a hundred times. Meanwhile, dendrites, the branchlike extensions that neurons use to receive signals from nearby axons, grow twiggy, and the most heavily used synapses—the little chemical junctures across which axons and dendrites pass notes—grow richer and stronger. At the same time, synapses that see little use begin to wither. This synaptic pruning, as it is called, causes the brain’s cortex—the outer layer of gray matter where we do much of our conscious and complicated thinking—to become thinner but more efficient. Taken together, these changes make the entire brain a much faster and more sophisticated organ.

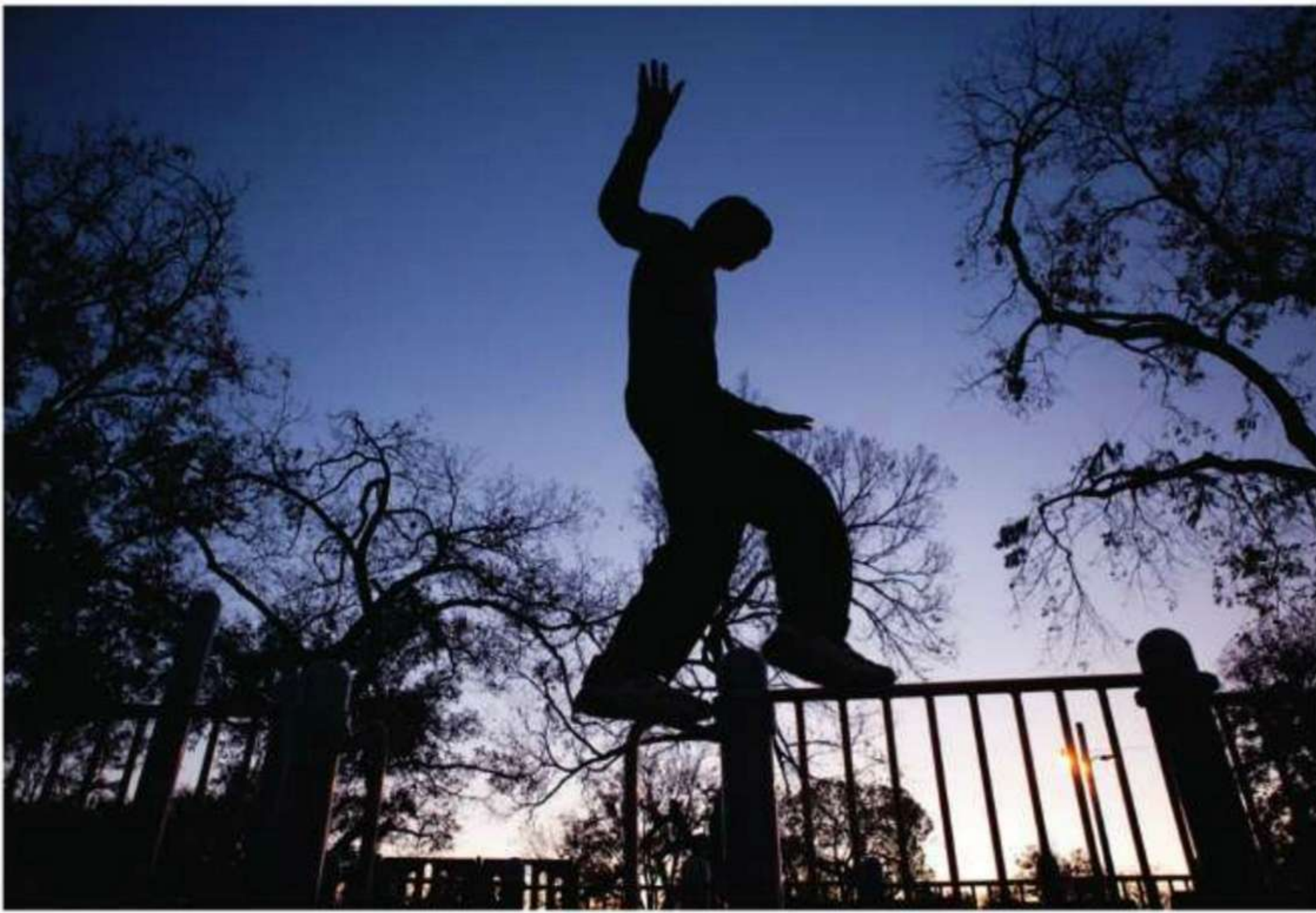
This process of maturation, once thought to be largely finished by elementary school, continues throughout adolescence. Imaging work done since the 1990s shows that these physical changes move in a slow wave from the brain’s rear to its front, from areas close to the brain stem that look after older and more behaviorally basic functions, such as vision, movement, and fundamental processing, to the evolutionarily newer and more complicated thinking areas up front. The corpus callosum, which connects the brain’s left and right hemispheres and carries traffic essential to many advanced brain functions, steadily thickens. Stronger links also develop between the hippocampus, a sort of memory directory, and frontal areas that set goals and weigh different agendas; as a result, we get better at integrating memory and experience into our decisions. At the same time, the frontal areas develop greater speed and richer

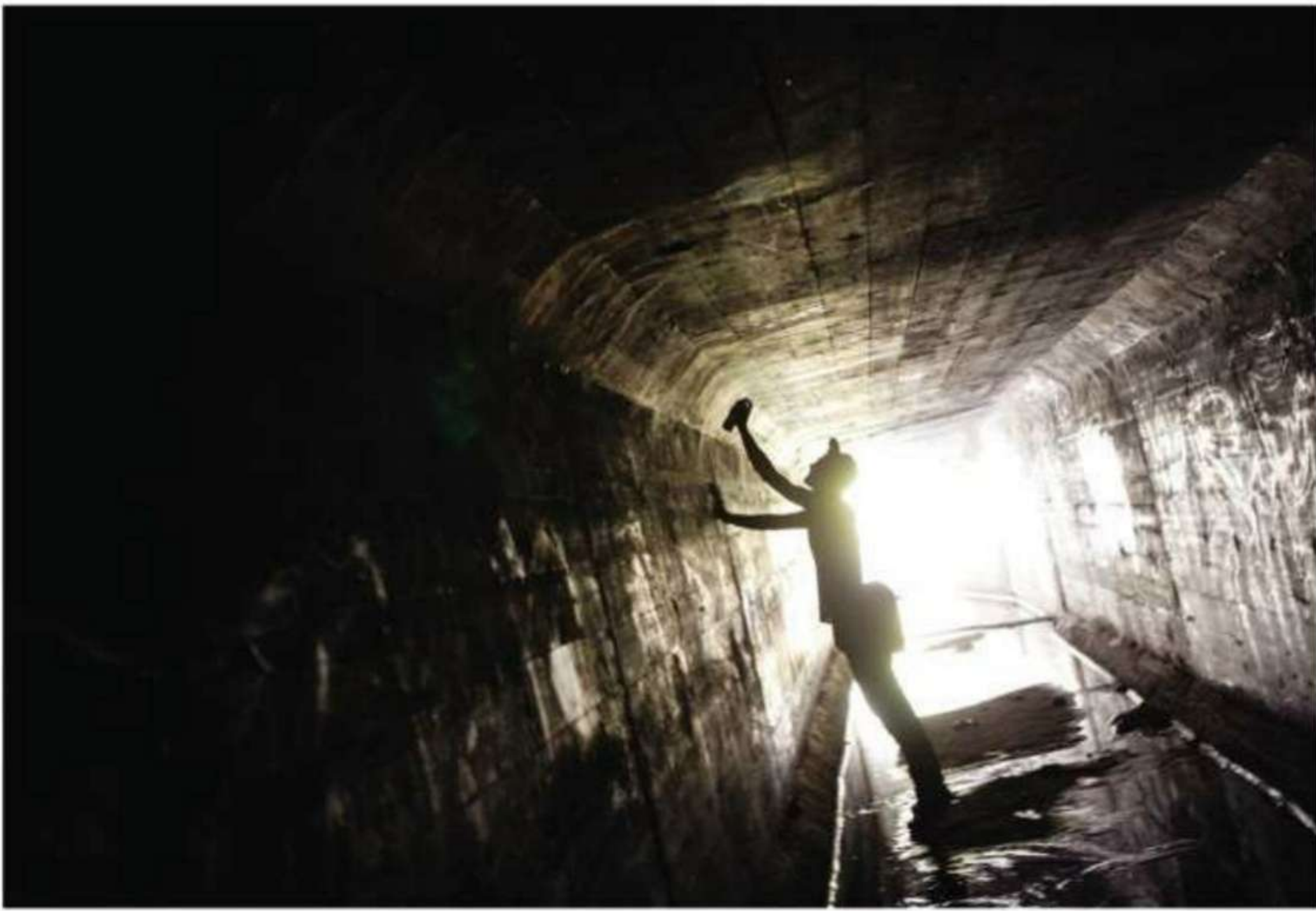
David Dobbs is the author of Reef Madness, on Darwin’s controversial theory of coral reef origins. This is Kitra Cahana’s first story for the magazine.

CRACKING JOKES IS PART OF the daily repartee between Deborah Kipp and her daughter, Anastassia. The 18-year-old considers her mom a role model, always there and never bossy. Neuroscientist B. J. Casey, known for her work on the adolescent brain, notes: "The last thing you want to tell your teenager is what to be interested in, because then they'll go as far from it as possible." And there's nothing wrong if the teenager questions the parent's beliefs. That's normal and healthy: It helps a teen develop a sense of identity.









Think of it as an equation, says psychologist Laurence Steinberg, where consequences aren't given the weight they should be. And when teens are around friends, that throws off the equation even more.

connections, allowing us to generate and weigh far more variables and agendas than before.

When this development proceeds normally, we get better at balancing impulse, desire, goals, self-interest, rules, ethics, and even altruism, generating behavior that is more complex and, sometimes at least, more sensible. But at times, and especially at first, the brain does this work clumsily. It's hard to get all those new cogs to mesh.

Beatriz Luna, a University of Pittsburgh professor of psychiatry who uses neuroimaging to study the teen brain, used a simple test that illustrates this learning curve. Luna scanned the brains of children, teens, and twentysomethings while they performed an antisaccade task, a sort of eyes-only video game where you have to stop yourself from looking at a suddenly appearing light. You view a screen on which the red crosshairs at the center occasionally disappear just as a light flickers elsewhere on the screen. Your instructions are to not look at the light and instead to look in the opposite direction. A sensor detects any eye movement. It's a tough assignment, since

Troublesome traits like idiocy and haste don't really characterize adolescence. They're just what we notice most because they annoy us or put our children in danger.

flickering lights naturally draw our attention. To succeed, you must override both a normal impulse to attend to new information and curiosity about something forbidden. Brain geeks call this response inhibition.

Ten-year-olds stink at it, failing about 45 percent of the time. Teens do much better. In fact, by age 15 they can score as well as adults if they're motivated, resisting temptation about 70 to 80 percent of the time. What Luna found most interesting, however, was not those scores. It was the brain scans she took while people

took the test. Compared with adults, teens tended to make less use of brain regions that monitor performance, spot errors, plan, and stay focused—areas the adults seemed to bring online automatically. This let the adults use a variety of brain resources and better resist temptation, while the teens used those areas less often and more readily gave in to the impulse to look at the flickering light—just as they're more likely to look away from the road to read a text message.

If offered an extra reward, however, teens showed they could push those executive regions to work harder, improving their scores. And by age 20, their brains respond to this task much as the adults' do. Luna suspects the improvement comes as richer networks and faster connections make the executive region more effective.

These studies help explain why teens behave with such vexing inconsistency: beguiling at breakfast, disgusting at dinner; masterful on Monday, sleepwalking on Saturday. Along with lacking experience generally, they're still

learning to use their brain's new networks. Stress, fatigue, or challenges can cause a misfire. Abigail Baird, a Vassar psychologist who studies teens, calls this neural gawkiness—an equivalent to the physical awkwardness teens sometimes display while mastering their growing bodies.

The slow and uneven developmental arc revealed by these imaging studies offers an alluringly pithy explanation for why teens may do stupid things like drive at 113 miles an hour, aggrrieve their ancentry, and get people (or get gotten) with child: They act that way because their brains aren't done! You can see it right there in the scans!

This view, as titles from the explosion of scientific papers and popular articles about the "teen brain" put it, presents adolescents as "works in progress" whose "immature brains" lead some to question whether they are in a state "akin to mental retardation."

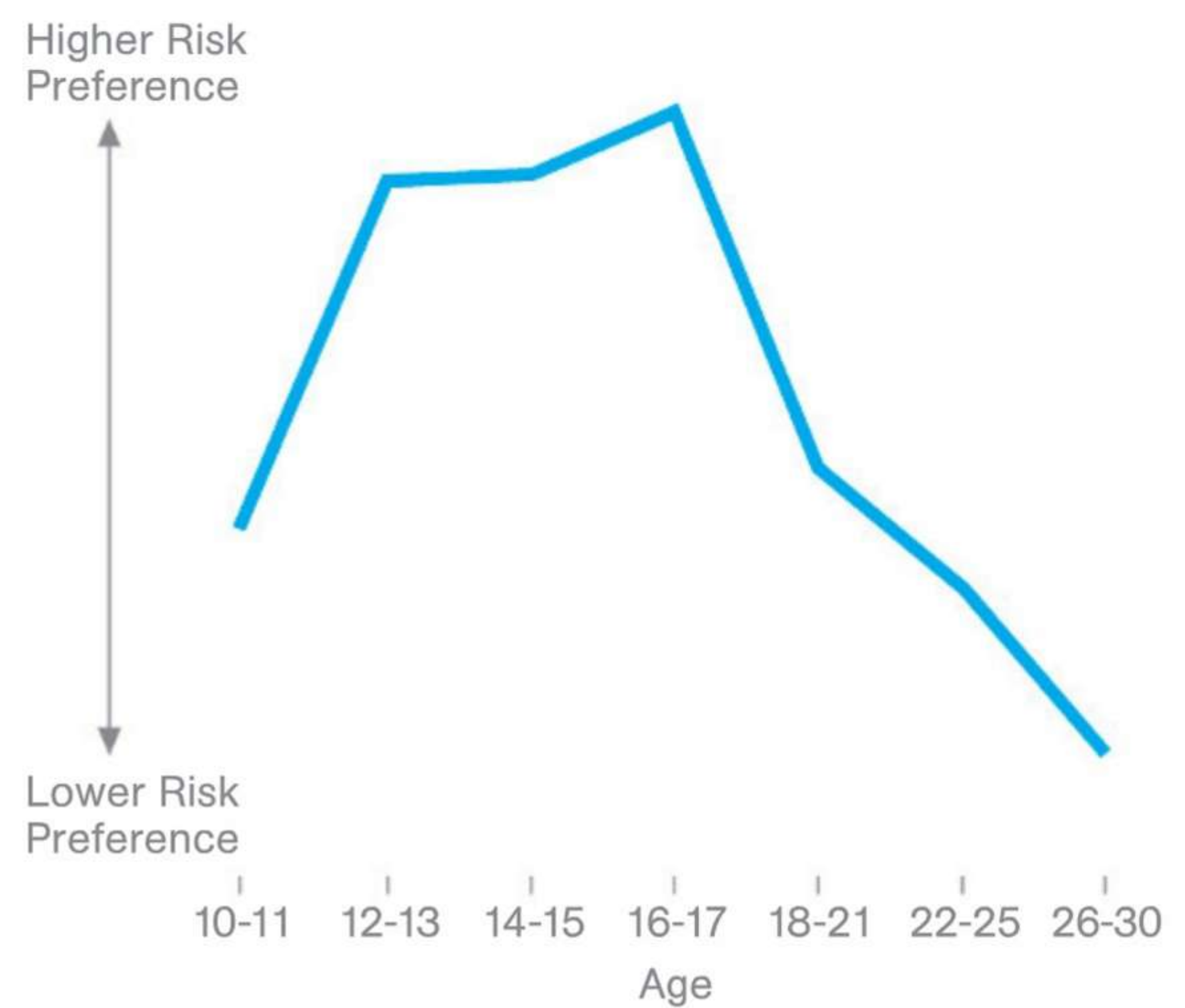
The story you're reading right now, however, tells a different scientific tale about the teen brain. Over the past five years or so, even as the work-in-progress story spread into our culture, the discipline of adolescent brain studies learned to do some more-complex thinking of its own. A few researchers began to view recent brain and genetic findings in a brighter, more flattering light, one distinctly colored by evolutionary theory. The resulting account of the adolescent brain—call it the adaptive-adolescent story—casts the teen less as a rough draft than as an exquisitely sensitive, highly adaptable creature wired almost perfectly for the job of moving from the safety of home into the complicated world outside.

This view will likely sit better with teens. More important, it sits better with biology's most fundamental principle, that of natural selection. Selection is hell on dysfunctional traits. If adolescence is essentially a collection of them—angst, idiocy, and haste; impulsiveness, selfishness, and reckless bumbling—then how did those traits survive selection? They couldn't—not if they were the period's most fundamental or consequential features.

The answer is that those troublesome traits don't really characterize adolescence; they're just what we notice most because they annoy us or put our children in danger. As B. J. Casey, a neuroscientist at Weill Cornell Medical College who has spent nearly a decade applying brain and genetic studies to our understanding of adolescence, puts it, "We're so used to seeing adolescence as a problem. But the more we learn about what really makes this period unique, the more adolescence starts to seem like a highly functional, even adaptive period. It's exactly what you'd need to do the things you have to do then."

TO SEE PAST the distracting, dopey teenager and glimpse the adaptive adolescent within, we should look not at specific, sometimes startling, behaviors, such as skateboarding down stairways or dating fast company, but at the broader traits that underlie those acts.

RISKY BUSINESS



Teens may understand that risky behaviors such as smoking and unprotected sex carry consequences. Yet adolescents tend to give more weight to the pleasures than to the costs.

Let's start with the teen's love of the thrill. We all like new and exciting things, but we never value them more highly than we do during adolescence. Here we hit a high in what behavioral scientists call sensation seeking: the hunt for the neural buzz, the jolt of the unusual or unexpected.

Seeking sensation isn't necessarily impulsive. You might plan a sensation-seeking experience—a skydive or a fast drive—quite deliberately, as my son did. Impulsivity generally drops throughout life, starting at about age 10, but this love of the thrill peaks at around age 15. And although sensation seeking can lead to dangerous behaviors, it can also generate positive ones: The urge to meet more people, for instance, can create a wider circle of friends, which generally makes us healthier, happier, safer, and more successful.

This upside probably explains why an openness to the new, though it can sometimes kill the cat, remains a highlight of adolescent development. A love of novelty leads directly to useful experience. More broadly, the hunt for sensation provides the inspiration needed to "get you out of the house" and into new terrain, as Jay Giedd, a pioneering researcher in teen brain development at NIH, puts it.

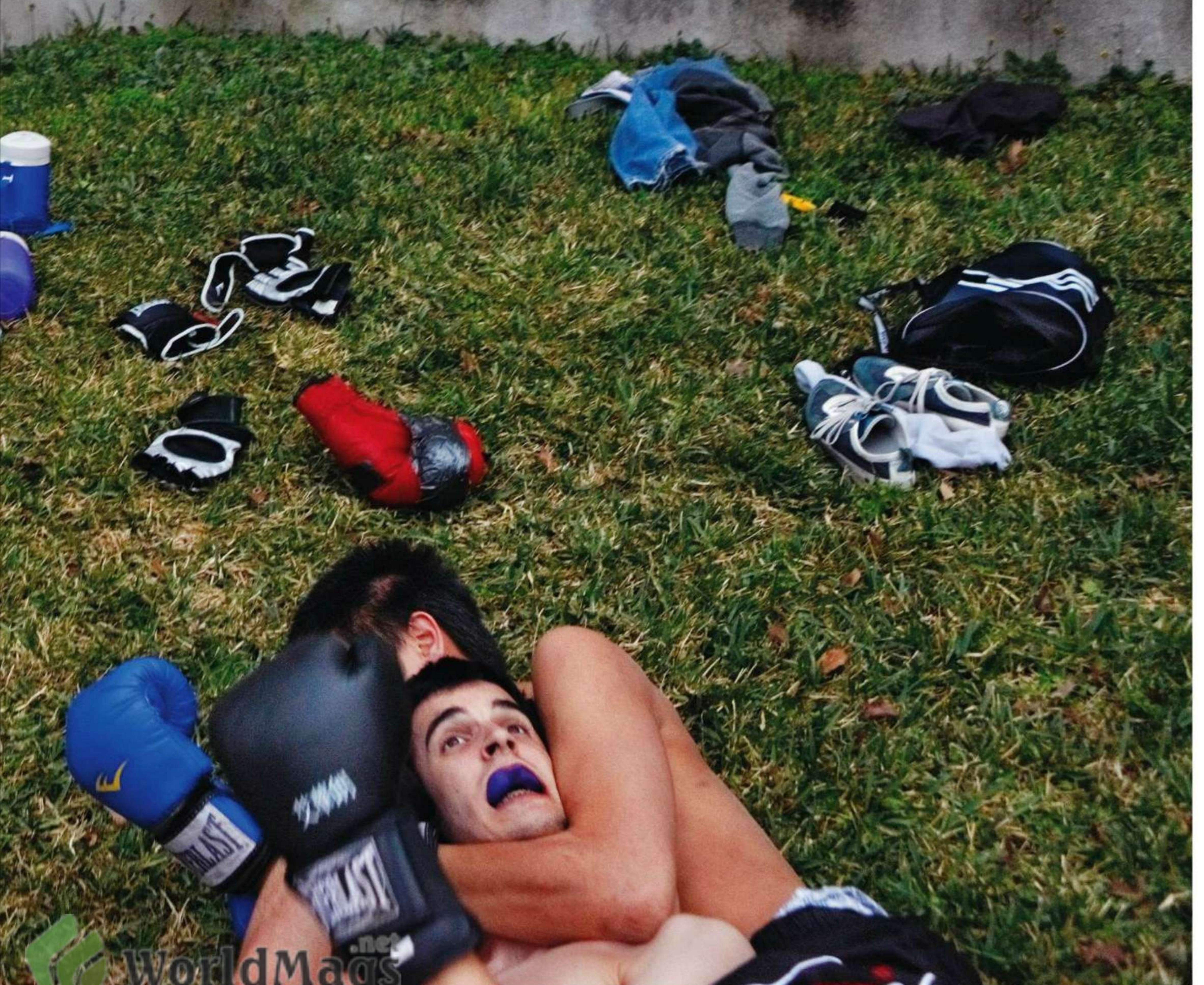
IT WAS KIND OF A DARE: If you do it, I'll do it. Taylor Dicristofalo (at right) said she probably wouldn't have had her tongue pierced if her best friend hadn't dragged her along on an "exciting and scary adventure" in downtown Austin. She tried to hide the piercing from her parents by not talking, but they figured it out. Months later, she removed the stud for a night. The hole closed up. Her grateful dad likened the stud's removal to an early Christmas gift.







NO ELBOWS, NO KNEES. Their “fight club” had rules. At least one Friday a month, boys gathered after school in the backyard of Bryan Campbell (at far left) to wrestle and box. Campbell’s mother gave her OK as long as they kept it safe; a bloody nose was the worst injury suffered. The boys often used phones to film their contests, then posted the videos to a private group on Facebook, where more friends could admire their prowess. The rush of a headlock, a bond between friends—their fights delivered both excitement and social rewards.



Also peaking during adolescence (and perhaps aggrieving the ancients the most) is risk-taking. We court risk more avidly as teens than at any other time. This shows reliably in the lab, where teens take more chances in controlled experiments involving everything from card games to simulated driving. And it shows in real life, where the period from roughly 15 to 25 brings peaks in all sorts of risky ventures and ugly outcomes. This age group dies of accidents of almost every sort (other than work accidents) at high rates. Most long-term drug or alcohol abuse starts during adolescence, and even people who later drink responsibly often drink too much as teens. Especially in cultures where teenage driving is common, this takes a gory toll: In the U.S., one in three teen deaths is from car crashes, many involving alcohol.

Are these kids just being stupid? That's the conventional explanation: They're not thinking, or by the work-in-progress model, their puny developing brains fail them.

Yet these explanations don't hold up. As

In scientific terms, teenagers can be a pain in the ass. But they are quite possibly the most fully, crucially adaptive human beings around.

Laurence Steinberg, a developmental psychologist specializing in adolescence at Temple University, points out, even 14- to 17-year-olds—the biggest risktakers—use the same basic cognitive strategies that adults do, and they usually reason their way through problems just as well as adults. Contrary to popular belief, they also fully recognize they're mortal. And, like adults, says Steinberg, “teens actually overestimate risk.”

So if teens think as well as adults do and recognize risk just as well, why do they take more chances? Here, as elsewhere, the problem lies less in what teens lack compared with adults than in

what they have more of. Teens take more risks not because they don't understand the dangers but because they weigh risk versus reward differently (see chart, page 49): In situations where risk can get them something they want, they value the reward more heavily than adults do.

A video game Steinberg uses draws this out nicely. In the game, you try to drive across town in as little time as possible. Along the way you encounter several traffic lights. As in real life, the traffic lights sometimes turn from green to yellow as you approach them, forcing a quick go-or-stop decision. You save time—and score more points—if you drive through before the light turns red. But if you try to drive through the red and don't beat it, you lose even more time than you would have if you had stopped for it. Thus the game rewards you for taking a certain amount of risk but punishes you for taking too much.

When teens drive the course alone, in what Steinberg calls the emotionally “cool” situation of an empty room, they take risks at about the same rates that adults do. Add stakes that the teen cares about, however, and the situation changes. In this case Steinberg added friends: When he brought a teen's friends into the room to watch, the teen would take twice as many risks, trying to gun it through lights he'd stopped for before. The adults, meanwhile, drove no differently with a friend watching.

To Steinberg, this shows clearly that risk-taking rises not from puny thinking but from a higher regard for reward.

“They didn't take more chances because they suddenly downgraded the risk,” says Steinberg. “They did so because they gave more weight to the payoff.”

Researchers such as Steinberg and Casey believe this risk-friendly weighing of cost versus reward has been selected for because, over the course of human evolution, the willingness to take risks during this period of life has granted an adaptive edge. Succeeding often requires

moving out of the home and into less secure situations. “The more you seek novelty and take risks,” says Baird, “the better you do.” This responsiveness to reward thus works like the desire for new sensation: It gets you out of the house and into new turf.

As Steinberg’s driving game suggests, teens respond strongly to social rewards. Physiology and evolutionary theory alike offer explanations for this tendency. Physiologically, adolescence brings a peak in the brain’s sensitivity to dopamine, a neurotransmitter that appears to prime and fire reward circuits and aids in learning patterns and making decisions. This helps explain the teen’s quickness of learning and extraordinary receptivity to reward—and his keen, sometimes melodramatic reaction to success as well as defeat.

The teen brain is similarly attuned to oxytocin, another neural hormone, which (among other things) makes social connections in particular more rewarding. The neural networks and dynamics associated with general reward and social interactions overlap heavily. Engage one, and you often engage the other. Engage them during adolescence, and you light a fire.

This helps explain another trait that marks adolescence: Teens prefer the company of those their own age more than ever before or after. At one level, this passion for same-age peers merely expresses in the social realm the teen’s general attraction to novelty: Teens offer teens far more novelty than familiar old family does.

Yet teens gravitate toward peers for another, more powerful reason: to invest in the future rather than the past. We enter a world made by our parents. But we will live most of our lives, and prosper (or not) in a world run and remade by our peers. Knowing, understanding, and building relationships with them bears critically on success. Socially savvy rats or monkeys, for instance, generally get the best nesting areas or territories, the most food and water, more allies, and more sex with better and fitter mates. And no species is more intricately and deeply social than humans are.

This supremely human characteristic makes

peer relations not a sideshow but the main show. Some brain-scan studies, in fact, suggest that our brains react to peer exclusion much as they respond to threats to physical health or food supply. At a neural level, in other words, we perceive social rejection as a threat to existence. Knowing this might make it easier to abide the hysteria of a 13-year-old deceived by a friend or the gloom of a 15-year-old not invited to a party. These people! we lament. They react to social ups and downs as if their fates depended upon them! They’re right. They do.

EXCITEMENT, NOVELTY, RISK, the company of peers. These traits may seem to add up to nothing more than doing foolish new stuff with friends. Look deeper, however, and you see that these traits that define adolescence make us more adaptive, both as individuals and as a species. That’s doubtless why these traits, broadly defined, seem to show themselves in virtually all human cultures, modern or tribal. They may concentrate and express themselves more starkly in modern Western cultures, in which teens spend so much time with each other. But anthropologists have found that virtually all the world’s cultures recognize adolescence as a distinct period in which adolescents prefer novelty, excitement, and peers. This near-universal recognition sinks the notion that it’s a cultural construct.

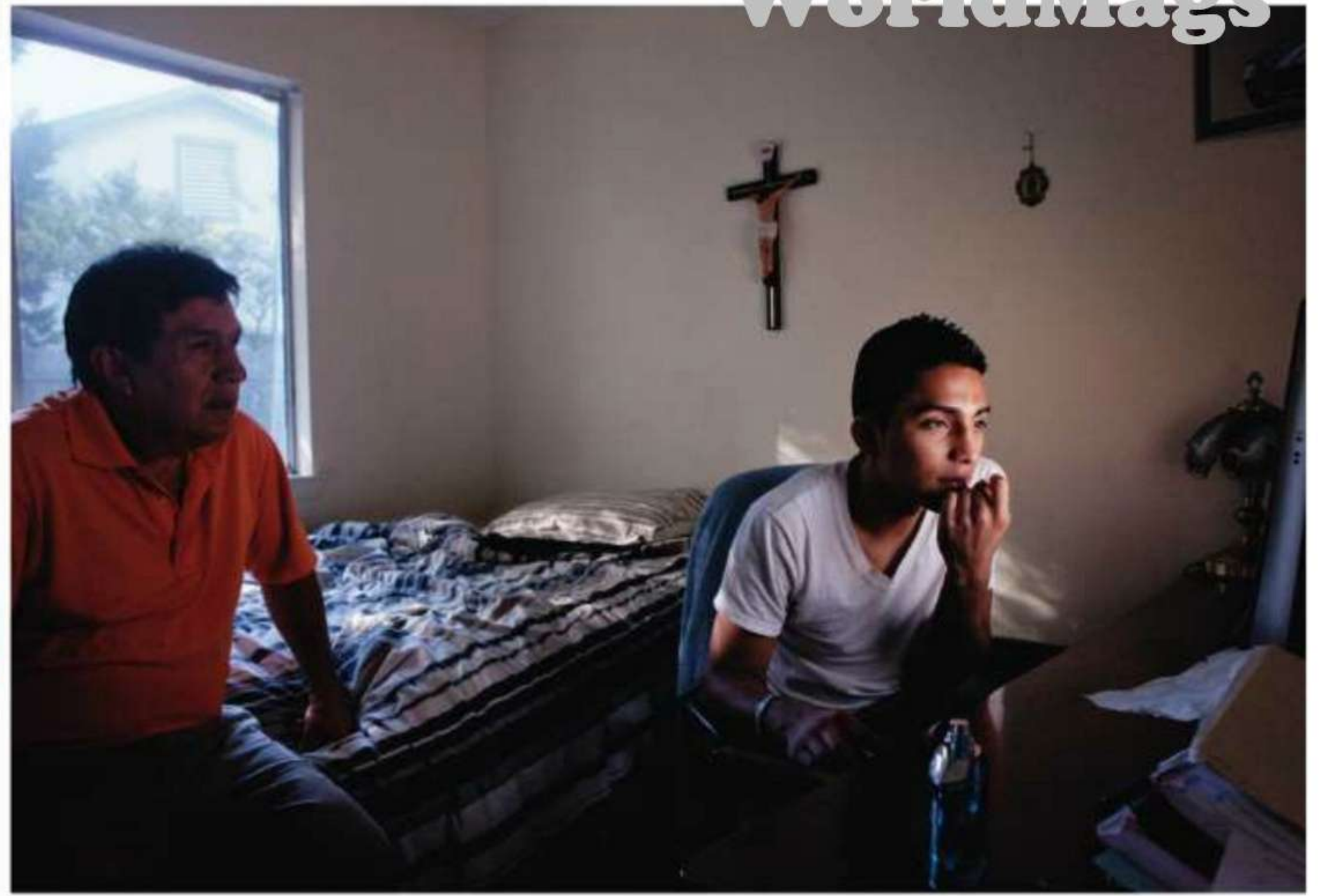
Culture clearly shapes adolescence. It influences its expression and possibly its length. It can magnify its manifestations. Yet culture does not create adolescence. The period’s uniqueness rises from genes and developmental processes that have been selected for over thousands of generations because they play an amplified role during this key transitional period: producing a creature optimally primed to leave a safe home and move into unfamiliar territory.

The move outward from home is the most difficult thing that humans do, as well as the most critical—not just for individuals but for a species that has shown an unmatched ability to master challenging new environments. In scientific terms, teenagers can be a pain in the ass. But they are quite possibly the most fully,

ON THE RANCH OUTSIDE AUSTIN where he and his father planned a hunt, Spencer O'Loughlin watches fellow hunters clean and pose with a buck. Teens may choose to hang out with peers, but structured interactions with parents and other adults are also crucial. O'Loughlin returned empty-handed after four days of waiting with a bow and arrow in a tiny camouflage tent, where even a head scratch could have scared off the quarry. To him the trip was an exercise in patience. Psychologists would call it a rite of passage.







SIDELINE LEADERS

Adults can guide teens as conductors, coaches, and cheerleaders. You just have to know when to pull back, says neuroscientist B. J. Casey, and let the teen do the work.

crucially adaptive human beings around. Without them, humanity might not have so readily spread across the globe.

THIS ADAPTIVE-ADOLESCENCE view, however accurate, can be tricky to come to terms with—the more so for parents dealing with teens in their most trying, contrary, or flat-out scary moments. It's reassuring to recast worrisome aspects as signs of an organism learning how to negotiate its surroundings. But natural selection swings a sharp edge, and the teen's sloppier moments can bring unbearable consequences. We may not run the risk of being killed in ritualistic battles or being eaten by leopards, but drugs, drinking, driving, and crime take a mighty toll. My son lives, and thrives, sans car, at college. Some of his high school friends, however, died during their driving experiments. Our children wield their adaptive plasticity amid small but horrific risks.

We parents, of course, often stumble too, as we try to walk the blurry line between helping and hindering our kids as they adapt to adulthood. The United States spends about a billion dollars a year on programs to counsel adolescents on violence, gangs, suicide, sex, substance abuse, and other potential pitfalls. Few of them work.

Yet we can and do help. We can ward off some of the world's worst hazards and nudge adolescents toward appropriate responses to the rest. Studies show that when parents engage and guide their teens with a light but steady hand, staying connected but allowing independence, their kids generally do much better in life. Adolescents want to learn primarily, but not entirely, from their friends. At some level and at some times (and it's the parent's job to spot when), the teen recognizes that the parent can offer certain kernels of wisdom—knowledge valued not because it comes from parental authority but because it comes from the parent's own struggles to learn how the world turns. The teen rightly perceives that she must understand not just her parents' world but also the one she is entering. Yet if allowed to, she can appreciate that her parents once faced the same problems and may remember a few things worth knowing.

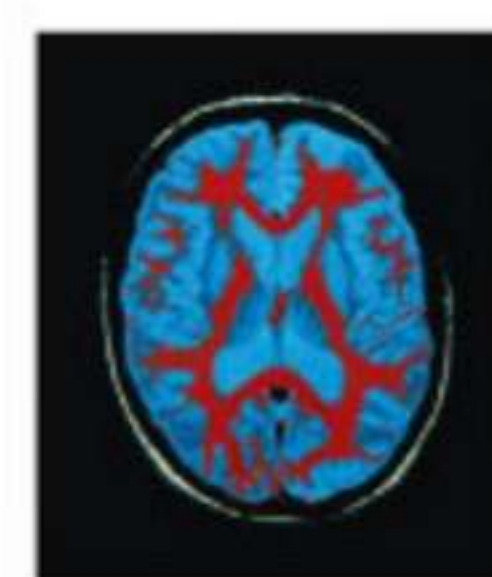
MEANWHILE, in times of doubt, take inspiration in one last distinction of the teen brain—a final key to both its clumsiness and its remarkable adaptability. This is the prolonged plasticity of those late-developing frontal areas as they slowly mature. As noted earlier, these areas are the last to lay down the fatty myelin insulation—the brain's white matter—that speeds transmission. And at first glance this seems like bad news: If we need these areas for the complex task of entering the world, why aren't they running at full speed when the challenges are most daunting?

The answer is that speed comes at the price of flexibility. While a myelin coating greatly accelerates an axon's bandwidth, it also inhibits the growth of new branches from the axon. According to Douglas Fields, an NIH neuroscientist who has spent years studying myelin, "This makes the period when a brain area lays down myelin a sort of crucial period of learning—the wiring is getting upgraded, but once that's done, it's harder to change."

The window in which experience can best rewire those connections is highly specific to each brain area. Thus the brain's language centers acquire their insulation most heavily in the first 13 years, when a child is learning language. The completed insulation consolidates those gains—but makes further gains, such as second languages, far harder to come by.

So it is with the forebrain's myelination during the late teens and early 20s. This delayed completion—a withholding of readiness—heightens flexibility just as we confront and enter the world that we will face as adults.

This long, slow, back-to-front developmental wave, completed only in the mid-20s, appears to be a uniquely human adaptation. It may be one of our most consequential. It can seem a bit crazy that we humans don't wise up a bit earlier in life. But if we smartened up sooner, we'd end up dumber. □



BRAIN GAMES

Delve deep into the workings of the human mind in a three-part special airing this month on **National Geographic Channel**. Check local listings.

DEEP DOWN UNDER

With ropes but no GPS,
daring Aussies plunge
into the hidden canyons
of the Blue Mountains.



A canyoneer descends by rope through one of Kanangra Main Canyon's three 150-foot waterfalls. After his teammates join him, they will pull down the ropes to use for the next stage—leaving no way out but to rappel, climb, boulder, and swim to the exit point near the canyon's bottom.

Cascades of mammoth ferns flourish in the humid air trapped between the narrow walls of Claustal Canyon. First explored in 1963, the formation was named for its claustrophobia-inducing passages and ranks among the region's most visited canyons.







Canyoneers make their way through a vine-choked rain forest of coachwood and sassafras on the way to Claustral Canyon. Locating a canyon's entry point can require hours of bushwalking. A canyoneer typically hauls as much as 20 pounds of gear, including rope, wet suit, food, and first aid supplies.





Flying into the void, author Mark Jenkins makes one of 14 rope descents in Kanangra Main. The reward? Views like the one from pagoda rocks (right).

By Mark Jenkins

Photographs by Carsten Peter



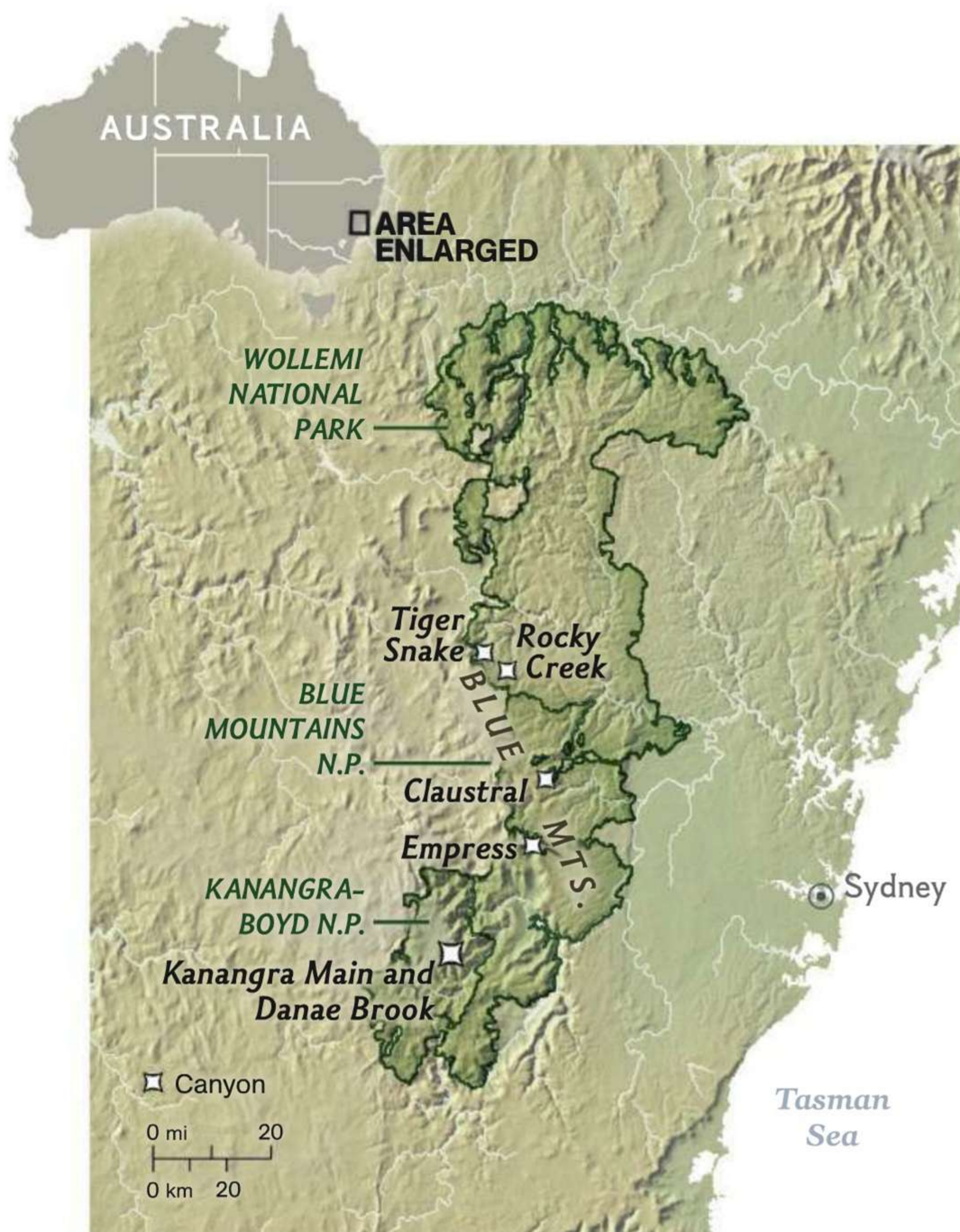
The Swiss have mountains, so they climb. Canadians have lakes, so they canoe. The Australians have canyons, so they go canyoneering, a hybrid form of madness halfway between mountaineering and caving in which you go down instead of up, often through wet tunnels and narrow passageways. Unlike other places with slot canyons, such as Utah, Jordan, or Corsica, Australia has a rich, deep heritage of canyoneering. In a way, it's an extreme form of bushwalking, something Aborigines were doing tens of thousands of years before

Mark Jenkins last wrote about big-wall climbing in Yosemite Valley in May 2011. Carsten Peter photographed an expedition into the crater of Nyiragongo, a volcano in the Democratic Republic of the Congo, for our April 2011 issue.





“It feels like being swallowed by the Earth,” says photographer Carsten Peter of the Black Hole of Calcutta in Claustral Canyon. Experienced canyoneers avoid it after heavy rains.



Europeans arrived. But without ropes and technical equipment, Aborigines couldn't explore the deepest slots.

Today perhaps thousands of Aussies hike canyons, hundreds descend into them by ropes, but only a handful explore new ones. These driven individuals tend to have a rugby player's legs, knees crosshatched with scar tissue from all the scratches, a penguin's tolerance for frigid water, a wallaby's rock-hopping agility, and a caver's mole-like willingness to crawl into damp, dark holes. They prefer to wear Volleys—canvas, rubber-soled Dunlop tennis shoes—ragged shorts, ripped gaiters, and thrift-store fleece. They camp beside tiny campfires and make “jaffles” for breakfast, lunch, and dinner. Jaffles are sandwiches containing all manner of ingredients—including Vegemite, a nasty-tasting yeast extract—cooked inside fire irons over the flames. Above all they search for the most remote, difficult to access canyons. “The darker, the narrower, the twistier the better,” says Dave Noble, one of the most experienced canyoneers in the country. “People say, What if you get stuck in there? But that's what you are after. To be forced to improvise to get yourself out.”

During the past 38 years Noble has made

some 70 first descents in the Blue Mountains, just a few hours' drive west of Sydney. This unexpectedly rugged region has hundreds of slot canyons. The “Blueys” aren't mountains at all but an ancient sedimentary plateau deeply incised by river erosion and densely carpeted in eucalyptus—imagine the canyonlands of Utah covered with Louisiana foliage.

Defiantly unconventional, Noble, 57, has never driven a car. He bicycles nearly 20 miles a day through suburban Sydney to teach high school physics. Although he has drawn heavily annotated topographic maps of canyons that he has explored and named—such as Cannibal, Black Crypt, Crucifixion, and Resurrection—and has posted pictures of them on his website, he won't tell anyone where these canyons are. He won't even let me have a good look at his maps. “It's our ethic,” he says. “Wilderness canyons should be left undescribed so they remain pristine and so others can have the challenge of exploring them on their own. That's part of the mystery.”

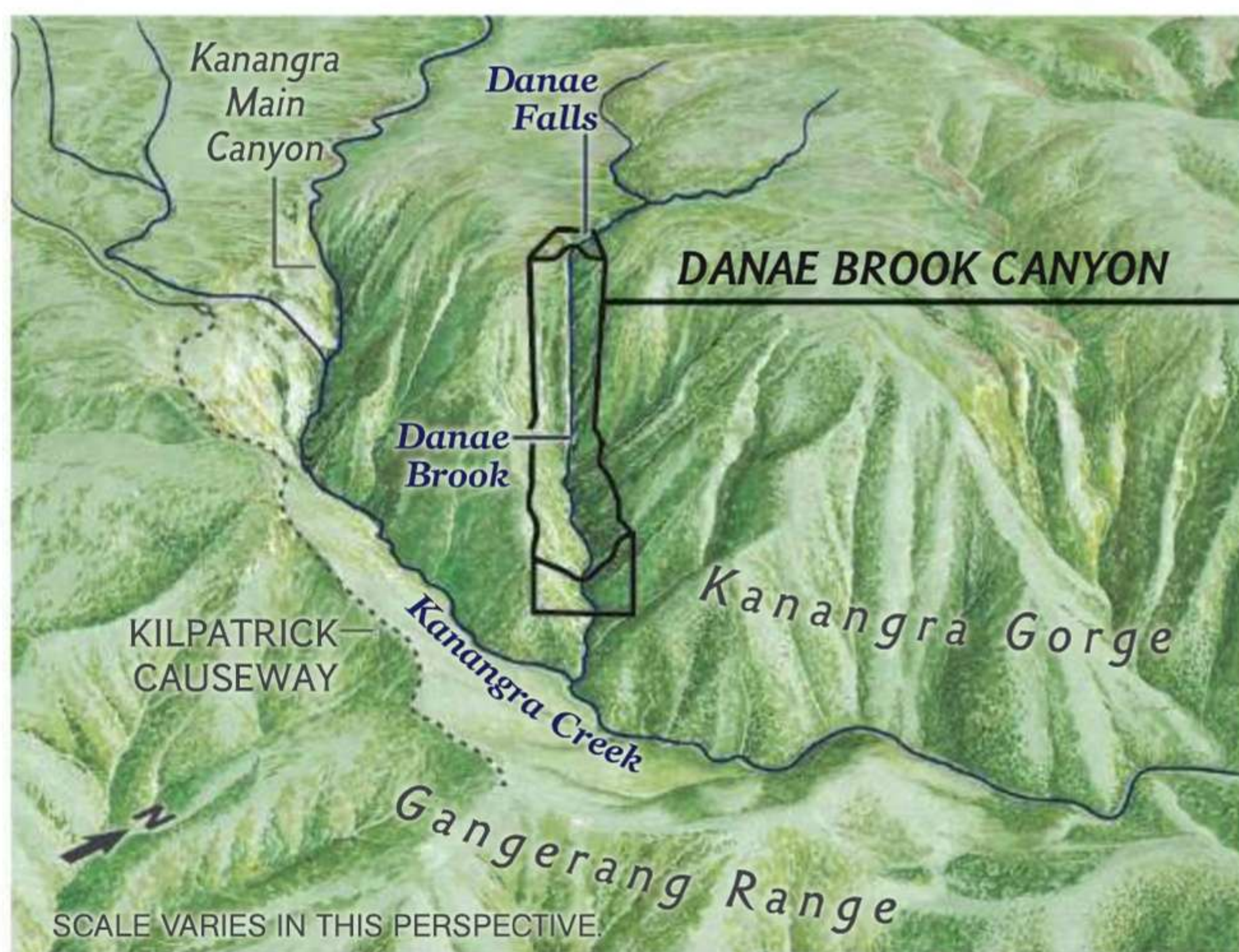
Noble's chief rival in the sport is a canyoneer named Rick Jamieson, who earned Noble's disapproval some years back by writing a guidebook that revealed a few secrets of the canyon landscape. More than a decade ago Jamieson, also a physics teacher, took me on the first complete descent of two big canyons in the Blueys, Bennett Gully and Orongo. A huge, good-natured boulder of a man at 70, he's still canyoneering and still laughing.

“Mighty!” exclaims Jamieson in his thick Australian accent when we get together for a beer. “We're lucky those GPS's don't work down in the canyons. Keeps the adventure.”

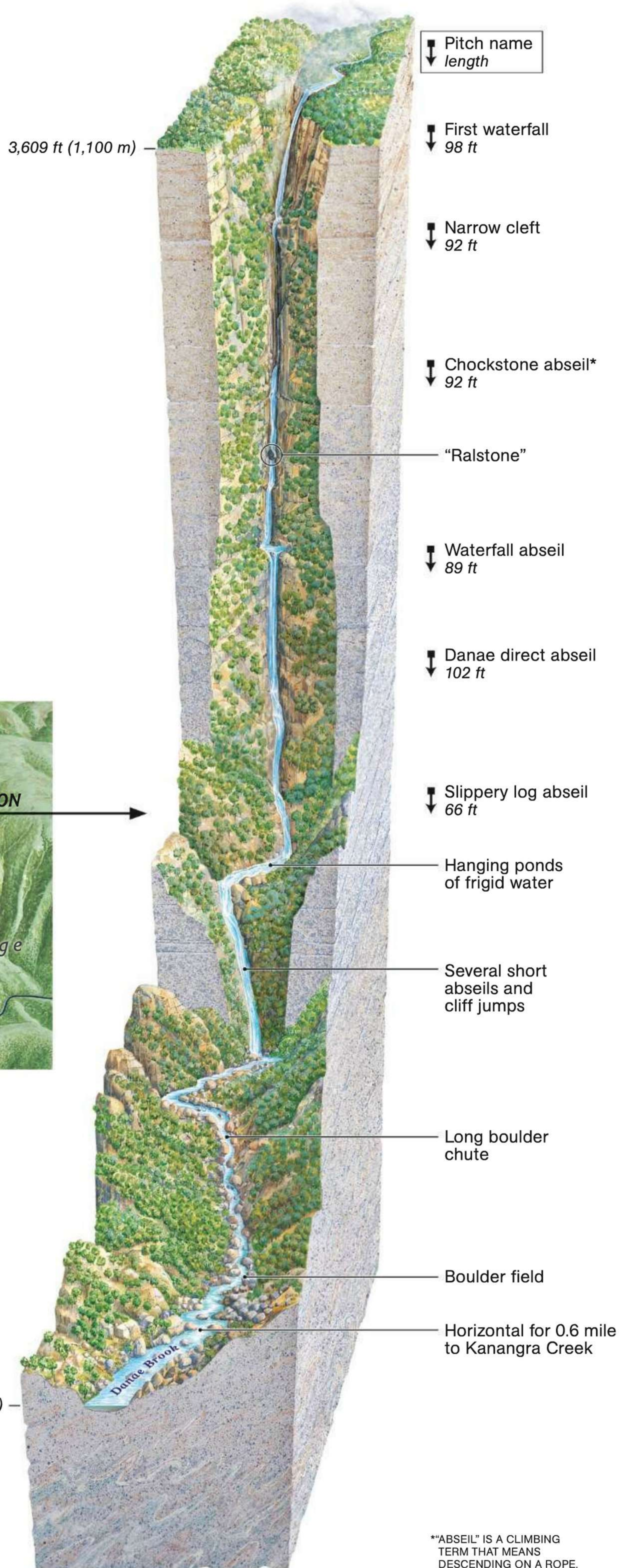
Canyoneering by sunburned white people began in the 1940s, but the biggest slots weren't explored until the 1960s, when modern climbing ropes and equipment were adopted. Danae Brook Canyon, hidden in the labyrinthine heart of the Blue Mountains, is one of the most difficult. In his guidebook Jamieson describes it as “one very, very long day” in which canyoneers must make nine or more tricky abseils, a climbing term for descending on a rope. Both Jamieson and Noble have done it, yet neither man is

Canyoneers and Cascades

Dropping more than 2,000 feet in 1.5 miles, Danae Brook Canyon requires canyoneers to make nine or more rope descents—one down an 89-foot waterfall—and to swim through deep pools. Myles Dunphy, a naturalist who helped create Blue Mountains National Park (map opposite), found the canyon in the 1920s. Today it's still a standard against which canyoneers measure their skills.



Hidden under a thick blanket of rain forest, hundreds of slot canyons have been found in the region's wrinkled topography, with new ones documented each year. The canyons were created over millions of years, as erosion cut through layers of basalt, sandstone, and shale.



- ↓ Pitch name length
- ↓ First waterfall 98 ft
- ↓ Narrow cleft 92 ft
- ↓ Chockstone abseil* 92 ft
- "Ralstone"
- ↓ Waterfall abseil 89 ft
- ↓ Danae direct abseil 102 ft
- ↓ Slippery log abseil 66 ft
- Hanging ponds of frigid water
- Several short abseils and cliff jumps
- Long boulder chute
- Boulder field
- Horizontal for 0.6 mile to Kanangra Creek

ARTIST'S DEPICTION NOT TO SCALE
 MARTIN GAMACHE, NGM STAFF. ART: GARY HINCKS
 SOURCES: TOM BRENNAN; RICK JAMIESON; DAVID NOBLE;
 JOHN ROBENS; KANANGRA-BOYD NATIONAL PARK

**"ABSEIL" IS A CLIMBING TERM THAT MEANS DESCENDING ON A ROPE.

available to go with me. But wiry John Robens is keen to give it a try.

We meet at his home in Sydney. Most weekends for the past ten years Robens, 39, has escaped the city to go canyoneering in the bush. A shaggy-haired, wry, soft-spoken, self-employed computer consultant, Robens, like Noble, fearlessly bicycles the city streets, and he has thighs like Lance Armstrong's to prove it. He lives with his wife, Chuin Nee Ooi, also an elite canyoneer and fellow computer programmer, in a compact midtown house that appears to have been hit by a typhoon: carabiners, canyoneering ropes, and mud-clotted clothes are scattered among computers, hard drives, disks, coffee cups, and a grand piano. A large wooden box on the diminutive porch is filled with worn-out Volleys.

Robens and I drive west from Sydney for four hours, camp in Kanangra-Boyd National Park, and by dawn are tramping down the Mount Thurat fire trail. We have wet suits, a rope, and lunch in our packs. After crossing Kanangra Creek, we strike out into the trailless bush, navigating by map and GPS. Canyoneers share an ability to travel swiftly through seemingly impenetrable brush; Robens glides through this giant briar patch so efficiently he's hard to keep up with. Following a compass bearing, we hop over fallen trees and branches and crash through scrub, passing through giant spiderwebs, mouse-size spiders scurrying across our necks.

"'Tis only the spiders that live in the ground that can kill you," Robens says brightly.

After less than an hour Robens has guided us precisely to the top of Danae Falls, although he's never been here before. A brook rushes to the edge of the plateau and leaps off.

"Our first abseil is off that," Robens says, pointing to a tree jutting precariously out over the cliff. We stretch into sticky wet suits, clap on helmets, cinch up our harnesses, and sail out into space. It's like rappelling off the edge of a green-cloaked Grand Canyon.

Up this high, Danae Brook hasn't yet cut a slot in the rock face, so we rappel through plumes of spray beside the waterfall, our feet slipping on giant fern fronds. By our next rappel the Danae



A foot-long crayfish dodges a hiker fording a stream in Claustal Canyon. The color of these crayfish, called yabbies by canyoneers, remains a puzzle. In some streams they're orange. In others they're blue. The difference is due partly to water purity—the blue ones are found in the clearest water.



has sliced a fissure that's only four feet wide but cuts 50 feet back into the stone. We descend at the back of the crack, looking out at a vertical seam of blue sky.

At the top of the third rappel we're deep in the dark slot, standing on a slick, sloppy ledge in a pouring waterfall. "To keep the rope from getting stuck," Robens shouts, "we'll have to pass to the inside of that dodgy ralstone."

"Ralstone?" I yell.

"You know, roll stone," Robens says with a smile, nodding toward a chockstone the size of a refrigerator in the slot below us. It's a canyoneer's

hard-knocks joke: "roll stone" for "ralstone," referring to Aron Ralston, the American who was forced to cut off his arm when a boulder rolled on top of it in a Utah canyon.

The walls are covered with moss. Sliding to the inside of the giant stone turns out to be like squeezing into a narrow, ten-story elevator shaft pouring with water. We're forced to swing into the pounding waterfall, an awkward maneuver that slams us both into the rock. But it's worth it: Standing in a pool at the bottom, we easily pull our rope down.

Below the big boulder the slot closes up, and



A canyoneer endures the deluge of a waterfall in Empress Canyon. Canyoneers say even a relatively easy rappel like this one can feel like drowning in midair.

Midday shafts of light intensify the cathedral-like atmosphere of Rocky Creek Canyon. Squeezing through Tiger Snake (far right), canyoneer David Forbes watches for the serpents the canyon is named after.





the silky water flows horizontally along the cave-like chamber back out to the edge of the cliff. We still have a thousand feet of air below us. We rappel directly into the bludgeoning waterfall. Halfway down I make the mistake of looking up, and the blast of water almost tears my head off.

The next three descents are just as extraordinary and drop us into hanging ponds of frigid water, like swimming pools midway up a skyscraper. We backstroke across these ponds, using the dry bags in our backpacks for flotation.

At 10 a.m. we share lunch on a sunny boulder with a water dragon, a two-foot, dinosaur-like

lizard with a brilliant crest, and drink directly from the cool, delicious *Danae*. Holding my head under the emerald water, I spot blue-shelled yabbies, the native crayfish, clawing their way along the bottom of the pool. Then we both strip off our wet suits.

Robens is perfectly happy to continue in his birthday suit, but I pull on heavy nylon pants. Two weeks earlier in another canyon I managed to step into a stinging tree, a uniquely horrific plant that burns like stinging nettles and leaves a painful rash that doesn't go away for a month. Mine is in an unreasonable place.



Veteran guide John Robens (at left) leads a soggy team through a moss-covered passage in Claustral Canyon, a few hours' hike from their exit point. Canyoneering is all about the serendipity of discovery, he says. "You walk for miles and suddenly you find yourself in *this* magical spot."

Several short rappels and two huge jumps follow. Robens throws himself off the stone, howling like a free man, arms and legs spread wide in the air, closing them like a butterfly right before he hits the water 20 feet below.

When we reach the bottom, the Danae becomes a steep boulder field, which Robens, naked but for his pack and tennies, practically runs across. He leaps, lands on a slimy, snot-slick stone, almost loses his balance, finds his balance, and leaps again, all in one fluid motion. It's amazing to watch, like witnessing the movements of some earlier, better adapted human. In an hour we cover a distance that typically requires three. Stumbling and falling, I watch Robens dancing and hopscotching as if he'd been born for it.

Where the Danae meets Kanangra Creek, our descent is complete. But like climbers who reach a summit, we can't celebrate yet. In canyoneering what goes down must come back up. We cross the creek, rest for ten minutes, then begin the agonizing, bushwhacking ascent. We could go up a slope like Murdering Gully but take a rocky rib instead, nicknaming it Manslaughter Ridge. The climb is so vertical we're pulling ourselves up branch by branch.

Wet with sweat, we reach the peninsular plateau of the Gangerang Range, directly opposite Danae Brook Canyon, shake hands, and whoop. From here we can take a trail, the Kilpatrick Causeway, and the going will be easy (although in 2006 a hiker fell off a 230-foot cliff on the same trail and died).

Striding along the track, the sun at my back, dreaming of the avocado-tomato-prosciutto-provolone jaffle I'll cook over our campfire tonight, feeling warm and tired, my body and mind cleansed by the descent of Danae, I see Robens swerve off into the bush.

"Wanta show you something," he says over his shoulder.

We curl around a sandstone knob on a ledge, and suddenly before us is aboriginal art. A row of stick figures drawn in ocher red, obviously naked, all with their arms and legs spread wide, all quite obviously rejoicing. □

Sharing with Sharks

In a surprising interaction at sea, colossal whale sharks home in on fishing nets near the island of New Guinea—and fishermen dole out snacks to the pilfering beasts.





PHOTOGRAPHS BY MICHAEL AW

The biggest fish in the sea is as long as a school bus, weighs as much as 50,000 pounds, and has a mouth that looks, head-on, wide enough to suck down a small car. Despite this distinctive profile, scientists know very little about *Rhincodon typus*—the whale shark.

The behemoths are indeed sharks: They breathe through gills, like fish. They are cold-blooded, like fish. The “whale” part of the name refers to size and how the animals eat. They are one of only three known shark species that filter feed, as baleen whales do, swimming slowly through plankton-rich water, maws agape. Water goes in carrying edibles of all sizes, and water sans food flows out.

The giant fish is hard to study in part because it is hard to find and track. By tagging individual specimens, scientists have learned that whale sharks can log thousands of miles in years-long trips. But they sometimes disappear for weeks, diving more than a mile down and resting in the chilly deep for a spell. No one has ever found mating or birthing grounds.

Whale sharks are ordinarily loners. But not in one corner of Indonesia. The photographs on these pages, shot some eight miles off the province of Papua, reveal a group of sharks that call on fishermen each day, zipping by one another, looking for handouts near the surface, and nosing the nets—a rare instance when the generally docile fish act, well, like the rest of the sharks. —Jennifer S. Holland

A whale shark tilts upright and yanks on a net, trying to make off with a fisherman's catch (left). “This behavior shows they can be opportunistic feeders,” says biologist Morgan Riley, a director of the Maldives Whale Shark Research Programme. Fishermen atop bagans (floating platforms) offer baitfish (right), which may help keep the sharks away from the nets.

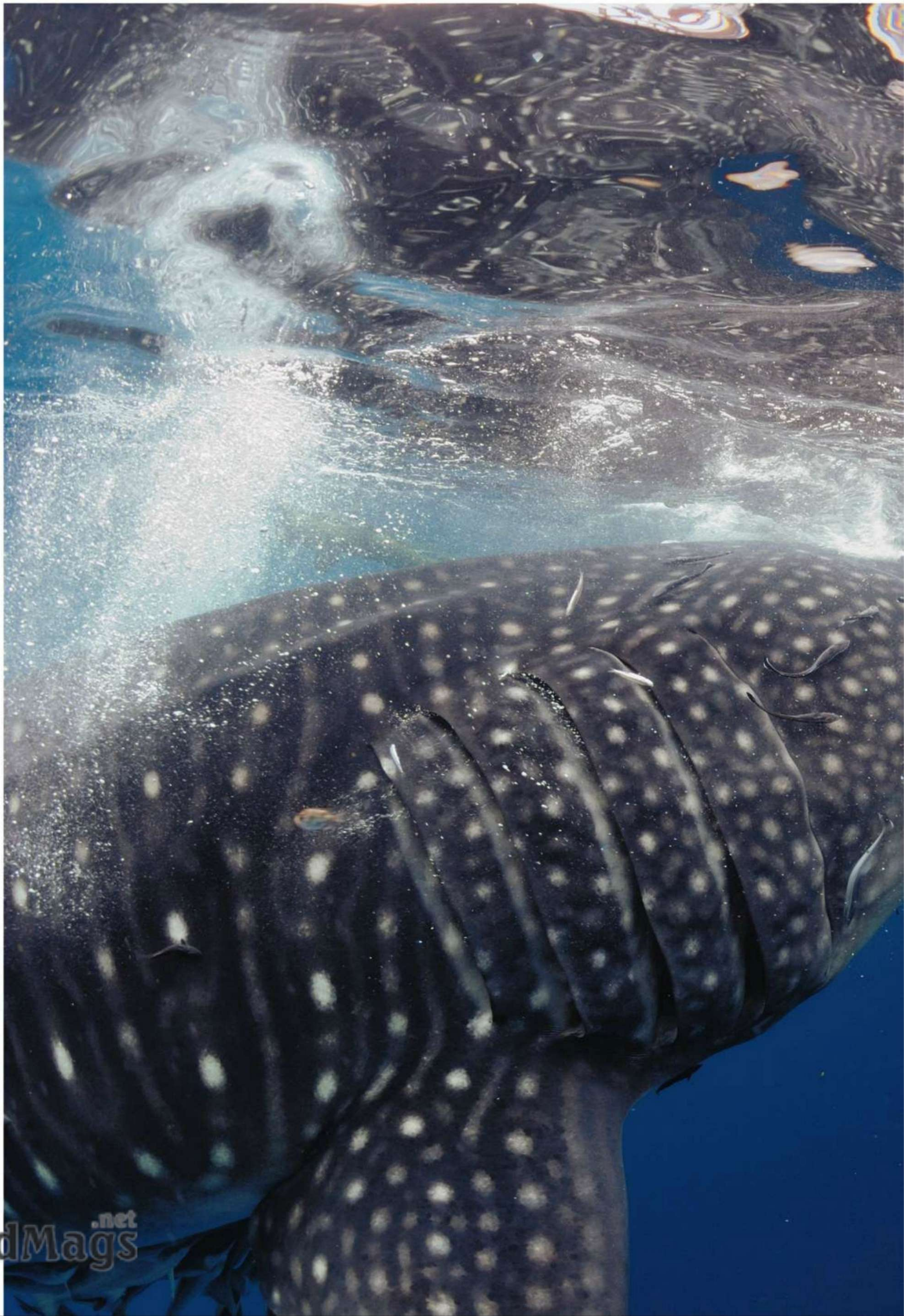


Vying for position under a bagan, male whale sharks—two of about twenty that visit this spot—scramble for a snack. Typically an adult shark might cruise night and day at a sedate one to three miles an hour, sucking in enough seawater to feed itself. This group likely spends a lot of time in Papua's Cenderawasih Bay, making it one of a few places where the species gathers year-round. Scientists, already working to identify each shark by its markings, hope to cooperate with locals to launch studies of the giants.





“Suddenly he just jumped in!” says photographer Michael Aw. Sarmin Tangadji, the Papua police officer who escorted the photographic team to where the sharks congregate, “was so excited to see them up close.” Aw shares that excitement when it comes to diving with a dozen whale sharks, animals that usually ignore divers: “You are sandwiched in, sharks ahead and behind, but you want to be there,” he says. “They make eye contact with you and then charge by. It blows your mind.”







56 million years ago a mysterious surge of carbon into the atmosphere sent global temperatures soaring. In a geologic eyeblink life was forever changed.

WORLD WITHOUT ICE

By Robert Kunzig

Photographs by Ira Block

Earth was hot and ice free at the end of the Paleocene epoch. With sea level 220 feet higher than now, the Americas—not yet joined by continental drift—were smaller. Look in vain for Florida.

Inuit Johnny Issaluk holds a recent photo of a South Carolina swamp. That's what his home, near the Arctic Circle on Baffin Island, would have looked like 56 million years ago, when summer water temperatures at the North Pole hit 74°F.





EARTH HAS BEEN THROUGH THIS BEFORE.

Not the same planetary fever exactly; it was a different world the last time, around 56 million years ago. The Atlantic Ocean had not fully opened, and animals, including perhaps our primate ancestors, could walk from Asia through Europe and across Greenland to North America. They wouldn't have encountered a speck of ice; even before the events we're talking about, Earth was already much warmer than it is today. But as the Paleocene epoch gave way to the Eocene, it was about to get much warmer still—rapidly, radically warmer.

The cause was a massive and geologically sudden release of carbon. Just how much carbon was injected into the atmosphere during the Paleocene-Eocene Thermal Maximum, or PETM, as scientists now call the fever period, is uncertain. But they estimate it was roughly the amount that would be injected today if human beings burned through all the Earth's reserves of coal, oil, and natural gas. The PETM lasted more than 150,000 years, until the excess carbon was reabsorbed. It brought on drought, floods, insect plagues, and a few extinctions. Life on Earth survived—indeed, it prospered—but it was drastically different. Today the evolutionary consequences of that distant carbon spike are all around us; in fact they include us. Now we ourselves are repeating the experiment.

The PETM “is a model for what we're starting at—a model for what we're doing by playing

Environment editor Robert Kunzig wrote about population for the January issue. This is Ira Block's 37th story for the magazine.

with the atmosphere,” says Philip Gingerich, a vertebrate paleontologist at the University of Michigan. “It's the idea of triggering something that runs away from you and takes a hundred thousand years to reequilibrate.”

Gingerich and other paleontologists discovered the profound evolutionary change at the end of the Paleocene long before its cause was traced to carbon. For 40 years now Gingerich has been hunting fossils from the period in the Bighorn Basin, a hundred-mile-long arid plateau just east of Yellowstone National Park in northern Wyoming. Mostly he digs into the flanks of a long, narrow mesa called Polecat Bench, which juts into the northern edge of the basin. Polecat has become his second home: He owns a small farmhouse within sight of it.

One summer afternoon Gingerich and I drove in his sky blue '78 Suburban up a dirt track to the top of the bench and on out to its southern tip, which affords a fine view of the irrigated fields and scattered oil wells that surround it. During the recent ice ages, he explained, Polecat Bench was the bed of the Shoshone River, which paved it with cobbles. At some point the river shifted east and began cutting its way down through the softer and more ancient sediments that fill the Bighorn Basin. Meanwhile the Clark's Fork of the Yellowstone River was doing the same to the west. Polecat Bench now stands between the two rivers, rising 500 feet above their valleys. Over the millennia its flanks have been sculpted by winter wind and summer gully washers into rugged badlands, exposing a layer cake of sediments. Sediments from the PETM are exposed right at the very southern tip of the bench.

It is here that Gingerich has documented a great mammalian explosion. Halfway down the slope a band of red sediment, about a hundred feet thick, wraps around the folds and gullies, vivid as the stripe on a candy cane. In that band Gingerich discovered fossils of the oldest odd-toed hoofed mammals, even-toed hoofed mammals, and true primates: in other words, the first members of the orders that now include, respectively, horses, cows, and humans. Similar fossils have since been found in Asia and Europe. They



WHEN THE OCEAN WENT DARK

Paleoceanographer James Zachos holds a replica of a sediment core that shows an abrupt change in the Atlantic Ocean 56 million years ago, at the onset of the Paleocene-Eocene Thermal Maximum (PETM). White plankton shells vanished from the seafloor mud, shifting its color from white to red (bar below). As planet-warming CO₂ surged into the atmosphere, Zachos says, it also seeped into the seas, acidifying the water and dissolving the shells.



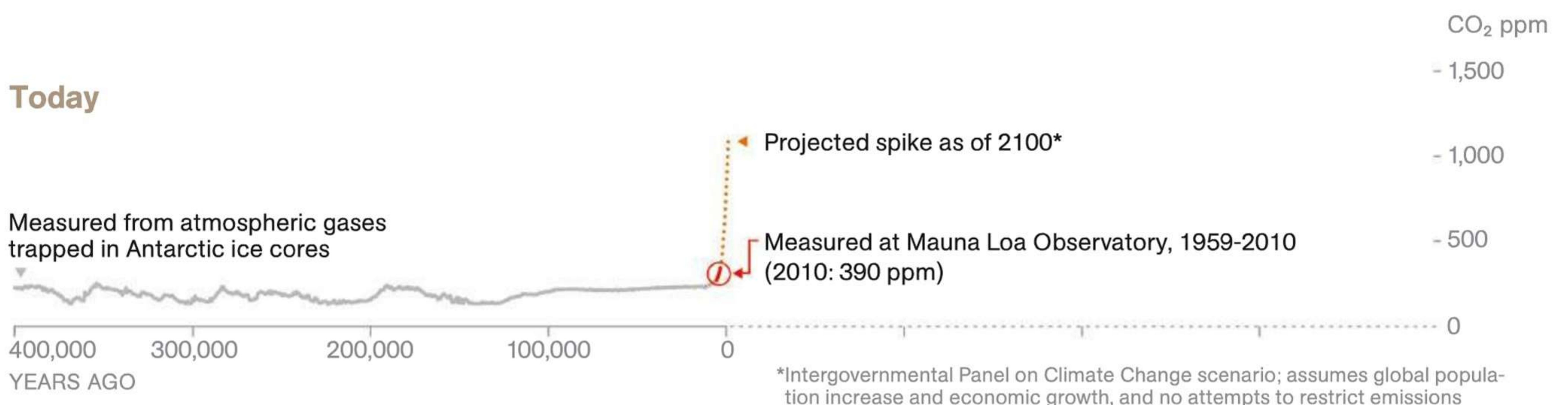
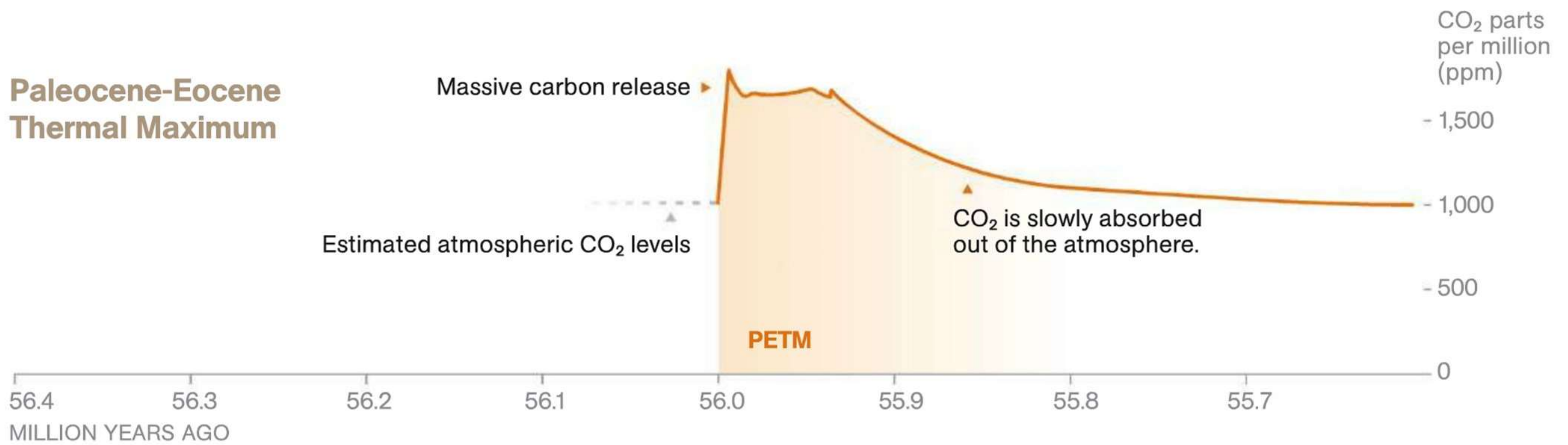
appear everywhere, and as if out of nowhere. Nine million years after an asteroid slammed into the Yucatán Peninsula, setting off a cataclysm that most scientists now believe wiped out the dinosaurs, the Earth seems to have undergone another shock to the system.

During the first two decades that Gingerich labored to document the Paleocene-Eocene transition, most scientists saw it simply as a time when one set of fossils gave way to another. That perception started to

change in 1991, when two oceanographers, James Kennett and Lowell Stott, analyzed carbon isotopes—different forms of the carbon atom—in a sediment core extracted from the Atlantic seafloor near Antarctica. Right at the Paleocene-Eocene boundary a dramatic shift in the ratio of isotopes in fossils of minuscule organisms called foraminifera (forams for short) indicated that an immense amount of “fresh” carbon had flooded into the ocean in as little as a few centuries. It would have spread into the atmosphere too, and there, as carbon dioxide, it

CARBON SHOCKS, THEN AND NOW

A mass of carbon roughly the size of today's coal, oil, and natural gas deposits entered Earth's atmosphere during the PETM. From where is unclear—but Earth, already warm, warmed another 9°F on average. It took more than 150,000 years for oceans and forests to absorb the excess carbon and the planet to cool. This chain of events, says Yale geochemist Mark Pagani, "eliminates any doubt that CO₂ is driving climate." If humans burn fossil fuels until they run out, the jolt to the planet will be comparable.



would have trapped solar heat and warmed the planet. Oxygen isotopes in the forams indicated that the whole ocean had warmed, from the surface right down to the bottom mud, where most of the forams lived.

In the early 1990s the same signs of a planetary convulsion began turning up on Polecat Bench. Two young scientists, Paul Koch of the Carnegie Institution and James Zachos, then at the University of Michigan, collected half-inch clumps of carbonate-rich soil from each of the sediment layers. They also collected teeth of a primitive mammal called *Phenacodus*. When Koch and Zachos analyzed the carbon isotope ratios in the soil and the tooth enamel, they found the same carbon spike seen in the forams. It was becoming clear that the PETM had been a global warming episode that had affected not

just obscure sea organisms but also big, charismatic land animals. And scientists saw that they could use the carbon spike—the telltale stamp of a global greenhouse gas release—to identify the PETM in rocks all over the world.

Where did all the carbon come from? We know the source of the excess carbon now pouring into the atmosphere: us. But there were no humans around 56 million years ago, much less cars and power plants. Many sources have been suggested for the PETM carbon spike, and given the amount of carbon, it likely came from more than one. At the end of the Paleocene, Europe and Greenland were pulling apart and opening the North Atlantic, resulting in massive volcanic eruptions that could have cooked carbon dioxide out of organic sediments on the seafloor, though probably not fast enough to explain the isotope

“With fossil fuels today... we’re taking what took millions of years to accumulate and releasing it in a geologic instant.”

—JAMES ZACHOS, UNIVERSITY OF CALIFORNIA, SANTA CRUZ

spikes. Wildfires might have burned through Paleocene peat deposits, although so far soot from such fires has not turned up in sediment cores. A giant comet smashing into carbonate rocks also could have released a lot of carbon very quickly, but as yet there is no direct evidence of such an impact.

The oldest and still the most popular hypothesis is that much of the carbon came from large deposits of methane hydrate, a peculiar, icelike compound that consists of water molecules forming a cage around a single molecule of methane. Hydrates are stable only in a narrow band of cold temperatures and high pressures; large deposits of them are found today under the Arctic tundra and under the seafloor, on the slopes that link the continental shelves to the deep abyssal plains. At the PETM an initial warming from somewhere—perhaps the volcanoes, perhaps slight fluctuations in Earth’s orbit that exposed parts of it to more sunlight—might have melted hydrates and allowed methane molecules to slip from their cages and bubble into the atmosphere.

The hypothesis is alarming. Methane in the atmosphere warms the Earth over 20 times more per molecule than carbon dioxide does, then after a decade or two, it oxidizes to CO₂ and keeps on warming for a long time. Many scientists think just that kind of scenario might occur today: The warming caused by the burning of fossil fuels could trigger a runaway release of methane from the deep sea and the frozen north.

Koch and Zachos concluded from their data that the PETM had lifted the annual average temperature in the Bighorn Basin by around nine degrees Fahrenheit. That’s more than the warming there since the last ice age. It’s also a bit more than what climate models predict there for the 21st century—but not more than what they forecast for the centuries to come if humans keep burning fossil fuels. Models also predict severe disruptions in the world’s rainfall patterns, even in this century, especially in subtropical regions like the American Southwest. But how to test the models? “You can’t wait 100 or 200 years to see what happened,” says Swedish geologist Birger Schmitz, who has spent

a decade studying PETM rocks in the Spanish Pyrenees. “That’s what makes the PETM story so interesting. You have the end result. You can see what *did* happen.”

What happened in the Bighorn was a wholesale rearrangement of life. Scott Wing, a paleobotanist at the Smithsonian National Museum of Natural History, has been collecting fossil leaves in the Bighorn for 36 summers—more leaves than he’ll ever have time to examine as thoroughly as he’d like. Every year at summer’s end, as he unpacks box after box of fossils, he tells himself that next year he’ll be reasonable and stay in Washington, D.C., to catch up on his cataloging. But come July he’s back digging again, hoping, as he puts it, “that lightning will strike.”

A few years ago it did. “I looked for about ten years for a fossil deposit like this,” Wing said. We were sitting on a hillside 15 miles south of Highway 16 between Ten Sleep and Worland, west of the Bighorn Mountains, hammering at rocks from a trench dug by Wing’s assistants. On distant slopes you could see the neat horizontal stripes of red, interspersed with gray and yellow, that identify that earth as dating from the PETM. Down in the hollow a pump jack seesawed out of earshot; from the top of the hill you could see half a dozen more. In the intermittent silences of our conversation, the only sound was the music of the hammers—muffled thuds, distant resonating pings as from a tuning fork, and crunching as the rocks gave way. When you tapped one persistently enough, it yielded along the plane separating two layers of mud, and sometimes that exposed, like the cream in an Oreo, a leaf preserved so perfectly that with Wing’s loupe you could see trails eaten into it by insects 56 million years ago.

Wing knew immediately when he’d found his first deposit of leaves from the PETM. “Many of the plants I had never seen,” he said. The fossils he’d already collected showed that before and after the warming the basin was covered with a dense forest of birch, sycamore, dawn redwoods, palm trees, and evergreens that resembled

THE RISE OF MAMMALS

LIFE IN THE BIGHORN BASIN, WYOMING



Some 25 million years before the first permanent ice formed in the Antarctic, Earth was already a hothouse. The Bighorn Basin was like Florida's Okefenokee Swamp today. Dinosaurs were gone; mammals were on the rise.



Champsosaurus vanished as the Paleocene ended, but turtles soldiered on.



Plesiadapis, a "proprimate," died out; another early mammal, *Ectocion*, lasted into the Eocene.

As warming dried the Bighorn, bean-family trees and lizards arrived from the south; dawn redwoods shifted north. Modern primates and hoofed mammals may have come from Asia, crossing a forested Arctic land bridge.

Not a mass extinction but a massive stirring of life: The PETM, as revealed by the fossils in Wyoming's Bighorn Basin, is "a narrow interval when the world goes quite crazy," says paleobotanist Scott Wing. As plants and animals migrated poleward in the heat, the first modern primates and hoofed mammals—perissodactyls and artiodactyls—spread around the planet.



77°F (9° increase)

EARLY EOCENE 55.8-48.6 M.Y.A.

68°F



Diacodexis was an early artiodactyl; *Hyracotherium*, a perissodactyl, was the first horse.



Cantius, a small primate, had two modern features: front-facing eyes and grasping hands.



Now long extinct, *Prolimnocyon* and *Meniscotherium* were new in the PETM.



Raccoonlike *Chriacus*, a Paleocene holdover, preys here on a new arrival from the south.

The climate returned to Paleocene conditions. But the new PETM mammals eventually displaced *Ectocion* and its kind. Their descendants—most hoofed animals alive today and every monkey, ape, and human—transformed Earth.

SEAN McNAUGHTON AND LAWSON PARKER, NGM STAFF
ART: ALDO CHIAPPE

CONSULTANTS: SCOTT WING, SMITHSONIAN NATIONAL MUSEUM OF NATURAL HISTORY; PHILIP GINGERICH, UNIVERSITY OF MICHIGAN; WILLIAM CLYDE, UNIVERSITY OF NEW HAMPSHIRE; PATRICIA HOLROYD, UC BERKELEY; KRISTER SMITH, SENCKENBERG MUSEUM



INTERLUDE WITH DWARFS

Plentiful holes in fossil leaves such as this one (right) indicate that insects in the Bighorn Basin got more abundant and voracious as CO₂ and temperatures rose during the PETM. Some mammals adapted by temporarily shrinking. Horses had shinbones the size of chicken drumsticks. The lesson, says Philip Gingerich: When it needs to be, "evolution is fast." One of the earliest complete horse skeletons (above), from a few million years later in the Eocene, is similar but 50 percent larger.



Today in the arid Bighorn, rust red bands of oxidized soil mark the sudden warming that occurred there 56 million years ago—which dried up the swamps that had been home to reptiles similar to the Okefenokee alligator pictured here.



magnolias. The ground would have been squishy underfoot, in places as swampy as the Atchafalaya or the Okefenokee are today. The Bighorn in both the Paleocene and the Eocene was like northern Florida is now.

But at the height of the PETM, Wing has found, the landscape morphed into something completely different. It became more seasonally dry and open, like the dry tropical forests of Central America. As the planet warmed, new plant species migrated rapidly into the basin from as far south as the Gulf Coast, a latitudinal distance of nearly a thousand miles. Many were beans—not garden-variety ones, but trees of the same family, similar to modern mimosas. And most had been riddled by bugs.

Of the hundreds of fossil leaves examined by Wing and his colleague Ellen Currano, of Miami University in Ohio, nearly six in ten have holes or curving channels chewed into them by insects. Maybe the heat had revved up the bugs' metabolism, causing them to eat more and reproduce more. Or maybe the extra carbon dioxide had directly affected the plants; when CO₂ is injected into modern greenhouses, the plants grow more, but their protein content is

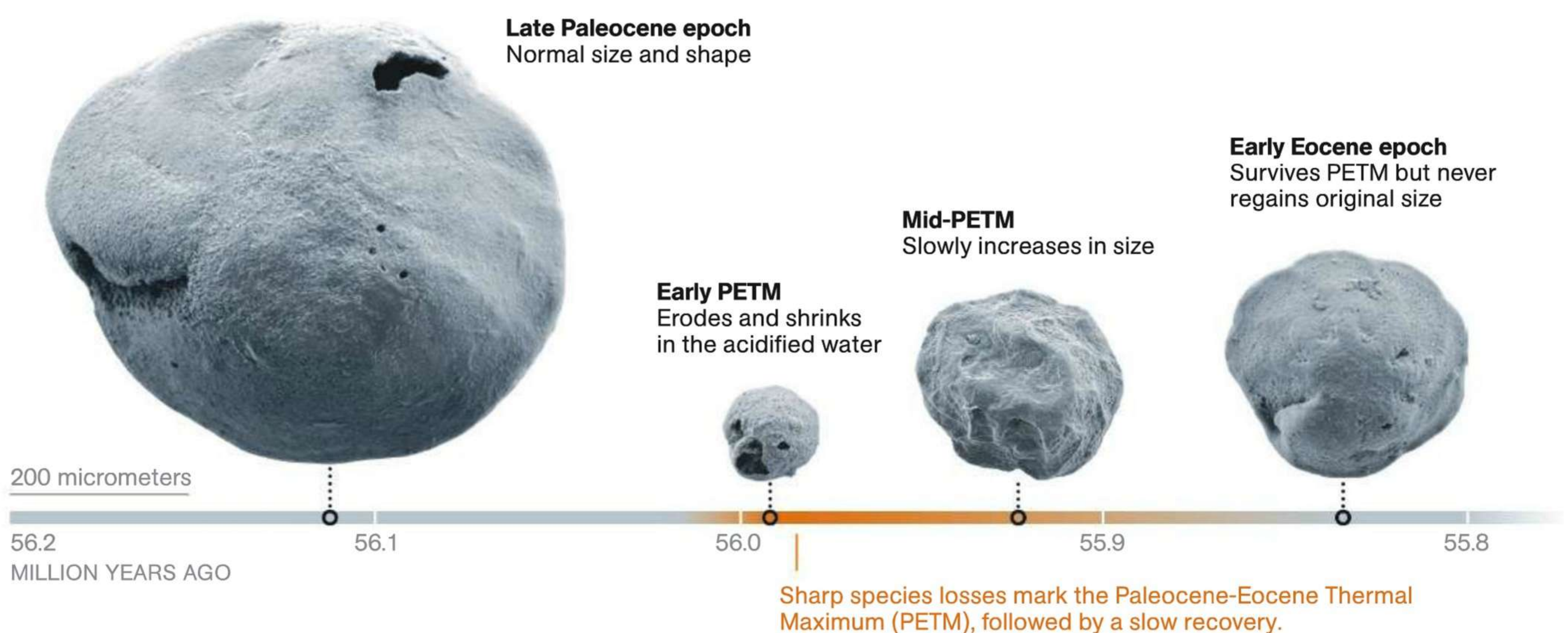
lower, making their leaves less nutritious. The same may have happened in the hothouse world of the PETM—maybe the insects had to eat so much foliage just to fill up.

Yet the bug-chewed PETM leaves were also much smaller than those of their Paleocene ancestors, because, Wing said, rainfall had dropped by around 40 percent. (When water gets scarcer, plants cut down on water loss by shrinking their leaves.) The drop in rainfall also gave the soil a chance to dry out every year and the iron in it to oxidize and turn rust red. These seasonally dry soils became the broad bands that now stripe the hillsides. Then, at the height of the PETM, the red beds disappeared—not because the climate got wetter overall, Wing said, but because the rains became more concentrated, like monsoons. The rivers in the basin constantly jumped their banks and flooded the countryside, washing away soil before it could deepen.

In the eastern Pyrenees, Birger Schmitz has found more dramatic evidence of catastrophic flooding during the PETM. He and colleague Victoriano Pujalte, from the University of the Basque Country in Bilbao, Spain, identified the trademark carbon spike at the base of a rock

DEEP-SEA EXTINCTIONS

This species of foraminifera—sand-grain-size creatures that abound in seafloor mud—survived the PETM by shrinking. But many other forams went extinct, victims of water that was too corrosive, low in oxygen, or hot: Even in the deep it warmed by 9°F.



“Eventually the system will stick [the carbon dioxide] back into rock, but that will take hundreds of thousands of years.”

—JAMES ZACHOS, UNIVERSITY OF CALIFORNIA, SANTA CRUZ

formation that, though now high in the mountains, probably lay on a coastal plain back then. A field of boulders had been washed out of the budding mountains and tossed onto a vast floodplain that the scientists believe extended over thousands of square miles. Some boulders were two feet across and could have been put there only by exceptionally violent water. Deposited over centuries by channel-jumping rivers, they're like fossil imprints of the energy in the hothouse atmosphere.

While bean trees were blooming in the Bighorn Basin, *Apectodinium* was blooming all over the ocean. The species is an extinct form of dinoflagellate—a group of single-celled plankton, some of which today give rise to toxic blooms known as red tides. All dinoflagellates have two flagella that they whip around to propel themselves through the water, a distinctive maneuver that Henk Brinkhuis, of Utrecht University in the Netherlands, demonstrated for me one day by folding one arm through his legs, the other around his slightly protruding belly, and flapping both. In the winter *Apectodinium* cells would retreat into hard cysts that sank to the seafloor. The following spring a flap on each cyst would fly open like a trapdoor—Brinkhuis stuck a finger in his cheek and made a cork-popping sound. The cell would then crawl out and ascend to the sea surface, leaving the empty cyst behind for Brinkhuis and his colleague Appy Sluijs to recognize in sediment samples 56 million years later—its open flap the only clue to a space-alien-like life history. In Brinkhuis's office there is a poster that reads, “Everything I know I learned from *Star Trek*.”

Before the PETM, Brinkhuis and Sluijs find *Apectodinium* only in the subtropics. But in PETM sediments they find it all over the world—confirmation that the ocean was heating up everywhere. In the Paleocene the summer water temperature in the Arctic Ocean was already around 64 degrees Fahrenheit; during the PETM it shot up to around 74. Swimming there would have been like swimming today on the mid-Atlantic seaboard, which, judging from

a New Jersey sediment core that Brinkhuis and Sluijs have also analyzed, would have been like the Caribbean. Today the water at the deep seafloor is just above freezing; in the PETM it was in the 60s.

As the ocean absorbed the carbon dioxide that was warming the planet, the water also became acidified, just as it will over the next century as CO₂ levels rise again. This is borne out in some deep-sea sediments, where the PETM is as obvious as the stripes in the Bighorn Basin. In 2003 Sluijs went along on an expedition led by James Zachos to the Walvis Ridge, a submarine mountain range in the South Atlantic. They extracted sediment cores from a range of depths on the flanks of the ridge, and in each case as soon as they opened the core on deck, they could see the PETM layer immediately. “It just stands out amazingly,” Sluijs says. “It's just red clay.”

The clay stood out because of what it lacked: the white ooze of calcium carbonate that brightens the sediments above and below the PETM. During the PETM the acidified ocean had dissolved the calcium carbonate away. At this point one might expect a simple morality tale: Acidified ocean wipes out myriad life-forms, dissolving the shells of corals, clams, and forams—the scenario many scientists now envision for the 21st century. But the PETM is more puzzling than that. Although coral reefs in the Tethys Ocean, a Mediterranean Sea forerunner that cut through the Middle East, seem to have suffered badly, the single documented mass extinction at the PETM is an unexpected one: It struck as many as half the species of forams that lived in the bottom mud. They were cosmopolitan species, adapted to a wide range of conditions, and they should have been able to handle whatever the PETM threw at them.

Given the degree of acidification of the ocean, Zachos and his colleagues have estimated that an initial burst of around three trillion metric tons of carbon flooded the atmosphere, then another trillion and a half leaked out more gradually. The total of 4.5 trillion tons is close to the total carbon now estimated to be locked up in fossil fuel deposits; the initial burst corresponds to about





The source of the carbon surge 56 million years ago is uncertain, but it was natural. Today's surge, which may prove much faster, is human made. Oceans and forests absorb atmospheric CO₂ but can't keep up with emissions from stacks like this one (at center) at a coal-fired power plant in England—the country where the industrial revolution began.

JASON HAWKES



Using a technology that might forestall a warmer epoch, test tanks at an American Electric Power plant in West Virginia captured a fraction of the plant's CO₂. But until the government sets limits on emissions, the company has shelved the costly project.

three centuries' worth of human-caused emissions at the current rate. Though the data aren't conclusive, most scientists assume the PETM release was slower, taking thousands of years.

However fast the carbon was released, it would have taken far longer for geologic processes to remove it. As the carbonates on the seafloor dissolved, counteracting the acidification, the ocean was able to absorb more CO₂, and within a few centuries or millennia of the sudden release, the atmospheric CO₂ peak had passed. Meanwhile CO₂ was also dissolving into rain droplets, which leached calcium from rocks on land and washed it to the sea, where it combined with carbonate

ions to make more calcium carbonate. The process, called weathering, happens all the time, but it happened faster during the PETM, because the climate was hotter and the rain more acidic. Gradually the rain scrubbed the added CO₂ from the atmosphere, and eventually it wound up in limestone at the bottom of the sea. The climate slowly returned to its previous state. "It's just like with fossil fuels today," Zachos says. "We're taking what took millions of years to accumulate and releasing it in a geologic instant. Eventually the system will stick it back into rock, but that will take hundreds of thousands of years."

Matt Huber, a climate modeler at Purdue University who has spent most of his career trying to understand the PETM, has also tried to forecast what might happen if humans choose to burn off all the fossil fuel deposits. Huber uses a climate model, developed by the National Center for Atmospheric Research in Colorado, that is one of the least sensitive to carbon dioxide. The results he gets are still infernal. In what he calls his "reasonable best

“If we continue down this road, there really is no uncertainty. We’re headed for the Eocene. And we know what that’s like.”

—MATT HUBER, PURDUE UNIVERSITY

guess at a bad scenario” (his worst case is the “global-burn scenario”), regions where half the human population now lives become almost unbearable. In much of China, India, southern Europe, and the United States, summer temperatures would average well over 100 degrees Fahrenheit, night and day, year after year.

Climate scientists don’t often talk about such grim long-term forecasts, Huber says, in part because skeptics, exaggerating scientific uncertainties, are always accusing them of alarmism. “We’ve basically been trying to edit ourselves,” Huber says. “Whenever we see something really bad, we tend to hold off. The middle ground is actually much worse than people think.

“If we continue down this road, there really is no uncertainty. We’re headed for the Eocene. And we know what that’s like.”

In the PETM the heat drove tropical species toward the Poles, and animal and plant species from all continents could cross land bridges and blend together. Hoofed running animals, the ancestors of horses and deer, showed up in the Bighorn. A little bit later, perhaps as the climate got wetter again and the forest canopy began to close over the more open land that had favored the runners, the first true primates showed up.

Humans, along with every other primate living today, are descended from a PETM primate—just as perissodactyls such as horses, tapirs, and rhinos are descended from another PETM ancestor, and artiodactyl ruminants such as deer, cows, and sheep from still another. The species that appeared suddenly in the Bighorn may have migrated from Asia, where fossil specimens that are slightly older than the Bighorn’s have been found. Those species in turn must have had ancestors deeper in the Paleocene. But so far there are no Paleocene fossils a paleontologist would look at and call a primate or a horse—and it is not, Gingerich told me, for lack of looking.

During the PETM itself a strange thing happened to some mammals: They got dwarfish. Horses in the Bighorn shrank to the size

of Siamese cats; as the carbon ebbed from the atmosphere, they grew larger again. It’s not clear whether it was the heat or the CO₂ itself that shrank them. But the lesson, says Gingerich, is that animals can evolve fast in a changing environment. When he first drove into the Bighorn four decades ago, it was precisely to learn where horses and primates came from. He now thinks that they and artiodactyls came from the PETM—that those three orders of modern mammals acquired their distinctive characteristics right then, in a burst of evolution driven by the burst of carbon into the atmosphere.

After 56 million years primates, then the size of mice or rabbits, are directing the show. They have tamed other descendants of the PETM—horses, cows, pigs, sheep—and spread with them around the planet. They have moved beyond agriculture to a mode of living that, while infinitely varied, is almost invariably powered by fossil fuels. As Gingerich and I bounced in his Suburban along the top of Polecat Bench, through the tall grass of deserted pastures, we saw pump jacks nodding slowly back and forth, bringing oil from the Cretaceous period to the surface, as they do throughout the Bighorn. To the east, in the Powder River Basin, giant shovels scratch at Paleocene coal seams that keep the lights on in one of every five houses in the U.S.

Fossil fuel burning has released more than 300 billion tons of carbon since the 18th century—probably less than a tenth of what’s still in the ground or of what was released at the PETM. That episode doesn’t tell us what will happen to life on Earth if we choose to burn the rest. (Global emissions set another record last year.) Maybe there will be a burst of evolutionary innovation like the one that gave rise to our primate ancestors; maybe this time, with all the other pressures on species, there will be mass extinctions. The PETM merely puts the choice in long perspective. Tens of millions of years from now, whatever becomes of humanity, the whole pattern of life on Earth may be radically different from what it would otherwise have been—simply because of the way we powered our lives for a few centuries. □

An influx of nomads
has turned the Mongolian
capital upside down.

The Urban Clan of Genghis Khan







Newcomers living in white gers—traditional round dwellings—and other small houses now make up more than half of the capital's 1.2 million people. Ger districts lack running water and other basic services. In the distance a coal-fired power plant helps make the city one of the world's most polluted.



By Don Belt Photographs by Mark Leong

Not long ago a young Mongolian livestock herder named Ochkhoo Genen loaded what was left of his life into a borrowed Chinese pickup truck and moved it to Ulaanbaatar, Mongolia's sprawling capital. Slender and dignified, Ochkhoo gave no outward sign of turmoil as he buried himself in the mechanics of packing, lifting, unpacking, and assembling. He may have been disappointed in himself, even shaken, but outwardly he was as smooth and focused as a socket wrench.

Within hours of arriving, Ochkhoo had pitched his *ger*—the nomad's traditional round dwelling—on a small, fenced plot of bare ground he'd rented on the outskirts of the city. Around it were thousands of other plots, each with a *ger* in the middle, jammed together on the slopes overlooking Ulaanbaatar. Once his stovepipe was raised and the stakes driven in, he opened the low wooden door for his wife, Norvoo; their baby boy, Ulaka; and their six-year-old daughter, Anuka.

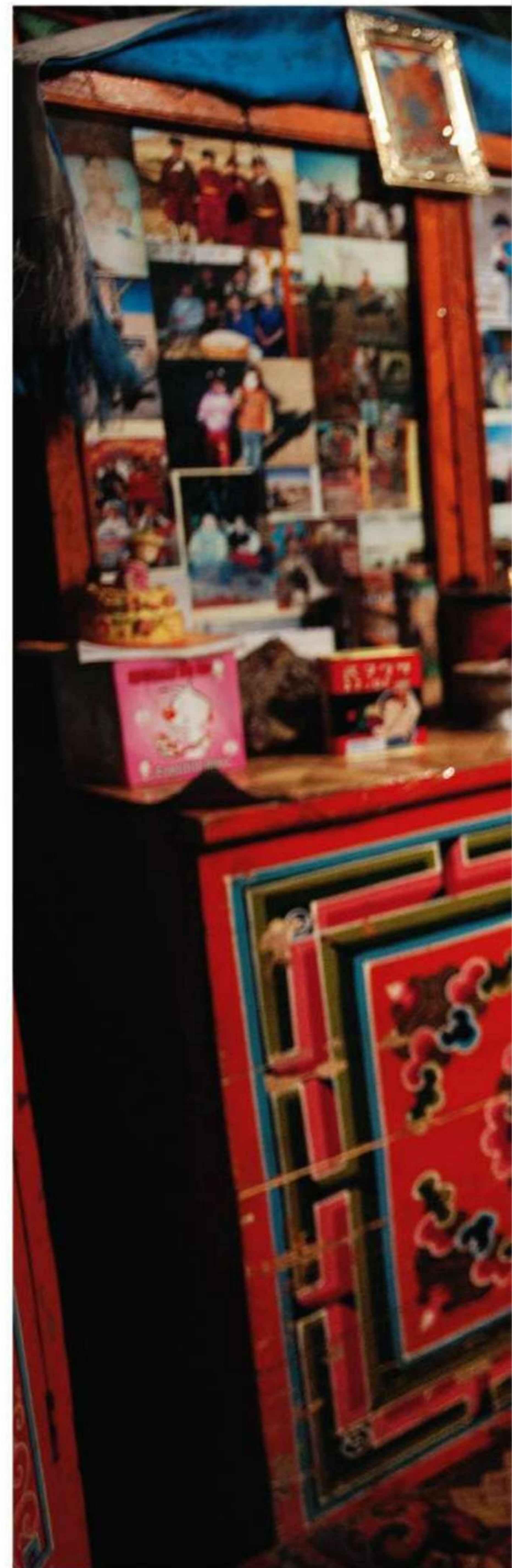
Norvoo also took comfort in the task at hand. She put aside her worries long enough to make sure their *ger* was as cozy as it had been in the countryside: linoleum floor, cast-iron stove, and cots around the edges, with family pictures neatly pinned to the wall and a small television on a wooden table.

Outside their door, however, the view was starkly different from what it had been on the steppe an hour southwest of the capital, where they'd raised their livestock next to the *ger* of Norvoo's parents. Here, in place of rolling grasslands, there was a seven-foot-high wooden fence a few feet away. And in place of Ochkhoo's cherished livestock—the horses and cattle and sheep—there was only the landlord's dog, a black and brown mongrel staked in the yard, who barked himself hoarse at the least provocation.

There was plenty of provocation just beyond the fence, in the ramshackle slums, or *ger* districts, where about 60 percent of Ulaanbaatar's 1.2 million people live without paved roads, sanitation, or running water. As in other urban slums, the *ger* districts are high in crime, alcoholism, poverty, and despair, which is why many people here do the unthinkable, for a herder: They lock their gates at night.

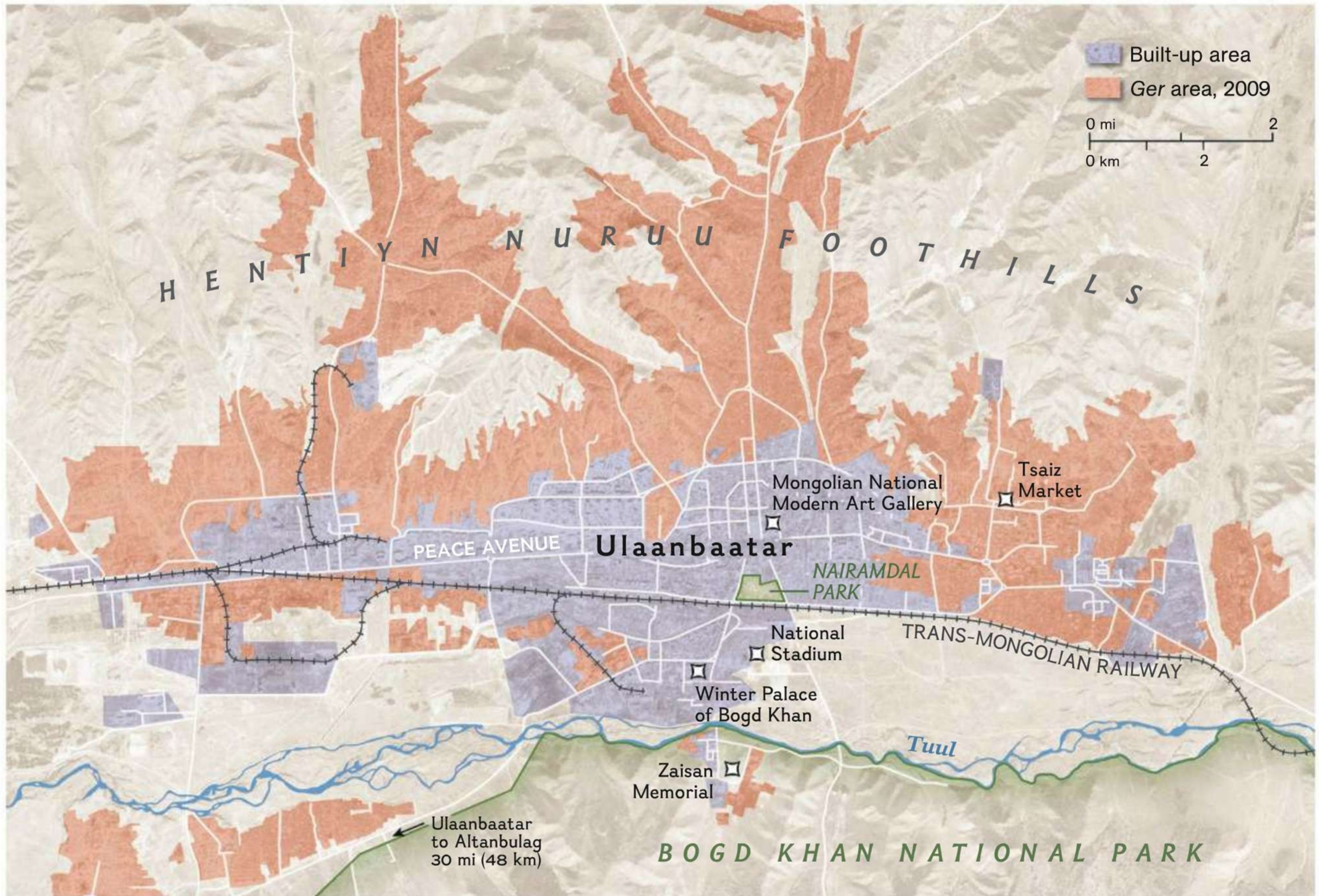
"We step outside the *ger* and all we can see is that fence," Ochkhoo said. "It's like living in a box."

Nomads were never meant to live in a box, but Ochkhoo and Norvoo weren't there by choice. During the winter of 2009-2010, most of the couple's livestock either froze or starved to death during a white *dzud*, a devastating period of snow, ice, and bitter cold that follows a summer drought; it lasted more than four months. By the time the weather broke, the couple's herd of 350 animals had been





Ochkhoo Genen and daughter Anuka watch a video on an iPhone in a relative's ger on the outskirts of Ulaanbaatar. Until recently, the family lived on the steppe. An unusually hard winter convinced Ochkhoo and his wife that they should bring their two young children to live in UB, the nickname for the capital.



Mongolia's Booming Capital

Nearly half of the nation's 2.8 million people live in Ulaanbaatar, wedged between the Tuul River and foothills to the north. Many former nomads cluster in outlying neighborhoods of gers, or traditional tents. Mining complexes some 340 miles to the south (map below) are pumping new wealth into the city.





With a sick heart, Ochkhuu (at left) and his father-in-law, Jaya, dispose of sheep and goat carcasses after the winter of 2009-2010, which killed millions of livestock across Mongolia. “These animals were my life,” says Jaya, who lost 800 of his 1,100 head to starvation and exposure—a fortune for a herder.

cut to 90. Across Mongolia some eight million animals—cows, yaks, camels, horses, goats, and sheep—died that winter.

“After that, I just couldn’t see our future in the countryside any more,” Ochkhuu said quietly. “So we decided to sell what was left of our herd and make a new life.”

It was also a clear-eyed calculation to improve the lives of their children. Ochkhuu and Norvoo feel no great affinity for city life, but they see its advantages. In the countryside they were far removed from nurses and schools, but here they

can get free medical care for their infant son, and Anuka can attend a public school.

There are more than half a million Ochkhuus and Norvoos living these days in UB, as Mongolians call Ulaanbaatar. Many have been driven from the steppe by bad winters, bad luck, and bad prospects. And now that Mongolia’s coal, gold, and copper mines are attracting billions in foreign investment, they also have flooded into UB in search of job prospects created by the economic upsurge from mining money.

Beyond the downtown high-rises, UB often feels like a frontier town run amok, strewn lengthwise along a river valley like gravel left behind by a flash flood. Founded in 1639 as a movable Buddhist monastic center and trading

Don Belt has authored 22 stories for National Geographic. Mark Leong was the 2010 Veolia Environnement Wildlife Photojournalist of the Year.

An ocean of green, Mongolia is the most sparsely populated country in the world, with just under three million people in a landmass larger than Alaska. Mongolian culture—physical, mobile, self-reliant, and free—developed out here on the steppe. “When people move to Ulaanbaatar, they bring that mentality with them,” says Baabar, a well-known publisher and historian.







Nationalism—even xenophobia—is on the rise, and foreigners are increasingly blamed for Mongolia’s problems.

post, the settlement took root in its present location in 1778. The town was laid out along one major thoroughfare, which runs along the base of a low mountain. Today that road goes by the name Peace Avenue, and it’s still the only direct way to get from one side of town to the other. From daybreak to nightfall, it’s jammed with traffic. Driving it is like getting on a conveyor belt that inches past crumbling Soviet-era apartment blocks, side streets that run promisingly for 50 yards and then end at a barricade, unexplained piles of rusted iron and concrete, and office



A sculpture of a mother and baby wearing gas masks is a comment on UB's chronic air pollution in artist Munkhtsetseg Jalkhaajav's "S.O.S." at the National Modern Art Gallery. Mongolian artists are gaining international popularity, including in China, for taking on edgy subjects.

buildings so clumsily situated and hidden from view that no taxi driver can find them.

Add to this a flood of nomads, many of them recent arrivals whose skill set doesn't include city driving, crossing a busy road, or the subtleties of social interaction in an urban environment, and you've got a heady mix. It's not unusual to be waiting in line at a kiosk and have some gnarled tree trunk of a man in herder clothes—steppe boots, felt hat, and the traditional wraparound *del*—stomp to the front of the line, shouldering customers out of the way like a hockey player,

just to see what the place is selling. If there are other herders in line, he gets pushed back just as hard. There are no fights, no hard feelings. That's just the way it goes.

"These people are completely free," says Baabar, a prominent publisher and historian who writes often about Mongolia's national character. "Even if they've been in UB for years, their mentality is still nomadic. They do exactly what they want to do, when they want to do it. Watch people crossing the road. They just lurch out into traffic without batting an eye. It doesn't occur to them to compromise, even with a speeding automobile. We're a nation of rugged individuals, with no regard for rules."

Early one Saturday morning Ochkhoo, Norvoo, and their kids returned to the country for a weekend at Norvoo's parents' home to prepare their farm for winter. Ochkhoo helped Norvoo's father, Jaya, cut hay for eight hours, and by Sunday night they had moved enough hay to the barn to keep his animals alive through the winter, even a dzud. Jaya too had lost huge numbers of animals during the last dzud—his herd had dropped from more than a thousand to 300 animals—but he was determined to make a comeback, banking on decades of experience as a herder both during and after communism, which he rather misses.

"There were bad things, of course. I hated being told what to do by bureaucrats. But communism protected us from disasters like last winter," he said. "Even if you lost all your animals, you wouldn't starve to death."

Although they supported Ochkhoo and Norvoo's decision to move, Jaya and his wife, Chantsal, often said how lonely they were without them next door. But moving to UB was out of the question. "I wouldn't last a week in that city," Jaya scowled. "Too much noise, too much jangling and banging. I'd get sick and die."

Men like Jaya and Ochkhoo are authentic livestock herders, unlike others who failed during the dzud, said historian Baabar. After the collapse of communism, when many Soviet-era factories closed down, thousands of people left UB to reclaim their pastoral roots. But "they'd forgotten everything they knew about being nomads, how

Children from the ger districts cool off in the polluted Tuul River. Even as billions in mining profits pour into the capital, infrastructure projects remain underfunded and jobs hard to find. Nearly half of all ger dwellers live below the poverty line.





Real estate magnate Bat-Erdene Khadbaasan instructs his racehorse trainer before Naadam, an annual festival outside the capital. “For an entrepreneur, UB is a great place to be,” says Khadbaasan, who rose from chauffeur to tycoon through street savvy, good luck, and the willpower of a nomad.





to raise livestock, how to survive these tough winters,” he said. The pity, says Baabar, is that they are also not fit to compete in the city.

All this comes at a time when Mongolia, communist until 1990, is seeking to reassert itself between the two powers next door, Russia and China, that have pushed it around for centuries. Nationalism—even xenophobia—is on the rise, and foreigners are increasingly blamed for Mongolia’s problems in the same breath as local and national politicians, who are widely considered, with justification, as deeply corrupt.

Visiting Chinese businessmen, accused of enriching themselves at Mongolia’s expense, no longer venture out after dark on the streets of the capital for fear of being attacked by young guys in black leather channeling Genghis Khan, who is back in vogue as a symbol of Mongolian pride. Banned during Soviet times, images of Genghis are everywhere you look today, from vodka labels and playing cards to the colossal, 131-foot steel statue of the conqueror on horseback that rises from the steppe an hour east of UB to cast the mother of all dirty looks toward China.

He’s not the only one looking in that direction. By many estimates, Mongolia is sitting on a trillion dollars’ worth of recoverable coal, copper, and gold, much of it concentrated near the Chinese border around Oyu Tolgoi, or Turquoise Hill. There Ivanhoe Mines, the Canadian mining giant, is tapping the world’s largest undeveloped copper and gold deposit in partnership with Rio Tinto, an Anglo-Australian company, and the Mongolian government, which holds a 34 percent share of the project, potentially adding billions of dollars to the national economy.

How much of that will migrate 340 miles north and into the pockets of ordinary people such as Ochkhoo is an open question. Experts at the World Bank and the United Nations are urging Mongolia to invest that money in infrastructure, training, and growing the economy, although the current government, led by Prime Minister Sukhbaatar Batbold, took a more direct approach, pledging to grant every man, woman, and child a payment of about \$1,200 from the mining windfall.

Making his rounds on a subzero day, Dorjsuren, at right, sells firewood and coal in the ger districts east of downtown but returns to the steppe near Altanbulag every summer to tend his livestock.

“Mongolians always go back because we need this countryside,” says Baabar. “In our hearts, we’re all nomads.”



Ochkhoo doesn’t believe he’ll ever see that money. But in the meantime, he needs to work. At first he tried his hand as an entrepreneur, having identified what he thought was a need in the community. He and a partner rented a room at a local hotel and then marketed it to ger dwellers, who lack running water, as a place to take a shower or a bath. He went door-to-door looking for customers. There were very few takers. Ochkhoo lost more than \$200 on the deal, a sizable chunk of his savings.

Now he’s thinking of buying a used car and



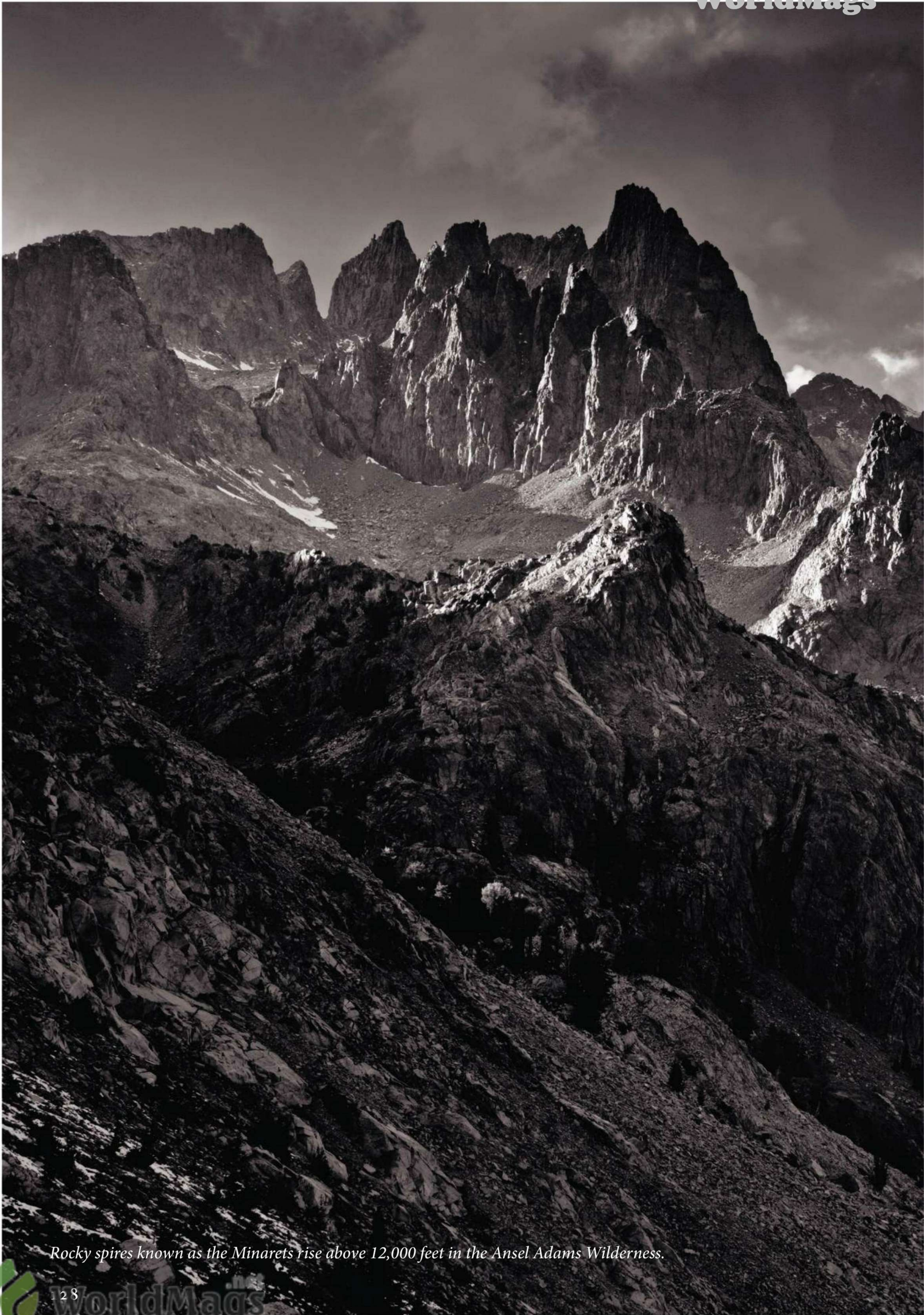
turning it into a taxi. He'd need to borrow the money, but he'd make a pretty good living, and the freedom of driving and being his own boss appeals to him. More important, he'd be able to drive his daughter to and from school.

"We may not be able to raise our animals in UB," he went on. "But it's a good place to raise our children."

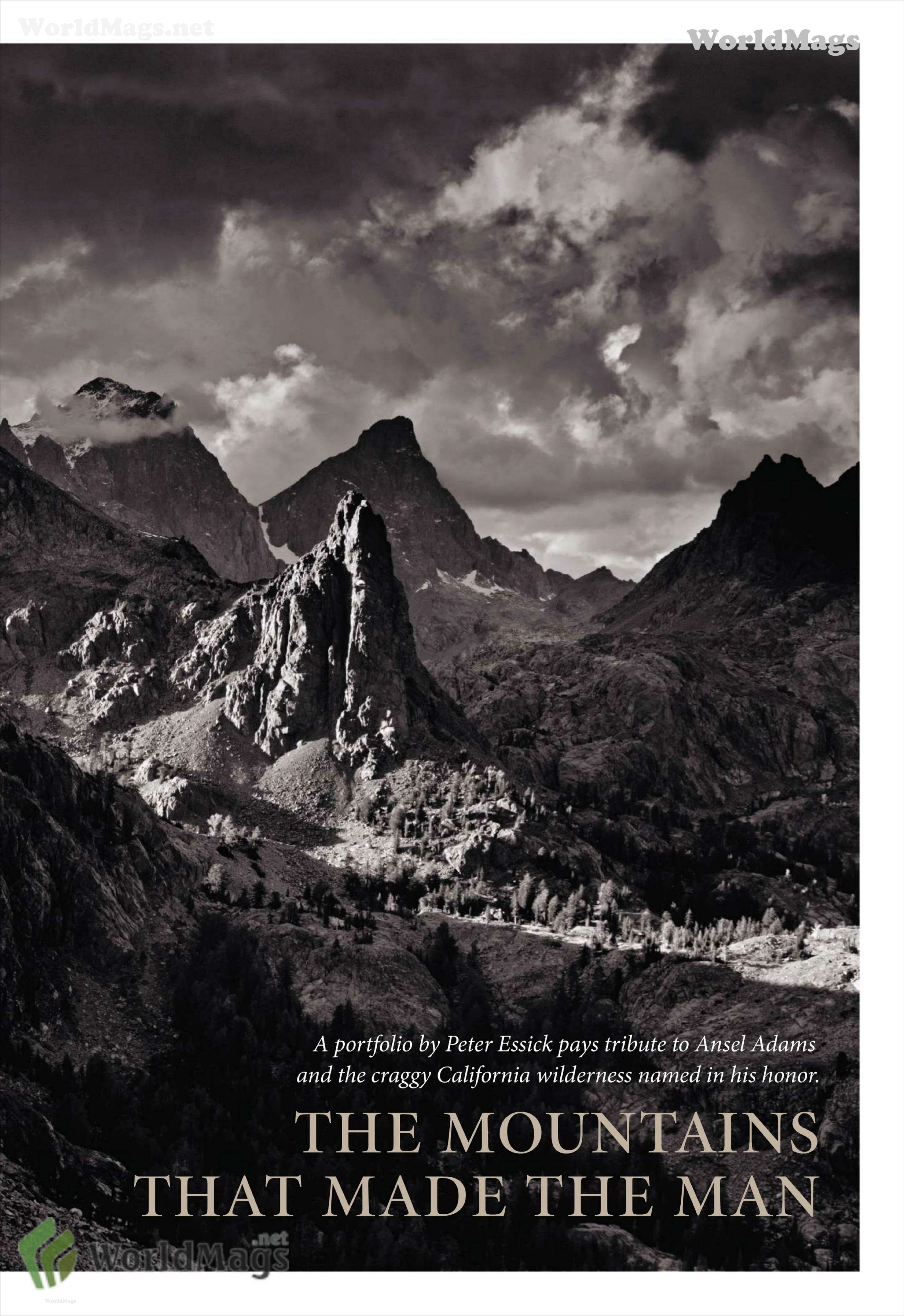
Passing through the fence into his yard, Ochkhuu drags the wooden gate behind him until the latch clicks.

"God, I miss my horses," he says. □

"These people are completely free," says historian Baabar. "They do exactly what they want to do, when they want to do it."

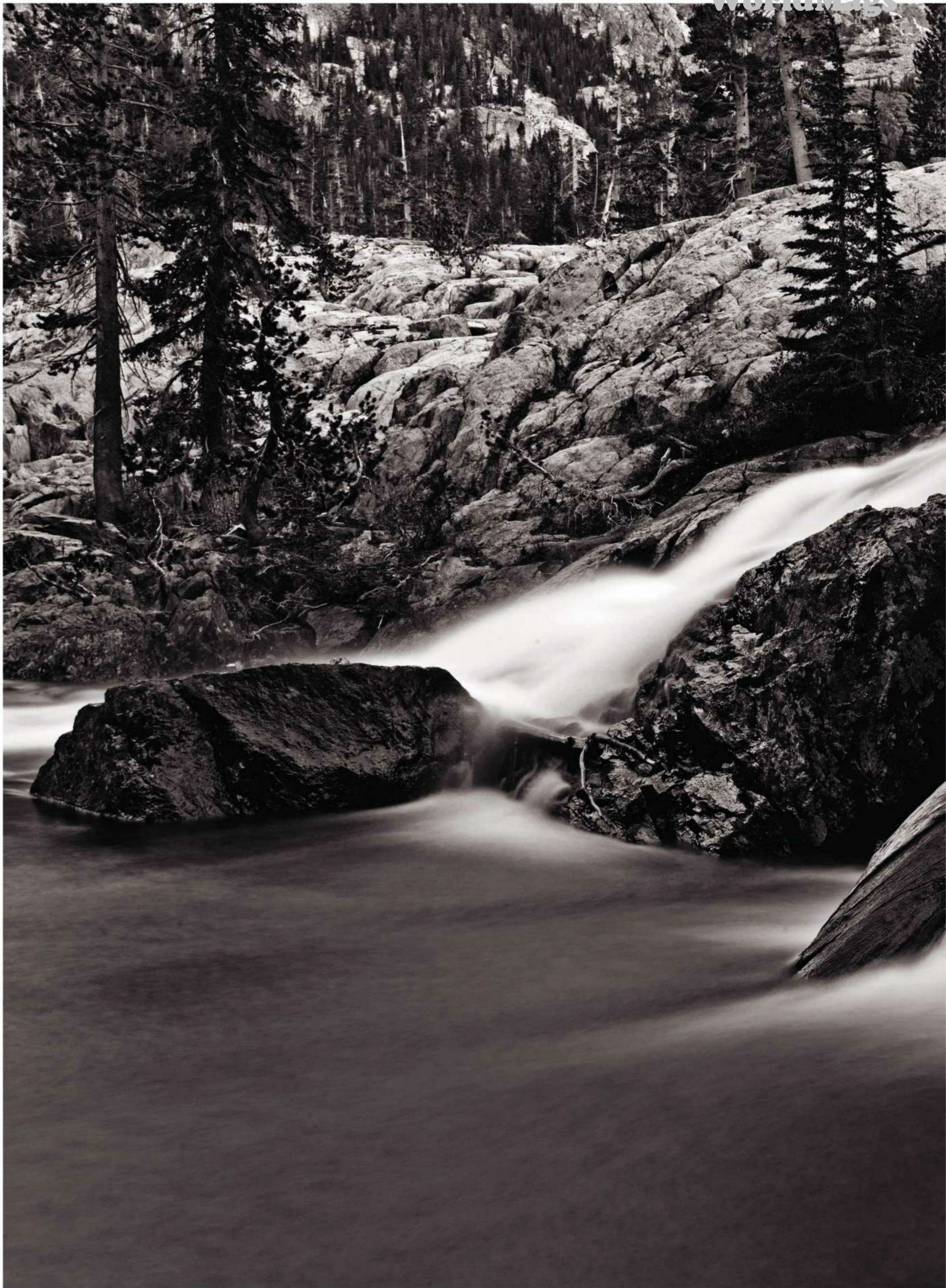


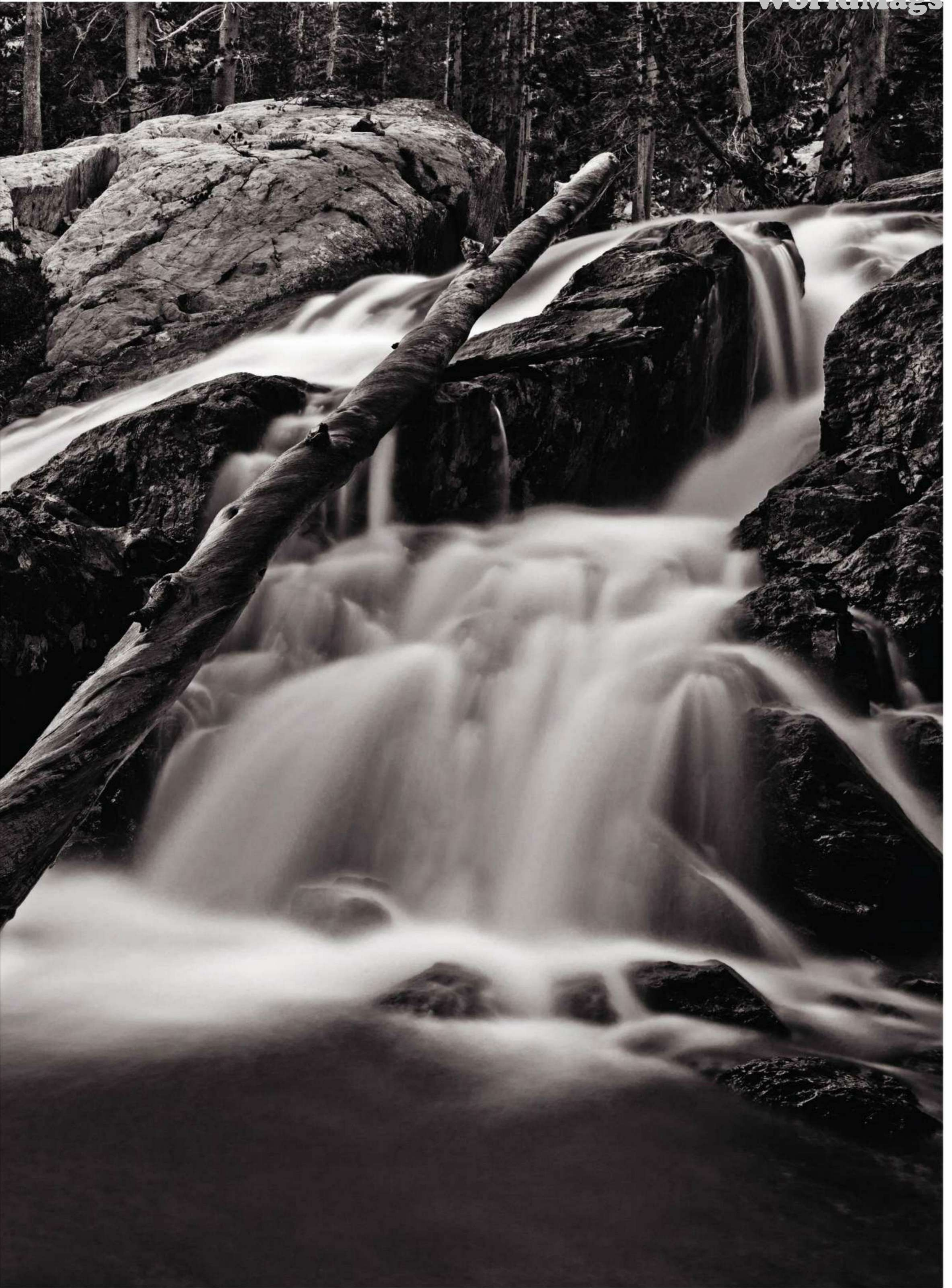
Rocky spires known as the Minarets rise above 12,000 feet in the Ansel Adams Wilderness.

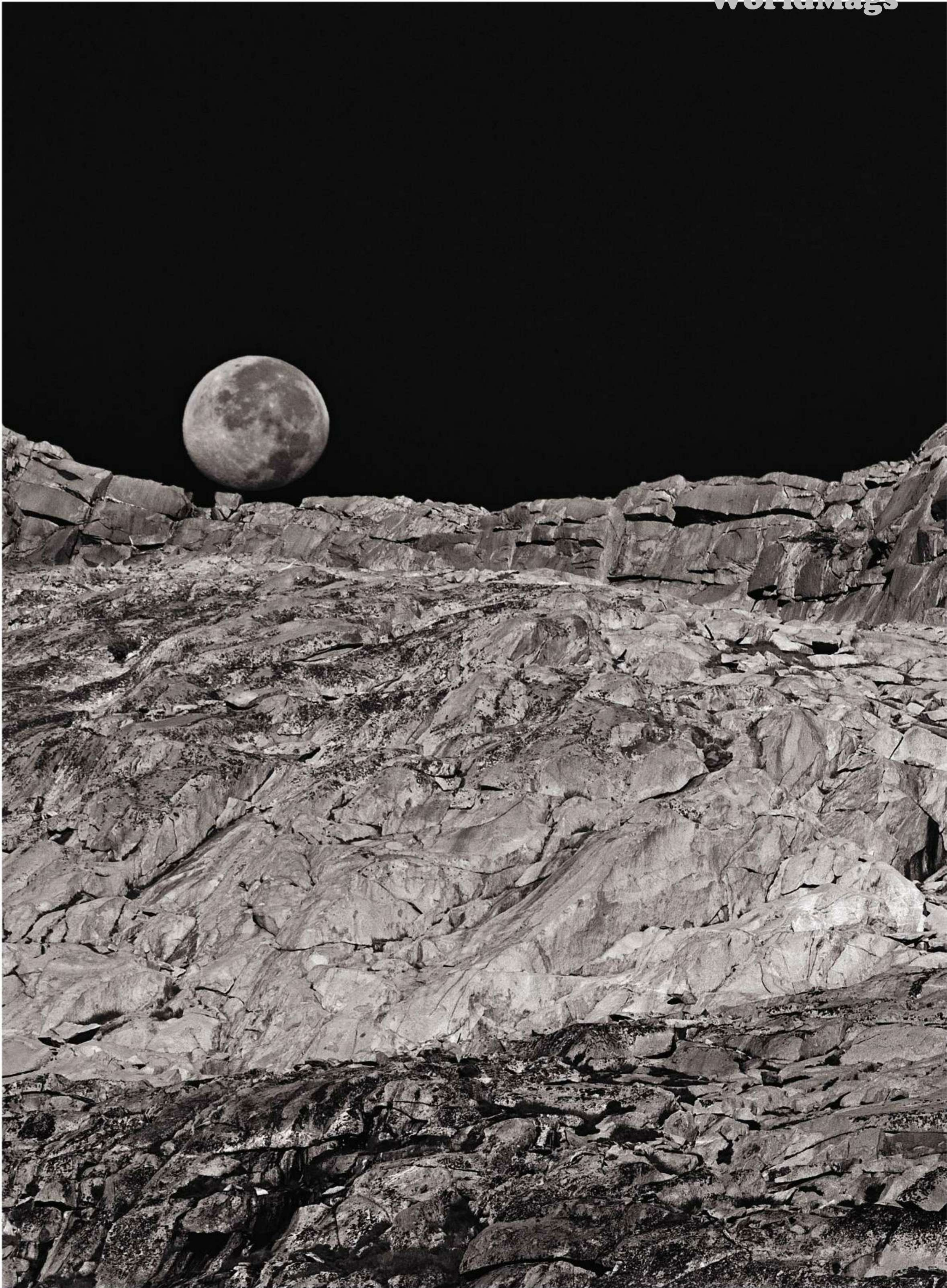


*A portfolio by Peter Essick pays tribute to Ansel Adams
and the craggy California wilderness named in his honor.*

THE MOUNTAINS THAT MADE THE MAN

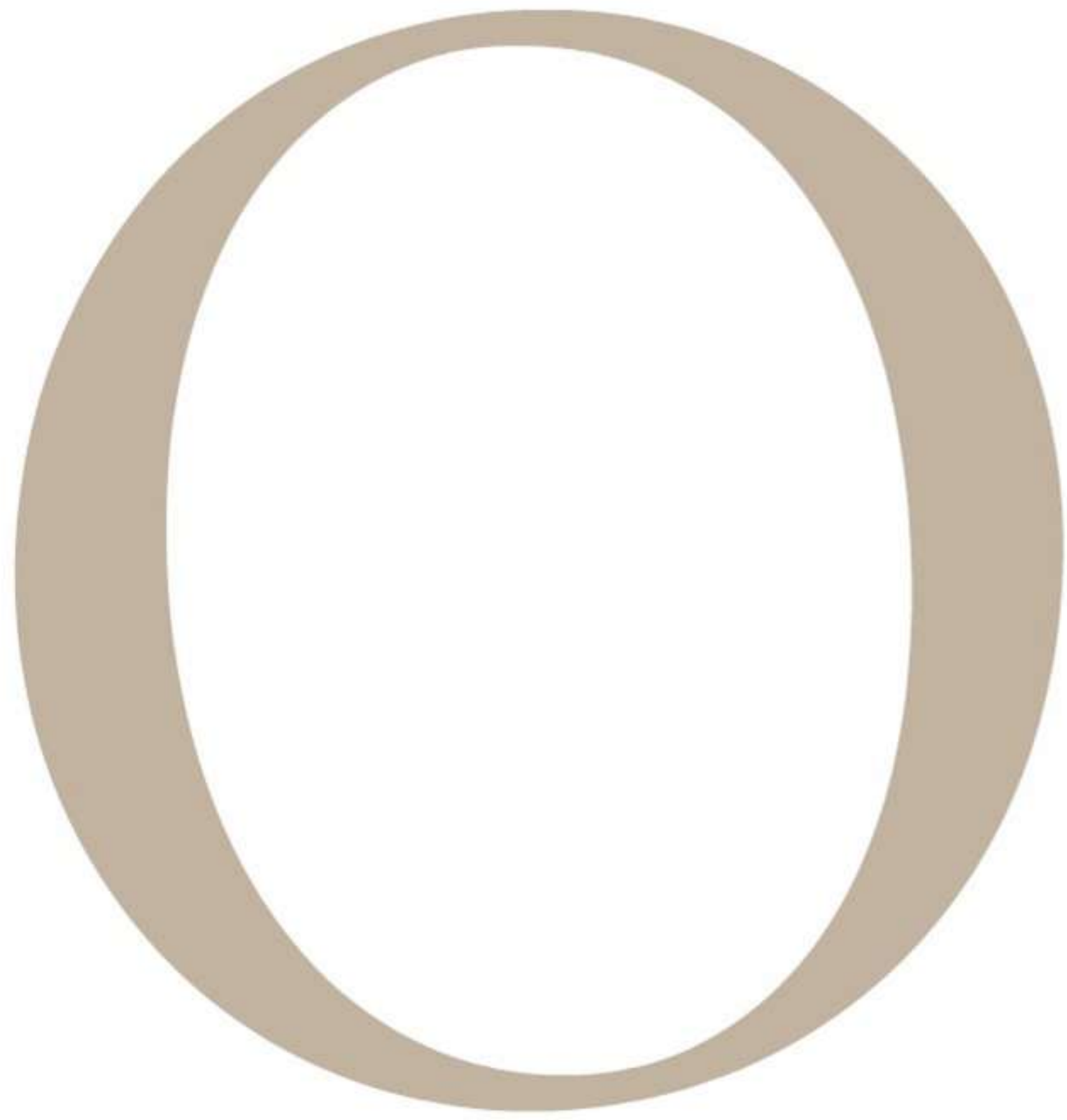








By Robert M. Poole



IN HIS FIRST TRIP to the Sierra Nevada, in June of 1916, Ansel Adams went armed with a camera—a Kodak No. 1 Brownie—and started shooting. “I expect to be broke if I keep up the rate I am taking pictures,” the budding 14-year-old photographer wrote to his Aunt Mary in San Francisco that summer. “I have taken 30 already.”

He kept shooting for almost seven decades, until his death at age 82 in 1984, by which time he had become a world-famous photographer and a powerful voice for wilderness. Although he traveled far and wide, he returned again and again to the Sierra—“a noble gesture of the earth,” in his phrase—for the adventure, artistic inspiration, friendship, and solace he found among its jagged granite peaks, snow-swept passes, and brooding skies. His uncompromising portrayal of these subjects still draws pilgrims to the wilderness that bears his name, deep in the heart of the High Sierra, in hopes of seeing what Ansel Adams saw there.

On a bright August morning, a group of Adams admirers emerged from the trees on horseback, making a cloud of dust as they came into view of Thousand Island Lake, at 9,833 feet a splendid prospect in the strong, slanting sunlight. The boulder-strewn lake, surrounded by lush alpine meadows, glittered under a flawless blue sky, with the black hulks of Banner Peak and Mount Ritter anchoring the scene. The horsemen picketed their mounts in a stand of pines, and one of them explained the object of this journey. “We’re looking for Ansel’s tripod holes,” said Michael, at age 77 an ebullient internist from Fresno, now retired. He was joking about the tripod holes but not about his hope of finding the exact spot where Adams had made a memorable early image of the lake and Banner Peak—and surprised himself in the process.

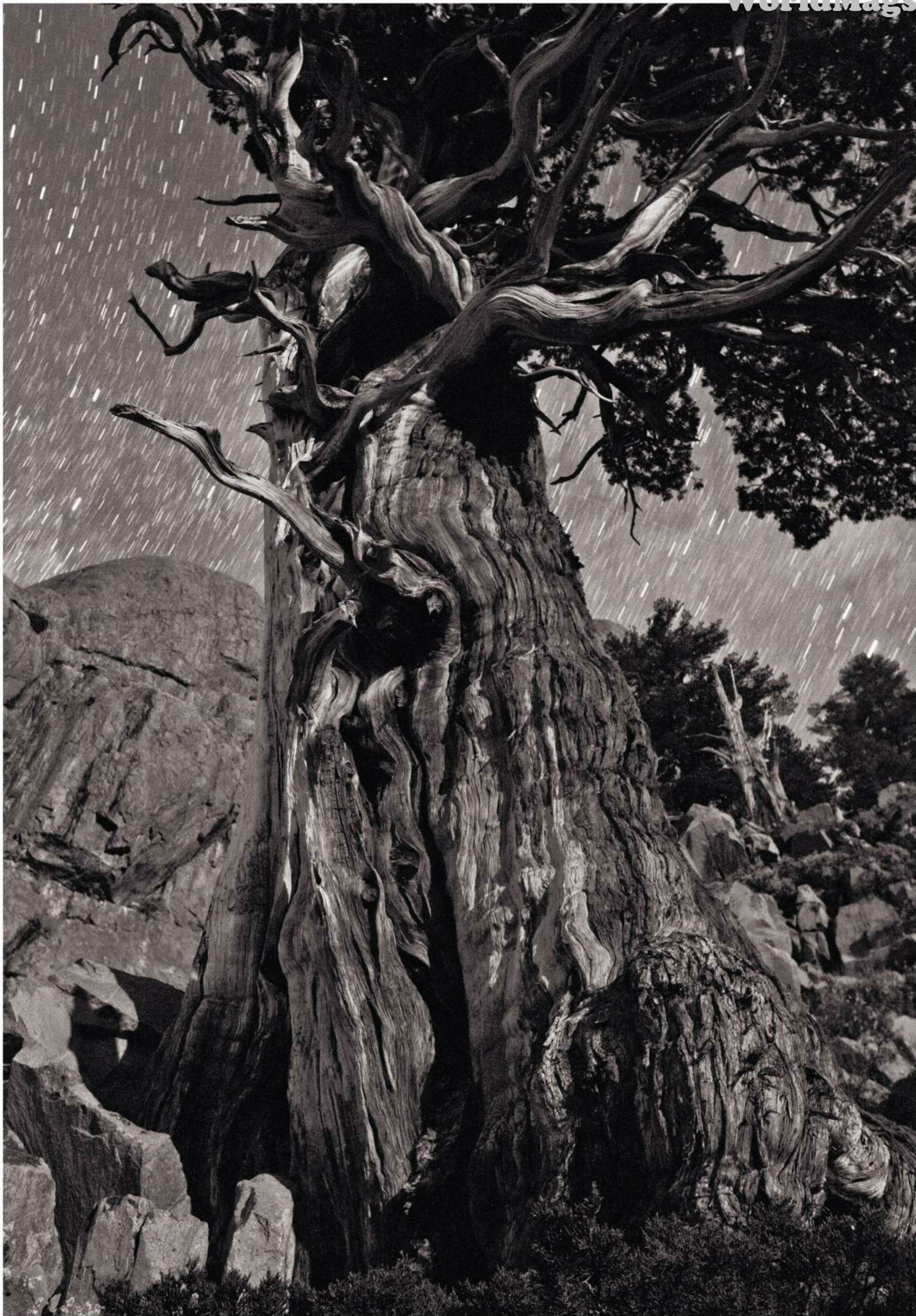
“I made many drab shots and suffered some embarrassing failures,” Adams wrote in his autobiography, recalling the 1923 trip to Thousand Island Lake. But one image proved an exception.

“I can recall the excitement of the scene,” he went on. “It seemed that everything fell into place in the most agreeable way: rock, cloud, mountain, and exposure... This picture still has a unity and magic that very few others suggested in those early years.”

It was a defining moment for Adams, then 21 and still undecided over whether to pursue a career as a classical pianist or a photographer. “That trip in 1923 helped push him toward photography—he knew he really had something,” said Michael, who had followed Adams’s career closely, analyzing his pictures, absorbing his writings, and traveling to many of the places where he had worked. But Michael had never visited this corner of Adams country, accessed via narrow trails that climb the eastern slope of the Sierra to emerge in the wilderness.

“Well, I finally made it to Thousand Island Lake,” crowed Michael, celebrating his arrival on the heights and seeming very much at home there. He wandered easily among the lakeside boulders in an old Stetson, and with his rugged good looks and white beard, he was the spitting image of Ansel Adams—for good reason: Michael Adams was the photographer’s only son, here to reconnect with the old man and round out a footnote of family history involving Banner Peak.

“When my father made that picture,” said Michael, “he was traveling with his friend Harold Saville. They had a burro to carry their equipment. Ansel took pictures, and Harold held the donkey. When the Banner Peak photo became famous, Harold loved telling everybody, ‘I held Ansel’s ass while he made that picture!’ Harold





Lodgepole pines cast long shadows at sunset.

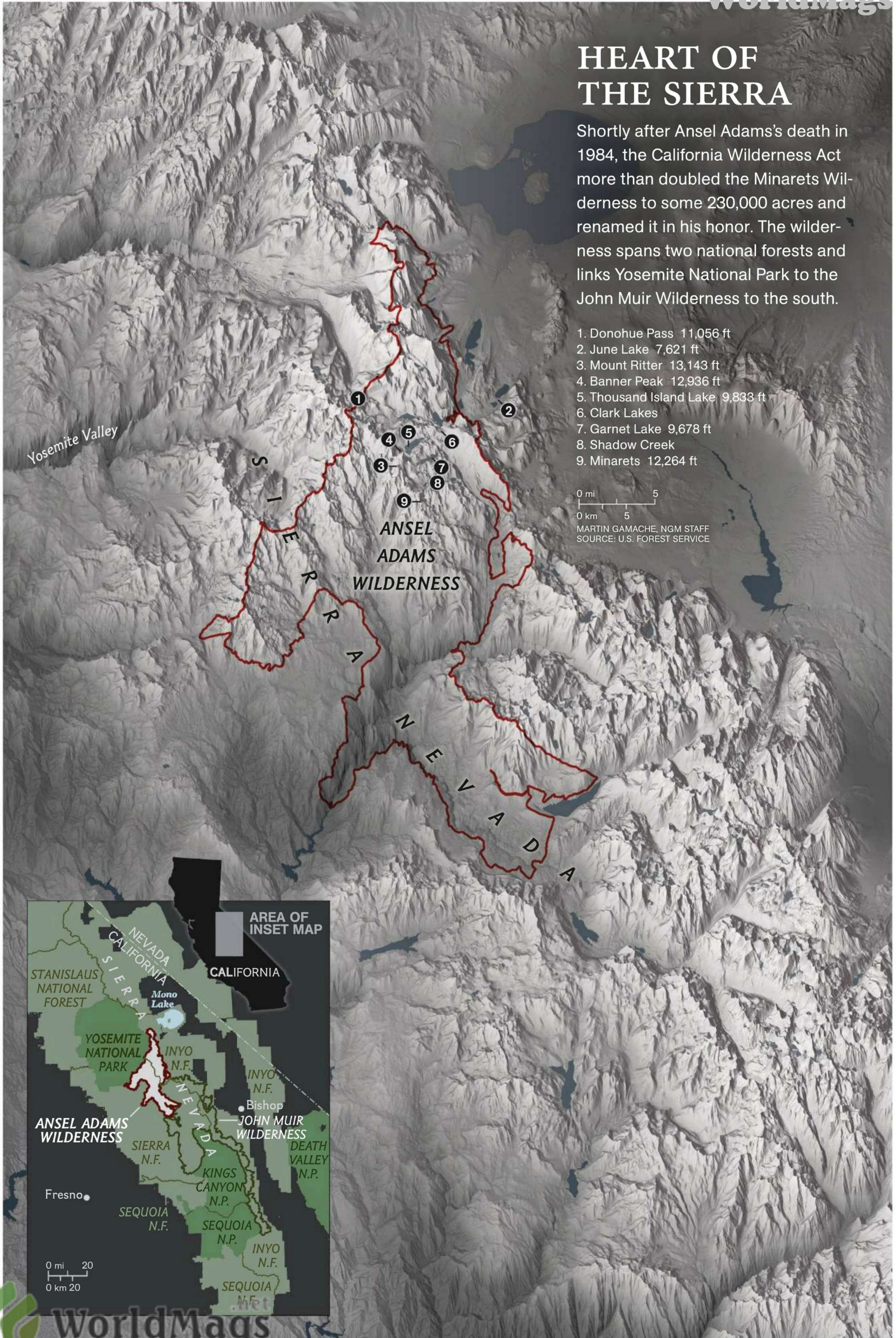


HEART OF THE SIERRA

Shortly after Ansel Adams's death in 1984, the California Wilderness Act more than doubled the Minarets Wilderness to some 230,000 acres and renamed it in his honor. The wilderness spans two national forests and links Yosemite National Park to the John Muir Wilderness to the south.

- 1. Donohue Pass 11,056 ft
- 2. June Lake 7,621 ft
- 3. Mount Ritter 13,143 ft
- 4. Banner Peak 12,936 ft
- 5. Thousand Island Lake 9,833 ft
- 6. Clark Lakes
- 7. Garnet Lake 9,678 ft
- 8. Shadow Creek
- 9. Minarets 12,264 ft

0 mi 5
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 MARTIN GAMACHE, NGM STAFF
 SOURCE: U.S. FOREST SERVICE



loved that story. And now I can say I've seen the place where Harold held Ansel's ass!"

Michael was still chuckling over that one as he picked his way along the lakeshore, searching for the ass-holding place, while his son, Matthew, and I wandered up and down the lake, scrutinizing the scene, roasting in the unobstructed sun, and feeling deflated that none of the venues looked quite right. Finally we triangulated a couple of boulders with Banner Peak and nailed the location at 37° 43' N, 119° 10' W. The view was just as Ansel Adams had seen it, except for the absence of the feathery clouds that brushed his mountains and the presence of a pine on the right, which had insinuated its way into the composition since 1923.

"Otherwise, pretty much what my grandfather saw," said Matthew Adams, who continues the family interest in photography as president of the Ansel Adams Gallery in Yosemite National Park. Loose-limbed and rangy, Matthew is a young version of his grandfather, with his Roman nose and dark, arching eyebrows. He whipped out a pocket camera and snapped a picture of his father, who took off his Stetson and beamed by the lake that had caught Ansel's eye so long ago.

Mission accomplished, we saddled up and plodded back to camp on the sturdy, steady horses we had picked up in June Lake. We eased down one trail and up another, through high meadows bright with lupine and Indian paintbrush, past twisted junipers on the heights, and over the pass to the Clark Lakes, where our tent camp commanded a fine view of the mountains. The shadows lengthened, the stars popped into place, and the air chilled abruptly. We pulled our chairs closer to the fire, remembering the man who had brought us together.

"I think my father was happy that the Sierra Club and others put his work to good use," Michael said. He had been fiddling with a new

Polaroid camera, which prompted the obvious question: Was he a photographer too? "No, I'm not," he said. "That's the first thing people ask me. The second thing they ask is what my father would think of digital photography. My answer is that he'd love it. He was always excited by the technical aspects of photography. He was always experimenting. So yes, I think he'd be very enthusiastic about digital, and he would find some way to use it."

To look at his photographs, you might get the mistaken notion that Ansel Adams was a severe man who viewed the world coldly, from a great distance and with little interest in humanity. In reality he was a gregarious creature with a salty sense of humor, a voluble style, and a sprawling network of friends who felt his death keenly.

Two such friends were William A. Turnage, then president of the Wilderness Society, and Alan Cranston, the California senator who rose to the position of Democratic whip in the late 1970s. When Adams died, Cranston wasted little time in calling Turnage to commiserate.

"What can we do for Ansel?" the senator asked. Turnage was ready with an answer: create a new Ansel Adams Wilderness area, which, along with the expanded John Muir Wilderness, would link two of the great High Sierra national parks, Yosemite and Sequoia. "This would thrill Ansel more than anything else could do—but it requires an act of Congress," Turnage recalls telling Cranston.

The senator readily agreed and ran with the idea. He persuaded his Republican colleague from California, Senator Pete Wilson, to co-sponsor legislation that added 119,000 acres to the existing Minarets Wilderness and renamed it to honor their friend. Within months of Adams's death, the designation sailed through Congress with bipartisan support and was signed into law by President Ronald Reagan.

The campfire at the Clark Lakes was burning down. Michael Adams stared into the embers and spoke again of his father, now a permanent presence in the mountains all around us. "He'd be tickled to know that this part of the country has his name on it. He'd love that." □

Robert M. Poole's latest book is On Hallowed Ground: The Story of Arlington National Cemetery. Photographer Peter Essick counts Ansel Adams as a major source of inspiration for his career.



Fungus whitens a plant pressed flat by snow.





Late summer thunderheads build above Garnet Lake.



NG CONNECT

Every month this page features our staff picks for National Geographic Society happenings. For more information go to nglive/events.org.

EXHIBIT

The President's Photographer

Decades of iconic images snapped by official White House photographers—including this one of Barack Obama (right)—are on exhibit beginning October 21 at the Harry S. Truman Library and Museum in Independence, Missouri. Visit trumanlibrary.org.



EVENT



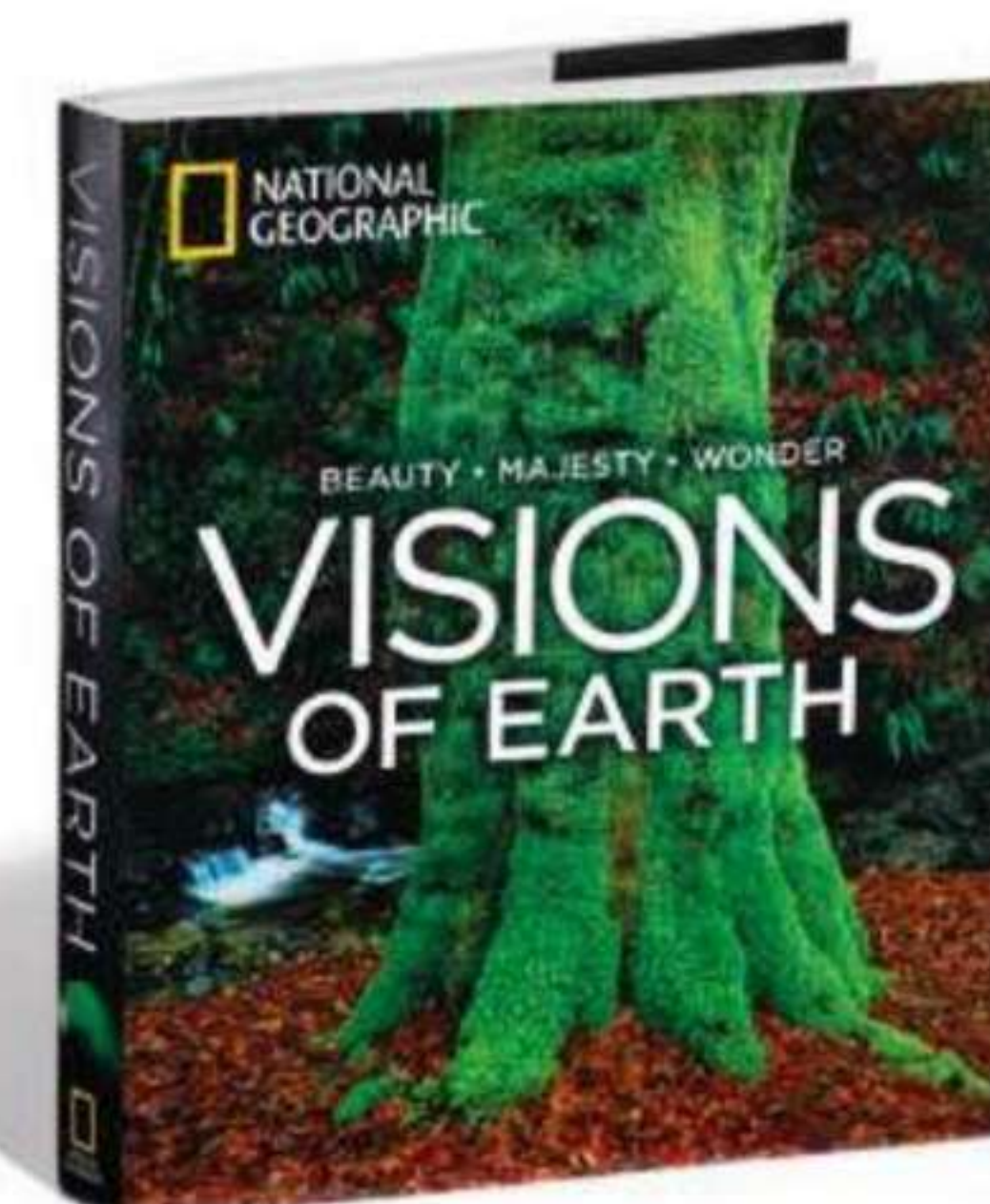
SAGUARO BIOBLITZ Team up with National Geographic and the National Park Service to identify as many species as possible in Saguaro National Park during this two-day event on October 21 and 22 in Tucson, Arizona. Register at nationalgeographic.com/bioblitz.

ACTIVITY

TRICK-OR-TREAT FOR BIG CATS Nat Geo WILD is ready to roar this Halloween. Kids can pounce on the fun by dressing up as big cats and collecting change for the Big Cats Initiative. See causeanuproar.org for information and costume ideas.

BOOK

VISIONS OF EARTH Awe-inspiring images, many of which have never before been published, are showcased in the pages of this new book. It's a visual tour of the world. In stores October 18 (\$40).

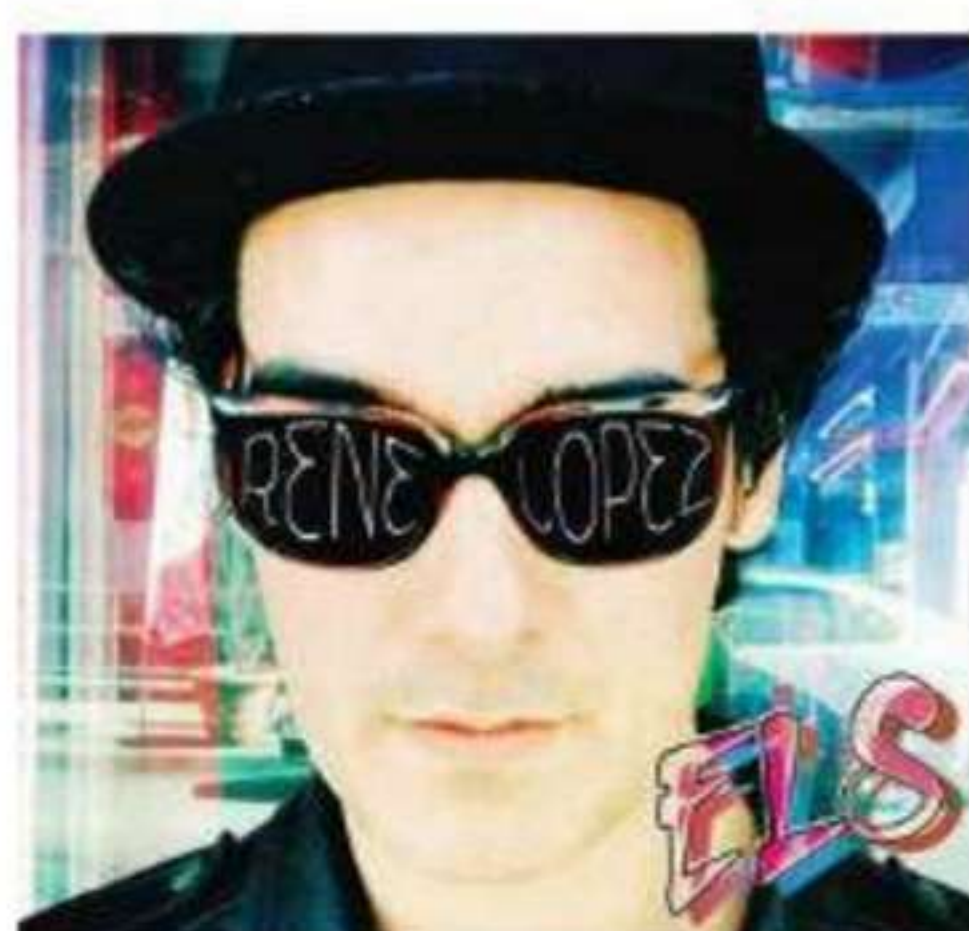


TRIP



BAJA CALIFORNIA Explore Baja California and the Sea of Cortez aboard the *National Geographic Sea Bird*. This eight-day expedition includes kayaking, hiking, and whale-watching, plus snorkeling amid sea lions and parrotfish. A team of experts accompanies each departure. For details go to nationalgeographicexpeditions.com.

Free Download
of the Month



Rene Lopez *E.L.S.*

Mining New York City's ever shifting musical landscape, Rene Lopez brings back gold on his Nat Geo Music debut album, *E.L.S.* This addictive, danceable mashup of new and old Latin sounds—from boogaloo to *cumbia*—infused with modern electro defines a new genre, electric Latin soul. Download a free song at natgeomusic.net/free.

LEGAL NOTICE

If you purchased Innova, EVO, California Natural, HealthWise, Mother Nature, or Karma dog or cat food you could get a payment from a class action settlement.

A \$2,150,000 settlement has been reached with Natura Pet Products, Inc., Natura Pet Food, Inc., Natura Manufacturing and Peter Atkins ("Defendants" or "Natura") in a class action lawsuit about the statements made in the advertising of Natura brand dog and cat food. Natura denies all of the claims in the lawsuit, but has agreed to the settlement to avoid the cost and burden of a trial.

WHO IS INCLUDED?

Those included in the class action, together called a "Class" or "Class Members" include anyone in the U.S. who purchased Natura brand dog or cat food products from March 20, 2005 through July 8, 2011.

WHAT DOES THE SETTLEMENT PROVIDE?

The maximum payment you can get is \$200. A \$2,150,000 settlement fund will be created by Natura. After paying the lawyers representing the Class for attorneys' fees of up to 35% of the fund and costs and expenses of up to \$60,000; costs to administer the settlement of up to \$400,000; and up to \$20,000 to the Class Representative (Judy Ko), payments will be made to Class Members who submit valid claim forms.

HOW DO YOU ASK FOR A PAYMENT?

Submit a claim form online, or get one by mail by calling the toll free number. The deadline to submit or mail your claim form is **January 8, 2012**.

WHAT ARE YOUR OPTIONS?

You have a choice about whether to stay in the Class or not. If you

submit a claim form or do nothing, you are choosing to stay in the Class. This means you will be legally bound by all orders and judgments of the Court, and you will not be able to sue or continue to sue Natura about the legal claims resolved by this settlement. If you stay in the Class you may object to the settlement. You or your own lawyer may also ask to appear and speak at the hearing, at your own cost, but you don't have to. The deadline to submit objections and requests to appear is **December 28, 2011**. If you don't want to stay in the Class, you must submit a request for exclusion by **December 28, 2011**. If you exclude yourself, you cannot get a payment from this settlement, but you will keep any rights to sue Natura for the same claims in a different lawsuit. The detailed notice explains how to do all of these things.

THE COURT'S FAIRNESS HEARING.

The U.S. District Court for the Northern District of California will hold a hearing in this case (*Ko v. Natura Pet Products, Inc.*, Case No 5:09cv2619), on February 17, 2012, at 9:00 a.m. to consider whether to approve: the settlement; attorneys' fees, costs, and expenses; and the payment to the Class Representative. If approved, the settlement will release the Defendants from all claims listed in the Settlement Agreement.

HOW DO YOU GET MORE INFORMATION?

The detailed notice and Settlement Agreement are available at the website. You can also call 1-888-768-2047, or write to Natura Settlement Administrator, c/o Analytics, Inc., PO Box 2005, Chanhassen, MN 55317-2005, or contact Class Counsel at 800-851-8716.

1-888-768-2047

www.PetProductsSettlement.com



✓Yes



✓Yes



xNo



✓Yes



✓Yes



✓Yes



✓Yes



✓Yes

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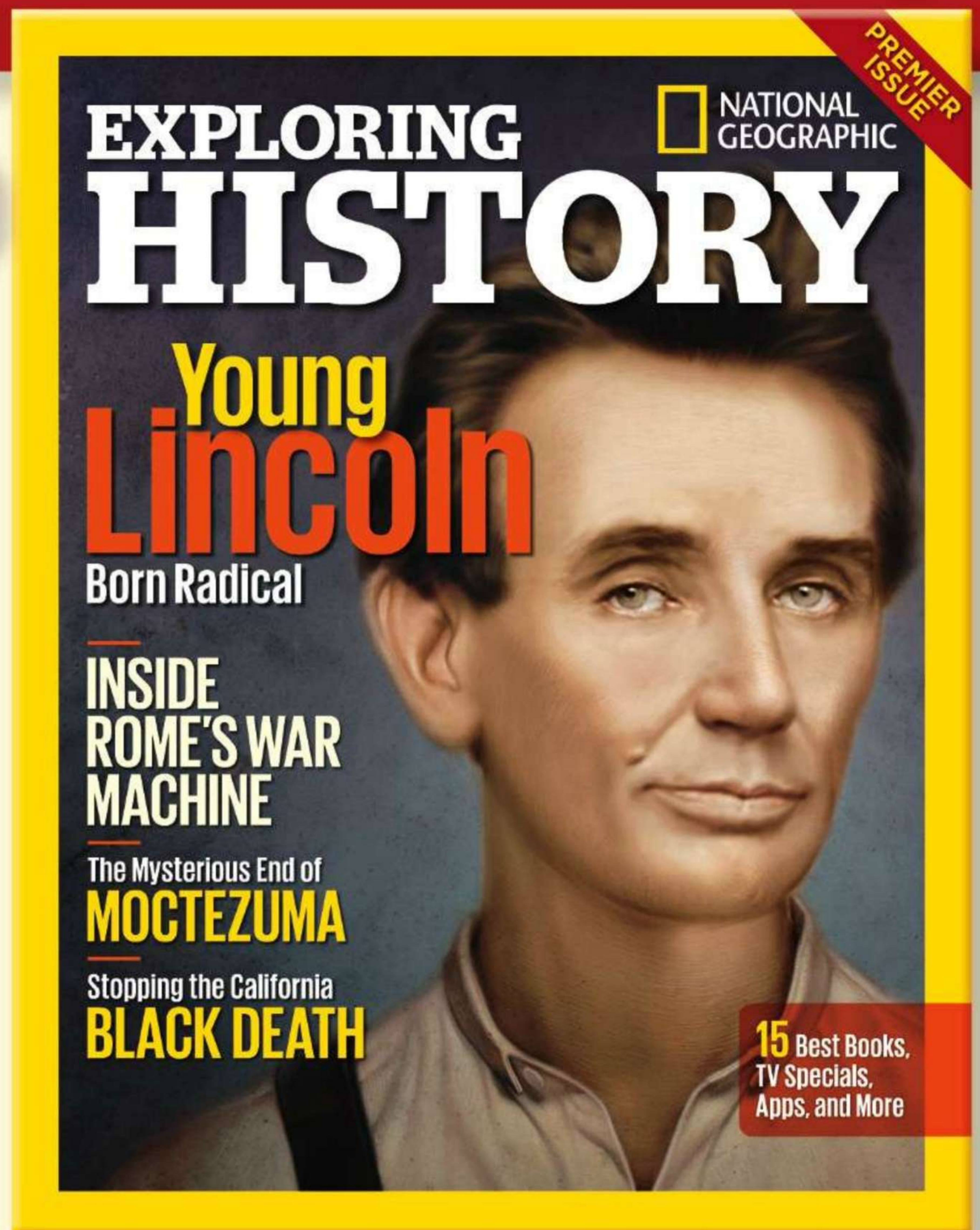
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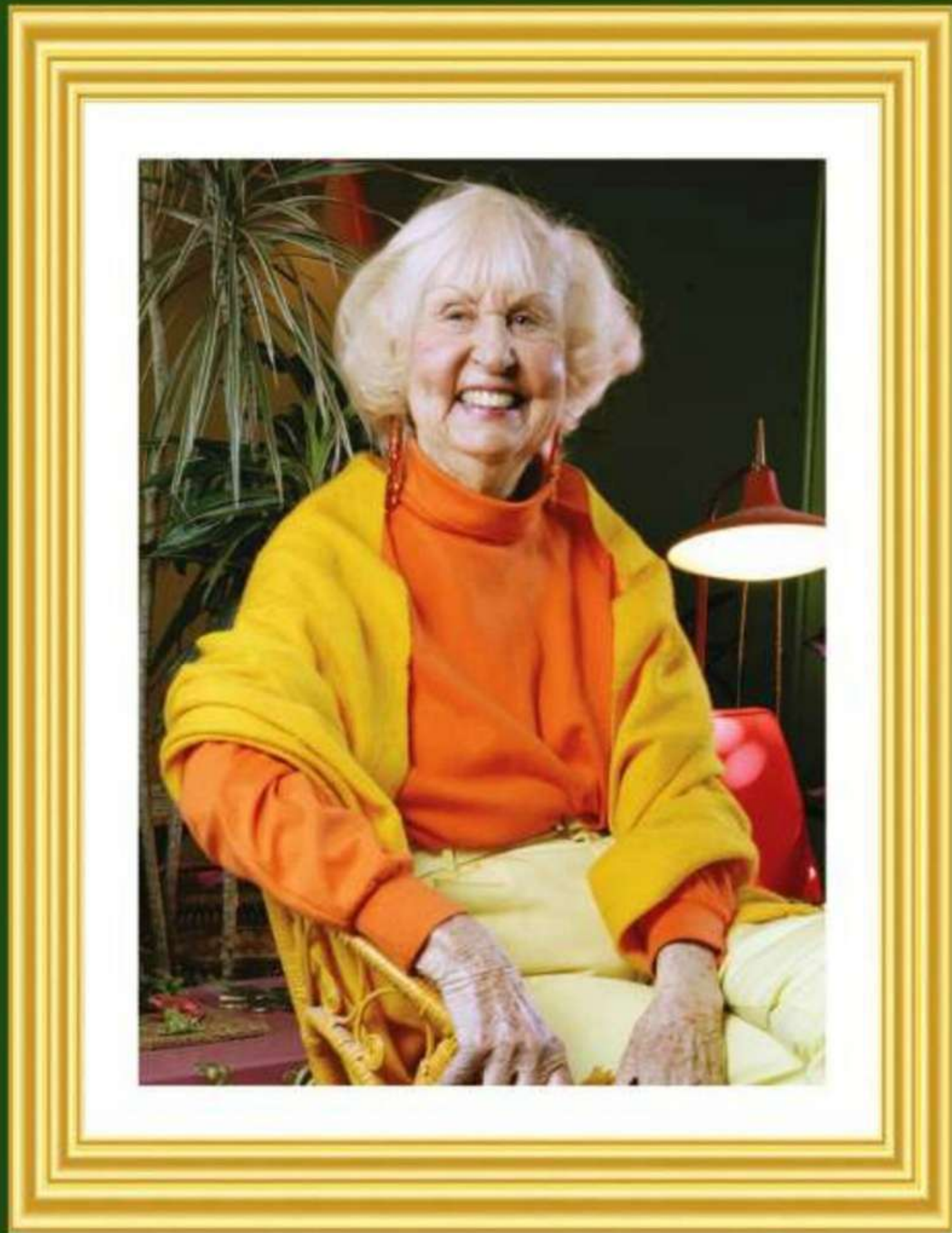
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Give An *Inspiring* Gift



Pat Minnick included National Geographic in her financial plans.

In 2007 Pat Minnick, a professional artist, decided to establish a charitable gift annuity to support National Geographic.

"I feel good knowing that National Geographic is doing so much to protect endangered wildlife," says Pat. "The environmental problems we face are vast, but by joining with National Geographic and their history of remarkable accomplishments, I know we can pass on a more beautiful world."

Pat now receives a guaranteed life income and is a direct part of the Society's efforts to inspire people to care about the planet.

For more information about a charitable gift annuity or other ways to include National Geographic in your estate plans, please see below.

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THE MOMENT *Peter Essick*

Stormy Weather When Peter Essick was in college, he wrote a letter to Ansel Adams. In it he asked the famous photographer to review his portfolio and perhaps offer a comment or two on his work. Usually fan mail goes unanswered, but Essick got a reply. “He invited me to come visit him at his house in Carmel,” remembers Essick, who took Adams up on his invitation. Essick echoes his mentor’s style in this issue through a series of black-and-white photographs of the California wilderness. Together these images represent something of a tribute, says Essick: “It’s a tip of the hat to Ansel’s aesthetic.” —*Catherine Zuckerman*



BEHIND THE LENS

That storm looks intense. Why did you want to photograph it?

PE: Most people visit the Ansel Adams Wilderness only in summer. We were there in February, and I wanted to show what this place is like during that harsh time of year. Conditions were rough when I skied over to these lodgepole pines. Winds were gusting over 50 miles an hour, and visibility was minimal. I think the wild nature of the area really comes through in this image.

What was it like working in all that snow and wind?

I had hired two experienced guides to help me with the logistics of getting out to the remote wilderness in winter. It was very cold for California, about zero degrees

Fahrenheit, and our shelter was a snow cave. We dug it ourselves. It had a small entrance; the inside was just big enough for us to lie down. During the snowstorm we took turns shoveling through the night, making sure fresh air was coming in.

Skiing was also tricky, particularly around areas where the avalanche risk was high. Going into this trip, I thought I was a pretty good skier, albeit a little rusty, but four feet of snow plus a 40-pound backpack turned me into a novice.

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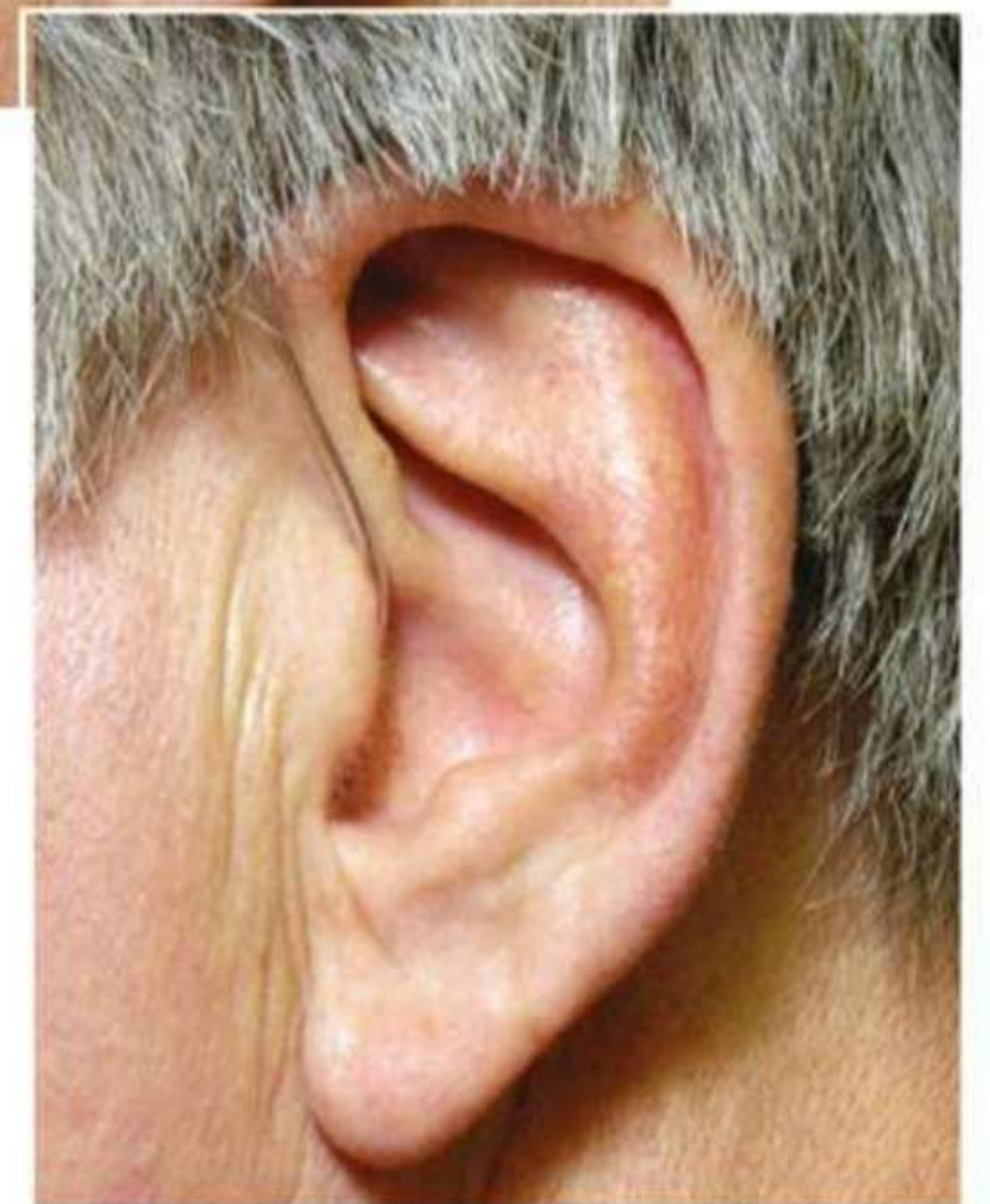
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FLASHBACK



Pouring It On

Young Walter Volk dumps a refreshing bucket of water over construction worker Louis Adesso, here taking a break on an East 41st Street stoop in Manhattan in August 1947. The steamy weather continued well into the fall. The Octobers of 1947 and 2007 tie as New York City's warmest to date. But the heat wave eventually broke: The year 1947 also brought one of New York's snowiest winters. Some 25 inches fell on December 27—a record for that day that still stands.

—Margaret G. Zackowitz

👉 **Flashback Archive** Find all the photos at ngm.com.

PHOTO: NEW YORK DAILY NEWS/NATIONAL GEOGRAPHIC STOCK

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**Grey Crowned Crane** (*Balearica regulorum*)**Size:** Head and body length, approx. 1 m (39.4 inches); wingspan, 1.5 - 1.7 m (59.1 - 66.9 inches)**Weight:** Approx. 3.5 kg (7.7 lbs) **Habitat:** A mix of wetlands and grasslands**Surviving number:** Estimated at 50,000 - 64,000

Photographed by Tui De Roy

WILDLIFE AS CANON SEES IT

Living history. The grey crowned crane is one of the most ancient living members of the crane family, with primitive species dating back in fossil records to the Eocene period. It is also one of only two cranes able to perch in trees, thanks to its unusually well-developed hind toes. Monogamous couples work together to build circular platform nests and take turns incubating their eggs for as long as 31 days. But the future of

these venerable birds is in doubt as they face habitat loss—primarily due to conversion for agriculture, heavy use of pesticides and changes in water management—and live-trapping for trade.

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