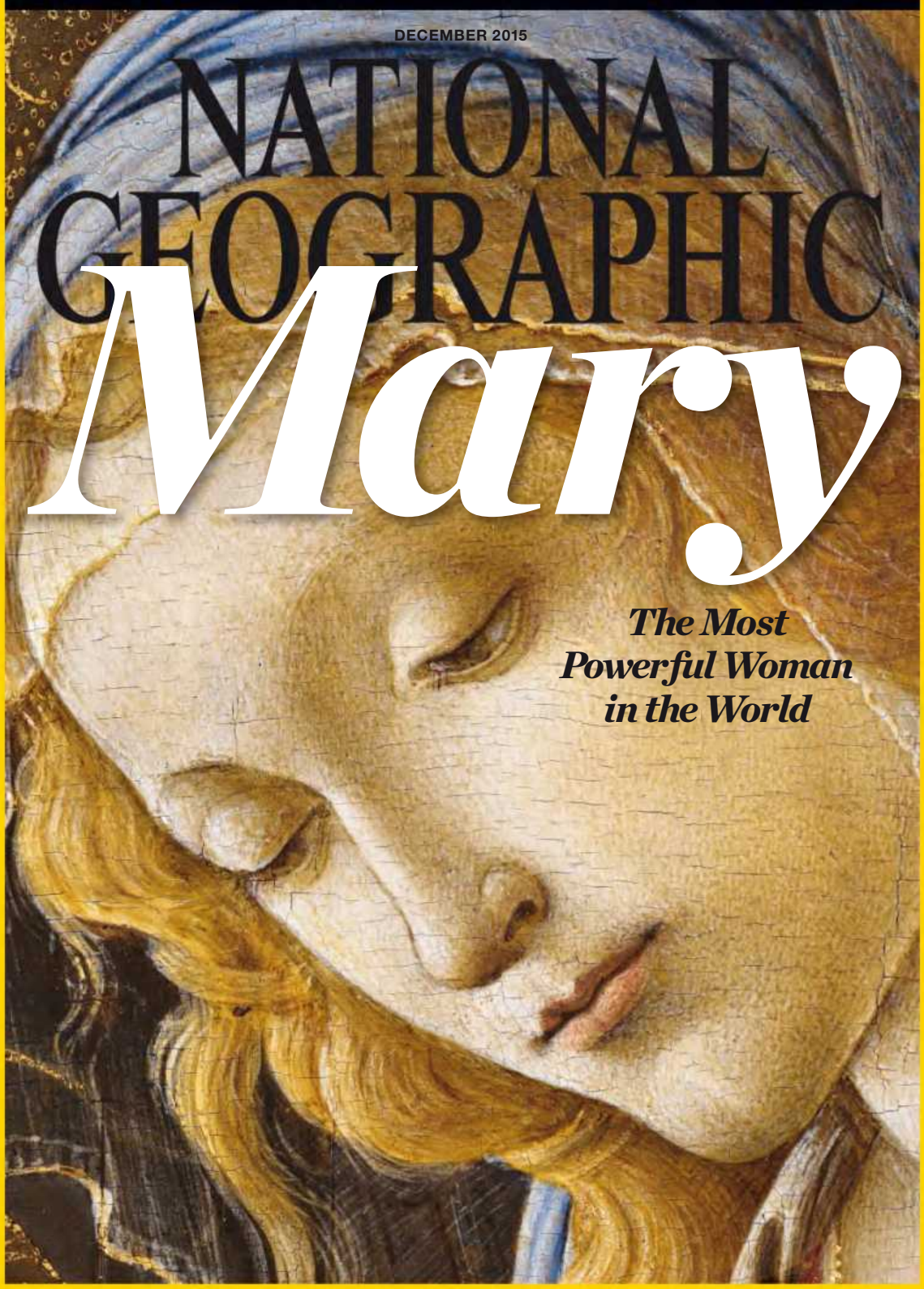
Science of Taste
WHAT MAKES FOOD DELICIOUS

EXPLORER *Watch 'The Cult of Mary' Sunday, Dec. 13, on the National Geographic Channel*

Leopards | ***The New New York***



DECEMBER 2015

NATIONAL GEOGRAPHIC

Mary

The Most Powerful Woman in the World


thrive™
With higher fiber, more vitamins and minerals of whole grain, plus the kid appeal of traditional white flour, Ultragrain® has quickly become the most widely used whole-grain flour in schools across the United States.

150

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It's just one story of how our taste innovations are helping people around the world *thrive*.

See more stories at **cargill.com/150**

Cargill®

WHO WE ARE IS WHAT WE LEAVE BEHIND.

It's been said our lives, our legacies, are simply the sum total of all the choices we make. Theodore Roosevelt certainly understood this when, in 1906, he fought the conventional wisdom of his time and set aside millions of acres of land to be preserved for future generations. And it's something Subaru understood when, over a decade ago, we became the first U.S. auto manufacturer to achieve zero landfill, with all waste recycled or turned into electricity. It wasn't easy. Doing the right thing rarely is. But like President Roosevelt, we made a commitment to something we believe in: the future. It's this promise that now leads us to share our expertise with the National Park Service as we work together toward the goal of making our irreplaceable national treasures zero landfill as well. Because loving the earth means understanding you can't throw anything away, because there simply is no "away."

To learn more, visit subaru.com/environment.

SUBARU

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The future of our parks rests in the hands of our kids.

AMERICA'S NATIONAL PARKS teach invaluable lessons about our planet, our history, and ourselves. In the past 100 years, our parks have become treasured landmarks for recreation, classrooms for biodiversity, shining examples of our country's great outdoor spaces, and bridges connecting us to the world of nature. However, if we want to keep them unspoiled for 100 more years, we need to educate the next generation to be stewards for their preservation.

Did you know, each year visitors to our National Parks generate 100 million pounds of trash?

That's why, with support from Subaru, National Geographic has developed a series of engaging educational activities, designed to inspire and guide the next generation of national park visitors and outdoor adventurers. Learning how to explore green spaces, discovering how to read maps, and understanding how to keep our parks clean are just some of the lessons we can teach our younger generation.

Teach the next generation how our actions impact nature and the most responsible way to enjoy, care for, and preserve our parks for the future. To download these free educational materials, visit natgeoed.org/loveyourpark.

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DECEMBER 2015
VOL. 228 • NO. 6

At Copenhagen's Nordic Food Lab, researchers distilled gin from a plentiful resource: ants. The taste? Pleasantly lemony, they insist.

60 **The Science of Delicious**
Taste receptors, volatiles, gustatory cortex: There's more to *yum* than you might think.
By David Owen Photographs by Brian Finke

30 **The World's Most Powerful Woman**
The Virgin Mary is both a personal intercessor and a global sensation.
By Maureen Orth Photographs by Diana Markosian

82 **New New York**
The bird's-eye views of the skyline make it clear: This city may never sleep, but it surely does change.
By Pete Hamill Photographs by George Steinmetz

98 **Haiti on Its Own Terms**
When young Haitians photograph their nation, determination shines through the hardship.
By Alexandra Fuller Photographs by students of FotoKonbit

120 **Out of the Shadows**
Leopards can adapt to living near humans—so well, in fact, that we may not know they're around.
By Richard Conniff Photographs by Steve Winter

140 **Proof | Remnants of a Failed Utopia**
In disused machines and abandoned buildings, a photographer sees the overreach of technology.
By Rena Silverman Photographs by Danila Tkachenko

On the Cover The Virgin Mary has been depicted by many renowned artists. This detail is from the circa-1480 painting "The Virgin and the Child," by Sandro Botticelli. *Poldi Pezzoli Museum Collection, Milan; photo by Malcangi. Image composed of eight photographs*

Corrections and Clarifications Go to *ngm.com/more.*

Our Unchanging Commitment

Now more than ever, Planet Earth needs our collective help. At National Geographic, we believe it needs the kind of thoughtful and engaged citizens that you, our members, have always been. It also needs individuals and institutions committed to illuminating the critical issues and exploring solutions to its challenges. With that in mind, I am delighted, in this end-of-the-year letter, to report that your Society is doubling down on its commitment to harness the power of science, exploration, education, and storytelling to change the world.

The creation of National Geographic Partners, which was announced a few months ago, is the catalyst for our renewed vigor. That move reconfigured our activities into two entities, each with enormous advantages.

The National Geographic Society will expand its work as one of the world's largest science, research, and educational nonprofit organizations. With an enhanced endowment of nearly one billion dollars, the Society will essentially double the resources we can invest in pushing the boundaries of knowledge. With our core programs financially stabilized, we can further broaden and build on our efforts. The possibilities and potential are exciting.

At the same time, our media properties—including this magazine, books, *Traveler,* and children's magazines, along with other consumer-oriented businesses—will be combined with our globally distributed cable and satellite channels to create National Geographic Partners. Through this entity, our rigorously reported, science-based photojournalism will enjoy vastly greater scale and reach than ever before—and have the means to make an even more profound positive impact on our precious planet.

We'll still be one National Geographic, committed to the highest standards of journalistic excellence and integrity but reorganized in a way that better empowers our efforts.

We'll work to protect wildlife through initiatives to save elephants, big cats, and more. We'll document the at-risk species on Earth with the goal of helping to save them. We'll push for healthier oceans. We'll search for new ways to preserve ancient treasures.

We'll collaborate with educators to ensure that our children are geographically literate and better able to take their places as the global citizens of tomorrow. We'll nurture and support the world's best researchers, explorers, and educators. And we'll find new and powerful ways to share all our work through storytelling, journalism, and photography.

As always, we'll need your help and support. Your involvement and engagement are the essence of impact that matters. Together, we have the power to change the world. And the world is counting on us—now more than ever.

Gary E. Knell, *President and CEO*

PHOTO: KEN GEIGER, NGM STAFF

Pygmy Raccoon
(Procyon pygmaeus)
Size: Body length, 68 - 79 cm (27 - 31 inches)
Weight: 3.1 - 3.8 kg (6.8 - 8.4 lb)
Habitat: Prefers mangrove forests and coastal wetlands
Surviving number: Estimated at 320 - 950

Photographed by Kevin Schafer

WILDLIFE AS CANON SEES IT

Island life. The pygmy raccoon is well adapted to the rhythms of the tropics, taking advantage of the abundance of crabs when available and shifting its diet to insects and fruit when hurricanes roar in and destroy beaches. But the world's smallest raccoon is facing oversized challenges: it has to compete with non-native coatis and feral dogs while doing its best to avoid introduced boa constrictors that can easily swallow it whole. A combination of competition, disease and habitat fragmentation is making for a cloudy future.

As Canon sees it, images have the power to raise awareness of the threats facing endangered species and the natural environment, helping us make the world a better place.

EOS System

Canon

Hail Mary

The genesis of this month's cover story dates to a year ago, when an exhibition opened at the National Museum of Women in the Arts. "Picturing Mary: Woman, Mother, Idea" brought together 74 artworks from the 14th through the 19th centuries, lent by galleries including the Uffizi Gallery in Florence, the Louvre in Paris, and the Vatican Museums.

The exhibition drew the largest crowd ever for the Washington, D.C., museum. That got us wondering: What is it about Mary? She is the world's most depicted woman, yet among the most mysterious, with more written about her in the Koran than in the Bible.

In Puebla, Mexico, a family's statue returns home after an annual parade honoring the Virgin of Guadalupe.

Her powers are invoked for anything and everything: by the sick in search of a cure and quarterbacks hoping for a Hail Mary pass to win the game; by mothers who feel a special kinship with her, and truckers—dashboards adorned with plastic Mary statuettes—seeking safe travels.

We wanted to understand why people from disparate cultures and places—Poland, Mexico, France, Rwanda, Egypt—share little but a belief that Mary stands up for them, approves of them, and watches out for them. So we sent writer Maureen Orth and photographer Diana Markosian to travel the globe in search of explanations and insights. What is it that makes Mary, as this month's cover story declares, "the most powerful woman in the world"?

"You see yourself and your concerns reflected," says Melissa R. Katz, an art history professor at Wesleyan University and author of a book on Marian imagery. "That's what Mary has always done, that Jesus could not. She's more accessible, less threatening, always on people's side."

Father Bertrand Buby, a Marianist scholar and author at the University of Dayton, answers the question with fewer words but more mysticism. "She is," he says, "the universal."

There's a unifying power in the faith that Mary inspires in so many. And that, it could be argued, is in itself something of a miracle.

Thank you for reading *National Geographic.*

Susan Goldberg, *Editor in Chief*

EXPLORER Why do humans long to connect with a divine mother figure? National Geographic's Explorer series visits a village in Bosnia and Herzegovina where visions of Mary have been reported. The episode, *The Cult of Mary,* airs December 13 on the National Geographic Channel.

PHOTO: DIANA MARKOSIAN

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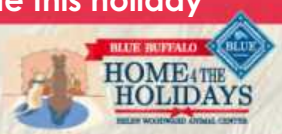

NATIONAL GEOGRAPHIC

We believe in the power of science, exploration, and storytelling to change the world.

The National Geographic Society is a global nonprofit membership organization. We inspire through exploration, illuminate through stories, and, always, teach.


Let's change the world together.
Now, more than ever, our planet needs our help. That's why the National Geographic Society is expanding its commitment to save wildlife, protect our oceans, and fund researchers and explorers who are pushing the boundaries of knowledge. As a nonprofit organization, we believe in the power of science, exploration, education, and storytelling to change the world. Join us, and let's change it together.
NATIONAL GEOGRAPHIC
natgeo.org/together

Why I Love Science and Don't Mind Aging

The world knows **Ron Howard** by different names—as Opie from *The Andy Griffith Show,* as Richie Cunningham from *Happy Days,* and as the Oscar-winning director of films like *A Beautiful Mind.* On November 29, Howard, 61, comes to the National Geographic Channel with *Breakthrough,* a documentary miniseries about scientific endeavors on the brink of discovery. The man who grew up in front of the camera directs an episode about aging.

Can you imagine a future when humans live 200 years?
Yes, but interestingly, the goal isn't simply to extend life. It's entirely about the extension of quality time, of years when someone can be highly productive and apply what he or she knows and has learned in a very active way. The research really focuses on delaying the onset of the diseases of aging, like heart disease, diabetes, cancer, and Alzheimer's. That's the way to enrich lives.

People remember you as a little kid, when you were a child actor [above]. How do you think you've aged?
[Laughs] Well, I still feel young and full of energy, but there are some aches and pains that I don't recall from ten, twelve years ago. They're not just sports injuries; there's something else going on there. I don't look ahead to the future as a vast endless one. I've begun to feel the calendar pages turning.

What draws you to projects grounded in science?
I have a lot of curiosity about it. I was a terrible science student, so I could never be a scientist; my mind doesn't work that way. But I've learned to love the stories around science, and I have so much respect and fascination for the people who can make discoveries and find applications. There's a lot of drama there.

Watch *Breakthrough* on the National Geographic Channel on Sundays from November 1 until December 13.

PHOTOS: MARTIN SCHOELLER; EVERETT COLLECTION (YOUNG RON)

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EXPLORE

Nat Geo Wild

A herder drives reindeer near Oymyakon in 1974, when the region was part of the Yakut Autonomous Soviet Socialist Republic.

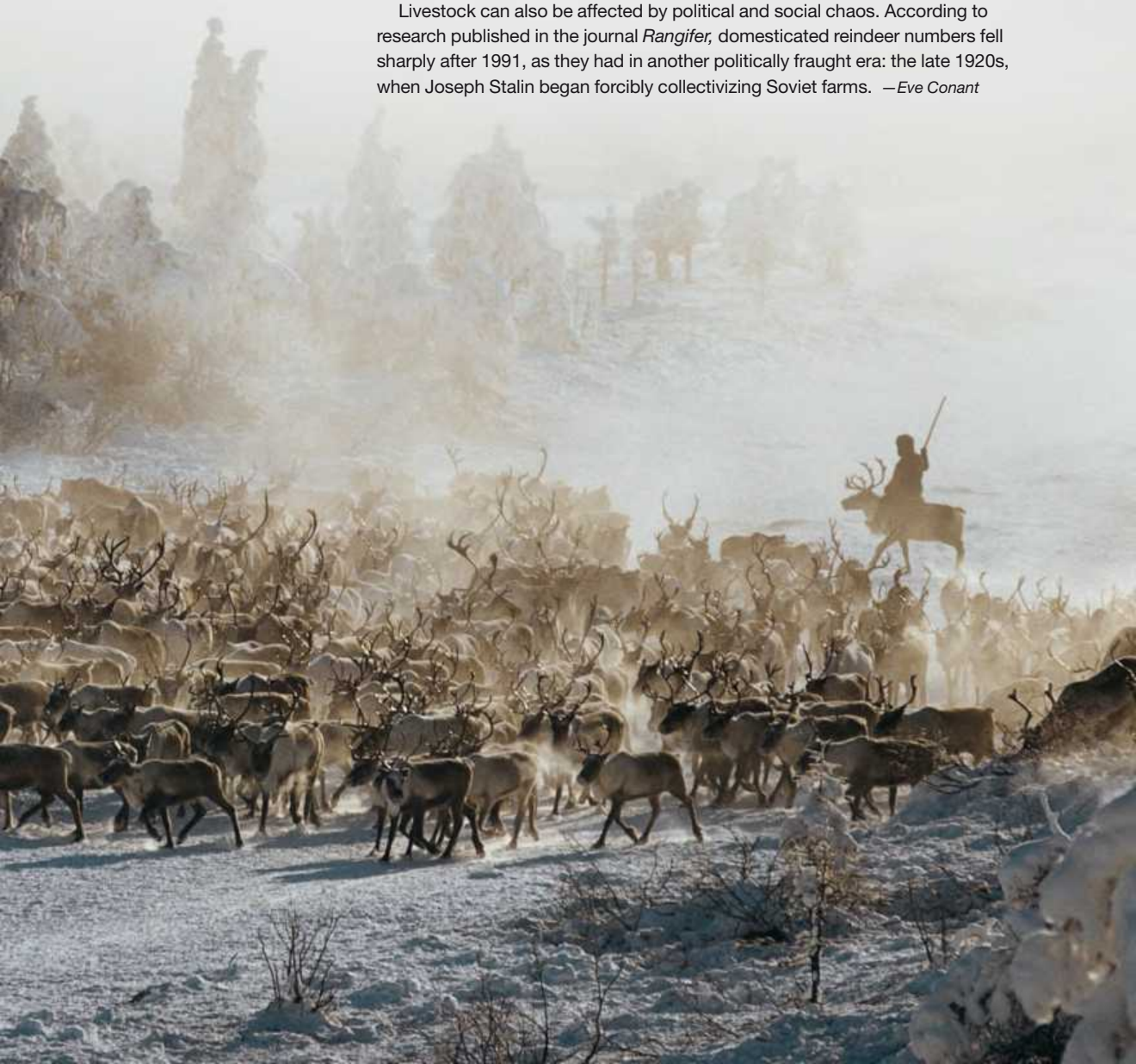
PHOTO: DEAN CONGER, NATIONAL GEOGRAPHIC CREATIVE

Political Animals

During times of political upheaval, a country's wildlife may be as likely as its people to suffer. To gauge the impact of socioeconomic shock on wild animals, a team led by Russian-born ecologist Eugenia Bragina recently studied the effects of the Soviet Union's collapse on eight large mammal species: reindeer, roe deer, red deer, moose, wild boar, brown bear, Eurasian lynx, and gray wolf.

All showed strong population fluctuations in the decade before and after the U.S.S.R. dissolved in 1991, with wild boar, brown bear, and moose numbers declining rapidly post-collapse, likely because of poaching, loss of farmland as foraging ground, and little enforcement of wildlife protection laws. Only gray wolf numbers rose—more than 150 percent—perhaps due to the end of population control programs. Bragina, a North Carolina State University researcher, says that "even widespread species may need careful monitoring in times of turmoil." One way to protect animals in hard times, she adds, "is to take care of people."

Livestock can also be affected by political and social chaos. According to research published in the journal *Rangifer,* domesticated reindeer numbers fell sharply after 1991, as they had in another politically fraught era: the late 1920s, when Joseph Stalin began forcibly collectivizing Soviet farms. *—Eve Conant*



BRIGHT IDEAS CAN CHANGE THE WORLD

EXTREME ENERGY EFFICIENCY FOR LOW-INCOME RESIDENTS

Habitat for Humanity's Passive House Project has provided nearly 300 low-income families with energy-efficient homes designed to help them consume significantly less energy overall and to greatly reduce their water usage. These benefits not only save the homeowners money, but empower them to create a more sustainable lifestyle. →

EMPOWERING A NEW GENERATION OF RENEWABLE ENERGY PIONEERS

Green Empowerment works with community-based organizations in Malaysian Borneo to train people how to design and implement micro-hydro projects. Their efforts have provided renewable energy to over 2,000 indigenous community members living in far-reaching areas that never had access to affordable and clean energy. →

BE PART OF THE SOLUTION. TAKE PART IN THE CHALLENGE.

Change happens when an epic idea transforms into a real-world solution. That's why National Geographic and Shell teamed up to launch the Great Energy Challenge. A smarter energy future is possible only if all of us band together as global citizens and take an active role. Let's talk about the energy challenges we face, learn about energy innovations that work, and do more to change the way we think about and consume energy.

GRANTEE SPOTLIGHT

These grantees represent the 29 real-world projects focused on innovative energy solutions that have received grants from The Great Energy Challenge, a National Geographic initiative in partnership with Shell. When we push the way we think about energy, we help ensure a sustainable energy future.

1. *Legacy Foundation:* Eco-Leña (Eco-Fuelwood), Guatemala
2. *reNo-va:* Managua, Nicaragua
3. *Seattle Biochar Working Group:* Talamanca region of Costa Rica
4. *Habitat for Humanity:* Washington, D.C.
5. *Carbon Roots International:* Cap-Haitien, Haiti
6. *EarthSpark:* Côte Sud, Haiti
7. *Solar Electric Light Fund:* Kalalé, Benin
8. *Impact Energies:* Ghana
9. *PEG Ghana:* Ghana
10. *Comprehensive Design Services:* Port Harcourt, Rivers State, Nigeria
11. *Solar Sister:* Gulu, Uganda
12. *Eco-Fuel Africa:* Kampala, Uganda
13. *Engineers Without Borders:* Teso region, Uganda
14. *Elephant Energy:* Namibia
15. *Qorax Energy:* Hargeisa, Somaliland
16. *African Christians Organization Network:* Bungoma district of Western Kenya
17. *Sanergy:* Nairobi, Kenya
18. *Sanivation:* Naivasha, Kenya
19. *Takamoto Biogas:* Rift Valley, Kenya
20. *EGG-Energy:* Pwani and Iringa Regions, Tanzania
21. *Frontier Markets:* Rajasthan, India
22. *Eco Energy Finance:* Karachi, Pakistan
23. *Ghonsla:* Azad Jammu and Kashmir (AJK), Pakistan
24. *International Development Enterprises (iDE):* Kathmandu, Nepal
25. *SunFarmer:* Kathmandu
26. *Swayam Krishi Sangam:* Orissa State, India
27. *Institute for Climate and Sustainable Cities (iCSC):* Quezon City, Philippines
28. *Green Empowerment:* Sabah, Malaysian Borneo
29. *Masarang:* North Sulawesi, Indonesia

Watch the stories of these energy innovators and other visionaries whose bright ideas have been powered by grants through The Great Energy Challenge. Follow @NatGeoEnergy on Twitter and visit **greatenergychallenge.com**.

The Great Energy Challenge

NATIONAL GEOGRAPHIC

A NATIONAL GEOGRAPHIC INITIATIVE IN PARTNERSHIP WITH SHELL

For Richer or Poorer

"A diamond is forever," De Beers jewelers declared in 1947. Millions of people were sold—on both the diamonds and the connection between lavish weddings and lasting marriages. Now a pair of economists have found evidence that the opposite is true. An Emory University survey of heterosexual adults found that men who spent more than $2,000 on a ring were more likely to end up divorced than grooms who spent less. And couples who had big-money nuptials (over $20,000) were three and a half times as likely to report shorter marriages.

Burdensome wedding debt may be one source of marriage stress, says Emory's Hugo Mialon. Also, the types of couples who have thrifty nuptials may just be better matched and thus less divorce prone, he says. Something else the survey associated with lasting unions? A honeymoon, no matter the cost. *—Daniel Stone*

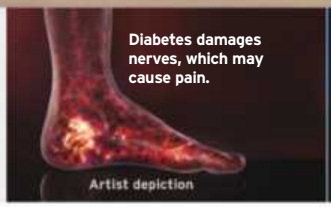
CATCH OF THE DAY: TRASH FISH

Conscientious chefs who cheered the farm-to-table and eat-local movements are turning their attention seaward. They're experimenting with bycatch, sea creatures and fish unintentionally brought in along with desired species. Also called trash fish or wasted catch, bycatch may account for up to 22 percent of commercial catches in the U.S., says a 2014 report from the nonprofit Oceana. Improved fishing practices may lessen the problem. Meanwhile, restaurateurs and home cooks are putting bycatch species on the menu: dogfish tacos or blowfish tenders, anyone? *—Lindsay N. Smith*

PHOTOS: BILL McCULLOUGH (TOP); COREY ARNOLD

FOR SOME PATIENTS, LYRICA CAN PROVIDE SIGNIFICANT RELIEF FROM DIABETIC NERVE PAIN.*

*Individual results may vary.



Prescription LYRICA is not for everyone. Tell your doctor right away about any serious allergic reaction that causes swelling of the face, mouth, lips, gums, tongue, throat, or neck or any trouble breathing, rash, hives or blisters. LYRICA may cause suicidal thoughts or actions in a very small number of people. Patients, family members or caregivers should call the doctor right away if they notice suicidal thoughts or actions, thoughts of self harm, or any unusual changes in mood or behavior. These changes may include new or worsening depression, anxiety, restlessness, trouble sleeping, panic attacks, anger, irritability, agitation, aggression, dangerous impulses or violence, or extreme increases in activity or talking. If you have suicidal thoughts or actions, do not stop LYRICA without first talking to your doctor. LYRICA may cause swelling of your hands, legs and feet. Some of the most common side effects of LYRICA are dizziness and sleepiness. Do not drive or work with machines until you know how LYRICA affects you. Other common side effects are blurry vision, weight gain, trouble concentrating, dry mouth, and feeling "high." Also, tell your doctor right away about muscle pain along with feeling sick and feverish, or any changes in your eyesight including blurry vision or any skin sores if you have diabetes. You may have a higher chance of swelling, hives or gaining weight if you are also taking certain diabetes or high blood pressure medicines. Do not drink alcohol while taking LYRICA. You may have more dizziness and sleepiness if you take LYRICA with alcohol, narcotic pain medicines, or medicines for anxiety. If you have had a drug or alcohol problem, you may be more likely to misuse LYRICA. Tell your doctor if you are planning to father a child. Talk with your doctor before you stop taking LYRICA or any other prescription medication.

Please see Important Risk Information for LYRICA on the following page.

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.

Ask your doctor about LYRICA and visit **LYRICA.com** or call **1-888-9-LYRICA (1-888-959-7422).**

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IT'S SPECIFIC TREATMENT FOR DIABETIC NERVE PAIN

IMPORTANT FACTS

LYRICA PREGABALIN capsules (**LEER**-i-kah)

IMPORTANT SAFETY INFORMATION ABOUT LYRICA

LYRICA may cause serious, even life threatening, allergic reactions. Stop taking LYRICA and call your doctor right away if you have any signs of a serious allergic reaction:
- Swelling of your face, mouth, lips, gums, tongue, throat or neck
- Have any trouble breathing
- Rash, hives (raised bumps) or blisters

Like other antiepileptic drugs, LYRICA may cause suicidal thoughts or actions in a very small number of people, about 1 in 500.
Call your doctor right away if you have any symptoms, especially if they are new, worse or worry you, including:
- suicidal thoughts or actions
- new or worse depression
- new or worse anxiety
- feeling agitated or restless
- panic attacks
- trouble sleeping
- new or worse irritability
- acting aggressive, being angry, or violent
- acting on dangerous impulses
- an extreme increase in activity and talking
- other unusual changes in behavior or mood

If you have suicidal thoughts or actions, do not stop LYRICA without first talking to your doctor.

LYRICA may cause swelling of your hands, legs and feet.
This swelling can be a serious problem with people with heart problems.

LYRICA may cause dizziness or sleepiness.
Do not drive a car, work with machines, or do other dangerous things until you know how LYRICA affects you. Ask your doctor when it is okay to do these things.

ABOUT LYRICA

LYRICA is a prescription medicine used in adults 18 years and older to treat:
- Pain from damaged nerves that happens with diabetes or that follows healing of shingles, or spinal cord injury
- Partial seizures when taken together with other seizure medicines
- Fibromyalgia (pain all over your body)

Who should NOT take LYRICA:
- Anyone who is allergic to anything in LYRICA

BEFORE STARTING LYRICA

Tell your doctor about all your medical conditions, including if you:
- Have had depression, mood problems or suicidal thoughts or behavior
- Have or had kidney problems or dialysis
- Have heart problems, including heart failure
- Have a bleeding problem or a low blood platelet count
- Have abused prescription medicines, street drugs or alcohol in the past
- Have ever had swelling of your face, mouth, tongue, lips, gums, neck, or throat (angioedema)
- Plan to father a child. It is not known if problems seen in animal studies can happen in humans.
- Are pregnant, plan to become pregnant or are breastfeeding. It is not known if LYRICA will harm your unborn baby. You and your doctor should decide whether you should take LYRICA or breast-feed, but you should not do both.

Tell your doctor about all your medicines. Include over-the-counter medicines, vitamins, and herbal supplements. LYRICA and other medicines may affect each other causing side effects. Especially tell your doctor if you take:

BEFORE STARTING LYRICA, continued

- Angiotensin converting enzyme (ACE) inhibitors. You may have a higher chance for swelling and hives.
- Avandia® (rosiglitazone)*, Avandamet® (rosiglitazone and metformin)* or Actos® (pioglitazone)** for diabetes. You may have a higher chance of weight gain or swelling of your hands or feet.
- Narcotic pain medicines (such as oxycodone), tranquilizers or medicines for anxiety (such as lorazepam). You may have a higher chance for dizziness and sleepiness.
- Any medicines that make you sleepy.

POSSIBLE SIDE EFFECTS OF LYRICA

LYRICA may cause serious side effects, including:
- See "Important Safety Information About LYRICA."
- Muscle problems, pain, soreness or weakness along with feeling sick and fever
- Eyesight problems including blurry vision
- Weight gain. Weight gain may affect control of diabetes and can be serious for people with heart problems.
- Feeling "high"

If you have any of these symptoms, tell your doctor right away.

The most common side effects of LYRICA are:
- Dizziness
- Blurry vision
- Weight gain
- Sleepiness
- Trouble concentrating
- Swelling of hands and feet
- Dry mouth

If you have diabetes, you should pay extra attention to your skin while taking LYRICA.

HOW TO TAKE LYRICA

Do:
- Take LYRICA exactly as your doctor tells you. Your doctor will tell you how much to take and when to take it. Take LYRICA at the same times each day.
- Take LYRICA with or without food.

Don't:
- Drive a car or use machines if you feel dizzy or sleepy while taking LYRICA.
- Drink alcohol or use other medicines that make you sleepy while taking LYRICA.
- Change the dose or stop LYRICA suddenly. If you stop taking LYRICA suddenly, you may have headaches, nausea, diarrhea, trouble sleeping, increased sweating, or you may feel anxious. If you have epilepsy, you may have seizures more often.
- Start any new medicines without first talking to your doctor.

NEED MORE INFORMATION?

- Ask your doctor or pharmacist. This is only a brief summary of important information.
- Go to **www.lyrica.com** or call **1-866-459-7422 (1-866-4LYRICA).**

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Version September 2014

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It's Big, and It Bites

Scientists analyzing the skull of the largest known rodent have determined that the prehistoric herbivore's front bite was as strong as a tiger's. What's more, its curved, foot-long incisors could withstand forces three times as powerful as the force its jaw muscles could generate. The conclusion? This distant cousin of the guinea pig "must have been doing something more with those teeth than just eating with them," says anatomist Philip Cox.

At an estimated weight of 2,200 pounds, *Josephoartigasia monesi* likely didn't face too many threats as it lumbered through the estuaries and deltas of South America more than two million years ago. Cox and his colleagues suspect that *J. monesi* relied on its front teeth for sparring with rivals and defending itself against predators, as well as for rooting in the ground for food. "That would make the teeth quite like the tusks of an elephant," Cox says. The beast's size made one other use of its teeth less probable, he says: A rodent roughly five feet tall and ten feet long is almost certainly "too big to be digging burrows." —*Rachel Hartigan Shea*

Only one fossil of *J. monesi* has been discovered. The paca-rana is its closest living relative.

ART: RAÚL MARTÍN. GRAPHICS: NGM ART. SOURCES: PHILIP COX; ANDRÉS RINDERKNECHT; ERNESTO BLANCO

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Saving Soil

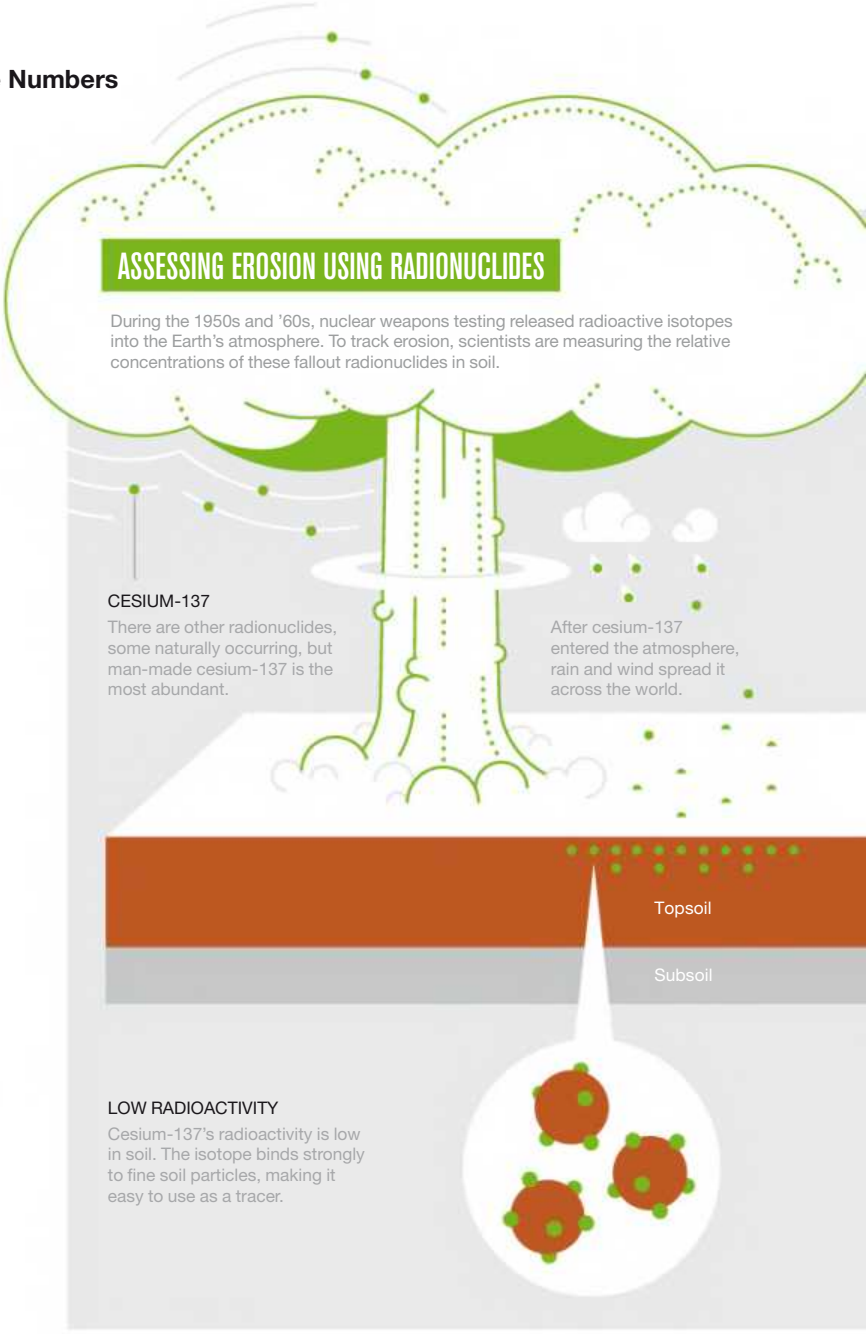
World Soil Day is celebrated every December 5. Soil, in which nearly all our food grows, is a living resource that takes years to form. Yet it can vanish in minutes, says Ronald Vargas of the United Nations Food and Agriculture Organization (FAO).

Each year 75 billion tons of fertile soil are lost to erosion. That's alarming—and not just for food producers. Soil can trap huge quantities of carbon dioxide in the form of organic carbon and prevent it from escaping into the atmosphere.

"If we protect and sustainably manage soils," says Vargas, "we can combat climate change." *—Kelsey Nowakowski*

ASSESSING EROSION USING RADIONUCLIDES

During the 1950s and '60s, nuclear weapons testing released radioactive isotopes into the Earth's atmosphere. To track erosion, scientists are measuring the relative concentrations of these fallout radionuclides in soil.

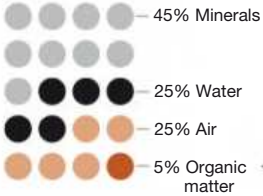


SOIL MATTERS

95%

OF THE WORLD'S FOOD GROWS IN SOIL.

AVERAGE SOIL COMPOSITION

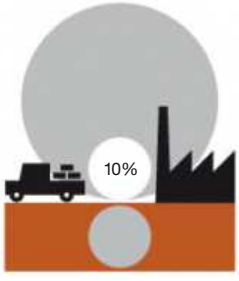


1/4

OF THE WORLD'S SPECIES LIVE IN SOIL.

CARBON CAPTURE

Over the course of 25 years healthy soils can absorb an estimated 10 percent of human-generated carbon emissions.



HOW IT WORKS

A Cesium-137 is a tracer that has allowed soil scientists at the FAO and the International Atomic Energy Agency to measure the variation in levels of cesium-137 to see where soil has eroded. Farmers can then work to stop the erosion.

REFERENCE SITE

To establish a base for comparison, scientists measure the cesium-137 levels of soil on a flat, undisturbed site.

FLAT FARMLAND

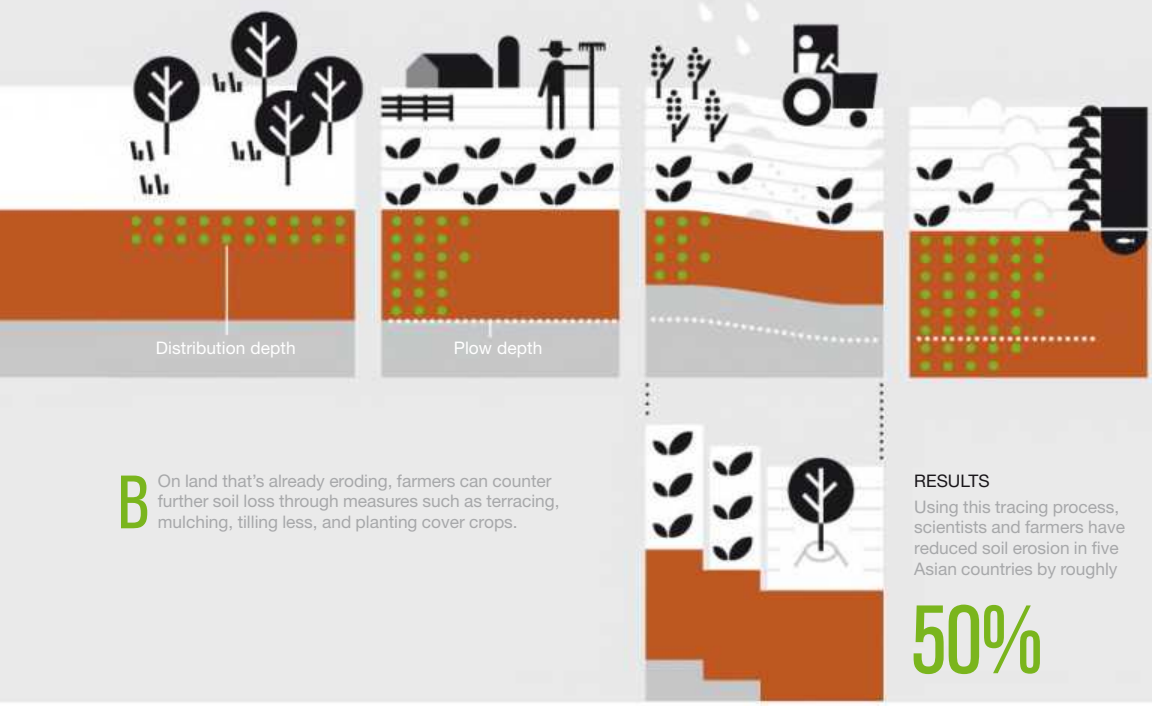
Tilling flat land distributes cesium-137 relatively evenly down through the soil to the depth the plow reaches.

SLOPED FARMLAND

Farming on steep hillsides can allow rain to wash away soil—and with it cesium-137.

EROSION SIGNPOSTS

Eroded soil often collects at the base of a hill or near waterways, concentrating the cesium-137.



B On land that's already eroding, farmers can counter further soil loss through measures such as terracing, mulching, tilling less, and planting cover crops.

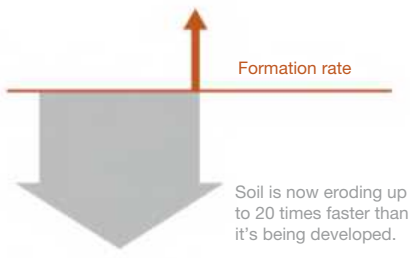
RESULTS

Using this tracing process, scientists and farmers have reduced soil erosion in five Asian countries by roughly

50%

A DWINDLING RESOURCE

Poor land management, urbanization, and climate change are making soils more prone to erosion. Population growth increases pressure on farmlands.



Soil is now eroding up to 20 times faster than it's being developed.

Since 1960 one-third of the world's arable land has been lost to erosion.

GRAPHIC: ÁLVARO VALIÑO. SOURCE: FAO, LAND AND WATER DIVISION; IAEA, JOINT FAO/IAEA DIVISION

Once found chiefly on "pets" (above), chia is often called an ancient grain but is technically a seed that becomes gelatinous when put in water or other liquids. The plant is now being grown on a small scale in the United States, where demand is rising thanks to its health benefits.

Chia Makes Waves

Gone are the days when chia, a member of the mint family, was associated mostly with a "pet" plant fad of the 1980s. Today its seeds are soaring in popularity for an arguably better reason: nutrition. They pack an omega-3 punch and are high in protein, fiber, and calcium. They're also gluten free and said to benefit everything from digestion to hair, skin, and nail health.

Until recently chia—which is native to Mexico and Guatemala—wasn't grown on a notable scale outside Central and South America and Australia. Now a handful of U.S. farmers are building a domestic supply, planting a variety that University of Kentucky researchers developed for the fewer hours of sun in North America. "Demand continues to increase," says seed breeder Tim Phillips, "and U.S.-cultivated chia will help ensure high-quality, consistent production." *—Catherine Zuckerman*

PHOTOS: REBECCA HALE, NGM STAFF; JOSEPH ENTERPRISES, INC. (CHIA PET)

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Deviant Burials

Vampires or victims? Bioarchaeologists working at the Drawsko cemetery in northwestern Poland may finally have the answer.

Six of the site's 333 excavated bodies had been buried as suspected vampires sometimes were: with sickles over their necks (left) or rocks wedged under their jaws—measures said to prevent the undead from rising. Researchers figured that in life they'd been ostracized outsiders.

But when Lesley Gregoricka measured the ratio of radiogenic strontium isotopes in their tooth enamel—a count that varies by location and can show where a person grew up—she saw just the opposite: Five were locals.

Could they have been victims of violence, disease, or homicide? Any of these fates would have made them suspect. In post-medieval Poland, says Gregoricka, blaming the supernatural was "a way to explain the unexplainable." *—Jeremy Berlin*

WHY IRISH EYES WERE SHINING

The Emerald Isle was bright with gold during the Early Bronze Age. Hoards of gold artifacts have been found in Ireland, including numerous small disks and more than 80 crescent-shaped neck ornaments, called lunulae (right). But where did the prehistoric artisans get the precious metal? Archaeologists haven't found any evidence of gold mining in Ireland 4,000 years ago, although there were plenty of gold deposits.

Using a geochemical technique called lead isotope analysis, archaeologist Christopher Standish identified the gold as coming from Cornwall. That only deepens the mystery. Why would the Irish import something that lay under their own turf? Perhaps they hadn't yet found local ore or were seeking a more potent version of the metal. "Gold often embodies supernatural or magical powers," says Standish. "An origin in distant lands might have imbued this shiny metal with extra powers." *—Rachel Hartigan Shea*

PHOTOS: AMY SCOTT, SLAVIA FOUNDATION (TOP); NATIONAL MUSEUM OF IRELAND

WHAT IF ONE STRAWBERRY COULD HELP PREVENT HEART DISEASE?

Wishful thinking, right?
But there is one step that can help protect you from another serious disease, pneumococcal pneumonia.
The PREVNAR 13® vaccine.

As you age, your risk of getting pneumococcal pneumonia increases. It's a serious disease that could put you in the hospital. Symptoms include coughing, fever, chest pain, and difficulty breathing. If you are 50 or older, one dose of the PREVNAR 13® vaccine can help protect you. Even if you've already been vaccinated with another pneumonia vaccine, PREVNAR 13® may help provide additional protection. Immune response may be lower if given within one year after another pneumonia vaccine. Ask your doctor or pharmacist if PREVNAR 13® is right for you.

Prevnar 13®
Pneumococcal 13-valent Conjugate Vaccine
(Diphtheria CRM_{197} Protein)

GET THIS ONE DONE.

INDICATION FOR PREVNAR 13®

- Prevnar 13® is a vaccine approved for adults 50 years of age and older for the prevention of pneumococcal pneumonia and invasive disease caused by 13 *Streptococcus pneumoniae* strains (1, 3, 4, 5, 6A, 6B, 7F, 9V, 14, 18C, 19A, 19F, and 23F)
- Prevnar 13® is not 100% effective and will only help protect against the 13 strains included in the vaccine

IMPORTANT SAFETY INFORMATION

- Prevnar 13® should not be given to anyone with a history of severe allergic reaction to any component of Prevnar 13® or any diphtheria toxoid–containing vaccine
- Adults with weakened immune systems (eg, HIV infection, leukemia) may have a reduced immune response
- In adults, immune responses to Prevnar 13® were reduced when given with injected seasonal flu vaccine
- In adults, the common side effects were pain, redness, or swelling at the injection site, limitation of arm movement, fatigue, headache, muscle pain, joint pain, decreased appetite, chills, or rash
- Ask your health care provider about the risks and benefits of Prevnar 13®. Only a health care provider can decide if Prevnar 13® is right for you

You are encouraged to report negative side effects of vaccines to the US Food and Drug Administration (FDA) and Centers for Disease Control and Prevention (CDC). Visit www.vaers.hhs.gov or call 1-800-822-7967.

Please see Important Facts for Prevnar 13® on the adjacent page.

Pfizer

IMPORTANT FACTS

Prevnar 13® (pronounced "Prev • nar 13")
Generic Name: Pneumococcal 13-valent Conjugate Vaccine (Diphtheria CRM_{197} Protein)

WHO SHOULD RECEIVE PREVNAR 13® (Pneumococcal 13-valent Conjugate Vaccine [Diphtheria CRM_{197} Protein])?

- Prevnar 13® is approved for adults 50 years and older for the prevention of pneumococcal pneumonia and invasive disease caused by the 13 vaccine strains
- Prevnar 13® is a vaccine also approved for children 6 weeks through 17 years of age for the prevention of invasive disease caused by the 13 strains of *Streptococcus pneumoniae* included in the vaccine, and for children 6 weeks through 5 years for the prevention of ear infections caused by 7 of the 13 strains
- Prevnar 13® is not 100% effective and will only help protect against the 13 strains included in the vaccine

Adults 50 years and older:

- A single dose of Prevnar 13® is recommended for adults aged 50 years of age and older

Children 6 weeks through 5 years of age:

- Prevnar 13® is recommended for children 6 weeks through 5 years of age
- Prevnar 13® is given as a 4-dose series at 2, 4, 6, and 12 to 15 months of age
- ***Transition schedule:*** Children who have received 1 or more doses of Prevnar® (Pneumococcal 7-valent Conjugate Vaccine [Diphtheria CRM_{197} Protein]) may complete the 4-dose immunization series with Prevnar 13®
- ***Catch-up schedule:*** Children 15 months through 5 years of age who are considered fully immunized with Prevnar® may receive 1 dose of Prevnar 13® to elicit immune responses to the 6 additional strains
- The immune responses from the transition or catch-up schedules might be lower for the 6 additional strains (types 1, 3, 5, 6A, 7F, and 19A) than if your child had received the full 4 doses of Prevnar 13®

Children 6 years through 17 years of age:

- In children 6 years through 17 years of age, Prevnar 13® is given as a single dose

WHO SHOULD NOT RECEIVE PREVNAR 13®?

Children or adults who have had a severe allergic reaction to any component of Prevnar 13® or any diphtheria toxoid–containing vaccine should not receive Prevnar 13®

BEFORE STARTING PREVNAR 13®

Tell your health care provider or your child's health care provider about all medical conditions, including:

- Previous allergic reactions to other vaccines
- Especially tell the health care provider if your child or you are taking medicines that can weaken the immune system, such as steroids (eg, prednisone) and cancer medicines, or are undergoing radiation therapy
- If you are pregnant or nursing, or if you plan to become pregnant

WARNING

- A temporary pause of breathing following vaccination has been observed in some infants born prematurely. Decisions about when to give Prevnar 13® to infants born prematurely should be based on consideration of the individual infant's medical status, and the potential benefits and possible risks of vaccination
- The safety and efficacy of Prevnar 13® when given to persons with a weakened immune system (such as HIV infection, damaged spleen, cancer, or kidney problems) is not known. Children or adults with a weakened immune system may have a reduced response to Prevnar 13®

WHAT ARE THE POTENTIAL SIDE EFFECTS?

- In adults, the common side effects were pain, redness, or swelling at the injection site, limitation of arm movement, fatigue, headache, muscle pain, joint pain, decreased appetite, chills, or rash
- The most commonly reported serious adverse events in children were bronchiolitis (an infection of the lungs) (0.9%), gastroenteritis (inflammation of the stomach and small intestine) (0.9%), and pneumonia (0.9%)
- In children 6 weeks through 17 years, the most common side effects were tenderness, redness, or swelling at the injection site, irritability, decreased appetite, decreased or increased sleep, and fever. Most commonly reported side effects in children 5 years through 17 years also included hives

WHAT SHOULD I KNOW ABOUT RECEIVING PREVNAR 13® WITH OTHER VACCINES?

- In adults, immune responses to Prevnar 13® were reduced when given with injected seasonal flu vaccine
- When given within 1 year following pneumococcal polysaccharide vaccine, immune response to Prevnar 13® may be lower

ADDITIONAL IMPORTANT INFORMATION

- The safety and effectiveness of Prevnar 13® when used in children less than 6 weeks of age is not known
- In a study in which children received acetaminophen prior to Prevnar 13®, immune responses to some strains in the vaccine were lower compared with responses among children who received acetaminophen after vaccination only as needed
- Ask your health care provider about the risks and benefits of Prevnar 13®. Only a health care provider can decide if Prevnar 13® is right for you or your child

NEED MORE INFORMATION?

- This is only a summary of important information. Ask your health care provider or your child's health care provider for complete product information
- Go to www.Prevnar13.com or call 1-800-666-7248

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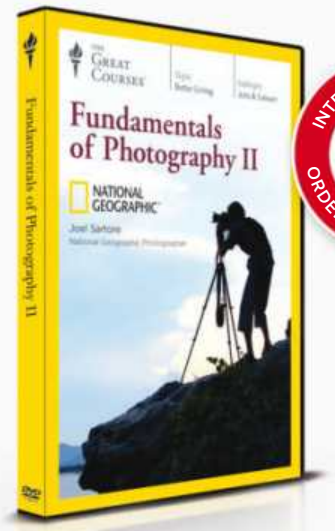

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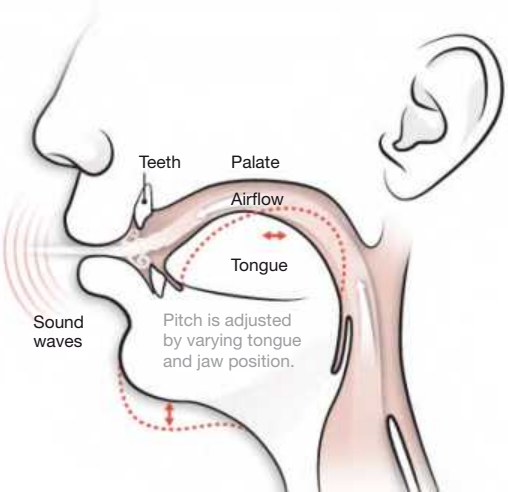
Backyard Universe

If you can't go to the moon, the closest you can get—while still on Earth—may be the Haughton Crater on Devon Island, Canada. Because the site resembles the desolate, cratered surface of the moon and Mars, NASA uses it as a planetary stand-in. On a 2010 "mission" there, the space agency mimicked a long trip in the southern polar region of the moon.

Space researchers frequently look for such celestial replicas, known as analogs, on Earth. Antarctica's cold, windswept landscape has helped engineers design a housing structure for use on Mars. An underwater "low gravity" lab off Florida's coast has been used to assess navigation and communication systems. "We wouldn't want to be out in space testing technology for the first time," says NASA's Kathryn Hambleton. The analogs help researchers peer into the future. Engineers have used Hawaii's Mauna Kea volcano to test equipment that may help tomorrow's explorers drill into the moon for evidence of water or ice. *—Daniel Stone*



HOW WE WHISTLE

What makes the high-pitched sound when lips pucker? Precise aerodynamics, says George Mason University physicist Ernie Barreto. Raising the tongue constricts airflow, producing a pattern of air vortices inside the mouth. When the position of the lips creates a certain geometry, he says, a whistling sound results.

Professionals in the art develop advanced skills, such as whistling through their teeth, to produce intricate tunes. To keep lips supple and toned, champion whistler Chris Ullman says he has a "no-kissing policy" 24 hours before competing. Also, plenty of Chapstick. *—DS*

PHOTO: NASA. GRAPHIC: SAMANTHA WELKER. SOURCE: CHRISTINE SHADLE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TOYOTA | Let's Go Places
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HABITAT/RANGE
The lined seahorse *(Hippocampus erectus)*—shown here about 1.7 times its actual size—inhabits coastlines and reefs in the Americas and the Caribbean.

CONSERVATION STATUS
Vulnerable

Some male seahorses can deliver a brood in the morning and be pregnant again by nightfall.

Marine Mr. Mom

Births in the *Hippocampus* clan involve a horse of a different gender. The 35 species in this seahorse genus are unique in the animal kingdom: Their males, not their females, get pregnant. Prolifically.

But first, there's dancing. During a days-long mating ritual, a seahorse couple swims in close unison for hours, sometimes snout to snout with tails entwined. "You've seen that design showing two seahorses forming a heart? It's almost true," says Leslee Matsushige, associate curator of the Birch Aquarium at the Scripps Institution of Oceanography.

The romantic posture aligns the female's egg-delivery organ with the opening of a "brood pouch" on the male's torso. She deposits hundreds of eggs; he fertilizes them and seals the pouch, where the eggs mature into fry. Male pipefish and sea dragons, seahorse relatives, incubate eggs in flaps or patches on their bodies. Only seahorse males use a womblike, enclosed pouch.

After 14 to 28 days' gestation, depending on the species, the male has contractions that expel the offspring, up to 1,500 in a brood. Only a fraction will survive. They die when habitats are destroyed, or as predators' meals or fishing bycatch. Mostly they're sold as curios and cures: Some 25 million a year are used in traditional Asian medicine, Matsushige says. It's fortunate, then, that these seahorses are reproducing fools. Some males can bear hundreds of fry in the morning and be pregnant again by nightfall. *—Patricia Edmonds*

PHOTO: DAVID LIITTSCHWAGER

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SAVE OCEANS
(AND SAVE MONEY TOO)

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VISIONS

Antarctica
Strong winds and heavy swells set two icebergs on a collision course near Franklin Island. Seen from a Russian ship, the bergs rise perhaps 200 feet above the surface and plunge some 800 below. They may have calved from the Ross Ice Shelf.

PHOTO: CAMILLE SEAMAN

Japan
As part of an annual Christmas event, a diver dressed as Santa Claus swims with a zebra shark at the Sunshine Aquarium. The facility is located on the top floor of a Tokyo high-rise. It has no reindeer but about 15,000 animals of some 450 species.

PHOTO: SHIZUO KAMBAYASHI, AP IMAGES

Norway
The sheer drop-off and lack of guardrails don't stop visitors—some 200,000 a year—from trekking two hours to perch on Preikestolen, aka Pulpit Rock. The flat granite slab in the Ryfylke region juts nearly 2,000 feet above the waters of the Lysefjord.

PHOTO: MASSIMO VITALI

world beat

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C. TOTAL PAID CIRCULATION	3,942,117	3,834,766
D. FREE DISTRIBUTION (Includes samples, no news agents)		
1. Outside County	62,307	34,873
2. In County	–	–
3. Other Classes Mailed Through USPS	–	–
4. Free Distribution Outside the Mail	3,166	3,074
E. TOTAL FREE DISTRIBUTION	65,473	37,947
F. TOTAL DISTRIBUTION		
(Sum of C and E)	4,007,590	3,872,713
G. OFFICE USE, LEFTOVERS, ETC.	309,270	295,899
H. TOTAL (Sum of F and G)	4,316,860	4,168,612
I. PERCENT PAID	98%	99%

If You Bought or Leased a New Motor Vehicle, or Bought Certain Replacement Parts for a Motor Vehicle Since 2000

You Could Get Money From Settlements Totaling Approximately $54 Million

Two Defendants and their affiliates ("Settling Defendants") have agreed to Settlements resolving claims that they fixed the price of certain motor vehicle components. This may have caused individuals and businesses to pay more for new motor vehicles and certain replacement parts. The Settling Defendants deny any claims of wrongdoing.

Am I included?

You may be included if, from 2000 to 2015, you: (1) bought or leased an eligible new vehicle in the U.S. (not for resale), or (2) indirectly paid for an eligible motor vehicle replacement part. Indirectly means you bought the replacement part from someone other than the manufacturer of the part. Eligible new motor vehicles are automobiles, light trucks, vans, mini-vans, and sport utility vehicles. Visit the website, www.AutoPartsClass.com or call 1-877-940-5043 for a full list of Settling Defendants and time periods.

What do the Settlements provide?

The Settlements provide money for consumers in 30 states and the District of Columbia as well as non-monetary relief, including cooperation, and an agreement by Settling Defendants not to engage in certain conduct for a period of 24 months.

The 30 states are: Arizona, Arkansas, California, Florida, Hawaii, Iowa, Kansas, Maine, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Mexico, New York, North Carolina, North Dakota, Oregon, Rhode Island, South Carolina, South Dakota, Tennessee, Utah, Vermont, West Virginia, and Wisconsin.

How can I get a payment?

No money will be distributed yet. Class Counsel will pursue the lawsuits against the Non-Settling Defendants. All funds received in this case will be distributed at the conclusion of the lawsuits or as ordered by the Court. You will need to file a valid claim to receive a payment. Notice about the claims process will be provided at a later date.

If you want to receive notice about the claims process or future settlements, you should register at www.AutoPartsClass.com.

What are my rights?

Even if you do nothing, you will be bound by the Court's decisions concerning these Settlements. If you want to keep your right to sue the Settling Defendants regarding a particular component part, you must exclude yourself from that Settlement Class by **March 28, 2016**. If you stay in a Settlement Class, you may object to one or more of the Settlements by **March 28, 2016**.

The Court will hold a hearing on **May 4, 2016** to consider whether to approve the Settlements and approve Class Counsel's request that up to $2 million be set aside for future litigation costs and expenses. Class Counsel will also request at the hearing, or at a later date, attorneys' fees of up to one-third of the Settlement funds, plus reimbursement of costs and expenses. You or your own lawyer may appear and speak at the hearing at your own expense.

If the cases are not dismissed or settled, Class Counsel will have to prove their claims against the Non-Settling Defendants at trial. Trial has not been set yet.

For More Information or to Register: 1-877-940-5043 www.AutoPartsClass.com

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EXPLORER

NEW EPISODE

THE CULT OF MARY

An in-depth look at how devotees of the Virgin Mary have impacted both historical and modern-day civilizations.

SUNDAY DECEMBER 13

8/7c

NATIONAL GEOGRAPHIC CHANNEL

natgeotv.com/Explorer

Create It

Assignment We asked the community to *make* photographs and then recruited three veteran Your Shot members to select the best.

EDITOR'S NOTE

"I can feel this photo; it speaks to me. It's her facial expression that does it, or maybe the elements of mystery and drama. To me, this image was like none other. It was captivating."

Ivan Lesica, Your Shot *guest editor*

Martin Shank and **Julie Larocque**
Montreal, Quebec

This light painting required a dark space and a still model. Larocque set up the camera and posed, and Shank painted her with a fiber-optic brush—all while hoping their cats wouldn't disrupt the session. "Doing light painting allows us to transcend into a fictional world," Larocque says.

HOLY MARY · HOLY MOTHER OF GOD ·
OF CHRIST · BLESSED MOTHER · MOTH
PURE · MOTHER MOST CHASTE · MOTHER
MOTHER MOST AMIABLE · MOTHER OF
MOTHER OF OUR CREATOR · MOTHER OF
THE VIRGIN MARY · VIRGIN MOST VE
VIRGIN MOST POWERFUL · VIRGIN MO
MIRROR OF JUSTICE · SEAT OF WISDOM
VESSEL OF HONOR · SINGULAR VESSEL
TOWER OF DAVID · TOWER OF IVORY ·
HELP OF CHRISTIANS · MORNING STAR
ROSE · COMFORTER OF THE AFFLICTED
REFUGE OF SINNERS · QUEEN OF PATR
QUEEN OF PROPHETS · QUEEN OF ALL
APOSTLES · QUEEN OF CONFESSORS ·
QUEEN OF MARTYRS · QUEEN CONCEIVED
SIN · QUEEN ASSUMED INTO HEAVEN

· HOLY VIRGIN OF VIRGINS · MOTHER
ER OF DIVINE GRACE · MOTHER MOST
MOST ADMIRABLE · MOTHER UNDEFILED
GOOD COUNSEL · MOTHER INVIOLATE
OUR SAVIOR · VIRGIN MOST PRUDENT
NERABLE · VIRGIN MOST RENOWNED
ST MERCIFUL · VIRGIN MOST FAITHFUL
· CAUSE OF OUR JOY · SPIRITUAL VESSEL
OF DEVOTION · ARK OF THE COVENANT
HOUSE OF GOLD · HEALTH OF THE SICK
· OUR LADY · MYSTICAL · THE WORLD'S
· GATE OF HEAVEN · MOST POWERFUL
IARCHS · QUEEN OF ANGELS · WOMAN
SAINTS · QUEEN OF
QUEEN OF VIRGINS
WITHOUT ORIGINAL
· QUEEN OF PEACE

As the sun sets in Medjugorje, Bosnia and Herzegovina—a hot spot for Virgin Mary sightings—devotees of diverse faiths and nationalities gather to pray. A million pilgrims a year, some holding signs (previous page), hope for a message or a miracle.

By Maureen Orth
Photographs by Diana Markosian

It's apparition time: 5:40 p.m. In a small Roman Catholic chapel in Bosnia and Herzegovina, in the village of Medjugorje, Ivan Dragicevic walks down the aisle, kneels in front of the altar, bows his head for a moment, and then, smiling, lifts his gaze heavenward. He begins to whisper, listens intently, whispers again, and doesn't blink for ten minutes. His daily conversation with the Virgin Mary has begun.

Dragicevic was one of six poor shepherd children who first reported visions of the Virgin Mary in 1981. She identified herself to the four girls and two boys as the "Queen of Peace" and handed down the first of thousands of messages admonishing the faithful to pray more often and asking sinners to repent. Dragicevic was 16 years old, and Medjugorje, then in communist-controlled Yugoslavia, had yet to emerge as a hub of miracle cures and spiritual conversions, attracting 30 million pilgrims during the past three decades.

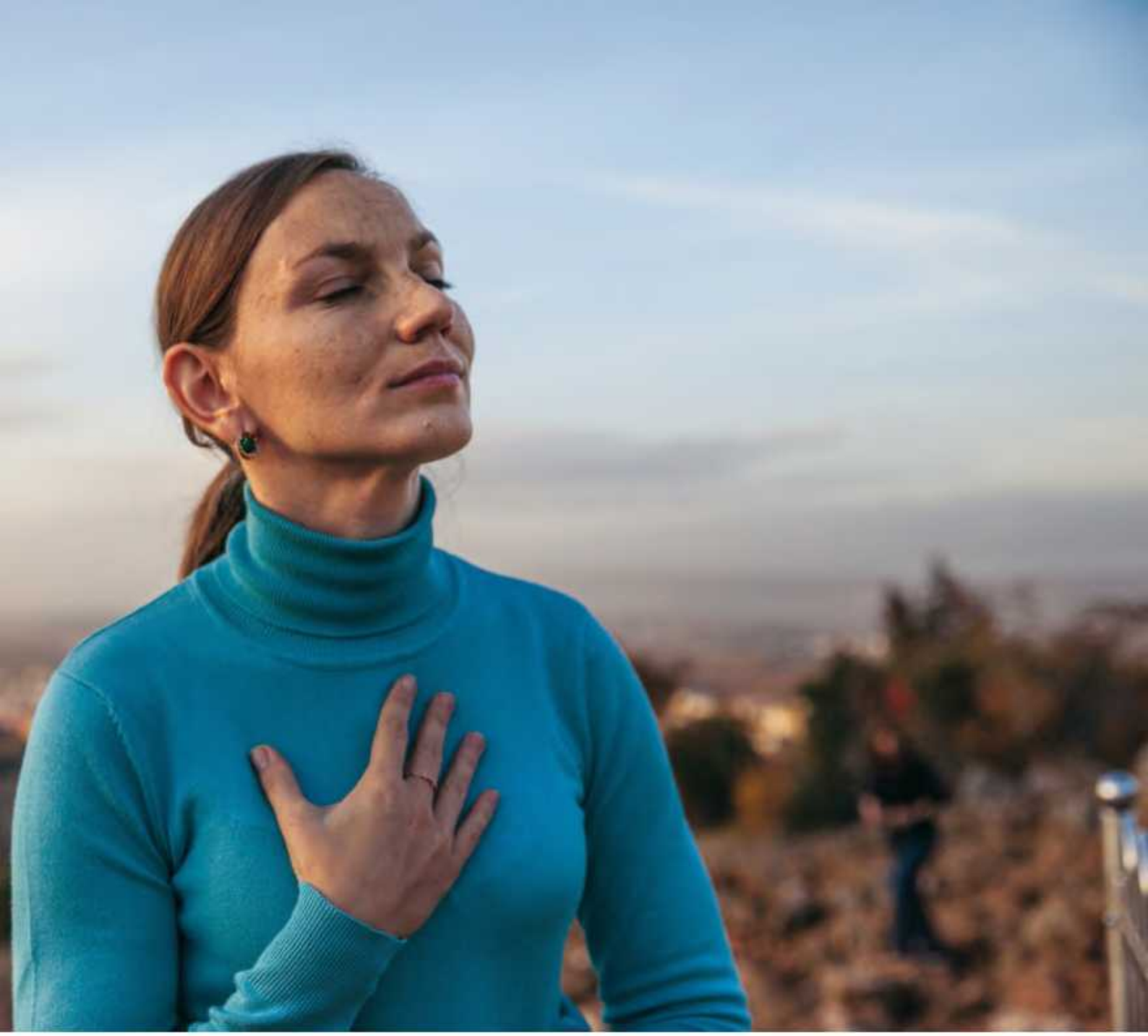
I'm in Medjugorje with a group of Americans, mostly hockey dads from the Boston area, plus two men and two women with stage 4 cancer. We're led by 59-year-old Arthur Boyle, a father of 13, who first came here on Labor Day weekend in 2000, riddled with cancer and given months to live. He felt broken and dejected and wouldn't have made the trip had not two friends forced him into it. But that first night, after he went to confession at St. James the Apostle church, psychological relief came rapidly.

"The anxiety and depression were gone," he told me. "You know when you're carrying someone on your shoulders in a swimming pool water fight—they come off, and you feel light

Anna Pidlisna, 32, of Ukraine, says she came to Medjugorje—where plaster statues can fetch about 30 euros apiece—after receiving a vision of Mary. Apparitions aren't the only Marian sign; many say they've seen a "spinning sun." Physicist Artur Wirowski has an earthly explanation: It can occur when sunlight reflects and refracts charged ice crystals vibrating in sync within the clouds.

EXPLORER

Tune in Sunday, December 13, to National Geographic Channel's Explorer series episode *The Cult of Mary.*



and free? I was like, Wait a minute, what just happened to me? Why is that?"

The next morning, with his friends Rob and Kevin, he met another of the "visionaries," Vicka Ivankovic-Mijatovic, in a jewelry shop and asked for her help. Gripping his head with one hand, she appealed to the Virgin Mary to ask God to cure him. Boyle said he experienced an unusual sensation right there in the store. "She starts to pray over me. Rob and Kevin put their hands on me, and the heat that went through my body from her praying was causing them to sweat."

Back in Boston a week later, a CT scan at Massachusetts General Hospital revealed that his tumors had shrunk to almost nothing.

Since then, Boyle has been back to Medjugorje 13 times. "I'm a regular guy," he said. "I like to play hockey and drink beer. I play golf." But, he continued, "I had to change things in my life." Today, Boyle said, he's become "a sort of mouthpiece for Jesus Christ's healing power and of course the Mother and the power of her intercession."

PRAYING FOR THE VIRGIN MARY'S intercession and being devoted to her are a global phenomenon. The notion of Mary as intercessor with Jesus begins with the miracle of the wine at the wedding at Cana, when, according to the Gospel of John, she tells him, "They have no wine," thus prompting his first miracle. It was in A.D. 431, at the Third Ecumenical Council, in Ephesus, that she was officially named Theotokos, Bearer of God. Since then no other woman has been as exalted as Mary. As a universal symbol of maternal love, as well as of suffering and sacrifice, Mary is often the touchstone of our longing for meaning, a more accessible link to the supernatural than formal church teachings. Her mantle offers both security and protection. Pope Francis, when once asked what Mary meant to him, answered, "She is my *mamá*."

Her reported appearances, visions experienced often by very poor children living in remote or conflict-wracked areas, have intensified her mystery and aura. And when the children can't be shaken from their stories—especially if the accounts are accompanied by inexplicable "signs" such as spinning suns or gushing springs—her wonder grows.

Mary is everywhere: Marigolds are named for her. Hail Mary passes save football games. The image in Mexico of Our Lady of Guadalupe is one of the most reproduced female likenesses ever. Mary draws millions each year to shrines such as Fátima, in Portugal, and Knock, in Ireland, sustaining religious tourism estimated to be worth billions of dollars a year and providing thousands of jobs. She inspired the creation of many great works of art and architecture (Michelangelo's "Pietà," Notre Dame Cathedral), as well as poetry, liturgy, and music (Monteverdi's *Vespers for the Blessed Virgin*). And she is the spiritual confidante of billions of people, no matter how isolated or forgotten.

Muslims as well as Christians consider her to be holy above all women, and her name "Maryam" appears more often in the Koran than "Mary" does in the Bible. In the New Testament Mary speaks only four times, beginning with the Annunciation, when, according to Luke's Gospel, the angel Gabriel appears to her and says she will bear "the Son of the Most High." Mary answers, "Here am I, the servant of the Lord." Her only extended speech, also in

MICHAEL O'NEILL IS THE VIRGIN MARY'S BIG DATA NUMBERS CRUNCHER. ON MIRACLEHUNTER.COM, HE HAS CODIFIED EVERY KNOWN APPARITION OF MARY BACK TO A.D. 40.

Luke, is the lyrical Magnificat, uttered in early pregnancy: "My soul magnifies the Lord, and my spirit rejoices in God my Savior, for he has looked with favor on the lowliness of his servant. Surely, from now on all generations will call me blessed."

Indeed they have.

Yet clues about her life are elusive. Scholars of Mary must take what they can from Hebrew Scriptures, first-century Mediterranean texts, the New Testament, and archaeological digs.

The Bible says she lived in Nazareth when Romans had control over the Jewish territory. After Mary became pregnant, her betrothed, Joseph, a carpenter, considered quietly leaving her until an angel came to him in a dream and told him not to. The birth of Jesus is mentioned in just two Gospels, Luke and Matthew. Mark and John refer to Jesus' mother several times.

The Evangelists were writing 40 to 65 years after Christ's death and were not biographers, says Father Bertrand Buby, the author of a three-volume study, *Mary of Galilee,* and a distinguished member of the faculty in the International Marian Research Institute at the University of Dayton, in Ohio. "So don't expect them to have all the elements about Mary. Her life is picked up from hearsay."

Some of the latest Mary scholarship focuses on her as a Jewish mother. María Enriqueta García, in her sacred theology dissertation at the Marian Institute, explains that Mary brings us to Jesus, who is the light of the world, just as Jewish mothers light the Shabbat candles. "We see the relationship of Mary with us isn't just any relationship—it's sacred."

During the first millennium, as Christianity became the official religion of the Roman Empire and began spreading into Europe, Mary typically was portrayed as an imperial figure, the equal of emperors, dressed in royal purple and gold. In the second millennium, beginning in the 12th century, says medieval historian Miri Rubin of Queen Mary University of London, "she underwent a dramatic shift," evolving into a more accessible, kinder, gentler maternal figure. She served as a substitute mother in monasteries and convents, which novices often entered at a tender age. "A mother's love," Rubin says, "came to express the core of the religious story."

Because so little is known of Mary from Scripture, "you can project on her whatever cultural values you have," says Amy-Jill Levine, a professor of New Testament and Jewish studies at Vanderbilt University. "A cultural confection," according to Rubin. Levine adds, "She can be the grieving mother, the young virgin, the goddess figure. Just as Jesus is the ideal man, Mary is the ideal woman."

During the Reformation (1517-1648), the idea of Mary as intercessor fell out of favor with Protestants, who advocated going straight to God in prayer. But Mary gained millions of new Catholic followers with the Spanish conquest in the New World in the early 1500s—and, more recently, in Africa as Christianity has spread there.

KIBEHO, A SMALL TOWN in southern Rwanda, is remembered as the place where the Virgin Mary appeared to three young girls and foretold of the blood and horror of the genocide that would traumatize the country in 1994, when the majority Hutu attacked the minority Tutsi and in three months more than 800,000 people were slaughtered.

In March 1982 the local bishop asked Venant Ntabomvura, a doctor, to go to a girls boarding school on a hillside in Kibeho. He was to investigate three students who had reported visions and conversations with the Virgin Mary. Ntabomvura, a kindly ear, nose, and throat specialist who, at 89, is still practicing, says Alphonsine Mumureke had first told of visits by apparitions the previous November. When they occurred, he says, "she was talking to someone exactly as if she were talking on the phone."

Mary appeared first to Alphonsine, then to Anathalie Mukamazimpaka, followed by Marie Claire Mukangango. The girls said they spent countless hours in conversations with the Virgin, who called herself Nyina wa Jambo, Mother of the Word. Mary spoke to the girls so often that they called her Mama.

I found Anathalie at *(Continued on page 44)*

Mary is a magnet for young and old. On August 12, during a Mass celebrating her assumption into heaven, Roman Catholic youths guard a life-size figure in Kalwaria Pacławska, Poland. The Feast of the Assumption is a weeklong festival here.

Seeing Mary

Starting in the 16th century, the Roman Catholic Church instituted a strict vetting process for miracles like the 2,000 sightings of the Virgin Mary claimed since A.D. 40. To be worthy of belief and church support, apparitions must be deemed miraculous with a high degree of certainty and in line with church doctrine, and found to have had a positive impact.

SUPERNATURAL

The local bishop or the Vatican finds evidence of the supernatural (the occurrence of a miracle).

- Recognized by the Vatican after approval by local bishop
- Approved by local bishop
- Virgin Mary's appearance to future saint

EXPRESSION OF FAITH

- Visions are approved as worthy of faith expression but are not established as supernatural.

LOCAL TRADITION

- Visions are part of local traditions and saint biographies but are not formally investigated.
- Virgin Mary's appearance to future saint

UNCONFIRMED

- Apparitions are not supernatural, have not yet been investigated, or are under investigation.

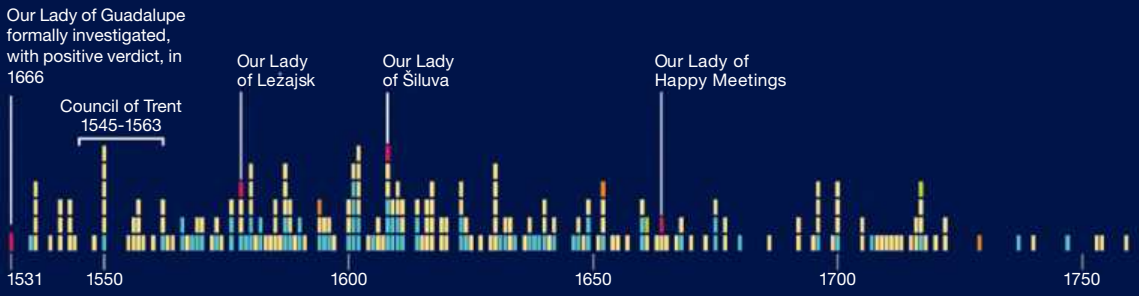
Centuries of Miracles

COUNCIL OF TRENT

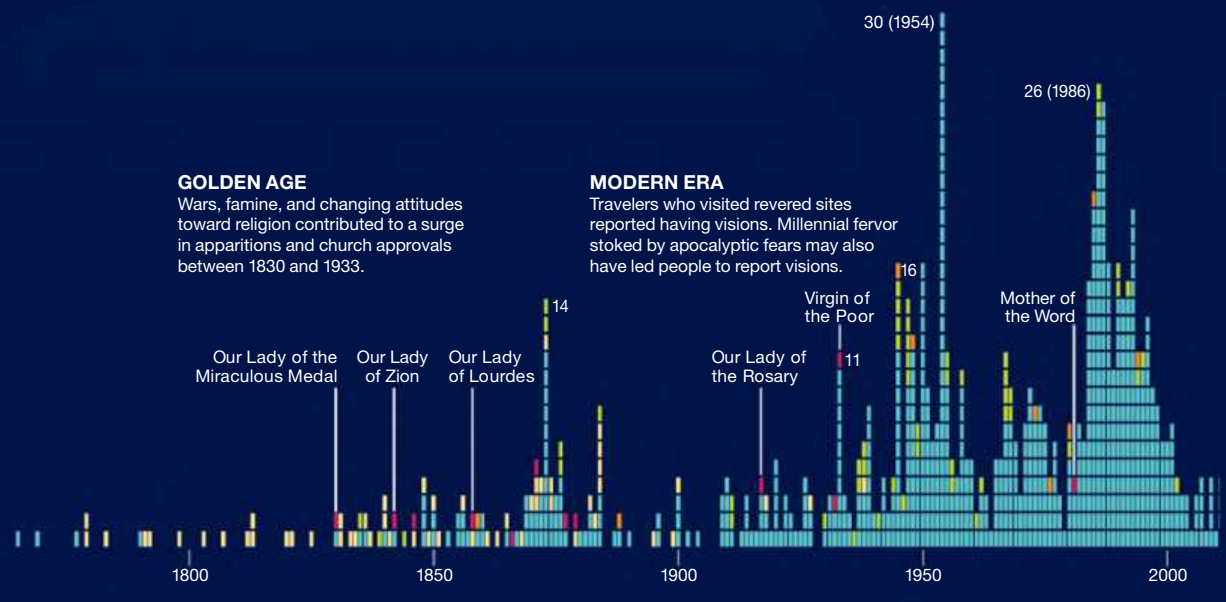
One of the most important ecumenical councils in Roman Catholic Church history, it defined doctrine and an approval process for visions.

Each vertical segment represents the date of an apparition's first sighting.

- Recognized by the Vatican after approval by local bishop
- Approved by local bishop
- Expression of faith
- Local tradition
- Unconfirmed



VIRGINIA W. MASON, NGM STAFF; VICTORIA SGARRO
SOURCE: MICHAEL O'NEILL, MIRACLE HUNTER



GOLDEN AGE
Wars, famine, and changing attitudes toward religion contributed to a surge in apparitions and church approvals between 1830 and 1933.

MODERN ERA
Travelers who visited revered sites reported having visions. Millennial fervor stoked by apocalyptic fears may also have led people to report visions.

SOME VISIONS MAY BE MISSING BECAUSE THE DETAILS OF TIME, LOCATION, AND WITNESSES HAVE BEEN LOST TO HISTORY.

For centuries Mary—Our Lady of Guadalupe—has been Mexico's patron saint, feted on December 12. Each year thousands of image-laden pilgrims like Felipe Méndez (at left), 24, and Esther Silva, 16, trek to her shrine in Mexico City. After days or weeks of walking, they offer thanks or pray for her help or blessing.

(Continued from page 37) dusk one evening in her modest home near her old school, surrounded by rosaries and statues of the Virgin.

"The first time she appeared," Anathalie said, "I was reciting the rosary, and she called me by my name. I heard her say, 'Nathalie, my child.' She looked very beautiful indeed, between 20 and 30 years old. She spoke in Kinyarwanda in a very calm and soft voice. She was in a blue veil and white dress. She never told me why she chose me. She said she appears to anyone she wants, anytime she wants, anywhere she wants." She never mentioned any particular religion, Anathalie said. "She only asks us to love her as much as she loves us."

Mary's dire prophecy came on a day in 1982 everyone expected to be especially happy: August 15, the Feast of Mary's Assumption into heaven. Ntabomvura was there, and Gaspard Garuka, who lived nearby. The girls were crying because, they reported, the Virgin was in tears too, Garuka says. He remembers that Alphonsine "fell down many times, because what she watched was very terrible. One time she even asked, 'Please, hide this from my eyes.'"

Anathalie said that what Mary predicted "is exactly what I saw" during the genocide 12 years later. "People killing others using spears, burning fire, people's skulls and heads cut off. I saw mass graves surrounded by so much darkness,

In the city of Puebla pilgrims carry paintings and bouquets to the Feast of Our Lady of Guadalupe. The roses point to Mary's first appearance in Mexico. According to tradition, she revealed herself to an Indian man, Juan Diego, in 1531. Speaking in Nahuatl, she produced roses in winter and imprinted her image on his cloak, miracles that led many indigenous Mexicans to convert to Catholicism.

blood running all over like rivers. All of this had been predicted." Anathalie was able to flee Rwanda to the Democratic Republic of the Congo and then Kenya. Alphonsine became a monastic sister in Italy. Marie Claire was killed in the genocide. On June 29, 2001, nearly 20 years after Alphonsine had first reported her apparition, Rwanda's Bishop Augustin Misago and the Vatican declared that, yes, the Virgin Mary had appeared at Kibeho.

MICHAEL O'NEILL, 39, a Stanford University graduate in mechanical engineering and product design, is the Virgin Mary's big data numbers cruncher. On his website, *MiracleHunter.com,* he has codified every known apparition of Mary back to A.D. 40. Systematic investigation and documentation of supernatural occurrences began with the Council of Trent, the Catholic Church's ecumenical reaction to the Reformation, more than 450 years ago. Of the 2,000 apparitions reported since then, Miracle Hunter cites a mere 28 as approved by local bishops, who are the first to decide whether "seers" seem plausible. Sixteen of those have been recognized by the Vatican.

O'Neill, in his newly published book, *Exploring the Miraculous,* details the Vatican's painstaking process when deciding whether to endorse an apparition as miraculous—"truly extraordinary." The "authenticity" and mental stability of the seer are prime, and anyone suspected of trying to gain fame or riches from contact with the Virgin Mary is ignored or condemned.

Medjugorje is one of some two dozen sites in wait-and-see mode for Vatican approval. The local bishops with authority over Medjugorje have never given credence to the apparitions and have been at odds with the Franciscan priests who run the parish and are staunch believers. To resolve the impasse, a Vatican commission was appointed. It concluded its work in 2014.

The Vatican would never approve an alleged apparition whose message contradicted church teachings, and the faithful aren't required to believe in apparitions. Many, including priests, do not. "What is from Mary versus what is

Mary has many faces. In Haiti she's Ezili Dantò—the Black Madonna. A fierce mother figure as well as a goddess, Ezili has been a revered Vodou spirit since the Haitian Revolution. Here dancers prepare for a midnight ceremony in her honor.

captured and interpreted by the seer is hard to distinguish," says Father Johann Roten, director of research and special projects at the University of Dayton's Marian Library, with more than a hundred thousand volumes on Mary. Ultimately the decision is based on faith.

"Miracles transcend physical nature and physical laws," says Robert Spitzer, a Jesuit priest who heads the Magis Center in California, which according to its website is dedicated to explaining faith, physics, and philosophy. As Spitzer says, "Science looks for physical laws in nature, so you're up against a paradox. Can you get a scientific test for miracles? No. Science will only test for physical laws or physical results."

Nonetheless, over the years, as part of the church's investigative process, seers have been subjected to batteries of tests. There have been attempts to get the visionaries in Medjugorje to blink or react to loud noises while they experience apparitions. In 2001 the peer-reviewed *Journal of Scientific Exploration* reported on the visionaries' "partial and variable disconnection from the outside world at the time of the apparitional experience." The extreme sound and light sensations traveled normally to their brains, but "the cerebral cortex does not perceive the transmission of the auditory and visual neuronal stimuli." So far, science has no explanation.

In the medical profession what you and

A mother and daughter in Ville Bonheur, Haiti, bathe in the sacred Saut d'Eau falls. Ezili Dantò is said to have appeared on a palm tree here in 1849. Father Johann Roten, a Marian scholar, says Mary's presence in the Caribbean can be traced to the merging of two cultures—Spanish Catholics and pre-Christian Africans—that began in the early 1500s.

I might call a miracle is often referred to as "spontaneous remission" or "regression to mean." Frank McGovern, the Boston urologic surgeon who had done all he could for Arthur Boyle, told me that the cancer's virtual disappearance was a "rare" but statistically possible happening. But, he added, "I also believe there are times in human life when we are way beyond what we ever expect."

Did the intense heat Boyle experienced when Vicka Ivankovic-Mijatovic held his head in her hand play a part in his healing? According to the 2006 book *Hyperthermia in Cancer Treatment: A Primer,* "Spontaneous regression of some cancers has been demonstrated to be associated [with] the induction of fever and activation of immunity."

Boyle said that although he continued his tests after his return from Medjugorje, "it was faith that enabled me to get into a state of peace where my immune system rebooted itself and killed the cancer—that was all done through God."

CERTAIN IMAGES and stories of the Virgin Mary are so powerful they help define a country. That's the case with Our Lady of Guadalupe, whose image on the tilma, or cloak, of a poor Indian man gave rise, in 1531, to Mexican identity. Anyone witnessing the outpouring of love and devotion that pilgrims demonstrate for their beloved Madre on the days leading up to the Feast of Our Lady of Guadalupe—broadcast live throughout the country on December 12—can see that the Virgin Mary is deeply embedded in Mexican hearts and souls.

Her image was what Mexicans carried into their war against Spain for independence in 1810 and their internal revolution in 1910. César Chávez marched with her banner in his fight to unionize farmworkers in California in the 1960s. Our Lady of Guadalupe conferred instant benediction on the once despised mestizo children of Spaniards and Indians. She is the symbol of *la raza,* the definition of what it means to be Mexican, and because of Our Lady of Guadalupe, Mexicans have always believed they're special.

At dawn on December 11, the day before the

In Lourdes, a small town in France with an outsize reputation for miracles and Marian signs, volunteers push the wheelchairs of terminally or chronically ill pilgrims. Some 80,000 sick or disabled devotees a year seek a cure at the shrine of Mary.

Feast of Our Lady of Guadalupe, I drove southeast from Mexico City toward Puebla. Pilgrims were thronging in the opposite direction, toward the Basilica of Our Lady of Guadalupe, the great shrine in the heart of the capital. Along the busy highway I saw people walking alone or in groups, packs of cyclists dressed alike, and numerous pickups flying by with flashing colored lights, artificial flowers, and statues of the Virgin wobbling in the back.

I pulled off the highway at a camp in the woods where pilgrims sleep at night on the cold ground. Mariachi music blared from portable speakers near a small fire. A breakfast stand had been set up, with free coffee, tea, and pastries. A volunteer told me that leading up to the Feast of Guadalupe, they feed 5,000 pilgrims a day here.

"Mexico belongs to the Virgin, and the Virgin belongs to Mexico," said volunteer Treno Garay as he ladled out coffee. Four generations of women from one family said they walk ten hours a day from the town of Papalotla, in the state of Tlaxcala, but spend nights in the family truck, driven by a male relative. A 77-year-old woman was making the trek from Santa María, in the state of Puebla, with her 19-year-old grandson. A truck driver who comes from California each year put it this way: "Everyone has to visit their mother."

The next morning when I arrived at the plaza

Volunteers help a man bathe in the ice-cold, spring-fed waters of Lourdes. The Massabielle Grotto has been the font of Lourdes's fame since 1858, when Mary is said to have appeared before a teenage girl and asked her to dig a spring in the hard earth. A small puddle soon grew into a pool; eventually it became this sacred water source, visited by some six million pilgrims every year.

in front of the basilica, a steady stream of people of all ages—including Alejandra Anai Hernán de Romero, an 18-year-old mother clutching her sick seven-week-old baby, Dieguito, born with a kidney malfunction—were shuffling on their knees across the square, standing only when they entered the basilica. Many had tears streaming down their cheeks. Most I talked to said they were coming to give thanks: They had made a promise to the Virgin, and she had answered their prayer.

In the basilica, behind the main altar, protected by glass, hung the original cloth image of Our Lady of Guadalupe, focusing the rapt attention of the faithful passing by on a moving walkway. According to legend, accepted by the church, it was in 1531 that the Virgin of Guadalupe spoke, in Nahuatl (the Aztec language), to Juan Diego, a baptized Indian canonized in 2002. She urged him to tell the bishop that she wanted a church built on the site, Tepeyac Hill, which had been a place for worshipping Aztec earth goddesses.

Juan Diego didn't have much luck with the bishop, who wanted a sign of some sort. Mary instructed him to climb the hill, cut some flowers, and present them to the bishop. Flowers don't bloom there in December, but Juan Diego gathered a bouquet of beautiful roses, which he folded into his tilma, believed to be woven from agave fibers. When he finally got to see the bishop and opened his cloak, the roses spilled out, revealing the image of Our Lady of Guadalupe. This is the only time Mary is said to have left a painted portrait of herself.

Many art historians see this as a standard European depiction of Mary, typical of the 16th century. But within the past several decades some church scholars have begun to interpret the visual imagery to be a combination of Catholic and what they consider to be Aztec iconography. According to such recent interpretations, an illiterate Indian would instantly be able to read the symbols as a nonverbal catechism. The dusky woman's dark hair is parted in the middle, possibly symbolizing that she's a virgin, but she wears a black bow high around her waist, a

sign that she's pregnant. Around her neck is a brooch—not the green stone Aztec deities often displayed but a cross. Her downcast eyes show that she isn't a goddess. Similarly, her hands, clasped in prayer, also communicate that she isn't divine. One of her legs is bent, suggesting that she could be dancing in prayer. The turquoise of her cloak signifies divinity and sky to the Aztec. The glyph of a four-petaled flower in the center of her rose-colored tunic supposedly means that she is the god bearer.

Sometime between 1531 and 1570 the original image on Juan Diego's tilma was embellished. Gold stars were added to the Virgin's mantle, a vague mark like a water stain. In 1921 Luciano Pérez Carpio, who worked in an office of Mexico's president tasked with weakening the grip of religion, placed a bomb in a bouquet of flowers below the image. The blast destroyed the altar and bent its bronze crucifix and the candelabra nearby. The image of the Virgin was untouched.

"When the devotion to the Virgin of Guadalupe disappears," Rodríguez Alatorre says, "the identity of Mexico will disappear."

LOURDES IS THE VIRGIN'S MIRACLE FACTORY, WITH MORE THAN 7,000 MIRACULOUS CURES CLAIMED SINCE THE MID-1800S. ONLY 69 HAVE BEEN RECOGNIZED BY CHURCH AUTHORITIES.

aligned, according to a Mexican study published in 1983, in their configuration at dawn on December 12, 1531, the day the image allegedly appeared on the tilma. The Aztec greatly revered the sun god, and glowing rays added behind Mary signify that she comes from heaven and that her god has divine power. One theory holds that in Nahuatl, the word "Mexico" comes from three words that mean "in the center of the moon"—and Mary is standing in the center of a black crescent moon. Borne on the shoulders of an angel who, some say, has native features, she dominates both light and darkness.

Remarkably, the image hasn't deteriorated, according to the church, even though the cloth hung in the basilica for more than a century without protection, vulnerable to dirt and smoke. "She's imprinted like a photo," says Nydia Mirna Rodríguez Alatorre, director of the basilica museum, who explains that in 1785 a worker cleaning the silver frame accidentally spilled nitric acid on the image. It remained intact. An affidavit from several decades later says that the spill left only

AS THE ONLY WOMAN to have her own sura, or chapter, in the Koran, Mary was chosen by God "above all other women of the world," for her chastity and obedience. As in the Bible, an angel announces her pregnancy to her in the Muslim holy book. But unlike in the Bible, Mary—Maryam—gives birth alone. There's no Joseph.

"Mary is the purest and most virtuous of all women in the universe," says Bakr Zaki Awad, dean of the theology faculty at Al Azhar University, Cairo's leading theological university.

In Egypt I talked with devout Muslims who, because of their reverence for the Virgin Mary, had no qualms about visiting Christian churches and praying to her in church as well as mosque. One day in Cairo I encountered two young Muslim women in head scarves standing in front of the old Coptic Abu Serga church, built over a cave that is said to have been used by the Holy Family. It was the eve of Coptic Easter, and inside, the congregants chanted and prayed for hours. Outside, the women said they loved Mary from studying her in the Koran.

"Her story tells us a lot of things," Youra, 21, said. "She is able to face lots of hardships in her life because of her faith, her belief in God."

Youra's friend, Aya, added, "There's a sura in her name in the Koran, so we were curious what was going on inside the church."

I met Nabila Badr, 53, at a Coptic church along the Nile in a part of Cairo called Al Adaweya—one of the many places in Egypt where the Holy Family is said to have stopped. Badr is a married mother of three and an events organizer for the governor of a state near Cairo. Along with her Koran, she carries Christian medals of the Virgin Mary in her purse. In a small room in the back of the church Badr mingled with Coptic Christians praying there, lit candle after candle, bowed, and prayed to an icon of Mary on the wall that was claimed to have once wept tears of oil. Badr said she talks to Mary about her life and that Mary has answered her several times by showing her visions in dreams that later came true.

Like many Egyptians, Badr also believes in jinn, or spirits, who influence life for good or bad, although she claims only to have her own angel. "He too believes in the Virgin Mary," she said. Badr often asks Mary to intercede for her, and she composed a poem to Mary. "When I feel down," Badr said, "I pray to God very much, but I also consult Mary, and after a while things calm down."

At St. Mary's church in Zaytun, a neighborhood in Old Cairo, apparitions of a silent Madonna bathed in white light are said to have appeared at night above the domes of the church for three years, from 1968 to 1971. Glowing white doves sometimes accompanied the apparitions. Yohanna Yassa, a Coptic priest who has ministered at St. Mary's since 1964, told me that often Muslim women who want to get pregnant come to his church to pray. "Today we had a lady who came for a blessing," he said. "Mary is calling us spiritually, and because of that, both Muslims and Christians love her and respect her."

FOLLOWING THE MANY paths of Mary, I learned that she has often appeared to people in crisis zones, such as Kibeho and Bosnia and Herzegovina, seeking to warn of danger or to serve as a symbol of healing. In her aftermath come physical cures said to be miraculous, as at Medjugorje, and spiritual healings too numerous to count. Lourdes, the Virgin's most famous pilgrimage site, at the foot of the Pyrenees in southwestern France, is her miracle factory, with more than 7,000 miraculous cures claimed since the mid-1800s. Only 69 have been officially recognized by church authorities.

Everything at Lourdes is about scale: more than a hundred acres, six million visitors a year, space for 25,000 worshippers in the giant underground basilica. It was built in 1958 to commemorate the centennial of the Virgin Mary's first appearance, in 1858, to Bernadette, an illiterate 14-year-old peasant girl. (St. Bernadette was canonized on December 8, 1933.) The nearby Grotto of Our Lady of Lourdes, its stones worn by millions of feet, is where the Virgin is said to have commanded Bernadette to scoop up the mud with her hands to make a spring gurgle from the damp soil. That miraculous water is the source for baths that attract thousands daily in wheelchairs, and thousands more on foot, to pray for cures. Volunteers push *les malades,* the sick, in blue buggies in endless, snaking lines along Lourdes's narrow streets, flanked by dozens of religious curio shops.

The day I visited the baths, it was pouring rain, and cold. There's a strict protocol for how you disrobe and then tie a light linen cloth around your body for a quick, private dip, supported under each arm by a volunteer. "Say your intention, make the sign of the cross, and we'll escort you down," a kindly Irish woman told me. Then came the freezing immersion—a bracing moment of deep peace.

Shortly after World War II, members of the French and German militaries met at Lourdes to reconcile and heal the wounds of war; now every spring veterans groups are among the hordes of pilgrims. On May 14, 2015, I joined 184 wounded warriors—U.S. combat veterans who had served in Iraq and Afghanistan—and their families, sponsored by the Archdiocese for the Military Services and the Knights of Columbus. They had come for the annual pilgrimage of militaries (from 35 nations this year) to celebrate peace. For the rest of their lives, all these quietly brave

In the Deir al Adra monastery, in Minya, Egypt, Muslims and Christians alike light candles to commemorate the Holy Family's stay during their biblical flight into Egypt. A Marian festival here draws two million of the faithful each year.

men and women and those who support them must contend with debilitating injuries suffered sometimes during multiple deployments.

Bustling among us was one of the most remarkable women I've ever come across: Army Col. (Ret.) Dorothy A. Perkins, 60, an affable triathlete and mother of two who was commanding a battalion of 480 soldiers at Fort Hood, Texas, when the United States was attacked on September 11, 2001. Because hers was the only battalion whose soldiers had crucial counterintelligence and interrogation expertise, she oversaw the soldiers' deployment to five countries, and she sent a group to Guantánamo Bay to set up facilities for POWs. By 9/11 Perkins had already been to Iraq twice with the United Nations Special Commission as a team leader for weapons inspectors, and spent more than a decade in the Army in special ops. In 2006-07 she served as the principal adviser to the U.S. ambassador for hostage affairs in Iraq.

Perkins grew up a poor white girl in a mostly black, inner-city neighborhood in Tacoma, Washington, with nominal support from her mother and alcoholic stepfather. At age ten, she was sent to pick berries in the fields. She learned German during a gap year between high school and college when she lived as an "indentured servant," cleaning rooms in a family-owned hotel in the Bavarian Alps. Her only recreation

A young boy in the Deir al Adra monastery reaches up to touch a painted image of Mary. In the Koran, Maryam (Mary) is the holiest woman mentioned. "So the Virgin Mary is not at all strange to Muslims," says Roten. "In fact, wherever there is a connection between Christians and Muslims—or any two groups that know and love her—there is a common value in the covenant mother."

was to hike the mountain trails, where she encountered little shrines to Mary.

"My faith has always been at the core of who I am," Perkins said. "It's a choice I made early on." Without family to rely on, Perkins said, the Virgin Mary became her anchor. "She loves you as much as you want. Through her to him, she focused me on making closer relations with Jesus."

Perkins attended the University of San Francisco, a Jesuit school, for 12 years but left a few credits short and graduated from SUNY, Albany. While in San Francisco, she took a job at Macy's, working her way up the corporate ladder to become a senior executive. In college she also joined the Army Reserve. After marrying a Green Beret, she signed up with the Army full-time and worked in counterintelligence.

For Perkins, "Lourdes really forces each person to look at herself spiritually. Everything is always rushing by so fast. We're overwhelmed by media and caught up in the day-to-day. People don't force themselves to look at what's most important—the integrity of the soul."

During the closing ceremonies at a giant Mass in the basilica, one of the European bishops, preaching in French, said, "World War III is already under way in the Middle East and Africa." He praised the military there for focusing "on peace, justice, and human rights. May this experience make you witnesses for hope."

I thought of the indelible scene of the candlelight procession the night before—thousands of pilgrims, from places ranging from Argentina to Zaire, silently lifting their candles in prayer. It had ended with dozens of veterans in wheelchairs lining up in front, next to the Grotto of Our Lady of Lourdes, for songs and prayers. So many souls yearning to be witnesses for hope, so many souls imbued with the belief that the Virgin Mary was lighting their way. □

REBECCA HALE, NGM STAFF

Award-winning journalist **Maureen Orth,** also a special correspondent for *Vanity Fair,* has been wandering the world and telling unexpected stories since her time as a Peace Corps volunteer in the 1960s.

TASTE IS CHEMISTRY

It begins when a food molecule touches a microscopic taste bud on the tongue. The buds hide inside papillae, the pale dots made visible here by blue food coloring. In the brain, where taste merges with other senses, it becomes the rich, personal, joyful experience that makes us long to eat.

THE SCIENCE OF DELICIOUS

BY DAVID OWEN

PHOTOGRAPHS BY

BRIAN FINKE

FEASTING THE EYES, EARS, AND NOSE

Inspired by research showing that flavor comes from more than our taste buds, Heston Blumenthal, owner of the Fat Duck restaurant in Bray, England, practices "multisensory cooking." These diners are enjoying a dish of razor clams, cockles, salty foam, and "edible sand," made from tapioca starch, panko, and baby eels. They're listening to crashing waves and crying seagulls on iPod Nanos concealed inside shells. On the menu it's called "Sound of the Sea."

'SO MUCH OF WHAT WE THINK OF AS TASTE IS ACTUALLY FLAVOR—AND SPECIFICALLY, THE OLFACTORY COMPONENT OF FLAVOR. VISION, BY COMPARISON, IS SIMPLE.'

Robert Margolskee

IT'S BROCCOLI, DEAR

A child's palate isn't a blank slate at birth. It has been stamped by evolution with inborn preferences and aversions and influenced by the mother's diet during pregnancy. This ten-month-old boy has been subjected to a first encounter with broccoli at the Monell Chemical Senses Center in Philadelphia. His natural resistance can be overcome, however. "After eight to ten days of exposure, the baby is more accepting," says Monell biologist Julie Mennella. "Changing the face takes longer."

'CHILDREN REALLY LIVE IN A DIFFERENT SENSORY WORLD. THEY PREFER MUCH HIGHER LEVELS OF SWEET AND SALT, AND THEY ARE MORE SENSITIVE TO SOME BITTERS.'

Julie Mennella

This story is part of National Geographic's Future of Food initiative, a special five-year project that seeks to show how what we eat makes us who we are.

Julie Mennella, a biologist who studies the sense of taste in babies and toddlers, often records her experiments on video. When I visited her recently at the Monell Chemical Senses Center in Philadelphia, she showed me a video of a baby in a high chair being fed something sweet by her mother. Almost as soon as the spoon is in the baby's mouth, her face lights up ecstatically, and her lips pucker as if to suck. Then Mennella showed me another video, of a different baby being given his first taste of broccoli, which, like many green vegetables, has a mildly bitter taste. The baby grimaces, gags, and shudders. He pounds the tray of his high chair. He makes the sign language gesture for "stop."

Human breast milk contains lactose, a sugar. "What we know about babies is that they're born preferring sweet," Mennella said. "It's only been a couple of centuries since the time when, if you didn't breast-feed from your mother or a wet nurse, your chance of survival was close to zero." The aversion to bitter foods is inborn too, she said, and it also has survival value: It helps us avoid ingesting toxins that plants evolved to keep from being eaten—including by us.

Food or poison? Vertebrates arose more than 500 million years ago in the ocean, and taste evolved mainly as a way of settling that issue. All vertebrates have taste receptors similar to ours, though not necessarily in the same places. "There are more taste receptors on the whiskers of a large catfish than there are on the tongues of everybody in this whole building," Gary Beauchamp, another Monell scientist, told me, indulging in a little hyperbole. Anencephalic infants, who are born with virtually no brain beyond the brain stem—the most primitive, ancient part—react to sweetness with the same joyful-seeming facial expressions I saw in Mennella's video. The broccoli grimace is also primitive. In fact, although our tongues have just one or two types of receptor for sweet, they have at least two dozen different ones for bitter—a sign of how important avoiding poison was to our ancestors.

The challenge many of us face these days is different: It's the pleasure we get from food that gets us into trouble. The modern food environment is a tremendous source of pleasure, far richer than the one our ancestors evolved in, and the preferences we inherited from them—along with a food industry that's increasingly adept at selling us what we like—often lead us to adopt unhealthy habits. Yanina Pepino, a nutritional scientist at Washington University School of Medicine in St. Louis, told me that she once watched a child on an airplane add sugar to Coca-Cola—an option that wasn't available to australopithecines.

Our preoccupation with food has led to a boom in research on taste. It has turned out to be a very complicated sense—more complicated than vision, said Robert Margolskee, director of

Can science create commercial tomatoes that taste the way tomatoes used to? At the University of Florida blind taste tests help researchers identify the flavors people like—and the volatile chemicals responsible. The next step: breeding tomatoes so that they produce those chemicals.

the Monell Center. Scientists have made great progress in recent years in identifying taste receptors and the genes that code for them, but they are far from fully understanding the sensory machinery that produces our experience of food. Margolskee described it to me as "one of these Rube Goldberg devices in which the little ball rolls down and activates this thing, which activates that thing, and there are about six different steps, and then a signal travels to your brain, and you either swallow what you've got in your mouth or spit it out."

ALMOST 25 YEARS AGO my wife introduced our daughter's Brownie troop to the "tongue map," which she'd learned about in a cookbook when she herself was a girl. Each of the basic tastes, she explained, is perceived by taste buds in a unique region on the tongue: sweet at the tip, salty and sour at the sides, bitter at the back. She gave the girls Q-tips and bowls of salt water, sugar water, and other liquids, and invited them to prove it to themselves.

"I can taste everything everywhere," one of the girls said.

"No, you can't," my wife said. "Try again, and really pay attention."

"I can taste everything everywhere too," said another girl.

As it happens, the Brownies were right, and their leader was wrong. It's true that in some people the receptors for particular tastes may be more concentrated in certain areas on the tongue, but all of them are found all over, and a Q-tip dipped in lemon juice will seem sour no matter where you dab it. (The receptors sit on the surface of taste cells, which are bundled together in taste buds.) The notion that each taste has its own tightly circumscribed detection zone can be traced, according to Linda Bartoshuk of the

University of Florida, to a 1942 misunderstanding by a Harvard professor of a paper published in Germany in 1901. The tongue map wasn't definitively debunked until the 1970s, and many people still believe in it, even though it takes only seconds for seven-year-olds to disprove it.

Aristotle counted seven basic tastes: the four known to my daughter's Brownie troop, along with astringent, pungent, and harsh. Nowadays most authorities agree on five: the Brownie four and umami, which was first described by a Japanese scientist a little over a century ago. It's the mouth-filling savory taste created or enhanced by things like soy sauce, aged beef, ripe or cooked tomatoes, and monosodium glutamate. More recently researchers have proposed at least half a dozen additional basic tastes. Fat and calcium are among the leading candidates—both are believed to be detected by receptors on the tongue—but there's no consensus yet.

Taste receptors alone don't produce tastes; they have to be connected to taste centers in the brain. In recent decades scientists have discovered receptors identical to some of those on the tongue in other parts of the body, including the pancreas, intestines, lungs, and testes. We don't "taste" anything with them, but if, for example, we inhale certain undesirable substances, the bitter receptors in our lungs send a signal to our brains, and we cough.

As animal species have evolved, they've sometimes lost tastes that their ancestors possessed. Cats and many other obligate carnivores, which eat only meat, can no longer detect sugars. (When cats lap milk, they're responding to something else—probably fat.) Most whales and dolphins, which swallow prey whole, have lost almost all taste receptors.

Something similar may have happened in humans. At Monell a scientist named Michael Tordoff handed me a plastic medicine cup containing a clear liquid and asked me to drink it. It tasted like water. He said, "You didn't taste much of anything, but this is something that rats and mice prefer to almost everything else we have ever, ever tested. If you give a rat a bottle of this and a bottle of sugar, it will drink more of this."

The liquid contained maltodextrin, a kind of starch that's a common ingredient in sports drinks. If a human athlete takes a mouthful of maltodextrin solution and immediately spits it out, Tordoff said, the athlete will perform better, despite having tasted and ingested nothing or next to nothing. "I don't have a good explanation," he continued. "There's something very special about starch that we don't understand. It may be there's a separate receptor for it or one specifically for maltodextrin. But the receptor is no longer plumbed into the conscious parts of the brain."

ALTHOUGH THE TONGUE MAP doesn't exist, there may be a taste map in the brain. A region called the gustatory cortex has been reported to contain clusters of neurons that are specialized to respond to individual basic tastes. Signals from the tongue reach them after passing through the brain stem, and in the gustatory cortex, or maybe along the way, they become part of a complex and only partially understood experience that we commonly call taste but should really call flavor. Linda Bartoshuk told me that only a small part of our experience of food comes from our taste buds. The rest is really the result of a kind of backward smelling.

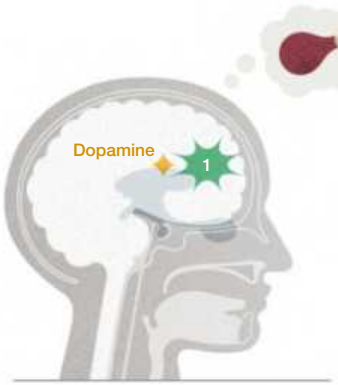
You can demonstrate this to yourself with candy. If you pinch your nose shut and chew, say, an anonymous-looking white jelly bean, your tongue will register immediately that it's sweet. That sweetness comes from sugar, and it's the jelly bean's primary taste. Let go of your nose, though, and you'll immediately perceive the flavor: Ah, vanilla. Conversely, if you pinch your nose shut and put a drop of vanilla on your tongue, you won't taste anything, because vanilla has no taste—only a flavor you can't detect with a pinched nose.

When we chew, swallow, and exhale, Bartoshuk explained, "volatile molecules from the food are forced up behind our palate and into our nasal cavity from the back," like smoke going up a chimney. In the nasal cavity they bind with odor receptors—and it's those receptors, of which humans have somewhere between 350 and 400

MORE THAN TASTE

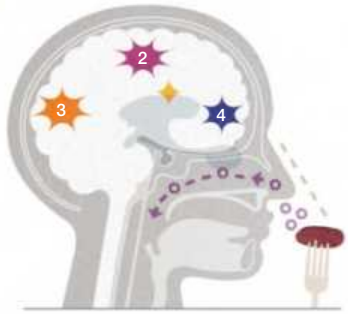
HOW THE BRAIN CONSTRUCTS FLAVOR

The tongue detects basic tastes, but the nose—with hundreds of receptors for chemicals that waft off food—contributes more to flavor. According to neurobiologist Gordon Shepherd, the brain draws on all the senses to assemble a complex "flavor image" that lingers in our memory.



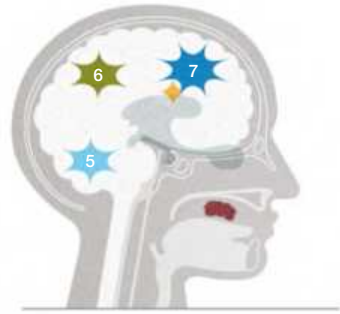
ANTICIPATION

A flavor experience may begin with a past meal: The memory 1 activates dopamine reward centers, leading us to crave the flavors to come. We salivate.



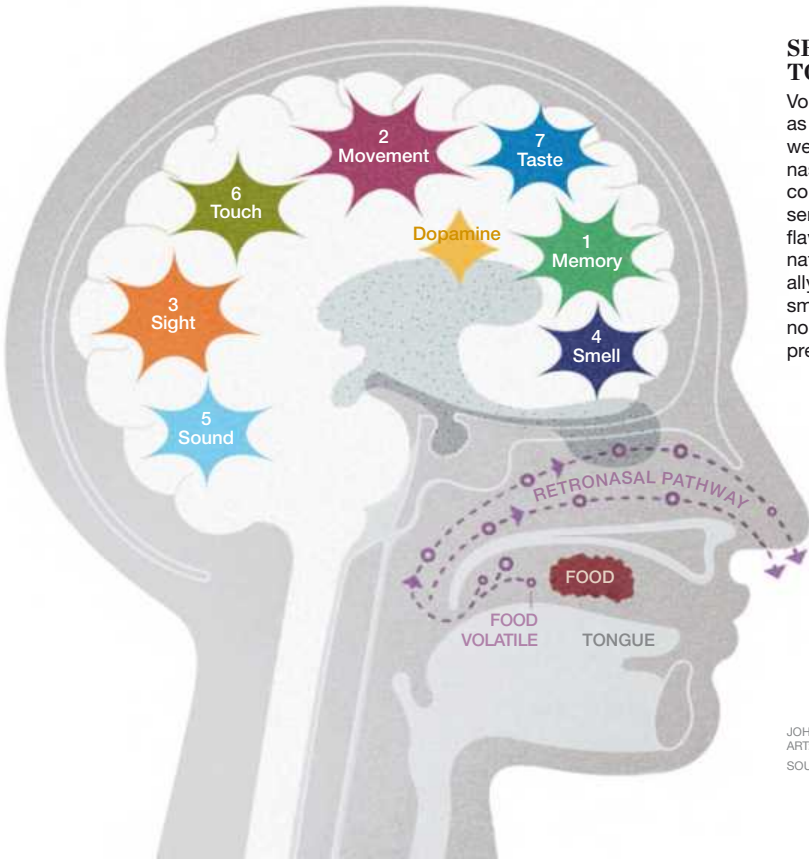
SENSORY OVERTURE

A brain primed for pleasure begins to receive sensory impulses from the food as we move it 2 to our mouth, see its colors and shapes, 3 and inhale its aromas 4.



SOUNDS DELICIOUS

We chew. Sound 5 and mouthfeel 6 add key information: Is the food gooey, crunchy, or crispy? Receptors in our taste buds register sweet, salty, sour, bitter, and umami 7.



SENSATIONS MERGE TO CREATE FLAVOR

Volatile chemicals waft off food as we chew and swallow it, and as we exhale, they're carried into the nasal cavity from behind. The brain combines information from all the senses to produce the experience of flavor. And though we think it originates in the mouth, most of it actually comes from these "retronasal" smells detected by receptors in the nose. They build the memory that prepares us for the next experience.

JOHN TOMANIO, NGM STAFF; SHELLEY SPERRY
ART: SCRIPT & SEAL

SOURCE: GORDON SHEPHERD, YALE UNIVERSITY

A RESTAURANT WITH A LAB

In the "science bunker" at Noma, a celebrated restaurant in Copenhagen, head of research and development Lars Williams and full-time food scientist Arielle Johnson adjust a rotary evaporator—a chemistry-lab machine they're using to extract a flavorful essence from rose petals. The experimentation continues in the restaurant's test kitchen. Among its recent creations: grilled wild duck served whole, with head and feathers, on a faux nest.

SWIMMING TONGUES

Catfish are the supertasters of the animal world: Their skin, gills, lips, and whisker-like barbels are covered with taste buds much like those on the human tongue. That great endowment helps the fish find food even in murky water—and it makes them excellent research subjects for neuroscientist John Caprio. At Louisiana State University, inside a Faraday cage that shuts out ambient voltages, he measures the nerve impulses coming from catfish taste buds. "Taste buds were first described in fish back in the 1820s—40 years before they were identified in mammals," Caprio says. "We're the product of what evolved in the water."

types, that are the main source of what we perceive as flavor. That's different from taste, which is the sensation derived from our taste buds, and it's also different from ordinary smelling, because the brain distinguishes between odors we sniff through our nostrils (orthonasal olfaction) and odors that reach our nasal cavity from behind as we eat (retronasal olfaction)—even though the same receptors detect both.

"The brain pays attention to whether you're sniffing or chewing and swallowing," Bartoshuk continued, "and it doesn't treat those signals the same. Odor information from retronasal olfaction goes to a different part of the brain—the one that also receives information from the tongue. The brain combines retronasal olfaction and taste, creating what we call flavor, although the rules of integration are not well-known."

Jelly beans can be props for another trick too, Bartoshuk said. Releasing your nostrils when you're chewing one doesn't just tell you what the flavor is; it also makes the jelly bean taste sweeter—an effect that's not caused by sugar, which contains no volatiles and therefore has no effect on smell receptors. The explanation, she said, is that other ingredients of a jelly bean contain volatile molecules that somehow "enhance the sweet message," making the brain think the jelly bean contains more sugar than it does. Such sweetness enhancers are common in fruits, maybe because producing them costs less energy than producing sugar and yet they're just as effective at attracting insects and other pollinators and seed dispersers. "Strawberries have something like 30 volatiles that enhance sweet," Bartosuk said, "and when you put all the signals together, you realize that a substantial amount of the sweetness is coming from their interaction in the brain."

> **'YOU DON'T THINK OF BARBECUE SAUCE AS BITTER, BUT IF YOU ADD A BITTER INGREDIENT, YOU REALIZE THAT BITTER CHANGES THE WHOLE GESTALT.'**
>
> *Barb Stuckey*

That effect occurs even though the enhancers themselves aren't sweet. Bartoshuk and her colleagues have isolated one from tomatoes that "has the smell of dirty socks."

LIFE WITHOUT RETRONASAL OLFACTION can be unpleasant. Barb Stuckey, the chief innovation officer of Mattson, a food-and-beverage development firm in California, was once approached by a woman who'd lost her sense of smell in a car accident. Her sense of taste—the taste buds on her tongue and their connections to the brain—seemed to be intact, but nothing tasted good anymore, because the connection between the odor receptors in her nose and her brain had been severed. She was missing most of the flavor of everything she ate. "She was in arbitration with the person who'd hit her," Stuckey told me, "and she needed to prove that she was disabled. That was a challenge, because she looked fine."

To help the woman demonstrate her impairment, Stuckey cut up a plain rice cake—one of those Styrofoam-like disks of puffed white rice that are as close to tasteless and flavorless as food gets—and seasoned the pieces with a mixture of standard reference compounds for all five basic tastes: sugar (sweet), table salt (salty), citric acid (sour), pure caffeine (bitter), and monosodium glutamate (umami). All those compounds are essentially volatile free and therefore have no effect on odor receptors. "I sent the rice-cake pieces to the woman and told her to give them to the arbitrators and explain that this is what everything tastes like to a person who has no sense of smell," Stuckey said.

She offered me the same experience, and I put a piece of rice cake in my mouth and chewed. The seasoning created a mildly complicated and slightly chemical sensation on my tongue, as I experienced the five basic tastes all at once. But because there were almost no volatiles, I perceived

Toiling on a new frontier of culinary science, a student at the Culinary Institute of America in Hyde Park, New York, grinds cheese solids—after having centrifuged them out of molten cheese and frozen them with liquid nitrogen. The goal: a fancy, food-truck-ready cheese sauce, reduced to a powder.

very little flavor, and nothing that made me want to reach for a second piece. "That's what every meal is like for her now—pizza, lobster, whatever," Stuckey said. "Can you imagine?" The woman won her case.

Remarkably, people who've lost just their sense of taste take even less pleasure in eating, even though taste buds make a relatively small contribution to flavor. The main reason seems to be that if the taste receptors on the tongue aren't functioning, the brain mostly ignores input from retronasal olfaction. Stuckey thinks the basic tastes also create a flavor's "structure." "I think of these as the girders, the steel beams," she said. "There are foods out there that, without the bitterness that occurs in them naturally, would taste really flabby and flat and one-dimensional. Tomatoes, for example."

In addition to her duties at Mattson, Stuckey teaches a course at the San Francisco Cooking School called "The Fundamentals of Taste." "Most culinary schools don't teach students how to taste before they start to cook," she said. "They jump right in with, like, knife skills. But how can you possibly start an education around food without the building blocks of flavor?" She and her students do an exercise in which they make barbecue sauce. Most of the ingredients she provides are ones you would guess: tomato sauce, tomato paste, sugar, honey, liquid smoke, paprika. But there's also a tray of ingredients whose predominant taste is bitter: coffee, cocoa, tea, bitters. "It's not really intuitive, because you don't think of barbecue sauce as bitter, but if you taste it before and after you add a bitter ingredient, you realize that bitter changes the whole gestalt. It adds a complexifying note." At home Stuckey uses soluble espresso—instant coffee—as a bitter complexifier for many dishes, and especially for sweet or sweetish sauces.

GETTING BEYOND YUCK

Our responses to basic tastes are inborn, but our perceptions of smells—the main constituents of flavor—are learned. Some researchers want us to unlearn a few. Nordic Food Lab, in Copenhagen, is battling prejudice against such unfamiliar foods as ants (above) and mackerel entrails (right). The entrails will be salted, heated, and fermented to make a sauce similar to *garum,* a staple in Roman times. "We're primarily concerned with flavor and with diversifying our sources of food through deliciousness," says lead researcher Josh Evans.

MIND YOUR ANTLERS

At a recent feast in Tasmania concocted by Bompas & Parr, a London firm specializing in "immersive flavour-based experiences," participants dressed as their spirit animals and sniffed their neighbors while drinking cocktails that resembled animal blood. Then they chowed down, primally. Taste evolved as a means of finding food and avoiding poison; for some, it has now become a route to extravagant adventure.

Mattson's research laboratories contain a lot of high-tech testing equipment, but in one of them I met three researchers who were chewing thoughtfully and staring into plastic cups. A food manufacturer had hired Mattson to replicate a spicy brown-rice dish sold by one of its competitors, and chemical analysis could take the folks in white lab coats only so far. "The human palate is the most sophisticated analytical device there is," Stuckey said. "You have to put it in your mouth."

IN THE LATE 1980s Linda Bartoshuk, who was on the faculty at Yale at the time, identified what she called supertasters—people whose taste buds are so numerous and so densely packed that they experience the basic tastes with uncommon intensity. That's not all good: Supertasters get more pleasure from the foods they like than ordinary tasters do, but they also dislike more foods, especially strong-flavored ones.

> **'SWEETNESS USES NEURAL PATHWAYS VERY MUCH LIKE THE ONES USED BY DRUGS OF ADDICTION, WHICH ARE BELIEVED TO HIJACK CIRCUITRY THAT EVOLVED FOR FOOD.'**
>
> *Linda Bartoshuk*

At Monell I got a vivid demonstration of how different a supertaster's experience can be. After Michael Tordoff gave me a sip of maltodextrin, a geneticist named Danielle Reed (who's married to Tordoff) had me drink a second clear liquid in a plastic medicine cup. Again I tasted nothing.

Hakan Ozdener, a colleague of Reed's, happened to walk past her door. She called to him and handed him a cup of the same solution. Almost the moment it touched his lips, he winced, then looked as if he'd taken a swig of gasoline.

"It's PTC," Reed said. "Phenylthiocarbamide. Seventy percent of Caucasians are taste blind to it, but for people who can taste it, it's extremely bitter." And for some it's intolerably so—Bartoshuk discovered supertasters while working on PTC. The concentration in Reed's solution was very low, almost homeopathic, but Ozdener was still gasping. ("People are afraid to walk past my office," Reed said.) As a bitter supertaster, Ozdener is less likely than I am to like Starbucks coffee or rapini. On the other hand, Tordoff told me later, he's probably less susceptible to some upper-respiratory tract infections—the PTC-detecting receptor is also in the nose, where it seems to detect certain bacteria and prompt us to expel them.

For tasters of all kinds, the critical problem nowadays, Julie Mennella said, "is that we live in a food environment that isn't like our evolutionary past." We hunt and gather in supermarkets and restaurants, and many of the manufactured foods we buy are so energy-dense that we could satisfy an entire day's caloric requirements with a single meal. The food industry has been attacked for loading products with ingredients we've evolved to crave, but when it tries to make healthier products, we don't always reward it.

In 2002, when McDonald's announced that it would stop frying foods in oils containing trans fats, it received complaints that its french fries didn't taste as good—and maybe they didn't, but some of the complaints came from cities where the change hadn't been made yet. Cutting salt from manufactured foods is even trickier. There's general agreement that most of us eat too much. Yet if you give consumers two bowls of soup that are identical except for their salt content, they'll usually prefer the saltier one, and if you describe a soup to them as low in salt, they'll generally rate it less favorably than the "regular" version, even if the two are identical. Food companies complain that if they do cut salt, they're almost forced to do so without taking credit—they can't promote the low-salt version the way beverage manufacturers have promoted sugar-free sodas.

And even that business is fraught. In recent years sugar has replaced fat and salt as the most vilified element of the modern diet, but replacements for it are controversial too. This

year PepsiCo removed the nonnutritive sweetener aspartame from Diet Pepsi, not because scientific studies had shown it to be harmful, but because aspartame has a lousy reputation among health-conscious consumers. The new aspartame-free Diet Pepsi contains two other sweeteners, sucralose and acesulfame potassium. There's no guarantee they're safer.

SUGAR IS ESPECIALLY CHALLENGING, because children respond to it in ways that aren't obviously related to taste, and almost all of them consume too much of it, at least in developed countries. "Sweet blunts expressions of pain during childhood," Mennella said. "It will reduce crying in a baby, and it's used as an analgesic during circumcisions and heel-stick blood draws." (The effective agent is sweet taste rather than sugar, because aspartame works too.) A child's response to sweetness can be so gratifying to parents that they end up reinforcing it: How many other mood-altering tricks work so quickly and so well?

But there are public health implications, and they go beyond increases in childhood obesity and type 2 diabetes. Mennella worries in particular about "baby-bottle caries"—tooth decay caused by sugar-containing beverages, including fruit juice—especially in children who are put to bed with bottles. Some children's permanent teeth come in already decayed. It's "a major preventable disease of childhood," she said, "and it's reaching epidemic proportions."

Bartoshuk told me that increasing the concentration of sweetness-enhancing volatiles in certain foods may make it possible to reduce their sugar content without making them taste less sweet. But she worries about unintended consequences. "As soon as we can produce a sweet experience that has no calories, isn't toxic, and has no nasty characteristics—what will that mean for the brain?" she said. "We know that sweetness uses neural pathways that look very much like the ones used by drugs of addiction, which are believed to hijack circuitry that evolved for food and particularly for sweet. So are we doing anything terrible? I don't know." Getting something for nothing looks good, she added, "but Mother Nature has a nasty side."

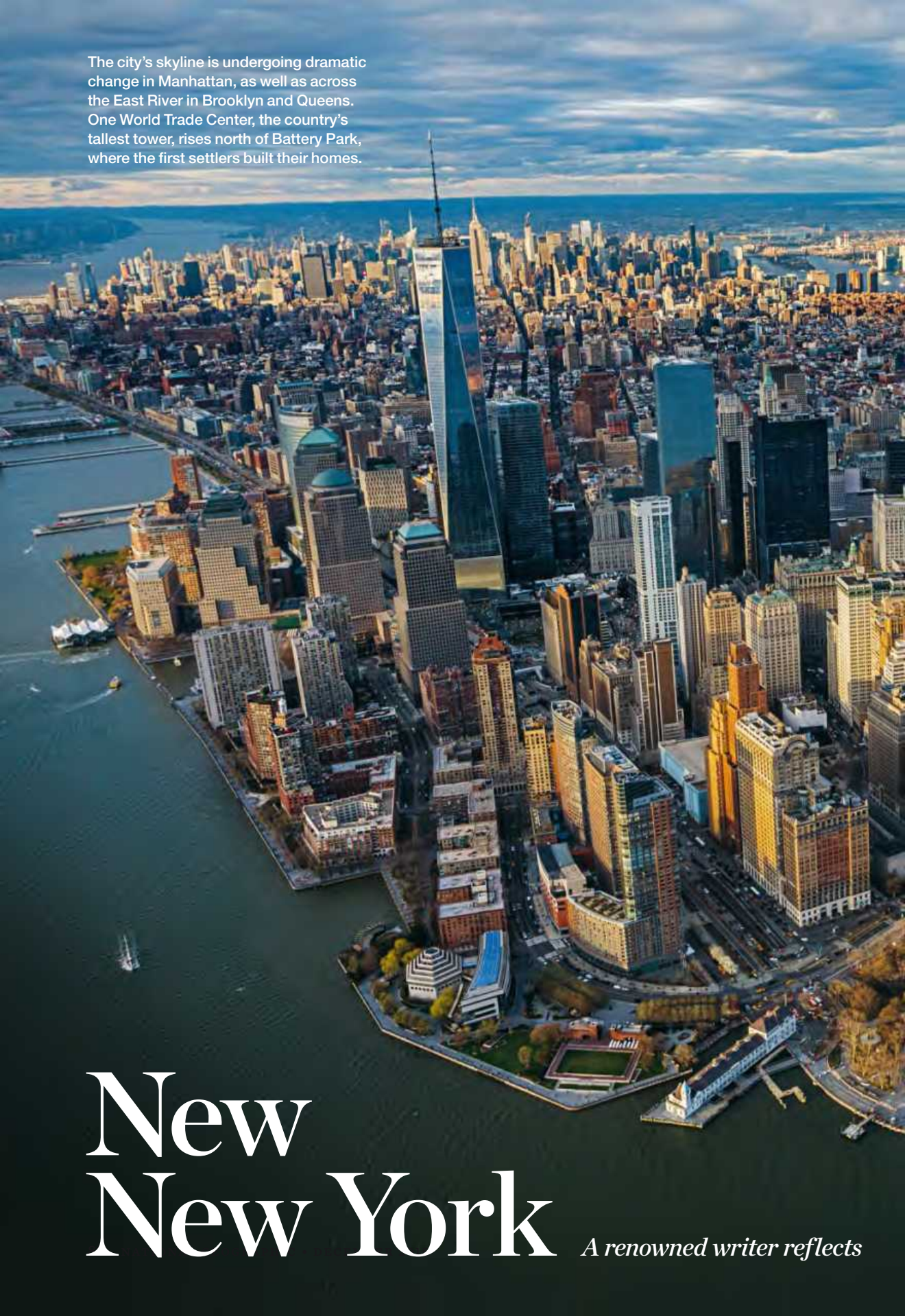
Our preference for sweets may hook us in ways we don't realize. A recent study by the Centers for Disease Control and Prevention found a large, sudden increase in the popularity among teenagers of electronic cigarettes, in which a battery-powered heating element turns a nicotine-bearing solution into vapor, which is then inhaled. "Vaping" has helped many longtime smokers cut back on real cigarettes, but it also circumvents a strong inhibition to taking up smoking in the first place: the repellent taste and smell. In teenagers it may do that in part by exploiting their vulnerability to sweetness—some popular vaping liquids contain sucralose, and young users often add it on their own.

The good news is that our inborn taste inclinations are not immutable. People who succeed in reducing salt in their diet typically find that their tolerance for highly salted food declines. And our natural resistance to broccoli, brussels sprouts, and other healthful but bitter foods can be overcome through experience—especially if it begins early. Mennella's research has shown that babies' flavor preferences are affected by their mothers' diet during pregnancy and by their own diet after birth. "Babies can learn to like a variety of foods," she said. "But they have to taste the food in order to like it." Her main advice to parents is to set good examples and not give up. When the baby in her broccoli video is offered a second spoonful, he still shudders—but he opens his mouth. ☐


ADRIENNE GRUNWALD

This is the second *National Geographic* magazine assignment for photographer **Brian Finke.** His work has been published in several books and featured in museum collections around the world.

What was the wildest food you tried while working on this story? The most interesting thing I ate during this assignment was ants on a bed of locally foraged herbs and flowers at the Nordic Food Lab in Copenhagen. Surprisingly, the insects were incredibly flavorful.



The city's skyline is undergoing dramatic change in Manhattan, as well as across the East River in Brooklyn and Queens. One World Trade Center, the country's tallest tower, rises north of Battery Park, where the first settlers built their homes.

New New York

A renowned writer reflects

on how his hometown has transformed over the past eight decades.

Praised as breathtaking, ridiculed as a boondoggle, the nearly four-billion-dollar World Trade Center Transportation Hub, designed by famed Spanish architect Santiago Calatrava, will link trains from New Jersey to 11 subway lines.

By Pete Hamill
Photographs by George Steinmetz

The 850-foot Pier 45 at Christopher and West Streets in Greenwich Village was refurbished as part of the longest riverfront park in the country and is now a favorite neighborhood spot for sunseekers. More than four miles of decaying docks, bulkheads, and parking lots were transformed into Hudson River Park, which has won awards for its design.

Long ago, as an eight-year-old boy standing on the roof of a three-story tenement in Brooklyn, I first experienced a sense of wonder.

We had moved to our unheated top-floor flat a few weeks earlier in 1943, leaving a damp ground floor apartment beside a clamorous factory. I had never climbed to the new roof alone. It was too dangerous, my mother said, a man-made cliff.

At dusk, my friends gone home to eat, my mother out shopping, I ventured up the last flight of stairs in a tentative, now-or-never way. I opened the hook on the tar-papered door and stepped into a world of planks, pebbles, chimneys, pigeons gurgling in a coop, and clotheslines. In that instant I felt my life change.

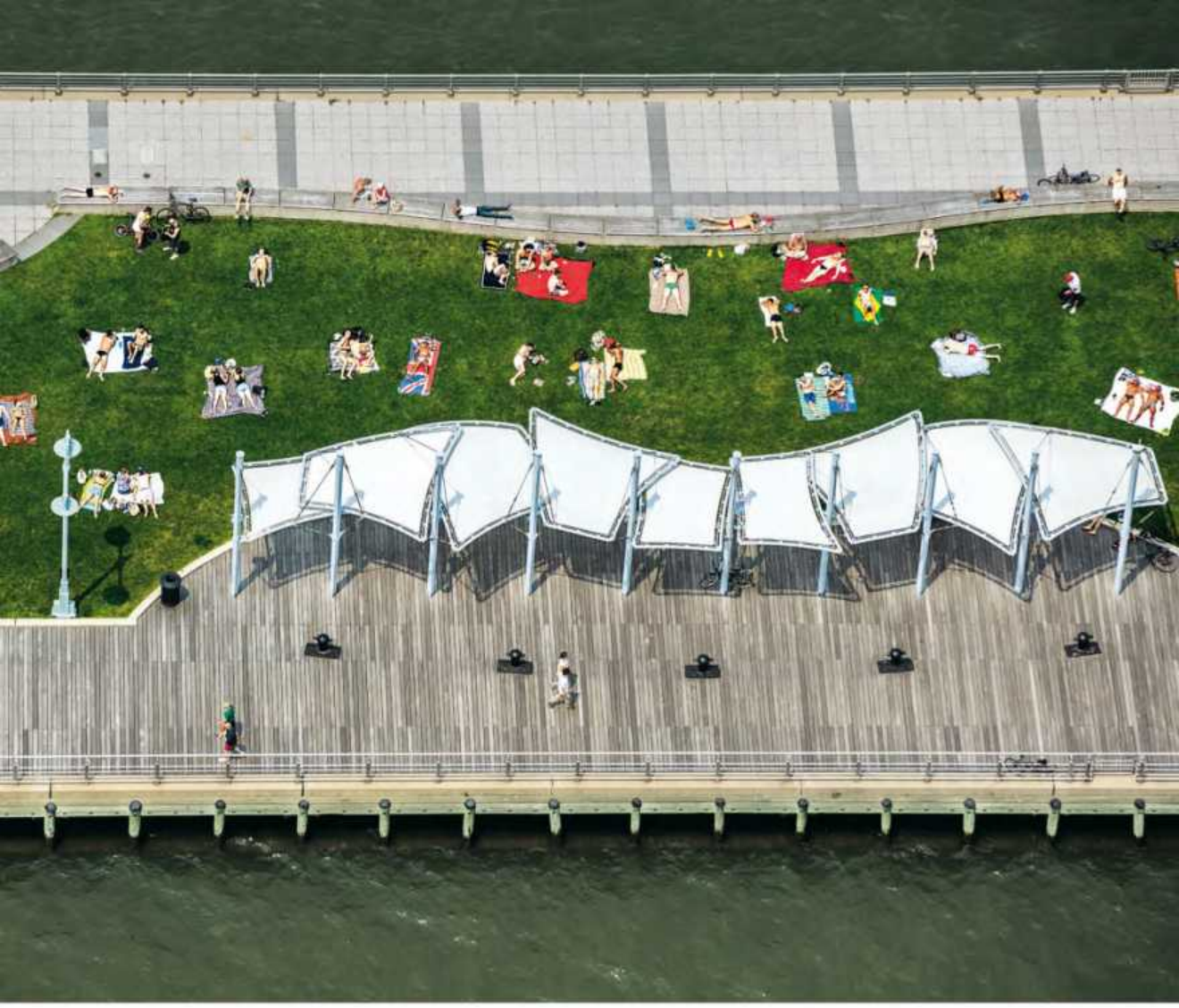
To the west, far off across the harbor, the sun was descending into a landscape I knew only as "Jersey." Clouds were slowly tumbling, dark in the foreground, edged orange in the distance. Freighters moved slowly, like toy boats, cutting fragile white lines in the black water. In Manhattan, the tall buildings were merging with the gathering darkness, no lights burning in that time of war. Above the distant, jagged mass, a few stars glimmered, tiny holes punched through the curtain of streaked, dark blue sky. Below me were the rooftops of half a hundred houses. All of it was a dazzling display of form, color, and mysterious shadow, rising past the limits of what we called "the neighborhood."

I tried to say something, but no words came. I didn't yet know how to describe what I felt. Surely the word was "wonder."

MANY WONDERS WERE YET TO COME, in what has been a long, rich life, much of it made possible by crossing the unmarked borders of the neighborhood, going "over New York," as we said when talking of Manhattan.

Below our living room windows lay Seventh Avenue, where streamlined trolley cars moved north and south. A subway entrance beckoned at Ninth Street. The trains were fiercely, metallically noisy, hurtling into black tunnels, emerging from the darkness to stop at Fourth Avenue, the doors opening, the sky visible, people leaving or boarding, the doors closing. The trains would start pounding forward again, heading for the wonders of Manhattan.

My kid brother Tom and I loved the first car of the train, where we could stand at the windowed door and watch stations emerge in the distance, form themselves, then fill with light. There would be subway trips to Chinatown and Little Italy. The sound of strange languages. Signs with indecipherable, hand-painted words. Huge buildings scraped the skies over Manhattan, so different from the low horizontal



ridges of Brooklyn. On that foggy day in July 1945 when a B-25 bomber crashed into the Empire State Building, Tom and I rode the subway to 34th Street to see it.

In the years ahead I fell in love with walking, comics, drawing, the Dodgers, reading, and stickball, along with the music of Billie Holiday, Edith Piaf, and above all, Frank Sinatra. Like everybody else in that time and place, I had no money. But from the kitchen radio, I had the songs, humming their music as I walked the streets to school or the library or the park. Sometimes on weekends in my teens, I would take the subway and get off at a stop where I had never been and just start to walk. I'd look at the houses, the tenements, the playgrounds, the schools, the shops, the churches, the synagogues. I'd try to imagine the lives of these people I didn't know. Each new neighborhood was at once familiar and obscure. Without yet knowing it, of course, I was training to become a writer, finding stories about this immense city and its people. All of them were living in neighborhoods too.

I'M NO LONGER EIGHT, or eighteen. I'm eighty. And if that sense of New York wonder now seems more elusive than ever in the city that gave me my life, this is not because of the glib seductions of nostalgia. We New Yorkers know that we live in a dynamic city, always changing, evolving, building. Sometimes for the better, sometimes not. The city's enduring slogan could be: Get on with it, my friend.

Long ago my now shrinking generation of native New Yorkers learned how to lose. Particularly we Dodger fans. Yes, even the greatest hitters in the history of baseball failed six times out of ten, and thus baseball had much to

teach us about life itself. But the continuing losses in the late 1940s and early '50s to the Yankees in the World Series were dreadful and wounding. Our slogan was usually "Wait'll next year." And so we did. Until 1955. After Brooklyn finally won the Series that year, one of the newspapers carried the headline: "This Is Next Year." But two years later we lost the Dodgers themselves, when they lammed to California.

Of course, we also lost Ebbets Field and the Polo Grounds, and eventually even the original Yankee Stadium. We lost the old Madison Square Garden, on Eighth Avenue and 50th Street, and Stillman's Gym, up the avenue from the Garden, where I first saw the great boxer Sugar Ray Robinson train. These were the rough churches and roofless cathedrals of our secular religion, called sports. Their loss was an outrage. Or so we thought.

Neighborhoods changed, of course, and we lost some of them too. Heroin arrived in my neighborhood in the mid-1950s, to suck the joy out of many blue-collar immigrant parents, who sobbed each night for their damaged American children. The crack epidemic of the 1980s was even worse. The first generation of working-class New Yorkers who took the educational benefits of the GI Bill began to move away early. They would carry their private cargoes of New York nostalgia and regret to other parts of the country. Over the years I would get letters from some, riddled with a sense of aching loss. I understood the feeling. I often felt it myself.

As a journalist, I was rooted in New York, exploring streets and neighborhoods for stories. But I was also a wanderer in foreign parts. I loved Mexico for its people, its music, its food, its literature, all discovered on the GI Bill. I also lived in Barcelona, in Rome, in Puerto Rico, in Ireland. I covered wars in Vietnam, Northern Ireland, Nicaragua, and Lebanon. Everywhere I went, I was a walker, a *flâneur,* as the French call the type. Trying to see, not just look. I didn't learn to drive until I was 36.

A few years ago I read some words by the Nobel Prize–winning Irish poet Seamus Heaney that clarified for me something about my own nature and others like me. "If you have a strong first world and a strong set of relationships," he said, "then in some part of you, you are always free; you can walk the world because you know where you belong, you have some place to come back to."

My place to come back to is still obviously New York.

BUT AS I MOVE into the ambiguities of old age, where wonder often mixes with regret, my heart often grows heavier over what I see. My beloved New York is in a bad way. To be sure, many things are better: schools, food, race relations, public safety, even manners. The city is wealthier and healthier than when I was young. But—hey, in New York there's always a but—its architectural face is colder, more remote, less human, seeming to be sneering. In Manhattan the new superthin, supertall buildings are blocking the sky, casting long, arrogant shadows on streets once caressed by sun. And those streets are jammed with traffic, like a welded pop art sculpture made of paralyzed cars, imperious limousines, honking yellow taxicabs, and fat, grunting delivery trucks.

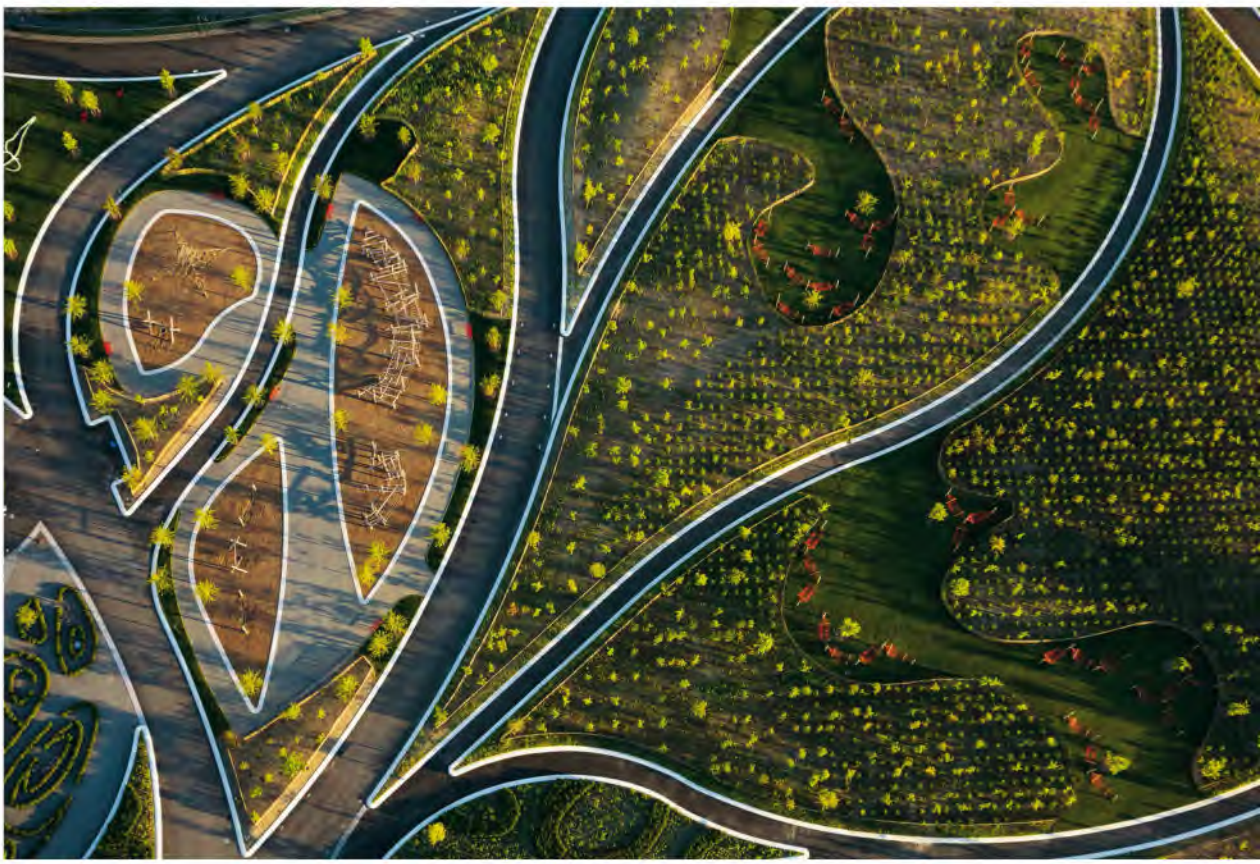
From the viewpoint of a card-carrying member of the street-bound rabble, most of these new buildings are examples of engineering mastery, not architectural beauty. Even in my beloved Brooklyn, across the East River and the emptier harbor that is the reason for New York's existence, new big-box buildings are rising. Developers

A bold new building testifies to the city's growing flirtation with adventurous residential architecture. Via 57 West, a distorted pyramid with more than 700 apartments surrounding a central outdoor plaza, will connect to Hudson River Park.

NGM MAPS

A winter storm limns the graceful geometry of the paths, café, and rink at the LeFrak Center at Lakeside in Brooklyn's Prospect Park (above). Built on a parking lot, the Mercedes House on West 54th Street has cascading balconies and a showroom for the luxury auto brand.

The Conrad New York, an environmentally friendly Lower Manhattan hotel, sports a green roof with a chef's garden (above). Once a military base, Governors Island has been reborn as a park filigreed with paths that offer sweeping views of the harbor and Statue of Liberty.



Visitors to the new Whitney Museum of American Art, designed by noted Italian architect Renzo Piano, explore its rooftop terraces, one featuring an art installation with brightly colored chairs. The 85-year-old museum moved from tony Madison Avenue to the hipper Chelsea area, reflecting the city's shift from a bastion of old money to a playground for new money.

have even announced plans to build "the Empire State Building of Brooklyn." The consoling wonders of the unlimited Brooklyn sky are vanishing, visible now only from those remote upper floors.

So, yes, to some extent this is a lament written by another old guy fighting off the longing for a lost past. As I move through the once familiar areas of today's big town, pausing the way I did in the past, too often I see people who are now long gone. Too many friends. A few lovers. How many times did I start a day with lunch at the Carnegie Deli? The table packed with friends, the talk a kind of chorus line, the laughter a torrent. Afterward, we would stroll along 57th Street, savoring the drama of the human show. Now it's called Billionaires' Row. Back then, it was just another neighborhood.

Over there stood a hotel, the Drake, where I once spent two hours at the bar with a mob wise guy who made me laugh out loud. Downtown a ways, at the Hotel Wentworth, lived a press agent who knew Damon Runyon and got me to read him more carefully. Down that block was the state boxing commission, where I covered weigh-ins while the regular boxing writer was on summer vacation. Over there was...

The new buildings replacing the old and familiar are rising as many as 90 stories into the New York air, gnawing at the sky as if famished. The entire island of Manhattan, from Inwood at the top to the Battery on the south end, seems to be glistening with new buildings, their glass facades blinding us all on sunny days.

In these supertall buildings, the owners are mostly the super-rich—often part of the global elite from China, Mexico, Brazil, Russia—and they don't choose to reveal their identities, using perfectly legal dodges to do so. Perhaps the most extreme example, on Billionaires' Row, is 432 Park Avenue, 1,396 feet tall and 88 floors. It lords over its neighbors, looking for all the world as if it's giving the finger to my city.

Even classic older buildings are caught in the swift tides of time, modernized into luxury residences. One of these is the splendid Woolworth Building, completed in 1913, briefly the tallest in New York. Its majestic presence still reigns over downtown, even though dwarfed by its newer neighbors. The Woolworth, you see, has been enriched by time.

As a young man just out of the Navy in the 1950s, I worked at 120 Broadway, a three-minute stroll from Trinity Church, the tallest structure in New York until 1890. At lunchtime in good weather, I loved walking uptown a few blocks to City Hall Park, finding an empty iron bench, or the lip of a dry fountain, and staring up at the neo-Gothic ornamentation on the facade of the Woolworth Building. I would imagine the superb European craftsmen working to make the walls speak. Hearing them speak to each other too, in musical streams of vowels.

Rumor has it that the 8,975-square-foot penthouse in the pinnacle of the 57-story Woolworth tower will cost a buyer $110 million. Once, for that price, you could've bought my entire

Brooklyn neighborhood and had a fortune left over. In my heart of hearts, though, I would love to live there, hoping each evening for the presence of ghosts.

It's possible, of course, that in the distant future, these new supertall buildings will attain a similar emotional aura with the passage of time. Possible, but I doubt it. Their faces are mostly blank, their facades full of resistance to human folly, gossip, imperfection, or need. The real estate business has always been riddled with issues of class. But this new architecture seems imprisoned by big money. Reports indicate that the inhabitants are usually in transit. It's doubtful that they belong to parent-teacher groups or block associations, or know the owners of their corner deli. I could be wrong. They might be wonderfully human, full of laughter and good heart. Yes, some of them must even fall in love with the wrong people. But they seem unlikely to produce a Henry James, Edith Wharton, or Louis Auchincloss, who knew how to turn the privileged life into a kind of prose poetry. They live in vertical fortresses, cut off from the rest of us. They surely must get lonely.

And this suggests another objection to the monumental changes under way: The failure to recognize the role of neighborhood.

In certain ways every New York neighborhood is a hamlet. All have class identities, and some have ethnic realities. All have a unique character, a unique street life of their own. Washington Heights, once largely Irish, is now heavily Dominican. East Harlem was Puerto Rican when I was young. Today it's largely Mexican. Brooklyn's Sunset Park also was Irish and is now heavily Mexican and Chinese. The Lower East Side was mainly working-class Jewish.

Whether seen as a scourge on the skyline or a marvel of engineering, 432 Park, shown under construction in autumn, has become the city's most visible supertall tower. Its highest apartments have breathtaking views of Central Park. The penthouse sold for $95 million.

Today Muslims work the stalls of Orchard Street, in the company of the millennial young. There are many other hamlets, with new names such as Nolita, Dumbo, the South Slope. I hope they prevail over the supertalls. I hope the people in them have as much fun as we did.

Two blocks from my loft in Tribeca, one of the new structures does make me pause and stare in admiration, feeling a cautious kind of hope. The address is 56 Leonard Street. Only the penthouses on top are sheathed in glass, so there are no blinding waves of contemptuous sunlight. Balconies rise nearly 60 stories to the top, giving the building a ribbed, accessible-looking surface. There's some chance we'll see actual human beings outside on good days: dining, scheming, reading, laughing, lying, dozing, or bad-mouthing rivals. High above the streets, yes, but recognizably human. A street life of the air.

THE BEST VIEW of New York might be from above, as the brilliant photographs of George Steinmetz help us to see. This is a city usually beyond our seeing. Steinmetz captures his images from a helicopter or "a flying lawn chair" he designed, freeing him to see the world's deserts, oceans, jungles, cities. Not just look at them. *See* them. Suddenly, through his eyes, we are above New York. On first seeing the Steinmetz images, I felt again, for the first time in several years, a sense of wonder.

One afternoon, in hopes of an existential shot of wonder inspired by Steinmetz, I visited One World Trade Center, the replacement for the original, destroyed on September 11, 2001. I was near here on that lovely morning. After the attack on the North Tower, I saw tiny humans jumping from the flames, saw the South Tower collapse, saw police, firefighters, photographers,

Four Freedoms Park was the last work designed by architect Louis Kahn in the 1970s, but it was only finished three years ago. It celebrates Franklin D. Roosevelt's 1941 speech calling for a world founded on freedom of expression and worship, freedom from want and fear. The park is on the southern tip of Roosevelt Island in the East River, which is being redeveloped.

and journalists heading toward the burning buildings while others were fleeing them. As a reporter, I kept coming back for weeks to the neighborhood of too much disaster and even more courage.

Now the new tower was open at last, and I felt a duty to visit. It will be for a long while the city's (and the nation's) tallest building, at 1,776 patriotic feet. The ride to the 102nd floor took 48 seconds. There was no sense of movement, no whooshing pull of the body. Inside the elevator car, a time-lapse panorama played images of the history of New York, with the Twin Towers appearing for only four fleeting seconds. With a whispery sigh, the door opened.

I walked into the enclosed observation deck. From those windows, I could see in all directions. North for about 30 miles up the Hudson River. East to my home borough of Brooklyn, parts of Queens, and a slice of Long Island. South to the Verrazano-Narrows Bridge, and beyond to the vast Atlantic. West to New Jersey, with a view of a tiny Statue of Liberty, our most famous French immigrant.

I moved closer to the windows and looked down. There it was, the Woolworth Building. My favorite. Still here. Changing color in the fading sun. My eyes briefly blurred.

The view was spectacular, but I felt no sense of wonder. Instead, I was seeing my father and his neighborhood friend, Eddie, going up the subway stairs in front of me and out onto Cortlandt Street and the wonders of Radio Row. Bulbs, tubes, extension cords, radios themselves, new and used, gleamed from stalls, shops, from under tents.

I remembered too the end of Radio Row, in 1966. The legal theorists of eminent domain had won. Radio Row was scraped away to make room for the first World Trade Center. My father wasn't the only New Yorker who never forgave them. But like other New Yorkers, I'd grudgingly gotten used to the Twin Towers. They'd grown familiar, if not loved. Now I missed them too.

After a while, I wanted to get back to street level. To look at strange faces, see the distraction, sorrow, joy, laughter in their eyes.

I descended to earth. On the sidewalk a young visitor asked me how to get uptown. I pointed him toward the subway.

He smiled. "No, I want to see all the way."

I gave him directions, telling him to go to Church Street; walk north; make a left at Waverly Place, which would bring him to Washington Square; and then…

"Enjoy the neighborhood," I said. □

George Steinmetz (far left) just published his fourth book of aerial photography, *New York Air: The View From Above.* **Pete Hamill** started writing about the city 55 years ago as a reporter for the *New York Post.* He has published 11 novels, two short story collections, two memoirs, a biography, and four works of journalism, including a new edition of his book *Why Sinatra Matters.*

Haiti on Its Own Terms

Photographs by young Haitians show pride and beauty in a land where struggle is the norm.

PHOTO BY MYRMARA PROPHÈTE, 14

Six-year-old Tamara Pierre, in Ca Douche, wears *choublak*—hibiscus blossoms—in her hair. "I took this picture," says Prophète, "because the hibiscus is one of my favorite flowers."


HYPPOLITE PRESIDENT D'HAITI 1889
TRAVAIL
Digicel

PHOTO BY ANGELAURE SAINT LOUIS, 17

The bustling Iron Market in Port-au-Prince, destroyed by the 2010 earthquake, was restored to look as it did when built more than a century ago. “So many people work in the Iron Market,” says Angelaure, “I was happy it was rebuilt.”

PHOTO BY WILKY DOUZE, 19

Douze caught the early morning action on the beach in Jacmel as fishermen hauled in their nets. “I love how our fishermen work,” he says, “with a lot of determination to catch fish in order to feed their families.”

By Alexandra Fuller
Photographs by students of FotoKonbit

The Haitian student photographers

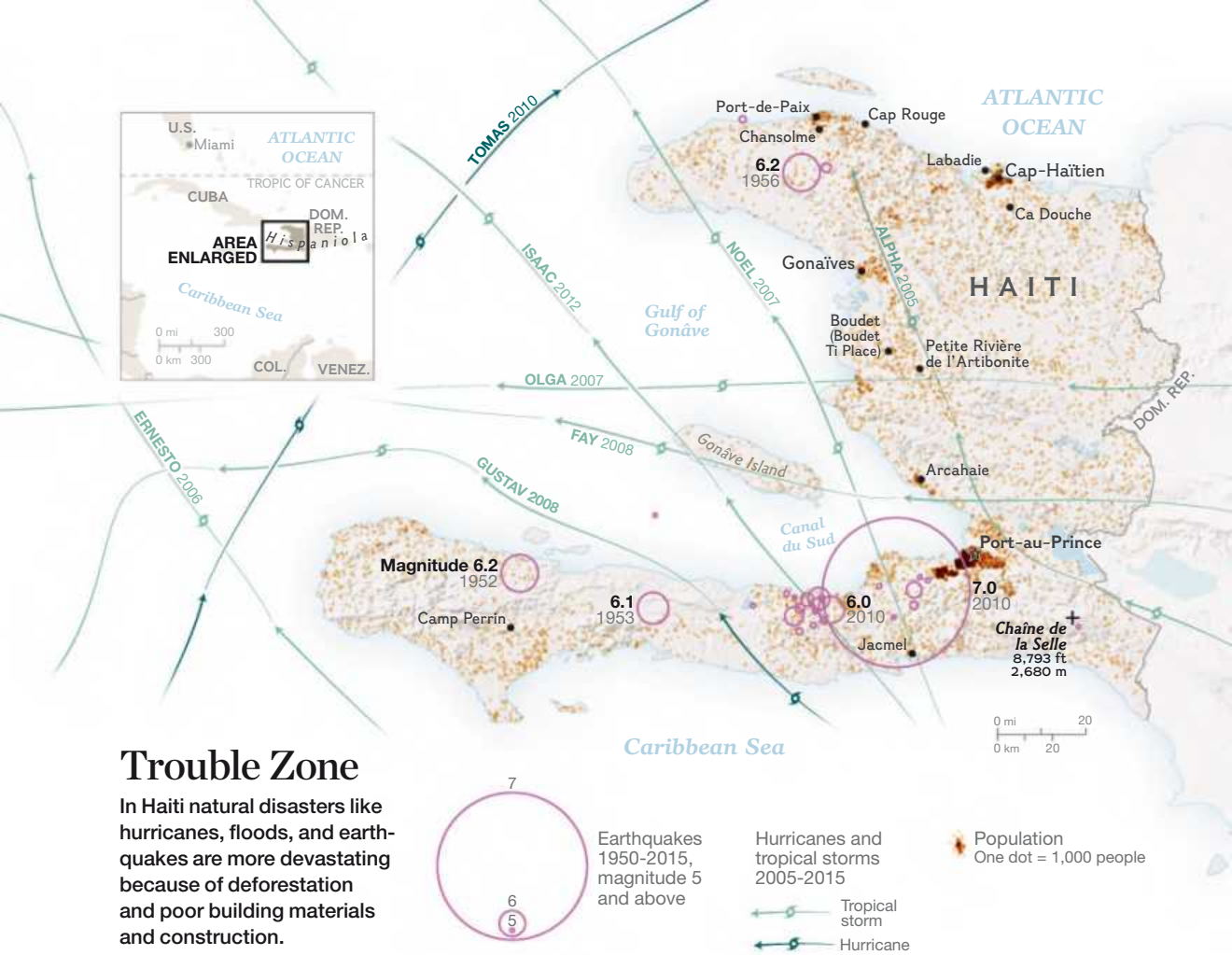
ranged in age from 14 to their mid-30s, and they'd come from all parts of the country and from all backgrounds. Their mandate was so simple it verged on radical: To show the world Haiti as it is rarely seen—as they saw it. Not just a country of disasters, shocks, and aftershocks but also a place shot through with sunlight and glittering sea, a place stunned into focus by a child in an impeccable school uniform, rollicked by music and the seemingly spontaneous eruption of dancers blowing on bamboo trumpets through the haze of a street party. A place of pride and possibility.

"That's good, because Haitians are tired of seeing stories in foreign papers about how helpless we are," said Junior St. Vil, my translator and a travel consultant who has also embarked on a law degree. "There is so much beauty here, so much power." St. Vil suggested I visit a Vodou priest, or *houngan,* in Arcahaie, a coastal town about 25 miles from Port-au-Prince. "He has the most elaborate temple in all of Haiti. And I

Founded in 2010, **FotoKonbit** is a Haitian-run, U.S.-based nonprofit organization *(fotokonbit.org)* that teaches photography to youths and adults in Haiti.

PHOTO BY SMITH NEUVIEME, 32

Manuela Clermont sells bread from a basket in her neighborhood in Camp Perrin. “I buy bread from her every day,” says Neuvieme. “I took this picture because they’re a happy family and work hard to be happy people.”



Trouble Zone

In Haiti natural disasters like hurricanes, floods, and earthquakes are more devastating because of deforestation and poor building materials and construction.

think he is a very impressive man," St. Vil said.

I arrived at the temple on a sweltering mid-August afternoon. Dogs roused themselves from the shade of banana trees and barked apologetically. An assistant hurried out to hush them. He explained that the priest was tired, that he'd been up much of the night performing telepathic services for a client in Miami. Nevertheless the venerated man, who asked me not to give his name, emerged from an inner room of the temple in a black wool beret, a polyester leopard-print T-shirt, black surfing shorts, and a gold chain. He reminded me of a Hollywood depiction of a minor African dictator on vacation.

"Are you one of those who agree that Haitians are incapable of running their own affairs?" he asked. "That we are children in need of supervision?" He spoke slowly and unexcitedly, in the manner of one not used to being contradicted, much less supervised. The scent of perfume recently offered to Vodou spirits hung in the air. Puddles of candle wax dotted the sprinklings of flour—intricate invocations to the spirits, called *vèvès*—at the center of the temple's floor.

Vodou recognizes the existence of a supreme god, Bondye, which is Creole for *Bon Dieu* (Good God), but leaves most of the day-to-day heavy lifting—success in business, happiness in love—to scores of spirits, or *lwas,* that are manifestations of Bondye. Most were borrowed from West African and Congolese pantheons and were made to correspond to Roman Catholic saints. Vodou originated as the religion of the island's slaves, and it remains deeply embedded in the culture of those slaves' descendants—in other words, almost everyone.

A ubiquitous religion that outsiders find difficult to comprehend and impossible to control is a threat to those who hope to have total power. When French colonial masters tried to suppress it in the 17th and 18th centuries, the practice went underground. After the country gained

NGM MAPS. SOURCES: USGS; MINUSTAH; NATIONAL WEATHER SERVICE, NOAA

independence, in 1804, the Haitian elite did all they could to eradicate Vodou. It went underground again. From 1915 to 1934, when the United States occupied Haiti, U.S. Marines destroyed Vodou temples, confiscating sacred drums, and the religion went subterranean yet again.

Today Vodou is visible everywhere. In yards and private homes there are altars devoted to Vodou spirits. Whole sections of the Iron Market in Port-au-Prince are dedicated to Vodou potions, Vodou art, and buckets of live turtles—"Vodou pets," a vendor explained. Although its mere existence is proof of its power of endurance, Vodou still feels secretive and elusive.

"No, we don't need promises of outside help," the priest said, gesturing toward the temple. "This temple was built and decorated entirely by the community, voluntarily." He leaned back in his chair. "The spirit of Haiti cannot be destroyed. Even the worst disaster cannot eradicate us."

HAITI IS THE COUNTRY in the Western Hemisphere most vulnerable to the effects of natural disasters. Hurricanes and floods are common. The first recorded earthquake hit in 1562. Quakes aren't nearly as frequent as hurricanes and floods, but since the early 1900s concrete block and reinforced-concrete construction—which hold up better than wood against wind, fire, and rushing water—has been used for houses, hospitals, and schools. Yet when the ground shakes, concrete buildings crack and collapse easily.

Haiti's latest and most catastrophic earthquake—a magnitude 7—struck just west of Port-au-Prince on January 12, 2010. Untold thousands perished in the disaster. The Haitian government eventually put the figure at 316,000. A team funded by the U.S. Agency for International Development (USAID) estimated that the number could not have exceeded 85,000. A group of American academics calculated fatalities at 158,000. The quake also exposed the weakness of modern Haitian buildings. In minutes the overcrowded city folded. Structures that represent the statehood of a nation—the presidential palace, the National Assembly, the main jail, the national cathedral, the central tax office—were all destroyed.

With each disaster, in an effort to help, foreign nongovernmental organizations (NGO) and missionaries flood the country with such predictability that some locals call the period in the aftermath of hurricanes "missionary season." Of course, not all do-gooding is created equal. Though many foreigners stay for only a few days, in what amounts to a mercy vacation, others remain for years of grueling, often vital, work in a country that lacks basic services. Haiti has more than 4,000 registered NGOs, but there is no effective oversight of foreign aid institutions, no formal impartial measure of the efficacy of the aid, not even a tally of how many missionaries are in the country. All anyone knows is that there are thousands.

"We haven't learned how to shut the door to the mechanics who want to come and fix us," Nixon Boumba, a Haitian human rights activist, told me. "They change the parts, but they don't fix the car. And of course, things got worse after the earthquake. People were so desperate for relief. They put out their hands for help." He stretched out his hands in an impression of the walking dead. "But after too long like that, you can become a zombie."

Of the more than six billion dollars in international aid donated to the country for humanitarian and recovery work following the disaster, only 9.1 percent was channeled directly to the government and less than 0.6 percent went directly to Haitian NGOs and businesses. The U.S.-based Center for Economic and Policy Research found that most of the USAID money it could follow went to U.S. companies and organizations, more than half in the Washington, D.C., area alone. "Money visits money," St. Vil said, citing an adage of his mother's.

What is not in dispute is that more than a million Haitians were displaced—as their ancestors had been by slavery, by natural disasters, and by despotic leaders. The most infamous of those leaders, at least in recent times, were the U.S.-backed Duvaliers: François "Papa Doc," whose dictatorship lasted from 1957

until his death in 1971, and Jean-Claude "Baby Doc," who took over his father's misrule.

Baby Doc was just 19 when he came to power, a pudgy teenager with a taste for the fast life. Most Haitians assumed his tenure would be mercifully short-lived. But the U.S., which had been sending up to $3.8 million a year in aid when Baby Doc took over—as a reward for the country's anticommunist stance—hiked that figure to $35.5 million in 1975, because of Baby Doc's pledge to continue his father's anticommunist ideology and because the son was more blatantly sycophantic to U.S. business interests. Baby Doc used most of the U.S. aid to keep himself in power, bankrolling a force of up to 9,000 soldiers and tens of thousands of Tonton Macoutes, the private militia formed by his father. (Tonton Macoute is Creole for Uncle Knapsack, a character in Haitian folklore who snatched mischievous children and made them disappear into his knapsack.) Baby Doc went further, creating the Leopard Corps, his own elite counterinsurgency and personal security force trained by the U.S. military.

By the time Baby Doc was ousted in a popular uprising, which culminated in his fleeing to France in February 1986, Haiti was an unmitigated mess. During the nearly three decades of tyranny under the Duvaliers, an estimated 30,000 to 60,000 Haitians were killed, many by the Tonton Macoutes, who also raped or tortured countless of their fellow citizens. Up to a million others fled, most to the U.S., elsewhere in the Caribbean, or to France.

Ten months after Baby Doc left, the International Monetary Fund loaned Haiti $24.6 million. In return the Haitian government was required to reduce tariffs on imported rice and other agricultural products. A trade liberalization push in the mid-1990s—championed by President Bill Clinton, a longtime visitor to Haiti and a self-proclaimed supporter of its people—pried open Haiti's markets even more, and rice tariffs were lowered from 50 percent to 3 percent. Heavily subsidized U.S. rice flooded the Haitian markets, much of it from Arkansas, Clinton's home state. Haitian farmers' rice

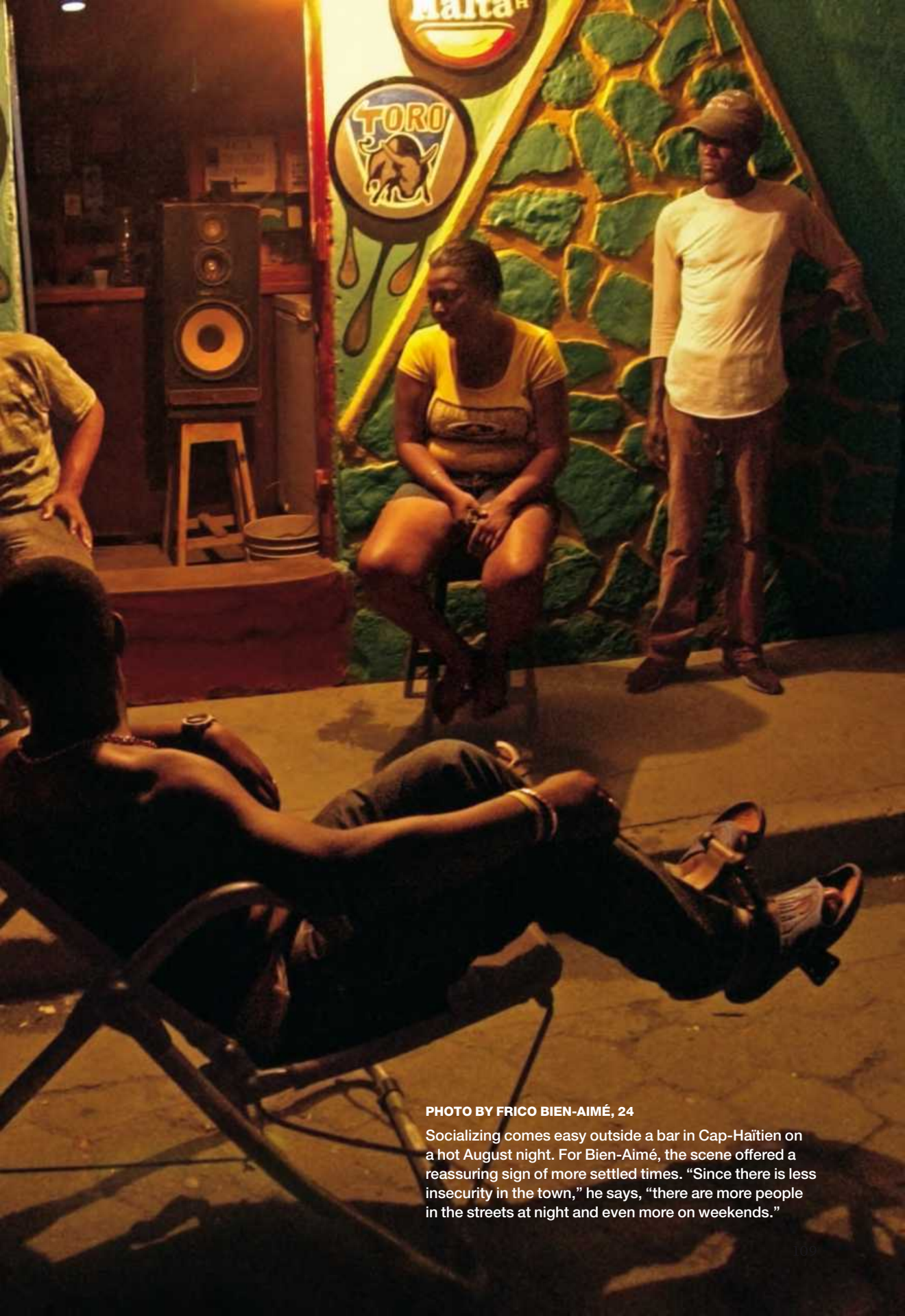


PHOTO BY FRICO BIEN-AIMÉ, 24

Socializing comes easy outside a bar in Cap-Haïtien on a hot August night. For Bien-Aimé, the scene offered a reassuring sign of more settled times. “Since there is less insecurity in the town,” he says, “there are more people in the streets at night and even more on weekends.”

PHOTO BY PHILOMÈNE JOSEPH, 20

In a street market in Cap-Haïtien Maryse (at right) and her friend Martine sell religious products used for Vodou rituals and ceremonies. "I love my roots, and I take a lot of photos that represent what my roots are," says Joseph.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'Haitians are rooted in resistance. No one can eradicate us.'

Samuel Nesner

couldn't compete with the cheap and donated imports. Many farmers, after chopping down the last of their trees to sell for charcoal, gave up and flooded the cities, crowding into slums.

In March 2010 Clinton apologized for his role. "It may have been good for some of my farmers in Arkansas, but it has not worked," he told the U.S. Senate Committee on Foreign Relations. "It was a mistake. It was a mistake that I was a party to...I have to live every day with the consequences of the lost capacity to produce a rice crop in Haiti to feed those people because of what I did."

IN 1492, WHEN Christopher Columbus first saw the island of what became known as Hispaniola, he called it "a wonder." But you can't eat beauty, so the Spanish did the next most ruinous thing: They mined every ounce of gold they could easily find, enslaving the native Taino to do so. As a result, almost all the Taino subsequently died, either from overwork or introduced European diseases, especially smallpox.

Then came the French colonists, who took over the western third of the island for 140 years and made themselves among the wealthiest people on Earth at that time. They brought up to a million African slaves to the colony they called Saint-Domingue to raze the land's legendary forests—"tall trees of different kinds which seem to reach the sky," Columbus had written—for hardwood to furnish their mansions in Europe and to make room for lucrative sugarcane and coffee plantations. The incipient environmental disaster—Haiti is now one of the most deforested nations on Earth, with less than 2 percent of its land covered by forest—paled in comparison with the human rights catastrophe that was under way.

French masters in Saint-Domingue treated their slaves so brutally that they died in the thousands. To replace their dead slaves, the French imported more. By the night of August 22, 1791, when a Vodou priest called Boukman gave the signal to begin the uprising that would become the most successful slave revolt in history, slaves—two-thirds of them African born—outnumbered masters by ten to one. In 1804, after 13 years of bloody insurrection, Haiti emerged as the world's first independent black state.

The impression of Africa in Haiti remains indelible. Almost as soon as I landed at Toussaint Louverture International Airport, I had the disquieting sense that I'd landed not on a lobster-claw-shaped chunk of island in the Caribbean but in a small sub-Saharan African nation. Or rather in an African country of the imagination, as if Haiti were a mythical chip off the mother continent, adrift in the wrong hemisphere.

It was the smell first and foremost: carbolic soap; charcoal smoke from the street-food kiosks selling fresh conch, corn fritters, and roasted pork; and the scent of tropical foliage emanating from irrigated gardens in the suburb of Pétionville. In one of these pockets of affluence, an ailing Baby Doc, having returned in 2011 from a 25-year exile in France, was living out his last days in unmolested peace.

The presence of the failing ex-dictator, who died on October 4, 2014, did not seem to be exciting much local attention, perhaps because people had enough current political incompetence to cope with. Parliamentary and municipal elections were already three years overdue. Nevertheless the electoral council of President Michel "Sweet Micky" Martelly, who once sang *konpa,* a modern Haitian merengue, announced that the elections would be postponed indefinitely. Preliminary parliamentary elections were finally held in August 2015. (By the time you read this, follow-up parliamentary and presidential elections may—or may not—have happened.) In the view of some of her citizens, Haiti had become less democratic than anarchic.

Wittily desperate graffiti was splashed across

the capital city. "Occupation = Martelly," a reference to the ongoing presence of the UN Stabilization Mission in Haiti (MINUSTAH), which since 2004 has kept thousands of troops in the country. "Martelly = cholera," a reference to an ongoing cholera epidemic that first hit Haiti in late 2010, presumed to have been brought by a Nepali contingent of MINUSTAH. "Martelly = pink flea," a reference to his pale complexion and his perceived bloodsucking propensities. And "Martelly = the colonists' servant," a reference to his subservience to Washington, D.C.

"The government has created a big hole, and then it does nothing to stop that hole being filled by those who come to extract every last drop of energy, initiative, and wealth from us," Nixon Boumba told me. "We can't keep giving ourselves away. We must continue to stand up for ourselves, for our land, for the wealth beneath our feet."

WHEN HE SPOKE OF THE WEALTH beneath Haitians' feet, Boumba wasn't speaking in metaphor. The value of the gold and other minerals—copper, silver, iridium—under Haiti's ground isn't known, but exploratory drilling suggests that they may be worth $20 billion. In December 2012 the Office of Energy and Mines issued the first three permits to mine gold and copper. A member of parliament later complained that he'd learned about the permits from the radio. Two months later the senate passed a nonbinding resolution calling for a moratorium on mining. To get around the deadlock, Haitian government officials invited the World Bank to redraft the mining law, which it did, in close consultation with mining-company officials.

In January 2015, with the assistance of the New York University School of Law's Global Justice Clinic and the California-based Accountability Counsel, the Haiti Mining Justice Collective lodged a complaint with the World Bank. It alleged that Haitians had been left out of World Bank–funded efforts to draft new legislation intended to attract foreign investors to finance extraction of Haiti's gold and other minerals. In February the Inspection Panel—a body established to address complaints by people affected by World Bank–sponsored projects—refused on technical grounds to register the complaint.

Some Haitian activists see the World Bank's cozy relationship with foreign mining companies and disregard for the concerns of Haitian civil society groups as an exhausting repetition of the disastrous arrival of cheap U.S. rice. "Recolonization comes in two forms," Boumba warned. "Either the foreign entities use your space to invade your markets with their own products, or they simply steal what you have. But there are a group of us prepared to fight the extractive habit." He told me about Samuel Nesner, a young farmer and activist in the country's remote northwest who volunteers in his spare time to help farmers better understand their rights and the language of those who would remove minerals from their land.

It takes about six hours to drive from Port-au-Prince to Chansolme, a community on the Trois Rivières, but it feels like a country apart from the city, more like the Haiti seen through the eyes of the students who took photographs for this story—a place of refuge and nurturing, as home is supposed to be. Mango and palm trees fringed the rough dirt road. There was also the occasional stand of ceiba trees, giants up to 200 feet tall with buttressed trunks like pylons. Sacred to Vodou's Loko—spirit of vegetation and guardian of sanctuaries—the trees haven't been chopped down. The wide river flowed clear and strong, coming in and out of view as we drove along its bucolic banks. Small herds of sleek cattle grazed its shores; villagers and their children bathed and swam.

Twenty-eight-year-old Nesner met me in Chansolme. The rest of his family has the surname Nelner, but when Samuel was born, his

MARIE ARAGO

Find additional images by the **Foto-Konbit** students who shot this story, including Myrmara Prophète (left), at *ngm.com/more,* along with photos of the students and more on what photography means to them.

mother, who's illiterate, had someone else put his name on the birth certificate. "I think I am the only person in Haiti with this name," he said. When Nesner was six, his father died of heart problems, and perhaps because of this, the child was always in search of a father figure to inspire him. When he was 17, Nesner met Hansy Vixamar, now 55, a longtime community activist who had settled in the region three decades earlier as a newlywed.

Leading me up to Vixamar's home, Nesner explained that the older man had inspired him to become a volunteer in his own community. "He reminds me that it is all about education and empowerment," Nesner said. "Historically mining has negatively impacted the environment, poisoning water and soil. The problem is, if you are an uneducated, illiterate peasant, how can you argue with someone with an engineering degree, someone in political power, someone from the World Bank?"

When we reached the house, we found Vixamar sitting almost motionless on his veranda, frail and slim, dressed in a clean white undershirt and matching shorts. He has diabetes and recently had suffered a stroke. He'd been hospitalized in Port-au-Prince, but his situation had appeared hopeless. "He seemed near death," his wife, Micheline, told me. But then, she said, Vodou spirits came to him in the hospital and told him to return home. It had proved something of a tonic.

As I asked questions, Vixamar replied softly and haltingly but with a gentle persistence, while his face remained infused with a peace that became all the more extraordinary as his story unfolded. In August 1988, during the shaky period following the Duvaliers' reign, with its series of short-lived governments dominated by henchmen, Vixamar had been arrested for attempting to help farmers negotiate a fair price for their coffee. "The peasants worked so hard to grow coffee, then the big guys—ex-military, lawyers, judges, people in power—would export the coffee and pay very low prices or pay nothing at all," he said. "I realized we have to come together and resist the ways in which

PHOTO BY SMITH NEUVIEME, 32

A regular at this pond in Camp Perrin, Johnny Pierre makes good use of available resources. “I’ve seen him catch fish for his family for months,” says Neuvieme, “and I wanted to capture this moment at dawn.”

PAUL SAINT FLEUR, 20 • CARNIVAL IN JACMEL

PHILOMÈNE JOSEPH, 20 • RUE DU COMMERCE IN JACMEL

CONSTANISE BARTHELEMY, 30 • CATHÉDRALE NOTRE-DAME IN CAP-HAÏTIEN

CHRISTANIA JEROME, 15 • TAISHA GUILLOTEAU IN JACMEL

ODALINE SARAH VINCENT, 15 • SISTERS KETIA, ROSE GERLINE, AND FABIOLA IN CAP ROUGE

PHILOMÈNE JOSEPH • MAXI SAINT JACQUES NEAR BOUDET TI PLACE

WOODENS SEJOUR, 20 • CROIX DES BOUQUETS OUTSIDE PORT-AU-PRINCE

MANIGE MÉSIDOR, 35 • JEFNY SAINT HILAIRE IN LABADIE

PHILOMÈNE JOSEPH • PETER-MICHAEL IN PETITE RIVIÈRE DE L'ARTIBONITE

Not just a country of disasters, shocks, and aftershocks but also a place shot through with sunlight and glittering sea, a place of pride and possibility.

PHILOMÈNE JOSEPH • A BOY AND HIS PUPPY IN JACMEL

WILKY DOUZE, 19 • COLLÈGE ALEXANDRE DUMAS FILS IN CAP-HAÏTIEN

others can so easily take advantage of us."

The farmers massed at the jail and demanded Vixamar's release. "That inspired me more," he said. "There was a unity among the peasants then. This was before the influx of aid and missionaries came and disrupted that unity. But the seed of that spirit remains."

Then Vixamar lifted a shaky hand and gestured toward his garden, as if his mind had suddenly slipped off its tracks. "When my wife and I came here," he said, "there was just one mango tree. So we built our house near the tree and started from there. Always planting and planting. This can happen all over. From one mango tree to a forest of mixed trees." I understood then that he was speaking in metaphor. He was the mango tree. Samuel was the beginning of a new indigenous forest.

By early afternoon Vixamar was clearly tiring. Before I left, I asked him if he had any message for the world beyond his shaded Haitian refuge. He smiled. "Please tell the U.S. government to stop bothering our country and give us a chance to take destiny in our own hands. That will contribute to peace in the world."

Vixamar's solution seemed unlikely and at the same time an understandable response to a history that experience would suggest is programmed to repeat itself. Nesner agreed, but he had an answer. "If ordinary Haitian people have a say on whether and how Haitian mineral wealth is extracted, that may finally change the pattern." He appeared undisturbed by the overwhelming odds against his endeavors. "Haitians are rooted in resistance. Logically, if Vodou is what took people from slavery to freedom, anyone who wants to dominate us again will have to take away our Vodou. But you cannot eradicate that which is secret, that which is everywhere. Imagine what we have survived already. No one can eradicate us."

I understood then that Nesner was casting deep into what it means to be Haitian, which is to say, where outsiders might see a history of defeat and disaster, he saw a history of struggle, instigated by African slaves and inspired by a collective culture. □

PHOTO BY PHILOMÈNE JOSEPH, 20

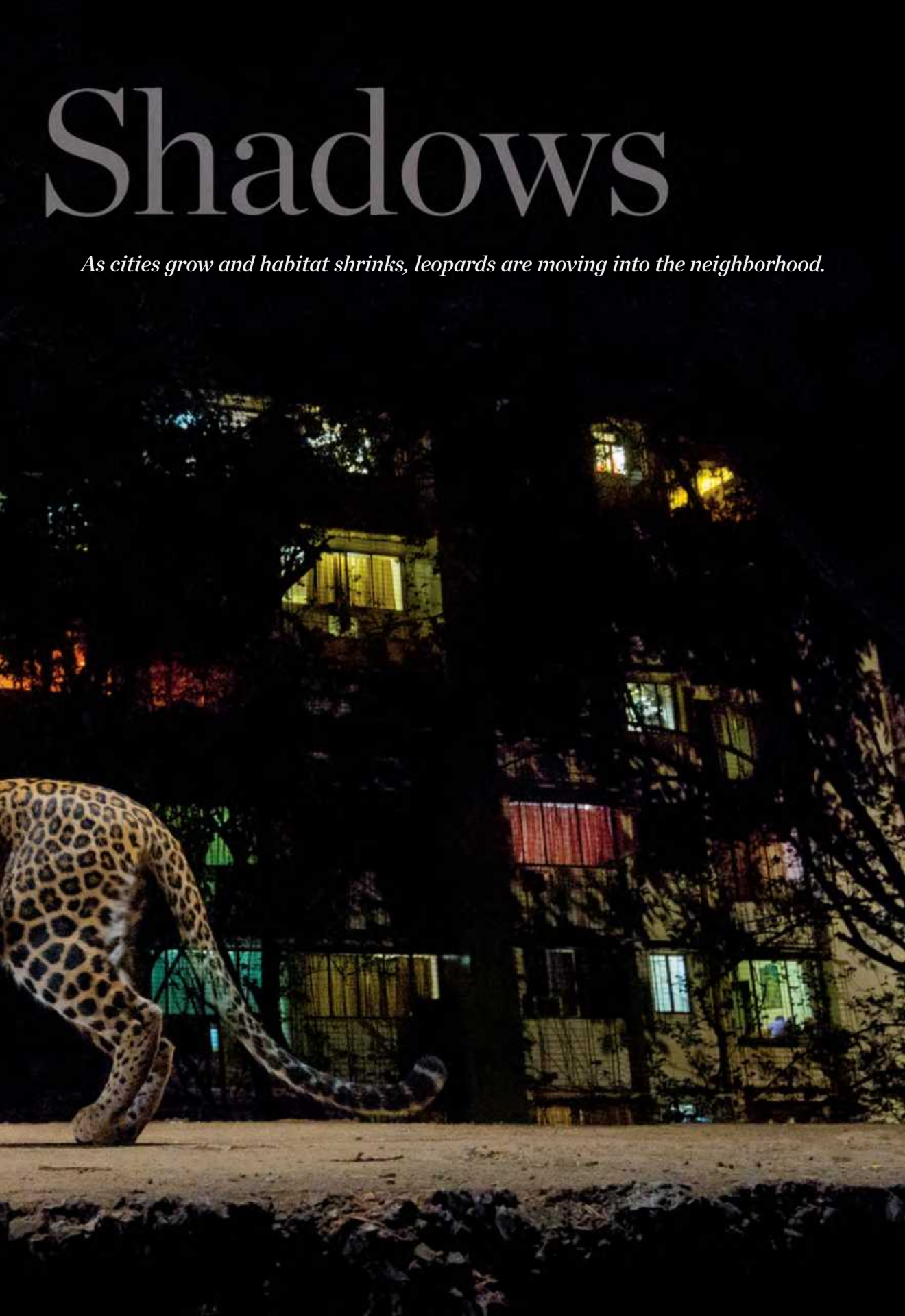
The historic Manoir Alexandra in Jacmel, which was damaged in the 2010 quake, is being rebuilt on the town's main square. Joseph says the scene conveys something special: "I like the old and the new."

Out of the

Lit by a camera-trap flash and the glow of urban Mumbai, a leopard prowls the edge of India's Sanjay Gandhi National Park.

Shadows

As cities grow and habitat shrinks, leopards are moving into the neighborhood.



Demand for the costly pelts worn in Christian-Zulu rituals like this one performed near Durban, South Africa, drives poaching. Panthera, a conservation group, promotes faux furs to help protect the wild cats.

By Richard Conniff
Photographs by Steve Winter

We were sitting in the dark, waiting for the leopards beside a trail on the edge of India's Sanjay Gandhi National Park, 40 square miles of green life in the middle of the sprawling gray metropolis of Mumbai. A line of tall apartment buildings stood just opposite, crowding the park border. It was 10 p.m.,

and through the open windows came the sounds of dishes being cleaned and children being put to bed. Religious music floated up from a temple in the distance. Teenage laughter, a motorcycle revving. The hum and clatter of 21 million people, like a great machine. Somewhere in the brush around us, the leopards were listening too, waiting for the noise to die down. Watching.

About 35 leopards live in and around this park. That's an average of less than two square miles of habitat apiece, for animals that can easily range ten miles in a day. These leopards also live surrounded by some of the world's most crowded urban neighborhoods, housing 52,000 people or more per square mile. (That's nearly twice the population density of New York City.) And yet the leopards thrive. Part of their diet comes from spotted deer and other wild prey within the park. But many of the leopards also work the unfenced border between nature and civilization. While the city sleeps, they slip through the streets and alleys below, where they pick off dogs, cats, pigs, rats, chickens, and goats, the camp followers of human civilization. They eat people too, though rarely.

They are fearful of people, and with good reason. Humans make fickle companions, admiring, rescuing, and even revering leopards in some contexts, and reviling them in many others—shooting them, snaring them, poisoning them, hanging them, even dousing a trapped leopard with kerosene, striking a match, and calmly filming as the animal writhes and whirls in a ball of fire, dying, but not nearly fast enough. Conservationists call leopards the world's most persecuted big cat.

And yet leopards have become our shadows, our quasi-companion animals. They have no

Forest guards grapple with the chaos of a leopard attack in West Bengal, India, in July 2012. The cat mauled six people before it was subdued.

AFP/GETTY IMAGES


GOVT. OF

choice. The two great leopard population centers, sub-Saharan Africa and the subcontinent of India, are among the most populous regions in the world. Human expansion has already cost leopards an estimated 66 percent of their range in Africa and 85 percent in Eurasia, with most of the loss occurring over the past five decades. In many areas the only place left to survive is side by side with humans.

Their adaptability means leopards are entirely capable of living among humans. The question is whether humans can learn to live with them.

Unlike most other big cats, leopards can adapt, up to a point. They can prey, for example, on anything from dung beetles and porcupines to a 2,000-pound eland. They can make a home at 110 degrees Fahrenheit in the Kalahari Desert or at minus 13 degrees in Russia. They can thrive in sea-level mangrove swamps on the coast of India or at 17,000 feet in the Himalaya. That adaptability, combined with a genius for hiding in plain sight, means leopards are entirely capable of living among humans, as they do in Mumbai. The question is whether humans can learn to live with leopards.

WE HAVE A LONG AND COMPLICATED relationship, and like much else, it began in Africa. Leopards are a young species: They emerged in their modern form as recently as 500,000 years ago. Like us, they spread out to populate a large chunk of the globe, from the southern tip of Africa to the Russian Far East, as well as west into Senegal and southeast to Indonesia. They may have shadowed early humans, to take advantage of our ability to drive off lions and other competitors or, later, to pick off our livestock. We may have shadowed them to scavenge on their kills. (They are more vulnerable than other carnivores to scavenging because of their practice of stashing a kill under a bush or up a tree, then wandering off a short distance to rest, returning later to eat.)

By their predatory behavior, leopards imprinted themselves on the genomes of our fellow primates: Even monkeys that have never seen a leopard nonetheless display an instantaneous and heightened attentiveness to that spotted yellow coat. And so do we, with a curious mix of alarm and attraction. Our ambivalence is evident in the jarring mix of headlines that turn up in any news search for the word "leopard." There's often something warm ("Newborn Leopard Cubs Make History, Melt Your Heart"), something violent ("Another Leopard Attack in Junnar"), and something fashionably titillating ("Gisele Bündchen Rocks Leopard-Print Bikini in Costa Rica"). Often the headlines also speak of anger and vengeance.

One day in South Africa's Limpopo Province I visited a cattle rancher, a big, friendly man in his 60s, dressed Boy Scout style in a short-sleeved shirt, green shorts, and green socks, rolled down an inch or two from the knees. He had a King James Bible open on his desk, heavily highlighted, and the skull of a leopard displayed on an end table. The skull had a small, precise bullet hole in it.

"We are very fond of these animals," he began. "It's a beautiful animal! But it's difficult to be on the same land with them. We have lots of natural prey for them—warthogs, baboons, wild pigs, *natural* prey." And yet the leopards insisted on taking his calves.

He opened the studbook in which he registers births and deaths of his Brahman cattle, a prized breed, and began to recite killings—one every six weeks or so over the previous 18 months. His farmworkers learn of a death on morning rounds, when a cow urgently informs them of her loss, and of her need for milking. Later she leads them "straight to where the calf is, half eaten or up a tree." The rancher estimated his loss for each calf at more than $2,000. "We have very experienced trackers,

and they'll say if the leopard is a young female or an older male. Usually the leopard will come back for two days."

The use of trackers—plus that skull on the end table—suggested someone waiting with a rifle to kill the attacker. But the rancher said only, "You live with them, and you keep quiet about them, because if you do anything about them, you are liable to be arrested and put in jail." (South African law permits both jail time and a fine, but sentences are almost always lenient.) Other people kill "hundreds of them every year," he said. "They're shot, stuck in a hole, you put petrol on it, put a match in, and that's it."

Some leopard pelts also end up being sold into a trade that is driven to a surprising extent by the worship of God.

ON A BRILLIANT SUNDAY IN JULY, in the eastern province of KwaZulu-Natal, thousands of religious devotees were making their barefoot pilgrimage to a sacred hilltop, to the blaring of trumpets and the slow thumping of two-liter soda bottles beating bass drums. The single women marched with beaded straps across their bare breasts. The married women, cloaked in black, lifted their black umbrellas in time with the horns. But the men were the real spectacle. By rough count, 1,200 of them passed by with the skins of leopards draped across their shoulders, and in bands around their foreheads, biceps, waists, and ankles.

On the grassy field the men began to dance in unison to the droning music. They looked like a Zulu battle line and moved as if stalking prey, crouching a little, stepping slowly forward, then shooting one leg up and stomping it down, raising a line of dust clouds. For the Nazareth Baptist (or "Shembe") Church, a century-old Christian denomination built on Zulu tradition, the dance is a form of worship and of meditation. Costumes matter too. In the past Zulu royalty wore leopard skins to symbolize power and enthrall their subjects. The Shembe men—accountants, lawyers, bureaucrats, and tradesmen—say that the leopard skins bring them closer to God and to their ancestors.

Cat conservationists, on the other hand, were horrified a few years ago when they stumbled on the festival. One of them called it "the biggest display of illegal wildlife contraband on Earth." The sheer number of skins was bad enough in a country with a dwindling leopard population, estimated at fewer than 7,000 animals. But the skins also need to be replaced regularly, every five or six years, as they become brittle and curled with use. With a growing church membership attending multiple events each year, extinction of the species would be the only real limit on demand.

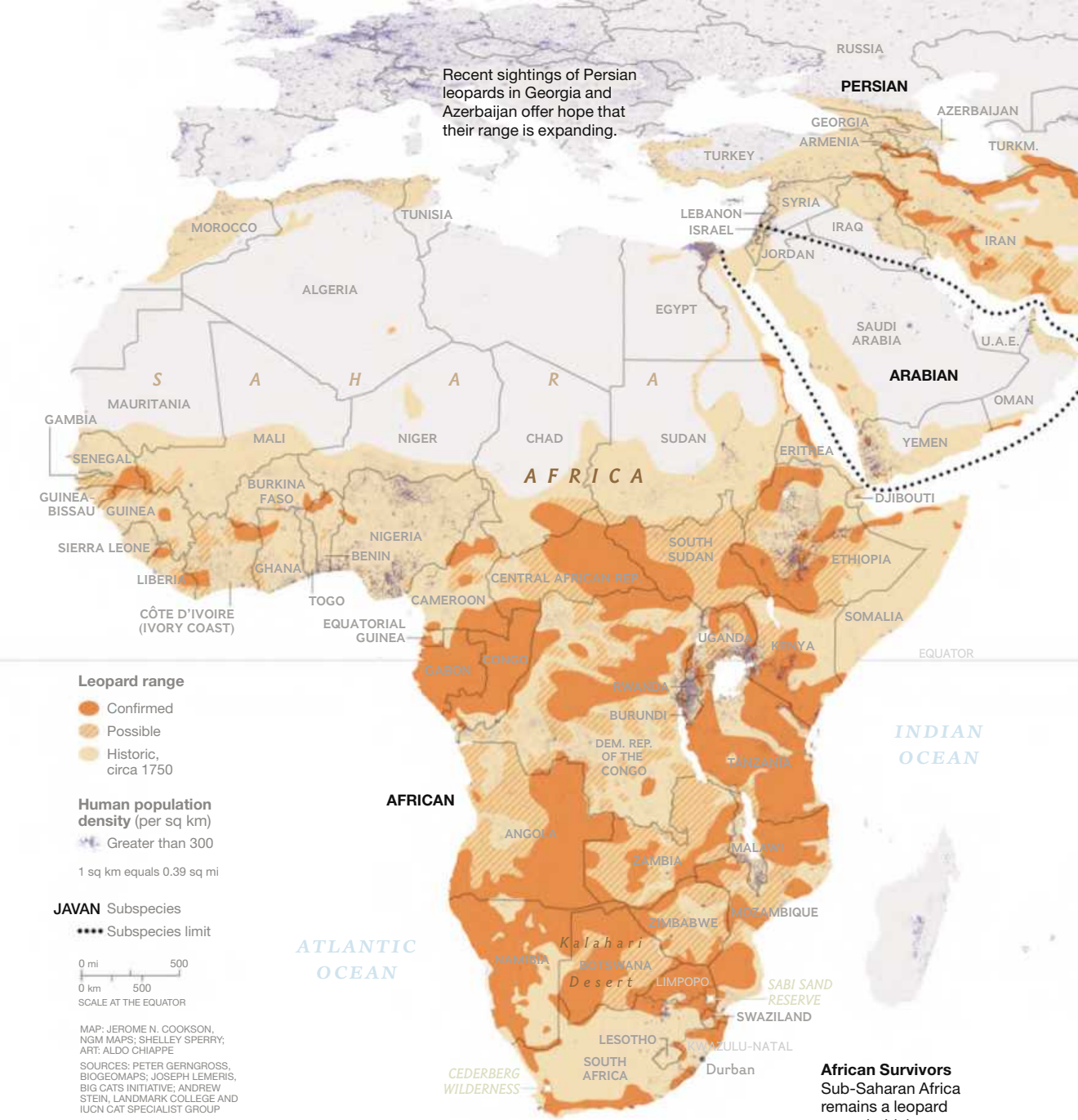
For leopard researcher Tristan Dickerson of the conservation group Panthera, the one hopeful sign at the first pilgrimage he attended was the presence of fakes in the crowd, mostly impala skins ineptly painted with leopard spots. It gave him the idea of making a better fake. He developed a design using a vinyl base and a pile fabric, with the colors matched to a real pelt.

"I'm going for the fake-Rolex effect," Dickerson said. Shembe leaders supported the plan, and a local workshop now produces the fakes under the "Furs for Life" brand. Panthera has distributed 9,000 of them free to church members and can barely keep up with demand.

On the Sunday when I visited, only a single real skin was openly for sale. The price was $390 for a cape made from the leopard's front half, and $425 for the back, serious money in a country where the per capita income is less than $13,000. One man complained that the fakes were a way for white people to thwart Zulu tradition. Another quibbled that a fake based on impala or other animal skins would be more acceptable to the ancestors than vinyl. Even so, most people seemed to want to get their hands on a fake skin. Dickerson calculated that 30 to 40 percent of leopard skins at Shembe gatherings are now Panthera fakes, up from 5 to 10 percent two years ago. It wasn't necessarily a victory for love, or even tolerance, of leopards. But it was one less reason to kill them. *(Continued on page 134)*

Society Grant Your membership helped provide camera traps for this project and training for park staff.

A camera trap set in South Africa's Cederberg Wilderness records the steady gaze of a Cape leopard cub. Though not classified as a separate subspecies, these shy mountain cats are smaller than their savanna kin.



African Survivors
Sub-Saharan Africa remains a leopard stronghold, but resources for counting cats across the vast continent are scarce, and reliable population figures don't exist.

Critically endangered
Endangered
Vulnerable

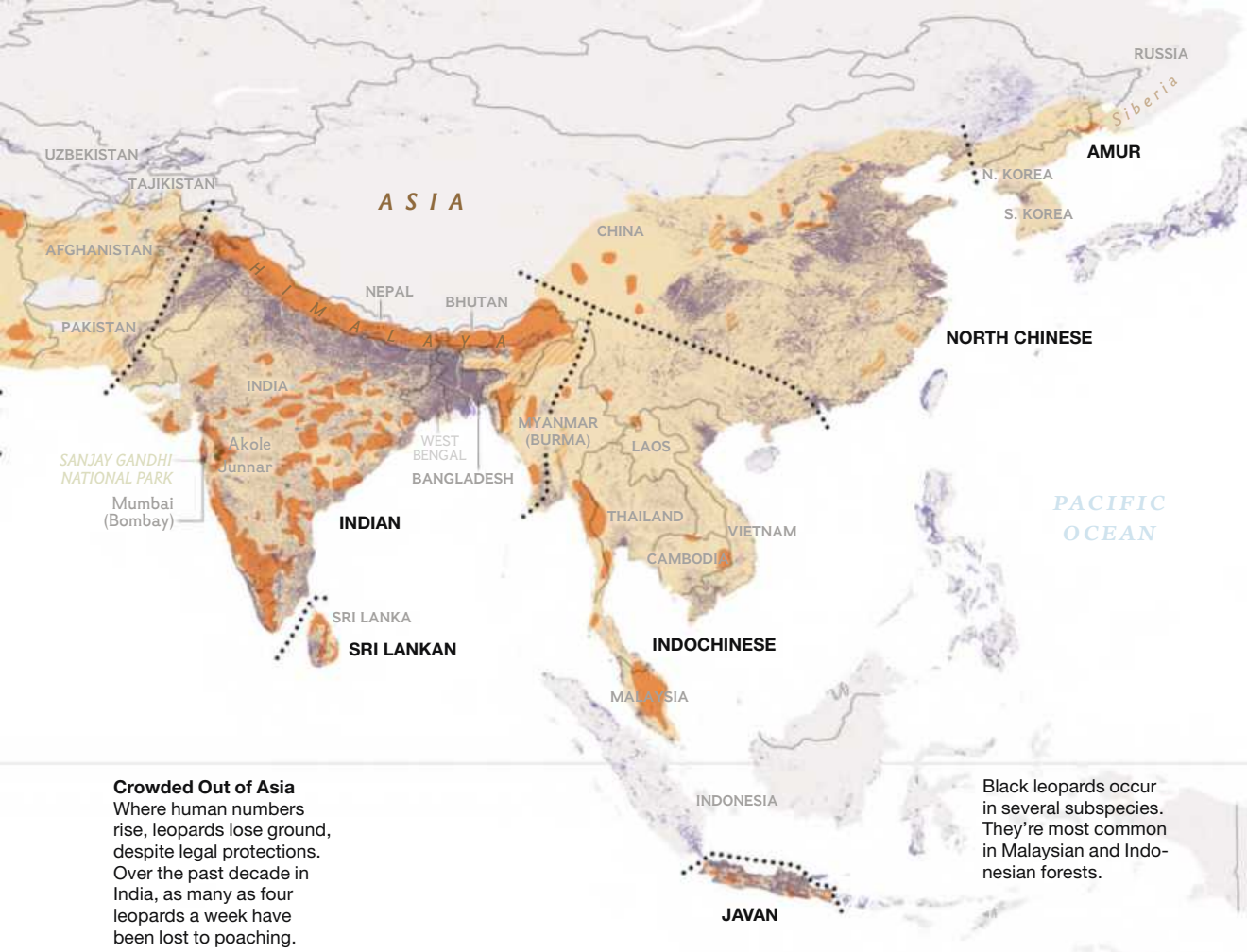
AFRICAN
(Panthera pardus pardus)
Population size: unknown

PERSIAN
(Panthera pardus saxicolor)
800-1,300

ARABIAN
(Panthera pardus nimr)
50-200

SRI LANKAN
(Panthera pardus kotiya)
700-950

Leopard sizes vary significantly even within each subspecies.



Crowded Out of Asia
Where human numbers rise, leopards lose ground, despite legal protections. Over the past decade in India, as many as four leopards a week have been lost to poaching.

Black leopards occur in several subspecies. They're most common in Malaysian and Indonesian forests.

Changing Spots

Leopards are gone from much of their historic range. Burgeoning cities, agriculture, and deforestation have fragmented habitat, and humans with a taste for bush meat are demolishing food supplies. The animals are taken for pelts, trophies, and body parts used in traditional medicine, and they're killed by farmers trying to protect their livestock. Despite these losses, leopards remain the most widespread and adaptable of all big cats. *Panthera pardus* includes nine subspecies, from petite Arabians to robust Africans. (So-called snow leopards are a separate species, more closely related to tigers than to leopards.)

AUSTRALIA

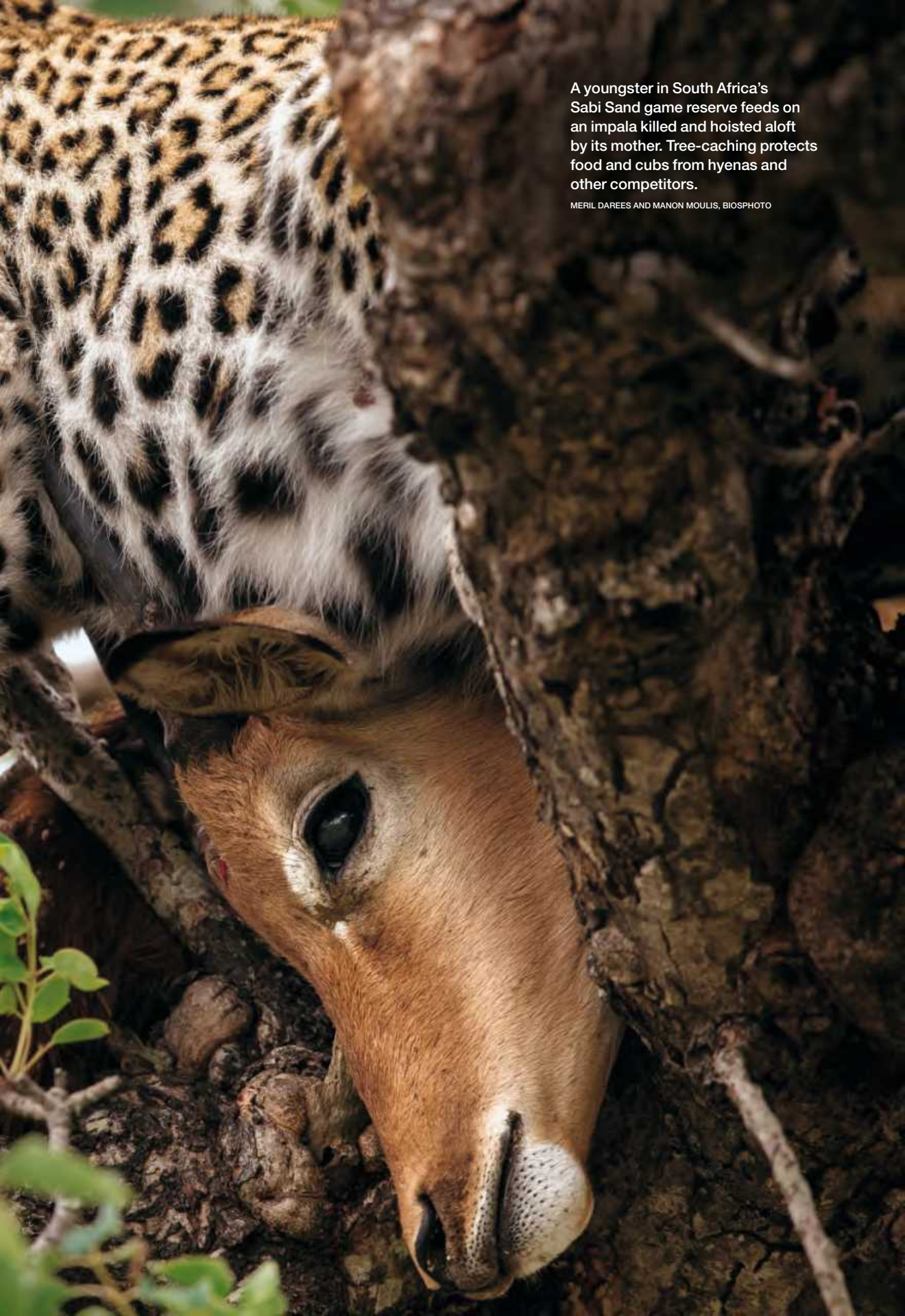
INDIAN
(Panthera pardus fusca)
12,000-14,000

INDOCHINESE
(Panthera pardus delacouri)
Fewer than 2,500

JAVAN
(Panthera pardus melas)
350-525

NORTH CHINESE
(Panthera pardus japonensis)
Fewer than 500

AMUR
(Panthera pardus orientalis)
Fewer than 60



A youngster in South Africa's Sabi Sand game reserve feeds on an impala killed and hoisted aloft by its mother. Tree-caching protects food and cubs from hyenas and other competitors.

MERIL DAREES AND MANON MOULIS, BIOSPHOTO

INDIA MAY BE THE REAL TEST of survival in a crowded world—and perhaps a model for it—because leopards live there in large numbers, outside protected areas, and in astonishing proximity to people. Tolerance of leopards is also generally high, though India (and the British hunter and author Jim Corbett) largely established the term "man-eating leopard" in our vocabulary. It's a misnomer: Women and children are the usual victims when leopards attack; size makes men more challenging. Because attacks often occur when people go into the brush to relieve themselves, men also gain an inadvertent survival advantage from being able to urinate while standing.

It's a puzzle: Much of the time leopards and humans coexist peacefully. So why do sudden violent outbreaks occur in an area such as Junnar?

In any case, attacks on humans are relatively rare. It is far easier to die in India from civilization than from wildness: Nationwide 381 people are killed every day in road accidents, 80 more on rail lines, and 24 by electrocution. But leopard killings get headlines, partly because they are uncommon and also because they touch something primitive in the human psyche.

Late on a Saturday morning in May, in the Junnar countryside, 95 miles east of Mumbai, a government car pulled up at a prosperous-looking little farmhouse. The occasion was horrific and yet polite. On the large veranda in front, surrounded by a waist-high concrete wall and shaded by a metal roof, a crowd waited for the man from the forest department.

Six days earlier, at about 10:30 on a Sunday night, a two-year-old named Sai Mandlik was kneeling on a bench on this veranda and running a toy bus along the top of the wall. His grandmother relaxed on a daybed beside him. In the tall grass 20 or 30 yards away, a leopard spotted something: a head moving back and forth, not much larger than the bonnet macaques that are among its natural prey. It began to stalk. If he was lucky, the boy never saw the leopard that snatched him over the wall and carried him away through the fields. His grandmother screamed. The rest of the family came pouring out into the night. They were too late.

Now the tragedy was being reduced to ritual. The women sat silently on the floor at the far end of the porch. Local officials, old men in white Gandhi caps, sat in mid-porch, and at the other end of the porch, the father sat on the spot where his son had been taken, with male family and friends huddled around him. The forest official introduced himself ("I am also from a rural area; I am not somebody coming in from above") and explained that he did not mean the compensation payment, about $12,300, as a substitute for their loss but as an acknowledgment from the government, which is responsible for the leopards. One of the local officials came to inspect the check, and they engaged in a cordial dance, with each of them saying the other should present it.

The family made a few small requests, and the forest official said he would try to help, and then it was over. Four miles down the road there was another house to visit with much the same story. When such leopard attacks occur, they tend to come in terrifying waves. Sai Mandlik's death was the third attack in the Junnar area in just over two weeks, and the second fatality.

It's a puzzle: Much of the time, even in Mumbai, leopards and humans coexist peacefully. So why do sudden violent outbreaks occur in an area such as Junnar? The morning after the presentation at the Mandlik house Vidya Athreya, a biologist with the Wildlife Conservation Society, sat beside a sugarcane field in the nearby town of Akole. On her laptop computer a map of the community was lit up in great turquoise splotches representing all the places she found leopards during her five-year study here, using camera traps and radio collars. In short,

On the night of July 15, 2012, a leopard killed a seven-year-old girl in Sanjay Gandhi National Park. Gathering in numbers in well-lit areas may help nearby villagers feel safe outdoors after dark.

she found them everywhere, 11 adults roaming by night in and around Akole, an area with no forests and no deer or other big, natural prey and where 20,000 people move around by day.

The first question was, Why so many leopards? As elsewhere in India, it begins with reliance on open trash and meat market dumps, which support a thriving community of stray dogs, feral pigs, and other small animals. Federal law and an influential animal-rights movement prevent removal of street dogs. So the dogs and other domestic animals in turn support a thriving community of leopards. (They made up 87 percent of the leopards' diet in Athreya's study.)

Irrigation schemes introduced since the 1980s also help attract leopards. Among other crops, sugarcane is now common in formerly dry areas such as Akole and the Junnar region, and this tall, thick grass provides a perfect hiding place for leopards—close to villages, garbage heaps, and dogs. It is an ecosystem.

ONE DAY DURING HER RESEARCH, Athreya said, she passed by a field where 15 women were picking tomatoes, and stopped to chat with a farmer. Oh, yes, the man said, he'd seen a leopard only a few days before. She didn't tell him that a leopard was resting in the sugarcane at that moment,

On a hill overlooking Mumbai a man-made water hole attracts one of an estimated 35 leopards living in and around Sanjay Gandhi National Park.

A cub just six to seven months old roams along the fence that separates the leopards of South Africa's Sabi Sand game reserve from villages and land where livestock graze.

just 65 feet away. They had no cause for concern. "Leopards are not as bloodthirsty as we think," said Athreya. "They are reasonable at some level." Anthropologist Sunetro Ghosal, who has also worked in Akole, described "a history of sharing space" and even "mutual accommodation," leopards and humans alike going out of their way to avoid confrontations. (Possibly as a form of insurance, people in the region treat leopards and tigers as gods, or *waghobas,* and make propitiatory offerings at small waghoba shrines.)

To understand where the human-leopard relationship goes awry, Athreya investigated a rash of attacks that occurred in the Junnar region from 2001 to 2003. In what seemed at first to be a coincidence, the forest department had been trapping leopards, more than a hundred of them, from problem areas in Junnar, mainly after attacks on livestock. Those animals got released in forests an average of 20 miles from the capture sites—a common technique for dealing with problem carnivores worldwide. But after the relocations, Athreya and her team discovered, attacks on humans in Junnar increased by 325 percent, and the percentage of those attacks that were fatal doubled.

"It was a typical case of the messed-up mind of a cat," Athreya said. Messed up, that is, by

the trauma of being caught in a box trap, handled by humans, and dumped in an unfamiliar landscape and in territories already occupied by other leopards. The outbreak of attacks wasn't, after all, a result of the leopards' innate ferocity, according to Athreya and her co-authors: "Translocation induced attacks on people."

Forest department managers generally got the message when Athreya first presented her research a decade ago. Sanjay Gandhi National Park in Mumbai stopped allowing itself to be used as a dumping ground for relocated leopards. (Like Junnar, it was also experiencing an outbreak of deadly attacks.) The city's media took up the idea that relocations were more dangerous than the leopards. Workshops for apartment dwellers around the park, and for residents of slums inside the park borders, began to promulgate the larger idea that merely seeing a leopard in the neighborhood does not constitute "conflict." Removing leopards—the first thing city dwellers often demand—disrupts the social system and opens the territory for new leopards that may be less experienced at the tricky business of "mutual accommodation." The workshops also emphasized the human side of mutual accommodation, including basic precautions like keeping children indoors at night. (Larger public health measures would also help, including garbage removal, provision of toilets, and removal of street dogs, but economic and political factors often put them out of reach.) The abiding message was that leopards in Mumbai, Akole, and other areas are not "strays" or "intruders." They are fellow residents.

Living by these ideas has not, however, always been easy. This is especially so for forest department rangers who show up in the aftermath of a leopard attack, and find themselves besieged and even beaten by enraged residents demanding action. They also come under pressure from local politicians. So the traps still come out, to give people the illusion of something being done, of safety, even if the actual result is to increase their danger. A few "problem" leopards end up being warehoused at crowded "rescue" facilities around the country, though there is in fact no way to identify a problem animal, short of catching it with its victim. A scapegoat will do.

Thus soon after the latest killings in Junnar, a forest ranger there emailed me: "Glad to inform you that we trapped a male leopard." He identified it flatly as "the same leopard which attacked a boy last month." It would spend the rest of its life at a "leopard rescue" facility in Junnar, which was already close to capacity, with 28 leopards. Most of the other leopards being caught in traps inevitably would be released, though for obvious reasons the forest department would not disclose how many leopards it was releasing in Junnar, or where. Two weeks after that, another leopard killed and dismembered a 60-year-old woman at a farm a few miles from where Sai Mandlik died.

I LEFT INDIA THINKING that what I had seen of leopards there was a messy, difficult business, far removed from the way people live in more developed countries. Then I arrived home to an unverified report of a mountain lion four miles from my home on the Connecticut coast, followed by news of a black bear in the nearby city of New Haven. Mountain lions now roam through Los Angeles, coyotes in Chicago, wolves on the outskirts of Rome, great white sharks off Cape Cod. As human populations expand and we make the Earth more urban, other carnivores also seem to be adapting and learning to hang on in our midst. This can be unnerving, but it's not necessarily a bad thing: Studies have repeatedly shown that healthy predator populations are essential to the health of almost everything else. If they are not gods, they are at least the great drivers of ecosystems.

Gradually, the Indian experience of leopards began to seem less like an otherworldly exception and more like a foreshadowing of how all of us may soon be learning to live. □

National Geographic's **Big Cats Initiative** is dedicated to halting the decline of wild felines around the world. Learn more at **causeanuproar.org.** **Nat Geo WILD**'s week of exotic felines premieres on November 27 with *Cougars Undercover* at 9 p.m. ET.

Remnants of a Failed Utopia

By **RENA SILVERMAN**
Photographs by **DANILA TKACHENKO**

Sometimes, as he traveled through former Soviet territories, photographer Danila Tkachenko waited days or weeks for the right amount of snow. To capture his vision of the abandoned spaceports and oil field pump jacks littering the land, "I needed a lot of snow falling," he says. "This created a special atmosphere in the photographs, a kind of ...very diffused light."

Other times, gusts whipped snow into blinding blizzards, obscuring what Tkachenko was determined to document: buildings, hardware, and monuments that once stood as symbols of progress and now were purposeless, rusting against the sky. To Tkachenko, these relics looked like "a metaphor of a postapocalyptic future." From 2012 to 2015 he spent months photographing them for a project he called "Restricted Areas."

The name came from the location where Tkachenko began work on the series. In 1957 a nuclear-waste tank exploded at a plutonium production facility, spewing radiation over a large area. The Soviets tried to keep the accident secret as they dealt with the contaminated villages. One was Ozyorsk, where residents were allowed to stay but entry was restricted to those who had a pass or had relatives living there.

Tkachenko's grandparents both lived in Ozyorsk until 2007, when his grandfather died from what the family says were the long-term effects of radiation. "This story, this fatality of progress, inspired me," Tkachenko says. Since his grandmother still lived there, he visited the restricted city in 2012 and took photographs.

Shooting in Ozyorsk prompted Tkachenko to look for other sites and structures that symbolized an abandoned

The Soviets made prototypes of the Bartini Beriev VVA-14, an amphibious aircraft, to use against U.S. Navy submarines, but they never mass-produced it. Photographer Danila Tkachenko added it to his gallery of "gigantic constructions" that failed.

march toward progress. He researched, pinpointed, and traveled through three former Soviet republics and Bulgaria to photograph "utopian gigantic constructions, which were left unfinished, or failed."

South of the town of Kazan, Russia, he photographed the decaying cruise ship *Bulgaria.* In July 2011, in a sudden storm, the boat sank in the Volga River, killing more than 120 people, many of them children. It had been raised from the bottom and towed to a riverbank for an investigation. There it remains, with a memorial nearby.

Tkachenko also visited a monument dedicated to "warrior liberators," near the city of Voronezh. It was placed next to a nuclear plant in a bid to raise the spirits of employees, he was told. But construction was never completed; the plant never opened.

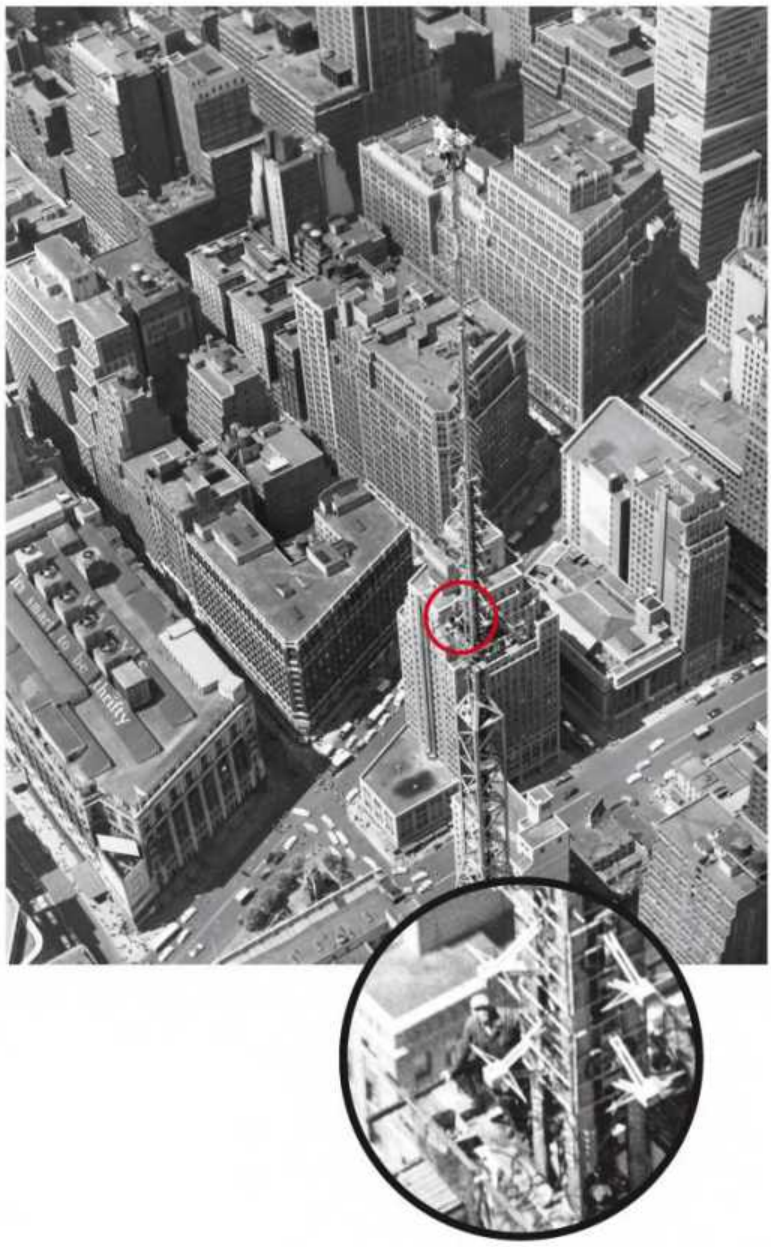
Tkachenko, 25, says he had no problems with security while photographing the sites. But his trips were not without risk, such as the chance of being exposed to radiation or being injured while exploring crumbling structures.

His project's message is less about the failures of the former Soviet Union than about the failures of technology as a whole, Tkachenko says: "One can't stop questioning the general thought that progress always serves the good of humanity." ☐

Diligent research led Tkachenko to forgotten places such as the tropospheric radio relay link near the town of Salekhard, in the Yamalo-Nenets Autonomous District. It was built to extend radio transmissions to distant areas of the U.S.S.R.

The abandoned large-scale relics that Tkachenko photographed include (clockwise from top left): the once sunken cruise ship *Bulgaria,* in the Republic of Tatarstan, Russia; a monument honoring "warrior liberators" near Voronezh, Russia; a former cultural center in Russia's Republic of Komi, on land later used as a bomb testing range; and a stadium-size monument built on Bulgaria's Mount Buzludzha as a tribute to socialism. Now closed and heavily vandalized, the monument is a "very surrealistic object," Tkachenko says.

In the mountains near Almaty, Kazakhstan, Tkachenko visited a Soviet-era observatory. Once deemed a prime spot for celestial observation, it's now abandoned. Arriving at these places, Tkachenko says he always feels "a bit afraid, or at least not very comfortable, though at the same time curious." It's "as if you suddenly are on another planet and see the remnants of some failed civilization."



Walking the Sky

There's a sameness to many big cities: rows of skyscrapers, blocky facades, geometric rooftops. What hints that this 1951 publicity photo is of New York City? In the center is a television antenna tower being built atop the Empire State Building. And midway up it, as if there's no more natural perch in the world, is a Mohawk Indian ironworker.

In the late 1880s a Canadian bridge company hired several Mohawks—residents of the Kahnawake reserve near Montreal—for a construction project. Tribe members proved to be fearless at great heights and, in a company official's words, "as agile as goats." That lofty reputation brought more offers of work in the United States; today Mohawks still commute from Canada for "high steel" jobs.

Over the past century generations of Mohawk ironworkers have toiled on virtually every skyscraper and bridge construction project in New York City. For their surefooted poise on steel beams at dizzying heights, they've earned a reverent nickname: "skywalkers." *—Patricia Edmonds*

PHOTO: PUBLICITY ASSOCIATES, NEW YORK CITY/NATIONAL GEOGRAPHIC CREATIVE

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