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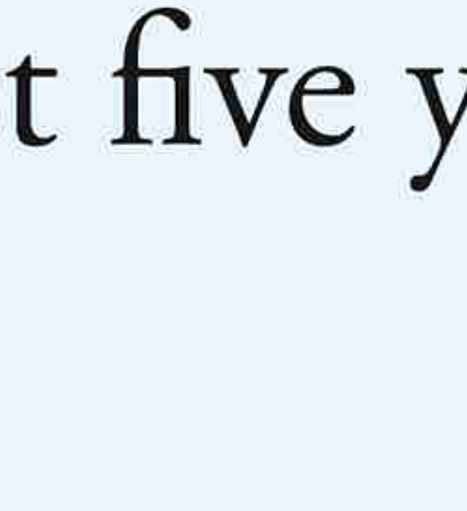

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NATIONAL GEOGRAPHIC

SEPTEMBER 2010 • VOL. 218 • NO. 3

PASCAL MAITRE

Place: Beheloka, Madagascar. Mask: turmeric root paste, used as a sunscreen and skin balm. Animals: lemurs kept (illegally) as pets. Story on page 80.

OFFICIAL JOURNAL OF THE NATIONAL GEOGRAPHIC SOCIETY

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NATIONAL GEOGRAPHIC

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Tut's Family Tree

DNA tests on Egypt's royal mummies tell a sometimes shocking tale. Our interactive family tree sorts out the incestuous relations that were part of Tut's world.

On the Cover

For its close-up, King Tut's 24-pound, gold burial mask was given a 90-minute reprieve from its glass case at Cairo's Egyptian Museum.
Photo by Kenneth Garrett

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EDITOR'S NOTE

Shot from Philippe Mathieu's helicopter, rice terraces surround the village of Andina in Madagascar.

As photographers in the field, we think we know the landscape. Then we step into a helicopter, and suddenly the terrain unfurls before us. Philippe Mathieu, the helicopter pilot who worked with Pascal Maitre on this month's Madagascar story, was a photographer's dream. "He never said, 'I can't do this.' It was always, 'Let's try,'" Pascal told me. Philippe knew how photographers think. He understood about waiting hours for a few minutes of perfect light. With Philippe's help, Pascal shot aerials of the Madagascar landscape and showed, in ways that could never be comprehended from the ground, the scarification of the land caused by mining and logging.

Philippe was a pro. But even the most careful pilot can be on the wrong side of a set of statistics. On April 11, just weeks after Pascal had left Madagascar, something went wrong—as yet no one knows what—and Philippe's chopper went down. He was 38 years old.

His mother and sister were visiting him in Madagascar at the time. Afterward, they waited for days to bring his coffin back to France, because ash from the Iceland volcano canceled all flights. "With Philippe I never worried about anything except the photographs," Pascal said. "We were a team."

COMING IN OCTOBER

The Gulf Oil Disaster Next month's *National Geographic* will put the Gulf of Mexico oil spill into context, providing an in-depth analysis of oil exploration and its impact on the ecosystem. A large, pullout map supplement will take a comprehensive look at the Gulf region. Working with dedicated people on the front lines of the catastrophe, we'll tell a story that is both timely and timeless. We'll use our expertise to provide information and analysis you can trust.

PHOTO (TOP): PASCAL MAITRE

Golden-cheeked Warbler *(Dendroica chrysoparia)*
Size: Head and body length, approx. 12 cm (approx. 4.7 inches) **Weight:** 8.7 - 12.1 g (0.3 - 0.4 oz)
Habitat: Breeds only in the juniper-oak woodlands of central Texas; in non-breeding season, inhabits the Central American pine-oak forest region **Surviving number:** Estimated at 9,600 - 32,000

Photographed by Gil Eckrich

WILDLIFE AS CANON SEES IT

Location, location, location. Only one place will do when it's time for the golden-cheeked warbler to breed: central Texas. This is where the beautiful bird locates Ashe juniper bark, which the female combines with feathers, grasses, leaves, mammal hair and spider webs to construct its open-cup nest. Males defend their breeding territory with song and chases, and will even attack invading males. They often return to the same site year after year, but they are finding fewer and fewer Ashe juniper trees standing when they do. As this vital raw material diminishes, so do the warbler's chances of building a life for the generations to follow.

As we see it, we can help make the world a better place. Raising awareness of endangered species is just one of the ways we at Canon are taking action—for the good of the planet we call home. Visit **canon.com/environment** to learn more.

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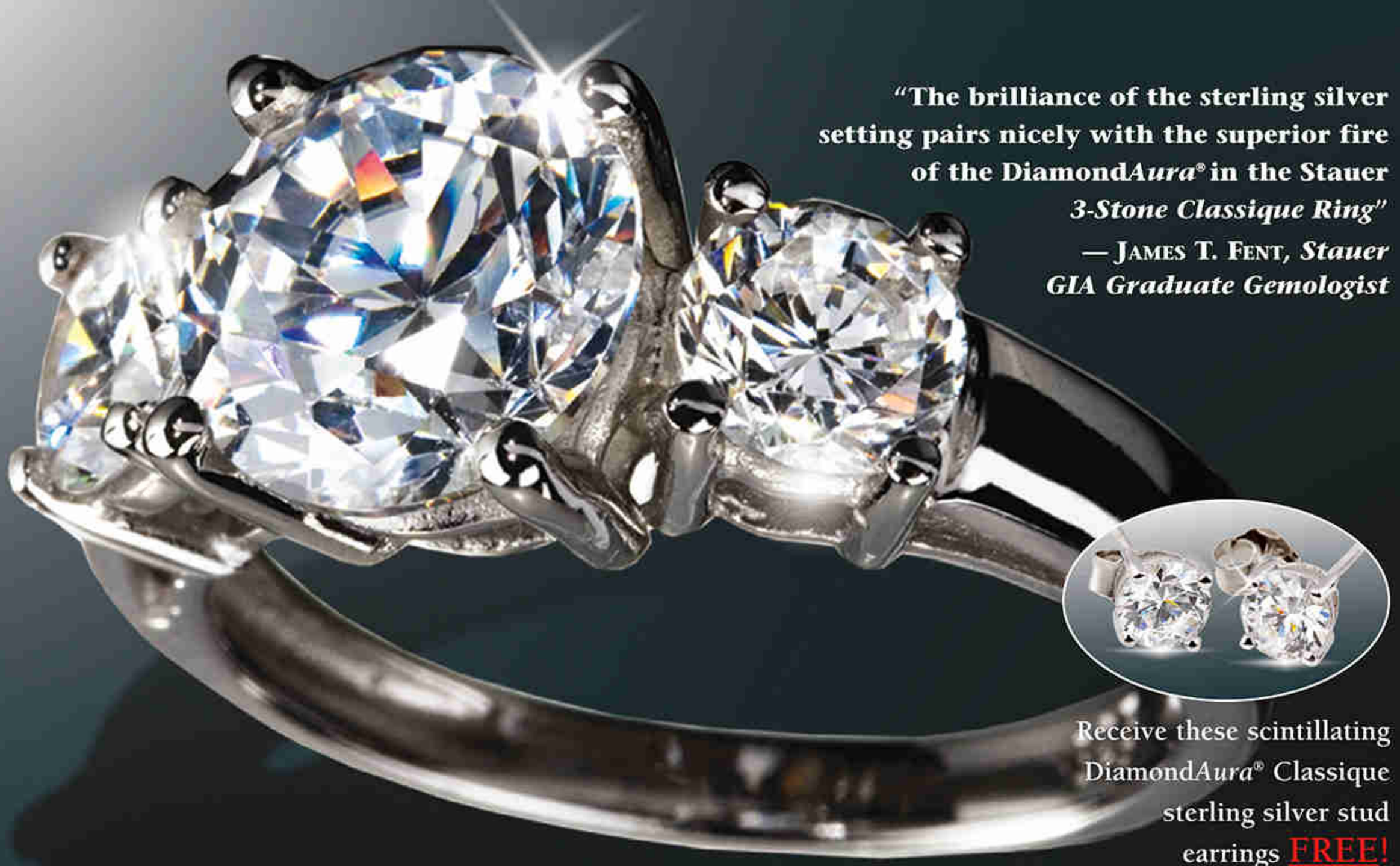

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Perfection from the laboratory. We named our brilliant cut stones Diamond*Aura*, because, "they dazzle just like natural diamonds but without the outrageous cost." The scientific process involves the use of rare minerals heated to an incredibly high temperature of nearly 5000˚F. This can only be accomplished inside some very modern and expensive laboratory equipment. Scientists finally created a clear marvel that looks even better than the vast majority of mined diamonds. According to the book *Jewelry and Gems–the Buying Guide*, the technique used in Diamond*Aura* offers, *"The best diamond simulation to date, and even some jewelers have mistaken these stones for mined diamonds."*

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Thousands of years before the first diver glimpsed the watery wonders of Biscayne National Park, its coral reefs began to form. Growing just one centimeter a year, they expanded to create one of the most complex, diverse, and fragile ecosystems on the planet—a crucial stronghold for thousands of fish and plants.

Saving BISCAYNE'S *crucial coral*

CENTURIES IN THE MAKING, DESTROYED IN AN INSTANT

Today, Biscayne's extraordinary coral is disappearing at an alarming rate. With 95 percent of the park underwater, coral reefs make up more than half of Biscayne's acres. Navigating these offshore reefs and shallow inshore bays is complicated, and inexperienced or careless boaters often damage sensitive coral areas. As coral vanishes, so does the life-support system that nurtures Biscayne's astonishing array of marine life.

RENEWING REEFS IN A NURSERY BELOW THE WAVES

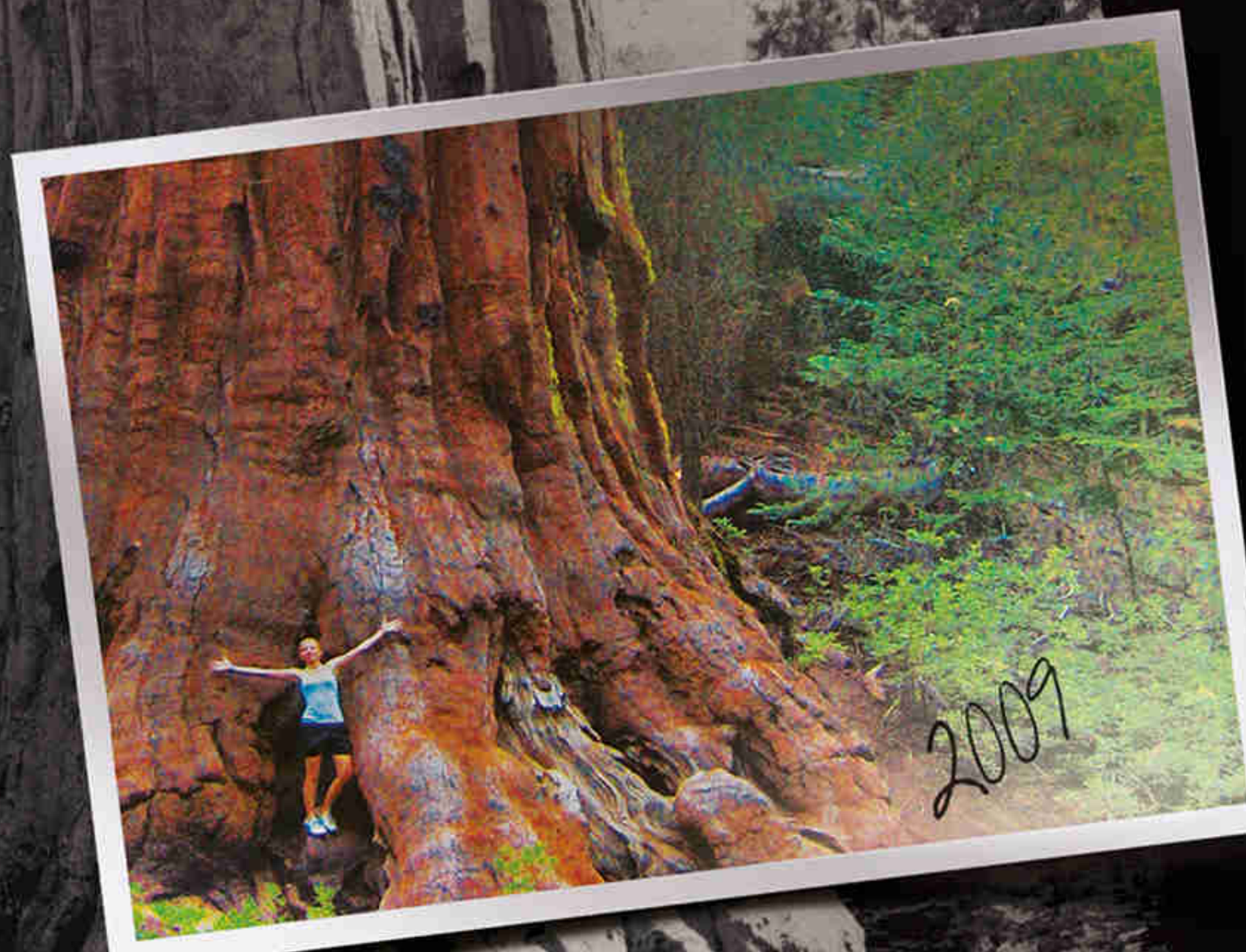
Biscayne National Park's Coral Nursery Program takes an innovative approach to rejuvenating damaged reefs. Nature Valley is partnering with the National Parks Conservation Association to make it happen. Dozens of volunteers work with park staff to rescue coral fragments from boat grounding sites, place them in protected nursery areas of the park that provide ideal growing conditions, and ultimately transplant them back on damaged reefs. With masks and flippers aimed toward the future, Nature Valley's effort makes sure America's largest marine national park will thrill generations of underwater visitors to come.

Nature Valley is helping and so can you. Donate to the National Parks Conservation Association, learn more, and track project progress at PreserveTheParks.com.

Your children's grandchildren will thank you.

Nature Valley is committed to supporting the National Parks Conservation Association, an organization that ensures the majesty of our national parks can be enjoyed for generations to come.

Join us at NatureValley.com to track our progress and to see how you can lend a hand.



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LETTERS

May 2010

Mount St. Helens

Your update on Mount St. Helens's recovery heightened old memories. Shortly after the first eruption in 1980, a colleague and I flew along the skirts of the mountain, looking down on rows of huge, downed trees laid out in military order like so many toothpicks. Then came ranks of still standing trees: green on one side and the other, charred, facing the mountain. A year later, accompanying a group of forestry-school deans, we flew by helicopter into the crater, still steaming with the smell of brimstone. Yet on the nearby slopes the rejuvenation had begun. Spots of green were emerging from the ash, and files of elk made their way across the blackened landscape.

JAMES M. MONTGOMERY
Atlanta, Georgia

As European transportation remains crippled from the effects of the Eyjafjallajökull volcano, I commend you on your luck/foresight in having the May issue arrive at my house this week. Two hundred square miles of destroyed forest at Mount St. Helens is impressive, but a fourth day (and counting) of a continent full of grounded air traffic seems equally so. I imagine that volcanoes, earthquakes, tsunamis, hurricanes, floods, and whatever else are not really more frequent than usual, but they do help us remember humility when we begin to get full of ourselves.

LONNIE HANAUER
West Orange, New Jersey

The most dramatic example of rebirth in the Mount St. Helens blast zone is seen on timber-company lands. By replanting their lands after the eruption in 1980, they now have a forest with 60-foot-tall trees. Wildlife and water quality also benefit from this active management.

ROD BARDELL
Lebanon, Oregon

Troubled Spirits

Perhaps some misguided or desperate people in Mexico call evil spirits "saints," but the author of "Troubled Spirits" must have known better. In the Catholic Church, saints are those who lived lives of virtue and piety and have been officially recognized by the church through canonization. They are held up as models of holiness, not idols to be worshipped. Surely they are not the cult figures described in your article. Please do not confuse saints and evil spirits. They are worlds apart.

JAN ALKIRE
Seattle, Washington

Your article successfully illustrated desperate people during a time of crisis. New controversial objects of prayer such as La Santa Muerte and Jesús Malverde simply tell us that humans suffering in hopelessness and destitution turn to otherworldly figures for answers to the unanswerable. The same saints form the complexities of both the human and heavenly realms. As your article suggests, Mexico is not rife with inherently savage people, just complex ones living in troubled times.

MATTHEW HOLDMAN
Murray, Kentucky

Just as during Prohibition, so long as drugs are illegal in the United States, drug lords all over the world will continue to battle for turf because of the high profits caused by the illegality of drugs. No matter how hard we try to stop them, as the author states very perceptively, "with every new military offensive, the traffickers…became stronger." The war on drugs is Prohibition on steroids, causing literally tens of thousands of needless deaths and horrible misery. If we are concerned for the welfare of people, including our own children and their safety, we must end drug prohibition in America. Then the Mexican drug lords will suffer a fatal blow. Otherwise Mexicans will continue to worship La Santa Muerte, and for good reason.

JOHN DAVIS
Richardson, Texas

Corrections, Clarifications

May 2010: The Secrets of Sleep
Page 80: William Dement, dean of sleep studies at Stanford University, was incorrectly described as retired.

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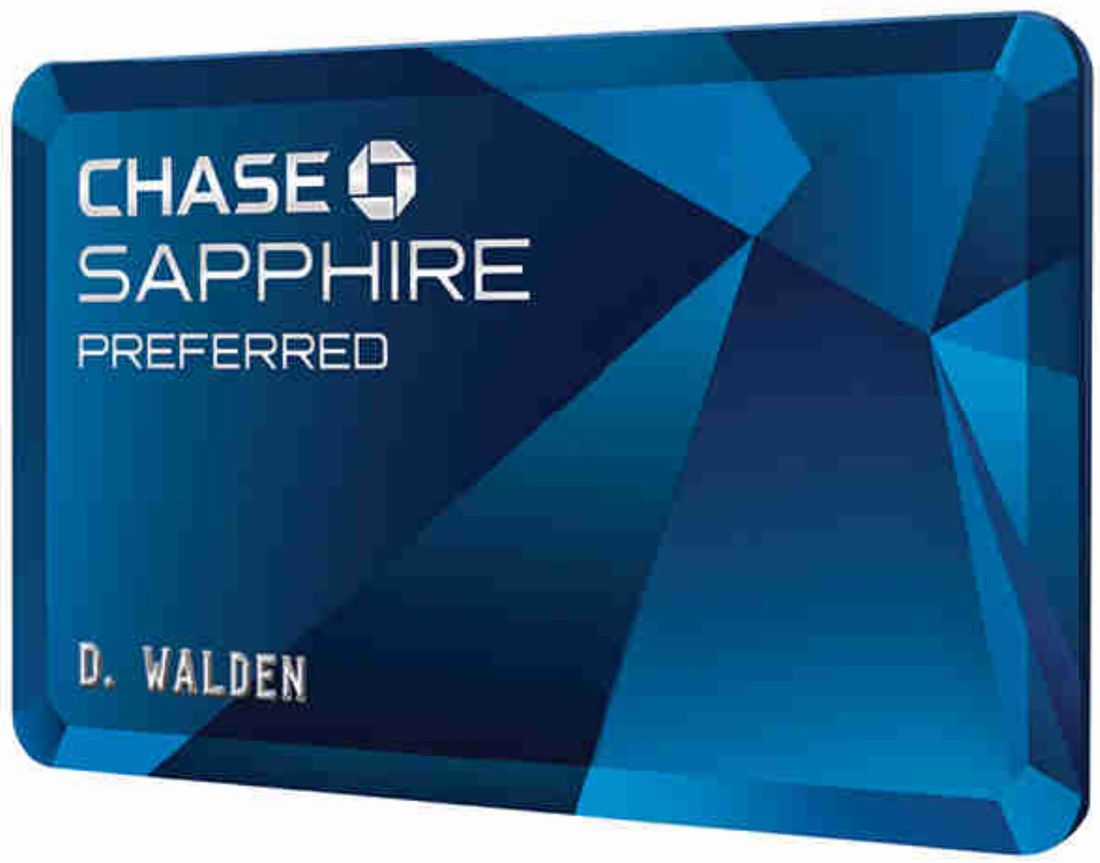

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LETTERS

I thought that "Death With No Possibility of Life" would have made a great subtitle for this article. I was struck by the tragic yet logical way in which the Mexican mafia runs its affairs. Its members have no option for protection nor chance of a future. Facing certain death, they carve out a life and religion of their own. Like most people with little hope, they turn to faith, seeking a higher power to guide and protect them. Religions have always been born this way, of a need: the need for rain, the need to govern large groups of people, the need for enlightenment. The Mexican mafia has so precisely homed in on its members' most crucial need and filled it with a religion flavored to meet their specific and dire requirements. La Santa Muerte seems to offer them a looser version of good and bad, one that flows less restricted through their hellish reality. And without the ancient confines of black and white, they find freedom to live in the thousand shades of gray that permeate their world.

PAULA WYATT
Windermere, Florida

The Secrets of Sleep

Your article treats waking as the normal state of organisms and sleep as a special state entered for special purposes. Sleep research might be more productive if sleep were considered to be the normal state of an organism and waking to be an alert state entered for special purposes only, such as feeding, reproducing, and defense. Really, there is little point in being awake unless one needs to be. Otherwise, wakefulness is a waste of energy. Cats and babies know this.

WALTER WELLER
Wakefield, Louisiana

I was stupefied by the article's scant coverage of two big factors affecting sleep. Could it be mass denial on the part of both medical and journalism workers, neither of whom wish to face up to their abuse of and dependence on caffeine and nicotine? There is a social stigma attached to sleeping normally. Those who encourage this attitude are invariably the biggest abusers of stimulants. I spent a large portion of my adult life wondering if I was just a wimp for feeling sluggish after seven hours of sleep. Now, at age 47, I allow myself to get the proper amount of sleep. I feel better than I did in my twenties, while all I hear from coffee-swigging peers are complaints about declining health.

I was struck by the tragic yet logical way in which the Mexican mafia runs its affairs. Its members have no option for protection nor chance of a future. Facing certain death, they carve out a life and religion of their own.

GUY McGRANE
Millers Creek, North Carolina

"Only one in five teenagers gets the optimal nine hours of sleep on school nights." Aside from the fact that many teens stay up late to watch TV, a good part of the problem rests (pardon the pun) with the schools. If the high school instruction day started later, i.e., 10 a.m., and ended at 5 p.m., students would have the opportunity to get the optimal nine hours of sleep. They would also have time to get prepared for the school day without the distraction of younger siblings getting ready at the same time. Extracurricular activities such as sports could hold practices in the midmorning, when the weather is cooler and bodies and brains are fresher. By the time a student is in high school, he or she should be independent enough to get up, get ready, and get to school on time. What better preparation is there for the "real world" than that?

BARBARA J. AUGSDORFER
Indianapolis, Indiana

I was happy to see confirmed what I have long thought: During sleep, the brain "files" thoughts and experiences to memory like a computer stores data. To further this thought, dreams may be bits of "corrupted files," pieces of information that were not perceived in the normal way. Perhaps these fragments go to a "recycle bin," or maybe they are rerouted by the brain to their correct storage place. The detour might take them across a neurological pathway while in the REM stage, one that we sometimes remember as a dreamscape of strange as well as familiar images.

KRISTINA CARPENTER
Wellington, Florida

Locks and ribbons at the Qingyin Monastery, Mt. Emei China.

Shot using the Samsung NX10 with 18-55mm lens set at 35mm, f/4.5, iso 400.

Unlocking the Secrets of a Great Shot

Of the four mountains considered holy by Chinese Buddhists, Mt. Emei is the largest. A green-clad giant that soars through the clouds in the middle of Sichuan Province, it holds 30 Buddhist temples on slopes rich with ancient trees, tumbling waterfalls and abundant wildlife. It is here that *National Geographic* photographer Tyrone Turner captured this shot that pleases the eye with its melange of light, texture and color, even as it teases the mind with its enigmatic subject matter.

Turner explains: "The locks and the ribbons are wishes. Pilgrims visit the monasteries on the mountain in order to pray and receive blessings. As well, people will buy these locks and ribbons for good luck and put them on the chain railings around the monastery … they have brief sayings on them that represent their wishes."

As if having been granted his own wish, Turner says that the combination of overcast lighting conditions and my Samsung NX10 camera were ideal for the photograph. "I enjoyed the fact that the camera took really high-quality images in less than optimal lighting conditions," he said. Turner also commented that the size of the NX10 provided significant advantages over heavier gear: "The camera is light and small so it was easy to handle quickly in order to get the shot I wanted. Because the camera is small, it is less imposing to other people and so it was easy to be spontaneous while shooting."

TYRONE TURNER

Tyrone Turner is a photojournalist based in Arlington, Virginia. His assignments have taken him from Brazil to Baghdad to the bayous of Louisiana with his camera in hand. In addition to his work for *National Geographic*, Turner has produced award-winning photographs for national and international publications such as *Time*, *Newsweek*, *U.S. News and World Report*, and the *Los Angeles Times*.

LETTERS

As a lifetime second and third shifter, I read your article on sleep with much interest. As I have gotten older, I have discovered that getting adequate sleep (not necessarily long, but thorough) has crept to nearly number one on my list of priorities: a sort of daily holy grail. I took a sleeping pill only one time, with disastrous results. Now, if I find I need to, I will take a well-timed caffeine pill (I dislike coffee) that keeps me just alert enough without sending me into heart-pounding overdrive. I chose my lifestyle for the small but important financial bonus of working the graveyard shift—plus the chance to be awake during the day, not staring out of an office window. I don't believe we are put on this Earth to achieve spotless floors, empty sinks, and fat bank accounts. So balancing the practical with the sublime, managing micro-naps and micro-wakefulness, has been a struggle, but for me, a worthwhile one.

E. BARNES
Browntown, Wisconsin

Lifeline for the Iberian Lynx

Does the loss of a species make us less human? I feel so. The article's opening states, "Not since the time of the sabertooth has a feline species gone extinct." But the Caspian tiger was hunted to extinction. This was a recent event.

STEPHEN MOORE
Sacramento, California

With a population of 225, how is the Iberian lynx "Earth's most endangered cat"? The Amur leopard numbers fewer than 60 in the wild, and the Asiatic cheetah is a close second with fewer than 100 wild specimens.

J. ZAUGG
San Francisco, California

Some other big cats do indeed have fewer individuals left in the wild than the Iberian lynx. However, the statement "Earth's most endangered cat" was referring to the species level. The Amur leopard and the others mentioned are considered subspecies. We should have been more specific in our wording to avoid confusion.

China's Tea Horse Road

Author Mark Jenkins bemoaned the Tea Horse Road forgotten as a result of time, technology, and fashion, but we Chinese

actually do not feel sad. The road is an old culture, a folklore that exists only in our memories. Chinese people in the developing southeastern cities want an advancement in their standard of living; so too do the Tibetan nomads. Modern technology is a good thing to them: Motorcycles are more indefatigable than horses.

QIAN CHU
Suzhou, China

The story mentions *chong cao,* the fungus-infected caterpillars. The fungus with which the caterpillars are infected is called *Cordyceps sinensis.* As a naturopathic doctor, I use it for many treatments. I tell people stories of how *C. sinensis* used to be worth more than its weight in gold. Now it's grown in great big tanks. We extract the benefits of the tank-grown "roots" of the fungus instead of relying on caterpillars and eagle-sharp eyes.

STEVE CLARK
Wolfeboro, New Hampshire

Wildlife: World's Widest Web

The golden orb weaver spider you featured lives in South Florida. Besides having the largest web, it shares web boundaries with others. This results in huge communal webs that I have seen spanning from power lines down to phone lines (approximately 12 feet). Communally they have very impressive "catch areas" and very strong webs. I think they could catch small birds.

JIM BIRDSALL
Juno Beach, Florida

Flashback: Deep Sleep

After seeing the black-and-white photograph taken of the Londoners sleeping in the Aldwych tube station in October 1940, my mother, aunt, and uncle all believe the young woman who is shown standing in the center back with her arms crossed to be my grandmother, Dinah Dackombe, at about 15 years of age. My grandfather was stationed in London in the U.S. Army Air Corps during World War II. He started dating Dinah during the war, and when the war ended, they got married and moved to Ohio. My grandmother passed away in January of 1979, but my grandfather is doing well.

NATHAN W. McLAUGHLIN
Nelsonville, Ohio

I CHOSE

- ☑ To work on controlling my blood sugar.
- ☑ To talk to my doctor about insulin.
- ☑ To add insulin to my treatment plan.

If you have type 2 diabetes, and pills alone aren't controlling your blood sugar anymore, this could be the right time to consider adding insulin. Insulin is an effective way to lower blood sugar. Controlling blood sugar is important because, over time, high blood sugar can lead to serious complications.

Today, insulin comes in an easy-to-use pen. Insulin should be used as part of an overall diabetes treatment plan, which includes diet, exercise, and other diabetes medications. Make the choice to talk to your doctor about whether insulin is right for you.

Important Safety Information for Lantus® (insulin glargine [rDNA origin] injection)

Do not take Lantus® if you are allergic to insulin or any of the inactive ingredients in Lantus.®

You must test your blood sugar levels while using insulin, such as Lantus.® Do not make any changes to your dose or type of insulin without talking to your healthcare provider. Any change of insulin should be made cautiously and only under medical supervision.

Do NOT dilute or mix Lantus® with any other insulin or solution. It will not work as intended and you may lose blood sugar control, which could be serious. Lantus® must only be used if the solution is clear and colorless with no particles visible. **Do not share needles, insulin pens or syringes with others.**

The most common side effect of insulin, including Lantus,® is low blood sugar (hypoglycemia), which may be serious. Other possible side effects may include injection site reactions, including changes in fat tissue at the injection site, and allergic reactions, including itching and rash. In rare cases, some allergic reactions may be life threatening.

Tell your doctor about other medicines and supplements you are taking because they can change the way insulin works. Before starting Lantus,® tell your doctor about all your medical conditions including if you have liver or kidney problems, are pregnant or planning to become pregnant, or are breast-feeding or planning to breast-feed.

Indications and Usage

Prescription Lantus® is a long-acting insulin used to treat adults with type 2 diabetes and adults and children (6 years and older) with type 1 diabetes for the control of high blood sugar. It should be taken once a day at the same time each day to lower blood glucose.

Do not use Lantus® to treat diabetic ketoacidosis.

Lantus® SoloSTAR® is a disposable prefilled insulin pen.

Please see additional important information on the next page.

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From the maker of Lantus® SoloSTAR.®

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BRIEF SUMMARY OF PRESCRIBING INFORMATION

HIGHLIGHTS OF PRESCRIBING INFORMATION

These highlights do not include all the information needed to use LANTUS safely and effectively. See full prescribing information for LANTUS.

LANTUS® (insulin glargine [rDNA origin] injection) solution for subcutaneous injection

Initial U.S. Approval: 2000

INDICATIONS AND USAGE

LANTUS is a long- acting human insulin analog indicated to improve glycemic control in adults and children with type 1 diabetes mellitus and in adults with type 2 diabetes mellitus. (1)

Important Limitations of Use:

- Not recommended for treating diabetic ketoacidosis. Use intravenous, short-acting insulin instead.

DOSAGE AND ADMINISTRATION

- The starting dose should be individualized based on the type of diabetes and whether the patient is insulin-naïve (2.1, 2.2, 2.3)
- Administer subcutaneously once daily at any time of day, but at the same time every day. (2.1)
- Rotate injection sites within an injection area (abdomen, thigh, or deltoid) to reduce the risk of lipodystrophy. (2.1)
- Converting from other insulin therapies may require adjustment of timing and dose of LANTUS. Closely monitor glucoses especially upon converting to LANTUS and during the initial weeks thereafter. (2.3)

DOSAGE FORMS AND STRENGTHS

Solution for injection 100 units/mL (U-100) in

- 10 mL vials
- 3 mL cartridge system for use in OptiClik (Insulin Delivery Device)
- 3 mL SoloStar disposable insulin device (3)

CONTRAINDICATIONS

Do not use in patients with hypersensitivity to LANTUS or one of its excipients (4)

WARNINGS AND PRECAUTIONS

- Dose adjustment and monitoring: Monitor blood glucose in all patients treated with insulin. Insulin regimens should be modified cautiously and only under medical supervision (5.1)
- Administration: Do not dilute or mix with any other insulin or solution. Do not administer subcutaneously via an insulin pump or intravenously because severe hypoglycemia can occur (5.2)
- Do not share reusable or disposable insulin devices or needles between patients (5.2)
- Hypoglycemia: Most common adverse reaction of insulin therapy and may be life-threatening (5.3, 6.1)
- Allergic reactions: Severe, life-threatening, generalized allergy, including anaphylaxis, can occur (5.4, 6.1)
- Renal or hepatic impairment: May require a reduction in the LANTUS dose (5.5, 5.6)

ADVERSE REACTIONS

Adverse reactions commonly associated with Lantus are:

- Hypoglycemia, allergic reactions, injection site reaction, lipodystrophy, pruritus, and rash. (6.1)

To report SUSPECTED ADVERSE REACTIONS, contact sanofi-aventis at 1-800-633-1610 or FDA at 1-800-FDA-1088 or *www.fda.gov/medwatch.*

DRUG INTERACTIONS

- Certain drugs may affect glucose metabolism, requiring insulin dose adjustment and close monitoring of blood glucose. (7)
- The signs of hypoglycemia may be reduced or absent in patients taking anti-adrenergic drugs (e.g., beta-blockers, clonidine, guanethidine, and reserpine). (7)

USE IN SPECIFIC POPULATIONS

- Pregnancy category C: Use during pregnancy only if the potential benefit justifies the potential risk to the fetus (8.1)
- Pediatric: Has not been studied in children with type 2 diabetes. Has not been studied in children with type 1 diabetes <6 years of age (8.4)

See Full Prescribing Information for PATIENT COUNSELING INFORMATION and FDA-approved patient labeling

Revised: 09/2009

GLA-BCPH-NG-SEP09 Rx Only

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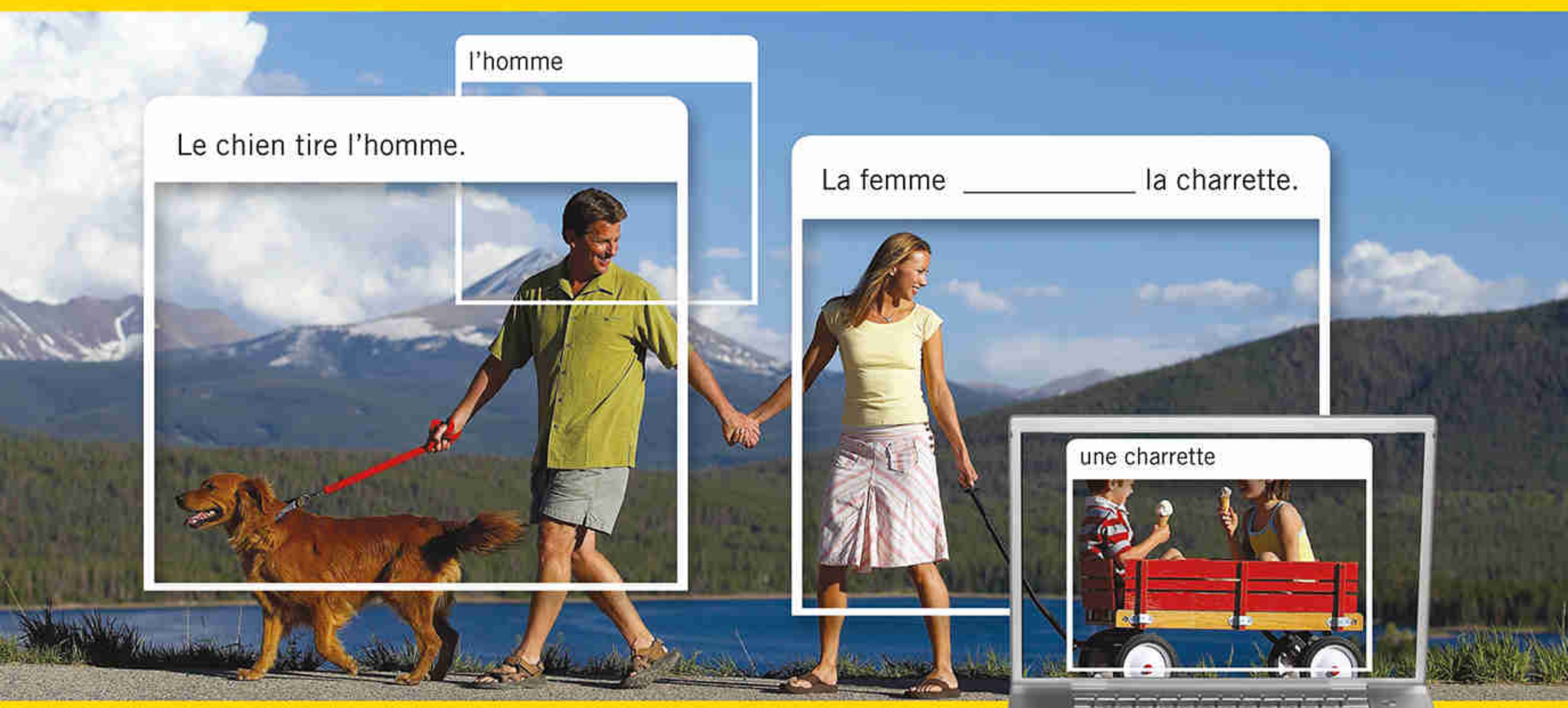

Arabic • Chinese (Mandarin) • Danish • Dutch • English (American) • English (British) • Italian
Filipino (Tagalog) • French • German • Greek • Hebrew • Hindi • Japanese • Korean • Latin • Pashto • Persian (Farsi) • Polish • Portuguese (Brazil) • Russian
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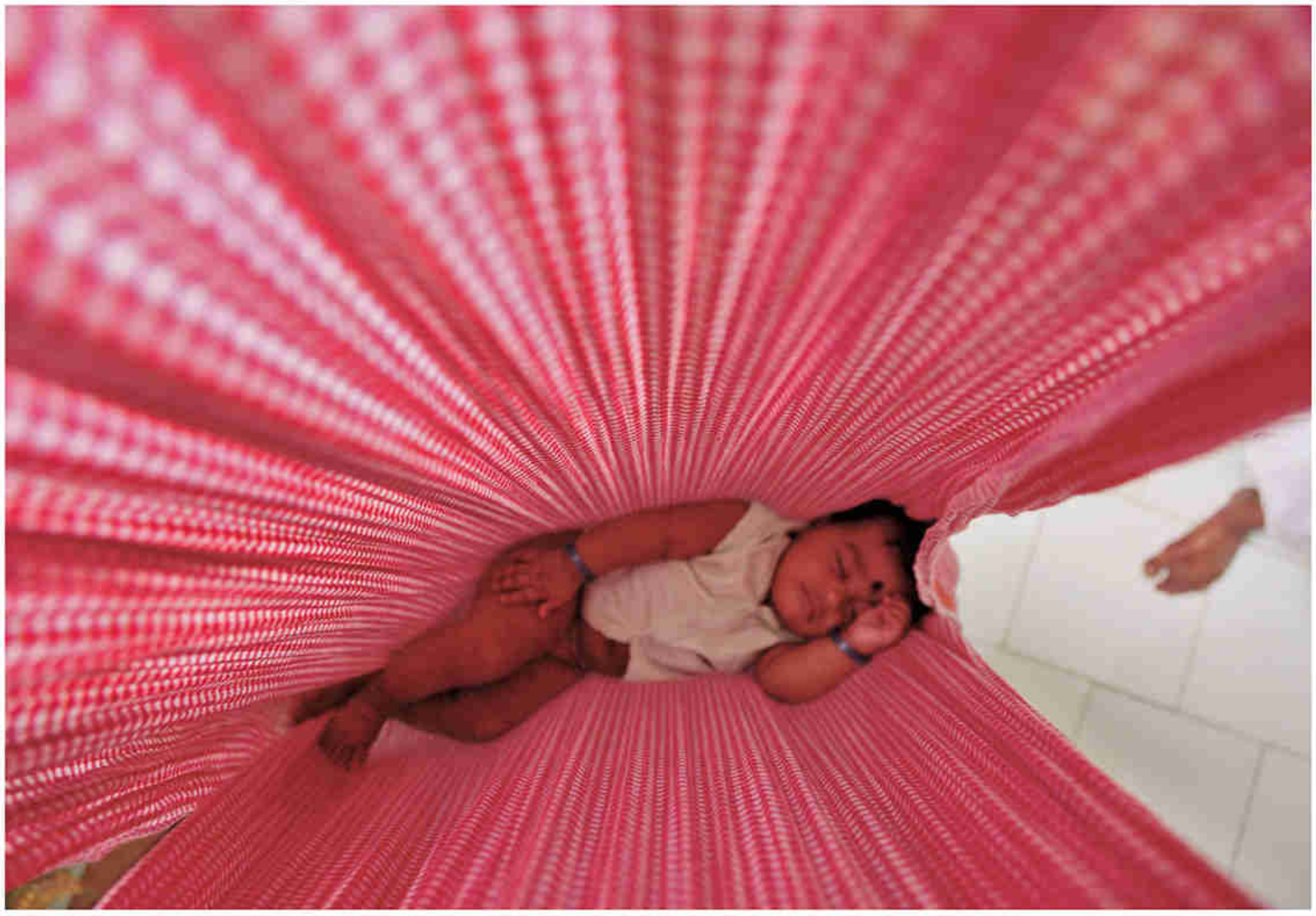
Baby Pictures Let's face it, most young things are adorable, regardless of size, shape, or species. But taking a perfect picture of one can be tricky. Our advice: Look for kids in odd poses or places, *then* capture their cuteness. When you've got just the right shot, send it to us. Every month this page features two photographs: one chosen by our editors, one chosen by our readers via online voting. For more information, go to *ngm.com/yourshot.*



EDITORS' CHOICE

Mariajoseph Johnbasco Neyveli, India

In India, hanging saris can double as rockers for toddlers. Johnbasco, 48, was visiting his mentor in Pondicherry when he noticed the man's granddaughter asleep in this colorfully cascading crib.

Linda Drake San Luis Obispo, California

"I go to this area in Manitoba every year to catch the bears coming out of their dens," says Drake, 40. Near Wapusk National Park she observed this little one hanging out with its mother. "We nicknamed it 'Velcro Cub,'" she says.

READERS' CHOICE

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TRAVEL AVALON CLASS

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TOYOTA
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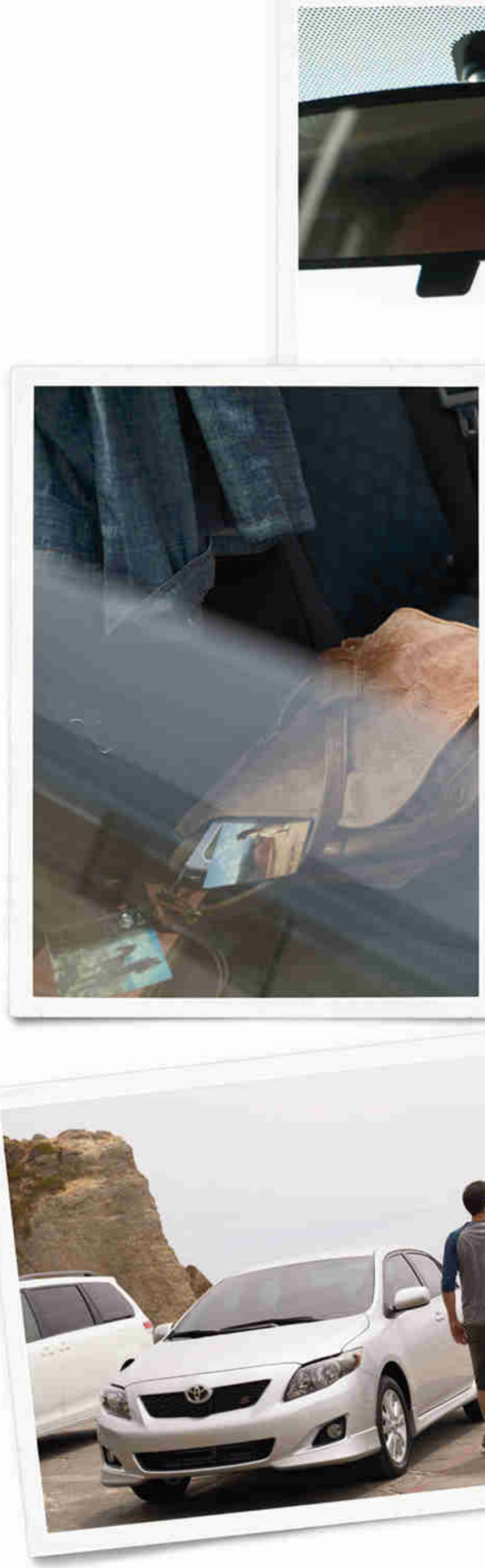
Options shown. Insurance Institute for Highway Safety 2010 rating for Avalon, vehicle class Large Cars. Ratings are only meaningful when comparing vehicles in the same weight class. 2011 model year tested. For more details on 2010 Top Safety Pick Awards, see www.iihs.org

YOUR SHOT

Miguel Costa **São Pedro de Moel, Portugal** Fishermen's sons sit atop the sand at a remote beach south of Luanda, Angola. "Their smiles are always there," says Costa, a freelance photographer.

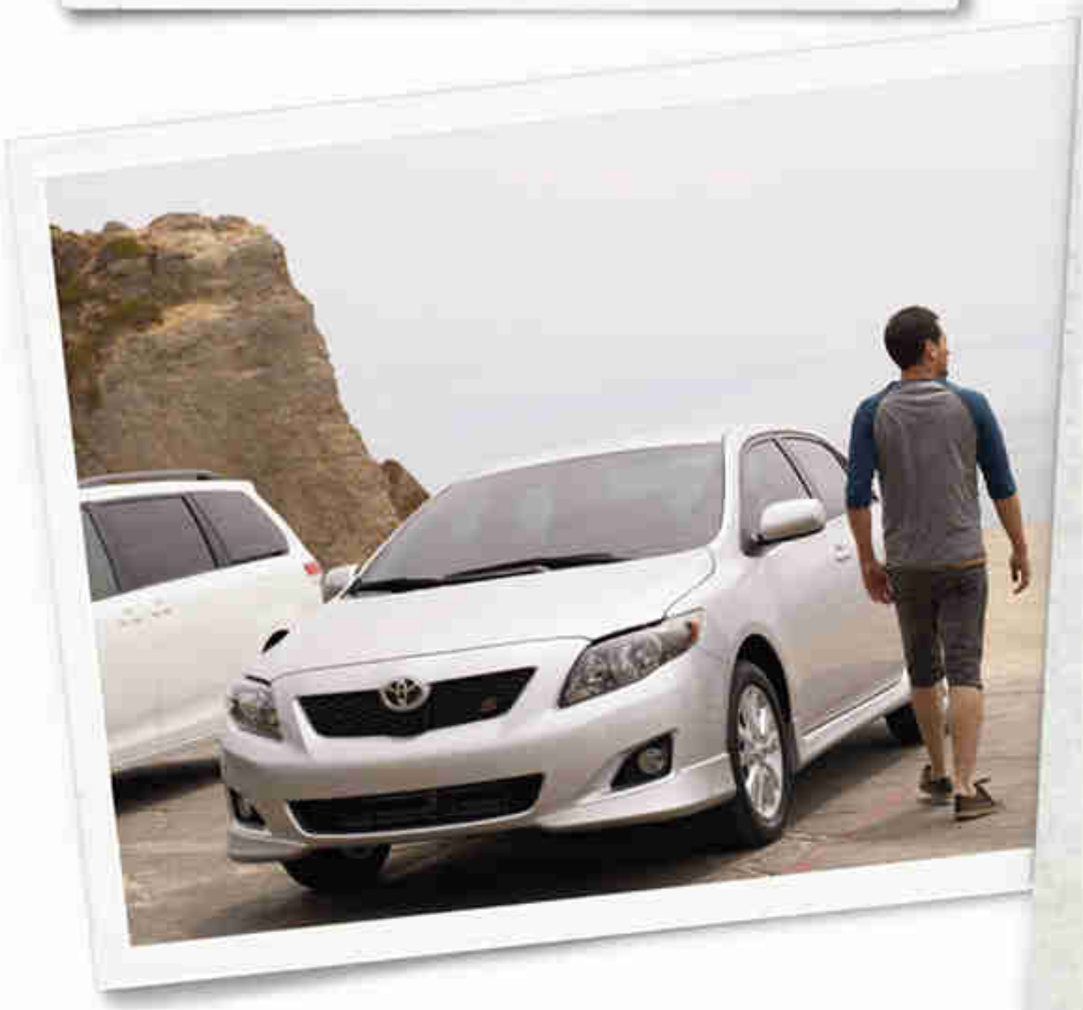
Sharona Beaupré **Maple Ridge, British Columbia** Friends Jonathan Wong (left) and Lincoln Clarke pose to celebrate their graduation from seventh grade. Photographer Beaupré is Clarke's foster mother—and a teacher at the school.



MPG = MY PERSONAL GOALS

WE DIDN'T HAVE A LOT OF MONEY GROWING UP. MY PARENTS CAME HERE FROM ECUADOR. THEY RAISED ME TO WORK HARD AND PROVIDE FOR MYSELF. MAKE MY OWN FATE. MY NEW COROLLA IS THE FIRST THING THAT I COULD SAY IS REALLY MINE. NOT USED. NOT A HAND-ME-DOWN. IT MAKES YOU FEEL GOOD. ANOTHER GOAL YOU'VE ACCOMPLISHED. IT JUST MAKES YOU FEEL LIKE YOU'RE DOING STUFF WITH YOUR LIFE. I'M FINALLY ON MY OWN.

SERGIO MONSERRATE
2010 COROLLA OWNER



Every Toyota has a story.
And with 35 million Corollas sold worldwide,* we want to hear yours.
Share it at facebook.com/toyota

TOYOTA
moving forward

Thanks for your story, Sergio!

Options shown. *Based on Toyota Motor Corporation sales data since Corolla's inception in 1966 through January 2009.

VISIONS OF EARTH

Barbados Several species of morning swimmers—human tourists, protected turtles, assorted fish—share the azure waters of Paynes Bay. Boat operators here feed fish-strip breakfasts to about 15 young hawksbill and green turtles.

PHOTO: CHARLIE HAMILTON JAMES

United States Seen from a satellite, the 2,600-acre "boneyard"—a 64-year-old depot at Davis-Monthan Air Force Base, in Tucson, Arizona—looks like parchment lined with toy planes. The site stores some 4,000 aircraft.

SATELLITE IMAGE: GEOEYE

England Membranous wings spanning two feet and head tucked out of sight, an adult male Egyptian fruit bat negotiates netting in a London studio. This nocturnal fruit-eater was the living subject of an anatomical study.

PHOTO: TIM FLACH

I LOVE THAT NEW ME SMELL

I had been in New York for eight years.
I needed a change of pace.
At twenty-six I kind of woke up and was
like, "All right, time to go." A couple of
months later, I drove out to California with
my dad. I had to have a car to get around
LA, so I got a new Corolla. It's my first
brand new car that I bought on my
own. It was like, I don't know, I made it.
like, I'm an adult.

Stephanie Powell
2010 Corolla owner

Every Toyota has a story. And with 35 million Corollas sold worldwide,* we want to hear yours.
Share it at facebook.com/toyota

Thanks for your story, Stephanie!

TOYOTA
moving forward

Options shown.*Based on Toyota Motor Corporation sales data since Corolla's inception in 1966 through January 2009. ©2010 Toyota Motor Sales, U.S.A., Inc.

HISTORY

Recovered artifacts bear witness to lives and buildings lost on September 11, 2001.

Found at Ground Zero

If every object tells a story, the ones displayed here speak of thousands with a common ending: a Georgia man whose wife slipped him a love note **1** for his trip to New York City; a woman with prayer beads **2** at work on the 98th floor of the World Trade Center; a husband who always carried a two-dollar bill **3** to remind him how lucky he was to have met his second wife.

Collected for the National September 11 Memorial & Museum, the objects tell of love, faith (Bible pages fused to metal **4**), lifestyles (a Mercedes key **5** and a golf ball **6**), and a workday (computer keyboard **7**) that came to a tragic end in 2001. The museum, set to open in September 2012, has some 3,000 artifacts so far, hundreds of them bestowed by relatives of those who perished.

A ladies' shoe **8** is one of several objects here that belong to survivors. The four-inch heels carried their owner down 62 floors, away from the crumbling south tower, and across the Manhattan Bridge to safety. *—Luna Shyr*

PHOTOS: IRA BLOCK
SOURCE: NATIONAL SEPTEMBER 11 MEMORIAL & MUSEUM

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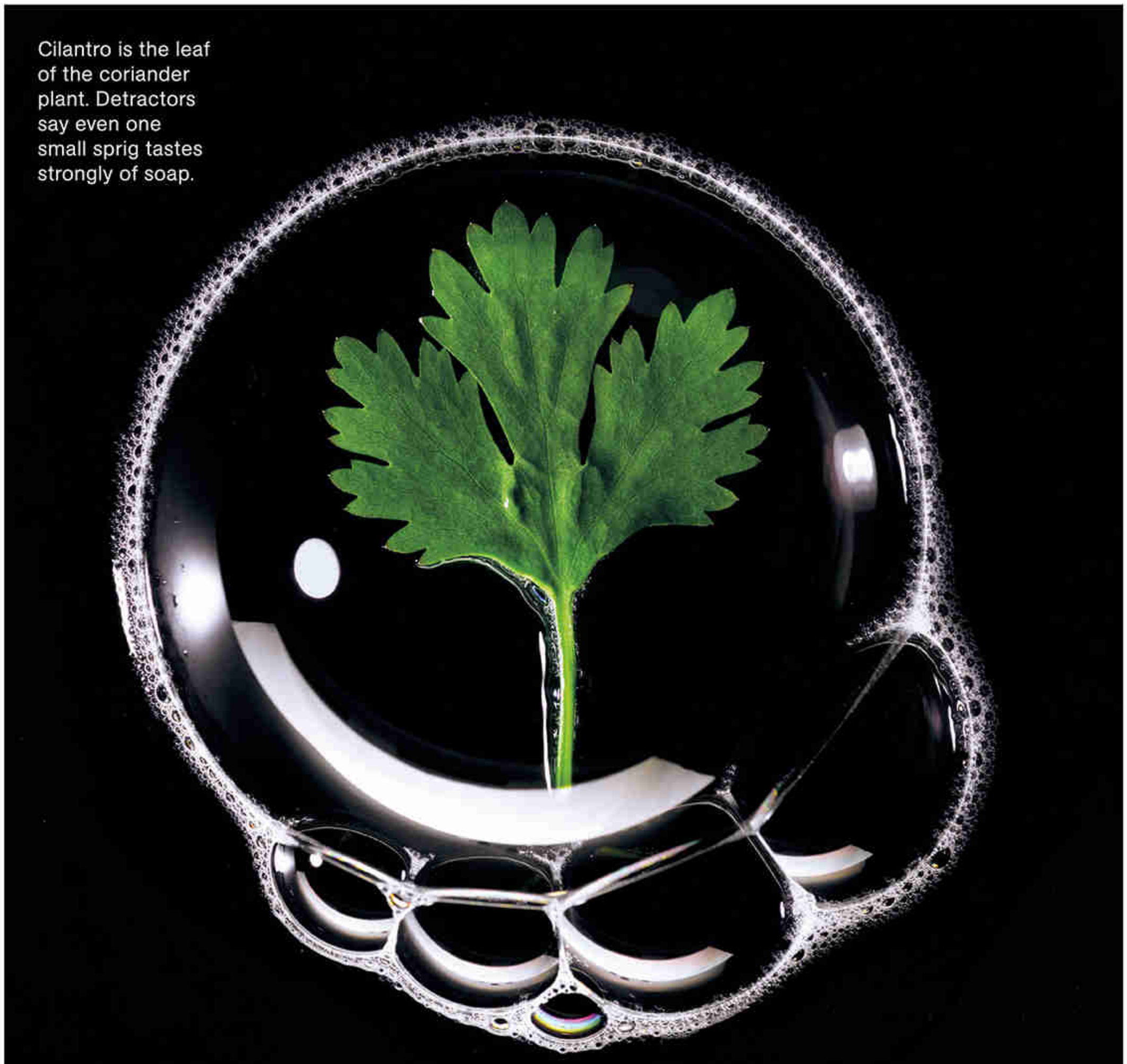


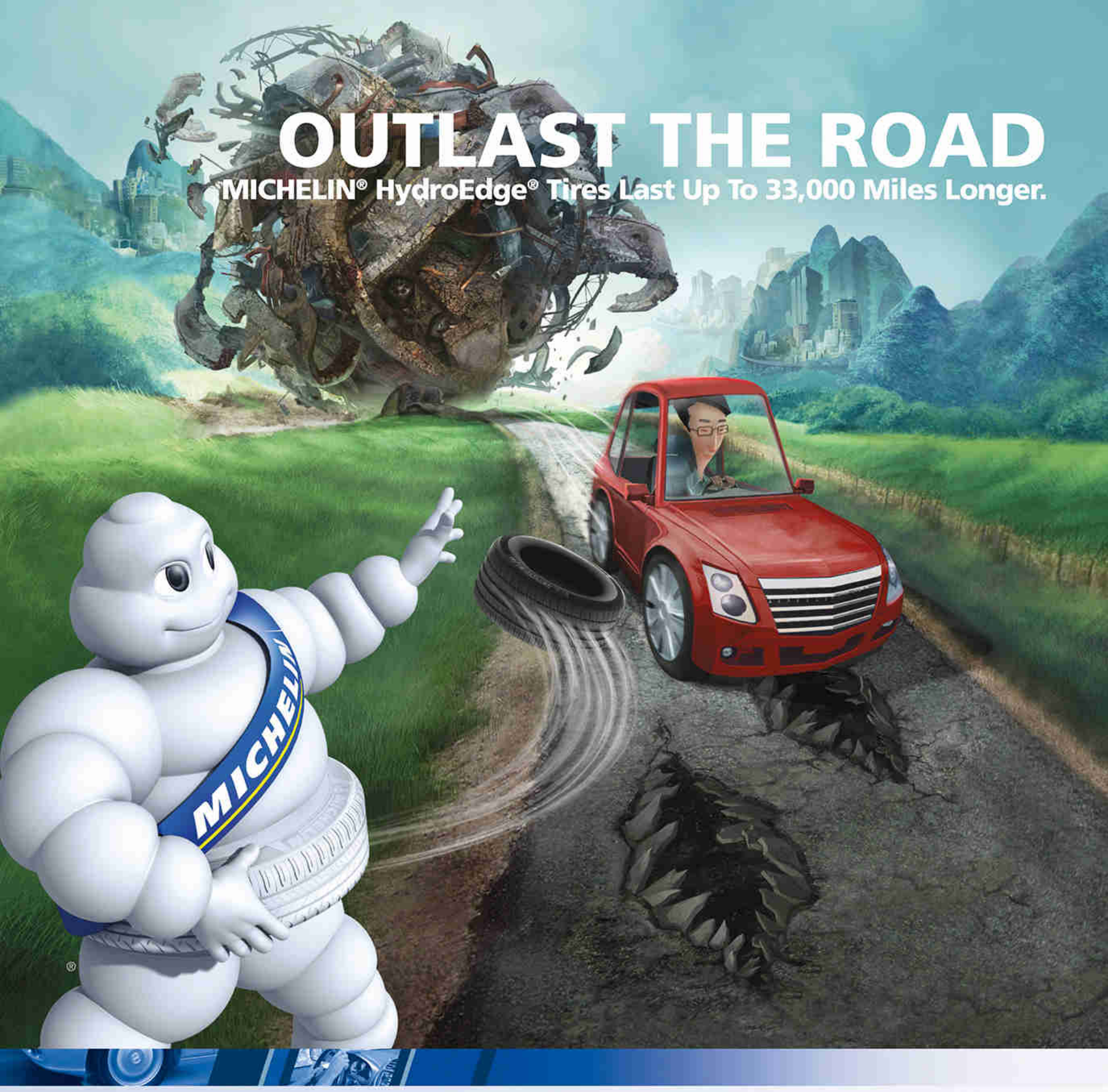
Herbaceous Debate Cilantro is one polarizing herb. The seemingly innocuous staple of Mexican, Asian, and Indian cuisines has become a fresh ingredient in news stories and inspired passion-fueled blogs. Fans liken its notes to those of citrus; haters say they smack of soap. Whichever side of the produce aisle you're on, solidarity abounds.

Yet it isn't simply a matter of taste. According to Charles Wysocki of the Monell Chemical Sense Center, it's actually about flavor, which the brain perceives based on a complex combination of taste, smell, heat, texture. In the case of cilantro, Wysocki has a hunch that genes play a role too. His ongoing study of twins shows that identical ones have the same reaction to it far more often than fraternal ones do.

The genetic verdict is still out, but one thing is certain: In California, where annual records are carefully kept, cilantro production has doubled in the past decade. Agricultural economist Gary Lucier says Americans are eating on average at least a third of a pound of it a year, likely due to our increasingly diverse culinary scene.

Does that taste like victory, or work you into a lather? *—Catherine Barker*

PHOTO: MARK THIESSEN, NGM STAFF



MICHELIN® HydroEdge® tires:

LONGEVITY	STOPPING DISTANCE	FUEL EFFICIENCY
LAST UP TO **33,000** MILES LONGER THAN A LEADING COMPETITOR[1]	STOP UP TO **14'** SHORTER IN WET CONDITIONS THAN A LEADING COMPETITOR[2]	**#1** IN CATEGORY[3]

Go the distance with MICHELIN® HydroEdge® tires. MICHELIN HydroEdge tires last up to 33,000 miles longer than the leading competitor,[1] saving you money by replacing your tires less often. In addition, the MICHELIN HydroEdge tire stops up to 14 feet shorter in wet conditions than the leading competitor[2] and is the most fuel efficient tire in the category.[3] See how the right tire changes everything at **michelinman.com/lastlonger.**

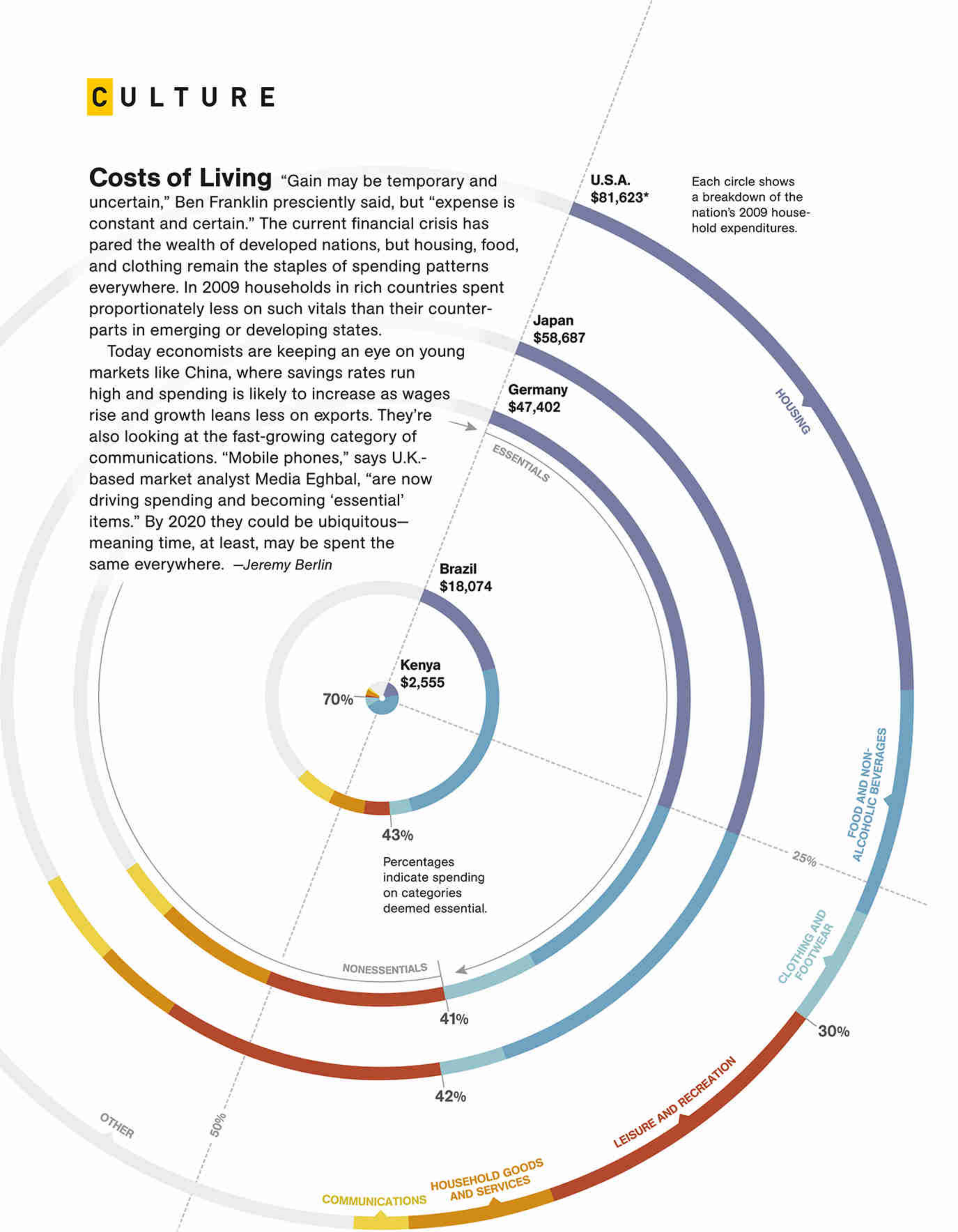
MICHELIN
A better way forward

1- Based on third-party wear test results versus Goodyear® Assurance® products. 2- Based on third-party wet braking test results versus the Goodyear® Assurance® ComforTred® product line in wet testing. 3- Comparisons based upon fuel efficiency testing between MICHELIN® HydroEdge® tires, Goodyear® Assurance® TripleTred™ tires, Goodyear® Assurance® ComforTred® tires, and Bridgestone® Turanza® EL400 tires. Fuel savings are estimates based on comparative rolling resistance. Actual on-road savings may vary. Based on comparisons against the leading competitors in the standard S/T-rated all-season category.

Costs of Living

"Gain may be temporary and uncertain," Ben Franklin presciently said, but "expense is constant and certain." The current financial crisis has pared the wealth of developed nations, but housing, food, and clothing remain the staples of spending patterns everywhere. In 2009 households in rich countries spent proportionately less on such vitals than their counterparts in emerging or developing states.

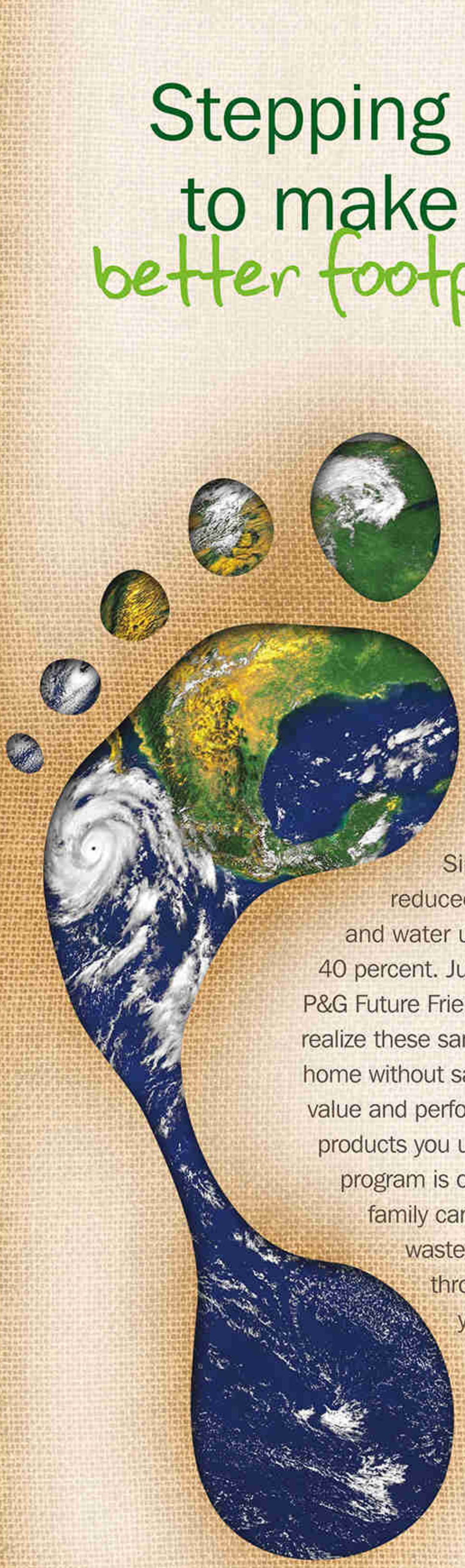
Today economists are keeping an eye on young markets like China, where savings rates run high and spending is likely to increase as wages rise and growth leans less on exports. They're also looking at the fast-growing category of communications. "Mobile phones," says U.K.-based market analyst Media Eghbal, "are now driving spending and becoming 'essential' items." By 2020 they could be ubiquitous—meaning time, at least, may be spent the same everywhere. *—Jeremy Berlin*



*TOTAL CONSUMER SPENDING DIVIDED BY NUMBER OF HOUSEHOLDS; KENYA DATA EXTRAPOLATED FROM PREVIOUS YEARS
GRAPHIC: MOLLIE BATES. SOURCE: EUROMONITOR INTERNATIONAL

YOUR KIDS' SCHOOL CAN
WIN BIG!
Enter The Find Your Footprint Contest.

Stepping up to make a better footprint.



Little changes can make a big impact.

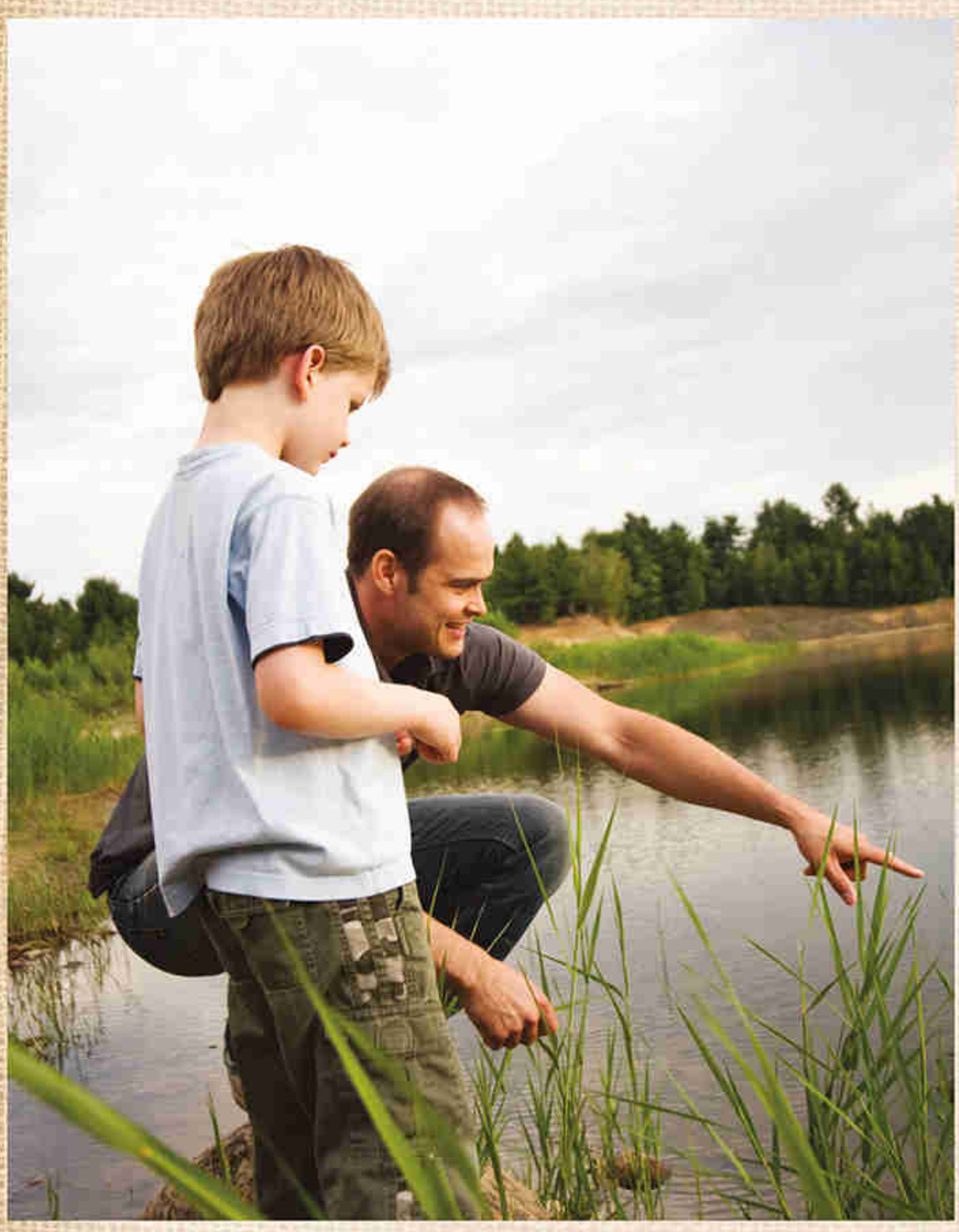
You prove it every time you recycle a newspaper, unplug your computer, or fix a leaky faucet. Just as you've made changes to reduce your human footprint, P&G has made changes to reduce its corporate footprint. Since 2002, P&G has reduced its energy, waste, and water use by more than 40 percent. Just as importantly, P&G Future Friendly helps families realize these same savings at home without sacrificing the value and performance of the products you use every day. The program is one simple way your family can save energy, reduce waste, and save water—even through something as simple as your next load of laundry or dishes.

Read on to learn more about what P&G is doing, plus, help your child's school get state-of-the-art educational tools by entering to win.

P&G FUTURE FRIENDLY™

Find Your Footprint

Help your kids put what they've learned at home into practice *at their school.*



Please visit this site to get ideas and tips on what you can do at home:
FutureFriendly.com/Partners/HomeGuide.aspx

Everything your family does at home to save energy, reduce waste, and save water makes a difference. But why stop there? Now your kids can inspire their entire school to make a difference by entering the P&G Future Friendly Find Your Footprint contest.

It all starts with a challenge from P&G Future Friendly to get kids involved in making their schools greener. Classes enter the contest by documenting their school's footprint and coming up with ways to improve it.

The winning class will receive five state-of-the-art Promethean ActivBoards for their school. This remarkable technology not only creates a more active, stimulating learning environment, but also saves paper and reduces waste.

Put your kids' creativity into action.

The P&G Future Friendly Find Your Footprint contest inspires kids to ask questions that will lead to positive changes throughout their schools.

- Are lights on in classrooms, copy rooms, or closets even when no one's there?
- Does the cafeteria have recycling and compost bins?
- Are all papers teachers hand out printed on both sides?
- Does the class recycle all the paper it throws away?
- Are energy-saving light bulbs and fixtures being used?
- Are dripping faucets wasting water?
- Are there gardens and trees planted outside to help clean the air?
- Are the shades drawn in classrooms to hold in heat on cold days and block out sun when it's warm?

We can't wait to see the creative solutions and new ideas kids can come up with to improve the footprint—and future—of their school.

Sample product shown. Prize product based on winner's preference and availability.

PROMETHEAN
LIGHTING THE FLAME OF LEARNING

GRAND PRIZE

FIVE ACTIVBOARDS BY PROMETHEAN
360-degree technology-enabled learning environments with interactive whiteboards and learner-response systems.

NATIONAL GEOGRAPHIC "LIBRARY"
Up to $1,000 worth of award-winning atlases, books, maps, and more.

***NATIONAL GEOGRAPHIC KIDS* MAGAZINE**
Every student in the winning class receives a one-year subscription.

Encourage your kids to get their class involved.

P&G FUTURE FRIENDLY™

FULL CONTEST DETAILS AT:

nationalgeographic.com/findyourfootprint

ENTRIES MUST BE RECEIVED BY DECEMBER 3, 2010.

Find Your Footprint

OFFICIAL RULES: See complete official rules at *www.nationalgeographic.com/findyourfootprint*. NO PURCHASE NECESSARY. A PURCHASE WILL NOT INCREASE YOUR CHANCES OF WINNING. Contest is open only to legal residents of the fifty (50) United States and D.C. at least 21 years old and who are kindergarten through sixth-grade teachers at a public or private school entering the Contest on behalf of his/her class. Employees of National Geographic Society, Procter and Gamble, Promethean, and related parties are ineligible. Entries must be received by 11:59:59 p.m. ET on December 3, 2010. Limit one entry per person and per classroom. To enter, go to *www.nationalgeographic.com/findyourfootprint* to download your free National Geographic Find Your Footprint Lesson Plan (the "Lesson Plan"). Using the Lesson Plan, develop a proposal by answering all of the questions to identify your school's footprint (consumption) and to outline steps that you could take to initiate environmentally responsible improvements to reduce waste and consumption at your school. You may include photos, videos, or drawings to further illustrate your action plan. Complete the entry by following the online directions. Entries will be judged as described in the Official Rules. The Grand Prize Winner's school will be awarded five (5) Promethean whiteboards, five (5) Promethean response devices, a library of National Geographic products, and thirty (30) one-year subscriptions to *National Geographic Kids* magazine. Approximate retail value ("ARV") is $13,600. CONTEST IS VOID WHERE PROHIBITED BY LAW.

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Uses 6.6 fewer liters of water per average sink load by cleaning directly with foam.*

Save Water

Eliminates up to 3,200 plastic water bottles per year, per household.**

Reduce Waste

Cuts energy use up to 80 percent in every laundry load.***

Save Energy

Day by day, choice by choice, P&G Future Friendly invites you to join in making Future Friendly decisions to save energy, save water, and reduce waste. From choosing products with less environmental impact to helping your kids make their school a greener place, every action adds up. The small steps we take together can create big benefits for our planet—now and for generations to come.

Learn more at ***WWW.FUTUREFRIENDLY.COM***

P&G FUTURE FRIENDLY™

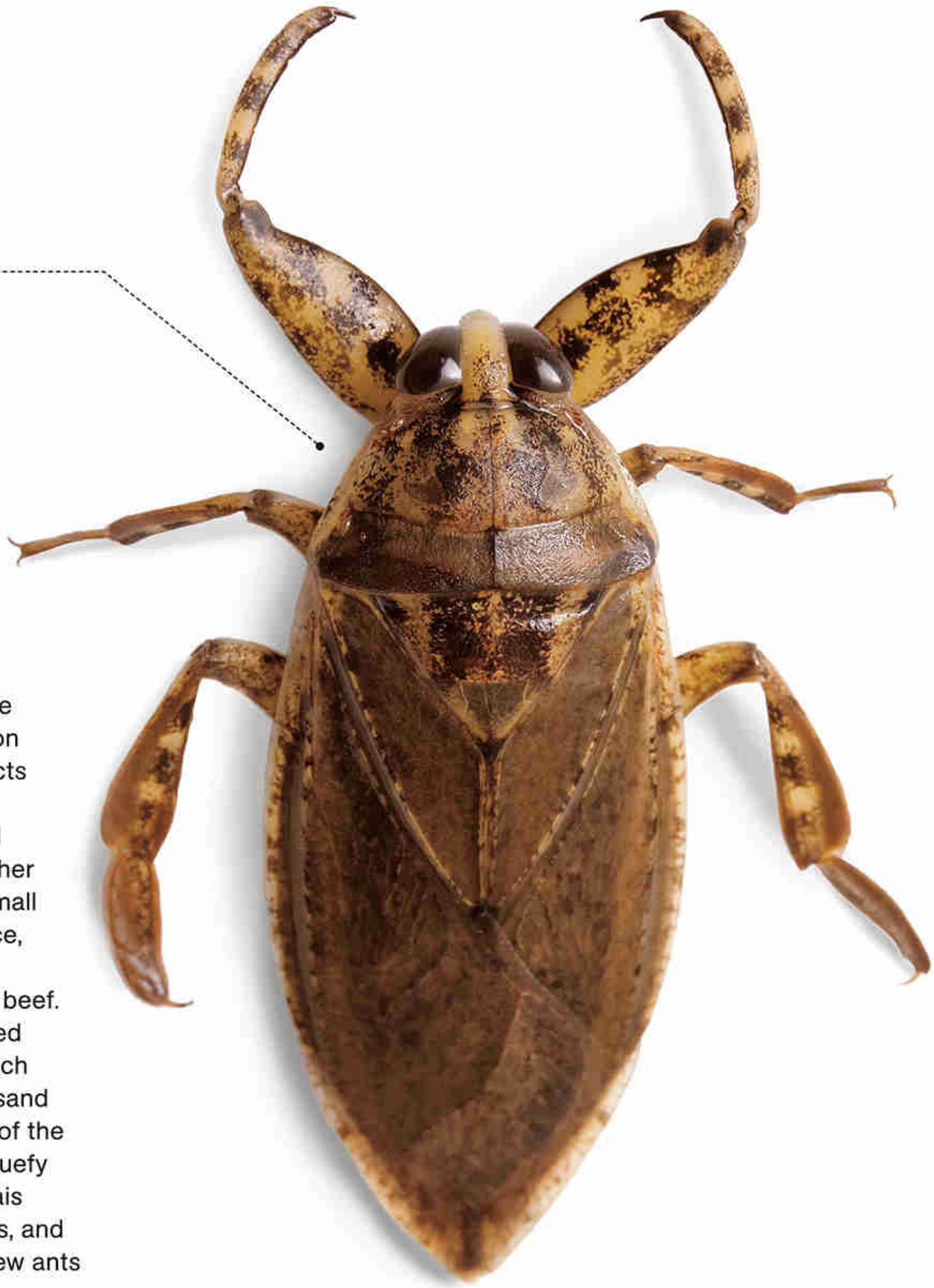
Find Your Footprint

*Vs. traditional dish liquid **When comparing the annual capacity and average price of the PUR faucet mount system and three refills based on filter life expectancy to corresponding number and average price of 16 oz. water bottles. ***By switching from warm/cold to cold/cold cycles for all loads in a standard top loader machine with an electric water heater set at 140F.

Nutrition Facts
Giant water bugs
Serving size: 100g

Amount Per Serving

Calories 62
Total Fat 8.3g
Phosphorus 226mg
Iron 14mg
Calcium 44mg
Carbohydrate 2.1g
Protein 19.8g



Crawly Cuisine

Don't bug out, but the UN's Food and Agriculture Organization is working on a policy to promote insects as food worldwide. Turns out beetles, crickets, and many other types are rather nutritious. A serving of small grasshoppers, for instance, packs nearly the same protein punch as ground beef. And insects can be farmed more cheaply and on much less land. At least a thousand species are already part of the human diet: Mexicans liquefy stinkbugs for sauces, Thais deep-fry giant water bugs, and Australian Aborigines chew ants that have a lemony flavor.

As the global population nears seven billion, the FAO sees insect farming as a move toward food security—a subject for its upcoming conference on entomophagy, the practice of insect eating. Getting skittish diners in the West to swallow the idea poses the biggest challenge, says entomologist Gene DeFoliart, who has a penchant for termites. "It's time to take this seriously," he says. Once we do, a fly in your soup could come with the chef's compliments. *—Jennifer S. Holland*

Small grasshoppers
Serving size: 100g

Amount Per Serving

Calories 153
Total Fat 6.1g
Phosphorus 238mg
Iron 5mg
Calcium 35mg
Carbohydrate 3.9g
Protein 20.6g

Red ant eggs
Serving size: 100g

Amount Per Serving

Calories 83
Total Fat 3.2g
Phosphorus 113mg
Iron 4mg
Calcium 8mg
Carbohydrate 6.5g
Protein 7g

Crickets
Serving size: 100g

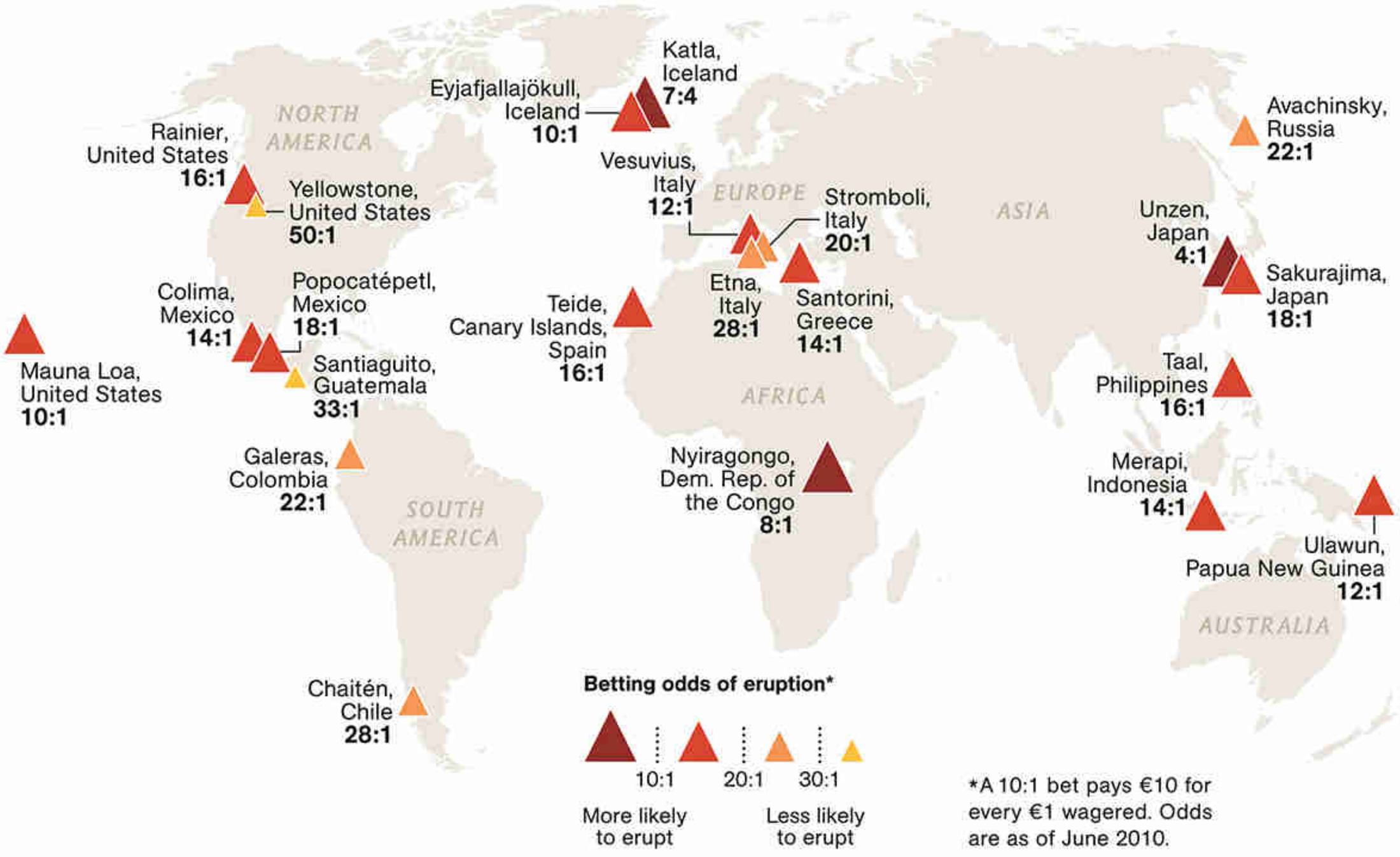
Amount Per Serving

Calories 122
Total Fat 5.5g
Phosphorus 185mg
Iron 10mg
Calcium 76mg
Carbohydrate 5.1g
Protein 12.9g

PHOTOS: JOEL SARTORE; STEFAN SOLLFORS, ALAMY (ANT)
SOURCE: JULIETA RAMOS-ELORDUY, *CREEPY CRAWLY CUISINE*

An Explosive Wager

Never mind the World Cup or Super Bowl. With a bevy of volcanoes in various states of agitation, a Dublin bookie offers the chance to cash in on the ones that blow.



It's an investment even more volatile than stocks: the next big volcanic eruption. Well before Iceland's Eyjafjallajökull blew this year, Ireland's largest bookie, Paddy Power, was letting punters bet on the peak they deemed most likely to explode. The seven-to-four favorite? Another Icelandic peak, Katla. Eyjafjallajökull now sits in fourth place, along with Hawaii's Mauna Loa (ten to one). Unlikely to go off, but with a big purse if it does: Yellowstone (50 to one).

"Volcanoes with regular lava flows or burps are hot favorites," says Paddy Power spokesman Darren Haines. "Dormant volcanoes can see odds as low as 500 to one." Probabilities are calculated using the Volcanic Explosivity Index—the scale, ranging from zero (nonexplosive) to eight (megacolossal), that scientists use to rank eruption severity. The first volcano to hit level three, with plumes at least two miles high, will prompt payouts.

Paddy Power's clients came up with the novel market after the 2009 eruption of the Philippines' Mount Mayon. If natural phenomena aren't your thing, this year's bets have also included the next Oscar winners, pope, and James Bond actor—and which country will make first contact with space aliens. (Ireland and the United States were top picks.) On a more somber note, one could have wagered on how many wild polar bears will exist as of the end of 2011 and how many species will be critically endangered. Here's hoping the odds land in the animals' favor.

—Jennifer S. Holland


Eyjafjallajökull volcano

NGM MAPS. PHOTO: ODD STEFAN THORISSON, NORDICPHOTOS/CORBIS

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more flight options, and more time where you want to be.

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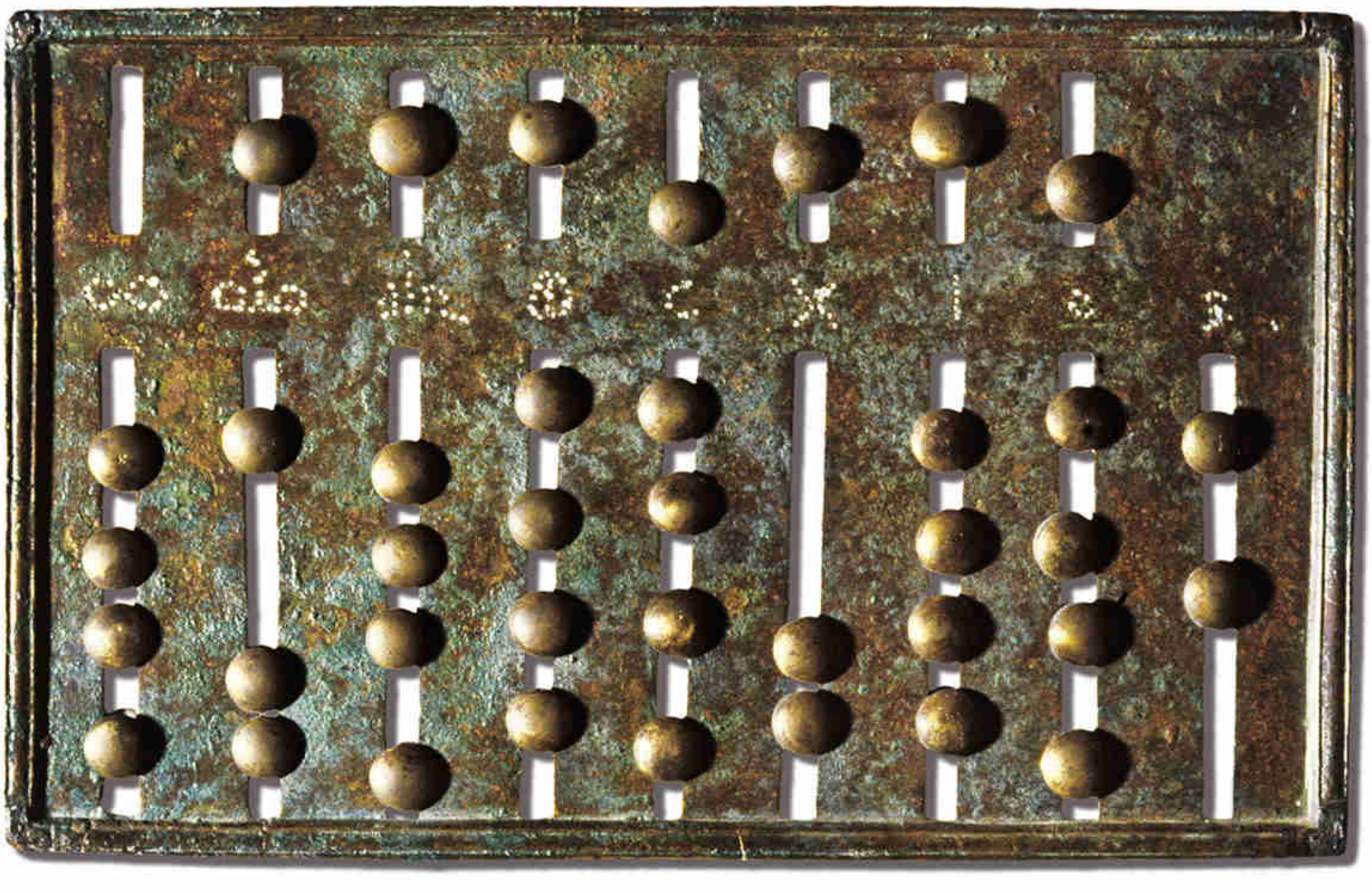
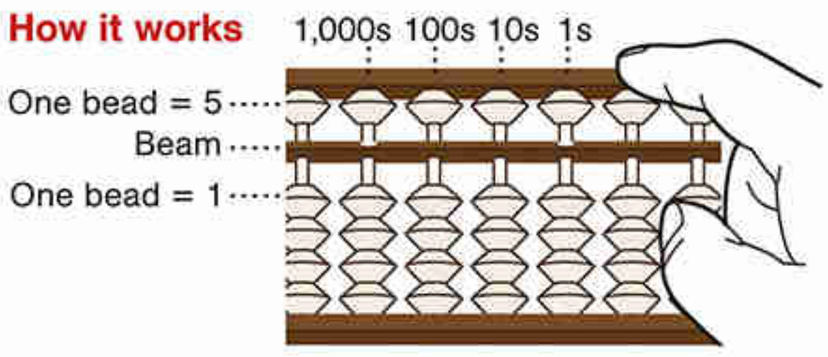


Abaci like this bronze one were used in ancient Rome. Japan's version (below) was adopted in the 16th century.

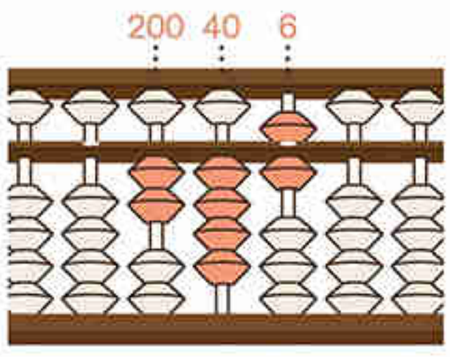
Abacus Masters Quick, what's 3,951,252 divided by 8,031? Royce Chen, 11, needs just a few seconds to answer 492. The California sixth grader, who once had some trouble in math, can now perform such problems in his head. His secret? An ancient tool that's far from obsolete: the abacus.

In fact, the calculating device, believed to be of Babylonian origin, is inspiring independent math courses across the United States. In May nearly 1,800 students tested for abacus proficiency and "mental arithmetic," the process of visualizing bead movements. That teaching method is already common throughout Asia, where youngsters flex their finger muscles in abacus contests. Studies show that abacus mastery helps develop the brain's visuospatial areas. "It contributes to all aspects of thinking, not just math," says Vinaya Kulkarni, whose Seattle-area Abacus West program incorporates memory games. It might also add up to more fun with numbers. *—Luna Shyr*

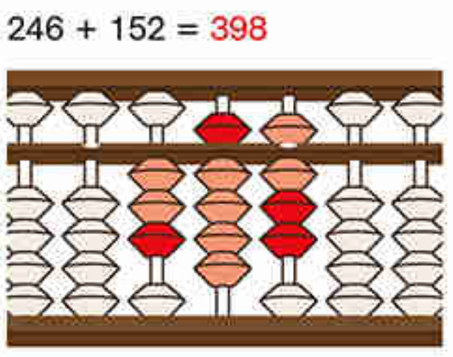
How it works



An abacus can be used to add, subtract, multiply, and divide. Each rod represents a power of ten.



Moving a bead toward the beam adds value. The position of the beads represents a number—in this case 246.



To add 152, add one to the hundreds rod, five to the tens rod, and two to the units rod, for a sum of 398.

PHOTO: NATIONAL MUSEUM OF ROME; SPECIAL SUPERINTENDENCY FOR ARCHAEOLOGICAL ASSETS OF ROME, MINISTRY FOR CULTURAL AFFAIRS. GRAPHIC: JASON LEE. SOURCE: CHINESE AMERICAN ABACUS ASSOCIATION

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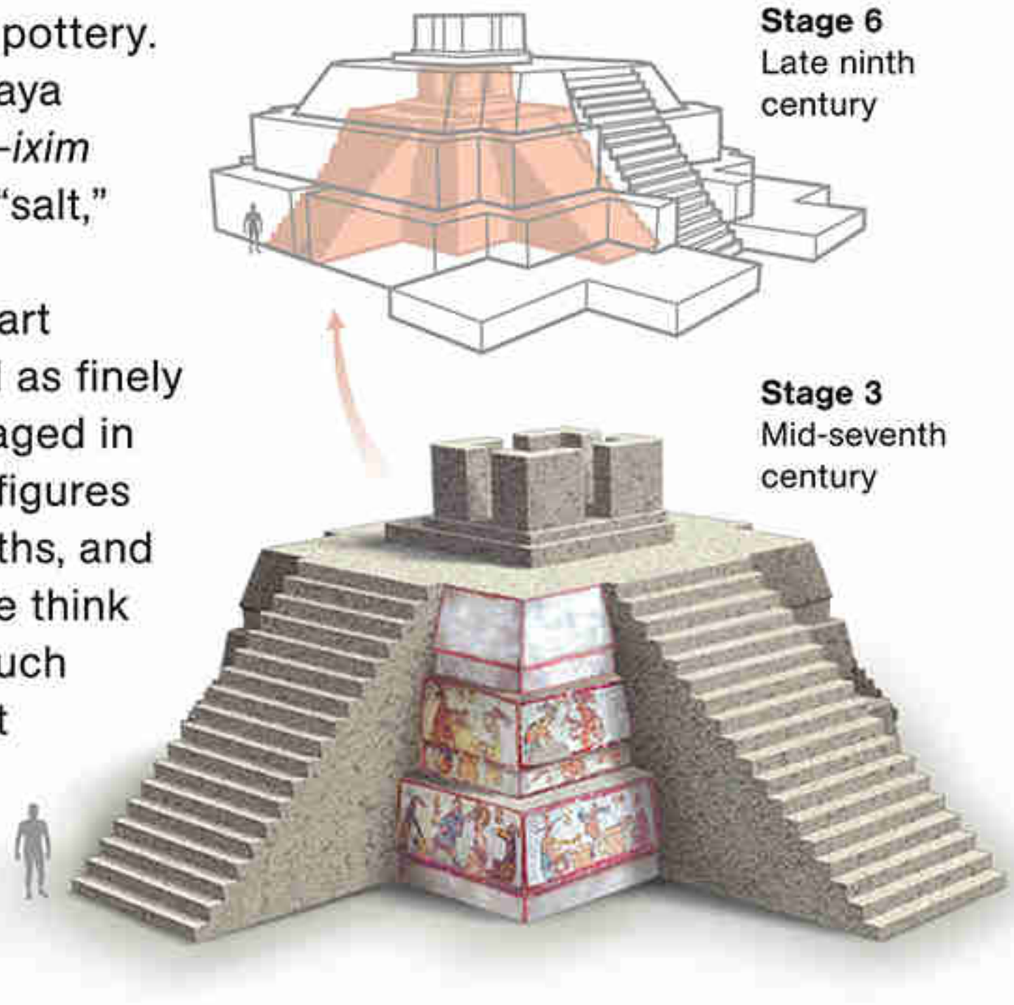
The Working Maya Colorful murals revealed at the site of Calakmul in southern Mexico offer a first ever look at daily activities that once animated great cities ruled by powerful kings. Painted on a pyramid in the seventh century, the murals' scenes show residents transporting and consuming an array of common goods. Hieroglyphs provide job titles—"corn gruel person," for example, and others in charge of tamales, tobacco, and pottery.

Words never seen before in Maya texts are especially intriguing—*ixim* for "raw corn" and *atzaam* for "salt," both important staples.

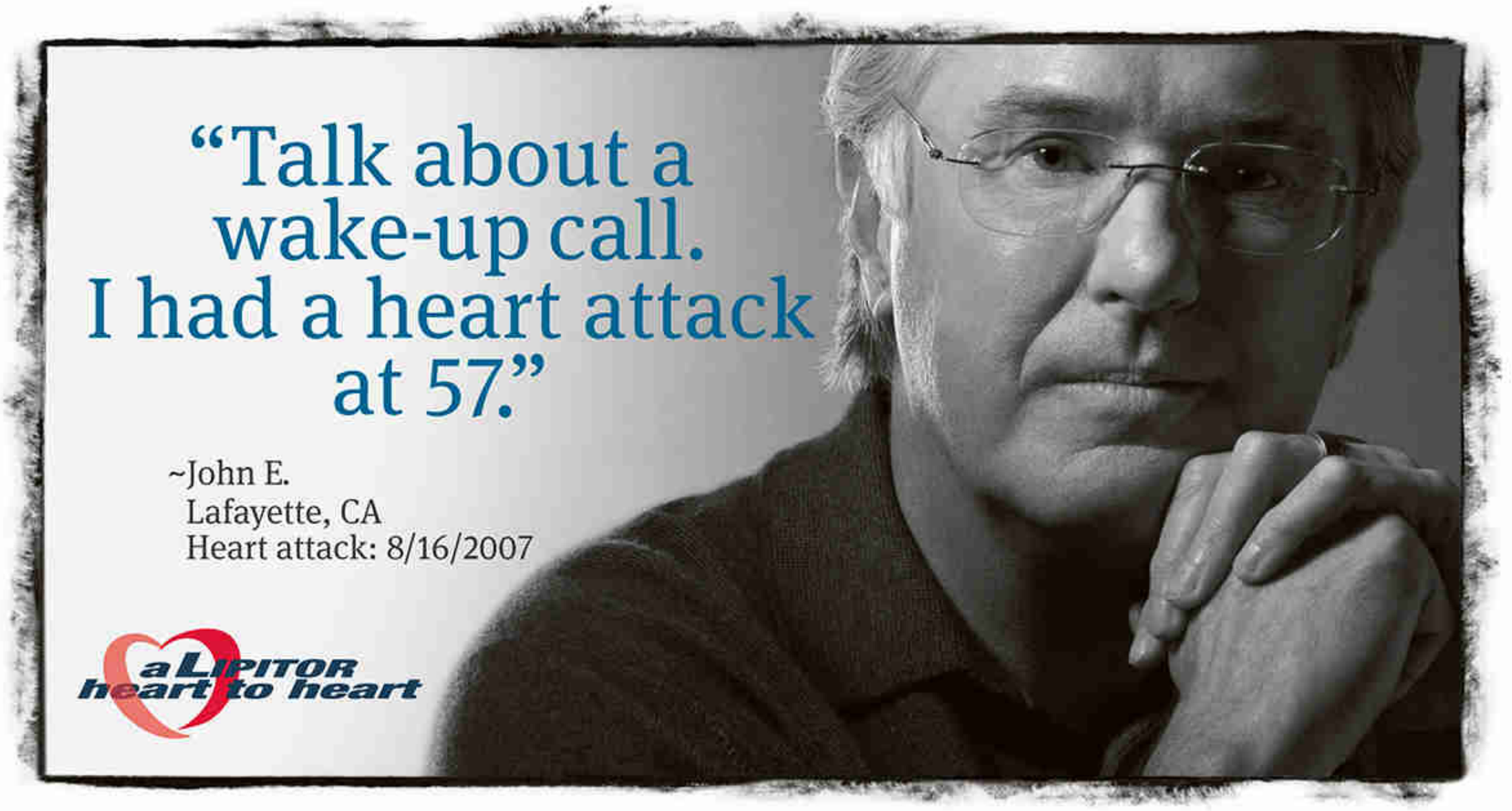
At other sites, monumental art shows mythical scenes as well as finely dressed gods and nobles engaged in wars and rituals. At Calakmul, figures wearing holiday tunics, loincloths, and headbands give experts a new view of Maya society. "We think these scenes represent a festival celebrating an event such as a king's accession to power," says head archaeologist Ramón Carrasco Vargas. Panels yet to be excavated may hold further details of Calakmul's citizens and how they went about their business. *—A. R. Williams*

TREASURED ART
At the corners of a pyramid with grand staircases, some 30 mural scenes have been uncovered beneath tiers added nearly two centuries later.



A Calakmul mural shows two vessels of corn gruel—a pot balanced on a woman's head and a man's sipping bowl.

PHOTO: KENNETH GARRETT
GRAPHICS: HIRAM HENRIQUEZ. SOURCE: CALAKMUL ARCHAEOLOGICAL PROJECT. NGM MAPS



"I should have been doing more for my high cholesterol. I learned the hard way. Now I trust my heart to Lipitor." Talk to your doctor about your risk and about Lipitor.

- When diet and exercise are not enough, adding Lipitor may help. Lipitor is FDA-approved to reduce the risk of heart attack and stroke in patients who have heart disease or risk factors for heart disease, including family history of early heart disease, high blood pressure, low good cholesterol, age and smoking.
- Lipitor has been extensively studied with over 18 years of research. And Lipitor is backed by over 400 ongoing or completed clinical studies.

IMPORTANT SAFETY INFORMATION:
LIPITOR is not for everyone. It is not for those with liver problems. And it is not for women who are nursing, pregnant or may become pregnant.

If you take LIPITOR, tell your doctor if you feel any new muscle pain or weakness. This could be a sign of rare but serious muscle side effects. Tell your doctor about all medications you take. This may help avoid serious drug interactions. Your doctor should do blood tests to check your liver function before and during treatment and may adjust your dose.

Common side effects are diarrhea, upset stomach, muscle and joint pain, and changes in some blood tests.

INDICATION:
LIPITOR is a prescription medicine that is used along with a low-fat diet. It lowers the LDL ("bad" cholesterol) and triglycerides in your blood. It can raise your HDL ("good" cholesterol) as well. LIPITOR can lower the risk for heart attack, stroke, certain types of heart surgery, and chest pain in patients who have heart disease or risk factors for heart disease such as age, smoking, high blood pressure, low HDL, or family history of early heart disease.

LIPITOR can lower the risk for heart attack or stroke in patients with diabetes and risk factors such as diabetic eye or kidney problems, smoking, or high blood pressure.

Please see additional important information on next page.

LIPITOR® atorvastatin calcium tablets

Have a heart to heart with your doctor about your risk. And about Lipitor.
Call 1-888-LIPITOR (1-888-547-4867) or visit www.lipitor.com/john

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.

IMPORTANT FACTS

LIPITOR
atorvastatin calcium
tablets

(LIP-ih-tore)

LOWERING YOUR HIGH CHOLESTEROL

High cholesterol is more than just a number, it's a risk factor that should not be ignored. If your doctor said you have high cholesterol, you may be at an increased risk for heart attack and stroke. But the good news is, you can take steps to lower your cholesterol.

With the help of your doctor and a cholesterol-lowering medicine like LIPITOR, along with diet and exercise, you could be on your way to lowering your cholesterol.

Ready to start eating right and exercising more? Talk to your doctor and visit the American Heart Association at www.americanheart.org.

WHO IS LIPITOR FOR?

Who can take LIPITOR:

- People who cannot lower their cholesterol enough with diet and exercise
- Adults and children over 10

Who should NOT take LIPITOR:

- Women who are pregnant, may be pregnant, or may become pregnant. LIPITOR may harm your unborn baby. If you become pregnant, stop LIPITOR and call your doctor right away.
- Women who are breast-feeding. LIPITOR can pass into your breast milk and may harm your baby.
- People with liver problems
- People allergic to anything in LIPITOR

BEFORE YOU START LIPITOR

Tell your doctor:

- About all medications you take, including prescriptions, over-the-counter medications, vitamins, and herbal supplements
- If you have muscle aches or weakness
- If you drink more than 2 alcoholic drinks a day
- If you have diabetes or kidney problems
- If you have a thyroid problem

ABOUT LIPITOR

LIPITOR is a prescription medicine. Along with diet and exercise, it lowers "bad" cholesterol in your blood. It can also raise "good" cholesterol (HDL-C).

LIPITOR can lower the risk of heart attack, stroke, certain types of heart surgery, and chest pain in patients who have heart disease or risk factors for heart disease such as:

- age, smoking, high blood pressure, low HDL-C, family history of early heart disease

LIPITOR can lower the risk of heart attack or stroke in patients with diabetes and risk factors such as diabetic eye or kidney problems, smoking, or high blood pressure.

POSSIBLE SIDE EFFECTS OF LIPITOR

Serious side effects in a small number of people:

- **Muscle problems** that can lead to kidney problems, including kidney failure. Your chance for muscle problems is higher if you take certain other medicines with LIPITOR.
- **Liver problems**. Your doctor may do blood tests to check your liver before you start LIPITOR and while you are taking it.

Call your doctor right away if you have:

- Unexplained muscle weakness or pain, especially if you have a fever or feel very tired
- Allergic reactions including swelling of the face, lips, tongue, and/or throat that may cause difficulty in breathing or swallowing which may require treatment right away
- Nausea, vomiting, or stomach pain
- Brown or dark-colored urine
- Feeling more tired than usual
- Your skin and the whites of your eyes turn yellow
- Allergic skin reactions

Common side effects of LIPITOR are:

- Diarrhea
- Upset stomach
- Muscle and joint pain
- Changes in some blood tests

HOW TO TAKE LIPITOR

Do:

- Take LIPITOR as prescribed by your doctor.
- Try to eat heart-healthy foods while you take LIPITOR.
- Take LIPITOR at any time of day, with or without food.
- If you miss a dose, take it as soon as you remember. But if it has been more than 12 hours since your missed dose, wait. Take the next dose at your regular time.

Don't:

- Do not change or stop your dose before talking to your doctor.
- Do not start new medicines before talking to your doctor.
- Do not give your LIPITOR to other people. It may harm them even if your problems are the same.
- Do not break the tablet.

NEED MORE INFORMATION?

- Ask your doctor or health care provider.
- Talk to your pharmacist.
- Go to **www.lipitor.com** or call **1-888-LIPITOR**.

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June 2009

Rx only

Amazing New Hybrid Runs Without Gas

The new face of time? Stauer's Compendium Hybrid fuses form and functionality for UNDER $50! Read on...

Innovation is the path to the future. Stauer takes that seriously. That's why we developed the ***Compendium Hybrid***, a stunningly-designed hybrid chronograph with over one dozen analog and digital functions that is more versatile than any watch that we have ever engineered.

New technology usually starts out at astronomical prices and then comes down years later. We skipped that step to allow everyone the chance to experience this watch's brilliant fusion of technology and style. We originally priced the Stauer ***Compendium Hybrid*** at $395 based on the market for advanced sports watches... but then stopped ourselves. Since this is no ordinary economy, we decided to start at 88% off from day one. That means this new technological marvel can be yours for only $49!

Welcome a new Digital Revolution. With the release of the dynamic new ***Compendium***, those boxy, plastic wrist calculators of the past have been replaced by this luxurious LCD chronograph that is sophisticated enough for a formal evening out, but rugged and tough enough to feel at home in a cockpit, camping expedition or covert mission.

The watch's extraordinary dial seamlessly blends an analog watch face with a stylish digital display. Three super-bright luminous hands keep time along the inner dial, while a trio of circular LCD windows track the hour, minutes and seconds. An eye-catching digital semi-circle animates in time with the second hand and shows the day of the week. The watch also features a rotating bezel, stopwatch and alarm functions and blue, electro-luminescence backlight. The ***Compendium Hybrid*** secures with a rugged stainless steel band and is water-resistant to 3 ATMs.

Guaranteed to change the way you look at time. At Stauer, we believe that when faced with an uphill economy, innovation and better value will always provide a much-needed boost. Stauer is so confident of their latest hybrid timepiece that we offer a money-back-guarantee. If for any reason you aren't fully impressed by the performance and innovation of the Stauer ***Compendium Hybrid*** for $49, simply return the watch within 30 days for a full refund of the purchase price. The unique design of the ***Compendium*** greatly limits our productions, so don't hesitate to order! Remember: progress and innovation wait for no one!

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- Stop watch function
- Water resistant to 3 ATMs
- Fits 6 3/4"–8 3/4" wrist

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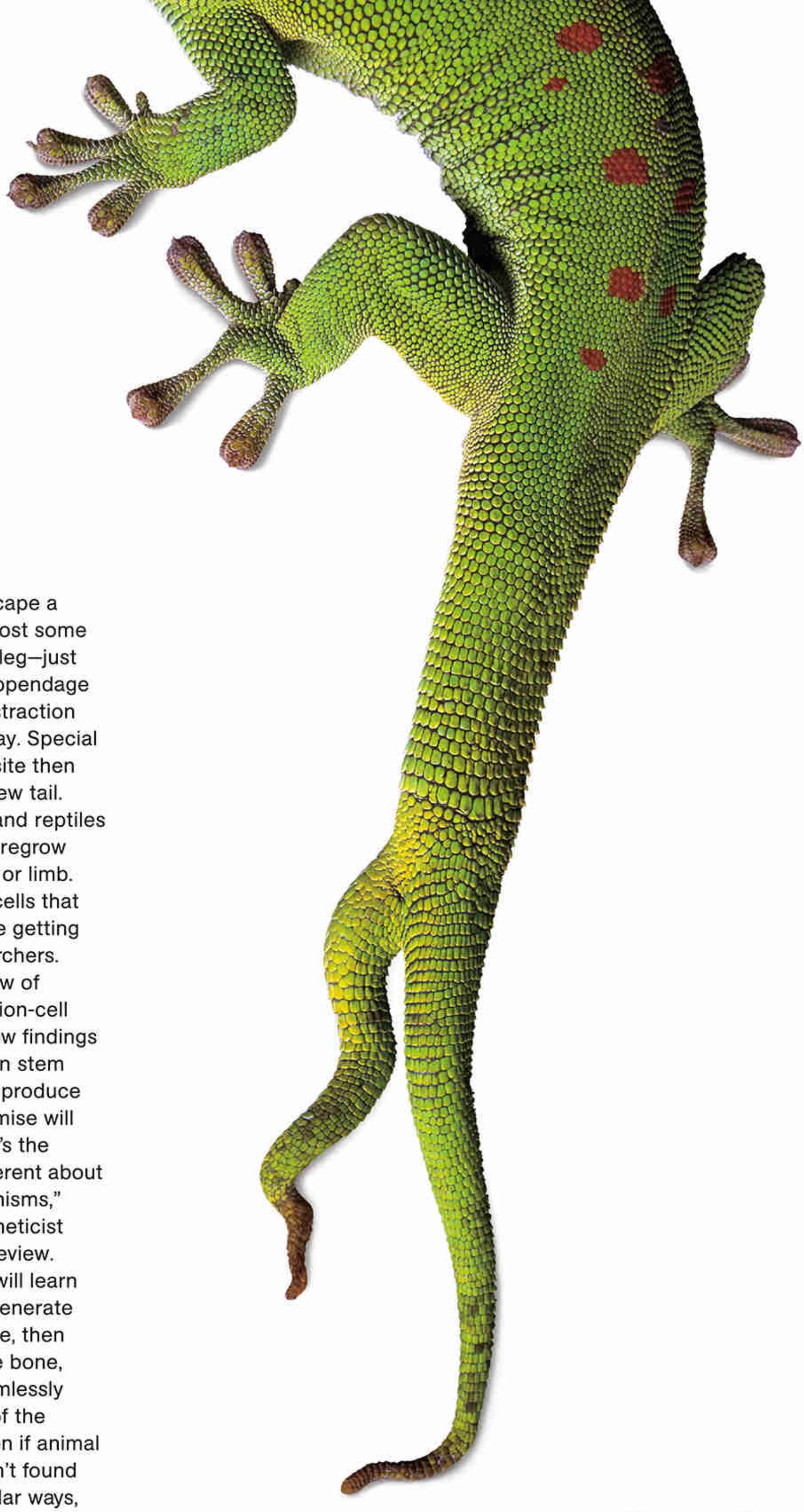
WILD

Tail Spin To escape a predator, it doesn't cost some lizards an arm and a leg—just a tail. The wiggling appendage is left behind as a distraction as the lizard gets away. Special cells at the fracture site then trigger growth of a new tail. Several amphibians and reptiles possess an ability to regrow portions of a lost tail or limb.

Now some of the cells that make this happen are getting attention from researchers. A 2010 Harvard review of amphibian regeneration-cell research included how findings could relate to human stem cells, which can also produce new tissue. "The promise will be to figure out what's the same and what's different about regeneration mechanisms," says Cliff Tabin, a geneticist who worked on the review. He hopes scientists will learn how animals that regenerate "get limbs and muscle, then hook that up with the bone, and have nerves seamlessly connect to the rest of the nervous system." Even if animal and human cells aren't found to regenerate in similar ways, the comparison "can give us a direct model to be applied to clinical studies," says Tabin. "It's a creative way to improve human health." *—Dana Cetrone*



The regeneration process went slightly awry for this day gecko, which lost its tail—and grew back two.

PHOTO: JOEL SARTORE

"REINA DOESN'T RISK
HER LIFE FOR A PAYCHECK.
SHE DOES IT FOR ME.

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HER EUKANUBA."

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Women in Malawi gather for export baobab fruits that once might have rotted on the ground.

BAOBAB PRODUCTS
The powdery white interior of the fruit can be used as an ingredient in many foods.

- **Jams** Rich in pectin, it also works as a thickener for gravy or smoothies.
- **Fruit drinks** Just mix in water and a sweetener.
- **Hot sauces** It adds tangy flavor to fiery toppings.

Vitamin Tree Within the velvety shell of its coconut-size fruits, Africa's iconic baobab packs a huge amount of nutrition. Its fruit contains six times as much vitamin C as oranges, twice as much calcium as milk, and plenty of B vitamins, magnesium, iron, phosphorous, and antioxidants. Until very recently those nutrients were enjoyed only by locals who ate the fruit fresh or crushed the crumbly pulp to stir into porridge and drinks. Few beyond the continent have been able to taste the baobab's distinctive tart flavor, described by Lucy Welford, of PhytoTrade Africa, as "somewhere between grapefruit, pear, and vanilla." Now baobab is headed to stores in Europe and the United States as an ingredient in jams and pepper sauces and, eventually, cereal bars and smoothies.

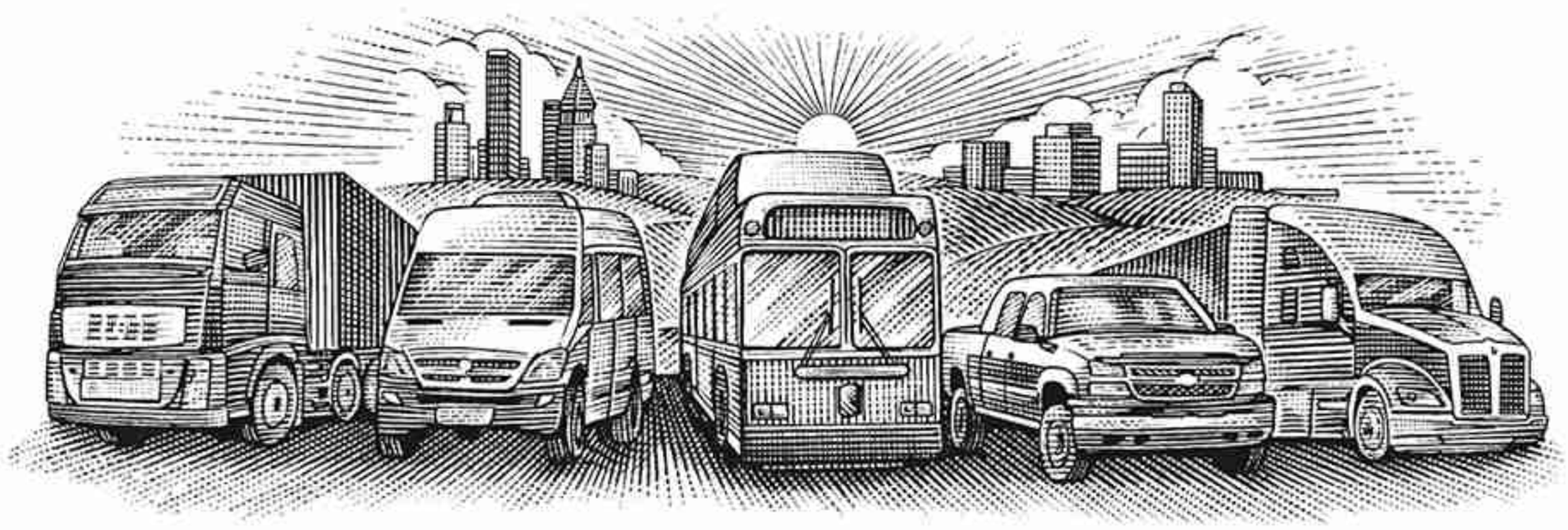
The European Union has approved the sale of baobab food products. Already, women in Malawi are harvesting the fruits for commercial use and earning enough cash to pay children's school fees. Will baobab ever be as trendy as the acai berry?

Experts estimate the potential size of the international market at a billion dollars a year. "Baobab is moving from cottage industry into the mainstream," says Malcolm Riley, of the Yozuna jam company in England. He now counts a large chain of British food stores among his customers. "It's got mass potential." *—Karen E. Lange*

PHOTOS: DAVID BRAZIER FOR PHYTOTRADE AFRICA

DID YOU KNOW

THE U.S. TRANSPORTATION SECTOR CONSUMES 14.3 MILLION BARRELS OF OIL A DAY, 70% OF WHICH IS IMPORTED.



The future runs on natural gas.

WHAT YOU NEED TO KNOW ABOUT NATURAL GAS AND ITS POTENTIAL FOR THE TRANSPORTATION SECTOR.

Natural gas for transportation is not a new idea; it is a proven technology. In fact, it's been around for decades globally. Natural gas vehicles (NGVs) are widely available for rental in Europe. And yet, here at home, NGVs currently use less than 1% of the U.S. natural gas supply.

If we're serious about ending our addiction to foreign oil and moving our country forward into a clean energy economy, we've simply got to get serious about the vast potential of natural gas.

Consider this: If we merely converted our over-the-road trucks, metro buses, refuse trucks and fleet vehicles to clean-burning American natural gas, we could reduce our foreign oil dependence by at least 30% within 10 years, all while improving our environment and saving $1 trillion of hard-earned American income as a result.

OVER-THE-ROAD ECONOMICS.

Today, U.S. production of Class 8 vehicles (tractor trailers) ranges from 200,000 to 300,000 units annually with assembly facilities employing approximately 37,000 individuals; utilizing natural gas in this sector will support and increase these American jobs.

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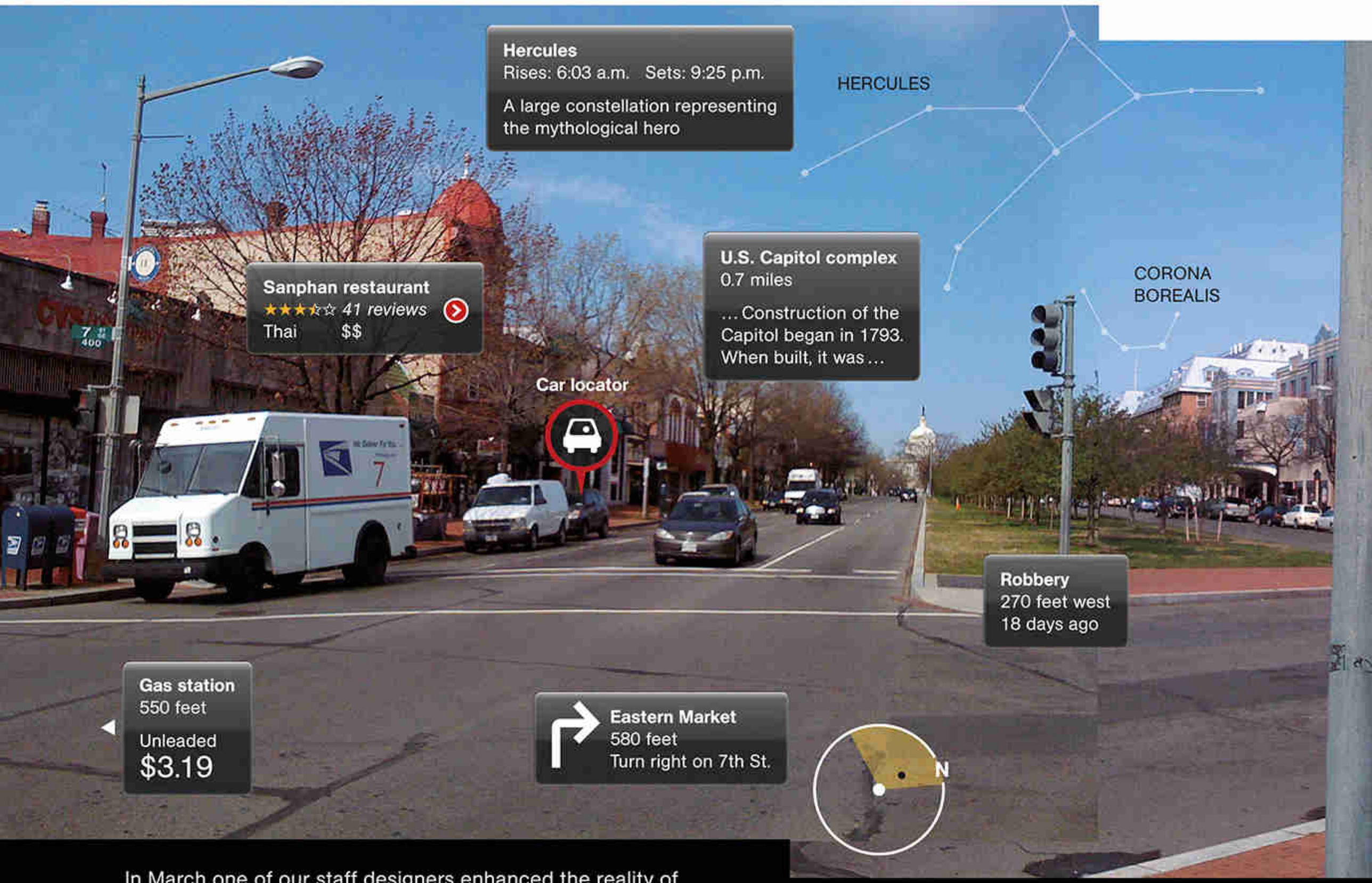
WHAT ARE WE WAITING FOR?

PUT AMERICAN NATURAL GAS TO WORK FOR AMERICA NOW.

Revealed World

Imagine bubbles floating before your eyes, filled with cool info about stuff you see on the street. Science fiction? Nope. It's augmented reality. And one day it'll be as routine as browsing the Web.



In March one of our staff designers enhanced the reality of his Washington, D.C., neighborhood. Smart phone applications (apps) added layers of information to what he saw—called out in this composite of five photos, each taken with his phone.

UP AND AWAY Point your phone at the sky and find stars hidden by daylight. Aim at a tourist spot and see its history plus info for visitors. For an augmented-reality check, tap into crime stats.

YOU COULD CALL IT REALITY 1.0—the unvarnished world presented to us by our five senses. It's not always the most user-friendly of places. We get lost in unfamiliar cities; we meet people whose language we don't understand. Fortunately there's an upgrade in the works that might eliminate some of the bugs: augmented reality, or AR. This emerging technology superimposes computer-generated images on the real world, courtesy of a cell phone camera or special video glasses.

Early forms of AR have already arrived. After downloading software, owners of smart phones like the iPhone and Droid can use the built-in GPS, compass, and camera to find information about nearby ATMs and restaurants, the closest subway stop, and other points of interest in some cities. With AR you might aim a phone's camera at a restaurant, and on the screen you'll see not just the venue but also a review hovering above it.

The U.S. Marine Corps is testing AR technology developed at Columbia University to train mechanics. They don headgear that projects animated 3-D computer graphics onto the equipment under repair, labeling parts and giving step-by-step guidance. "The marines worked faster with our AR program than with laptop-based manuals," says Steven Feiner, a computer scientist at Columbia.

Early adopters can test out the world's first augmented-reality glasses for consumers, *(Continued)*

REAL DEALS Various apps can steer you to the cheapest gas around, mass-transit options, good food, and Wi-Fi spots. You can also learn the price of that town house that's up for sale.

STREET PALS The Tweeps Around app tells if tweeters are near. Flickr displays area photos by members (Eastern Market, above). In the works: an app to match faces to social-network profiles.

ART AND PHOTOS: OLIVER UBERTI, NGM STAFF

FOUND! AMERICA'S ELUSIVE SILVER DOLLAR!

"Teddy Roosevelt Silver Dollars" Unearthed at Old Texas Ranch

After getting a call from a gentleman who had inherited a historic Texas ranch, one of our coin buyers found himself in a dusty storm cellar. The ranch was once owned by a veteran of WWI, who as local legend had was said to have always held true to a peculiar tradition: when he lost at pool (which was rare) he paid only with silver dollars. Now, a successful man with silver coins to spare must have had a stash of them right? That's precisely what his grandson was hoping when he found, in a dark corner under a rotten floorboard, five heavy, unmarked canvas bags.

As he opened them, one by one, he found 6,000 U.S. Territorial Silver Dollars—the coins he'd heard stories of! These were "Teddy Roosevelt Silver Dollars," the only silver dollar created during TR's presidency!

Hard to Hunt Down

This scarcely seen U.S. Territorial Silver Dollar was issued from 1907 to 1912, but is missing from virtually every U.S. silver-dollar collection. In fact, many collectors don't even know it exists! It was struck at the renowned San Francisco Mint for use only in the Philippines, a U.S. Territory at the time. Sadly, millions of the coins were lost over the years or melted down for their silver content, and very few made their way back to the United States. It's estimated that less than 10 percent of these coins remain!

Silver Legacy of Teddy Roosevelt

In the White House from 1901 to 1909, Roosevelt believed in America's destiny as a world power. His efforts led to building the Panama Canal, eliminating the dreadful yellow fever in the Philippines, Cuba, and Puerto Rico and helping end a war between Russia and Japan, for which he was the first American to be awarded the Nobel Peace Prize.

A Big, Beautiful Silver Dollar

The U.S. Territorial Silver Dollar is as rugged as the old Rough Rider himself. It weighs a hefty 20 grams and has a 1.37-inch diameter. The coin has a fineness of .800 silver.

Lady Liberty is featured on the front of the coin, symbolizing the forging of a new territory. The back depicts an eagle standing proudly atop a U.S. shield.

The San Francisco "S" mintmark

Larger than actual size of 35 mm

Valuable Coins at a One-Time-Only Price

Only after weeks combing the U.S. coin market did we find even one dealer selling the U.S. Territorial Silver Dollar—for $49.95. But thanks to discovery of this hoard, you can own the U.S. Territorial Silver Dollar for as little as $24.95.

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Your satisfaction is assured by our 30-Day Money-Back Guarantee. Own the U.S. Territorial Silver Dollar for a full month. If you are not 100% satisfied, simply return the coin by insured mail and in the condition you received it, for a full refund (less S&H). Please note that your Silver Dollar will be dated between 1907 and 1912 but we cannot honor requests for a particular date.

U.S. Territorial Silver Dollar $29.95 *(plus S&H)*

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BBB ACCREDITED BUSINESS

FIX-IT PIX Military mechanics are testing headgear that guides them as they repair vehicles. Right before their eyes they see computer images and labels that provide diagnostic tips, step-by-step instructions, labels, even safety warnings. Columbia University developed the augmented-reality system that they're testing.

from a U.S. company called Vuzix. They look like wraparound sunglasses, except you can't see directly through the lenses. Instead, small cameras centered on the outside of each lens feed continuous video through a mobile computer (say, an iPhone) to an LCD screen mounted inside each lens. So you look at the world indirectly, through the two tiny cameras' feed. (And without a panoramic field of view, you'll have to be careful where you walk.) The price for the glasses with cameras is about $600.

When connected to an iPhone, an iPod, or a PC for at-home gaming, the glasses combine computer input with the live video, creating a single stereoscopic field of view on the LCD, where computer graphics merge with the real world. Paul Travers, president of Vuzix, says that in the near future video glasses will deliver spectacular AR effects. "Instead of a little cell phone display, you'll have an image on the LCD that looks like an IMAX theater filling your field of view."

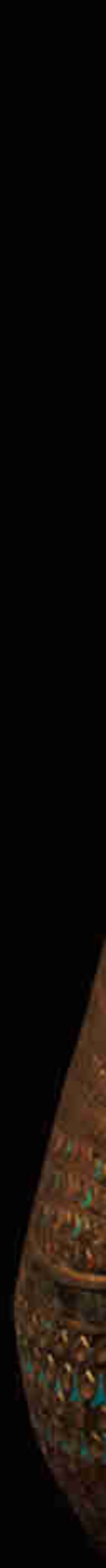
The next stage in the evolution of AR is taking shape in the lab of Babak Parviz, an associate professor of bio-nanotechnology at Seattle's University of Washington. Parviz has made a contact lens etched with a tiny, transparent electronic circuit that contains a single LED. Over the next several years he hopes to add hundreds of LEDs to the lens, allowing it to display text and images that would appear to hover in space at a readable distance in front of the eye. "With enough processing power, the lens could translate speech into text in real time and display it for deaf people," says Parviz. The lens would be powered wirelessly by radio waves transmitted from a cell phone in your pocket.

But for many users, AR might add to the toll that distracting technologies take on personal interaction. Scott Rigby, founder of Immersyve, a research group that studies the psychological effects of video games, wonders: "What will the consequences be of immersing yourself in a world that is isolated from the person standing next to you?" Welcome to reality 2.0. *—Tim Folger*

PHOTO: STEVEN HENDERSON AND STEVEN FEINER, COMPUTER GRAPHICS AND USER INTERFACES LAB, COLUMBIA UNIVERSITY

KING TUT'S FAMILY SECRETS

DNA evidence reveals the truth about the boy king's parents and new clues to his untimely death.



A COFFIN OF SOLID GOLD WEIGHING ALMOST 250 POUNDS HELD THE KING'S MUMMIFIED REMAINS.

Icon of ancient Egypt, the teenage pharaoh's funerary mask immortalizes his features in gold, glass, and semiprecious stones. This and other treasures from his tomb, now in Cairo's Egyptian Museum, attract a constant swirl of visitors.

Hidden in the desert canyons west of the Nile, the Valley of the Kings holds the tombs of King Tut and his royal relatives. In antiquity this was considered a secluded spot. Today the growing suburbs of Luxor shimmer nearby.

By Zahi Hawass Photographs by Kenneth Garrett

MUMMIES CAPTURE OUR IMAGINATIONS AND OUR HEARTS. FULL OF SECRETS AND MAGIC, THEY WERE ONCE PEOPLE WHO LIVED AND LOVED, JUST AS WE DO TODAY.

I believe we should honor these ancient dead and let them rest in peace.

There are some secrets of the pharaohs, however, that can be revealed only by studying their mummies. By carrying out CT scans of King Tutankhamun's mummy, we were able in 2005 to show that he did not die from a blow to the head, as many people believed. Our analysis revealed that a hole in the back of his skull had been made during the mummification process. The study also showed that Tutankhamun died when he was only 19—perhaps soon after he suffered a fracture to his left leg. But there are mysteries surrounding Tutankhamun that even a CT scanner cannot reveal. Now we have probed even deeper into his mummy and returned with extraordinary revelations about his life, his birth, and his death.

To me the story of Tutankhamun is like a play whose ending is still being written. The first act of the drama begins in about 1390 B.C., several decades before Tutankhamun's birth, when the great pharaoh Amenhotep III assumes the throne of Egypt. Controlling an empire stretching 1,200 miles from the Euphrates in the north to the Fourth Cataract of the Nile in the south, this king of the 18th dynasty is rich beyond imagining. Along with his powerful queen Tiye, Amenhotep III rules for 37 years, worshipping the gods of his ancestors, above all Amun, while his people prosper and vast wealth flows into the royal coffers from Egypt's foreign holdings.

If Act I is about tradition and stability, Act II is revolt. When Amenhotep III dies, he is succeeded by his second son, Amenhotep IV—a bizarre visionary who turns away from Amun and the other gods of the state pantheon and worships instead a single deity known as the Aten, the disk of the sun. In the fifth year of his reign, he changes his name to Akhenaten—"he who is beneficial to the Aten." He elevates himself to the status of a living god and abandons the traditional religious capital at Thebes, building a great ceremonial city 180 miles to the north, at a place now called Amarna. Here he lives with his great wife, the beautiful

Egypt's head archaeologist, Zahi Hawass (at right) confers with DNA experts after the extraction of bone tissue from one of the mummies found in KV35, a tomb in the Valley of the Kings.

Nefertiti, and together they serve as the high priests of the Aten, assisted in their duties by their six cherished daughters. All power and wealth is stripped from the Amun priesthood, and the Aten reigns supreme. The art of this period is also infused with a revolutionary new naturalism; the pharaoh has himself depicted not with an idealized face and youthful, muscular body as were pharaohs before him, but as strangely effeminate, with a potbelly and a thick-lipped, elongated face.

The end of Akhenaten's reign is cloaked in confusion—a scene acted out behind closed curtains. One or possibly two kings rule for short periods of time, either alongside Akhenaten, after his death, or both. Like many other Egyptologists, I believe the first of these "kings" is actually Nefertiti. The second is a mysterious figure called Smenkhkare, about whom we know almost nothing.

What we know for sure is that when the curtain opens on Act III, the throne is occupied by a young boy: the nine-year-old Tutankhaten ("the living image of the Aten"). Within the first two years of his tenure on the throne, he and his wife, Ankhesenpaaten (a daughter of Akhenaten and Nefertiti), abandon Amarna and return to Thebes, reopening the temples and restoring their wealth and glory. They change their names to Tutankhamun and Ankhesenamun, proclaiming their rejection of Akhenaten's heresy and their renewed dedication to the cult of Amun.

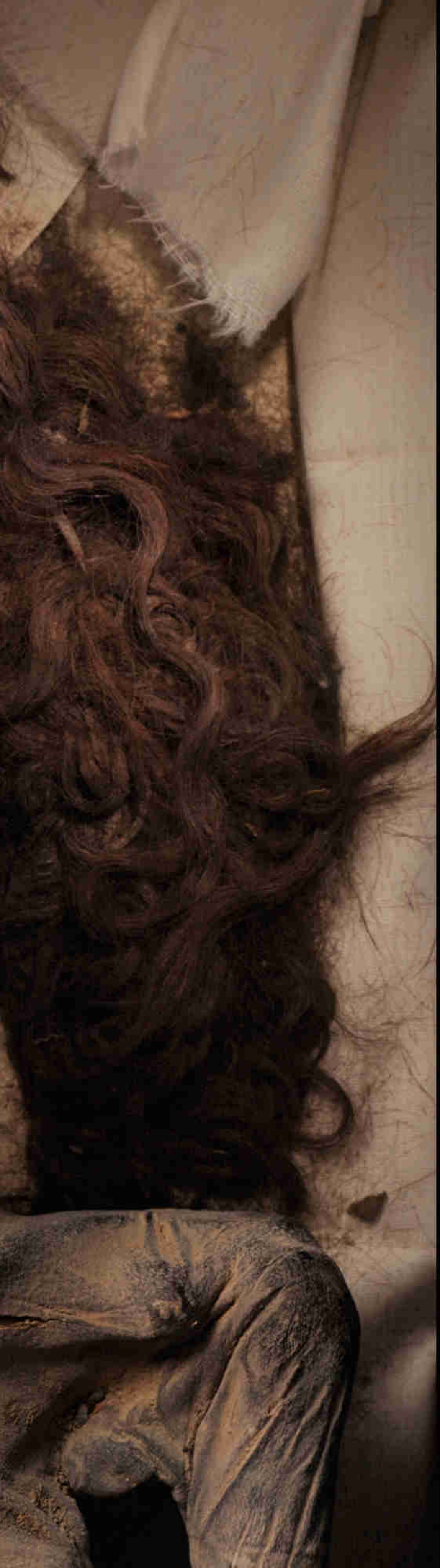
Then the curtain falls. Ten years after ascending the throne, Tutankhamun is dead, leaving no heirs to succeed him. He is hastily buried in a small tomb, designed originally for a private person rather than a king. In a backlash against Akhenaten's heresy, his successors manage to delete from history nearly all traces of

NGM MAPS

GRAND-FATHER

Amenhotep III KV35

Now identified as Tut's grandfather, Amenhotep III (below and at right) ruled in splendor some 3,400 years ago. His mummy was buried with a wealth of goods. Several hundred years later, priests seeking to protect such royal remains from tomb robbers wrapped the mummies in fresh linens and reburied them in groups. Amenhotep III's body was found in 1898 hidden along with more than a dozen other royals in KV35, the tomb of his own grandfather, Amenhotep II.



GRAND-MOTHER

Tiye KV35EL

Among the remains in the KV35 cache was an unidentified mummy known until now only as the Elder Lady. DNA has identified this regal beauty as Amenhotep III's wife Tiye, the daughter of Yuya and Tuyu, a nonroyal couple discovered in 1905 in their own undisturbed tomb, KV46. The grandmother of Tut, Tiye was embalmed with her left arm bent across her chest—interpreted as a queen's burial pose. Her statue from the temple at Karnak (below) displays a similarly bent left arm.

the Amarna kings, including Tutankhamun.

Ironically, this attempt to erase his memory preserved Tutankhamun for all time. Less than a century after his death, the location of his tomb had been forgotten. Hidden from robbers by structures built directly above, it remained virtually untouched until its discovery in 1922. More than 5,000 artifacts were found inside

HIDDEN FROM ROBBERS, TUT'S TOMB REMAINED VIRTUALLY UNTOUCHED UNTIL ITS DISCOVERY IN 1922.

the tomb. But the archaeological record has so far failed to illuminate the young king's most intimate family relationships. Who were his mother and father? What became of his widow, Ankhesenamun? Are the two mummified fetuses found in his tomb King Tutankhamun's own prematurely born children, or tokens of purity to accompany him into the afterlife?

To answer these questions, we decided to analyze Tutankhamun's DNA, along with that of ten other mummies suspected to be members of his immediate family. In the past I had been against genetic studies of royal mummies. The chance of obtaining workable samples while avoiding contamination from modern DNA seemed too small to justify disturbing these sacred remains. But in 2008 several geneticists convinced me that the field had advanced far enough to give us a good chance of getting useful results. We set up two state-of-the-art DNA-sequencing labs, one in the basement of the Egyptian Museum in Cairo and the other at the Faculty of Medicine at Cairo University. The research would be led by Egyptian scientists: Yehia Gad and Somaia Ismail from the National Research Center in Cairo. We also decided to carry out CT scans of all the mummies, under the direction of Ashraf Selim and Sahar Saleem of the Faculty of Medicine at Cairo University. Three international experts served as consultants: Carsten Pusch of the Eberhard Karls University of Tübingen, Germany; Albert Zink of the EURAC-Institute for Mummies and the Iceman in Bolzano, Italy; and Paul Gostner of the Central Hospital Bolzano.

The identities of four of the mummies were known. These included Tutankhamun himself, still in his tomb in the Valley of the Kings, and three mummies on display at the Egyptian Museum: Amenhotep III, and Yuya and Tuyu, the parents of Amenhotep III's great queen, Tiye. Among the unidentified mummies was a male found in a mysterious tomb in the Valley of the Kings known as KV55. Archaeological and textual evidence suggested this mummy was most likely Akhenaten or Smenkhkare.

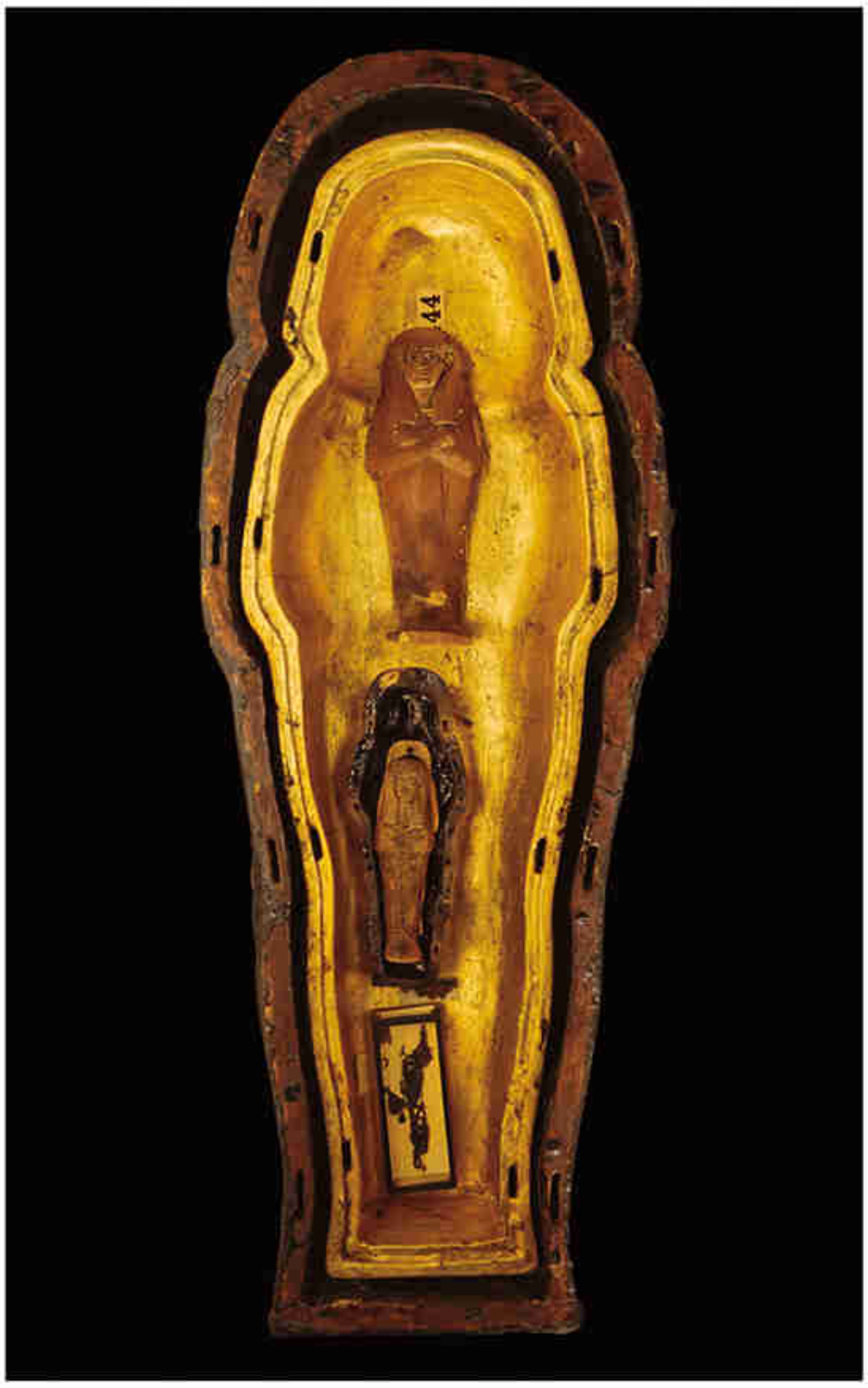
Our search for Tutankhamun's mother and wife focused on four unidentified females. Two of these, nicknamed the "Elder Lady" and the "Younger Lady," had been discovered in 1898, unwrapped and casually laid on the floor of a side chamber in the tomb of Amenhotep II (KV35), evidently hidden there by priests after the end of the New Kingdom, around 1000 B.C. The other two anonymous females were from a small tomb (KV21) in the Valley of the Kings. The architecture of this tomb suggests a date in the 18th dynasty, and both mummies hold their left fist against their chest in what is generally interpreted as a queenly pose.

Finally, we would attempt to obtain DNA from the fetuses in Tutankhamun's tomb—not a promising prospect given the extremely poor condition of these mummies. But if we succeeded, we might be able to fill in the missing pieces to a royal puzzle extending over five generations.

A DECADE OF DISCOVERY

Since 2001 the Society has supported the research of Zahi Hawass, secretary general of Egypt's Supreme Council of Antiquities and a National Geographic explorer-in-residence. He is the author of *Zahi Hawass's Travel Guide to Secret Egypt,* forthcoming from National Geographic Books.

Kenneth Garrett has photographed 15 stories on Egypt for the magazine and collaborated with Zahi Hawass on six books.



The innermost coffin of a miniature nested set from Tut's tomb was inscribed with the name of Tiye. Inside lay a lock of hair (above, box at bottom), perhaps a memento of a beloved grandmother.

A mummified fetus of at least seven months' gestation (above right) was found in Tut's tomb along with a tinier, more fragile fetus. One or both may have been the pharaoh's daughters.

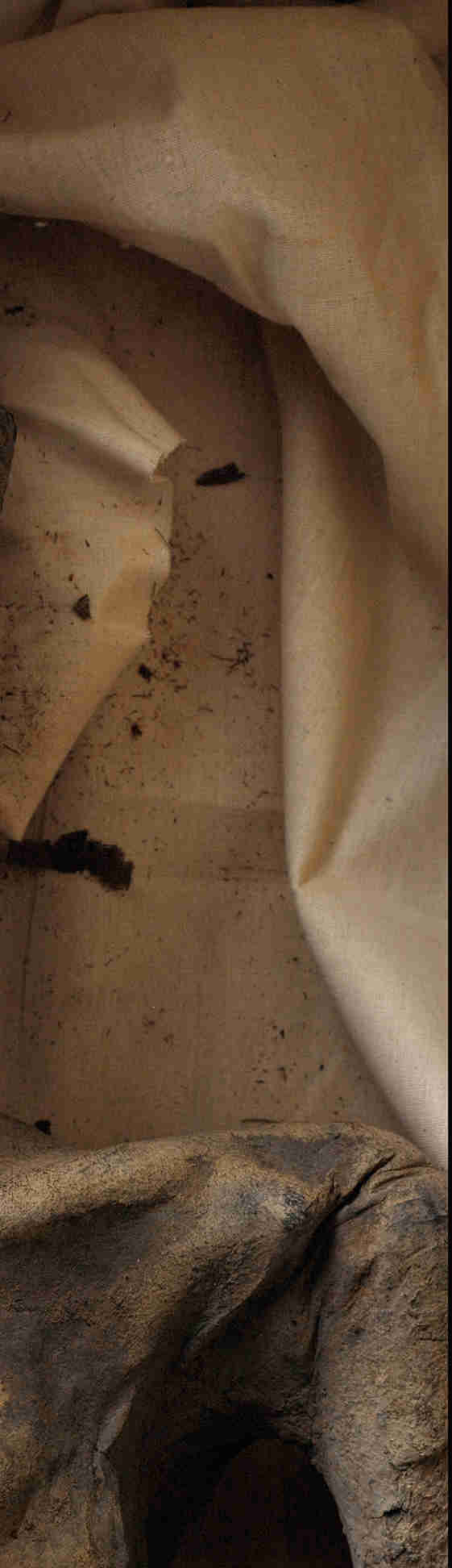
TO OBTAIN WORKABLE samples, the geneticists extracted tissue from several different locations in each mummy, always from deep within the bone, where there was no chance the specimen would be contaminated by the DNA of previous archaeologists—or of the Egyptian priests who had performed the mummification. Extreme care was also taken to avoid any contamination by the researchers themselves. After the samples were extracted, the DNA had to be separated from unwanted substances, including the unguents and resins the priests had used to preserve the bodies. Since the embalming material varied with each mummy, so did the steps needed to purify the DNA. In each case the fragile material could be destroyed at every step.

At the center of the study was Tutankhamun himself. If the extraction and isolation

FATHER

Akhenaten KV55

The identity of King Tut's father has long been a mystery. One candidate is the heretic pharaoh, Akhenaten, who abandoned the gods of the state to worship a single deity. In 1907 a badly decayed mummy was discovered in KV55, a small tomb in the Valley of the Kings containing a jumble of artifacts connected to various kings and queens of the late 18th dynasty. Royal epithets on the defaced coffin suggested the body inside might be Akhenaten. DNA now confirms the mummy to be a son of Amenhotep III and Queen Tiye—known to be the parents of Akhenaten—and the father of King Tut.



MOTHER

KV35YL

According to DNA tests, this mummy, known as the Younger Lady, is both the full sister of the KV55 mummy—probably Akhenaten—and the mother of his child, Tutankhamun. (Incestuous relationships were not unusual among Egyptian royalty.) History records that Akhenaten married both the famous Nefertiti (bottom left) and a woman named Kiya (bottom right), but neither of these two women was ever said to be his sister. The Younger Lady is probably one of the five known daughters of Amenhotep III and Tiye.

ROYAL RELATIONS

Genetic testing on 11 mummies revealed the remains of Tut's parents, who were brother and sister. Tut's father is very likely Akhenaten. The identity of his mother is still unknown.

HOW DO WE KNOW? Scientists collected DNA, then looked at eight sets of genetic markers (colored boxes in diagram below) to create a genetic fingerprint. Numerals in squares indicate the number of times a pattern of DNA is repeated. Shared numbers help determine kinship.

DNA ORIGIN

- Yuya
- Tuyu
- Amenhotep III
- Non-transmitted DNA
- Insufficient data

- Brother and sister
- Proposed relationship, insufficient data
- ♂ Male
- ♀ Female
- Pharaoh

GREAT-GRANDPARENTS

♂ Yuya (KV46)

11 13 | 6 15 | 22 27 | 29 34 | 6 10 | 12 22 | 9 12 | 20 25

TOMB WHERE FOUND

♀ Tuyu (KV46)

9 12 | 10 13 | 19 26 | 26 35 | 11 13 | 8 19 | 7 12 | 24 26

GRANDPARENTS

♂ Amenhotep III (KV35)

10 16 | 6 15 | 16 27 | 25 34 | 8 13 | 16 22 | 6 9 | 23 31

Paired genetic markers: one inherited from each parent

♀ Tiye (KV35EL)

11 12 | 10 15 | 22 26 | 26 29 | 6 11 | 19 22 | 9 12 | 20 26

Marker 12 passed from Tuyu to Tiye, then from Tiye to a son and daughter. One of them passed the marker to their son Tutankhamun.

PARENTS

♂ Akhenaten (KV55)

10 12 | 15 15 | 16 26 | 29 34 | 11 13 | 16 19 | 9 12 | 20 23

♀ Name unknown (KV35YL)

10 12 | 6 10 | 16 26 | 25 29 | 8 11 | 16 19 | 6 12 | 20 23

KING TUT

♂ **Tutankhamun** (KV62)

10 12 | 10 15 | 16 26 | 29 34 | 8 13 | 19 19 | 6 12 | 23 23

Wife of Tut

KV21A (possibly Ankhesenamun) is the more likely candidate for Tut's wife and the mother of the fetuses.

♀ Name unknown (KV21A)

10 16 | | | 26 | 35 | 8 | | 10 | | 12 | 23

♀ Name unknown (KV21B)

10 | | | 17 26 | | | 11 13 | | | 12 | |

CHILDREN

♀ Fetus 1 (KV62)

12 16 | 10 13 | 16 | 29 | 8 | | 19 | | 12 | 23 |

♀ Fetus 2 (KV62)

10 | 6 15 | | 26 | 29 35 | 8 13 | 10 19 | | 12 | 23 |

JUAN VELASCO, AMANDA HOBBS, AND LAWSON PARKER, NGM STAFF. SOURCES: ZAHI HAWASS, SUPREME COUNCIL OF ANTIQUITIES, EGYPT; CARSTEN PUSCH, EBERHARD KARLS UNIVERSITY OF TÜBINGEN, GERMANY

succeeded, his DNA would be captured in a clear liquid solution, ready to be analyzed. To our dismay, however, the initial solutions turned out a murky black. Six months of hard work were required to figure out how to remove the contaminant—some still unidentified product of the mummification process—and obtain a sample ready for amplifying and sequencing.

After we had obtained DNA as well from the three other male mummies in the sample—Yuya, Amenhotep III, and the mysterious KV55—we set out to clarify the identity of Tutankhamun's father. On this critical issue the archaeological record was ambiguous. In several inscriptions from his reign, Tutankhamun refers to Amenhotep III as his father, but this cannot be taken as conclusive, since the term used could also be interpreted to mean "grandfather" or "ancestor." Also, according to the generally accepted chronology, Amenhotep III died about a decade before Tutankhamun was born.

Many scholars believe that his father was instead Akhenaten. Supporting this view is a broken limestone block found near Amarna that bears inscriptions calling both Tutankhaten and Ankhesenpaaten beloved children of the king. Since we know that Ankhesenpaaten was the daughter of Akhenaten, it follows that Tutankhaten (later Tutankhamun) was his son. Not all scholars find this evidence convincing, however, and some have argued that Tutankhamun's father was in fact the mysterious Smenkhkare. I always favored Akhenaten myself, but it was only a theory.

Once the mummies' DNA was isolated, it was a fairly simple matter to compare the Y chromosomes of Amenhotep III, KV55, and Tutankhamun and see that they were indeed related. (Related males share the same pattern of DNA in their Y chromosome, since this part of a male's genome is inherited directly from his father.) But to clarify their precise relationship required a more sophisticated kind of genetic fingerprinting. Along the chromosomes in our genomes there are specific known regions where the pattern of DNA letters—the A's, T's, G's, and C's that make up our genetic code—varies greatly between one person and another. These variations amount to different numbers of repeated sequences of the same few letters. Where one person might have a sequence of letters repeated ten times, for instance, another unrelated person might have the same sequence stuttered 15 times, a third person 20, and so on. A match between ten of these highly variable regions is enough for the FBI to conclude that the DNA left at a crime scene and that of a suspect might be one and the same.

Reuniting the members of a family separated 3,300 years ago requires a little less stringency than the standards needed to solve a crime. By comparing just eight of these variable regions, our team was able to establish with a probability of better than 99.99 percent that Amenhotep III was the father of the individual in KV55, who was in turn the father of Tutankhamun.

We now knew we had the body of Tut's father—but we still did not know for certain who he was. Our chief suspects were Akhenaten and Smenkhkare. The KV55 tomb contained a cache of material thought to have been brought by Tutankhamun to Thebes from Amarna, where Akhenaten (and perhaps Smenkhkare) had been buried. Though the coffin's cartouches—oval rings containing the pharaoh's names—had been chiseled off, the coffin bore epithets associated only with Akhenaten himself. But not all the evidence pointed to Akhenaten. Most forensic analyses had concluded that the body inside was that of a man no older than 25—too young to be Akhenaten, who seems to have sired two daughters before beginning his 17-year reign. Most scholars thus suspected the mummy was instead the shadowy pharaoh Smenkhkare.

Now a new witness could be called on to help resolve this mystery. The so-called Elder Lady (KV35EL) mummy is lovely even in death, with long reddish hair falling across her shoulders. A strand of this hair had previously been matched morphologically to a lock of hair buried within a nest of miniature coffins in Tutankhamun's tomb, inscribed with the name of Queen Tiye, wife of Amenhotep III—and mother of Akhenaten. By comparing the DNA of the

Elder Lady with that from the mummies of Tiye's known parents, Yuya and Tuyu, we confirmed that the Elder Lady was indeed Tiye. Now she could testify whether the KV55 mummy was indeed her son.

Much to our delight, the comparison of their DNA proved the relationship. New CT scans of the KV55 mummy also revealed an age-related degeneration in the spine and osteoarthritis in the knees and legs. It appeared that he had died closer to the age of 40 than 25, as originally thought. With the age discrepancy thus resolved, we could conclude that the KV55 mummy, the son of Amenhotep III and Tiye and the father of Tutankhamun, is almost certainly Akhenaten. (Since we know so little about Smenkhkare, he cannot be completely ruled out.)

AKHENATEN HAD CONCEIVED A SON WITH HIS OWN SISTER. THE CHILD WOULD BE KNOWN AS TUTANKHAMUN.

Our renewed CT scanning of the mummies also put to rest the notion that the family suffered from some congenital disease, such as Marfan syndrome, that might explain the elongated faces and feminized appearance seen in the art from the Amarna period. No such pathologies were found. Akhenaten's androgynous depiction in the art would seem instead to be a stylistic reflection of his identification with the god Aten, who was both male and female and thus the source of all life.

And what of Tutankhamun's mother? To our surprise, the DNA of the so-called Younger Lady (KV35YL), found lying beside Tiye in the alcove of KV35, matched that of the boy king. More amazing still, her DNA proved that, like Akhenaten, she was the daughter of Amenhotep III and Tiye. Akhenaten had conceived a son with his own sister. Their child would be known as Tutankhamun.

With this discovery, we now know that it is unlikely that either of Akhenaten's known wives, Nefertiti and a second wife named Kiya, was Tutankhamun's mother, since there is no evidence from the historical record that either was his full sister. We know the names of five daughters of Amenhotep III and Tiye, but we will probably never know which of Akhenaten's sisters bore him a child. But to me, knowing her name is less important than the relationship with her brother. Incest was not uncommon among ancient Egyptian royalty. But I believe that in this case, it planted the seed of their son's early death.

THE RESULTS of our DNA analysis, published in February in the *Journal of the American Medical Association*, convinced me that genetics can provide a powerful new tool for enhancing our understanding of Egyptian history, especially when combined with radiological studies of the mummies and insights gleaned from the archaeological record.

Nowhere is this more evident than in our quest to understand the cause of Tutankhamun's death. When we began the new study, Ashraf Selim and his colleagues discovered something previously unnoticed in the CT images of the mummy: Tutankhamun's left foot was clubbed, one toe was missing a bone, and the bones in part of the foot were destroyed by necrosis—literally, "tissue death." Both the clubbed foot and the bone disease would have impeded his ability to walk. Scholars had already noted that 130 partial or whole walking sticks had been found in Tutankhamun's tomb, some of which show clear signs of use.

Some have argued that such staffs were common symbols of power and that the damage to Tutankhamun's foot may have occurred during the mummification process. But our analysis showed that new bone growth had occurred in response to the necrosis, proving the condition was present during his lifetime. And of all the pharaohs, only Tutankhamun is shown seated while performing activities such as shooting an arrow from a bow or using a throw stick. This

was not a king who held a staff just as a symbol of power. This was a young man who needed a cane to walk.

Tutankhamun's bone disease was crippling, but on its own would not have been fatal. To look further into possible causes of his death, we tested his mummy for genetic traces of various infectious diseases. I was skeptical that the geneticists would be able to find such evidence—and I was delighted to be proved wrong. Based on the presence of DNA from several strains of a parasite called *Plasmodium falciparum*, it was evident that Tutankhamun was infected with malaria—indeed, he had contracted the most severe form of the disease multiple times.

Did malaria kill the king? Perhaps. The disease can trigger a fatal immune response in the body, cause circulatory shock, and lead to hemorrhaging, convulsions, coma, and death. As other scientists have pointed out, however, malaria was probably common in the region at the time, and Tutankhamun may have acquired partial immunity to the disease. On the other hand, it may well have weakened his immune system, leaving him more vulnerable to complications that might have followed the unhealed fracture of his leg we evaluated in 2005.

In my view, however, Tutankhamun's health was compromised from the moment he was conceived. His mother and father were full brother and sister. Pharaonic Egypt was not the only society in history to institutionalize royal incest, which can have political advantages. (See "The Risks and Rewards of Royal Incest," page 60.) But there can be a dangerous consequence. Married siblings are more likely to pass on twin copies of harmful genes, leaving their children vulnerable to a variety of genetic defects. Tutankhamun's malformed foot may have been one such flaw. We suspect he also had a partially cleft palate, another congenital defect. Perhaps he struggled against others until a severe bout of malaria or a leg broken in an accident added one strain too many to a body that could no longer carry the load.

There may be one other poignant testimony to the legacy of royal incest buried with Tutankhamun in his tomb. While the data are still incomplete, our study suggests that one of the mummified fetuses found there is the daughter of Tutankhamun himself, and the other fetus is probably his child as well. So far we have been able to obtain only partial data for the two female mummies from KV21. One of them, KV21A, may well be the infants' mother and thus, Tutankhamun's wife, Ankhesenamun. We know from history that she was the daughter of Akhenaten and Nefertiti, and thus likely her husband's half sister. Another consequence of inbreeding can be children whose genetic defects do not allow them to be brought to term.

So perhaps this is where the play ends, at least for now: with a young king and his queen trying, but failing, to conceive a living heir for the throne of Egypt. Among the many splendid artifacts buried with Tutankhamun is a small ivory-paneled box, carved with a scene of the royal couple. Tutankhamun is leaning on his cane while his wife holds out to him a bunch of flowers. In this and other depictions, they appear serenely in love. The failure of that love to bear fruit ended not just a family but also a dynasty. We know that after Tutankhamun's death, an Egyptian queen, most likely Ankhesenamun, appeals to the king of the Hittites, Egypt's principal enemies, to send a prince to marry her, because "my husband is dead, and I have no son." The Hittite king sends one of his sons, but he dies before reaching Egypt. I believe he was murdered by Horemheb, the commander in chief of Tutankhamun's armies, who eventually takes the throne for himself. But Horemheb too dies childless, leaving the throne to a fellow army commander.

The new pharaoh's name was Ramses I. With him begins another dynasty, one which, under the rule of his grandson Ramses the Great, would see Egypt rise to new heights of imperial power. More than anyone else, this great king would work to erase from history all traces of Akhenaten, Tutankhamun, and the other "heretics" of the Amarna period. With our investigations, we seek to honor them and keep their memories alive. □

TUT

Tutankhamun KV62

Offspring of a union between siblings, this often studied pharaoh is now revealed to have had a congenital clubfoot afflicted with bone disease, which would have made walking painful. Inbreeding may have caused the deformity and even prevented him from producing an heir with his wife, who was probably his half sister. Whatever flaws King Tut inherited in this life, however, the image he left for eternity is one of luminous perfection—his iconic funeral mask crafted of gold, regarded by the ancient Egyptians as the flesh of the gods.

WIFE

KV21A

When tomb KV21 was found in 1817, two well-preserved female mummies lay inside. Vandals later ripped them apart. Preliminary DNA results suggest that the one now missing her head (below) could be the mother of at least one of the fetuses from King Tut's tomb. If so, she is most likely Ankhesenamun, a daughter of Akhenaten and the only known wife of Tutankhamun. An ivory-paneled box (right), also from Tut's tomb, shows him with his beloved queen. New information about his health suggests that he probably needed to use the staff he holds as a crutch.

THE RISKS AND REWARDS OF ROYAL INCEST

King Tut's family was not the only royalty to have close relations among its close relations.

WHEN NEW ENGLAND MISSIONARY Hiram Bingham arrived in Hawaii in 1820, he was dismayed to find the natives indulging in idolatry, hula dancing, and, among the ruling family, incest. The Hawaiians themselves did not share Bingham's shock at the royals' behavior. Royal incest, notes historian Joanne Carando, was "not only accepted but even encouraged" in Hawaii as an exclusive royal privilege.

In fact, while virtually every culture in recorded history has held sibling or parent-child couplings taboo, royalty have been exempted in many societies, including ancient Egypt, Inca Peru, and, at times, Central Africa, Mexico, and Thailand. And while royal families in Europe avoided sibling incest, many, including the Hohenzollerns of Prussia, the Bourbons of France, and the British royal family, often married cousins. The Spanish Habsburgs, who ruled for nearly 200 years, frequently married among close relatives. Their dynasty ended in 1700 with the death of Charles II, a king so riddled with

BARON/GETTY IMAGES (ABOVE); BISHOP MUSEUM

When Western values pressed ashore, Hawaii's King Kamehameha III (above) donned a suit, but skirted a ban on royal incest. Thailand's King Rama V, posing with his half sister—and wife—and their children, faced no such prohibition.

health and development problems that he didn't talk until he was four or walk until he was eight. He also had trouble chewing food and couldn't sire a child.

The physical problems faced by Charles and the pharaoh Tutankhamun, the son of siblings, point to one possible explanation for the near-universal incest taboo: Overlapping genes can backfire. Siblings share half their genes on average, as do parents and offspring. First cousins' genomes overlap 12.5 percent. Matings between close relatives can raise the danger that harmful recessive genes, especially if combined repeatedly through generations, will match up in the offspring, leading to elevated chances of health or developmental problems—perhaps Tut's partially cleft palate and congenitally deformed foot or Charles's small stature and impotence.

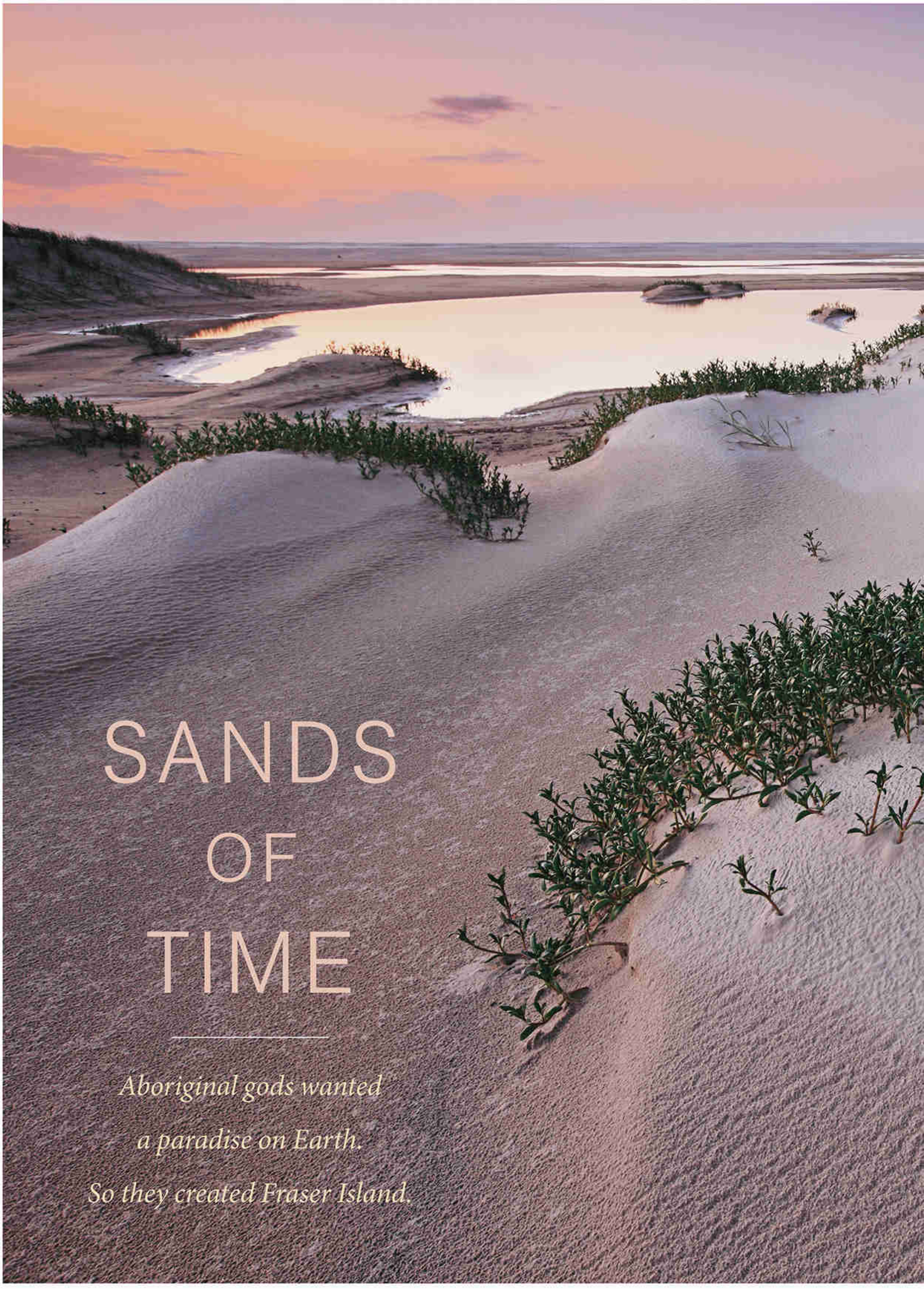
If the royals knew of these potential downsides, they chose to ignore them. According to Stanford University classics professor Walter Scheidel, one reason is that "incest sets them apart." Royal incest occurs mainly in societies where rulers have tremendous power and no peers, except the gods. Since gods marry each other, so should royals.

Incest also protects royal assets. Marrying family members ensures that a king will share riches, privilege, and power only with people already his relatives. In dominant, centralized societies such as ancient Egypt or Inca Peru, this can mean limiting the mating circle to immediate family. In societies with overlapping cultures, as in second-millennium Europe, it can mean marrying extended family members from other regimes to forge alliances while keeping power among kin.

And the hazards, while real, are not absolute. Even the high rates of genetic overlap generated in the offspring of sibling unions, for instance, can create more healthy children than sick ones. And royal wealth can help offset some medical conditions; Charles II lived far better (and probably longer, dying at age 38) than he would have were he a peasant.

A king or a pharaoh can also hedge the risk of his incestuous bets by placing wagers elsewhere. He can mate, as Stanford classicist Josiah Ober notes, "with pretty much anybody he wants to." Inca ruler Huayna Capac (1493-1527), for instance, passed power not only to his son Huáscar, whose mother was Capac's wife and sister, but also to his son Atahualpa, whose mother was apparently a consort. And King Rama V of Thailand (1873-1910) sired more than 70 children—some from marriages to half sisters but most with dozens of consorts and concubines. Such a ruler could opt to funnel wealth, security, education, and even political power to many of his children, regardless of the status of the mother. A geneticist would say he was offering his genes many paths to the future.

It can all seem rather mercenary. Yet affection sometimes drives these bonds. Bingham learned that even after King Kamehameha III of Hawaii accepted Christian rule, he slept for several years with his sister, Princess Nahi'ena'ena—pleasing their elders but disturbing the missionaries. They did it, says historian Carando, because they loved each other. —*David Dobbs*


SANDS
OF
TIME
Aboriginal gods wanted
a paradise on Earth.
So they created Fraser Island.

Pioneering plants get a toehold above the tide line on Australia's Fraser Island.

Following its keen nose, a dingo prowls the edge of a sand blow—an ever shifting expanse of silica.

Tannin-rich runoff from Fraser's interior stains the sea in the aftermath of a summer storm.

By Roff Smith

Photographs by Peter Essick

It wasn't enough simply to create the world; the Aboriginal god Beeral wanted it to be beautiful as well. And so he sent two trusted messengers, Yindingie and his spirit helper K'gari, to render the raw material of creation into a paradise. They did such a splendid job that by the time they were finished, K'gari longed to stay in this wonderful place forever. She lay down in the warm waters of a particularly beautiful bay, and there she went to sleep.

While she slept, Yindingie transformed her body into a long, slender island of crystalline sand, the largest such island in all the world. He clothed her with the most luxuriant of rain forests, painted her soft, sandy skin a rainbow of colors, and fashioned a chain of jewel-like lakes to be her eyes into heaven. He filled the air with colorful birds, and then, so she would never be lonely, he set a tribe of Aborigines on the island—the Butchulla people, who passed down the story of its creation and in whose language K'gari came to be the word for "paradise."

A lot of water has washed its shores since then. Today paradise goes by the name of Fraser Island, renamed by newcomers after a Scottish sea captain and his wife were famously marooned here among the Aborigines in 1836. But by any name or reckoning, it remains a place apart, with an uncanny ability to weave itself into the dreams of all who draw near.

Fraser Island's storied landscapes have inspired many of Australia's greatest writers and artists, and its delicate ecosystems fired passions in one of Australia's first great grassroots

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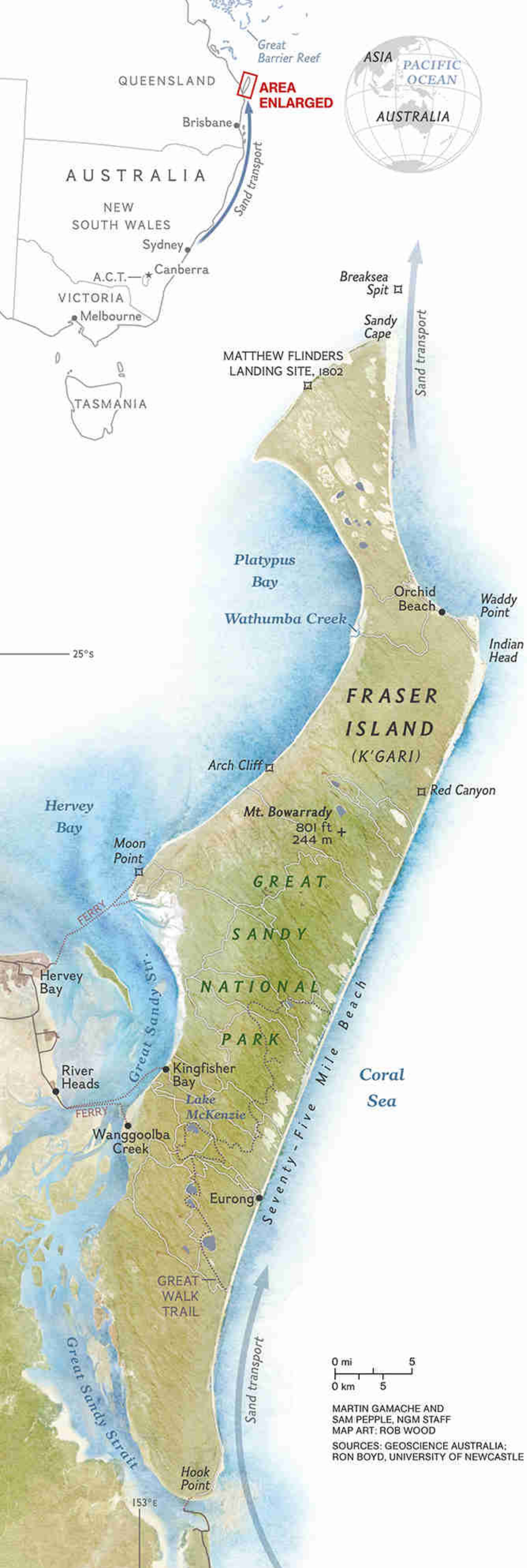
Roff Smith has covered every corner of Australia, his adopted country since 1981. Peter Essick specializes in nature and environmental photography.

Iron oxide colors Arch Cliff a luminous red, one of a palette of hues seen in Fraser's mineral-rich sands. Bound together by a kind of natural cement, some dunes rise 800 feet high. Trees and other vegetation manage to survive thanks to fungi that release nutrients from the sand.

environmental campaigns in the 1970s, stopping the mining of its mineral-rich sands and bringing an eventual end to logging on the island. And for succeeding generations of locals and visitors alike, it has been a prism through which to see and appreciate the often nuanced beauty of the Australian bush.

For all the paintings, poetry, and prose Fraser Island has inspired, this is not an easy place to categorize. One moment you're hiking through a cathedral rain forest, all giant ferns and piccabeen palms, and the next you're in fragrant eucalyptus woodland, gazing through a break in the trees at a sea of golden dunes—and beyond them, in the soft, summery haze, rolling coastal heaths bright with wildflowers. Changes in landscape that logic tells you should be hundreds of miles apart happen here one after the



other, as swiftly and magically as a twist of a kaleidoscope barrel.

The greatest wonder of all, perhaps, is that most everything here grows on nothing more substantial than sand held in place by humble fungi. No dreamscape could be woven of slenderer thread.

"I like to think of this island as a living organism in its own right, like the Great Barrier Reef," says Peter Meyer, a naturalist who has been living and working as a guide on Fraser Island for the past 15 years. "But here, instead of coral polyps, it's mycorrhizal fungi and their symbiotic relationship with plants that's the basis for everything. By liberating the nutrients in the sand, they make it possible for all these amazing things to grow. Without the fungi, this would be just another sandbar."

Make that a very big sandbar: more than 75 miles long, about 15 miles wide, and with dunes soaring to 800 feet. Sand has been accumulating along this stretch of the Queensland coast for some 750,000 years, in part because volcanic bedrock here provides a natural catchment for sediment moved up the eastern seaboard by a powerful longshore current.

English navigator James Cook, who sailed along this coast in 1770, was the first European known to have sighted Fraser Island. The globe-trotting Yorkshireman didn't think much of it, dismissing it with a few cursory lines in his journal. Likewise explorer Matthew Flinders, who landed here some 30 years later. Wilderness in those days was a commodity to be tamed and brought to profitable service, not admired for its own sake.

From that perspective, the interior of the island pleased Edward Armitage, an early 20th-century timber merchant. It is from his pen that we have some of the first descriptions of Fraser's magnificent rain forests, as he lamented that many of "these great Monarchs of the forest" were too big for the sawmills of the day.

The future soon supplied bigger machinery, and for more than a century the forests here were heavily logged. The dense timber was

The world's largest sand island, Fraser was formed over some 750,000 years by current and wind, which transport tons of sand up Australia's east coast (map). The island is named for Captain James Fraser, who, with his wife Eliza, was shipwrecked there in 1836. Eliza's sensational—and often contradictory—accounts of the ordeal include lurid tales of the murder and torture of passengers by local "savages," depicted in this illustration from an 1838 book.

shipped around the world and used for such empire-building projects as lining the Suez Canal and, after World War II, for rebuilding London's Tilbury Docks.

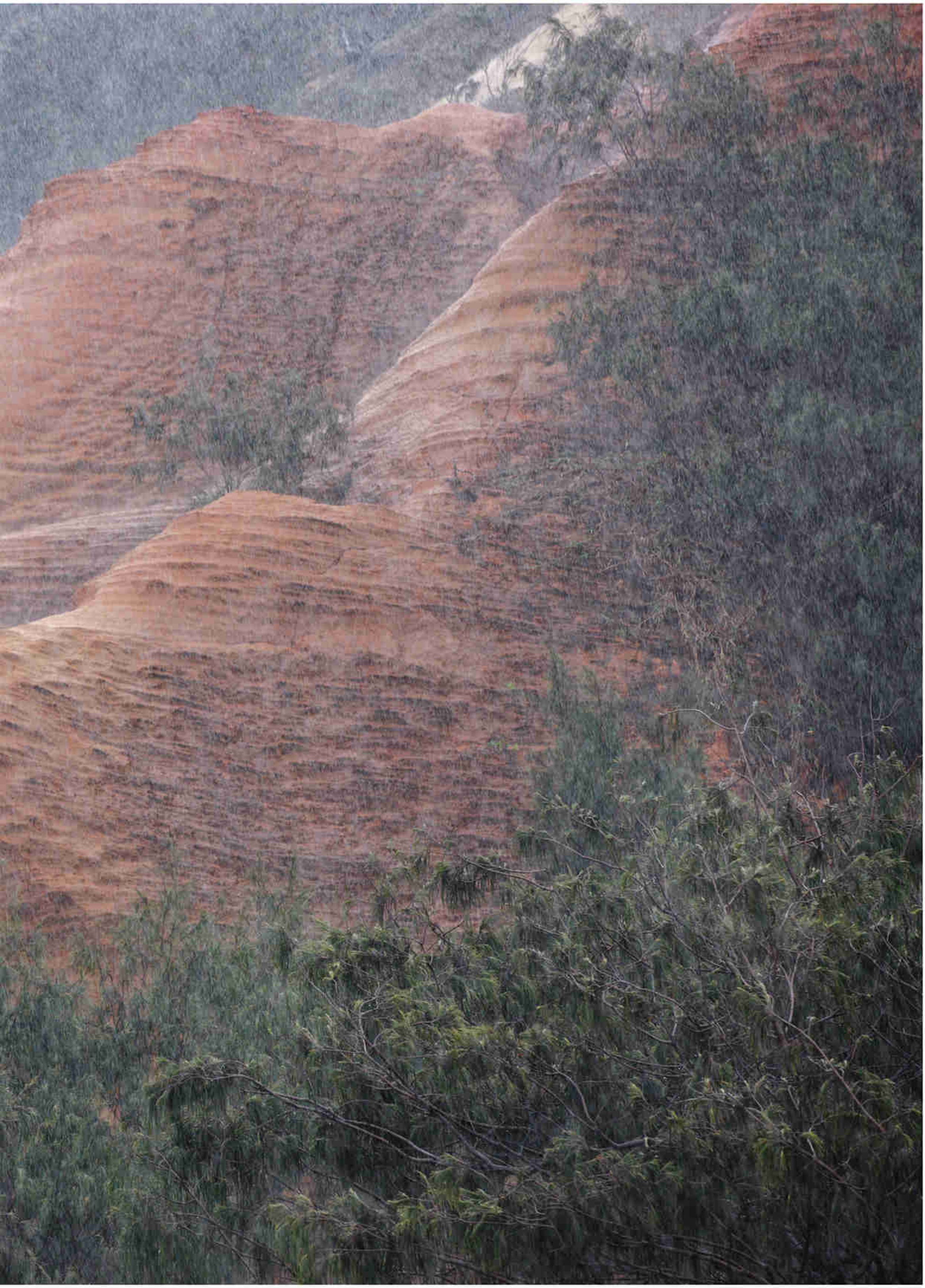
A rare early tourist appeared on the scene in the late 1940s. Sidney Nolan, one of Australia's greatest 20th-century painters, had been traveling through Queensland, looking for inspiration in the landscape. He found it in the nearly forgotten story of shipwreck and survival that a century earlier had given Fraser Island its name.

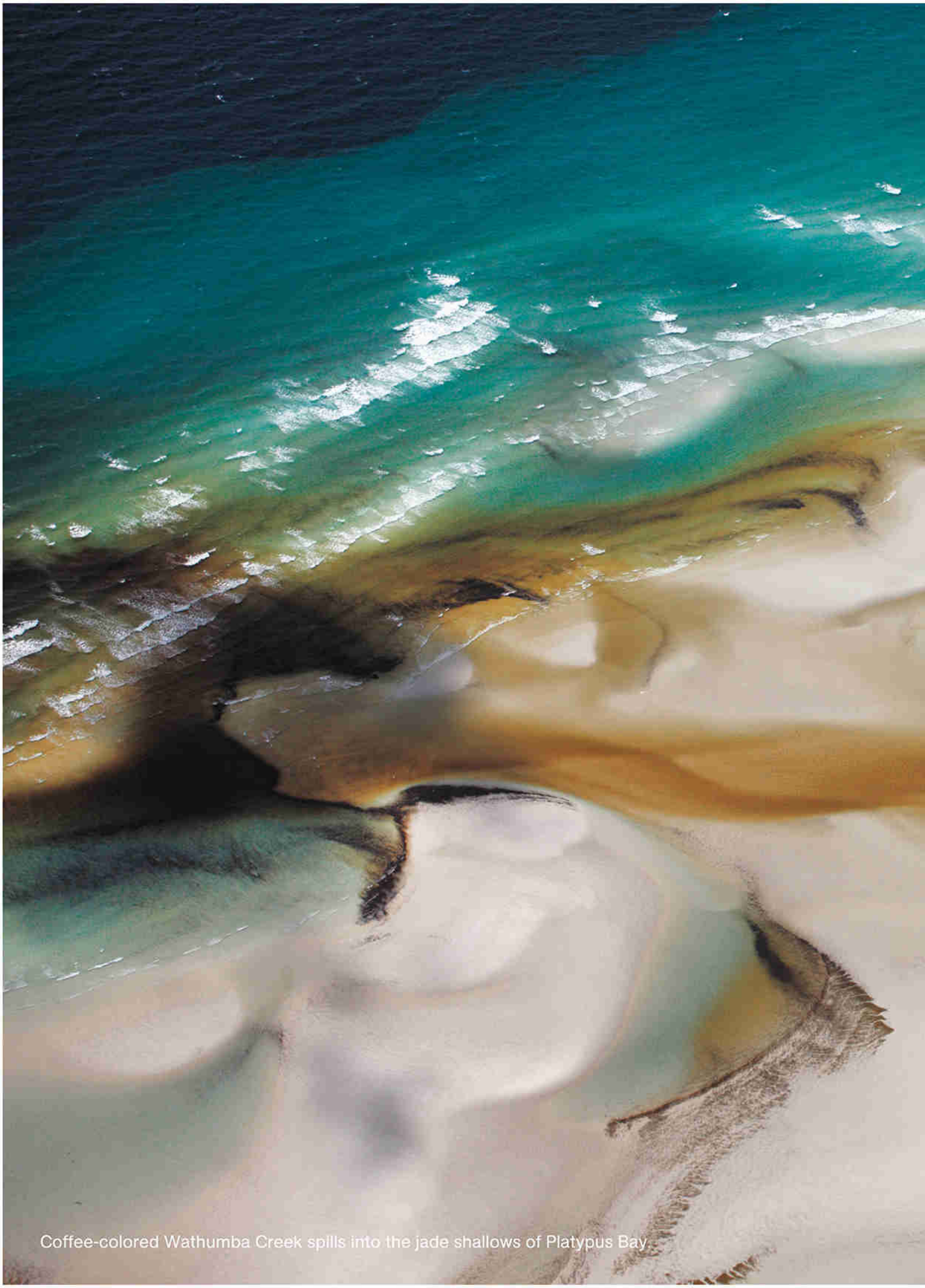
In 1836 the *Stirling Castle,* commanded by Captain James Fraser, set sail from Sydney to Singapore with 18 crew and passengers, whose number included the captain's wife, Eliza. Some days later, as the ship threaded its way through the labyrinthine passages of the Great Barrier Reef, it holed itself on the coral and began slowly sinking. Passengers and crew bundled themselves into two lifeboats and set off down the coast toward a settlement at Moreton Bay (now Brisbane), hundreds of miles to the south. It was a harrowing journey, not least for Eliza, who reportedly was heavily pregnant at the time and wound up giving birth in the badly leaking longboat; the infant died shortly afterward.

Things grew worse for the embattled survivors in the longboat *(Continued on page 78)*

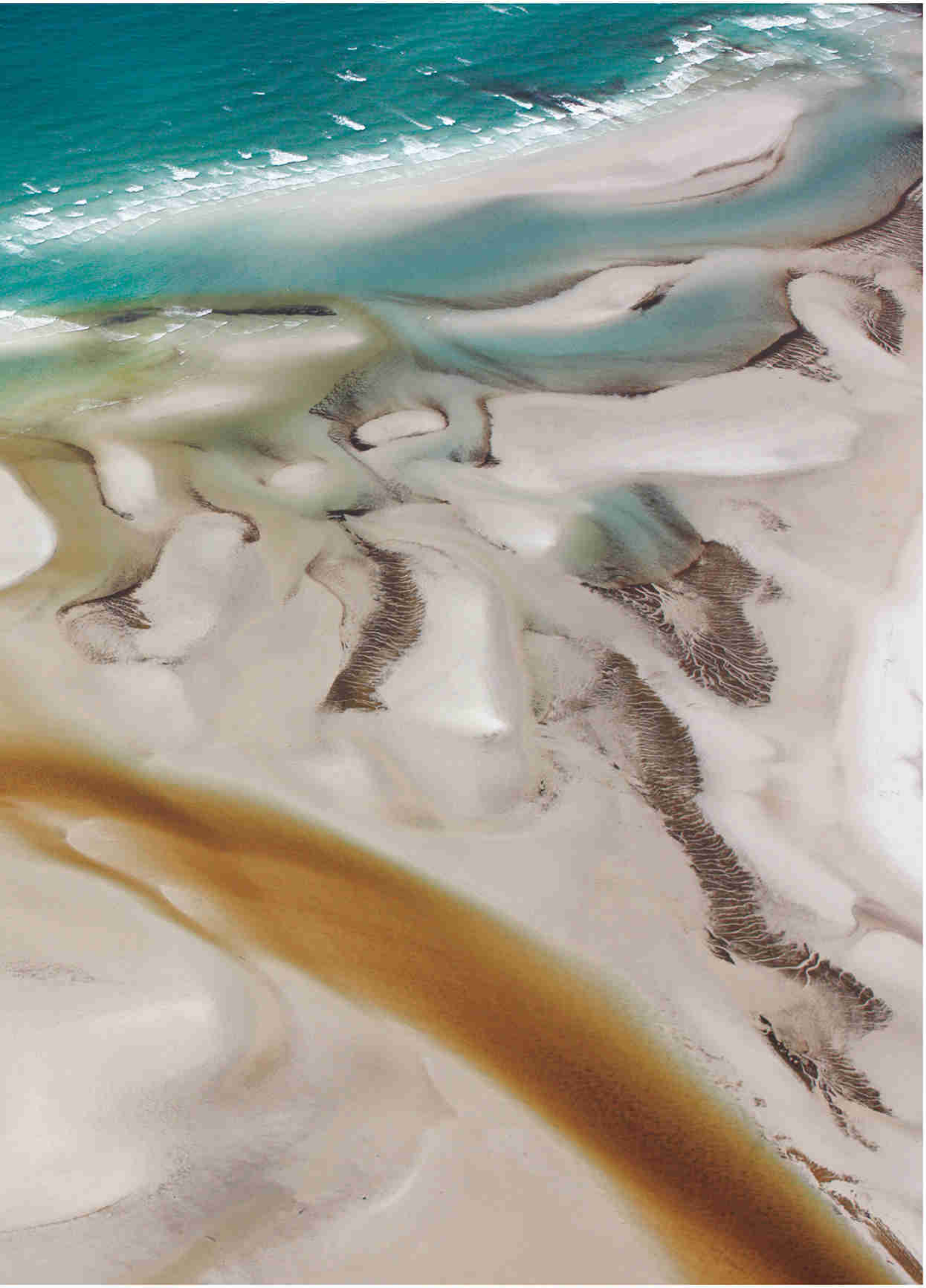
Ridges of peat and pools of dark, acidic water form a patterned peatland near Moon Point.

Wind and rain lash the face of Red Canyon, an ancient dune complex on the island's eastern flank.





Coffee-colored Wathumba Creek spills into the jade shallows of Platypus Bay.



carrying Captain and Mrs. Fraser. As their flimsy craft grew more and more unseaworthy, the other boat abandoned them and sailed on. Finally, more than a month after the shipwreck, they were forced to beach themselves on what was then known as the Great Sandy Island.

What happened next is unclear. Some accounts say the survivors bartered with the Butchulla people, giving up their clothing in exchange for food. Others claim the Aborigines stripped the castaways naked and treated them as slaves. Either way, it seems likely that hunger, disease, and exhaustion finished off most of the survivors, including Captain Fraser.

For her part, Eliza later claimed that she had been forced to work as a drudge around the Aborigines' camp, gathering firewood and digging up roots. Word of her plight eventually reached

One of dozens of lakes on the island, Lake McKenzie shimmers in the starlight. During the day the lake's sugar white beach and windowpane water attract hundreds of visitors. Like the painters and poets who celebrated Fraser's otherworldly allure, they return home with stories and images of soul-stirring beauty.

the authorities at Moreton Bay. A rescue party was sent out, and an Irish convict named John Graham, who had previously lived in the bush as an escapee and who spoke the Aboriginal language, ultimately negotiated her release.

The rest of the story follows in the finest tabloid tradition. Within months of her rescue, Eliza met and married another sea captain, moved to England, and went on to become a sideshow attraction in London's Hyde Park. There she spun increasingly wild tales of murder, torture, white slavery, and cannibalism to spellbound audiences at sixpence a head.

Alas for Eliza, nothing fades quicker than yesterday's news, and she soon lapsed into obscurity. She is said to have moved to New Zealand and was killed in a carriage accident during a visit to Melbourne in 1858.

Sidney Nolan was captivated by the operatic quality of Eliza Fraser's tale and the rich symbolism of Europeans, stripped of their civilizing veneer, grubbing for survival in an alien landscape. So the artist hopped on a timber barge and went to see Fraser Island for himself.

"The psyche of the place has bitten into me deeply," he wrote to a friend. Its spell would remain on him for the rest of his life, inspiring two series of paintings and dozens of canvases. Nolan in turn passed on his fascination to his friend Patrick White, a Nobel Prize-winning author who visited the island in the 1960s and early 1970s. White used its primal wilderness as the setting for his 1973 novel *The Eye of the Storm* and again in *A Fringe of Leaves,* a fictionalized retelling of Eliza's saga.

In 1770 Captain Cook had been unimpressed by the scrubby, sandy bluffs visible from his ship. Little more than 200 years later artists and writers, scientists and statesmen saw such value in Fraser Island that in 1992 it was declared a World Heritage site. Having helped transform Australians' sense of wild beauty, the island now draws boatloads of admirers—an outcome wise old Beeral might have hoped for when he sent Yindingie and K'gari to beautify the world those many eons ago. □

The island's geographic isolation created a wonderland of biological richness. Now population pressures and political turmoil speed the plunder of its rosewood, minerals, and gems.

THE PIERCED HEART OF MADAGASCAR

AVENUE OF THE BAOBABS, an area near Morondava protected since 2007, is all that remains of a once thick forest cleared for farmland. Growing 80 feet or more, baobabs are valued for fruit and bark.

THEIR EFFORTS scored in the earth like tree rings, laborers dig for sapphires near Ilakaka, a boomtown since the gems were discovered there in 1998. The area once supplied a third of the world's sapphires, but today exports have dropped sharply.

A LOCAL MARKET in the highland city of Antsirabe draws flower sellers as well as hungry children begging for handouts. Fewer families send their kids to school as the economy reels from falloffs in aid and tourism following a 2009 coup.

IN MASOALA National Park an illegal logger bares the valuable purple-black timber of a rosewood tree. One of hundreds of former farmers and city dwellers invading the park, he earns six dollars felling a tree worth several thousand to exporters.

FAR FROM ANY law enforcement, a camp swells with workers and rosewood logs on the Ankavia River. Alarmed conservationists report that loggers ax as many as 200 trees a day in national parks, despite the ban on rosewood exports.

BY ROBERT DRAPER

PHOTOGRAPHS BY PASCAL MAITRE

THE YOUNG MAN in the shorts and sleeveless T-shirt stands in his pirogue and pulls it upstream with a long bamboo pole. The Onive River is shallow and moves swiftly against him. Overhead a brooding sky opens up and dispenses barrages of rain, then sunlight, then more rain. The young man, whose name is Remon, is as heedless of the weather as the crocodiles lying prostrate on the shore.

Gliding past him in the opposite direction, one every three minutes, are other piroguemen. Remon calls out to them; they holler back. They are his river mates, each ferrying a dark, monstrous log of illegally harvested rosewood downstream from the rain forest to the lumberyards in the northeastern Madagascan city of Antalaha. There a paycheck awaits. Once Remon drops us off at the edge of the forest, he will do the same.

Remon doesn't like the work. The timber boss who employs him—but whose name he does not know—has told Remon that he must paddle all day without pause because the rangers have been bribed to stay away for only a finite period, after which another bribe will be expected. Still, transporting the fallen trees is better than cutting them down, which had been Remon's previous job. He quit after concluding that the risks had become too great. While illegal logging had been going on for years, the pace had suddenly escalated: The forest was unpoliced and filled with organized gangs, a free-for-all of deforestation spurred by the collapse of Madagascar's government in March of 2009 and by the insatiable appetite of Chinese timber procurers, who imported more than 200 million dollars' worth of rosewood from the country's northeastern forests in just a few months. One rosewood cutter Remon knew had been robbed of his harvest by forest thugs who told him, "There's 30 of us, one of you." And he's just heard that two men were decapitated with a machete over a timber dispute a few days ago.

The river grows still, and Remon lights a cigarette of tobacco and marijuana. He speaks of the *fady,* the taboos that protected the forest for centuries. There is always anxious talk among the timber thieves whenever an errant tree crushes a skull or the river rapids shatter a leg: *We have angered our ancestors. They are punishing us.* Elders have lectured Remon about pillaging sacred turf.

"Fine," he tells them. "Try feeding the trees to your family."

REMON USED TO FEED his family by working in the vanilla fields outside of Antalaha, a coastal town that is, like the island itself, rich in resources and poor in every other way. Two decades ago Madagascar's president at the time, Didier Ratsiraka, was so proud of Antalaha's reputation as the world's vanilla capital that he dispatched an official to pay tribute to the town. "He thought we would be full of big buildings and paved roads," says a longtime vanilla exporter, Michel Lomone. "The president was very disappointed by the report his counselor gave him."

Since then a succession of cyclones and slumping prices have conspired to jostle the crown

RISKING LIFE AND CARGO, a deliveryman rides Onive River rapids. His 400-pound rosewood log is tied to a raft of lighter wood to keep it afloat. On slower water (below) a crew ferries a truck loaded with logs. Most end up in China to make high-cost furniture and musical instruments.

from the vanilla king's head. Today Antalaha is dusty and somnolent, and though its main boulevard, Rue de Tananarive, was finally paved in 2005 with funding from the European Union, the street's traffic consists largely of a few dinky taxis, rusty bicycles, chickens, goats, and, above all, pedestrians striding barefoot in the rain and holding over their heads the elephantine leaves known as traveler's palms to stay dry.

Or such was the traffic until the spring of 2009. During that season the streets of Antalaha suddenly began to roar with motorcycles. The one store on Rue de Tananarive that carried such vehicles promptly sold out. Responding to the demand, a second store opened up down the street and began doing crazy business as well. The buyers were rawboned young men, and everyone in Antalaha knew where their fleeting cash came from. It wasn't the vanilla fields. The same young men could be seen driving into town in the backs of pickup trucks astraddle great loads of illegally harvested timber, systematically filling their pockets by selectively cutting Madagascar's precious rosewood trees from the forest.

Madagascar is an island—the world's fourth largest, at over 225,000 square miles, but an island nonetheless. Though all islands are blessed with their own unique biosphere, Madagascar (which was dislocated from Africa some 165 million years ago) is a special case: Roughly 90 percent of its flora and fauna is found nowhere else on the planet. The extraterrestrial spectacle of carrot-shaped baobab trees, ghostly lemurs, and whole "forests" of towering stone spikes is inclined to make the world-weariest of visitors grow wide-eyed with innocent delight.

Its rare and haunting beauty coexists with a desperation among its people that defines everyday life. The Malagasy, the island's major ethnic group, have an expression that is elegant in its fatalism: *"Aleo maty rahampitso toy izay maty androany,"* or "It's better to die tomorrow rather than today." The typical Madagascan lives on about a dollar a day.

And considering that Madagascar's population of more than 20 million is growing 3 percent a year—one of the most rapid rates in Africa—the tension between rich land and poor residents on a finite landscape increases by the day. For this reason alarmed ecologists have termed Madagascar a biodiversity hot spot, deploring, in particular, the Malagasy practice of slash-and-burn agriculture, in which swaths of forest are torched and converted to rice fields. Just as the global environmental community rejoiced in 2002 when Marc Ravalomanana assumed the presidency on a green-friendly platform, so did they react with dismay in the spring of 2009 as the military routed Ravalomanana from office and installed a constitutionally underage former radio disc jockey in his place. As one veteran aid worker stationed in Madagascar said, "I feel like the past 25 years of work has been undone."

In September 2009, after months during which up to 460,000 dollars' worth of rosewood was being illegally harvested every day, the cash-strapped new government reversed a 2000 ban on the export of rosewood and released a decree legalizing the sale of stockpiled logs. Pressured by an alarmed international community, the government reinstated the ban in April. Yet logging continues.

The outside world is in no position to lecture, given its own voracious appetite—sometimes benign, sometimes less so—for Madagascar's wondrous resources. The raiding of the forests illustrates how easily the frail balance between human and ecological imperatives can be undone. But that balance has always been wobbly in Madagascar. Various foreign-owned holding groups own most of the rights to prospect and mine the country of its gold, nickel, cobalt, ilmenite, and sapphire (which once supplied a third of the world market). ExxonMobil began deep offshore oil exploration in Madagascar four years ago. Some of the finest American guitar makers have long featured fingerboards constructed of rare Madagascan ebony. In recent years the

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Writer Robert Draper and photographer Pascal Maitre reported on the failed state of Somalia for the September 2009 issue. The article won the National Magazine Award for photojournalism.

A HIGH POPULATION GROWTH RATE MEANS THE TENSION BETWEEN RICH LAND AND POOR RESIDENTS INCREASES BY THE DAY.

island's federal government has attempted to lease arable land to the South Koreans and sell water to the Saudis. In this come-and-get-it climate, much is extracted but little is gained on behalf of the average Malagasy. Small wonder, then, that local miners loot the countryside of precious gemstones to be sold in Asian markets. Or that animals such as the leaf-tailed gecko and the endangered plowshare tortoise are smuggled by small operators off the island to collectors. Or that the rawboned young men of Antalaha would decide it's better to die tomorrow while taking the money of Chinese rosewood buyers today.

"It's good for the economy, bad for the ecology," observes one man involved in the illicit rosewood business, smiling and shrugging as he hops on his motorcycle and speeds off. But the boomlet in Antalaha has proved to be a false one. Even leaving aside the devastating, long-term consequences of a plundered forest—the disappearance of precious wood in as much as 25,000 acres of the country's 11.3 million acres of protected areas, the extinction of lemurs and other endemic species, a plague of soil erosion that silts up rivers and wipes out nearby farmland, the loss of tourism revenue—the perverse side effects of the rosewood raiding are more immediately felt. The residents of Antalaha who suddenly found themselves dodging motorcycle traffic also began to notice the price of fish, rice, and other daily goods begin to climb. The reason was simple: Fewer men were out at sea or in the fields.

"They're in the forest," says Michel Lomone, the vanilla exporter. "Everyone's gone to the forest."

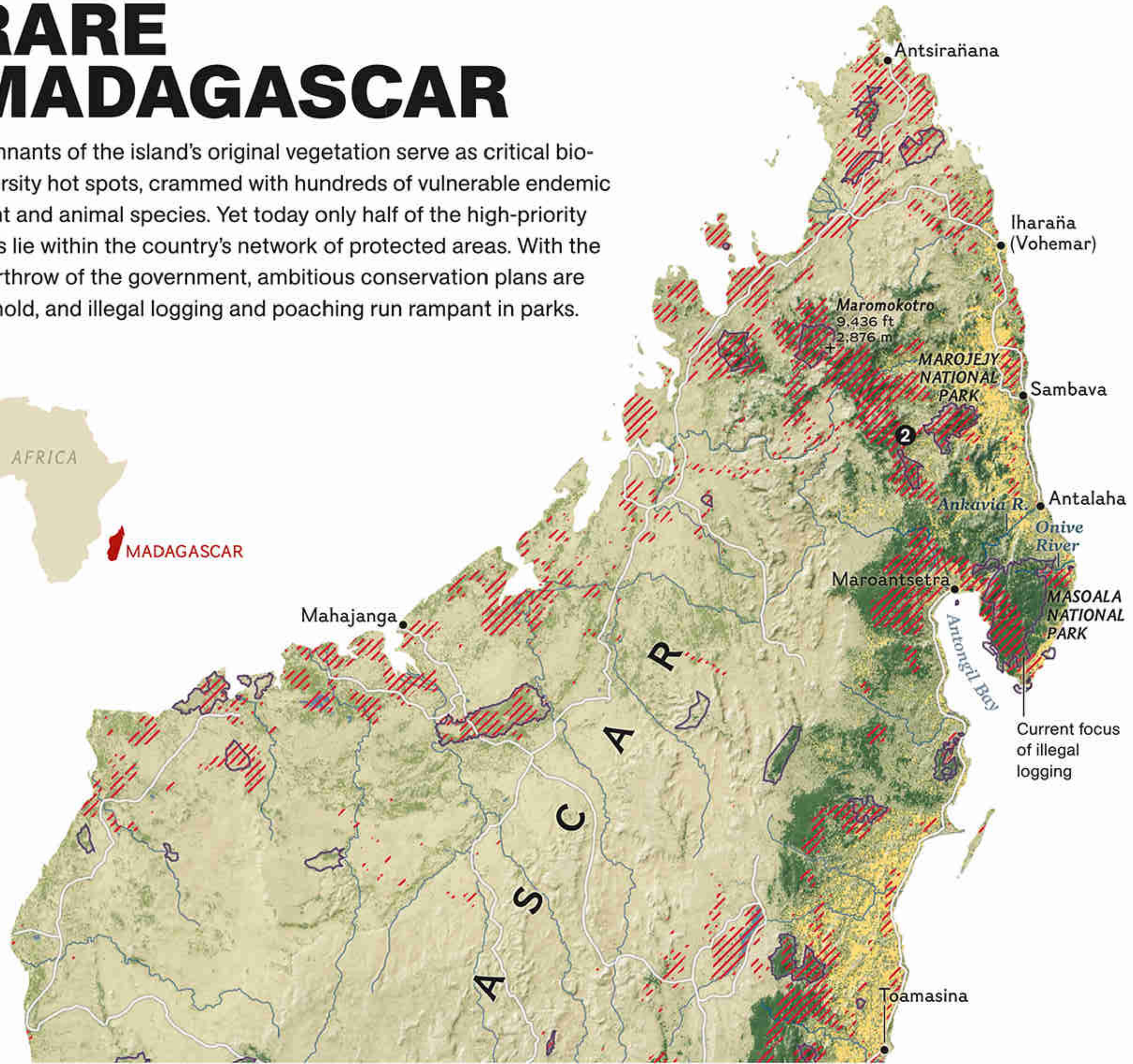
TO GO FROM ANTALAHA to the forest—meaning Masoala National Park, Madagascar's largest—requires a journey no one would undertake who does not need to do so. It begins with a three-hour drive southwest from the town, along dirt roads so badly mangled from the weight of lumber trucks that vehicles sink into the muddy ditches, and locals must be rounded up to help push them out. Then comes the four-hour pirogue trip up the Onive River, followed by a four-hour slog on foot through spongy rice fields, and another two hours along a slippery mud trail up and down the granite spine of dense primary forest—all of this under sporadic rainfall. Thus does one arrive at the edge of Masoala. But to find rosewood that has not yet been cut, one must push deeper, for many hours.

The park's southwestern border is Antongil Bay, where humpback whales noisily give birth between July and September. Within the wild, green womb of the 580,000-acre tropical rain forest, a stranger's doggedness may be rewarded with cameo appearances by orchids, carnivorous plants, serpent eagles, the dazzling Parson's chameleon, and the red ruffed lemur. Masoala offers a seeming infinity of medicinal herbs, wild berries, and firewood to villagers, who stride barefoot in and out of the forest daily, singing and chatting. In contrast, the young men who are here from the city on business appear lost in this damp, mysterious thicket.

For weeks they camp out in small groups beside the trees they've singled out for cutting, subsisting on rice and coffee, until the boss shows up. He inspects the rosewood, gives the order. They chop away with axes. Within hours a tree that first took root perhaps 500 years ago has fallen to the ground. The cutters hack away at its white exterior until all that remains is its telltale violet heart. The rosewood is cut into logs about seven feet long. Another team of two men tie ropes around each log and proceed to drag it out of the forest to the river's edge, a feat that will take them two days and earn them $10 to $20 a log, depending on the distance. While staggering through the forest myself, from time to time I come upon the jarring apparition of two

RARE MADAGASCAR

Remnants of the island's original vegetation serve as critical biodiversity hot spots, crammed with hundreds of vulnerable endemic plant and animal species. Yet today only half of the high-priority sites lie within the country's network of protected areas. With the overthrow of the government, ambitious conservation plans are on hold, and illegal logging and poaching run rampant in parks.

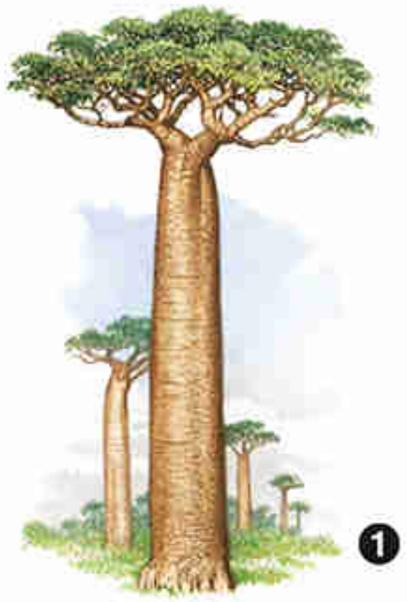


DWINDLING WONDERS

Some 90 percent of Madagascar's plant and animal species are found nowhere else, having evolved in isolation for millions of years after the island broke from Africa and India. Many are restricted to small, unprotected biodiversity areas.

Plants

Most of Madagascar's estimated 13,000 plant species are endemic, like the threatened Grandidier's baobab, one of six baobab species unique to the island.



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Mammals

Lemurs live only on Madagascar and the nearby Comoros islands. Fifty species make up nearly half of Madagascar's mammals. More than 20, including the silky sifaka, are endangered.

2

MOZAMBIQUE

MADAGASCAR

INDIAN OCEAN

AMBATOVY NICKEL AND COBALT MINE

MANTADIA N.P.

VOHIMANA

ANALAMAZAOTRA SPECIAL RESERVE

Antananarivo

Antsirabe

AVENUE OF THE BAOBABS

Morondava

Mananjary

Fianarantsoa

Morombe

Mangoky

Manakara

Farafangana

ILAKAKA SAPPHIRE MINES

Toliara

Onilahy

Beheloka

ILMENITE MINE

Tôlañaro

Rain forest (primary rosewood habitat)

Degraded rain forest

Other forest

Critically important biodiversity area

Protected area

Species found mostly in this biodiversity area

0 mi 60

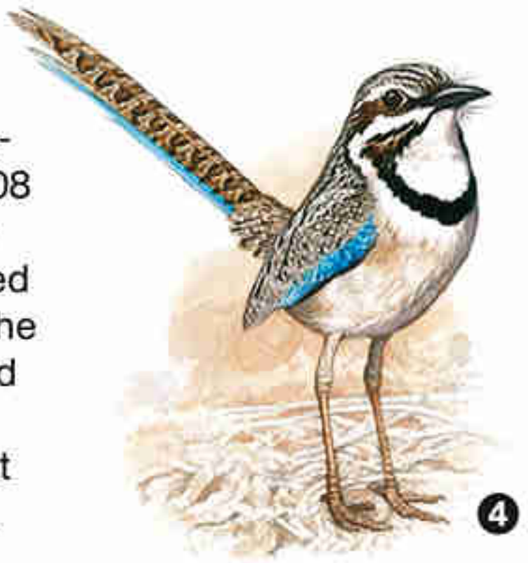
0 km 60

Reptiles

Chameleons, such as the colorful lesser chameleon, likely originated on Madagascar; two-thirds of the species are found here. Reptiles are under pressure from the pet trade.

Birds

As many as three-quarters of the 108 endemic species live only in wooded areas, including the long-tailed ground roller, restricted to the spiny forest of the southwest.



Amphibians

This population is all frogs, with 99 percent of the 373 species endemic, including the critically endangered harlequin mantella, found only on the central high plateau.

WILLIAM E. McNULTY, SAM PEPPLE, AND LISA R. RITTER, NGM STAFF; INTERNATIONAL MAPPING

ART: ALDO CHIAPPE

SOURCES: REBIOMA; MADAGASCAR PROTECTED AREAS SYSTEM; WILDLIFE CONSERVATION SOCIETY; ROYAL BOTANIC GARDENS, KEW; MISSOURI BOTANICAL GARDEN

A PATH CUT for a pipeline serving the Ambatovy nickel mine slices into a species-rich forest. Ignoring the previous government's pledge to set aside 10 percent of the island for protected areas, the new leaders promote mining instead.

FOR SALE: four-month-old ring-tailed lemur, $50 or best offer. The owner poached the primate in a forest on the west coast. Hunters are increasingly catching lemurs, many of them endangered, to cash in on the illegal pet trade or to sell to restaurants like one in Sambava serving bush-meat stew.

stoic figures tugging a 400-pound log up some impossible gradient or down a waterfall or across quicksand-like bogs—a hard labor of biblical scale, except that these men are doing this for money. As is the man the pair would meet up with at the river, waiting to tie the log to a hand-crafted *radeau,* or raft, to help it float down the rapids ($25 a log). As is the pirogueman awaiting the radeau where the rapids subside ($12 a log). As is the park ranger whom the timber bosses have bribed to stay away ($200 for two weeks). As are police at checkpoints along the road to Antalaha ($20 an officer). The damage to the forest is far more than the loss of the precious hardwoods: For each dense rosewood log, four or five lighter trees are cut down to create the raft that will transport it down the river.

At a bend in the river, the pirogues pull up to shore. A man with a mustache squats in a tent, smoking a hand-rolled cigarette. His name is Dieudonne. He works with the middleman, the boss on the ground, entrusted by the timber baron to select the trees for cutting and oversee the logs from the riverbank to the transport trucks. There have been 18 trucks this morning. Thirty or so rosewood logs lie scattered around Dieudonne's tent. His cut is $12 a log. I ask him what he'll do with his money. He reflects for a moment.

"I'd like to buy a motorcycle," he says.

THE MAN WHO ENTRANCED the West with his pledges to usher in an eco-conscious era of *"Madagascar naturellement"* was Marc Ravalomanana, a former yogurt vendor who ascended to mayor of the capital city of Antananarivo, toppled the socialist President Ratsiraka, and formed the Tiako I Madagasikara (I Love Madagascar) political party in 2002. The president built roads and hospitals, distributed school uniforms, and symbolically cut the cord from the country's French colonialists by switching the currency from francs to Malagasy ariary. He also strengthened the ban on slash-and-burn agriculture (to no apparent effect, unfortunately), announced the Madagascar Action Plan to promote the country's biodiversity, and made a commitment to triple the size of Madagascar's protected reserves. Utterances such as "our most important asset is our environment" were music to the green community's ears, and, as one environmentalist said, "I felt like we had a seat at the table."

Alas, different kinds of "action plans" were transpiring under the president's table: He reportedly confiscated harvested rosewood from the timber barons only to sell it for personal profit. He demanded, in the presence of reporters, a 10 percent cut of an oil company's exploration costs. As the president's wallet grew fatter, the purchasing power of his countrymen plummeted. Thousands of protesters stormed the presidential palace on February 7, 2009. They were met by gunfire, which left at least 30 dead. But a month later the military turned on Ravalomanana, who fled to Swaziland. Once in exile, he was convicted of confiscating city land for his family's business and using public funds to purchase a $60-million plane from Walt Disney's nephew.

The world community refused to recognize the new government, led by 34-year-old former Antananarivo mayor Andry Rajoelina. The World Bank, the UN, USAID and other donors withdrew funding, and Madagascar achieved the dubious distinction of being the first country to receive a $110-million U.S. Millennium Challenge Account grant and then, four years later, be kicked out of the program. Western countries issued travel advisories against going to Madagascar. Ravalomanana's green hand had been slapped away. The new government had no money to pay for enforcement of park regulations.

One group was plainly delighted by the turn of events. On March 17, 2009, the day Marc Ravalomanana signed his resignation papers, as many as 20,000 packed Antalaha's soccer stadium. Twelve zebu cattle were roasted, beer flowed in abundance, and villagers danced to live music all night. The tab was paid for by the area's 13 timber barons. The forest was unprotected.

It was theirs.

THE TIMBER BARON sits behind a desk of ebony, in a palisander chair, surrounded by palisander

LURED BY RUMORS of pink sapphires as big as a fist, many who flock to Ilakaka end up earning a few dollars on a shovel brigade (left and bottom right), lifting dirt out of an open-pit mine. While traders from Sri Lanka and Thailand take the best stones, Malagasy buyer Soaraza Arifeno (top right, wearing a sun mask made from root paste) selects second-tier gems for her African clients.

walls and ceiling and floor. Though his parents came over from China in the 1930s, and as he observes, "the Chinese people are crazy about rosewood," he himself was born near Antalaha and is partial to the russet brown color of palisander, a species closely related to the more beet-colored rosewood. His office is redolent with vanilla, owing to his adjacent warehouse, filled with bundles awaiting export. The growling of timber saws comes from his lumberyard, where piles of rosewood lie unhidden. Lean and muscular young men sit on benches outside the office door, where a note says, "People coming to pick up their paycheck must present their I.D."

His name is Roger Thunam, and it is widely believed that he is among the biggest rosewood businessmen in Madagascar. He is a compact, bespectacled man of middle age with distinctly Asian features, calmly self-possessed in the way of those who wield great power. The country's small population of Chinese émigrés are thoroughly assimilated into the community. Thunam is proof of this: He is a gregarious presence around Antalaha, a soft touch when a local peasant needs help paying for a funeral, not to mention a good man to see when gainful employment is sought. Still, despite the many fees paid up the timber chain—to the cutters, the draggers, the rafters, the piroguemen, the middlemen, the truck drivers and cops along the highway en route to the ports at Iharaña and Toamasina—the lion's share reverts to men like this one who, as he confesses, "can't remember when I was last in the forest."

"Thunam isn't a businessman—he's a trafficker," says one local official. "He cuts what isn't his. He's taken from the people's park. And now others think it's acceptable to take what's forbidden." Unsurprisingly, Thunam asserts otherwise. Born into the vanilla business, he expanded into timber 30 years ago. Since that time, he says, the government has issued him various permits.

Indeed, the government has lifted the ban on exporting rosewood when cyclones ravage the forest along the eastern coast of Madagascar, allowing trees damaged by the storms to be cut and traded. This fluctuating policy has allowed timber barons to stockpile illegal logs when the ban is in effect and then sell them as "salvaged" timber when the ban is temporarily lifted. The loophole only encourages further illegal cutting in the national parks—where the most rosewood can still be found.

Thunam insists he cuts only legal timber—though yes, his lumberyard is currently cluttered with rosewood logs, and he can explain this: "You wouldn't believe all of the men out there cutting. They're the same ones who've done slash and burn in the past. They've never been to school. They don't care about the next generation. They're the destroyers… But this lumber is already cut. If we don't buy it from them, someone else will."

He acknowledges that the rosewood-crazy Chinese are "the most important buyers." (A rosewood dining room set produced in China retails for upwards of $5,000.) And even when the new government allowed a temporary reversal of the ban to expire during the summer of 2009, the Chinese continued to place orders with Thunam for rosewood. To let his competitors have all that business would diminish him, he says. "In six months, we'd be very small."

The timber baron's wife, an ample middle-aged woman, enters the office and listens to the exchange. When her husband departs, she confesses, "I don't like to destroy the forests. I'd prefer to stop cutting and to just export what's already been cut. A few weeks ago I was on a plane, and I flew low over the forest. I could see the destruction. That's when I decided it should be stopped."

But how? Later I ask Antalaha's mayor, Risy Aimé. "To stop it is easy," he replies. "Go arrest 13 people"—referring to Roger Thunam and the other timber barons.

Every so often, the government has done just that, bringing charges against timber barons suspected of illegal trading. But the traders wield enormous power and have been able to take advantage of the chaotic legal status of logging. According to a report by Global Witness and the Environmental Investigation Agency, Thunam was one of only two barons (out of six known cases) found guilty of exporting rosewood; he was released from custody in 2008 after paying an

DESPITE THE MONEY PAID TO THE CUTTERS, THE RAFTERS, THE COPS, THE MIDDLEMEN— THE LION'S SHARE GOES TO THE TIMBER BARONS.

out-of-court settlement. Charged again in 2009, Thunam was found not guilty. The timber baron can once more be found behind his ebony desk, presiding over a humming lumberyard.

MY GUIDE IN MASOALA, a former park employee named Rabe, has been into the forest over a hundred times in the past decade. He keeps up a brisk and barefoot pace through a tangled, claustrophobic wilderness, seeing it with intimate familiarity. But to his surprise, something has changed since his last visit a few months before.

"No lemurs," he says. "They've disappeared."

The rosewood thieves are behind this. Weary of a rice-only diet, they have begun to lay traps. We learn of one team that captured 16 lemurs in a single day. Not all of them are being eaten on the spot. In the town of Sambava, just north of Antalaha, three restaurants feature lemurs on their menu, despite federal laws. In this way the rain forests of northeastern Madagascar are rapidly losing the red ruffed, the fork-marked, the greater dwarf, and the aye-aye. Lemurs are found in no other country on Earth, save the nearby Comoros islands.

"We don't want to conserve an empty forest, where the only thing you can come to see is trees," says primatologist Jonah Ratsimbazafy of the Durrell Wildlife Conservation Trust. For all of Madagascar's ecological richness, central to its multimillion-dollar tourist trade is its quintessential mascot, attested to by the thousands who visit the Analamazaotra Special Reserve. These bug-eyed, tree-dwelling primates fascinate not only because they are here and only here, but also because they are here in such diversity. Though virtually all 50 species of lemurs are polygamous, have luxurious tails, and many tend to grunt like pigs, there's also the black-and-white indri, which is monogamous, has no tail, and rocks the forest with spectral wails. Incredibly, scientists continue to discover new species of lemurs on the island. But each species is few in number, and in the meantime, five different lemurs inhabit the list of the world's 25 most endangered primates.

As yet, no national outpouring of sympathy for the lemur's plight has emerged. The Malagasy "should be proud of lemurs because Madagascar's the only place for them," says Ratsimbazafy. "But some people here don't know or care. The Malagasy who don't live near tourist areas think that lemurs are just for the *vazaha* [white people]—they don't see the benefits." In fact, although some tribes consider certain species of lemur to be sacred, the rather alarming-looking aye-aye, with its outsize eyes and ears, is believed by tribes in the north to be an evil omen and is therefore killed on the spot.

Such taboos have governed Malagasy conduct for centuries. They're admonitions from the ancestors, believed to linger on Earth as intermediaries to the afterlife and, therefore, to be heeded and appeased—sometimes, as I witnessed, through *famadihana,* a ceremony in which ancestors' bones are dug up, ceremonially wrapped in fresh white shrouds, and danced with around the tomb before being returned to the earth. In different tribes, it's fady to touch a chameleon or to talk about crocodiles or to eat pork or to work on Thursdays. Numerous fady prohibit the desecration of a mountain, a large boulder, a stand of trees, or even an entire forest—all evidence of a deep, if complicated, connection to the land and a spiritual investment in its good health. Nonetheless, the fady that tend to be heeded most reliably are those that do not collide with the Malagasy verity that it's better to die tomorrow.

"YOU SEE THAT BALD PATCH?" says Olivier Behra, pointing to a conspicuously deforested swath

ANCESTORS RECEIVE hands-on love during *famadihana,* a "turning the bones" reburial ceremony still popular in rural areas. Every five years or so, Jean Louis Rakotondrasoa (above) opens the family tomb to take the remains of relatives outside, where they are rewrapped in new shrouds and feted with music and dancing (below). Families save for years to pay for the feast (left).

ONLY FRAGRANT VANILLA pods pass a sniff test at an Antalaha warehouse, where workers check for whiffs of mold. Prices for vanilla, a leading export earner, have plunged due to global overproduction, pushing farmers into forests to hunt and chop.

amid acres of trees. "There's a guy over there who's been cutting. I'm trying to get him to stop."

"How do you propose to do that?" I ask.

Smiling, Behra says, "Employ him."

Behra's efforts represent an enlightened, if localized, solution to Madagascar's resource dilemma: Promote the immediate benefits of a vital forest to villagers. The Frenchman first came to Madagascar in 1987 on a UN project to save the unloved but seriously depleted crocodile population. Realizing that "if you give value to crocodiles, then people will become interested," he began to pay the locals to harvest crocodile eggs. Since 2000 Behra has been applying the same formula to the endangered forests of Madagascar through his NGO, Man and the Environment. In the woodlands of Vohimana a hundred miles east of the capital, Behra encountered a forest that had been halved over the previous four decades. Using the expertise of the locals, he cataloged 90 medicinal plants, then set up schemes to market them overseas. The French fragrance company Chanel became interested in extracts from Madagascan leaves like *marungi*. By 2007 the deforestation in Vohimana had ceased. Instead of hundreds of villagers slashing and burning, they're now collecting and selling leaves never thought to have economic value.

"I built myself a house here," says Behra. "The people see I'm not leaving tomorrow, so they can trust me." He's been a resourceful but unimposing presence. Recognizing that "you can't just take a lifelong woodcutter and expect to train him in agriculture," Behra persuaded the Madagascan government to allow the locals to continue to use a portion of the forest to harvest wood for domestic charcoal use. Having learned that there was a lemur hunter in the village, Behra employed the man as a guide for lemur-obsessed tourists. Another man who had made a living harvesting the forest's rare orchids is now the head of Behra's orchid conservatory. When Behra considered a project to farm the forest's wild pigs, which were destroying the cassava plantation he had set up, the Betsimisaraka tribesmen informed him that pigs were fady, and "you have to respect that." He has persuaded Chanel to donate money for medical staff and school lunches in Vohimana.

"Working on a small scale the way Behra is doing may be more effective than these dreams of saving the whole forests," says Jean-Aimé Rakotoarisoa, for 30 years the director of the Museum of Art and Archaeology at the University of Antananarivo. "Most of the environmental programs say, Don't burn the forest because this is your future. But these people can't wait for the future. They're hungry now. You have to show the immediate benefit to the community."

That's a message getting through to a handful of large-scale resource extractors. Rakotoarisoa now serves as a consultant to the Ambatovy project, a $4.5-billion nickel and cobalt mining operation led by a foreign consortium and located near Olivier Behra's forest. The project, though controversial because it has not yet delivered on all of its promises, has taken care to avoid fady sites, compensate (and, where necessary, relocate) affected villagers, and continually engage with the community. These efforts aren't altruistic, Rakotoarisoa readily concedes. "For the sake of the company's image, they have to take care of the environmental and social concerns. They can't do business here if there's social protest."

On the southeastern tip of the island near Tôlañaro, the Anglo-Australian mining company Rio Tinto is attempting an ambitious good-neighbor policy to offset its $940-million project along the Indian Ocean coast extracting ilmenite, rich in titanium, a common ingredient in paints, paper, and plastic. The activity has involved gutting unique littoral forests containing 19 endemic species as well as medicinal plants and basket-weaving reeds. Still, in contrast to the timber barons several hundred miles up the coast, Rio Tinto is trying to preserve every single species. The company has set aside forestland for conservation, launched an agricultural training program, built a public seaport, and has plans to begin rehabilitating the land next year.

"We have high standards, and we'd like to influence other mining companies to be the

A FARMER AND HIS OXEN haul children to family rice plots near Morondava, along a path obscured during a flood. Madagascans are trying to figure out how best to survive in uncertain terrain.

same way," says Manon Vincelette, a forest engineer hired in 1996 to direct Rio Tinto's biodiversity program. Though the residents of Tôlañaro have a new road, new and renovated schools, and, in some cases, new jobs at the mine, local skepticism remains as to whether the foreign company is looking after any interest other than its own. "Rio Tinto is doing good things," says the ethnologist Jean-Aimé Rakotoarisoa. "But I've heard the rumors in that community—and from a social standpoint, rumor is more important than facts. You can't just deal with engineers and experts. There is no other way; you must know exactly the mind of the people."

THE ANTALAHA AIRPORT is small and wholly unadorned. Dogs and chickens poke around for scraps of food. Several dozen people await the incoming flight from Antananarivo. Through the doorway steps Roger Thunam, accompanied by his assistant. The timber baron walks from one side of the building to the other, shaking everyone's hands, hugging women, trading fond words.

Then he strolls outside and, until the arrival of the plane, leans contentedly against a fruit stand and drinks from a coconut with the other villagers—no different from the rest of them, a man of the people, one who knows their mind… and one who provides, at least for today. □

Perched on the tendril of a Passiflora *plant, the egg of the Julia heliconian butterfly may be safe from hungry ants. This species lays its eggs almost exclusively on this plant's twisted vines.*

DRYAS IULIA

Exquisite Castaways

ENGINEERED FOR SURVIVAL, INSECT EGGS HANG ON AND HATCH WHEREVER THEIR PARENTS DEPOSIT THEM.

By Rob Dunn Photographs by Martin Oeggerli

Owl butterfly egg

WE FOOL OURSELVES MOST DAYS.
WE IMAGINE THE EARTH TO BE OURS,
BUT IT BELONGS TO THEM. WE HAVE BARELY
BEGUN TO COUNT THEIR KINDS. NEW FORMS
TURN UP IN MANHATTAN, IN BACKYARDS, NEARLY
ANYTIME WE FLIP A LOG. NO TWO SEEM THE SAME.
THEY WOULD BE LIKE EXTRATERRESTRIALS AMONG
US, EXCEPT THAT FROM ANY DISTANCE WE ARE
THE ONES WHO ARE UNUSUAL, ALIEN TO
THEIR MORE COMMON WAYS OF LIFE.

As the vertebrate monsters have waxed and waned, the insects have gone on mating and hatching and, as they do, populating every swamp, tree, and patch of soil. We talk about the age of dinosaurs or the age of mammals, but since the first animal climbed onto land, every age has been, by any reasonable measure, the age of insects too. The Earth is salted with their kind.

We know, in part, what makes the insects different. Those other first animals tended to their young, as do most of their descendants, such as birds, reptiles, and mammals, which still bring their young food and fight to protect them. Insects, by and large, abandoned these ancient traditions for a more modern life.

Insects evolved hardened eggs and with them a special appendage, an ovipositor, which some use to sink their eggs into the tissue of Earth. Lift a stone and you will find them. Split a piece of wood, and they are there, but not only there. Birds struggle to find good places to nest, yet insects evolved the ability to make anything—wood, leaves, dirt, water, even bodies (especially bodies)—a nursery. If there is a single feature that has ensured insects' diversity and success, it is the fact that they can abandon their young nearly everywhere and yet have them survive—because of those eggs.

They began simply, smooth and round, but over 300 million years, insect eggs have become as varied as the places where insects reign. Some eggs resemble dirt. Others resemble plants. When you find them, you might not know what you are seeing at first. The forms are unusual and embellished with ornaments and apparatuses. Some eggs breathe through long tubes that they extend up through water. Others dangle from silky stalks. Still others drift in the wind or

PAGES 112-13: *Stinkbugs often lay their eggs in clumps. Individual eggs are glued not only to each other but also to the leaf on which they are left. The delicate projections may aid, like snorkels, in respiration.* PENTATOMIDAE

PAGES 114-15: *The mosaic pattern on an owl butterfly egg looks like a landing pad. At the center is a minute opening, called a micropyle, through which the sperm enters the egg.* CALIGO MEMNON

ride on the backs of flies. They are as colorful as stones, shaded in turquoises, slates, and ambers. Spines are common, as are spots, helices, and stripes. More than biology, their designs suggest the work of an artist left to obsess among tiny forms. They are natural selection's trillion masterpieces; inside each is an animal waiting for some cue to break free.

The basic workings of insect eggs, however, like the basics of any egg, are recognizable. The egg develops its shell while still inside the mother. There the sperm must find and swim through an opening at one end of the egg, the micropyle. Sperm wait inside the mother for this chance, sometimes for years. One successful sperm, wearied but victorious, fertilizes each egg, and this union produces the undifferentiated beginnings of an animal nestled inside a womblike membrane. Here eyes, antennae, mouth parts, and all the rest form. As they do, the creature respires using the egg's aeropyles, through which oxygen diffuses in and carbon dioxide out. That all of this occurs in a structure typically no larger than a grain of raw sugar is simultaneously beyond belief and ordinary. This is, after all, the way in which most animals ever to have lived on Earth had their start.

What you see on these pages are the eggs of a few small branches of the insect tree of life. Among them are those of some butterflies that face extraordinary travails to defend themselves against predators and, sometimes, against plants on which they are laid. Some passionflowers transform parts of their leaves into shapes that resemble butterfly eggs; mother butterflies, seeing the "eggs," move on to other plants to deposit their babies. Such mimics are imperfect, but fortunately so is butterfly vision.

Eggs must also somehow escape having the eggs of another type of insect, parasitoids, laid inside of them. Parasitoid wasps and flies use their long ovipositors to thrust their eggs into the eggs and bodies of other insects. Roughly 10 percent of all insect species are parasitoids. It is a well-rewarded lifestyle, punished only by the existence of hyperparasitoids, which lay their eggs inside the bodies of parasitoids while they are inside the bodies or eggs of their own hosts. Many butterfly eggs and caterpillars eventually turn into wasps as a consequence of this theater of life. Even the dead and preserved eggs shown here are likely to hold mysteries. Inside some are young butterflies, but inside others may be wasps or flies that have already eaten their first supper and, of course, their last.

Every so often, and against all odds, a group of insects has regressed a little and decided to care more actively for its young. Here and there we see the evidence. Dung beetles roll dung balls for their babies. Carrion beetles roll bodies. And then there are the roaches, some of which carry their newborn nymphs on their backs. The eggs of these insects have become featureless and round again, like lizard eggs, and in so doing also become more vulnerable and in need of care, like our own young. Yet they survive. Perhaps they are the vanguard of what will come next, the next kingdom beginning to rise. Though perhaps not. Recently I watched a dung beetle rolling a ball, and the ball looked like a rising sun. Above that beetle was a fly trying to lay an egg inside the beetle's head.

Insects have been cracking out of eggs for hundreds of millions of years. It is happening now, all around you. If you listen, you can almost hear the crumbling of the shells as tiny feet, six at a time, push into the world. □

Rob Dunn and Martin Oeggerli worked together on the story about pollen in the December 2009 issue.

The orange hue of this zebra longwing butterfly egg may warn predators: "Eat me if you dare." The threat would not be idle. The egg contains cyanide and other toxins ingested by adults from the plants they eat.

HELICONIUS CHARITHONIA

The Adonis blue butterfly is rare because it's choosy. It lays its eggs (like the one above) only on horseshoe vetch, a European perennial. What's more, it looks for patches cropped by rabbits that allow easy landing.

LYSANDRA BELLARGUS

The eggs in this story range in diameter from 0.7 to 2 millimeters. The images were made with a scanning electron microscope, which uses beams of electrons to trace the surfaces of objects. The resulting black-and-white images were then colored to reflect the eggs' natural appearance.

PHOTOGRAPHIC COVERAGE PRODUCED IN COOPERATION WITH PRÜFTECHNIK URI AND SCHOOL OF APPLIED SCIENCES, FHNW

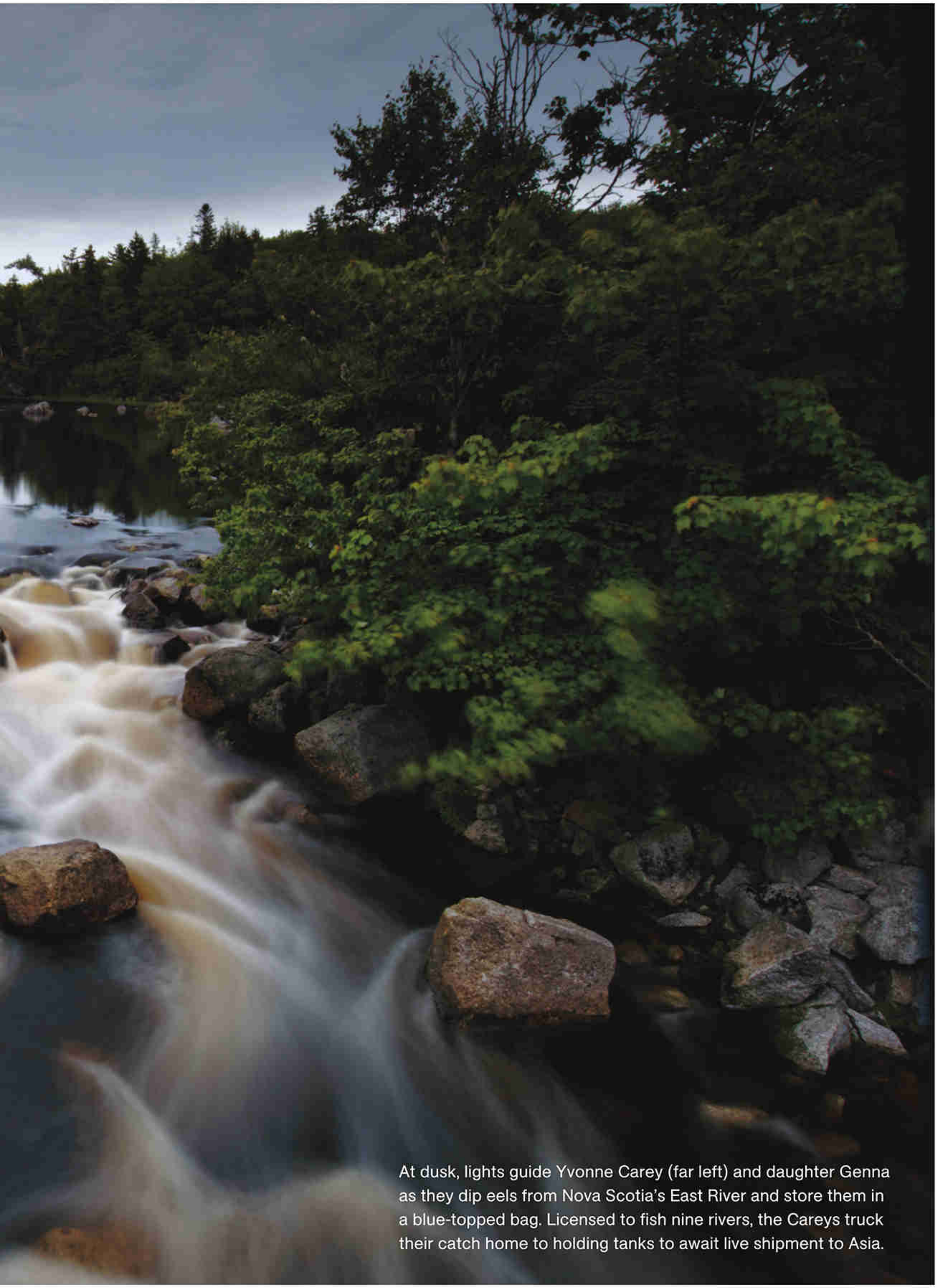
The red band signals a chemical reaction that follows fertilization. Inside the egg is the germ of a blue morpho, one of the world's largest butterflies, with a wingspan of five to eight inches.

MORPHO PELEIDES

Year-old “glass” eels hole up in Maine’s Pemaquid River.

They spend decades in rivers and lakes, then cross oceans and spawn in secret.

MYSTERY TRAVELERS eels



At dusk, lights guide Yvonne Carey (far left) and daughter Genna as they dip eels from Nova Scotia's East River and store them in a blue-topped bag. Licensed to fish nine rivers, the Careys truck their catch home to holding tanks to await live shipment to Asia.

As a kid, I encountered eels more often in crossword puzzles or Scrabble (a good way to unload *e*'s) than in the wilds near my Connecticut home. But in the flesh, when my friends and I caught them by mistake on fishing outings, they were alien and weird, unnameable things—snakes, maybe, or what?—and we were afraid to retrieve our hooks from their mouths.

One day an old man casting nearby told us they were fish. I knew that if this was true, eels were fish like no others.

For much of my life I had little occasion to pay attention to eels. Then six years ago, while heading down Route 17 in the Catskills of New York State on a cold November day, I decided to follow a sign that said, "Delaware Delicacies, Smokehouse." Past the Cobleskill quarry, down a sinuous dirt road through a shadowy hemlock forest, I came to a small tar-paper shack with a silver smokestack, perched on a high bank overlooking the East Branch of the Delaware River. A man with a pointy white beard and a ponytail, who resembled a wood imp, hopped from behind the plywood door of the smokehouse. His name was Ray Turner.

Every summer when the river is low, Turner—slippery, resilient, and a bit mysterious himself—refurbishes the V-shaped stone walls of a weir that funnels water through a wooden rack designed to trap fish. It takes him the better part of four months to finish the work, in preparation for the eel run that occurs during just two nights in September, around the dark time of the new moon, when maturing eels swim downstream toward the ocean. The run often corresponds with floods brought on by storms during hurricane season, when the sky is at its blackest and the river at its highest. As Rachel Carson observed, the eel is "a lover of darkness."

We paddled in a canoe upstream from Turner's house toward the weir. "There's Baldy," he said, pointing to a bald eagle circling low, keeping an eye on the rack, looking to snag any fish before Turner did. In this broad valley, reminiscent of a Hudson River school painting, the weir made an impressive piece of land art. Turner spoke of it in metaphorical terms. "This is the womb," he said, as we perched on the rack. "Those are the legs." He gestured toward the stone breakwaters stretching diagonally on either side of the river. "You see? It's a woman. All the river's life comes here."

When the September run is good, Turner can take up to 2,500 eels. "Every year I let the biggest girl back in the river," he said. (Assuming the eel is a female and that she makes it out to sea to spawn, she will lay up to 30 million eggs.) Turner hot smokes his eels and sells them to passersby, as well as to restaurants and retailers, earning him up to $20,000 a year. "I consider the eels to be the best quality protein in my line—a very unique flavor of fish, applewood smoke, and a momentary

Ray Turner stirred the water, agitating

lingering of dark, fall honey. All the fish I smoke, trout and salmon, are farm raised, except the eels. The eels are wild. They're like free-range."

Back at the smokehouse, Turner showed me the two concrete-block chambers where the eels—dressed and brined in salt, brown sugar, and local honey—are hung on rods. Behind each chamber is a 55-gallon-drum stove with a door on the front and a chimney hole with two pipes in the back. Once the fire is going in the stove, Turner directs the heat and smoke into the chamber, and the eels are cooked at 160 to 180 degrees Fahrenheit for a minimum of four hours.

He ushered me through the back door, past

BY JAMES PROSEK PHOTOGRAPHS BY DAVID DOUBILET

neat stacks of hand-split applewood, to a wooden tank, like a giant wine cask cut in half, covered in moss and dripping water through its swollen slats. I peered over the chicken wire around the rim into a clear pool. Turner stirred the water with a net, agitating some 500 silvery eels, most about as big around as a dollar coin and up to three feet long. They were lithe and sensuous—just magical.

FRESHWATER EELS, OF THE GENUS *Anguilla*, are ancient fishes. They began evolving more than 50 million years ago, branching into 16 species and three subspecies. Most migratory fish, such as salmon and shad, are anadromous, spawning in fresh water and living as adults in salt water. The freshwater eel is one of the few fishes that do the opposite, spawning in the ocean and spending their adulthood in lakes, rivers, and estuaries—a life history known as catadromy. In general, female eels are found upstream in river systems, while males stay in the estuaries. Eels may spend decades in rivers before returning to the ocean to spawn, after which they die. No one has ever been able to witness freshwater eels spawning, and for eel biologists, solving this eel-reproduction mystery remains a kind of holy grail.

some 500 eels, about as big around as a dollar coin and up to three feet long. They were lithe and sensuous—just magical.

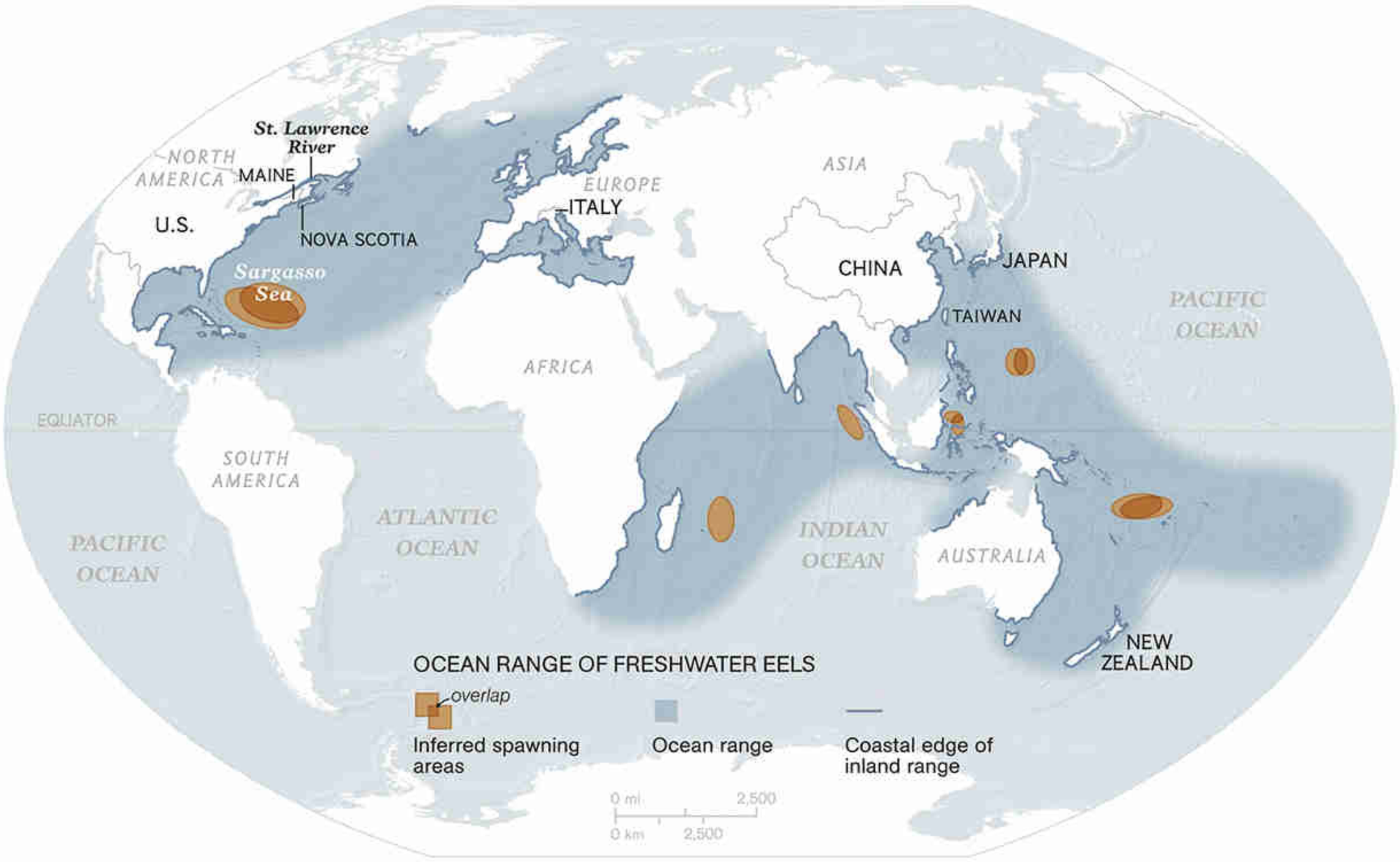
In biology class we were told that the eels we caught in creeks and ponds had emerged from eggs suspended in the ocean, specifically the Sargasso Sea, the southwestern part of the clockwise gyre in the North Atlantic—an idea that required more faith than imagination. We know that freshwater eels reproduce in the ocean because larvae have been found drifting near the surface thousands of miles from any shore. Eel larvae—tiny, transparent creatures with thin heads, bodies shaped like willow leaves, and outward pointing teeth—were thought to be a separate species of fish until 1896, when two Italian biologists watched one in a tank metamorphose into an eel.

Eels are relentless in their effort to return to their oceanic womb. I can tell you this from personal experience because I've tried to keep them in a home aquarium. The morning after the first night of my attempt, I found eels slithering around the floor of my kitchen and living room. After securing a metal screen over the tank with heavy stones, I was able to contain them, but soon they were rubbing themselves raw against the screen. Then one died trying to escape via the filter outflow. When I screened the outflow, eels banged their heads against the glass until they had what appeared to be seizures and died. That's when I stopped trying to keep eels.

They're wondrous in their ability to move. They show up in lakes and ponds and postholes with no visible connection to the sea, leaving the inquisitive shaking their heads. On wet nights eels have been known to cross land from a pond to a river by the thousands, using each other's moist bodies as a bridge. Young eels have been seen climbing moss-covered vertical walls. In New Zealand it's common for cats to bring eels to the doorsteps of farmhouses, having caught them in grassy paddocks.

"How many animals are there that live in such diverse habitats?" David Doubilet mused while photographing eels in New Zealand, knee-deep in a spring-fed creek, watercress dangling from his mask and snorkel. "Here we have a fish that is born in the deepest, darkest depths of the ocean, and yet here you have them in a farm paddock with cows."

French farmers in Normandy say that eels will leave rivers on spring nights and find their way to vegetable patches to feed on peas. That's a fable, but eels are one of the only fishes that will emerge from the water to take offerings of



From Sea to Stream

Scientists know where some of the 16 freshwater eel species and three subspecies spawn, but no one has ever reported seeing eel reproduction in the wild. Larval eels ride ocean currents to lagoons, estuaries, rivers, and lakes. Many eels—almost exclusively females—move far inland. Years or even decades later adult eels return home by unknown routes to spawn and die.

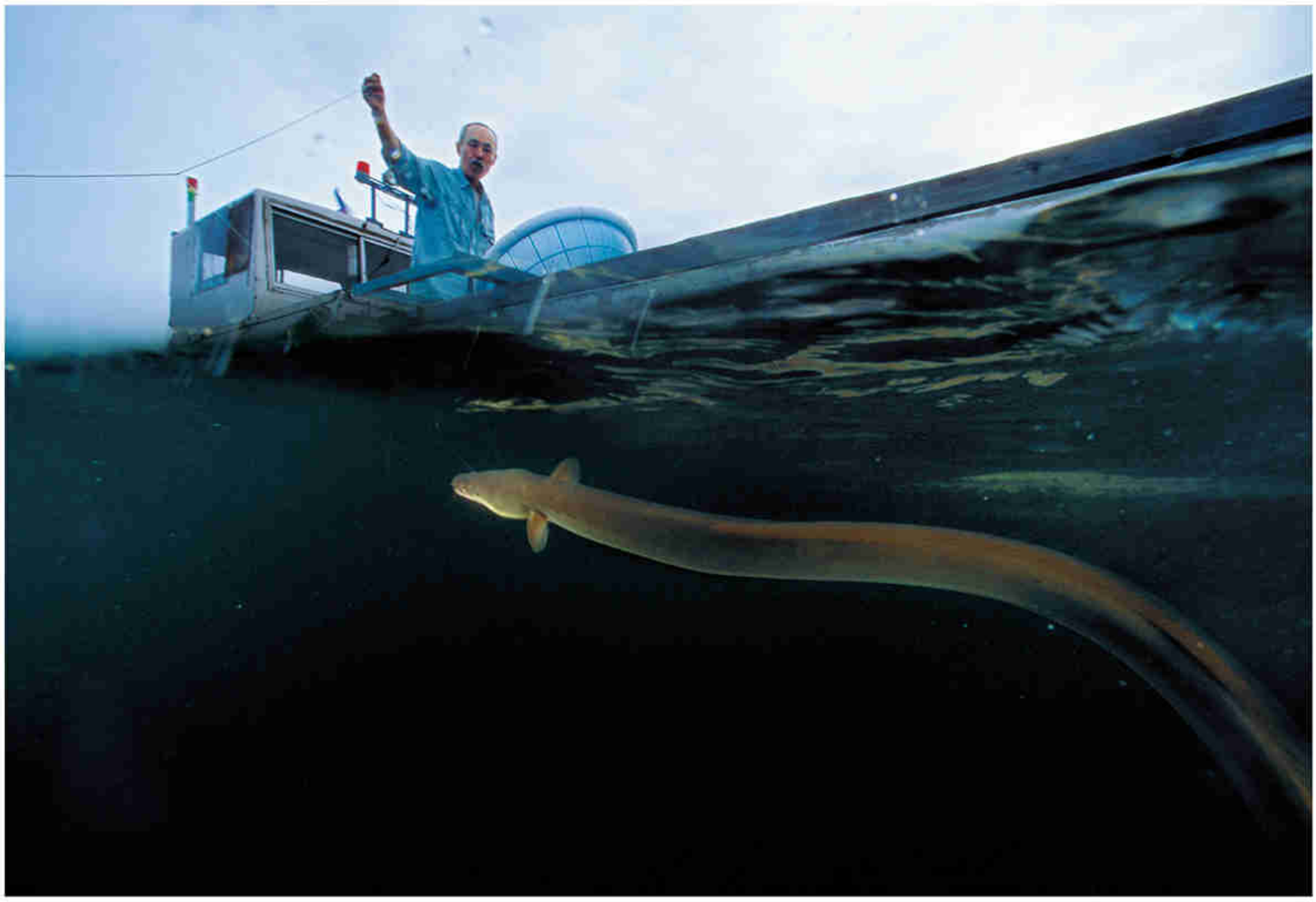
food—canned mackerel or dog food—on riverbanks. I've observed them doing this at sacred Maori eel-feeding sites in New Zealand. Under normal circumstances, an eel's diet is quite varied—everything from aquatic insects and fish to mussels and other eels.

Adaptability aside, the migrations millions of adult eels make from rivers across oceans must be among the greatest unseen journeys of any creature on the planet, spanning thousands of miles. Along the way they face a long list of dangers: hydroelectric dams, river diversions, pollution, disease, predation (by striped bass, beluga whales, and cormorants, among others), and increasingly, fishing by humans. Now, with climate change, another potential disaster looms: shifts in ocean currents that may confound eels during their migrations. Regrettably, although sublime in the eyes of some, the eel is not likely to be the poster child for a conservation movement anytime soon.

FROM ARISTOTLE TO PLINY THE ELDER, Izaak Walton to Carl Linnaeus, naturalists put forward various theories as to how eels came to be: that the young emerged from the mud, that eels multiplied by rubbing themselves against rocks, that they were born from a particular dew that falls in May and June, that they bear live young. One problem was that no one could identify sperm or eggs in eels. Over a 40-year period in the late 1700s, at the famous eel fishery at Comacchio, Italy, more than 152 million adult migratory eels were caught and cleaned, not one of which was found carrying eggs. No one could say for sure whether eels even had gender, because no one could identify their reproductive organs. (It turns out that the sex organs of eels become enlarged with eggs and sperm only after the adults leave the mouths of rivers for their oceanic spawning grounds and disappear from sight.)

In the late 1800s in Trieste, Italy, a medical student named Sigmund Freud was assigned to

LISA R. RITTER, NGM STAFF; MAGGIE SMITH
SOURCE: MICHAEL J. MILLER, ATMOSPHERE AND OCEAN RESEARCH INSTITUTE, UNIVERSITY OF TOKYO



Yoshiaki Miyamoto hooked just one eel on his morning stint on Lake Biwa, near Kyoto. The Japanese believe eels boost energy and cool the blood in summer; local stocks are in decline.

investigate the testes of the male eel, postulated to be loops of white matter festooning the body cavity. (Freud's paper on eels was his first published work.) This was confirmed in 1897, when a sexually mature male eel was caught in the Strait of Messina.

In 1904 Johannes Schmidt, a young Danish oceanographer and biologist, got a job aboard the *Thor,* a Danish research vessel, studying the breeding habits of food fishes such as cod and herring. One day that spring, a larva of the European eel, *Anguilla anguilla,* showed up in one of the expedition's trawls west of the Faroe Islands. Was it possible that eels living in the creeks of Denmark spawned way out in the middle of the Atlantic Ocean?

A year earlier Schmidt had made what would end up being an auspicious betrothal to the heiress of the Carlsberg Brewery, a Danish company that donated generously to marine research. Outfitted with schooners capable of ocean crossings, he amassed data showing that the farther from the European coast, the smaller the eels. Schmidt asserted that eels must spawn in the southwestern part of the North Atlantic, in the Sargasso Sea. "No other instance is known among fishes of a species requiring a quarter of the circumference of the globe to complete its life history," he wrote in 1923. "Larval migrations of such extent and duration…are altogether unique in the animal kingdom."

After Schmidt's death in 1933, some scientists cast doubt on his Sargasso proposition. They showed that he had concealed certain data to make his case more plausible, and they questioned how he could say with any certainty that this was the only eel breeding ground, since he hadn't witnessed an actual hatching and had barely looked for eels anywhere else. Yet such criticism does little to diminish the profound story of eels he conveyed, which still appears to be true.

In 1991 an expedition headed by Katsumi Tsukamoto of the Atmosphere and Ocean Research

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James Prosek celebrates eels in a book for HarperCollins, out in October. David Doubilet photographed clownfish for the January issue.

New Zealand's longfin eels are giants, some topping six feet and 80 pounds, that can live for decades. Traditional Maori prize them as guardians of sacred spaces—and as dinner. These females at South Island's Willowbank Wildlife Reserve could be 30 years old.

Institute of the University of Tokyo that included Michael Miller, then a graduate student at the University of Maine, made another breakthrough. On a dark night in the Pacific Ocean west of Guam, the team found hundreds of larvae of the Japanese eel, *Anguilla japonica,* within days of their hatching, thus locating the spawning area of this species for the first time. Nineteen years later Tsukamoto and Miller are still searching the oceans for spawning eels.

When I met Miller in his Tokyo office, he ruefully acknowledged that he and Tsukamoto have come tantalizingly close to finding the parents of Japanese eel hatchlings. But, he said, "you could be 50 meters away and not find anything. It's an issue of scale—the ocean is huge. To get where eels are spawning, it's statistically very low probability. Almost impossible. You'd have to be very lucky." What's more, he added, every year that he and Tsukamoto go looking, they seem to run afoul of the elements. "I can't remember a single eel cruise when there hasn't been a typhoon that's caused us to change course. It's almost like Poseidon is trying to keep the eels secret."

THAT'S THE GREATEST BEAUTY I find in eels: the idea of a creature whose very life beginnings can remain hidden from humans. It makes it all the harder for me to accept the thought that we may lose this creature before its life picture can be completed. Populations of American, European, and Japanese eels are all declining, some precipitously. As John Casselman, a biologist at Queen's University in Kingston, Ontario, told me, "It is truly a crisis. A crisis of concern."

In November 2004 two brothers, Doug Watts, a freelance journalist who lives in Augusta, Maine, and Tim Watts, a janitor at a college in Easton, Massachusetts, petitioned the U.S. Fish and Wildlife Service (FWS) to list the American eel, *Anguilla rostrata,* as a threatened, or even endangered, species. They were motivated by Casselman's documentation of the collapse of eel populations in the upper St. Lawrence River: From the mid-1980s to the middle of the past decade, the number of juveniles there fell by almost 100 percent. The region encompassing the upper St. Lawrence River system and Lake Ontario and its tributaries is North America's largest eel nursery, where it is thought that female eels alone once made up 50 percent of the inshore fish biomass.

One problem for the eels was the earlier construction of the Beauharnois and Moses-Saunders hydroelectric dams, which have blocked their migrations to and from the upper St. Lawrence River system and Lake Ontario. Even if a young eel, aided by fish ladders, succeeds in getting upriver, when she comes downriver as an adult, she may be sucked into a dam's electricity-generating turbines. "Some eels come out with their skin pulled off, like a sock off your foot," Doug Watts told me. The bigger the eel, the greater the danger. In New Zealand, where longfins grow to six feet or more, turbines mean certain death.

In February 2007 the FWS announced in a 30-page report that listing American eels under the Endangered Species Act was "not warranted," in part because some eels have been found to spend their whole lives in salty estuaries. "The findings basically said that eels don't need freshwater habitat to survive," Watts said, throwing up his hands in exasperation. "That's like saying bald eagles don't need trees to nest in—they can use telephone poles." Because eels have always been ubiquitous and abundant, Watts says, no one seems to believe they could ever go extinct. "That's what they said about cod as recently as the 1990s, when stocks were collapsing. 'There's no way you can fish out cod—that's insane!' they said." He paused. "You can only beat an animal so hard before it finally just gives up."

In one Maori myth, eels come from the

EELS THAT SURVIVE DAMS may not survive Earth's top predator. The international trade, driven largely by Japan's appetite for grilled eel, called *kabayaki,* is a multibillion-dollar industry. In Japan, eel is believed to increase one's stamina

in the heat, and Doyo Ushi No Hi, eel day, usually falls in late July. During that month in 2009 at Tokyo's famed Tsukiji seafood market, more than 111,500 pounds of fresh eel were sold. Eel is almost always eaten in eel-only restaurants, because of the difficulty in cleaning and cooking the fish. It is never served raw: The blood contains a neurotoxin that's neutralized when cooked or hot smoked. (A tiny amount of eel-blood serum injected into a rabbit causes instant convulsions and death.)

The eel is grilled on bamboo skewers over a hot wood fire, repeatedly dipped in water, and returned to the fire to steam the meat. Then it's glazed with a sauce of soy, mirin (sweet rice wine), and sugar and sprinkled with *sansho,* mountain pepper. This dish, most often a single eel split and splayed over a bed of rice in a black, lacquered box with a red interior, is called *unaju.* No part of the fish goes to waste. The liver is served in a soup, and the spine is deep-fried and eaten like a cracker. Though it may be part of Japan's food folklore, it is said that in Tokyo the eel is filleted along the back to avoid mimicking the samurai warrior's ritual knife-in-the-belly suicide. In Kyoto, where there were fewer samurai, it is filleted along the belly. Kyoto people say that the women in their city have such beautiful skin because they eat plenty of eel. Indeed, the meat is high in vitamins A and E, and because of its high concentration of omega-3 fatty acids, it has been found to help prevent type 2 diabetes.

An eel served in a restaurant in Manhattan may have hatched in the Atlantic Ocean, been netted in a river mouth in the Basque region of France, flown to Hong Kong, raised at a farm in nearby Fujian or Guangdong Provinces, cleaned, grilled, and packaged in factories near the farms, and finally flown to New York City. Readying eels for market usually involves catching babies—called glass eels because of their transparency—when they arrive in fresh water from the ocean and shipping them to warehouse-style farms in China for fattening up. The trade remains dependent on the capture of wild fish because no one has figured out how to reproduce eels profitably in captivity.

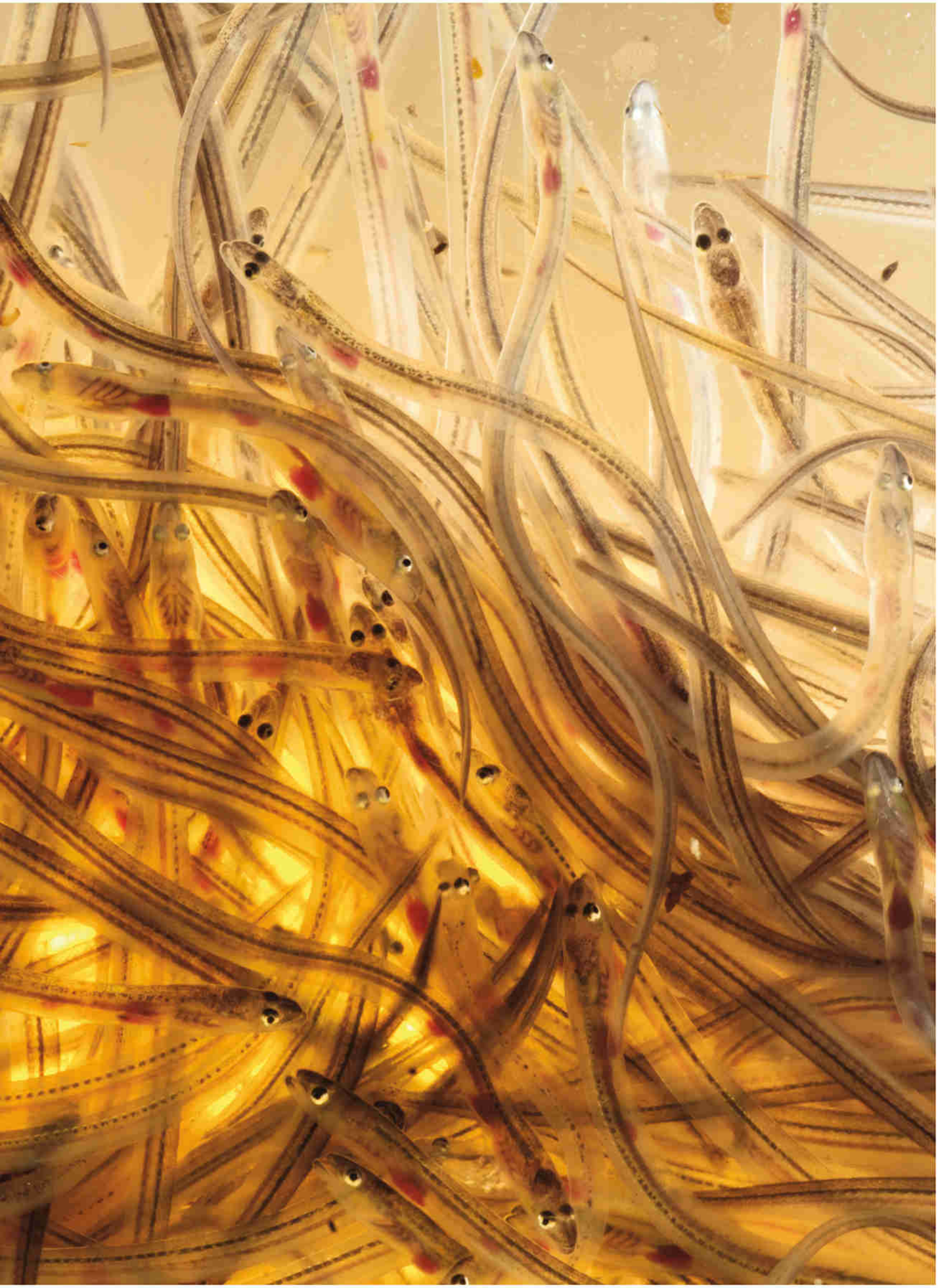
IN THE U.S. DURING THE 1970S, when aquaculture farms were burgeoning in China, eel fishing to supply the Asian market went on pell-mell from January through June in every East Coast state. Pat Bryant of Nobleboro, Maine, was one of the first in the state to catch glass eels for export to China. By day she ran a hairdressing salon in the coastal town of Damariscotta, and at night, to make a little extra money, she went down to the mouth of the Pemaquid River to check her nets.

The commercial operation in Maine grew explosively from the mid-1980s to the mid-1990s, when the more than 1,500 fishers with permits could each make several thousand dollars a night at the dock for their catch. People began stealing and vandalizing nets and pulling .357 Magnums to stake out or preserve fishing territories. In one creek, fishermen had a net called the green monster. "It went clear across the river," Bryant said in her raspy voice, ashing her cigarette in a scallop shell. "It was a goddamn fiasco." She and a few others appealed to the state, "just out of our own preservation." Today the allowable eel take in Maine—the state with the most active fishery—is restricted to a few locations and a short season, from March 22 to May 31.

In 1997 record-low catches of prized Japanese glass eels sent prices soaring—a single kilo (2.2 pounds), about 5,000 of them, sold for as much as $16,500, making eel more valuable at the time than gold. When the supply of Japanese

sky, having fallen when the heavens became too hot. On Earth,
some say, the movements of eels make the rivers flow.

Black eyes and red hearts dot glass eels scooped into a tank from Maine's Damariscotta River. This batch, worth some $400 a pound, is bound for China. Eeling in the U.S. is heavily regulated; Maine is one of the few states allowing the export of glass eels.



Eels cook over a beech and oak fire at Dutchman Alex Koelewijn's smokehouse. They melt in your mouth like fine chocolate, he says. "It's the oily and smoky taste that gives the most joy."

glass eels crashed, the price for American glass eels briefly increased tenfold—the eel gold rush, as Bryant calls it. Japanese connoisseurs weren't happy. "American eels are not as tasty," Shoichiro Kubota, who runs a 120-year-old eel restaurant in the Akihabara district of Tokyo, told me. (His father was eel handler to Emperor Hirohito.) "Even the French eels are not as good—like American cherries. Not as tasty. We like our native things."

Bryant buys glass eels from fishermen up and down the Maine coast and babysits them in tanks near her home until they're ready for shipment from Boston to Hong Kong, live, in plastic bags filled with oxygenated water and packed in foam containers. Until recently, Jonathan Yang, a dealer from Taiwan, was the middleman between Bryant and eel farmers in China and Taiwan, buying eels from her by the kilo and selling them by the piece, or individual eel. He paid cash, typically wiring a million dollars to a bank in Maine at the end of the season.

When the selling was good, Yang doubled his money, but more often than not he had to accept a modest profit. "This is a very big business, very risky," he said. If the price for adult eels fell during the 14 to 18 months it took to raise a glass eel for market, his Chinese buyer could go bankrupt. "One year the farm sells high—they all drive Mercedes-Benzes," Yang said. "Next year price falls—they're riding bicycles."

Before he went into eels, Yang was in the lucrative business of selling shark fins in China for soup. He says he quit when he saw dolphins, caught accidentally on longline hooks, being dragged aboard ship, beaten to death, and thrown back into the sea. "When they take the dolphins on the ship," Yang said, "you know they're weeping—you can see the tears." He put his hand over his heart. "When I look at eels, I feel good. When they move, they look very nice."

LIKE JONATHAN YANG, I get a good feeling from eels. The times I've spent with them, especially during the fall migration, have pulsed with energy. Standing in Ray Turner's weir on a cool September night on the eve of the new moon, watching veinlike ropes of eels fill his womb of wood and stone, I could almost believe the Maori's yarns about encounters they've had with the *taniwha*—the water guardian or monster. For many indigenous people throughout the Polynesian Islands, the eel is a god that replaces the archetypal snake in creation myths, an important source of food, and an erotic symbol—the word many islanders use for eel, *tuna,* is synonymous with "penis." In one Maori myth, eels come from the sky, having fallen when the heavens became too hot and inhospitable for them. On Earth, some Maori say, the movements of eels make the rivers flow. The eel is integral to everything.

We allow ourselves to believe we can understand nature by organizing and explaining it through systems of taxonomy and computerized studies of genes and DNA, fitting everything into neat categories. With each passing year, researchers peer deeper into the hidden lives of eels; in 2006 and again in 2008, scientists released adult eels from the west coasts of Ireland and France outfitted with pop-up tags, hoping to track them to the Sargasso Sea. But "knowledge," as we amass it (ever available, at our fingertips), can hinder imagination and the wonder that can come from our own observation. Eels—with their simplicity of form, their preference for darkness, their gracefulness—have helped me embrace the unnameable and get to the essence of experience, that which cannot be cataloged or quantified. They have been my way back.

The immense pressures on eels today will test their ability to adapt and survive. A Maori bush guide named Daniel Joe spoke of the staying power of eels as we sat by a campfire on the Waipunga River. "He's an old fish, and he's absolutely relentless," Joe said. "The eel is *morehu,*" a survivor. "I think they will be there till the end of the world as we know it."

I hope he's right. □

A weeks-old eel larva in a petri dish glows under blue light. In a recent breakthrough, Japanese scientists raised eels hatched in the lab until they spawned. Though there is much still to learn, captive breeding could someday give wild stocks a reprieve.

Villagers carry Moimango, mummified half a century ago, up to his cliff-niche perch. His son, current "big man" Gemtasu

(crouching), hopes to be mummified someday too.

PAPUA NEW GUINEA

Mastering Mummy Science

Mummy expert Ronald Beckett is helping a South Pacific culture revive a disappearing ancient tradition.

I LOVE MEETING NEW MUMMIES. As a biomedical specialist, I've worked on hundreds of them over the past 15 years, everywhere from Thailand to Peru. Normally I study them in labs and museums, but in Koke, a village in Papua New Guinea, where I started working in 2008, mummies are a daily part of the living culture. There's a physical, emotional, human connection with them that's unique.

The first time I visited Koke, I was greeted by a man in tapa cloth with a cassowary bone through his nose. He was holding a bow and arrow. I smiled and thought, Wow, neat! In fact, he was issuing me a warrior's challenge: Why have you come? "I'm here to work on the mummy called Moimango," I said. "I'm here to examine and restore him so he can sit on the cliff for many years to come." The next thing I knew, the man was rubbing his nose against mine. He'd accepted my answer. Locking noses makes an official statement of welcome.

It was easier when I met Gemtasu, head of the Anga people of Koke. Thanks to photographer Ulla Lohmann's introduction, I had come at his request. Moimango was his father. He'd been a great warrior and shaman, and some 50 years ago he'd returned to the village from a hunt or a battle complaining of having the "short wind." He lay down by a fire and died. In keeping with tradition, Gemtasu *(Continued)*

PHOTO: ULLA LOHMANN. NGM MAPS

Ronald Beckett (at right) inspects the carcass of a forest pig villagers used to practice mummification techniques. The smoke, he found, is extremely acidic, inhibiting enzymes that contribute to decomposition.

and other family members mummified his body in a special smoking hut, and Moimango was placed in a cliffside gallery alongside other ancestors to watch over the village. But after many years out in the elements, Moimango needed some care.

Mummification was practiced for centuries in Koke, but it's a skill that's largely been forgotten. Christian missionaries have told the Anga there should be no mummifying because it's against God's law. Gemtasu requested my help in bringing this tradition back to life. When he dies, he'd like to be mummified too, so he can sit next to his father on the cliff overlooking their village.

As in treating a living patient, one of our biggest concerns is not harming the mummy. When Moimango was first brought down for me to examine, I was nervous about how he was propped up. His head was bouncing—we needed to pay attention to that right away. Normally we'd stabilize the head with a neck brace, but I realized Koke would not have access to this. Still, the Anga knew the jungle. So we created a special patch from tapa cloth. We heated thick, sticky sap from the *komaka* tree to get his skin to adhere to the scalp. We cleaned the rodent nests from his abdominal cavity and the lichens that had grown on his toes and fingers, using lime from crushed shells. Then we covered him in ritual ocher clay.

When we finished and brought Gemtasu to see his father, he touched him on the shoulder. He started crying and jumping. He took my hands. He was saying, "I'm very pleased. He's here again. Thank you." We left the village a how-to-restore manual, and when I returned this year, Moimango still looked pretty darn good. It was such a thrill to see him again. His head was stable. They'd been taking good care of him. It made me so happy to do a good job for an old man who loved his father. Science is what brought me there, but the human experience meant the most to me.

About Our Grantee

Ronald Beckett, 57, is a professor emeritus of biomedical sciences at Quinnipiac University in Connecticut. He did fieldwork in April 2010 to study mummification techniques and rituals of Papua New Guinea's Anga culture.

PHOTO: ULLA LOHMANN

LEGAL NOTICE

If you used your Credit or Debit Card in the United States between December 26, 2007 and December 31, 2008, you could get benefits from a class action settlement involving Heartland Payment Systems.

Para una notificación en Español, llamar o visitar nuestro website.

A settlement has been reached with Heartland Payment Systems, Inc. in a class action lawsuit about a 2008 intrusion into credit and debit card information processed by Heartland. The settlement provides benefits to those consumers who file valid claims for losses from the intrusion.

The United States District Court for the Southern District of Texas will hold a hearing to decide whether to give final approval to the settlement, so that the benefits can be issued to those with valid claims. Those included have legal rights and options, such as excluding themselves from or objecting to the settlement. Eligible Class Members can submit a claim for benefits from the settlement. Get a detailed notice at www.HPScardholdersettlement.com.

Heartland denies any claims of wrongdoing in this case, and the settlement does not mean that Heartland violated any laws or did anything wrong.

WHO'S INCLUDED?

The Class includes everyone in the United States who had or has a payment card (credit or debit) that was used in the United States from December 26, 2007 to December 31, 2008 (the "Settlement Class Period"), and who claims or may claim "Losses," which are certain unreimbursed out-of-pocket expenses (including identity-theft-related charges) or lost time. To have a valid claim, it must be determined that your card was processed by Heartland during the Settlement Class Period. For more information, read the detailed notice referred to below.

WHAT DOES THE SETTLEMENT PROVIDE?

To make a valid claim for reimbursement of "Losses" under the settlement, you must submit documentation showing that you had unreimbursed, out-of-pocket expenses or lost time because your credit or debit card account information was stolen or placed at risk of being stolen as a result of the Heartland intrusion.

a) Qualifying losses are telephone or postage costs, other third-party charges resulting from card cancellations or replacements, unauthorized and unreimbursed account charges, identity-theft-related charges, or time spent to address those matters. Valid claimants can receive reimbursements up to $175 per Settlement Class Member, with no more than two valid claims allowed per household.

b) In the event the losses in a valid claim include identity-theft-related charges, claimants can receive reimbursements of up to $10,000. To qualify as "identity-theft-related," the charges must result from someone's assuming the claimant's identity as a result of the Heartland intrusion and taking out and using credit or otherwise obtaining monies or other things of value fraudulently in the name of the claimant. The identity-theft-related charges must be separate and apart from any charges on the affected credit or debit card account itself.

c) All claims must include the number and expiration date of the payment card account for determination whether the card was processed by Heartland during the Settlement Class Period and evaluation of the claim. The Claims Administrator will determine, on a "more likely than not" basis, whether the documentation submitted by the claimant supports the claim, including whether the loss resulted from the Heartland intrusion. Reimbursements will be reduced proportionally if the amount payable on all valid and final claims exceeds $2.4 million.

For more information, including limitations and conditions on these benefits, read the detailed notice referred to below.

HOW DO YOU ASK FOR BENEFITS?

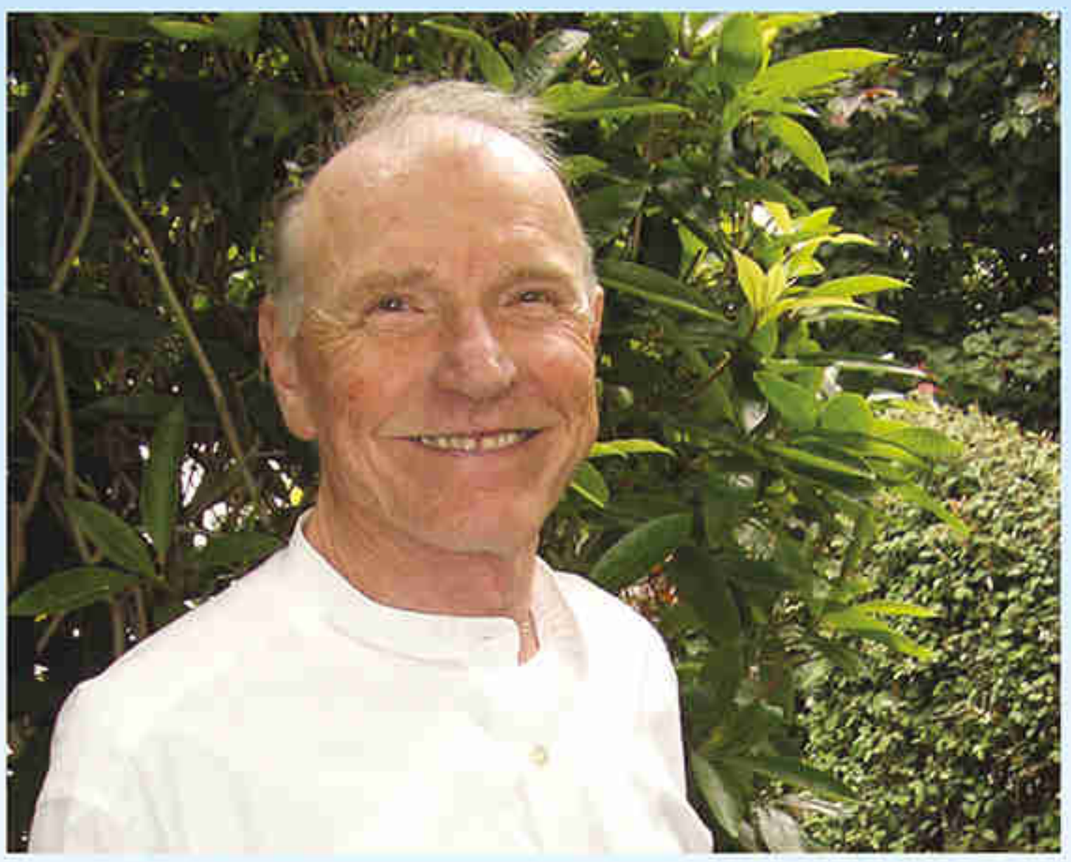
Eligible Class Members can call 1-877-271-1547 or go to the website for a claim form, then fill it out, sign it, include the documentation it requires, and mail it to the address on the form. The deadline to make a claim for benefits is **August 1, 2011**.

YOUR OTHER OPTIONS.

If you do not want to be legally bound by the settlement, you must exclude yourself by **November 19, 2010**, or you will not be able to sue, or continue to sue, Heartland about the legal claims this settlement resolves, ever again. If you exclude yourself, you cannot get any benefits from the settlement. If you stay in the Settlement Class, you may object to it by **November 19, 2010**. The detailed notice explains how to exclude yourself or object.

The Court will hold a hearing in this case, known as *In re: Heartland Payment Systems, Inc. Customer Data Security Breach Litigation*, No. 4:09-MD-2046, on **December 10, 2010**, to consider whether to approve the settlement, and a request by Class Counsel for fees of up to $725,000, costs and expenses of up to $35,000, and incentive awards of $100 to $200 for each named plaintiff who filed a lawsuit in the case. You or your own lawyer may ask to appear and speak at the hearing at your own cost, but you do not have to do so. For more information, go to the website shown below, which has a copy of the detailed notice.

www.HPScardholdersettlement.com



John-Joseph van Haelewyn

John McCallister included National Geographic in his estate plans.

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world beat

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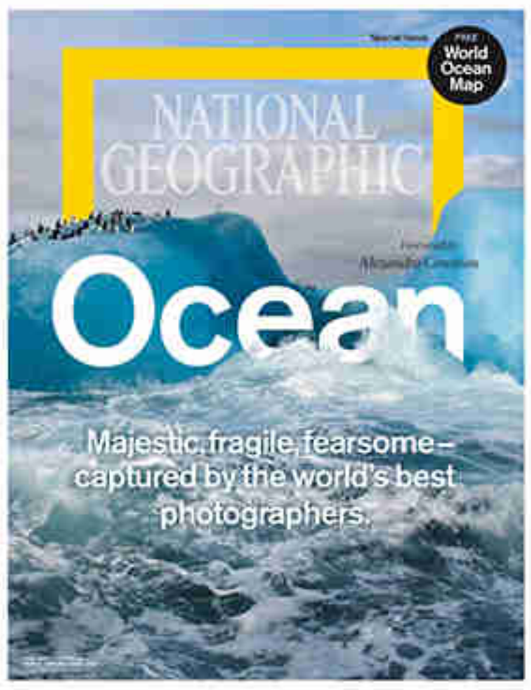
NATIONAL GEOGRAPHIC KIDS

NATIONAL GEOGRAPHIC

INSIDE GEOGRAPHIC

In a tank at a New Zealand aquarium an eel greets Jennifer Hayes.

ON ASSIGNMENT **Eel Appeal** Inside the National Kiwi Centre in Hokitika, New Zealand, is a two-story tank full of old eels. How old? "About 85 to 100 years," says David Doubilet, who documented the fish with his photographic assistant and wife, Jennifer Hayes (above), for this issue. Doubilet and Hayes were allowed in the tank to demonstrate the length—about six feet—of these freshwater New Zealand longfins. The two were told to cover up fully or risk being chomped on. Although the eels did try to wriggle under their neoprene hoods and face masks looking for flesh, recalls Doubilet, "they were polite enough not to bite their guests."



SPECIAL ISSUE

Water World Oceans cover nearly three-fourths of our globe and play a role of equal significance in Earth's biodiversity. Our newest special issue explains the workings of our seas and explores ways to improve our relationship with them. Find *Ocean* on newsstands September 14 or at *ngm.com/ocean-special* ($10.99).

Society Updates

NAT GEO CHANNEL

Go on patrol with the law officers of America's largest state in *Alaska State Troopers,* a weekly series beginning September 21 at 10 p.m. on the National Geographic Channel.

NG BOOKS

Soul of a Lion chronicles the true story of conservationist Marieta van der Merwe and the imperiled wild animals she devotes her life to in Namibia. Look for it in bookstores September 21 ($26).

GeoPuzzle Answers

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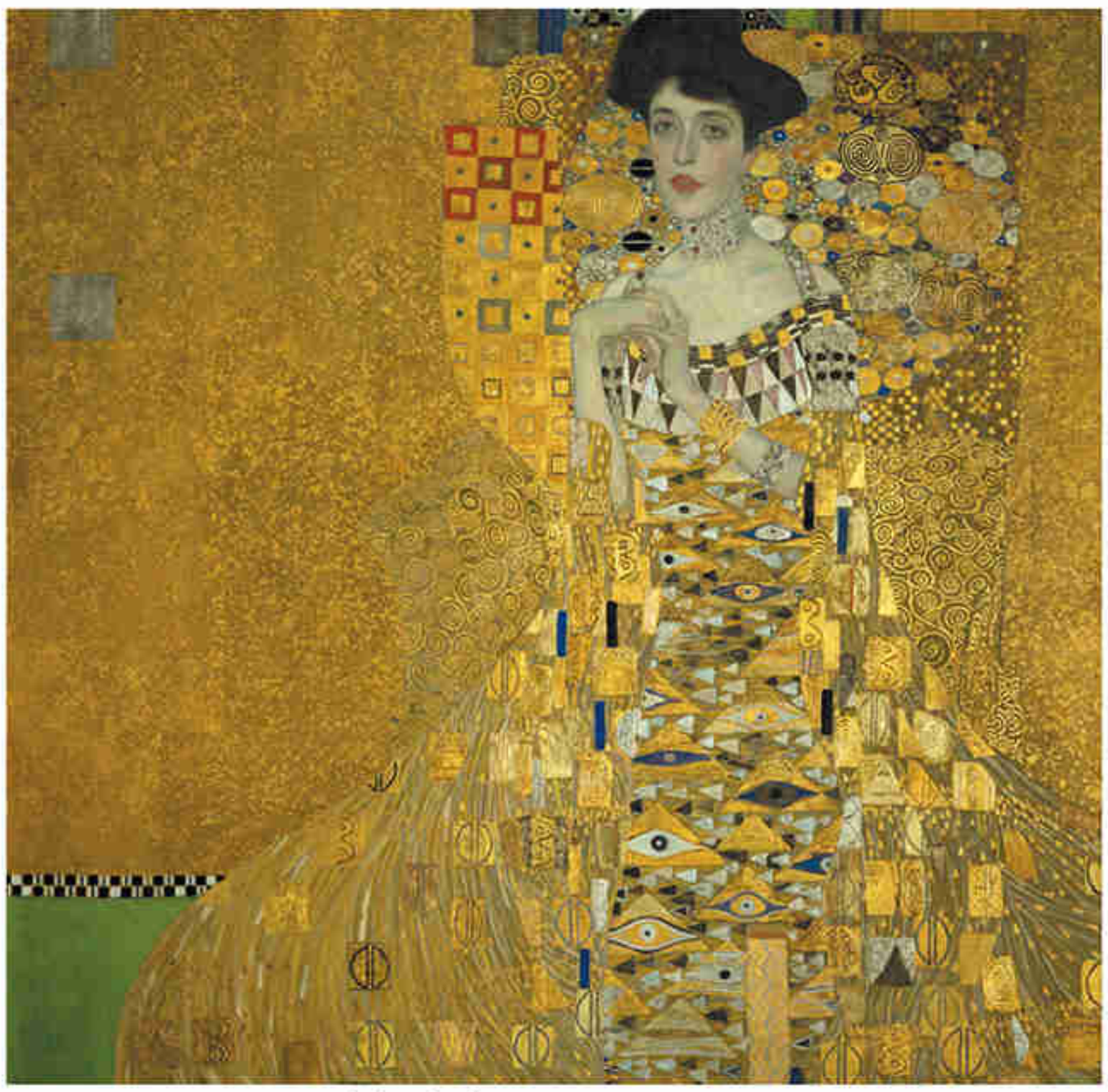
PHOTO: DAVID DOUBILET



Klimt's painting of **Adele Bloch-Bauer I** recently sold to Ronald Lauder for $135 million

GUSTAV KLIMT

The Needlepoint Kit Collection

The backgrounds in Gustav Klimt's paintings have fascinated decorative artists for over a hundred years. They seem as intoxicating now as they must have seemed to Fin-de-Siecle Vienna in the 1890's. Rich and sparkling they merge mosaic-like blocks of color with swirling oriental pattern and they make magnificent needlepoint pillows.

RIGHT:
KLIMT: MANDARIN
14" x 14".
10 holes to the inch canvas.
~~$90.00~~
now $78.00

ABOVE: **KLIMT: BLUE** 15" x 15". 10 holes to the inch canvas.
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Needlepoint is the new knitting inspiring a whole new generation of stitchers. Candace Bahouth, one of the world's leading textile designers, has brilliantly adapted Klimt's patterns to produce this wonderful range of pillows mixing gold threads with wool. The kits come conveniently packaged with all the materials needed and only require the mastery of one simple stitch. Always one of the most relaxing pastimes needlepoint is once again back in fashion to be enjoyed by us all.

All our kits include 100% printed cotton canvases in full color, all the necessary yarns (100% wool and gold thread), a needle and an easy to follow instruction guide to get you underway.

ABOVE: **KLIMT: CHOCOLATE**
RIGHT: **KLIMT: CORAL** FAR RIGHT: **KLIMT: TAUPE**
14" x 14". 10 holes to the inch canvas.
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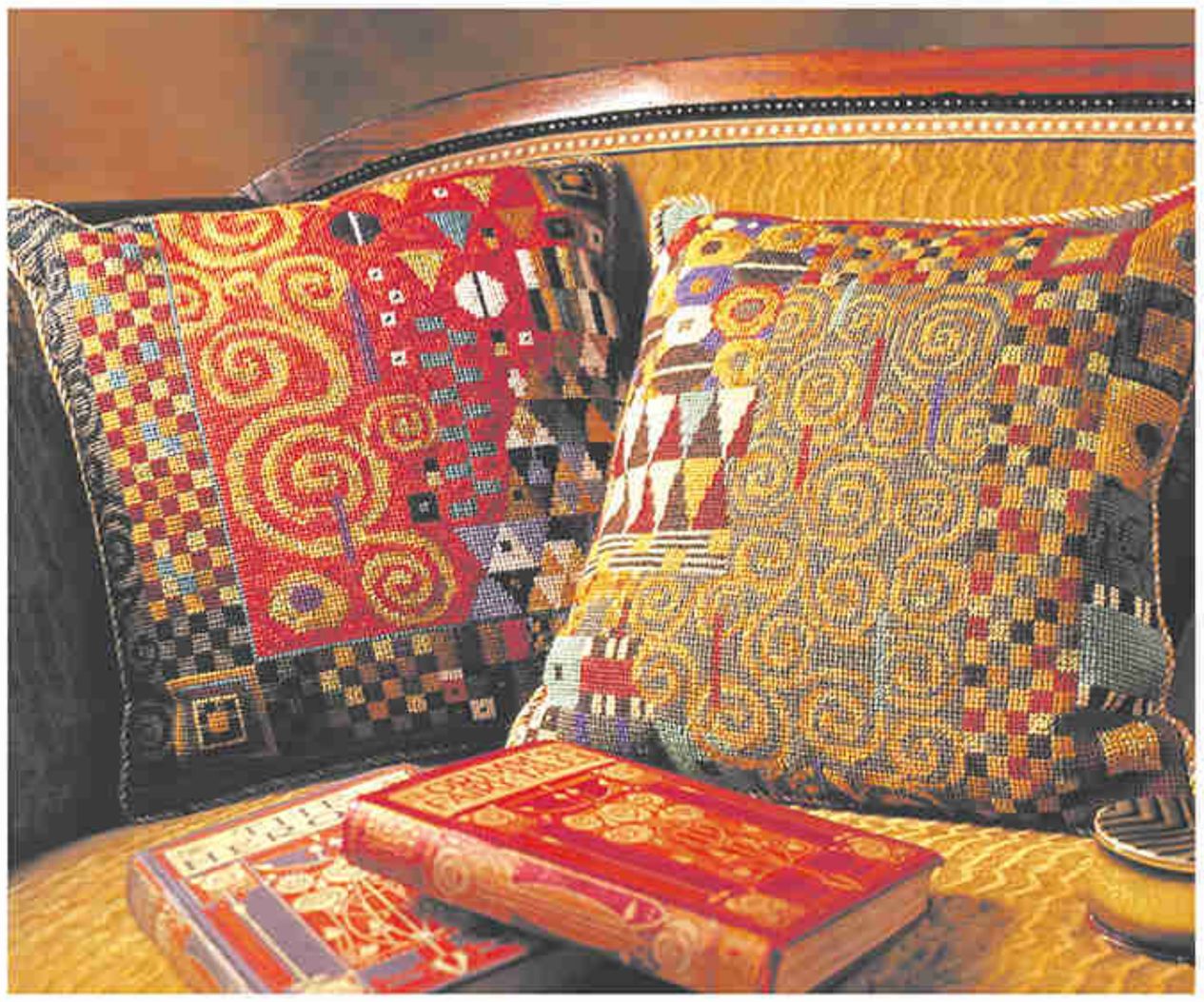

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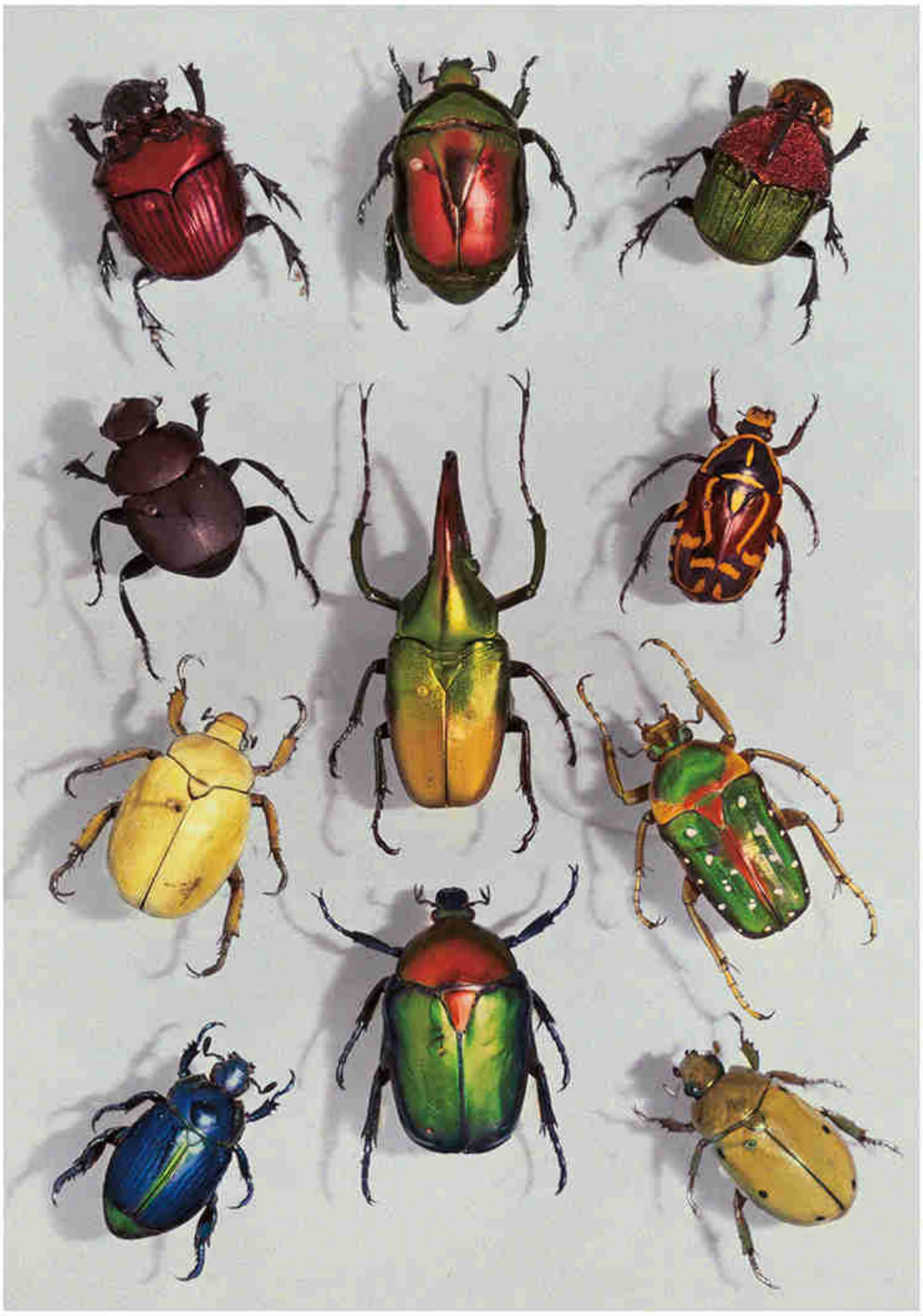
FLASHBACK



Meet the Beetles "Scarabs that might have made a pharaoh envious" were among 263 insects photographed for the July 1929 *Geographic.* They were first "placed with care in relaxing jars (a sort of humidor) to render flexible their delicate legs, wings, and antennae, so that they might be 'posed' in lifelike attitudes," notes the accompanying text. "Their irreplaceable value…and the fragile nature of their many anatomical members added materially to the sense of responsibility of the members of the National Geographic Society's illustrations staff." *—Margaret G. Zackowitz*

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

PHOTO: EDWIN L. WISHERD, NATIONAL GEOGRAPHIC STOCK

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Nel Cepeda

Pat Minnick included National Geographic in her financial plans.

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In 2007 Pat Minnick, a professional artist, decided to establish a charitable gift annuity to support National Geographic. She now receives a guaranteed life income and is a direct part of the Society's efforts to inspire people to care about the planet.

"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."

For more information about a charitable gift annuity or other ways to include National Geographic in your estate plans, please contact the Office of Estate Planning.

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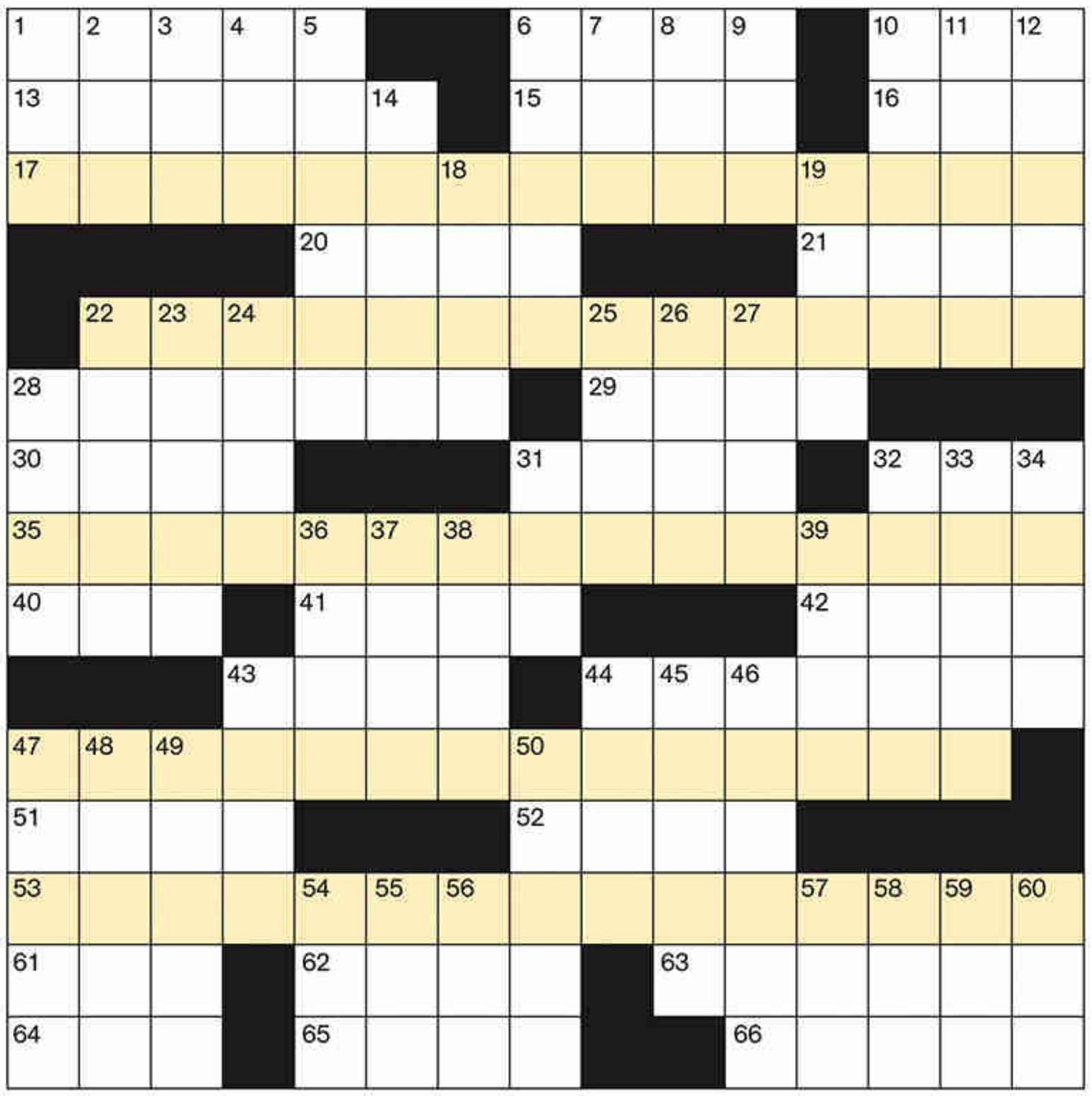


Sister Dearest

Puzzle by Cathy Allis

For a long time no one knew who lay in the coffin at left, found in tomb KV55 in Egypt's Valley of the Kings. DNA tests seem to have solved the mystery, identifying the royal within as King Tut's father. For more DNA revelations, read the story on page 34—and the tinted verse in this month's GeoPuzzle.

ACROSS

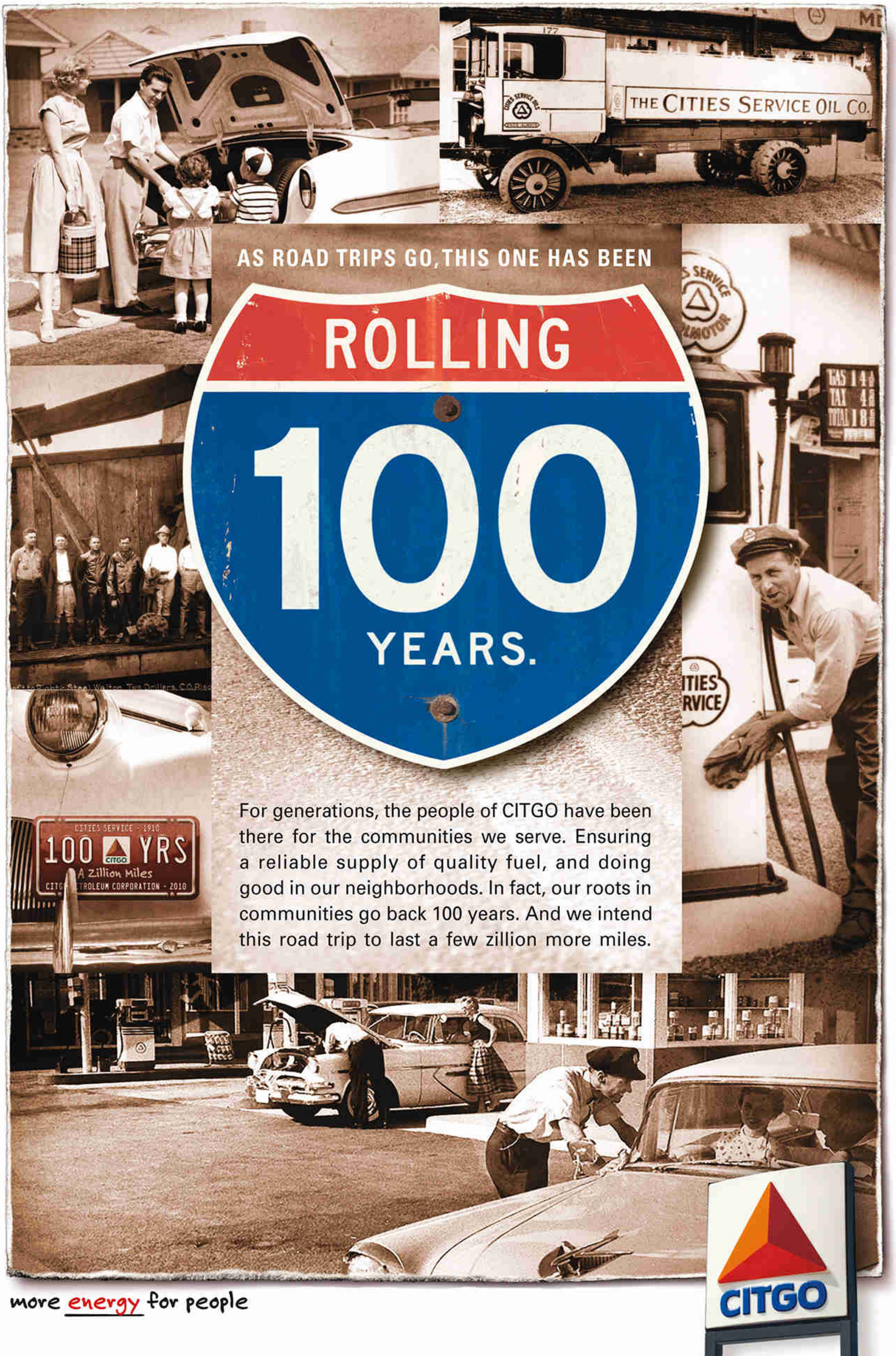
1 Woody Allen pseudo-documentary
6 Feeling no pain
10 Fla. neighbor
13 Flared skirts
15 Pisa is on it
16 Card table shout
17 With 22 and 35 Across, lines 1 and 2 of an original verse about a new DNA discovery
20 Ancient Greek portico
21 Fried on both sides
22 See 17 Across
28 Kuala Lumpur native, e.g.
29 Numbered composition
30 Designer von Fürstenberg
31 Touched down
32 Prefix meaning atmosphere
35 See 17 Across
40 It makes kin kind?
41 Lapse
42 French Riviera resort
43 Grandson of Adam
44 Alternatives
47 With 53 Across, lines 3 and 4 of the verse
51 __ cloud, theoretical sphere of comets
52 Vaulted church recess
53 See 47 Across
61 We're in the Cenozoic one
62 Street-fleet member
63 Washington city near Mount Rainier
64 Caustic solution
65 Neat freak's bane
66 Full of chutzpah

DOWN

1 Drummer Starkey, Ringo's son
2 Yalie
3 Vietnam Memorial architect Maya
4 Gerund maker
5 Manages to make ends meet
6 Tears into
7 Nest egg for one's sr. years
8 Serengeti antelope
9 Darlin'
10 Plant source of tequila
11 LP jacket
12 Tennist who married Brooke, then Steffi
14 "Kama __"
18 Warner Bros. animation
19 AAA jobs
22 The __, Dutch seat of government
23 Tie the knot on the lam
24 Verbal storm
25 Blessed
26 Grand-scale tale
27 Judges' follower, or a judge Bill appointed
28 Knit, as broken bones
31 European peak
32 Friends, in Firenze
33 Roast host
34 Bar or bakery shelfload
36 "Say it __ so!"
37 Baseball's Moisés, Felipe, Matty, or Jesús
38 What a shopper may consult
39 Basic element
43 *"¿Cómo __ usted?"*
44 Heads: Italian
45 Brazen type
46 Like the Broadway show *Tru*
47 White sale item
48 White with old age
49 Constellation bears
50 "Sir" in colonial India
54 Those of Columbo's rank: abbr.
55 "Erie Canal" song mule
56 Losing tic-tac-toe row
57 Instrument played by Don Ho
58 Bygone Russian space station
59 Year Pope Benedict XVI was elected
60 Woo-hoo!

Answers in Inside Geographic

PHOTO: KENNETH GARRETT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