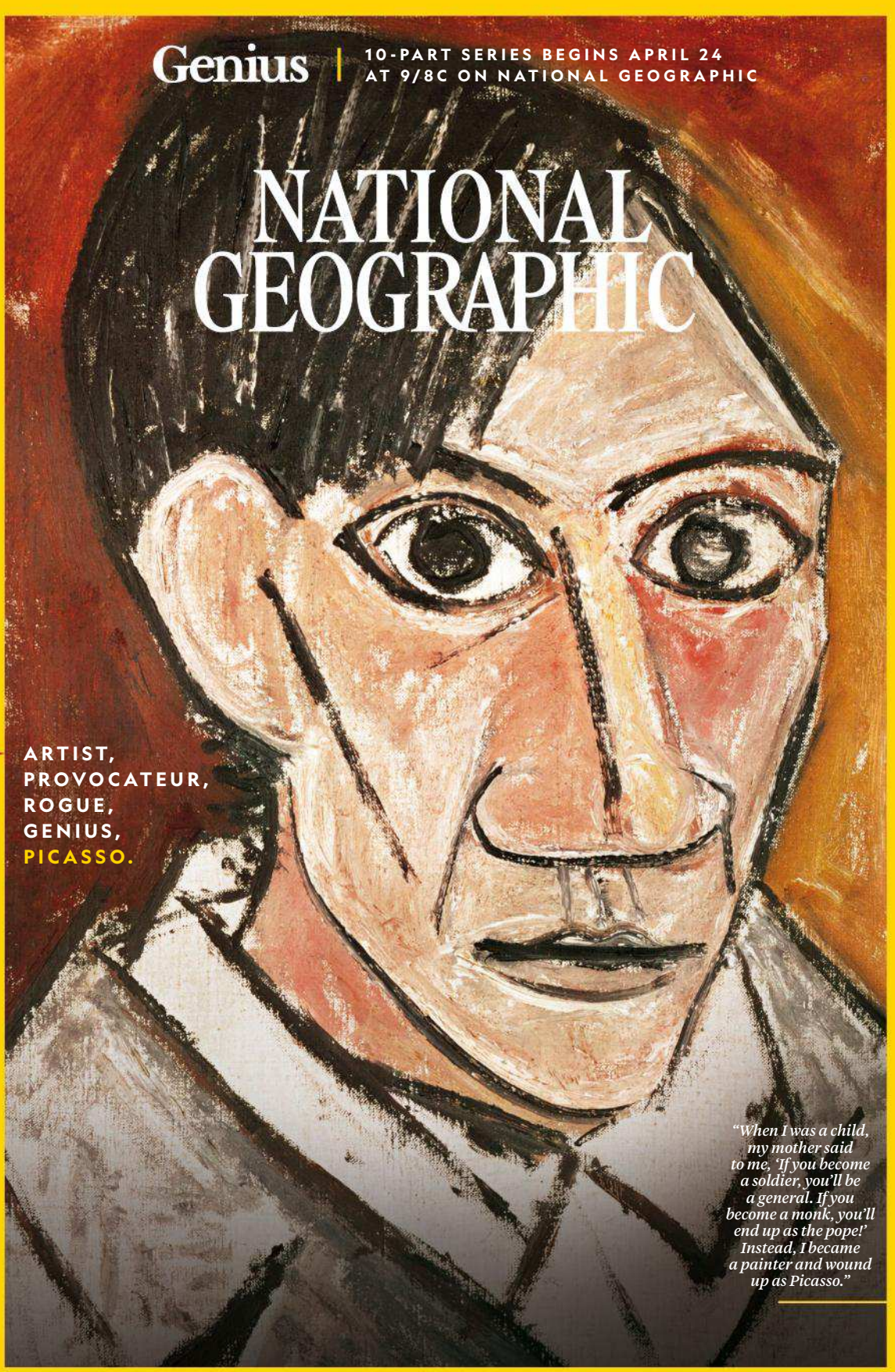
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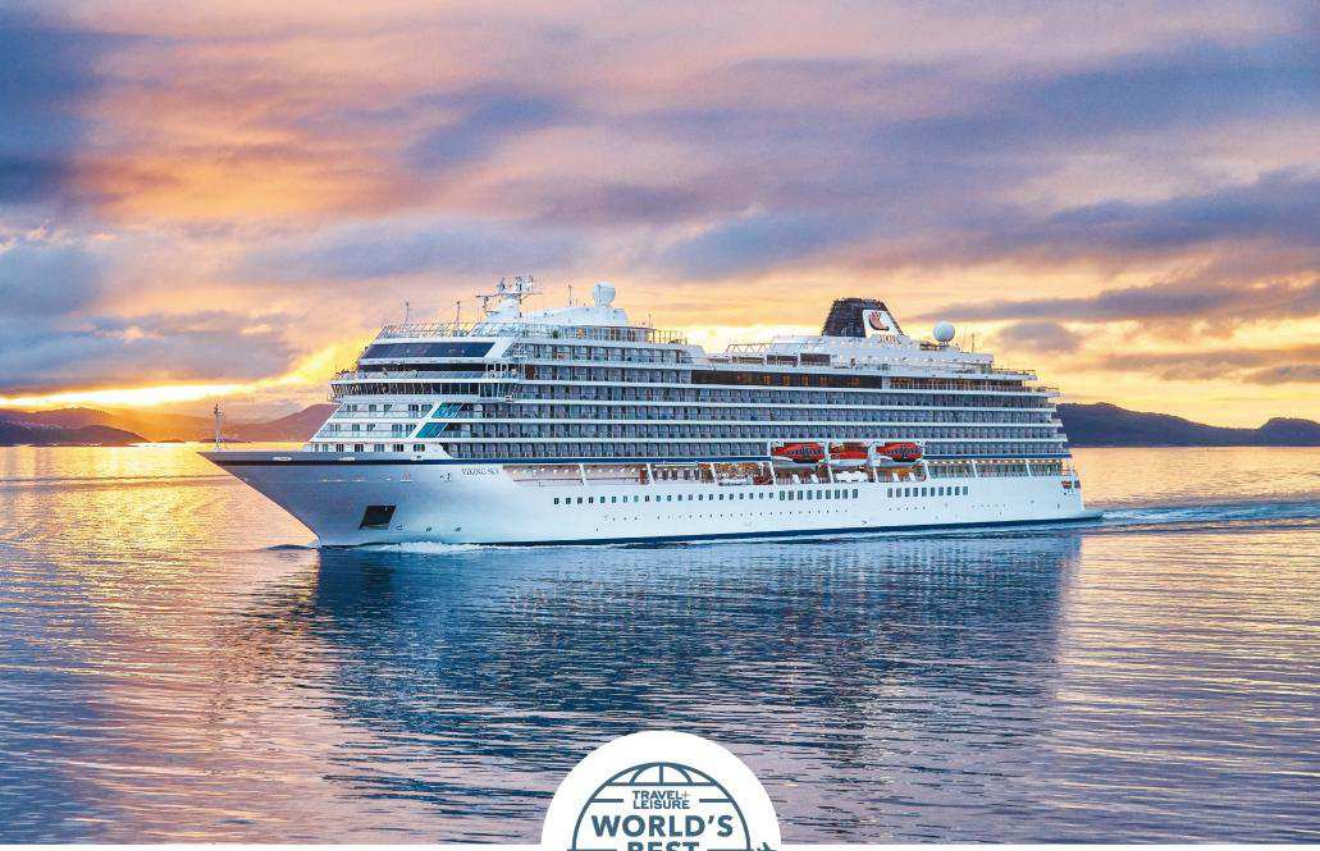

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A NEW 'GENIUS' SEASON

The Unorthodox Artistic Genius of Pablo Picasso

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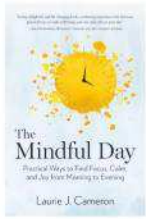

BOOKS

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TELEVISION

Travel Around *The Mighty Northwest*

Sample the many sights of America's Pacific Northwest, from Earth's tallest trees to glaciers, volcanoes, and wildlife. The five-part series airs Fridays at 10/9c from April 27 to May 25 on National Geographic.

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PHOTO: DUSAN MARTINCEK, NATIONAL GEOGRAPHIC

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TODAY, UNDER THE STARS, I LEARNED I COULD GO ANYWHERE.

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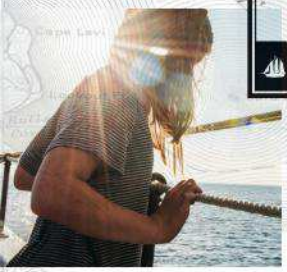
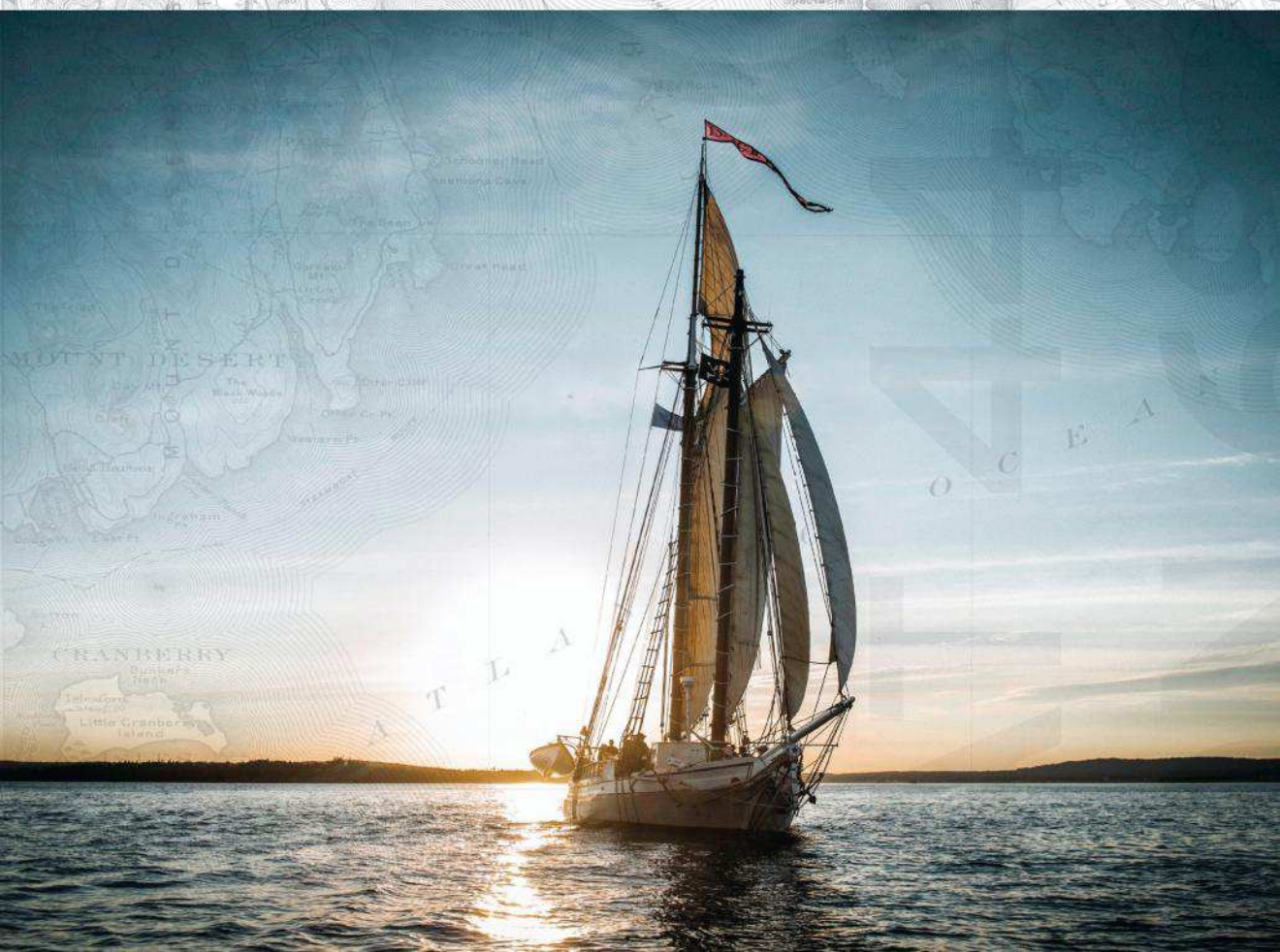


JOURNEY | NO.56 | MIDCOAST REGION

At sunset, after a day of sailing, I had no idea where we were. So I asked the captain. He unrolled a huge paper map, which seemed a little old-timey but I was curious. He called it a nautical chart. Then he weighed down the edges with funny smelling lanterns and my dad said, "No batteries. Just good old kerosene." He is such a nerd. The captain traced our route with his finger. We could have gone anywhere, but here we are. This is me.



REDESIGN

Welcome to Your New National Geographic

BY **SUSAN GOLDBERG** EDITOR IN CHIEF

YOU'LL PROBABLY FEEL the redesign of *National Geographic* magazine before you see it. Did you notice the heavier paper on the cover and the more luxurious touch of these pages? We hope so. They're just two of many changes introduced in this issue, to bring you a better way to read the most compelling and visually stunning stories in the world. In its 130th year, this magazine is beloved by intellectually curious people around the globe—so we took care in updating it. Please tell us what you think of the changes; our email is editor@natgeo.com. And as ever, thank you for reading *National Geographic*.

WHAT WE'VE CHANGED

New front sections
Three distinct sections in the front of the magazine are densely packed with accessible information. **Proof** is a story told through photography. We wanted to start with what this publication does best: visual storytelling. **Embark** addresses timely topics. It kicks off this month with an essay on sexual harassment in the sciences. **Explore** illuminates the world's wonders. New elements include "Atlas," a story told through maps, and "Through the Lens," the backstory of a single, memorable photograph.

Even more emphasis on visual storytelling
Instead of four or five feature stories of roughly the same length in each issue, we're mixing it up. Look for several shorter, visual features rich with illustrations and photos; two traditional-length stories with the deep, global reporting and imagery that are our hallmark; and one major, marquee package, which this month focuses on Muslims in America. This look at the nation's most misunderstood religious group showcases revealing, moving photos by Lynsey Addario and Wayne Lawrence.

A bolder design and new typefaces
You'll notice a more muscular, modern design, with new typefaces that let our headlines better reflect the stories. Check out **Earle,** named for famed National Geographic Explorer-in-Residence Sylvia Earle. It's modeled on a typeface the magazine used in the 1970s; you'll see it in the Muslims story. Also look for **Marden,** named for photographer and explorer Luis Marden, which sets the mood for our story about Picasso; and for **Geograph,** used across our products and platforms.

WHAT WE HAVEN'T

Our core principles—and body type
In my previous life as a newspaper editor, I learned to never change the comics (who knew "Marmaduke" was so popular?) or the main typeface for stories. So we're keeping the same **Grosvenor Book** body type that we've used for years. And we're also keeping what's most important: We haven't changed—and won't change—three principles that underlie all that we do. We are on the side of science, on the side of facts, and on the side of the planet.

SEE THE CAT SHE WAS BORN TO BE

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PROOF

PHOTOGRAPHS BY **NORA LOREK**

NATIONAL GEOGRAPHIC

LOOKING AT THE EARTH FROM EVERY POSSIBLE ANGLE

WHAT THEY CARRIED

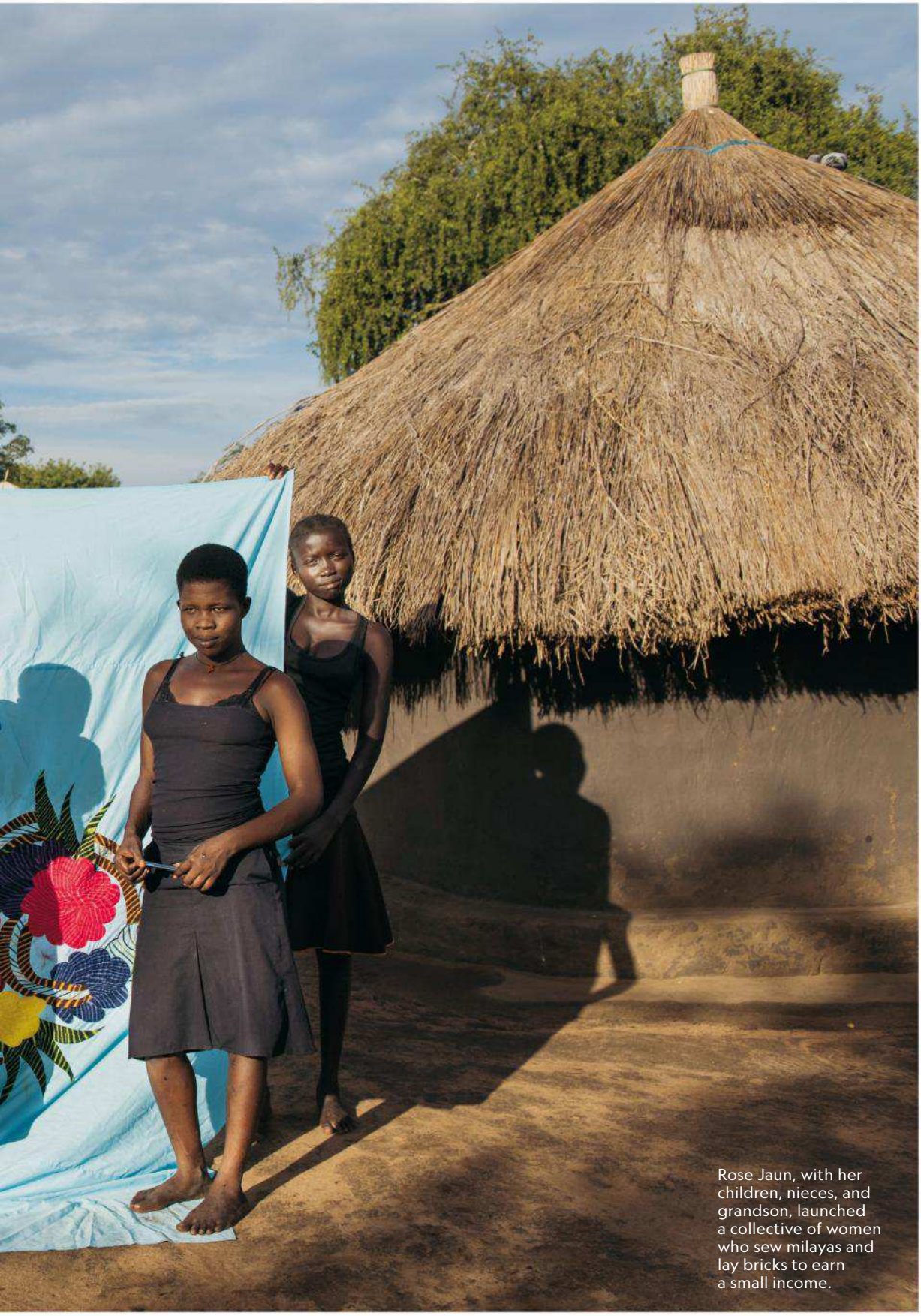
For refugees, sometimes a bedsheet is all that remains of home.

VOL. 233 NO. 5

Irene Sonia poses in front of a *milaya,* or bedsheet—one of the few things her mother managed to bring when they fled South Sudan for Uganda.

Viola Kide, 22 (center), walked from her home in South Sudan to the border of Uganda, carrying a milaya with her on the two-week journey. She doesn't know if her mother, father, and brothers managed to escape.

Clockwise from top: Angelina Nyakum, 27, and her daughter; Esther Minella, 46, a member of her section's council; Angelina Nyanuba, 25, and two of her children; Grace Monia, 13, with her foster mother's milaya.



Rose Jaun, with her children, nieces, and grandson, launched a collective of women who sew milayas and lay bricks to earn a small income.

THE BACKSTORY

WHEN WAR RETURNED, HUNDREDS OF THOUSANDS OF SOUTH SUDANESE LEFT HOME WITH ONLY WHAT THEY COULD CARRY.

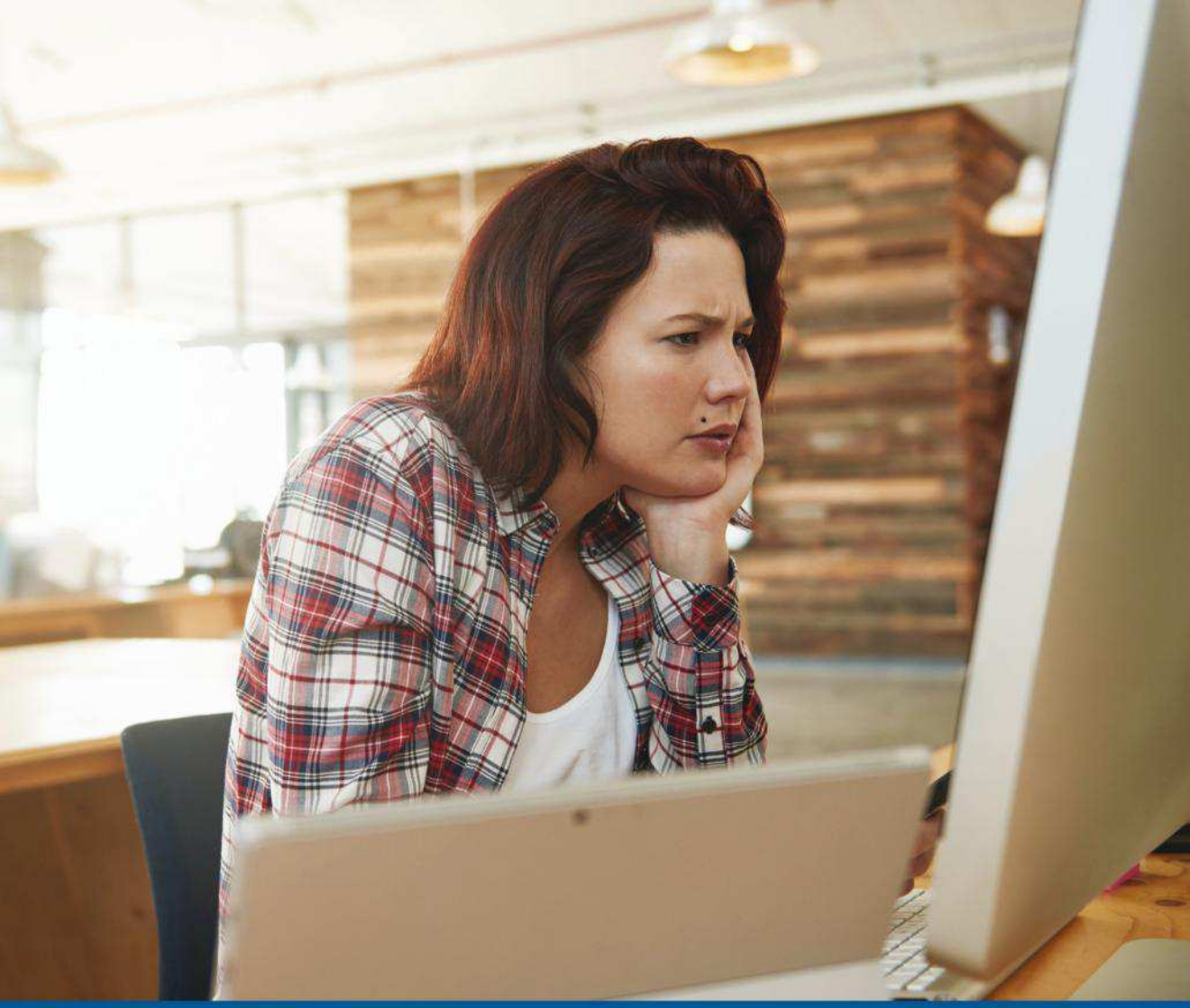
ON HER FIRST DAY in the sprawling South Sudanese settlement of Bidibidi in Uganda, home to almost 300,000 refugees, Swedish-German photographer Nora Lorek approached a woman and asked what she'd brought from home. "Nothing," she replied, "except for some clothes wrapped in my bedsheet." Lorek scribbled, "bedsheet???" in her notebook.

In 2011, South Sudan became the world's newest country. Soon after, in 2013, it plunged into civil war. When a peace deal fell apart in 2016, more refugees streamed across the border into Uganda, where they're allowed to work, farm, and go to school. For some it was their second, third, or fourth time fleeing home. In August 2017 the millionth refugee arrived, stretching the neighboring country's hospitality.

When Lorek asked around about the sheets, Bidibidi's residents pulled out their *milayas:* cloths covered in ornately sewn birds, flowers, and designs. The women had learned to make them from their mothers and grandmothers. The sheets covered beds, hung on walls, and were often included in dowries.

For many refugees, the milayas are the only thing left from home—and a means to make a meager living. Rose Jaun, 38, started a collective for women in Bidibidi to sew and sell milayas. "It gives us time to talk and share thoughts, and an income," she told Lorek. Sixty women produced two a week until a fabric shortage slowed them down.

Women in the settlement take care of their own children and often foster others. In many cases, their husbands were killed or stayed behind to fight or protect their land in South Sudan. After multiple failed attempts by both sides to maintain peace, going home feels like a distant hope for refugees. One mother told Lorek, "We're staying here on our own because there's no way of going back without peace." —NINA STROCHLIC



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THE DISCOVERIES OF TODAY THAT WILL DEFINE THE WORLD OF TOMORROW
NATIONAL GEOGRAPHIC | VOL. 233 NO. 5

Rid the Sciences of Harassers

THANKS TO #METOO, SEXUAL HARASSERS IN MANY FIELDS HAVE LOST THEIR JOBS—BUT WHAT ABOUT THE SCIENCES?

BY **KATHRYN CLANCY**

I HAVE WATCHED THE #METOO campaign as avidly as anyone. I have gone to bed each night wondering who will be outed as a sexual harasser in the morning, whether it will be another one of my political heroes or someone we all recognize from mainstream media or Hollywood. We've seen many of these perpetrators lose jobs, be forced to resign, and face economic difficulty because of their abhorrent behaviors.

But I have not gone to bed a single night in all these months wondering what scientist would be sacked in the morning because of his transgressions—let alone be publicly outed—because scientist-harassers rarely lose their jobs.

Allow me to explain. For the past six years I've conducted research on sexual harassment in the sciences and worked to raise awareness of it. I've surveyed more than a thousand people, conducted dozens of interviews, and collaborated across multiple disciplines. I've given lectures and delivered

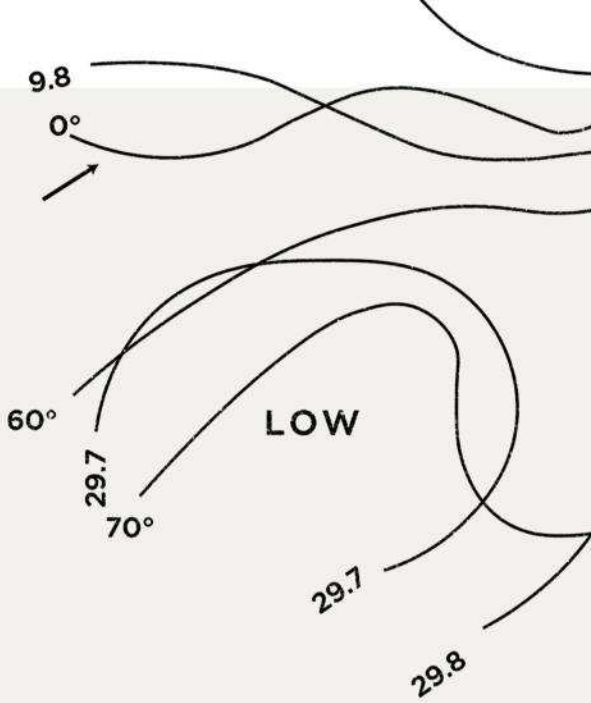
I HAVE NOT GONE TO BED A SINGLE NIGHT IN ALL THESE MONTHS WONDERING WHAT SCIENTIST WAS GOING TO LOSE HIS JOB—BECAUSE SCIENTIST-HARASSERS DON'T LOSE THEIR JOBS.

congressional testimony on the topic. Here's what the research shows:

- In our samples both sexual harassment and sexual assault were reported by more women than men—mirroring the situation in society at large.
- Women's experiences of sexual misconduct during scientific fieldwork were not just quantitatively higher but also qualitatively worse than men's. Women victims were more often targeted by perpetrators above them in the hierarchy and felt they could not fight back or say no. Few individuals had any awareness of a sexual harassment policy or reporting mechanism; even fewer dared report their experiences.
- Scientists who are harassed face significant career consequences, ranging from having to make lateral career moves to not feeling safe enough to attend professional events—or even stay in the field.

Too often the story is the same: A man sexually harasses a woman, the woman reports it, and she gets told that's just how it is. There are variations on this theme: women harassing women, people harassing those they don't think conform to their gender well enough, women of color receiving a toxic blend of racial and gender harassment. Want a story of women being mocked when they need to urinate and being body shamed if they eat dinner? I've got one of those. How about a man who has a mistress that students at his field site have to keep secret from his wife and kids at home? I've got a few of those. Nearly every person of color and white woman I spoke to for an astronomy and planetary science project had stories of being told by their colleagues that they were the affirmative action hire, the implication being that their science was no good.

In the past few years brave scientists have come forward to share their experiences: Several high-profile academics were accused of sexually harassing students or colleagues, were investigated, and then were put on leave or forced to step down. We know the names now: Geoff Marcy, Brian Richmond, David Marchant, Christian Ott, among others (right). These men were allowed to flourish while their victims struggled. Even after their abuses were reported, after their stories were made public, it took an



Investigations of Misconduct

Astronomer Geoff Marcy was allowed to resign in 2015 from the University of California, Berkeley after an investigation concluded that for roughly a decade he had subjected students to unwanted sexual contact.

Paleoanthropologist Brian Richmond resigned from the American Museum of Natural History in December 2016, ending a series of investigations into sexual-misconduct claims lodged by multiple women over several years.

Boston University's investigation of **geologist David Marchant** concluded that he sexually harassed a graduate student during fieldwork in Antarctica; Marchant is appealing the November 2017 ruling.

A California Institute of Technology investigation found that **astrophysicist Christian Ott** subjected two students to "unambiguous gender-based harassment." He was suspended in fall 2015 and resigned in December 2017.

ILLUSTRATION BY CRISTIANA COUCEIRO. ORIGINAL IMAGES: GLOBALP/ISTOCKPHOTO; FERGREGORY/ISTOCKPHOTO; 3DSCULPTOR/ISTOCKPHOTO; TOMMASO TUZJ, GETTY IMAGES; CFRANKE CFRANKE/GETTY IMAGES; CC0 CREATIVE COMMONS; JOELENA, ISTOCKPHOTO; NATIONAL ARCHIVES; *THE CLIMATE AND WEATHER OF BALTIMORE* (1907)

WHEN ILLUSTRATOR Cristiana Couceiro looked through stock photos of scientists, the images of men looked "credible and real," while the depictions of women were "flirty and sweet." That feeds a mind-set that promotes sexual harassment, Couceiro reasoned. So she designed this illustration to project "a feeling of fighting back." Although it's surrounded by threats and pressures represented by symbols of the sciences, the womanly mouth "is tired of the silence," Couceiro says. "It's finally screaming all the things that were kept quiet for so long."

interminably long time for them to face any repercussions. And perhaps more importantly, it was rare for the victims to get the resolution they deserved.

In the sciences a true reckoning about sexual harassment faces a number of roadblocks. The first is the myth that these perpetrators, mostly men, have exceptional abilities to offer science. Next is the idea that repercussions for the perpetrator may trickle down to his trainees, so we should avoid any consequences at all (I hear this one in particular when the perpetrator has a lot of federal funding). Finally, the way most universities interpret the legal definition of sexual harassment makes it hard for victims' claims to prevail—so at the end of an exhausting investigation, many still have to endure a hostile workplace environment.

Let's take these on one by one.

Are people who engage in sexual misconduct actually making scientific advances that would not be made without them? I'd say it's more likely that swifter, greater advances would have occurred if there were fewer perpetrators limiting opportunities for their victims. When part of your brain has to be occupied with workplace stress—from unwanted sexual advances to witnessing abuse between colleagues—you have less to give to your science.

If we punish these perpetrators, especially by taking away their funding, won't their trainees suffer? I wonder how many grad students would be better off, relieved of the pressures of working for a predator. As federal funding agencies grapple with this problem, they have begun to figure out solutions, such as assigning a new principal investigator if the original one can't continue. It doesn't kill the project or leave students and staff out of their jobs. Removing the perpetrator from a project also saves the pedigree of the trainees; few want their published work tainted with the name of a known sexual harasser.

The last concern is the trickiest: Why don't we do anything when we know about the perpetrators in our midst? So far, consequences for scientist-harassers are few and far between. In academia it's common to get sanctions like "no more female grad students" or "no more undergraduate teaching" or "please work at home for now." These are mild punishments at best, but departments are unsure what other options they have—and universities don't make it easy to fire professors. The institutions know that perpetrators generally have more resources than victims and are more likely to sue if they are fired. It is a good financial decision, then, to do nothing about a perpetrator, even if they are guilty.

WE COULD SETTLE FOR GETTING RID OF ONLY THE MOST EGREGIOUS, THE HARVEY WEINSTEINS OF OUR PROFESSION. OR WE COULD TAKE THIS OPPORTUNITY TO SET REAL CHANGE IN MOTION.

So this is where we find ourselves today: In many professions sexual misconduct is now cause for dismissal. In the sciences, not so much. What's more, many science workplaces use legal definitions of sexual harassment to set the standard for workplace conduct. If that is the bar that has to be met for a disgusting behavior to be considered actionable by a university, research institute, or field station, it is a high one. An enormous range of disrespectful and even frightening behavior can slip under that bar, even though it damages the careers of victims and bystanders, holding back scientific advancement.

Here's the real question for scientists today: What's the culture we want to create? We could settle for getting rid of only the most egregious, the Harvey Weinsteins of our profession. Or we could take this opportunity to define problem behaviors more clearly. Let's make it unacceptable to behave with bias toward gender, racial, and sexual minorities. Let's make it OK to call out those who use their rank to overpower and exploit, rather than to encourage and mentor.

My research suggests how we can set this change in motion. When the leaders of science workplaces sit down with their workers and trainees to create a code of conduct, and then enforce it with real consequences, the result is less harassment—and better resolution for victims when harassment does occur.

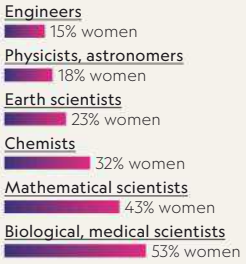
If we really want a meritocratic space where the most interesting, insightful, and life-changing science gets done, we must build a culture that makes room for more types of people. To tackle the complex challenges of the 21st century, we'll need every scientist's best work. That will happen in the best workplaces.

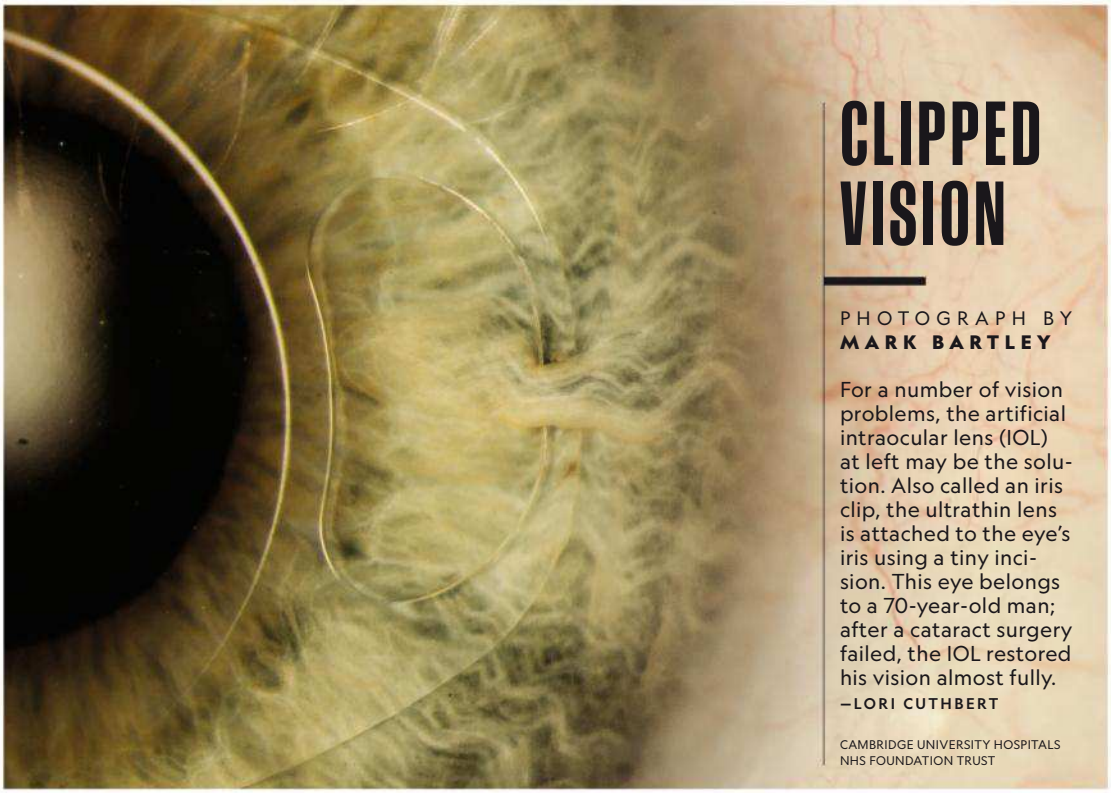
Kathryn Clancy (@kateclancy) is an associate professor of anthropology at the University of Illinois.

Gender and jobs

Women accounted for half the United States' college-educated workforce in 2015 but only 28 percent of workers in science and engineering occupations. There was rough gender parity in some science and engineering fields, but many remained disproportionately male.

SOURCE: NATIONAL SCIENCE BOARD, *SCIENCE AND ENGINEERING INDICATORS 2018*





CLIPPED VISION

PHOTOGRAPH BY
MARK BARTLEY

For a number of vision problems, the artificial intraocular lens (IOL) at left may be the solution. Also called an iris clip, the ultrathin lens is attached to the eye's iris using a tiny incision. This eye belongs to a 70-year-old man; after a cataract surgery failed, the IOL restored his vision almost fully.
—LORI CUTHBERT

CAMBRIDGE UNIVERSITY HOSPITALS NHS FOUNDATION TRUST

ENVIRONMENT

THE LIVING PLANET

PHOTOGRAPH BY **DAVID ELLINGSEN**

THE ANTHROPOCENE. That's the name that is starting to be used to describe the current epoch of Earth's history. The "anthro," of course, refers to how people have altered the planet. The dire effects of human activity—climate change and pollution, to name a couple—are well-known.

But we are also learning how to make the planet a better place, as the examples to the right demonstrate. Advances in technology have enabled people to farm more efficiently, reclaim water more effectively, and replenish distressed land. In his "Anthropocene" series, photographer David Ellingsen combines relics of the human and natural worlds (above). The works reflect both hope and concern about how our species is remaking the planet. —DANIEL STONE

DISPATCHES FROM THE FRONT LINES OF SCIENCE AND INNOVATION

1. TREE DELIVERY

FORESTS

Can drones fight deforestation? Engineers at U.K.-based BioCarbon Engineering have developed seed-depositing drones designed to plant a billion trees a year. More nimble than current aerial methods, the drones can reach places humans can't.

2. PLASTIC CLEANUP

OCEANS

The Ocean Cleanup, a Dutch nonprofit, has an idea to clear out the Great Pacific Garbage Patch, the sprawling expanse of floating plastic and trash in the North Pacific. Using floating screens and anchors, the system will corral plastic on the water and hold it until it can be collected.

3. FLYING ABOVE ICE

THE ARCTIC

San Diego Zoo Global, in partnership with Northrop Grumman, has outfitted an autonomous hexacopter with high-resolution cameras and sensors that can monitor sea ice and polar bear behavior. The project was devised to illustrate how the bears are adapting to longer summers and melting ice.

4. CITY APPETITES

FARMING

Plenty, a Bay Area start-up, is using LED lights to boost growth in indoor hydroponic farms. Designed for hyper-efficiency, a Plenty farm can achieve yields up to 350 times as great per square foot as conventional fields. The firm is exploring expanding to Chinese cities.

5. CROSSING THE ROAD

WILDLIFE

Can the amount of roadkill be reduced? To mitigate the danger to both animals and drivers, Brazilian company ViaFauna is testing roadside sensors—similar to those used for speed traps—to identify disturbances on the road and then illuminate signs to alert drivers.

PSYCHOLOGY

OF ROMANCE AND PUPPIES

This study appeared in a science journal—but its findings could form an advice column. Call it "Feel Great About Your Mate in Six Easy Steps":

1. Insert your mate's photo as directed.
2. Look at the photos of the cute puppies.
3. Look at the photo of your mate.
4. Look at all the photos together.
5. Look again. Keep looking.
6. Keep looking until you feel as good about your mate as you feel about the puppies.

According to a study reported in the journal *Psychological Science,* married adults who were shown photos of puppies and other pleasing sights next to a photo of their partner developed more positive feelings toward that partner than did people who weren't shown the photos.

"I was actually a little surprised that it worked," said researcher James K. McNulty. The U.S. Department of Defense funded the study in hopes of using the process to help married couples cope with the stress of one partner's deployment.

—SARAH GIBBENS

PHOTOS (CLOCKWISE FROM TOP LEFT): TIM FLACH; G.K. AND VIKKI HART; BRIGHTON DOG PHOTOGRAPHY; DAN HALLMAN; SOMNUK KROBKUM; LAMBERT; GANDEE VASAN; RETALES BOTIJERO. GETTY IMAGES (ALL)

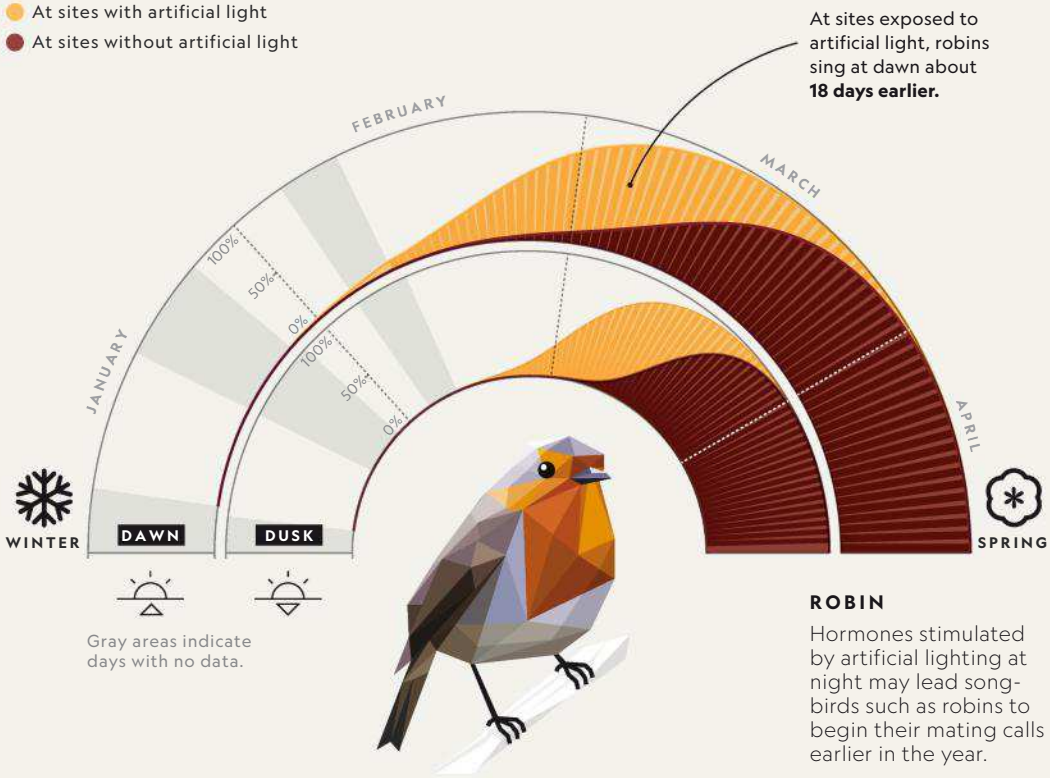
WHEN THE TOO-EARLY BIRD SINGS

IN SPRING songbirds greet the rising and setting sun with a cacophony of chirps meant to entice mates and claim territory. But artificial light has made the night sky brighter and disrupted the seasonal rhythms of birds that use day length as a cue to sing. Of six songbird species that scientists studied in Germany, four started singing earlier in the year because of night lighting. The long-term effects of light pollution on birds' ecosystems, and their survival, remain unclear.

BY **MÓNICA SERRANO** AND **RYAN T. WILLIAMS**

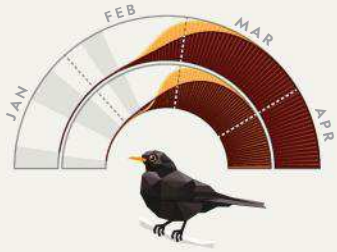
LIKELIHOOD OF SINGING

- At sites with artificial light
- At sites without artificial light



ROBIN

Hormones stimulated by artificial lighting at night may lead songbirds such as robins to begin their mating calls earlier in the year.



BLACKBIRD

During winter, blackbirds (and robins) may spend more time foraging in well-lit urban areas where they find warmth and more food.

BLUE TIT

Both tit species sing earliest in the year, at both dawn and dusk. For the blue tit, artificial light has a significant impact only at dusk.

GREAT TIT

Scientists don't know if longer mating seasons caused by artificial light will increase nesting success or exhaust birds like the great tit.

SOURCES: ARNAUD DA SILVA, MIHAI VALCU, AND BART KEMPENAERS, MAX PLANCK INSTITUTE FOR ORNITHOLOGY

FOOD

No-Melt Ice Cream

Scientists have found a solution to sticky ice-cream hands—entirely by accident. After the 2011 tsunami damaged Japanese strawberry fields, the fruit was too unsightly to be sold whole. Pharmacy professor Tomihisa Ohta and his team at Kanazawa University thought they had a solution: They would make an extract from the strawberries—liquid polyphenol—that could be used as a new dessert topping. When they added polyphenol to cream, though, it solidified instantly, making it useless as a topping—but perfect as a binding agent. They'd inadvertently created a frozen dessert that doesn't melt. Kanazawa ice-cream pops, which stay frozen for an hour at room temperature, are now sold throughout Japan. —NATASHA DALY

PHOTO: STEPHEN LEWIS, ART+COMMERCE

GENIUS

JUNA KOLLMEIER

BY **RACHEL HARTIGAN SHEA**
PHOTOGRAPH BY **MARK THIESSEN**

Mapping the Stars to Solve Mysteries Large and Small

Juna Kollmeier wants to understand the substance of the universe: What forms space structures like galaxies, supermassive black holes, and the intergalactic medium that fills the gaps between galaxies? "On every physical scale that you look at, there are processes that make intricate and complex patterns that we see," says Kollmeier, an astrophysicist with the Carnegie Institution for Science. And, she argues, we're capable of understanding it all.

Last year Kollmeier was named director of the fifth version of the Sloan Digital Sky Survey, a project that aims to map the universe. The survey, which launches in 2020, will employ telescopes in the Northern and Southern Hemispheres to scan the entire sky. The telescopes will obtain spectra of bright objects in the sky, breaking up that light into component parts. "That's where the astrophysics is," says Kollmeier. "That tells you all the chemical abundances. That tells you all the transitions in the objects." And that's where she'll begin to find answers to her questions: How do supermassive black holes grow? Can stars be used as clocks that tell us when and how a galaxy was formed?

Kollmeier didn't get into astronomy by looking up at the stars. She meant to be a lawyer until she went to what she calls "nerd camp" and learned how to write code to classify stars. "The idea that you could interrogate the universe in this way ... I felt like an explorer." Now she's going further than she once thought possible.

WEAPONRY

STONE AGE SLUGGER

DID OUR ANCESTORS BLUDGEON EACH OTHER WITH THIS ANCIENT CLUB?

The "Thames beater," a fourth-millennium B.C. wooden club unearthed in London (below), looks like it could crack a human skull. Archaeologists at Edinburgh University wanted to make sure. They acquired a fake human skull made of bonelike polyurethane, rubber "skin," and gelatin to mimic human tissue. Then they smashed it with a replica wooden club (above). The result: The fractures on the fake skull matched those on a Neolithic skull found in Austria. It was the first time a blunt-force Stone Age weapon has been identified in Europe. "If we understand the violence of a time period, we can start to understand social interactions," says Meaghan Dyer, author of the 2017 study in the journal *Antiquity*. Her next test: beatings with ancient tools made of antler and stone. —NINA STROCHLIC

PHOTOS, FROM TOP: MEAGHAN DYER, UNIVERSITY OF EDINBURGH; MUSEUM OF LONDON

BIODIVERSITY

Limpets to the Rescue

A hungry algae-eater can protect an entire ecosystem from the effects of climate change, a study finds. Limpets—aquatic mollusks that graze on algae—kept microalgae from overtaking a rocky intertidal ecosystem and erasing its diversity. "If important consumers like these are lost, the ecosystem is more likely to be harmed by a warming climate," says lead researcher Rebecca Kordas of the University of British Columbia.
—LORI CUTHBERT

AGRICULTURE

PLANTS THAT DON'T SLEEP

'SPEED BREEDING' YIELDS SEEDS IN MUCH LESS TIME

Fields of wheat and barley would grow faster if the sun didn't go down at night. So an international group of scientists is essentially keeping the sun's light on, as part of a method to "speed breed" plants. LED lights at the optimal color wavelength bathe greenhouse plants in light all day and most of the night. The result is highly productive crops. Compared with a wheat plant in the field that seeds once annually, a plant under 22-hour light goes through as many as six generations in a year, and at a sliver of the energy cost of yesterday's heat lamps.

Mammals that forgo sleep risk illness or worse—but despite the growth demanded of the plants, "they're healthy and productive," says Lee Hickey, a seed biologist with the Queensland Alliance for Agriculture and Food Innovation in Australia. Trends toward urban farming and crop efficiency may open the method to other edible crops, such as corn and rice. And gene testing on productive crops will yield new answers for faster, less intensive, and more efficient growth—under lights or in the farmer's field. —DANIEL STONE

1.4 INCHES

3,500-Year-Old Stone an Art Mystery

A battle scene etched on a tiny piece of agate is raising questions for historians: How was it carved? What legend does it depict? The answers may refine our knowledge of art from the ancients. —LC

PHOTOS, FROM TOP: HANNAH HARDY, UNIVERSITY OF QUEENSLAND; REBECCA KORDAS; DEPARTMENT OF CLASSICS, UNIVERSITY OF CINCINNATI

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Arctic Ocean Camping
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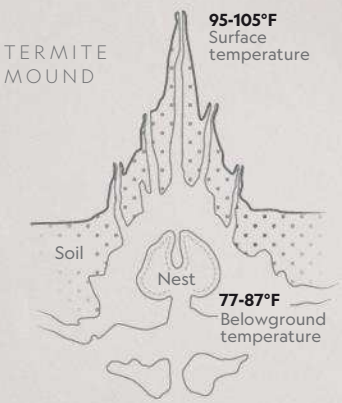
NATIONAL GEOGRAPHIC | VOL. 233 NO. 5

INSPIRED BY TERMITES

How the Eastgate Building Keeps Cool

THE CHALLENGE: Design a modern office and retail building without expensive air-conditioning for relief from Zimbabwe's tropical heat. The solution: Emulate the engineering prowess of native termites by copying aspects of their systems. This approach, called biomimicry, enabled architect Mick Pearce to insulate the Eastgate building by harnessing nature, not hiding from it.

Keeping it constant
Termites nest deep underground, with spires for ventilation that can reach 30 feet high. Soil absorbs the sun's heat slowly, providing a consistent climate.



A prickly exterior (modeled after desert plants) reduces heat absorption and disperses warmth better than a smooth one.

1

Double-thick brick walls and precast concrete have high "thermal masses"; it takes a lot of heat to change their temperatures. The same is true of soil around termite nests.

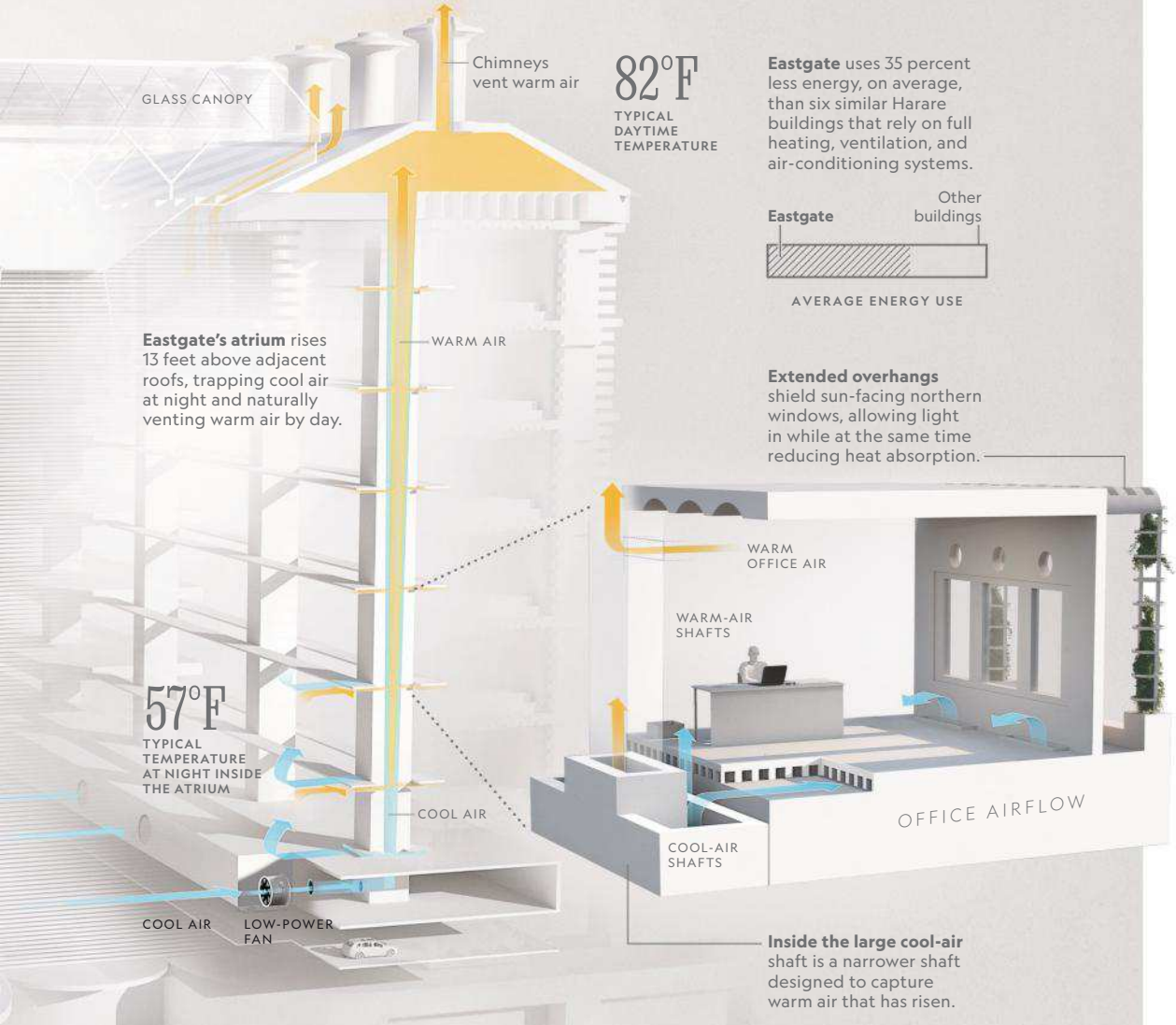
Windows are relatively small, minimizing heat absorption.

PLACE Eastgate building

LOCATION Harare, Zimbabwe

DISTINCTION Eastgate's insect-inspired, 90 percent passive climate control has made it a global landmark since it opened in 1996.

DECODER BY **MANUEL CANALES**



2

Air shafts direct night-cooled, filtered air in the mornings from the lower atrium up through seven floors of office space. The airflow is assisted only by low-power fans.

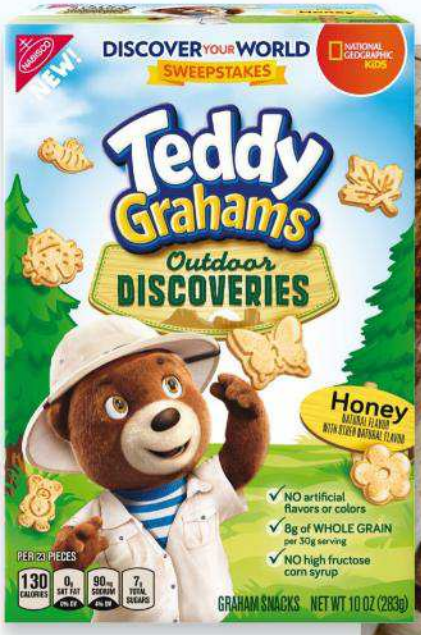
3

Double-layer concrete floors are cooled by night air flowing between their layers. They keep the circulating air as cool as possible until it warms and is vented out at the ceilings.

SEAN McNAUGHTON. ART: ANTOINE COLLIGNON. SOURCES: MICK PEARCE, ARUP; J. SCOTT TURNER, SUNY COLLEGE OF ENVIRONMENTAL SCIENCE AND FORESTRY

NATIONAL GEOGRAPHIC KIDS

DISCOVER YOUR WORLD SWEEPSTAKES



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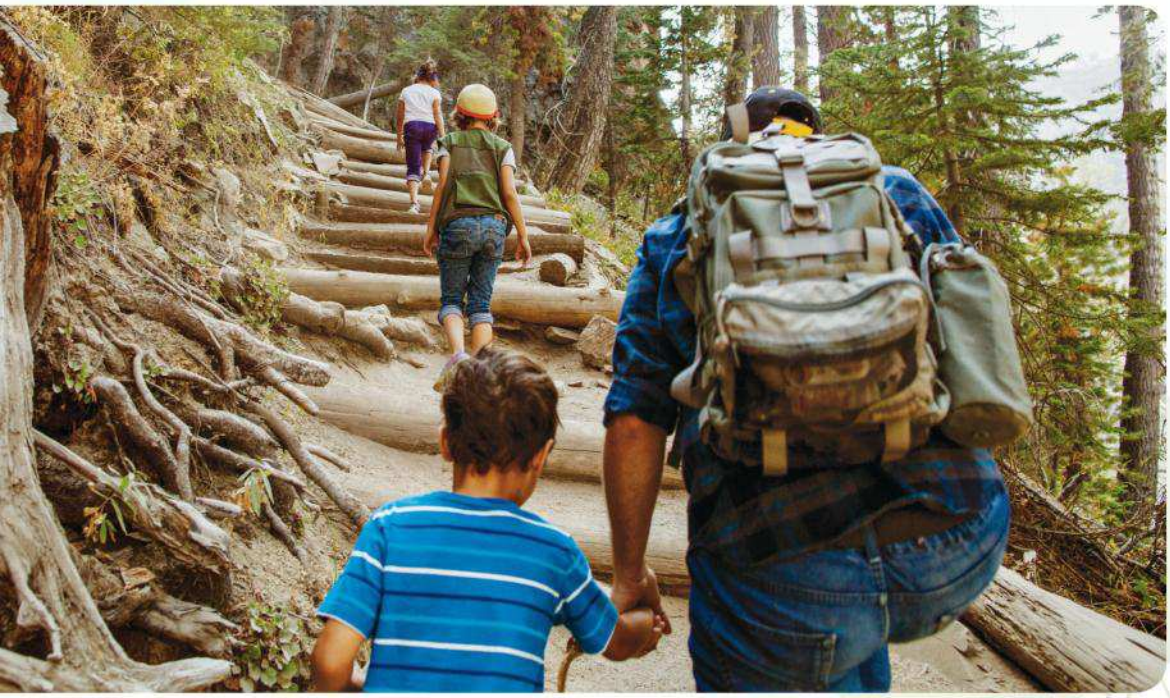

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OCEAN CAMPING IN

Riding mountain bikes in Canada's Auyuittuq National Park,

T MINUS SIX MONTHS

GEARING UP

I'll be photographing a team of extreme adventurers mountain biking across the frozen Arctic Ocean in Canada. I'll be on a snowmobile, which is still hard work, so I need to get in good shape. A few months before, I start running and doing core workouts. In the Arctic you can't sit down if you're tired—you have to keep moving or get in your sleeping bag. I also put in a request to my sponsors for some gear: a down-filled sleeping mat and gloves I can shoot with.

"THE ICE WAS THREE OR FOUR FEET THICK. WE SLEPT RIGHT ON THE OCEAN, WITH THE TIDE ROLLING UNDERNEATH."

—Jon Golden

where officials say winter travel is "often impossible."

T MINUS TWO WEEKS

ESSENTIAL PACKING LIST

Our camp in Auyuittuq is 50 miles from civilization in any direction, so I take everything I need for the 2.5-day February trip.

- Emergency beacon
- A satellite phone (which will be on for only two hours a day, so I go over safety protocols with my family beforehand).
- Macadamia nuts (they have the highest fat content)
- A toothbrush with pre-applied toothpaste
- A dozen camera batteries. The cold zaps their power, so I keep them in my vest or sleeping bag.
- Two sets of long underwear

T MINUS TWO DAYS

READY FOR LAUNCH

I get excited in various stages, but it doesn't feel real until I get on the plane in Virginia. When we land in Qikiqtarjuaq, I go to our Inuit guide's mom's house to repack. The team members set up their bikes, and we go over hand signals so I can direct them into the camera's frame while they ride. Before we head out, I put my stuff into a dry sack in case the snowmobile goes through the ice. The devil's in the details. I don't deviate from the plan.

BY THE NUMBERS

2,100
TOTAL MILES TRAVELED

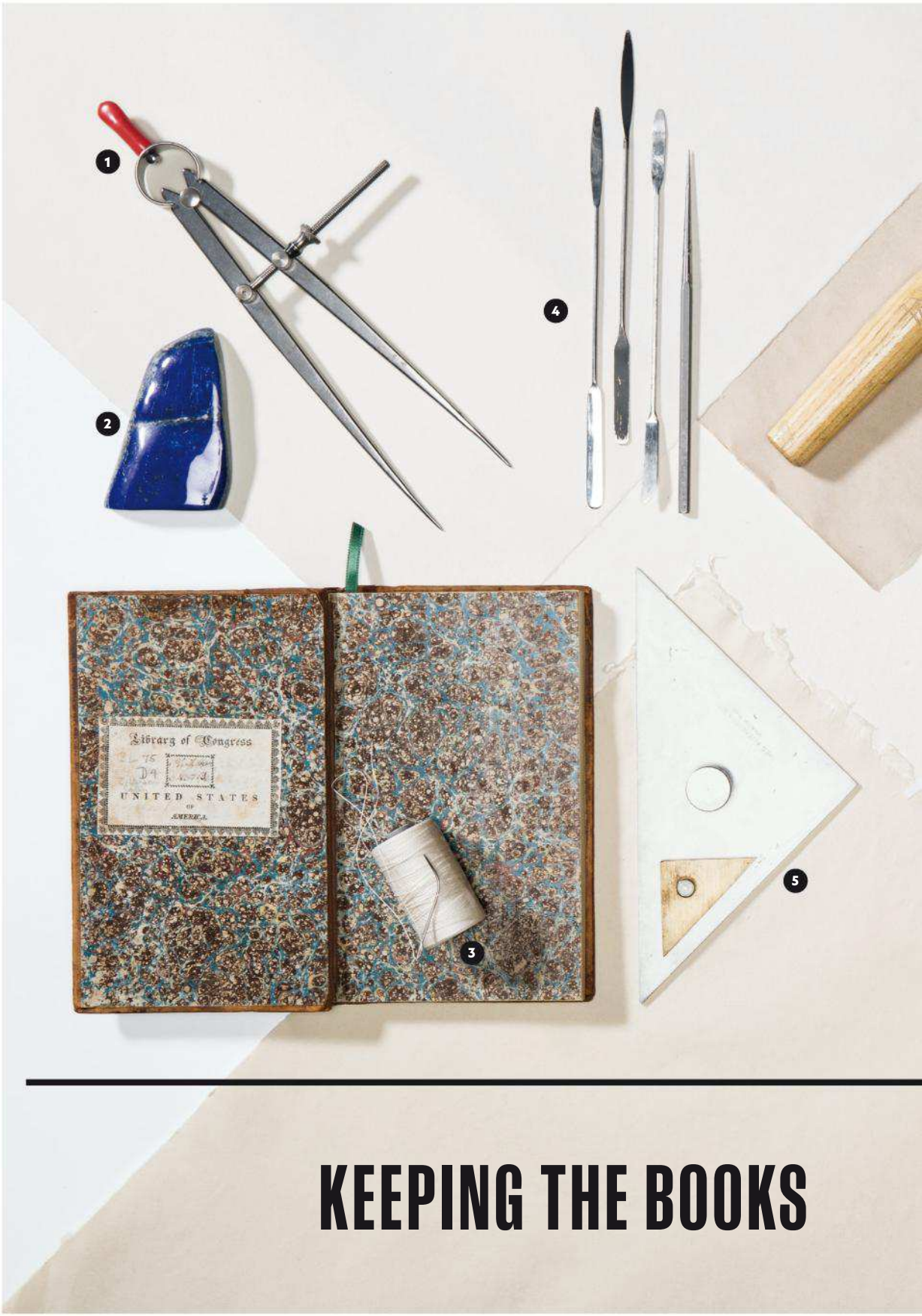
-25°F
AVERAGE LOW IN FEBRUARY

-9°F
AVERAGE HIGH IN FEBRUARY

THE ARCTIC

STORY AND PHOTOGRAPH BY **JON GOLDEN** AS TOLD TO NINA STROCHLIC

NGM MAPS



KEEPING THE BOOKS

PHOTOGRAPH BY **MARK THIESSEN**

A RARE-BOOK CONSERVATOR MUST HAVE patience, an eye for detail, and the guts to deconstruct priceless national treasures. When a book is going to be exhibited, digitized, or, say, used for a political swearing in, it lands on the desk of Yasmeen Khan, one of 10 rare-book conservators at the Library of Congress. She'll mend its pages with wheat-starch paste and tissue paper, resew its binding, or dismantle it entirely. Books that need a full renovation can take months of painstaking work. In them, Khan is able to see "the logic of the craftsmen of the past." –NINA STROCHLIC

1. Divider
This tool can quickly transfer measurements from one surface to another without need for a ruler.
2. Polished lapis lazuli
Traditionally an agate is used to polish paper; Khan found this stone at a market in Pakistan and uses it to maintain the sheen on some Islamic and South Asian documents.
3. Needle and thread
A bent needle and unbleached Irish linen thread stitch book sections together. (The book belonged to Thomas Jefferson.)
4. Spatulas
These thin tools can scrape off old adhesive or slide between pages to lift them apart. An etching needle (right) pokes holes.
5. Right-angle triangles
A stainless steel triangle and a copper one are used to cut leather or cloth at a 45-degree angle.
6. Backing hammer
Khan gently rolls the back of the hammerhead over the spine of an old book to restore its rounded shape.
7. Bone folders
A bamboo folder (left) gently scrapes adhesive off the spine of a book, stainless steel (middle) pushes cloth into corners, and ivory (right) slips between layers of paper.
8. Ginger-grating bowl
Wheat-starch paste, in a custom-made bowl, is applied to tissue paper with a paintbrush to mend pages.
9. Tamping and glue brushes
Brushes apply adhesive to book pages and covers.
10. Paring knives
These knives can thin pieces of leather. Khan made the bottom one of tempered steel.

MAY

2

A cornucopia of culture, history, and media to sample this month.

BY **DANIEL STONE**

1

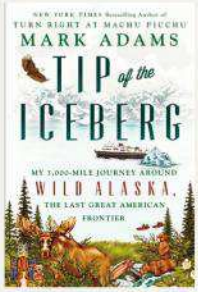
NEW SHOW

Watch *Civilizations,* a PBS and BBC series on art from the dawn of time to the present day. Learn how creativity powered the most successful eras of history.

DAY TO HONOR

THE UNITED NATIONS DESIGNATED MAY 2 AS WORLD TUNA DAY TO HIGHLIGHT ONE OF THE WORLD'S MOST CONSUMED FISH AND THE NEED FOR SUSTAINABLE FISH STOCKS. FIND OUT MORE AT *UN.ORG/EN/EVENTS/TUNADAY*.

3



WHAT TO READ

Tip of the Iceberg Follow Mark Adams's 3,000-mile journey across wild Alaska. He retraces the steps of the 1899 Harriman expedition to explore how its coast has changed.

4

ANNIVERSARY

THE LUSITANIA In May 1915 the British ship was torpedoed by a German U-boat.

5

GOOD NEWS

THE LONG-CLOSED UPPER LEVELS OF ROME'S COLOSSEUM ARE NOW OPEN TO VISITORS.

PHOTOS, CLOCKWISE FROM TOP LEFT: OLIVER CHILDS, GETTY IMAGES; GRANT CORNETT/ART PARTNER LICENSING; CHRISTOPHER LIN (JACKET DESIGN), LISEL ASHLOCK (JACKET ILLUSTRATION); AKG-IMAGES/ALAMY STOCK; SKIP BROWN, NATIONAL GEOGRAPHIC CREATIVE

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PLOTTING PLUTO

BY **MATTHEW W. CHWASTYK**

DISCOVERY

1 **VENETIA BURNEY**
This 11-year-old British girl gets credit for the idea to name the celestial body "Pluto," after the Roman god of the underworld.

2 **CLYDE TOMBAUGH**
He discovered the dwarf planet on February 18, 1930, while working at Lowell Observatory in Flagstaff, Arizona.

SCIENTISTS AND EXPLORERS

3 **MUHAMMAD AL-IDRISI**
The 12th-century Arab cartographer's book of global maps, *The Book of Pleasant Journeys Into Faraway Lands,* remained a definitive record for centuries.

4 **JAMES LUDLOW ELLIOT**
By carefully observing how planets block and reveal the light of distant stars, he discovered Uranus's rings and Pluto's thin atmosphere.

5 **EDMUND HILLARY**
The New Zealand mountaineer and Sherpa Tenzing Norgay were the first people to summit Mount Everest, Earth's highest point.

6 **TENZING NORGAY**
The icy mountain range—as high as 11,000 feet (3,350 meters)—is named for the Nepali Sherpa.

Latin translations
Cavus: *steep-sided depression*
Dorsa: *ridges*
Fossa, fossae: *long, narrow depression(s)*
Montes: *mountains*
Planitia: *low plain*
Regio: *region*
Terra: *large landmass*

ART: MATTHEW TWOMBLY SOURCES: ALAN STERN, SOUTHWEST RESEARCH INSTITUTE; R. SCHULZ, IAU-WGPSN; R. HAYWARD, USGS; NASA/JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY

Pluto's landscape was unknowable until the spacecraft New Horizons sped past in 2015. Now our cartographers have created National Geographic's first map of the dwarf planet, with Pluto's physical features officially named by the International Astronomical Union. Here are the people, spacecraft, and myths that provided inspiration.

330°
300°
270°
240°
210°
60°
30°
0°
EQUATOR
HAYABUSA TERRA
9
SLEIPNIR FOSSA
13
TARTARUS DORSA
14
UGH REGIO
PLANITIA
ADLIVUN CAVUS
12

Pluto's diameter is 1,476 mi (2,376 km), 19 percent of Earth's 7,926 mi (12,756 km).

PIONEERING SPACECRAFT

7 VOYAGER
The twin probes from NASA's first interstellar mission launched in 1977. Voyager 1 has left the solar system; Voyager 2 is on its way.

8 SPUTNIK
Launched by the U.S.S.R. in 1957, Sputnik 1 was the first human-made satellite to successfully enter Earth orbit.

9 HAYABUSA
In 2005 this unmanned Japanese spacecraft captured the first ever sample of a near-Earth asteroid.

UNDERWORLD MYTHOLOGY

10 DJANGGAWUL
In some Aboriginal lore the Djanggawul are three siblings from the land of the dead who created Earth's vegetation.

11 VIRGIL
In Dante's *Divine Comedy* the spirit of this ancient Roman poet guides the author through the levels of hell and purgatory.

12 ADLIVUN
From Inuit mythology, Adlivun, or "those who live beneath us," is both an icy, barren underworld and the souls who reside in it.

13 SLEIPNIR
In Norse mythology this eight-legged horse carries the god Odin on journeys to the underworld.

14 TARTARUS
The deepest pit in the ancient Greek underworld, it is a prison for criminals, monsters, and defeated deities.

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Down the Mountain

BY **CORY RICHARDS**

AFTER SURVIVING AN AVALANCHE, CLIMBER AND PHOTOGRAPHER CORY RICHARDS CAPTURED THE MOMENT. BUT THEN WHAT?

I

TOOK THIS PHOTO about an hour after digging out of an avalanche that nearly killed me and two friends as we were descending the world's 13th tallest mountain. It was February 4, 2011, and we'd just completed the first winter ascent of Pakistan's Gasherbrum II. Since then, this image has run on the cover of *National Geographic,* appeared on posters and billboards, and circulated on the Internet. In a way, it's become my "brand" and has led to many lucrative assignments. But over the years, the story that the picture suggests—of a heroic mountaineer who has just cheated death—has bothered me deeply.

I've always found it difficult to think of climbing as heroic, though I understand how some might view it this way. Stand at the foot of a Himalayan peak, and you quickly understand that getting to the top is going to require exceptional strength, stamina, concentration, and courage. But I've always thought that an act of heroism requires some sort of higher purpose than just risking your life to see if you can make it to the top. Sure, I can make the case that mountaineering supports developing local economies in many places, including Pakistan, and that climbing remote peaks taps into something vital in the human psyche. But let's not kid ourselves: A lot of it comes down to expensive, dangerous recreation and a certain amount of self-indulgence.

It wasn't my idea to climb Gasherbrum II. I was invited by two veteran climbers, Simone Moro and Denis Urubko, to join their expedition. I was a young climber who'd progressed from peaks in North America and the Alps and finally made it to the ultimate proving ground, the Himalaya. Simone and Denis were icons in the climbing world who'd pioneered new routes on some of the

AS TIME WENT ON, WAVES OF PANIC WOULD SUDDENLY SWEEP OVER ME LIKE MINI-AVALANCHES. A THERAPIST FINALLY EXPLAINED I WAS SUFFERING FROM PTSD.

world's tallest, most dangerous mountains.

It's difficult to describe how excited I was when they asked me to join them for a winter attempt on Gasherbrum II. Mountaineers choose their climbing partners with extreme care. It's a decision that can determine whether or not you survive an expedition. You need someone who can tolerate prolonged suffering—frostbite burns on your cheeks, grinding hunger, losing feeling in fingers and toes, overwhelming weariness—all while maintaining the will to push forward and the coherence to respond to an emergency.

These two legendary climbers asking me to join their expedition was sort of like an ordination into a priesthood. That might sound weird, but for many mountaineers, climbing is a kind of religion. I know it saved me, offering a path out of a rocky adolescence. I dropped out of high school, got into alcohol and drugs, and lived on the street for a while. Climbing was my salvation. It gave me a singular purpose, focused my mind and body, and made me healthy.

The more I climbed, the farther I seemed to get from the insecurities and anger that had defined so much of my life. After any ascent, regardless of how dangerous or benign, I'd find myself overlooking the world below and discover that I could finally breathe deep, satisfied, relaxed breaths. But then I would descend back into the world below, and my inner turmoil would return. When Simone and Denis asked me to be a part of a potentially historic climb, I felt that if I could just make it to *that* summit, then I would be permanently "fixed."

We summited after a mad push during a brief window of clear weather. Winter climbing really comes down to timing—being able to slip up the mountain between fast-moving winter storms that load the peaks with unstable snow. But reaching the summit is only the halfway point. Fatalities often occur on the way down as climbers navigate minefields of crevasses—deep cracks concealed beneath thin veneers of snow—and multi-ton drifts that threaten to release thunderous avalanches at any moment.

We were hurrying—the three of us roped together—hoping to beat a line of storms moving toward us, when I heard the roar. Mountain guides teach that if you're caught in an avalanche, you should try to swim your way to the top. I remember futilely trying to move my arms and kick my legs, but very soon I was being spun like I was in a furious washing machine. I'd catch a blurred glimpse of blue sky then dark, then blue, then dark, then black. My mouth and nose were packed with powder, and snow was stuffed into my down suit. The roar was replaced by a profound silence, and a heavy cold began seeping into my body.

It's hard to put into words the terror of that experience—being caught like prey in the teeth of a primordial monster, waiting for your spine to snap, your consciousness to wink out, the mountain to swallow you. But we all survived.

Far from fixing me, my experience on Gasherbrum II broke me. As time went on, waves of panic would suddenly sweep over me like mini-avalanches. I'd break out in sweats. I'd suddenly get irritated or enraged. It was like the mayhem of my adolescence had returned, bigger and darker. To escape, I drank heavily and cheated on my wife, which added shame and self-loathing to the mix. I ended up buried and choking to death all over again. I got divorced, lost my main professional sponsor, made an ass of myself, hurt people I care about. There is no excuse for bad behavior and bad decisions. But sometimes the ensuing chaos yields a bit of clarity.

A therapist finally explained that I was suffering from post-traumatic stress disorder, and with the love and support of a lot of people, I've gradually been able to dig myself out. I've quit drinking and started climbing again, and have returned to the Himalaya. I've come to recognize that the notion that summiting a mountain could fix me was as much an illusion as the idea that that photo of me post-avalanche somehow portrayed a hero.

Still, I can't escape the photo. It seems to follow me around like a ghost of some former self, reminding me of how fragile I really am. How fragile we all are.

8,035 m

Elevation of Gasherbrum II, one of Earth's 14 tallest mountains. All are more than 8,000 meters (26,247 feet) above sea level.

NGM MAPS

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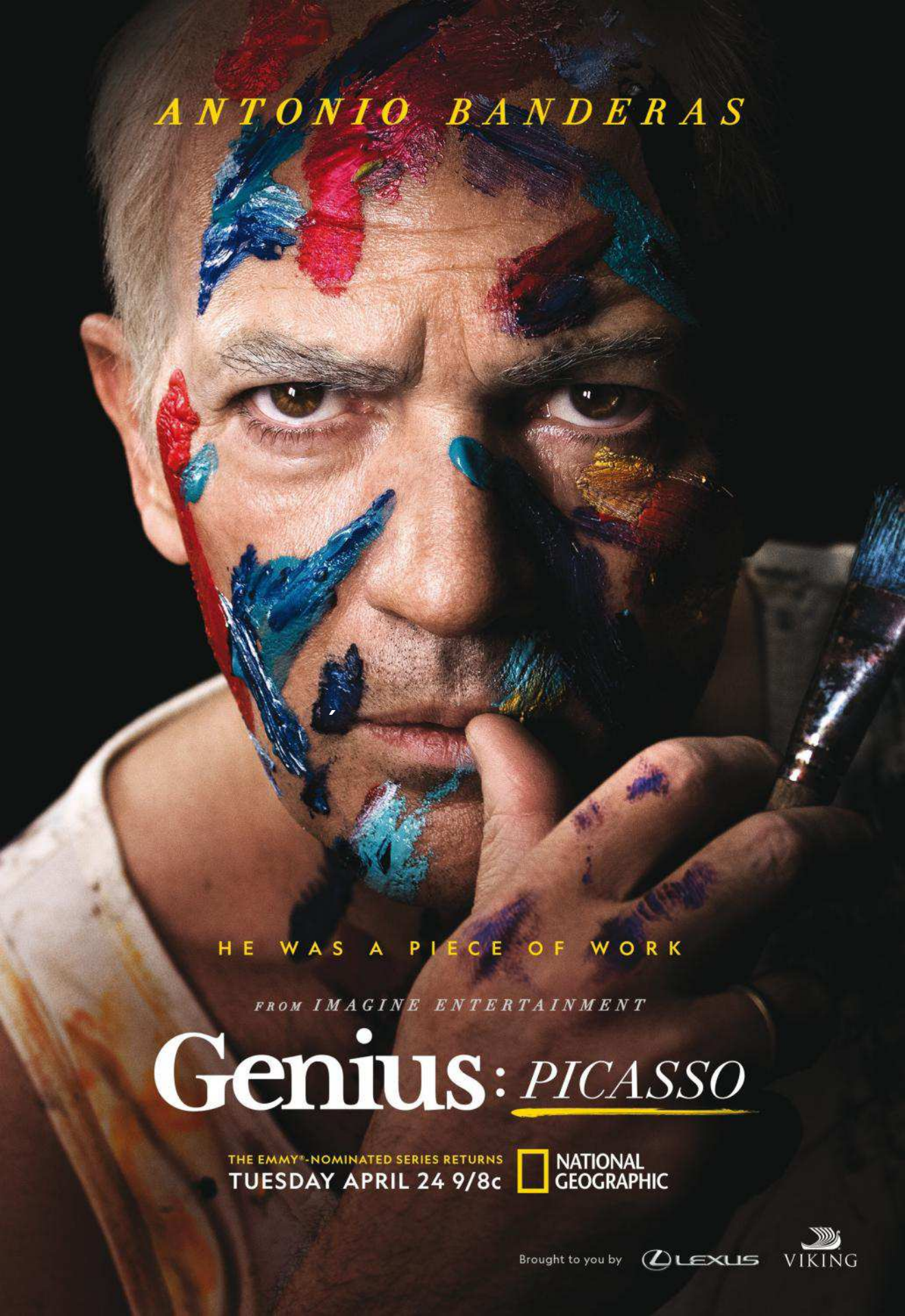
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FEATURES

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'TO THE SHARKS, WE HUMANS ARE OBSTACLES, NOT TARGETS. WHEN WE DIVE AT NIGHT, THEY APPROACH US CONSTANTLY; SOMETIMES THEY BUTT US HARD ENOUGH TO BRUISE.'

PHOTO: LAURENT BALLESTA

BEING MUSLIM IN AMERICA

MISUNDERSTOOD AND OFTEN MALIGNED, THEY'RE A VIBRANT AND INCREASINGLY VISIBLE PART OF THE NATION'S TAPESTRY.

BY **LEILA FADEL** | PHOTOGRAPHS BY **LYNSEY ADDARIO**

Airaj Jilani, a retired oil-and-gas project manager from suburban Houston, performs as Elvis Presley. He has been a fan since he was a boy growing up in Pakistan. "I was the Elvis fan. My brother was the Beatles fan," he says. In 1978 he visited Presley's Graceland mansion in Memphis, Tennessee; the following year he moved to Texas.

PREVIOUS PHOTO

Children in South Los Angeles celebrate Eid al-Fitr, the holiday that marks the end of Ramadan, the holy month of fasting, at a picnic co-sponsored by Islah LA, a Black Muslim community center. Led by Imam Jihad Saafir, the center works to promote community, education, and social and economic empowerment.

NEXT PHOTO

Jumana Mussa, Dana Mussa, Jana Hassan, and Marya Tailakh, Girl Scouts from Troop 3408 in Anaheim, California, perform an anti-bullying skit at a public library. Bullying of Muslim children in the United States is rising largely because of cultural and religious misunderstanding, according to an institute that studies issues affecting Muslims.


Scouts of Orange
Troop 340
110C
Brownies
Juniors
HELLO
3408


Begorra
Book

There was nothing to do but watch as the copper-domed building in the southern Texas oil town of Victoria burned down.

Imam Fazal Hassan and Amjad Shaik survey damage to their mosque in Bellevue, Washington, after it was set on fire last year. A mentally ill man who had earlier assaulted a member of the mosque pleaded guilty but was not charged with a hate crime.

NEXT PHOTO

Mourners in Dearborn, Michigan, attend a traditional funeral for a relative, an Iraqi police officer who died fighting Islamist extremists.

The mosque where Abe Ajrami's Beyoncé-loving daughter was feted with other high school graduates, the mosque where his children went to religion classes, the mosque where he and his family went every Friday to pray and mingle over a potluck of seven-layer dip and spiced biryani, was gone.

"I was trying not to break down," says Ajrami, a Palestinian American who raced to the mosque after getting a phone call in the dead of night. He recounts the experience to me in his living room as his wife, Heidi, an American convert to Islam, sits to his right and his daughters, Hannah and Jenin, sit to his left, while his son, Rami, sleeps upstairs.

This family reminds me of my own. My father,

from Lebanon originally, also came to the United States for an education and a better future, as Ajrami did. My mother was a Unitarian Universalist, like Heidi, and she met her future husband in college and converted. My parents have raised five ambiguously tan American Muslim kids.

Born to a poor family in the Gaza Strip, Ajrami studied nursing because it was all he could afford. In 1994 a friend helped get him a visa and a scholarship to Clarkson College in Omaha, Nebraska. There he met Heidi, a Texas-born Army brat. He wooed her with picnics and jokes; she took him to his first football-watching party. They moved to Victoria when Heidi got a job there as a college English instructor. Ajrami became director of nursing at a hospital. He now runs a medical-staffing business, and the family lives in a large house with a pool. God is a big part of their lives, the way God is the center of most people's lives in this town.

On the night the mosque was set on fire, January 28, 2017, Ajrami watched with others from this small Muslim community. They wept, hugged, and prayed. Only hours before, President Donald Trump, delivering on a campaign promise to stop Muslims from entering the United States, had issued an executive order aimed at barring anyone arriving from seven Muslim-majority countries.

The fire, allegedly set by an arsonist who has been charged with a hate crime, caused sections of the building to collapse. Only the copper


يا اباعبدالله
يا امام

On an outing to the Showboat Drive-in Theater in Hockley, Texas, children from Centro Islamico in Houston wait while a parent buys them snacks. The mosque, which opened in 2016, serves Spanish-speaking Muslims.

PREVIOUS PHOTO

After a traditional Bengali wedding, the groom, Tazer Khan, takes the stage at the Athena Banquet Center in Roseville, Michigan, with his three brothers' wives—Papia Jeani, Fatima Koli, and Ferdous Akthar—while he waits for his bride to arrive for photographs.

domes and marble slabs carved with quotations from the Muslim holy book, the Quran, would survive. Ajrami took pictures and posted them online. "We will rebuild, with LOVE!" he captioned them. It went viral. Within days the mosque raised a million dollars. The town rallied to support them. And even today they still get checks in the mail.

In the ashes of his mosque, Ajrami clearly saw the task ahead. "I didn't want that label, Muslim, to define me as a person. But because of the fire we really had to be on the front lines," he says. Ajrami made himself available to the media and gave talks on his faith, becoming a spokesman despite his misgivings.

"You have to take deep breaths because at some point you do start to question yourself," he says. "Why am I doing this? Why do I have to prove to you that I'm a good guy?"

TODAY AN ESTIMATED 3.45 million Muslims in America are living in a climate of hostility, their faith distorted by violent extremists on one end and an anti-Muslim movement on the other. The rise in animosity was stoked by fiery anti-Muslim rhetoric from conservative commentators and politicians, including the president. Trump repeatedly has described Islam as a threat, retweeting anti-Muslim videos from a British hate group and keeping his distance from the religion, like when he decided the White House,

for the first time in more than two decades, would not host a dinner to mark Ramadan.

Ajrami's mosque was one of more than 100 targeted last year with threats, vandalism, or arson across the country, according to the Council on American-Islamic Relations. Hate crimes are up. In 2016 the FBI documented a 19 percent increase in incidents against Muslims over the previous year. Muslim children report being bullied more than kids from other faiths, according to the Institute for Social Policy and Understanding, which studies Muslims in America. Half of American Muslims say that being Muslim has become more difficult in recent years, according to a Pew Research Center survey.

And yet Muslim communities in America are thriving. Modest clothes for women who cover their hair are being created by Muslims in the U.S. under labels like Haute Hijab and Austere Attire, and Macy's is now selling fashion for Muslim women. Halal products, the Muslim equivalent of kosher, are available at Costco and Whole Foods. Mattel has even debuted a Muslim Barbie. The doll, complete with a head scarf, is modeled on Olympic fencer Ibtihaj Muhammad. There's a Muslim liberal arts college in Berkeley, California, and a graduate school in Claremont, California. Community activism is thriving, and Muslim activists are forging alliances with other marginalized communities.

In reaction to feeling targeted, Muslims are getting political. Groups such as the Pluralism Project are supporting and training dozens of Muslim candidates in Maryland alone to run for office. A hijab-wearing Somali-American woman now sits in the House of Representatives in Minnesota; a Muslim man is running for governor of Michigan. There are two Muslims in Congress and more running in this year's elections.

Relatively new immigrants and their children make up the largest portion of the faith's adherents. Many prayer leaders across the country are foreign-born. But there's also a growing number of Muslim leaders and scholars speaking in the language of a U.S.-raised generation of Muslims—black, white, brown—to translate a faith often seen as foreign into culturally relevant lingo. Almost half of Muslims in America were born here. The face of the faith in the United States is young; nearly half are millennials and came of age after the terrorist attacks of September 11, 2001.

One of the leaders who speaks to that generation is Usama Canon, a half-black, half-white preacher from California. He converted in 1996 and studied with Islamic scholars in the United States and abroad.

"One of the great scholars said that Islam was kind of like a pure and clear water that takes the color of whatever riverbed it flows over," Canon says, talking to me after an all-night lecture at a mosque in Houston. "And so I'm hoping that Muslims in America can kind of color that bedrock in a beautiful way and can contribute to what is the American project in a way that when that water flows over it, it has a uniquely American and a distinctly American color and flavor but is authentic to itself as a faith tradition."

Imam Jamil Bastress is the prayer leader and shepherd at the Farm of Peace, a spiritual retreat in Pennsylvania. When the time comes, he's also the halal butcher. The goal here, he says, is to love the Earth and each other. Bastress is a convert to Islam, as are most members of this small Sufi community.

THAT COLOR AND FLAVOR are coming from a mosaic of Muslim communities across the country like nothing I saw in over a decade of writing about the Muslim world. Islam is one of the most diverse faiths in the United States, with adherents from some 75 countries bringing distinct ways of worshipping. I visited Muslims in the South, West, Northeast, and Midwest. What I found was a variety of race, practice, class, culture, and language that I'd seen just once before—in Mecca, during the hajj, the pilgrimage that the roughly 1.8 billion Muslims around the world are obligated to make once in their lifetime.

My exploration of Islam in America led me to Sufi converts, mostly white, in rural Pennsylvania who meditate, praise God, and farm together at a spiritual retreat. In the ecolodge each room is named for an important word in Islam: Mercy, Courage, Praise, Love. It's called the Farm of Peace, and it has a yogi, earthy vibe, so it's not surprising that the imam, or prayer leader, does cupping therapy and acupuncture. He's also the shepherd and the butcher on the 150-acre farm.

I met Bosnian Muslims in Chicago listening to a girls choir sing hymns praising the Prophet Muhammad. I went to the mosque my father attends, a largely South Asian Shiite congregation, next to a strip mall in a Chicago suburb. There's a new digital lock on the door for an added layer of security. The imam urged congregants

to vote, run for office, and get involved in community organizing and service. And I visited the mostly Arab Muslims in Dearborn, Michigan, where much of my father's family lives. There people mix Arabic and English in local slang, signs are in both languages, and Middle Eastern cuisine is more common than pizza.

In Houston I spent time at the country's first Spanish-language mosque, Centro Islamico. It opened its doors in 2016, and on the night I visited, more than a hundred people gathered to pray. Latinos are one of the fastest growing Muslim populations in the country. The mosque's founder, Mujahid Fletcher, said Islam was his path to a better life after getting involved with gangs. He found the faith just before 9/11, so it was hard to explain his new religion to his Roman Catholic, Colombian family. There weren't many Spanish books on Islam or Spanish-speaking scholars to dispel misconceptions. His mosque publishes those books now and webcasts sermons in Spanish, English, and Arabic.

Any mapping of U.S. Muslims must include black American adherents, many of whom call themselves indigenous Muslims. They make up at least a fifth of the country's Muslims. Islam is often referred to as hip-hop's unofficial religion. Praises to Allah, the Arabic word for God, and other phrases, such as *assalamu alaikum,* or peace be upon you, are in the lyrics of celebrated artists from the Roots and Rakim to a Tribe Called Quest. New York City's Harlem is still home to historic Black Muslim communities with signs in their restaurants that say, "No Pork on My Fork." And in Philadelphia, Arabic words from the faith such as salaam (peace) and zakat (alms) are uttered by Muslims and non-Muslims alike. In South Los Angeles, Jihad Saafir, an imam and son of a Black Muslim cleric, turned his father's storefront mosque into a vibrant community center and school that teaches the history of Islam through the lens of empowerment and African and African-American history.

It's at Saafir's mosque that Hamidah Ali sits next to me as we break our fast during Ramadan on halal Chinese food. I ask her what Islam in America is to her. She doesn't hesitate. "Islam is cool," the 27-year-old, African-American, second-generation Muslim says. Her hoop earrings peek out from her turban-wrapped head scarf, and she lists her idols, from hip-hop artists such as Yasiin Bey, formerly known as Mos Def, to America's most famous Muslim, the late Muhammad Ali, who once said, "I am America. Only I'm the part you won't recognize. But get used to me. Black, confident, cocky; my name, not yours; my religion, not yours; my goals my own—get used to me!" Ali was a controversial figure during his career—a conscientious objector to the Vietnam War, a proud Black Muslim popular among civil rights activists—but his pursuit of social justice later made him a cultural icon. His Muslim funeral in 2016 was broadcast on every major U.S. network. There's even a book on the topic—*Muslim Cool,* by anthropologist Su'ad Abdul Khabeer. She writes on the Muslim identity formed at the intersection of black culture, hip-hop, and Islam.

All of this is Islam in America. Canon, the

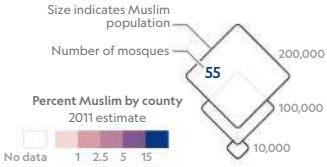
MUSLIMS IN AMERICA

PROGRESS IN SPITE OF PREJUDICE

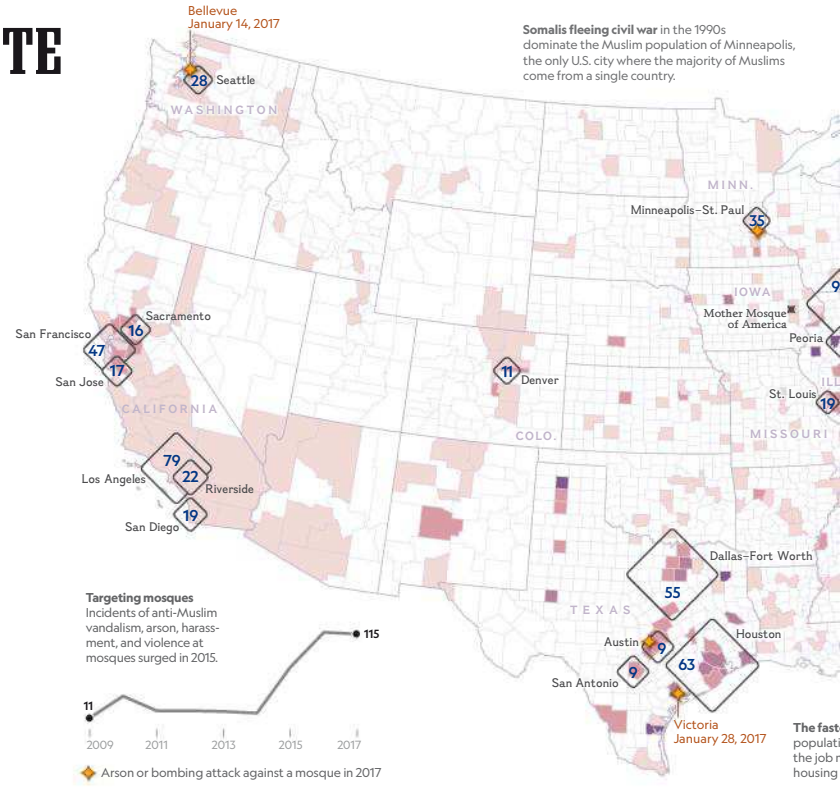
Muslims in the United States are a racially and ethnically diverse group—and a growing one, despite a recent rise in anti-Muslim hostility. From dozens of different countries and representing multiple branches of their faith, Muslims now total about 3.45 million people, or one percent of the U.S. population. With roots dating back to the 16th century, the Muslim population is currently growing faster in suburbs than in cities, especially in southern and western regions. There are now more than 2,100 mosques in the U.S., up from 962 in 1994.

MUSLIM MOSAIC

Muslim communities are growing across the United States, anchored by a rising number of mosques.

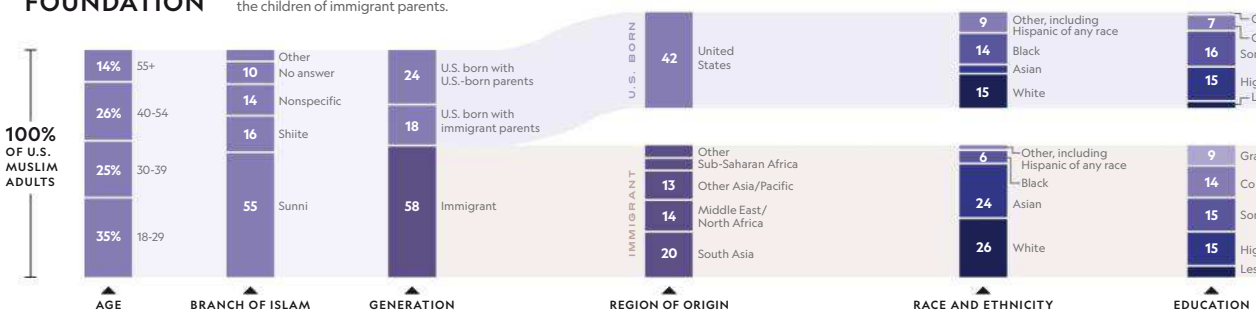


STATISTICS FOR CITIES REPRESENT METROPOLITAN STATISTICAL AREAS; MOSQUES AND MUSLIM POPULATIONS IN HAWAII, ALASKA, AND U.S. TERRITORIES ARE NOT SHOWN.



LAYING A FOUNDATION

Muslim adults in the U.S. are about three times as likely as the general population to be immigrants or the children of immigrant parents.

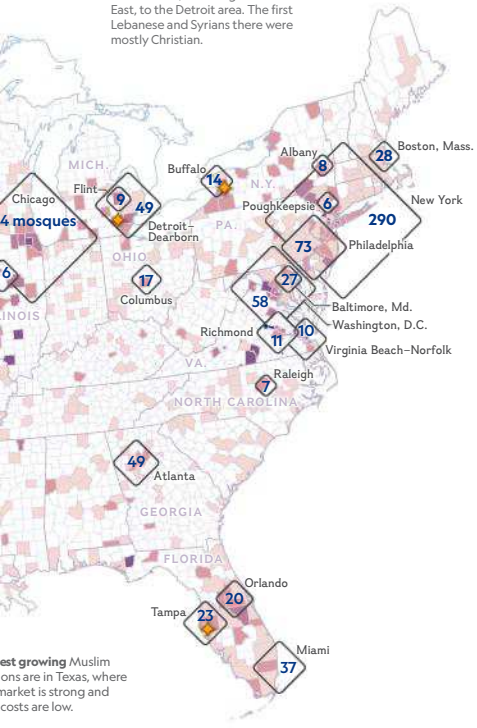


MARTIN GAMACHE AND MANUEL CANALES, NGM STAFF; KELSEY NOWAKOWSKI. SOURCES: IHSAN BAGBY, UNIVERSITY OF KENTUCKY; PEW RESEARCH CENTER; U.S. RELIGION CENSUS; COUNCIL ON AMERICAN-ISLAMIC RELATIONS

THE MANY FACES OF ISLAM

PORTRAIT SERIES BY **WAYNE LAWRENCE**

The Ford Motor Company in the early 1900s attracted immigrants from all over, including the Middle East, to the Detroit area. The first Lebanese and Syrians there were mostly Christian.



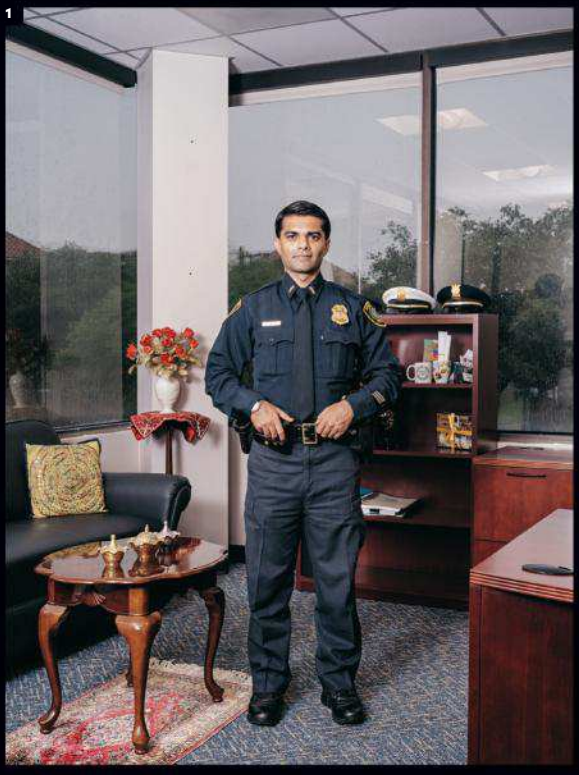
est growing Muslim ons are in Texas, where market is strong and costs are low.

PERCENTAGES MAY NOT SUM TO 100 DUE TO ROUNDING.

BEING MUSLIM IN TEXAS

God is a big part of many Texans' lives, and the state's Muslims are no different. Houston has more Muslims than anywhere else in the state, and they're as diverse as the city itself. It's also home to the first Spanish-language mosque in the country, Centro Islamico, which offers sermons, reading material, and videos on Islam for Latinos who are Muslim. Texas boasts the largest Muslim population in the country and has more than 240 mosques, but it's also become a poster child for religious tensions. It's where a Muslim teen was arrested in 2015 after his teacher mistook a clock he'd built for a bomb.

1



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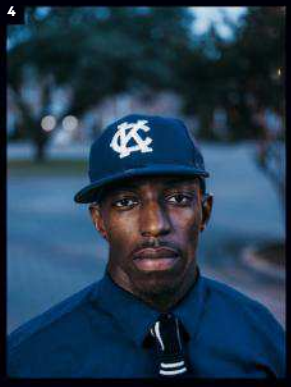

5

1. Yasar Bashir, a Pakistani American, was promoted to captain in the Houston Police Department last year. "Being a police officer makes me a better Muslim," he says, "and being a Muslim makes me a better police officer." **2.** Sarah Ahmad Waseeq, Safa McBride, and Jumada Muharram attend Centro Islamico in Houston. **3.** Sabah Shams, who grew up in Dallas with parents from Pakistan and Bangladesh, identifies as queer and has grappled with connecting her faith to her identity and society's expectations. "I am not nearly close to resolving this conflict," she says. "I'm not sure I ever will, and somehow I'm OK with that." **4.** Husain Ibn Muhammad Abdullah, an executive coach and retired professional football player who lives in Dallas, skipped a season so he could make a pilgrimage to Mecca with his wife, brothers, and parents. **5.** Sarah Zaheer, a family physician who was born in Pakistan, and Elham Karajah, a nurse practitioner student who was born in Syria, take a break at a Muslim community clinic in Richland Hills, Texas. "I feel I live here with more freedom and courage than anywhere else in the world," Karajah says. "That makes me a better Muslim and a better citizen."

6

7

8

9

6. Fatima Kebe, an industrial engineer from Dearborn, Michigan, whose parents are from Senegal, says, "My primary purpose in life is to worship God, so I am thankful to live in a country that supports freedom of religion." **7.** Reginald Muhammad, an electrician, sells the Nation of Islam's *Final Call* newspaper in Detroit. **8.** Iman Saleh, whose parents are from Yemen, is a journalism student at Wayne State University in Detroit. **9.** Chris Blauvelt and Amani Hammoud, with daughter Maryam, live in Dearborn. Blauvelt runs a crowdfunding platform for Muslim entrepreneurs, while Hammoud, who's Lebanese-American, is a stay-at-home mother. **10.** Kamilah Munirah Bolling and Adil Justin Cole stand outside their home in Farmington Hills, Michigan.

Wayne Lawrence is a documentary photographer born in St. Kitts and based in Brooklyn, New York. His work focuses on communities that are often overlooked. This is his fourth feature for the magazine.

BEING MUSLIM IN MICHIGAN

When many people think of Muslims in America, they think of Dearborn, a Detroit suburb often called the Arab capital of North America. Shiite Islam is prevalent there; Lebanese, Iraqis, Syrians, Yemenis, and other Muslims call it home. Fordson High School drew attention in 2011 when its mostly Muslim football team practiced at night to accommodate players fasting during Ramadan. Nearby Hamtramck is the first Muslim-majority city and has the first Muslim-majority city council. Abdul El-Sayed, an Egyptian-American doctor, is running for Michigan governor. If elected, he would be the first Muslim governor in the U.S.

10

LEFT
Lena Sareini, a Lebanese-American executive pastry chef, grew up in her family's kitchen in Dearborn, Michigan. In her desserts she often incorporates recipes from her childhood and aspects of Lebanese cuisine. She says her heritage gives her an edge in her work.

BELOW
Juan Pablo Osorio, who was born in Colombia and raised Roman Catholic, converted to Islam. The former Marine sergeant from Houston studied the faith while he served in Iraq and Afghanistan. "It helps me to live a life conscious of what's right and wrong," he says.

preacher from California, says it's one of the only places where pluralism openly flourishes, because Americans have the freedom to practice the religion in all its forms. As he talks to hundreds of mostly millennials in a Houston suburb at the Maryam Islamic Center—named for the Virgin Mary, the only woman mentioned by name in the Quran—he seamlessly switches from slang to jokes to quotes from the Quran. They ask him about how to handle customs that irk them: women being judged for wearing makeup in the prayer hall or immigrant parents who expect you to marry within the same culture. His answers come in candid stories that mix personal experiences with Islamic teachings about mercy, love, and respect.

It's the cornerstone of his organization, the Ta'leef Collective. With campuses in Fremont, California, and Chicago, Canon has tried to create a welcoming space that largely caters to younger Muslims and converts.

For American-born Muslims the mosque can sometimes feel like a foreign place, a mash-up of immigrants from many countries bringing different cultural references. And Islam, like all religions in America, is struggling to keep young people in the fold. "The aim was to create an environment with unreserved welcome that people can come to at their own pace," Canon says, "and on frankly their own terms."

ISLAM HAS LONG BEEN PART of the tapestry of American identity; the first Muslims were brought here as slaves in the 16th century, many from West Africa. In the New World, 10 to 20 percent of slaves were Muslim, according to scholars. Barred from practicing their faith, they did it in secret, so clandestinely that scholars say Islam largely died out among the families that brought it here.

But elements of Islam were resurrected in African-American communities through black nationalist and civil rights movements as a tool of empowerment, seen as reclaiming a culture stripped from a people. It started with movements such as the Nation of Islam. But today the majority practices a more mainstream form of the faith, following the lead of Malcolm X and later Imam Warith Deen Mohammed. The son of Elijah Muhammad, the prominent Nation of Islam leader, Mohammed abandoned a black separatist narrative and is credited with bringing a more traditional practice to Black Muslims.

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Young Afghan Americans enjoy a night out at Big Al's Pizzeria in Maywood, California, which specializes in halal beef and chicken toppings. The group—some of them friends, some meeting for the first time—was in the Los Angeles area to celebrate Nowruz, the Persian New Year, which falls on the spring equinox.

wave of Muslim immigrants in mod- began in the late 1800s; mostly from , they sought economic opportuni- ttled largely in the Midwest. The first as in North Dakota. Iowa is home to surviving place of worship built for he Mother Mosque of America. But but closed for Muslims in 1924, with tion act that barred people from Asia. next wave began, when new legislation he U.S. to the world. That immigration today. The largest Muslim immigrant from South Asia. There are now more mosques across the country.

ome, having a mosque of their own ive, like the Muslim families in rural Santa Clara County, south of San Jose, California.

The area is a beautiful landscape of rolling hills and sheep farms. But the barn on Mohammed Idris Hussain's farm in San Martin—where the retired Fijian-American Vietnam War veteran has lived with his family since the 1980s—is no longer for his sheep. It's where the ethnically mixed South Valley Islamic Community prays.

It was supposed to be a temporary fix, to save the $1,500 a month in rent for a storefront in a strip mall. The community pooled its money, bought a piece of land, and drew up plans for the Cordoba Center. But the project quickly became a lightning rod. More than a decade after those first steps, the community now numbers about a hundred families, and they still squeeze into Hussain's barn to worship.

The community has spent about three million dollars trying to build this mosque, but the Islamic center is still just a blueprint in Sohail Akhter's kitchen. The Pakistani American is the project manager. "Fearmongering is the greatest weapon that they've used against us because we're so few," he explains to me, saying that opponents have accused them of trying to build a terrorist training camp. "Not a lot of people here have ever met a Muslim. They associate all of us with that. They're afraid."

The main opponents are the Gilroy-Morgan Hill Patriots and the People's Coalition for Government Accountability. The Patriots have posted anti-Muslim rhetoric on Facebook and


William McGinn
Eric Allen
Andrew Fredericks
David Halderman
Timothy Haskell
Manuel Mojica
Lawrence Virgilio
CAUTION
WHEN ALARM BELL SOUNDS
TANK FILLED TO CAPACITY
DO NOT OVERFILL
FDNY

Every morning Abdelrahman Abdelaziz (at left) greets neighbors at Squad 18's firehouse in New York City's West Village. The Palestinian American, a lieutenant on the force, sees himself as a little bit of an ambassador for his faith. "I wanted to show that not all Muslims are terrorists," he says. "We are productive members of society."

NEXT PHOTO

About 20,000 Muslims attended a morning prayer last year at Angel Stadium in Anaheim, California, to celebrate Eid al-Fitr. Muslims often dress up in their finest clothes on the holiday. The prayer marks the start of three days of celebrating and eating. In the U.S. the holiday is not typically recognized by employers or schools, so most Muslims must take time off to celebrate.


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Team Lally
LEXUS
FOX WEST
LEXUS
PLE
TE GENEROUSLY


WA ALA AZWAJIE SAYYEDNA MUHAMM


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Yogur
Ice Cream
OREO
CHOC
STRAWBERRY
King Softee
$3.50
$5.00
$3.50
$5.00
CARAMEL
BUTTER
SCOTCH


313 694·9391
BANANA BOAT
VANILLA
NACHOS
$5
$5
Oreo Cup
Strawberry Cup
$2.00
$4.00
$3.00
$2.50
$2.00
$2.75
$2.25
Sunday Toppings
Pineapple
Strawberry
Chocolate
Caramel
Sprinkles
$1.50
$1
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FASHION
NEXT

An Iranian-American music producer known as Metal Sanaz unwinds in her Los Angeles studio. She was raised in a family that does not practice. Muslims, like adherents of all faiths, range from secular to devout. Some jokingly call themselves Ramadan Muslims, praying only during the holy month.

PREVIOUS PHOTO

In Hamtramck, Michigan, children flock to an ice-cream truck to buy cool treats. In this neighborhood most of the children have parents who came from Yemen. The city (population 21,750), which is surrounded by Detroit, has a mostly Muslim population, and Muslims hold the majority on the city council.

sponsored an anti-Muslim speaker at the library and the town's Lions Club to talk about his view that Islam is a threat to America.

The president of the Patriots says its opposition was never about Islam but about the environment. "The bottom line is these people came and bullied themselves into the neighborhood," says Georgine Scott-Codiga. "All the traffic, all the cars, the noise. We want to protect that land." But, she adds, she can understand people who worry that Muslims will change "the way of life."

Civil rights advocates say using environmental concerns is a tactic commonly employed by anti-Muslim groups to block mosques or Muslim cemeteries. Similar arguments have been used to block, or try to block, projects in Georgia, Massachusetts, Minnesota, Tennessee, and Texas.

In the first land-use meeting before the county planning commission in 2012, Akhter and others in the Muslim community were shouted down and told to go back to their countries.

"I've been here since 1990, and that was the first time I really felt scared," Akhter says. "I grew up in Fort Wayne, Indiana, once a hotbed of KKK activity, and never saw this kind of stuff until post-9/11."

The fight over the mosque and the demonization of Muslims have had an effect on Akhter's now grown American children. He's watched as they have distanced themselves from the faith after being bullied at school and called terrorists. Nudrat, Akhter's wife, a real estate agent,

is afraid to show homes on her own now. "There are times I don't feel safe; sometimes I go with him," she says, pointing to her husband.

She's worried people might react badly to her head scarf. There have been incidents that shocked her. "Once I was at the local Costco, and this lady came to me and handed me a small booklet and said, 'You might enjoy reading this,'" she says. "I didn't realize what it was, and when I opened it up, it was a whole Muslim comic book saying, 'Oh, we're going to kill everybody.' It was all stuff making fun of Muslims, and I didn't know what to do. It was so sudden."

The contempt has been upsetting, Akhter says, but it's also made Muslims here more resolute in defending their faith and their rights. "This is our home," Akhter says. "Somebody comes and tells you to leave your home—are you going to quit? That's the most absurd thought."

Despite the troubles, Bakri Musa, a Malaysian-American surgeon in the community, says he prefers a lawsuit to the alternative. "I'd rather they sue us than they burn the mosque down. This is a quantifiable obstacle," he says.

That's what Musa loves about being Muslim in America: The rights of expression and worship are protected. Here, he says, he can choose to be the kind of person, the kind of American, the kind of Muslim he wants to be. He points to his shelves at his rustic home on a sheep farm. They're filled with books written by Shiite and Sunni scholars, reflecting the many schools of thought under those two main Islamic sects.

"This is the place to be a Muslim, scholarship without intervention," he says. "In Malaysia I could go to jail because I have Shiite literature in my house, and in Malaysia that's the equivalent of being a commie in America."

The day after we talked, the mosque rents out the community center to host an interfaith dinner with Jewish and Christian leaders, as well as guests. Musa and his wife, Karen, a Canadian American, sit next to a Jewish couple and explain the different South Asian foods being served. It's something the community does a lot now—interfaith work, community outreach. Despite how loud their opponents are, they say they feel welcome in the community and are hopeful they'll soon have a mosque of their own.

MANY YOUNG MUSLIM AMERICANS are tired of constantly having to explain themselves or speak for all Muslims. They're searching for a place to belong that combines their faith and American sensibilities.

I meet Rami Nashashibi on West 63rd Street on the South Side of Chicago, where his Inner-City Muslim Action Network (IMAN) has operated for two decades. He stops traffic as he runs from the clinic and offices on one side of the street to the Mexican restaurant turned prayer room, cafeteria, and extra office space on the other.

The 46-year-old community activist founded this place to use Islam to serve the underserved. Now he's built a coalition of Muslims—black, South Asian, Arab, white, Latino, some from the impoverished South Side, others from suburban communities—to use the faith to tackle the social

Marya Ayloush laughs as she oversees a fashion shoot in Los Angeles for her online hijab company, Austere Attire. Ayloush will use the photos to market her clothing on social media and her website. The business of creating modest fashion for religious women has taken off in the United States.

issues that plague this neighborhood.

Nashashibi was born to nonreligious Arab parents and found his way to the faith, like many American converts, through hip-hop and the social justice movement. When speaking about IMAN, Nashashibi often quotes Imam Warith Deen Mohammed, a cleric he considers an inspiration who died in 2008. "He best reflects the tradition of Islam that resonates with me now," he says. "The life-giving message of Islam. Islam as a source of mercy, a source of reconciliation."

Today Nashashibi and the staff at IMAN work with corner-store owners to bring fresh food and a more inviting environment—things like no bars on the windows—to food deserts in low-income neighborhoods. They get residents involved in community organizing, provide free medical services, and run a reentry program for former inmates who leave prison with a few dollars and often no family support.

I visit during Ramadan, the busiest time of year at IMAN. To break this day's fast, a community dinner is served in the parking lot behind the clinic. Vendors hawk cold-pressed juices, bean pies, and colorful jewelry. The guests are from the neighborhood: community organizers, politicians, faith leaders, and friends. In the background the graffiti mural on IMAN's building has a verse from the Quran. "Is there any reward for good other than good?"

Nashashibi addresses the crowd. "Whether we're delivering health care or building houses,

we understand that you have to do it by building power, building relationships, building alliances," he says. "You will continue to see us—as we have, ever since this election—use the hashtag 'Fight Fear, Build Power' as the ultimate response to the moment that we're in."

"I want to hear it," he tells the crowd. "Fight fear!" he calls. The crowd shouts, "Build power!"

The next day a group from IMAN heads to a corner store, Morgan Mini Mart, for an event called Refresh the 'Hood. Outside an emcee tweaks the words to a Tupac song, rapping, "The sweeter the juice, the deeper the roots." To passersby, volunteers hand out fresh smoothies and mango salsa made from produce sold inside.

Sadia Nawab, the 28-year-old arts-and-culture manager for IMAN, sits on the ground outside the store with a pair of teens painting trash cans to beautify the place. Her hair is covered in a stylish multicolored head wrap knotted at the top, her nose pierced.

Nawab grew up culturally confused. She's the daughter of parents from Pakistan, she was raised in a largely Arab immigrant suburb of Chicago, and she went to a mostly white school but identified with various cultures, including black culture and hip-hop. "I knew I was Muslim," she says. "I just didn't know what it meant. And people put you in boxes: Arab, Muslim, immigrant, doesn't speak English. I didn't know how I fit in."

Through IMAN she began to figure out what being Muslim meant to her. She found her way back to her faith. "It had this transformative effect on me, working in the trenches of the South Side of Chicago," she says. "I was able to thrive, emotionally and mentally. I was 17 when I started volunteering, and that's a precious age." She says she needed mentors who understood her as an American Muslim teen. That's what she found at IMAN. "Here I don't always feel like an outsider. It feels natural," she says.

IMAN is a way to make Islam relevant to American Muslims, Nashashibi says, especially those searching for a purpose and a connection to a faith so often portrayed as a foreign threat on American television. For this work he was recognized last year with a prestigious MacArthur Foundation "genius" award. "We're trying to celebrate the legacy of the spirit of a transformational, empowering, inspirational Islam that is not constantly trying to apologize and explain itself," he says.

It's the antidote, he says, to the apathy that leads people away from the faith or the vulnerability, disenfranchisement, and anger that lead people to violence, be it on the South Side of Chicago or the battlefields in Syria and Iraq. And America, he says, is the best place to be a Muslim today. "America has always provided, even in its darkest hours, spaces through which people have challenged it to live up to unfulfilled ideals." □

Leila Fadel, based in Las Vegas, is a correspondent for NPR covering race and diversity. Before that she reported on the Middle East and North Africa for more than a decade. In addition to this feature, Fadel's first for the magazine, a series of her stories on Muslims in America will air on NPR. **Lynsey Addario,** based in London, has photographed the Muslim world for 18 years. This is her eighth feature.

THE DINOSAURS THAT DIDN'T DIE

An asteroid strike 66 million years ago devastated the dinosaurs. But today's birds are proof there were a few survivors.

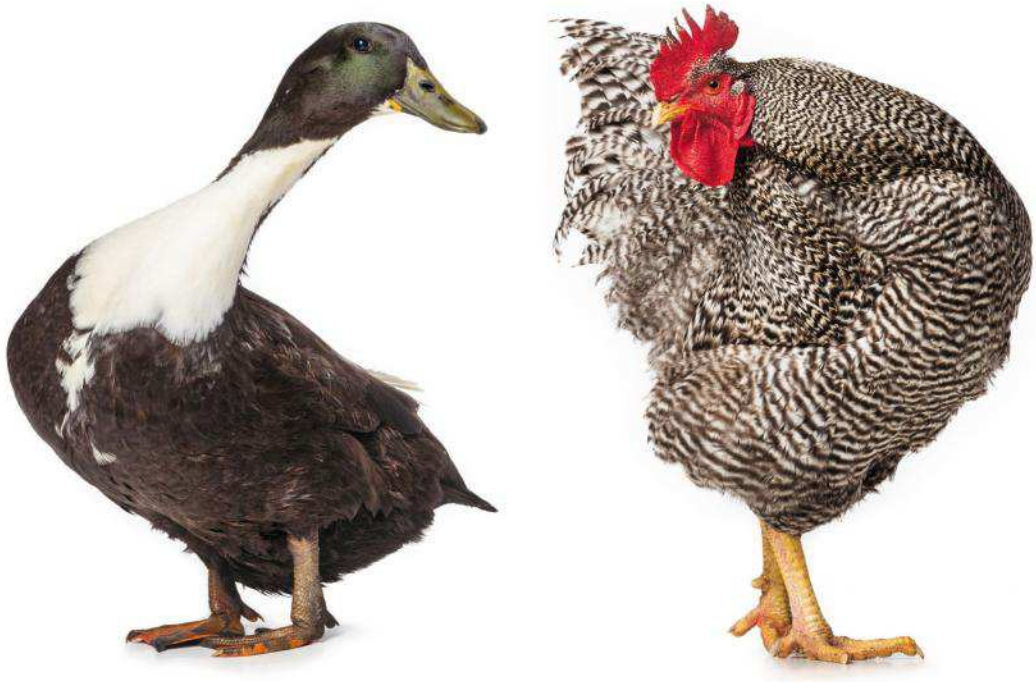
Ghostly feathers of an early swift are preserved on a 48-million-year-old fossil found in Germany. Swifts and hummingbirds share an ancestor that may have evolved a few million years after the mass extinction.

PHOTOGRAPHED AT SENCKENBERG NATURAL HISTORY MUSEUM, FRANKFURT, GERMANY

BY **VICTORIA JAGGARD**
PHOTOGRAPHS BY **ROBERT CLARK**

Did dinosaurs like these dromaeosaurs dine on ancient duck relatives in Antarctica? The frozen continent was very different some 67 million years ago, but fossils reveal that *Vegavis iaai* looked remarkably like a modern duck. It's the oldest known fossil tied to a modern bird group that survived the asteroid strike that wiped out all the non-avian dinosaurs.

MÓNICA SERRANO, NGM STAFF; PATRICIA HEALY. ART: RAÚL MARTÍN. SOURCES: JULIA CLARKE, UNIVERSITY OF TEXAS AT AUSTIN; MARCELO LEPPE, CHILEAN ANTARCTIC INSTITUTE; JUDD A. CASE, EASTERN WASHINGTON UNIVERSITY



Nestled among white-sand beaches and brightly colored resorts, the mangrove swamps along Mexico's Yucatán coast are a paradise for birds and the people who enjoy watching them. The densely wooded swamps, located along a major avian migration route, offer safe haven to the millions of birds that make fraught intercontinental flights between the Americas each year.

My guide to this flyway rest stop, Luis Salinas-Peba, is a soft-spoken scientist at the local campus of the National Autonomous University of Mexico. A botanist by training, Salinas-Peba is also a master of bird identification who can name just about every species we see and hear packed among the mangroves. The mix of long-distance migrants and local species is dazzling: Blue-winged teals from Canada cross paths with endemic Yucatán wrens. Towering pink flamingos mingle with teacup-size hummingbirds.

The air pulsates with the guttural alarm cries of cormorants, which get louder and more insistent as our tiny boat glides closer to their nests. Several of the sleek black birds suddenly launch into the sky, pulling my gaze upward and my thoughts toward the past, when a visitor from space 66 million years ago turned a primeval paradise into a burning apocalypse.

Roughly 30 miles to the east of this mangrove swamp sits Chicxulub Puerto, a calm seaside village at the center of an immense impact crater that stretches into the Gulf of Mexico. The ever shifting earth has softened the crater rim, which today is only visible using advanced satellite sensing. But its footprint on the planet tells an incredible tale. On one infamous day in the late Cretaceous period, an asteroid the size of a mountain slammed

Scrappy survivors—ostriches, ducks, and chickens descend from two of the three groups of birds that arose in the late Cretaceous and somehow lived through the destruction 66 million years ago, according to the latest genetic data and fossil clues.

PHOTOGRAPHED AT ROAMING ACRES FARM, LAFAYETTE, NEW JERSEY (OSTRICH); LITTLE GHENT FARM, GHENT, NEW YORK (BOTH)

A 3-D digital model of the "first bird," *Archaeopteryx,* appears to pop out of its stony tomb thanks to x-ray scanning and photogrammetry led by National Geographic Emerging Explorer and biologist Ryan Carney. The plumage on its wings is based on actual fossil feathers (like the one at right) from the 150-million-year-old animal.

RYAN CARNEY, UNIVERSITY OF SOUTH FLORIDA

into what is now the Yucatán coast, gouging the earth and setting off a series of catastrophic events. Vaporized rock and noxious gases choked the atmosphere, forests were obliterated across the globe, and temperatures fluctuated dramatically. The impact and its aftermath ended the reign of the dinosaurs, wiping out a group of creatures that had ruled the planet for 135 million years.

Well, almost.

Ask just about any paleontologist, and he or she will tell you that life found a way and that some dinosaurs survived the mass extinction. That's because today's birds are the last remaining twig on an otherwise demolished dinosaur family tree, grown from fierce predators and sculpted by evolution into an array of flapping, feathery fowl.

"There is no doubt that birds are dinosaurs," says Luis Chiappe, director of the Dinosaur Institute at the Natural History Museum of Los Angeles County. "The evidence is so overwhelming, I would put it next to whether you're going to question if humans are primates."

In the hellscape left by the asteroid, what gave the ancestors of modern birds an edge over their Cretaceous cousins? It's a tough nut to crack, given how rare birds are in the fossil record. But some exceptional discoveries over the past dozen years, coupled with advances in genetic analysis, are starting to reveal how the Chicxulub impact shaped the modern-bird origin story. That, in turn, is offering some of the first plausible clues to how birds made it through the cataclysm

Record of Disaster

A slice of rock from Canada, representing a span of 500,000 to 750,000 years, offers clues to what the world was like before, during, and after the meteor struck Earth.

Paleogene: Microfossils in coal indicate that forests collapsed and ferns took over. No dinosaur fossils are found in or above this layer.

Cracked quartz and rare metals such as iridium (scarce on Earth but plentiful in some meteorites) suggest a meteor strike.

Cretaceous: The transition from pale mudstone to coal shows the climate shifting from dry to wet, perhaps stressing dinosaurs, other fauna, and flora.

PHOTOGRAPHED AT ROYAL TYRRELL MUSEUM OF PALAEONTOLOGY, ALBERTA, CANADA

SOURCE: DENNIS BRAMAN, ROYAL TYRRELL MUSEUM OF PALAEONTOLOGY

and exploded into the more than 10,000 species that exist today.

THE OLDEST KNOWN ROOT on the bird family tree is the raven-size *Archaeopteryx,* a 150-million-year-old animal that bore a telling mix of attributes. While all of today's birds are toothless, *Archaeopteryx* had jaws bristling with sharp teeth. It sported claws on its front limbs and a long, bony tail. These traits are lost in birds and instead reveal close ties to its more reptilian cousins, such as the *Velociraptors* of *Jurassic Park* fame. But *Archaeopteryx* had characteristics of modern birds too. Its fossils show prominent wings covered in aerodynamic feathers and a wishbone not unlike one plucked out of a chicken dinner.

Not long after its discovery in the 1860s, the species was hailed as a clear transitional step between dinosaurs and birds. But few new fossils emerged to fill in the evolutionary gaps, and details about its ancestors and descendants remained murky for decades.

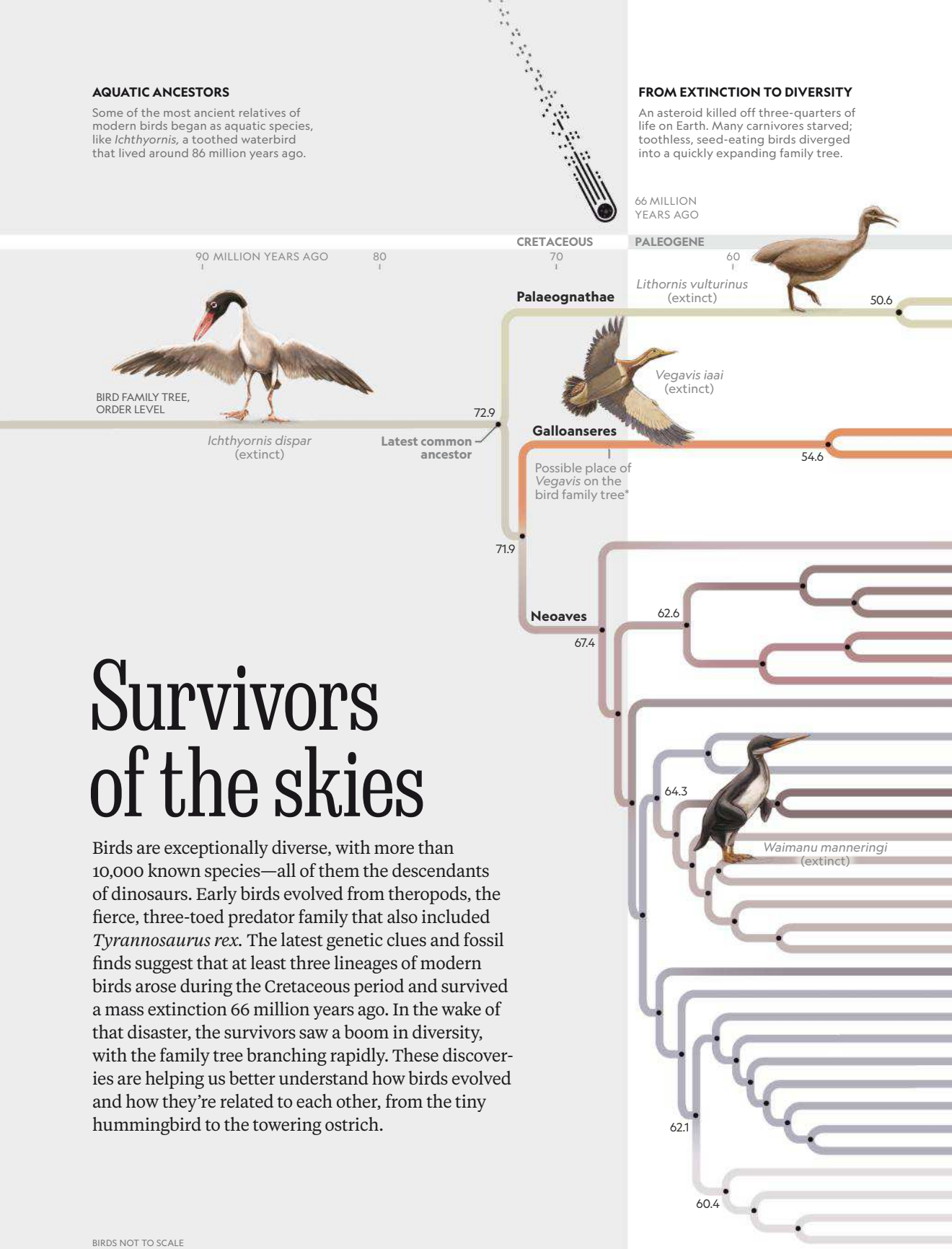
That finally changed in 1996, when scientists unveiled the first known fossil of a feathered dinosaur unrelated to birds. Dating back nearly 130 million years, *Sinosauropteryx prima* was a game changer among the dozens of spectacular species being mined from early Cretaceous rock formations in China, mainly in Liaoning Province. There, primordial lakes and active volcanoes had created all the right conditions for exquisite fossil preservation. The result

AQUATIC ANCESTORS

Some of the most ancient relatives of modern birds began as aquatic species, like *Ichthyornis,* a toothed waterbird that lived around 86 million years ago.

FROM EXTINCTION TO DIVERSITY

An asteroid killed off three-quarters of life on Earth. Many carnivores starved; toothless, seed-eating birds diverged into a quickly expanding family tree.

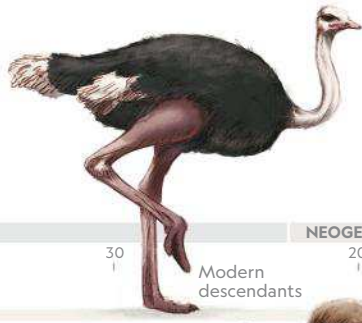


Survivors of the skies

Birds are exceptionally diverse, with more than 10,000 known species—all of them the descendants of dinosaurs. Early birds evolved from theropods, the fierce, three-toed predator family that also included *Tyrannosaurus rex.* The latest genetic clues and fossil finds suggest that at least three lineages of modern birds arose during the Cretaceous period and survived a mass extinction 66 million years ago. In the wake of that disaster, the survivors saw a boom in diversity, with the family tree branching rapidly. These discoveries are helping us better understand how birds evolved and how they're related to each other, from the tiny hummingbird to the towering ostrich.

BIRDS NOT TO SCALE
MÓNICA SERRANO, NGM STAFF; MESA SCHUMACHER. SOURCES: DANIEL J. FIELD, UNIVERSITY OF BATH; INTERNATIONAL ORNITHOLOGICAL CONGRESS; IUCN RED LIST; REPTILE DATABASE; AMPHIBIAWEB TAXONOMY

*THE EXACT RELATIONSHIP OF *VEGAVIS IAAI* TO MODERN WATERFOWL IS UNCLEAR.



RISING ABOVE THE REST

Modern birds consist of 247 families and 10,731 species, more than any other vertebrate group except fish.

NEOGENE

40 | 30 | 20 MILLION YEARS AGO | 10 | TODAY

Modern descendants

Ostrich
Rheas
Kiwis
Emu, cassowaries
Tinamous
Land fowl
Waterfowl
Nightjars, hummingbirds
Turacos
Bustards
Cuckoos
Mesites
Sandgrouses
Pigeons
Cranes, rails, and relatives
36.7
Flamingos
Grebes
Shorebirds and relatives
Sun bitterns
Tropic birds
Loons
Penguins
Tube-nosed seabirds
Storks
Cormorants and relatives
Ibis, herons, pelicans
Hoatzins
Raptors, vultures
Owls
Mousebirds
Cuckoo rollers
Trogons, quetzals
Hornbills
Kingfishers and allies
Woodpeckers and allies
Cariamas
Falcons
Parrots
Perching birds

Flamingos have typically been grouped with long-legged birds like storks and herons, but DNA and fossils show they're actually related to grebes.

TOTAL BIRD SPECIES

PALAEOGNATHAE
60
SPECIES

GALLOANSERES
477
SPECIES

NEOAVES
10,194
SPECIES

Perching birds are the largest order within Neoaves, with more than 6,000 species.

OUTNUMBERED BY BIRDS

REPTILES
10,450
SPECIES

AMPHIBIANS
7,801

MAMMALS
5,500

is a menagerie of non-avian dinosaurs and their primitive bird contemporaries, often accompanied by feathers, scales, and skin that are sometimes so detailed they even retain traces of pigment. Like *Archaeopteryx*, many of these animals are surreal mash-ups between the standard notion of a modern bird and classic images of a predatory dinosaur.

With feathers dark as an oil slick, the non-avian dinosaur *Microraptor gui* probably glided between branches using stiff feathers on all four of its limbs. Nearby, the primitive bird *Longipteryx chaoyangensis* was flitting along waterways, snapping up fish with its reptilian, tooth-studded jaws. And *Anchiornis huxleyi,* a charcoal-hued dinosaur with a crown of rusty fluff, was stalking the forest floor like a goth pheasant, unable to truly fly because of its stubby, three-clawed wings.

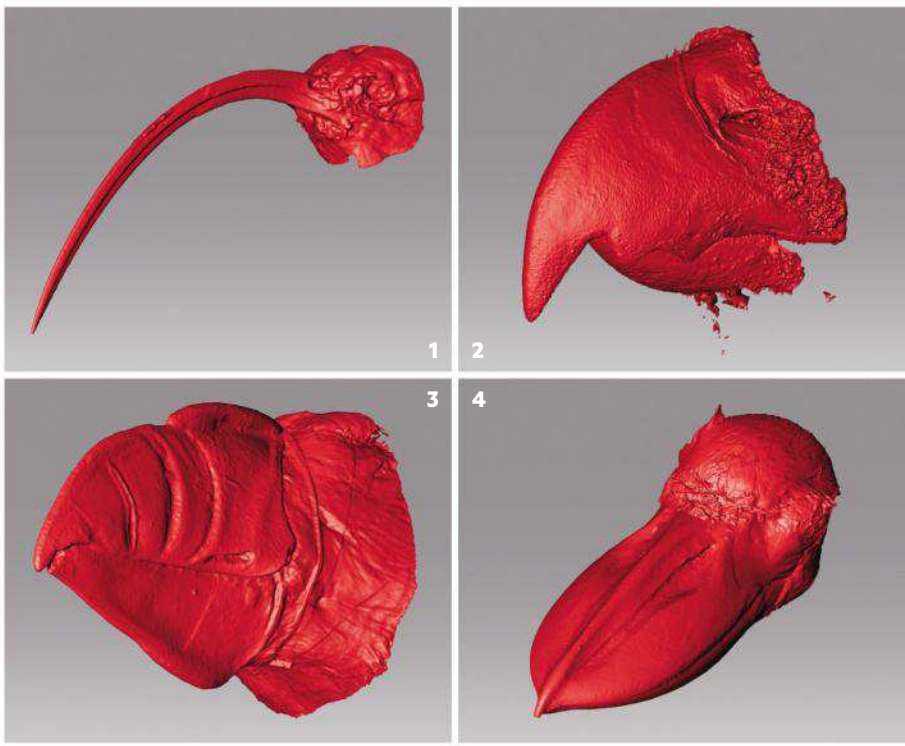
"If you didn't see the fossils themselves, you wouldn't think these things existed," says Shannon Hackett, a bird curator at the Field Museum in Chicago.

Despite this bounty of finds from Liaoning, paleontologists still faced gaps in the fossil record, which they sometimes tried to fill based on patchy data from mere fragments of bone. Some DNA work put the origin of modern birds deep in the Cretaceous, with many of the avian groups that exist today springing up very early in the time line. This implied a tale of mega survivorship, with a bunch of modern bird ancestors somehow making it through the mass extinction in one giant flock.

Other experts argued that all birds living before the cataclysm were of the more primitive persuasion, like the ones whose fossils were found in China. Under that theory, a few ancient species survived the impact and gave rise to a "big bang" of modern bird evolution only after the rest of the dinosaurs died.

For years the debate was as contentious as asking whether cheesecake is cake or pie. But in 2005 bones from Antarctica threw an exciting new ingredient into the mix: a bird that lived just before the Chicxulub event and looked stunningly similar to a modern duck.

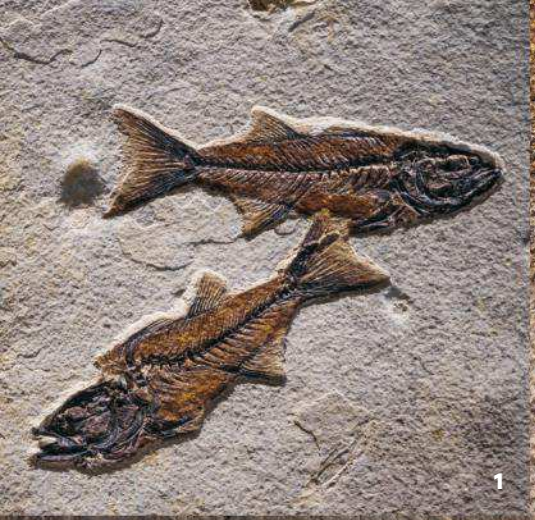
Julia Clarke at the University of Texas at Austin first described *Vegavis iaai* based on a fossil dated to around 67 million years ago, just before the asteroid strike. Traditional anatomical analysis and a digital reconstruction of the bones show that *Vegavis* seems to bear traits in its skeleton that exist only in today's birds, signs it is indeed



Evolutionary biologist Gavin Thomas holds a great hornbill specimen from London's Natural History Museum. He and his team have studied 3-D scans of thousands of beaks, from birds such as the black-billed scythebill (1), double-toothed kite (2), tufted puffin (3), and boatbill (4), and have added to the evidence that birds likely diversified rapidly after the rest of the dinosaurs died.

GAVIN THOMAS (BEAK SCANS)

(1) *CAMPYLORHAMPHUS FALCULARIUS*
(2) *HARPAGUS BIDENTATUS*
(3) *FRATERCULA CIRRHATA*
(4) *COCHLEARIUS COCHLEARIUS*


1


2


3


4


5

Bountiful Birds

While fish (1) are far more common finds, more than a hundred complete bird fossils have sprung from the limestone slabs of Fossil Lake in Wyoming, including mousebirds (2), early parrots (3), flightless wading birds (4), and frigatebirds (5). The 52-million-year-old rock layer holds abundant, exceptionally preserved fossils, such as this early songbird (6), and is intensively excavated from May through October. This combination creates what Lance Grande of the Field Museum calls "the perfect storm of paleontology."

PHOTOGRAPHED AT
FIELD MUSEUM, CHICAGO

(1) *MIOPLOSUS LABRICOIDES*
(2) *CELERICOLIUS ACRIALA*
(3) *CYRILAVIS COLBURNORUM*
(4) *FAMILY SALMILIDAE*
(5) *LYMNOFREGATA AZYGNOSTERNON*
(6) *EOZYGODACTYLUS AMERICANUS*

part of a modern line. Clarke and her team place it in the same group that includes present-day ducks and geese.

In 2016 they examined a second, more complete skeleton of *Vegavis* and found that the animal not only looked like a duck, it may have also quacked like a duck. The fossil contains the oldest known example of a vocal organ called a syrinx, a squawk box akin to the ones found in today's waterfowl.

"*Vegavis* is easily one of the most important early fossils" for understanding the spread of birds, says Daniel Field, an evolutionary paleobiologist at the University of Bath. This evidence of a modern bird group popping up just before the asteroid's impact added to a growing need to rethink the polarizing positions on bird evolution that reigned in the 1990s.

Closer looks at fragmentary bones, combined with more advanced methods of genetic backtracking, are fleshing out the story. In a study published in 2015, a team led by Yale University ornithology professor Richard Prum combed through the genes of 198 living bird species and calibrated their results against the latest fossil finds. Their detailed avian family tree suggests that only three modern groups got their start just before the asteroid strike.

The picture emerging now shows animals that looked very much like modern birds, flying and diving and pecking in the shadow of the dinosaurs. A select few made it through the mass extinction, and that's when birds as we know them really took off.

KEMMERER, WYOMING, is built on bones. About a hundred miles northeast of Salt Lake City as the crow flies, the town sits among crumbling buttes packed with billions of fossils. Known for these riches since the 19th century, the land hosts about a dozen commercial quarries that supply trade shows and gift shops around the

THE YEAR OF THE BIRD

National Geographic is partnering with the National Audubon Society, BirdLife International, and the Cornell Lab of Ornithology to celebrate the centennial of the Migratory Bird Treaty Act. Watch for more stories, books, and events throughout the year.

Today mousebirds like this museum specimen are found only in sub-Saharan Africa. But the delicate fossil held in these vials shows that an ancient mousebird, *Tsidiiyazhi abini,* lived in what's now New Mexico about 62 million years ago. The rare fossil helped scientists better pinpoint when different bird lineages split from each other, in turn supporting the notion that birds experienced an evolutionary boom soon after the asteroid strike.

PHOTOGRAPHED AT NEW MEXICO MUSEUM OF NATURAL HISTORY AND SCIENCE, ALBUQUERQUE

world. Whole family dynasties rise and fall and engage in understated rivalries over the discovery, preparation, and sale of animals that died some 52 million years ago.

In the heart of Kemmerer, a couple of doors down from the first store opened by J.C. Penney, Lacey Adams perches on a metal stool at her prep table inside Tynsky's fossil shop. As her safety glasses pin down parts of her spiky blond hair, Adams uses a compressed air chisel and needles to painstakingly remove the pale rock surrounding tea-brown bones.

"I know offhand what species I'm looking at because of the ridges," she says, turning a thin slice of stone under the light to reveal otherwise imperceptible bumps. "Like, that one's obviously *Knightia,"* a member of the herring family commonly found in the region.

This dry, rugged land is mostly known for its abundant fossil fish. After all, we're standing in what used to be a massive lake, a subtropical everglade that would have made a South Floridian feel at home. As with the much older wetlands in China, this lake left an entire ecosystem frozen in time, including a valuable collection of ancient birds. Quarry workers and scientists here have unearthed partial bones, stray feathers, and well over a hundred complete bird skeletons. "They're the best picture we have of how Earth's biota was recovering after the great extinction event at the end of the Cretaceous," says Lance Grande, a curator at the Field Museum and my host at the dig site.

Grande has been coming to this paleontological wonderland, prosaically known as Fossil Lake, for more than 40 years. He usually spends a few weeks each summer mining privately held land leased by the Tynskys. The most scientifically valuable finds return with him to Chicago, and the Tynsky family keeps the rest for commercial sale.

For a blistering week in late June I join him

up on the butte, where a cadre of enthusiastic high school students and museum volunteers teach me how to lift large slabs out of the earth and check them for signs of past life. About midmorning on one achingly bright day, Grande asks me to pause my sweaty efforts and come see something amazing: A worker from a neighboring quarry has brought us a bird.

Grande has built relationships with several other local families, and they often share their most interesting finds in case he wants to make a purchase on behalf of science; some they donate. During a tour of the town, I happened to see one long-time fossil hunter affably barter his most recent discovery—a stunningly detailed ancient shrimp—for a wad of cash and a copy of Grande's latest book, simply titled *Curators*.

This time, though, the potential prize came to us, lovingly displayed from the back of a dusty pickup truck. The animal is only partially uncovered from its limestone tomb, but I can clearly see delicate bones and the impression of a feathered wing. Grande wants a closer look, so we wrap it for transit and race down to the local hospital to get an x-ray. The radiology techs greet us with less surprise than I would have expected—this is clearly not their first fossilized patient. It takes a couple of tries, but by the end of our impromptu visit, Grande is convinced there's a complete bird skeleton inside the hunk of rock. He'll later negotiate with its discoverer to buy the fossil for further study.

In this way, many of the birds from the hills around Kemmerer have come to roost in Chicago, held in the display cases and storage rooms of the Field Museum. During a visit to the storied institute a few weeks after our dig, I get a closer look at an early parrot, a perching songbird, and a type of mousebird that have all been recently described by scientists. These remains show that the postimpact ecosystem was an exceptionally diverse aviary. "Every time we find a new bird specimen, one out of two times, it's something completely new," Grande says. "It's pretty exciting."

The past few years have been a boon to researchers trying to capture an image of bird life recovering after planetwide disaster. In New Mexico, paleontologists recently extracted parts of a different mousebird that lived 62 million years ago. *Tsidiiyazhi abini,* Navajo for "little morning bird," is now one of the oldest known avians on this side of the extinction event. It joins a 61-million-year-old giant penguin found recently in New Zealand that looks different from other penguins that lived around the same time.

The picture emerging now shows animals that looked very much like modern birds, flying and diving and pecking in the shadow of the dinosaurs.

All these fossils seem to fit with the latest genetic puzzle pieces. A number of papers released in 2014 looked at the full genomes of 48 living bird species and concluded that modern birds saw a rapid boom in diversity soon after the asteroid impact. The 2015 genetics study came to a similar conclusion. Even if the two teams don't agree on some of the finer details, they each support a picture of survivors making a strong comeback.

"Evolution took tens of millions of years to produce a small dinosaur with wings that could fly by flapping its arms. And then that body plan proved really successful when the asteroid hit," says Stephen Brusatte, a paleontologist at the University of Edinburgh. "Some of those birds made it through, and then, on the other side, there was a whole new world to conquer."

THE TOUGHER QUESTION is *why* these particular ancestors of modern birds made it through. With

more fossils and faster gene sequencing, theories about survivorship abound.

Examining the lifestyles of species that lived before and after the asteroid, Daniel Field and his colleagues think the widespread disappearance of forests may have had something to do with it. In the last days of the Cretaceous, the world as a whole was a warmer, wetter place than it is today. Lush forests were abuzz with all types of exotic birds, including many that might have passed for contemporary species at first glance.

Field's research is revealing that when the asteroid hit, whole forests disappeared, and the world was plunged into an impact winter. One ancient bird group that didn't survive was the Enantiornithes. Many of these once abundant birds have feet suited for perching in trees, suggesting they were largely arboreal. So far, not a trace of them has been found beyond the Cretaceous. Instead, the surviving bird species seem to be more at home on scrubland or at sea. All of today's birds that depend heavily on thickly wooded zones arose well after the mass extinction, around the time forests would have been bouncing back too.

Another attractive notion is that certain birds were better at proliferating in a disaster zone. In 2017 a team led by Gregory Erickson at Florida State University presented evidence that egg-laying, non-avian dinosaurs took months to incubate and hatch their young. Since many modern-style birds generally reproduce quickly and mature in a matter of days or weeks, they might have had a competitive edge over their more reptile-like cousins in the grim aftermath of the asteroid strike.

Depending on whom you ask, smaller bodies, polar adaptations, seed-based diets, and even nest designs may have played roles in determining who lived and who died. Solving the mystery will almost certainly require exhaustive hunts for animals that lived even closer in time to the impact. Ongoing fieldwork in places like South America, New Zealand, and the frosty deserts of Antarctica already hint at fresh discoveries in the near future. And richer genetic clues should flood the field in the coming years. At the China National GeneBank in Shenzhen, scientists are using faster, more precise techniques to churn out drafts of entire genomes for all living bird species by 2020. Their work should help researchers not only to understand living birds but also to match useful traits in fossil animals to those in the animals' living descendants.

"We're going to see an explosion in the number of bird genomes," Clarke says. "It's going on right now, and it's amazing, and I love it."

The most likely answer to the question of survivorship is that it took a suite of characteristics for certain birds to be successful. That's why it's important to keep adding evidence and probing each new theory. "These are global, very complex patterns that we're trying to piece together from more than 60 million years later," Field says. But "trying to dive into all of those related questions is gradually improving our understanding of survival across one of the most severe mass extinction events in the history of the world."

BACK ON THE RIM of the impact crater, Xavier Chiappa-Carrara, head of the academic unit of the National Autonomous University of Mexico in the Yucatán, is investigating how birds will cope with a more insidious kind of mass extinction. Mexico is home to more than a thousand bird species, and about half of them can be found in the Yucatán. Roughly 220 are migrants, spending the winter in the region or just passing through on their way between hemispheres. Today many of these birds are at risk due to habitat loss.

During our visit to the mangroves, we saw a large, plastic-lined shrimp farm cutting into the coastline. Vacation homes and hotels creep around the edges of the swamp. And all across the peninsula, increasing numbers of people are drawing water from the underground aquifers that support the entire coastal ecosystem. Chiappa-Carrara and his team are now racing to understand how humans are affecting the wildlife.

It's a familiar refrain around the world. We are changing the environment so quickly, wiping out habitats and altering the climate, it's like an invisible asteroid hit the planet.

But while the ancient space rock couldn't have cared less, people can alter the course of this catastrophe, which is why Chiappa-Carrara has hope. He and his colleagues help organize a Yucatán bird festival every year, bringing the wonders of all things feathered to the public. Every year they inspire more visitors to appreciate and protect these survivors from a fallen kingdom—the dinosaurs that still share the land and sea and sky. □

Victoria Jaggard is a senior science editor with *National Geographic*. **Robert Clark** has photographed more than 40 stories for the magazine. His latest book is *Evolution: A Visual Record*.

BY **CLAUDIA KALB**

PHOTOGRAPHS BY **PAOLO WOODS** AND **GABRIELE GALIMBERTI**

INTENSE PROVOCATIVE DISTURBING CAPTIVATING GENIUS **PICASSO**

HIS JOURNEY FROM PRODIGY TO ICON REVEALED THE DEPTH OF HIS ARTISTRY, AND THE RESTLESS BRILLIANCE BEHIND IT.

At Reina Sofía museum in Madrid, schoolchildren visit Picasso's iconic painting "Guernica," which depicts death and anguish in the aftermath of the bombing of the Basque town in 1937. Although precipitated by the Spanish Civil War, the image represents universal suffering, no matter the time or place.

PREVIOUS IMAGE

Picasso never stopped reinventing his artistic style, and nothing was out of reach. He created thousands of paintings, sculptures, ceramics, watercolors, and engravings. "He said he had no secrets in his work," says the artist's granddaughter Diana Widmaier Picasso. "It was like a diary." Picasso drew this self-portrait when he was 90 years old.

IT'S THE MORNING
BEFORE CHRISTIE'S IMPRESSIONIST
AND MODERN ART EVENING SALE
IN NEW YORK CITY, AND SUDDENLY,
THERE IT IS.

Picasso's art was intertwined with his personal life and relationships. His muses were his children, lovers, and wives, including Jacqueline Roque, depicted here. At Christie's auction house in New York City, art handlers carry "Femme Accroupie (Jacqueline)" from a private viewing to the gallery.

Just past the auction house's entrance at Rockefeller Center, Pablo Picasso's vibrant geometric portrait "Femme Accroupie (Jacqueline)" jaunts down a hallway, carried by two art handlers dressed in black.

Painted in the south of France in October 1954, the canvas features Jacqueline Roque, Picasso's 27-year-old mistress, later to be his wife, her arms clasped around a patchwork skirt of green and purple triangles. The artist, then 72, painted "Femme Accroupie" in a single day, and it gushes with vigorous brushstrokes, thick pigment, rambunctious shapes, misaligned eyes, and an inverted nose. Golden light rings Jacqueline's body. Even off the wall, the painting commands attention.

That evening, auctioneer Adrien Meyer will start the bidding at $12 million, and it will quickly surge upward as two Christie's representatives duel in a telephone bidding war on behalf of their anonymous clients. His back straight, his head jutting forward like a jaguar eyeing a peccary, Meyer will pivot between the pair until one of them signals defeat. Finally, with a bang of his hammer, he'll announce the winning price: $32.5 million.

Astounding but not surprising. Nearly half a century after his death, Picasso continues to bewitch, confuse, entice, and provoke. From his early days as an artist, Picasso shattered our most primal understanding of the world with his fractured faces and splintered perspectives. He worked voraciously, reinventing his style at a rapid pace—his blue and rose periods, the African period, cubism, surrealism—creating thousands of sculptures, drawings, copperplate etchings, ceramics, and paintings. Just as Albert Einstein envisioned gravitational ripples in the cosmos, Picasso saw undulations in the world we live in, long before we saw them ourselves.

Sitting on a chartreuse couch in his living room in Geneva, Picasso's son Claude contemplates the impact of his father's work. "He went on to destroy everything we were accustomed to," he says, "and created a new vision for everyone."

How does a person evolve from newborn to mastermind? How can a single soul redefine the way we see? Picasso the man was messy. He loved life at the circus and death at the bullfights. He could be both boisterous and silent, amorous and domineering. But from his beginning as a prodigy to his final years painting musketeers and matadors, Picasso seemed destined for artistic greatness, his journey to genius fixed as firmly as paint on canvas. All the elements were there: a family that cultivated his creative passion, intellectual curiosity and grit, clusters of peers who inspired him, and the good fortune to be born at a time when new ideas in science, literature, and music energized his work and the advent of mass media catapulted him to fame. Unlike creative geniuses who died young—Sylvia Plath at age 30, Wolfgang Amadeus Mozart at 35, Vincent van Gogh at 37—Picasso lived to the age of 91. The arc of his life was not only prodigious; it was long.

PABLO PICASSO WAS BORN on October 25, 1881, in Málaga, Spain, a baby so lethargic he was feared stillborn. He was revitalized, Picasso said, by a

puff of smoke from his uncle Salvador's cigar. Landmarks of the artist's childhood brim with vitality today in this sunlit Mediterranean city. A choir sings *Man of La Mancha*'s "Impossible Dream" in the Church of Santiago, where Picasso was baptized with holy water as a baby. Plaza de la Merced, where the artist etched his first drawings in the dust outside his home, bustles with tourists at cafés ordering, if they desire, a 12-euro ($15) *hamburguesa* Picasso. Pigeons light on the stones; the waters of the Alboran Sea lap at the shoreline; and Gypsies, like those who taught young Picasso to smoke a cigarette up his nostril and dance flamenco, continue to traverse Málaga's streets.

Sipping tea out of a red cup in the courtyard of the Museo Picasso Málaga, the artist's grandson Bernard Ruiz-Picasso reflects on how these early influences shaped Picasso's art. Everything about this place is rich with history and sensuality, he says. Civilizations collided on the soil Picasso inhabited: Phoenician, Roman, Jewish, Moorish, Christian, and Spanish. Aromas filled the air. Gesturing to a nearby orange tree, Bernard says Picasso drew inspiration from the color of the fruits, from the violet flowers that drape Spain's jacaranda trees, and from the beige and white stones of Málaga's 11th-century Alcazaba, set into Gibralfaro hill, steps from the museum.

"He kept in his mind all those senses, all those images, all those smells and colors, which nourished and enriched his brain," says Bernard, who established the museum—which opened in 2003—with his mother, Christine Ruiz-Picasso, fulfilling his grandfather's wish.

Genius is almost always cultivated by parents and teachers who support and nurture the seeds of greatness. Picasso's mother, María Picasso López, prayed for a son and revered her firstborn child. "His mother was gaga about him," says Claude Picasso, who is the legal administrator of his father's artistic estate. From the start, young Pablo communicated through art, drawing before he

Picasso's love of bullfighting stemmed from childhood visits to the Plaza de Toros de la Malagueta in Málaga, Spain, where young people train and fight today. Picadors and bulls are a recurring motif in his work, as is the half-man, half-bull Minotaur.

Genius: *PICASSO*

To learn more about Pablo Picasso and the art he created, tune in to National Geographic's 10-part series *Genius,* which airs Tuesdays starting April 24. Antonio Banderas plays the adult Picasso.

could speak. His first word was *"piz,"* short for *lápiz*, or pencil. Like the composer Mozart, Picasso had a father in the business, José Ruiz Blasco, who was a painter and his son's first teacher. "He was the best student his father ever had," Claude says. Picasso was still a child when his artistry began surpassing that of his father, who may have been "not only astonished but petrified by the talent of his son," Bernard says.

Such a mix of awe and fear is not uncommon when it comes to prodigies. The Latin *prodigium* carries the connotation of something that's unexpected but also "unwelcome and possibly dangerous," says David Henry Feldman, a longtime researcher in the field. Prodigies perform at an advanced adult level before adolescence, playing Ludwig van Beethoven's piano sonatas or doing complex math problems while some of their peers are still learning to jump rope. "It shakes your view of the world," Feldman says.

Where does such early expertise come from? Prodigies are rare, making it difficult to gather robust sample sizes to research, but Ellen Winner, director of the Arts and Mind Lab at Boston College, has found several core features among those she has studied. Precocious artists have acute visual memories, show remarkable attention to detail, and are able to draw realistically and create an illusion of depth years before their peers. Winner believes these children have an innate talent propelled by a "rage to master"—a passion so intense they feel compelled to draw

The legacy of genius looms large among family members. Olivier Widmaier Picasso never knew his grandfather but has written two books about the artist "to set the record straight about rumors and legends and truths," he says. Trained in law, Olivier brokered a deal with French carmaker Citroën to make a signature Picasso automobile. You live with Picasso, by Picasso, or without Picasso, he says.

From his earliest days as a prodigy, Picasso seemed destined for artistic greatness, his journey to genius fixed as firmly as paint on canvas.

Picasso was penniless during his early years as a painter living in Paris; he died a millionaire. Forty-five years after his death, Picasso's work is a global brand. Chinese film mogul Wang Zhongjun bought this Françoise Gilot portrait for $29.9 million in 2015. Last fall Wang opened the Song Art Museum outside Beijing, where he paints and sometimes uses Picasso's art as inspiration.

or paint whenever possible.

These characteristics mesh like a checklist with Picasso, who boasted about his exceptional artistry early in life. After seeing a children's art exhibit in 1946, he famously said that he would never have been able to participate in such a show because "at the age of 12, I drew like Raphael." Family members recalled that Picasso would draw for hours at a time as a child, sometimes taking requests—his cousin Maria's favorite was a donkey—until he was too exhausted to continue. His earliest surviving works are believed to date to 1890, the year he turned nine, and include his oil painting "Le Picador," which depicts a bullfighter on horseback.

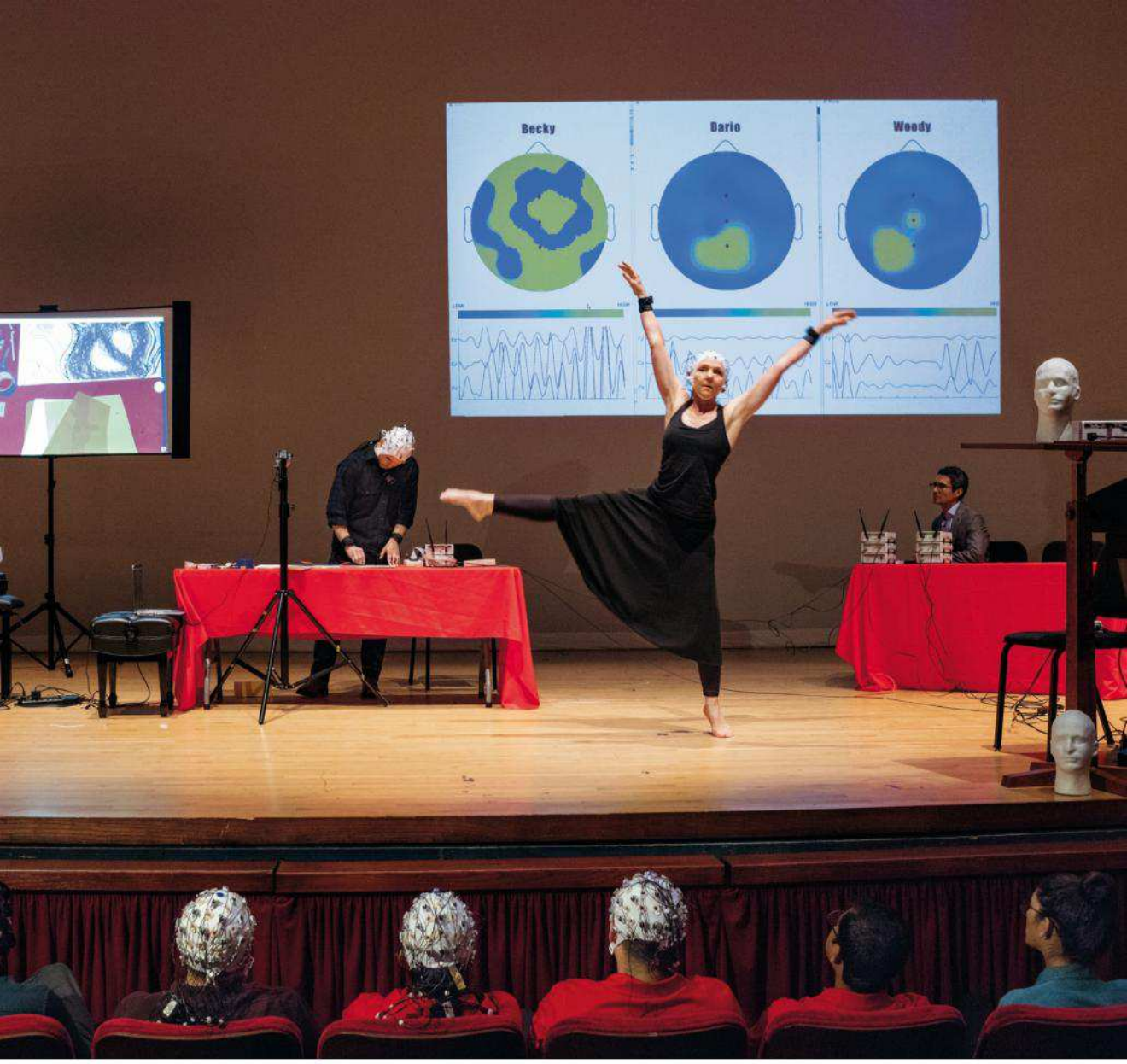
Within a few years, Picasso was painting skilled portraits of family and friends. By the age of 16, his work had landed him a place in the prestigious Royal Academy of Fine Arts of San Fernando in Madrid. At the Prado Museum he studied the Spanish masters he admired, including Diego Velázquez and El Greco. Art, Claude says, was "the only thing he was interested in. That's the only thing he was. He was an artist through and through."

THE VAST MAJORITY of prodigies don't grow up to be geniuses, no matter how flawlessly they master a skill. Genius requires a game-changing personality, endowed with the courage and vision to transform a discipline. Picasso was a boy when Paul Cézanne, Georges Seurat, and other Postimpressionists liberated themselves from the luminous brushwork of Impressionism, adding defined forms and emotional intensity to their canvases.

When his turn came, Picasso charged forward with the intensity of a fighting bull. With his 1907 painting "Les Demoiselles d'Avignon," the artist upended traditional composition, perspective, and aesthetic appeal. The canvas's depiction of five naked women at a brothel—their faces distorted, their bodies jagged—alarmed even Picasso's closest friends. But the painting would become the cornerstone of a radical art movement, cubism, and vault to the top of the list of the most important paintings of the 20th century. In that moment, "he brought down everything that anyone knew about art," Claude says.

Picasso's art was never meant to please. He avoided commissions, instead painting what he wanted and expecting people to be interested, his son says. So why do we find it so compelling? Science is providing interesting fodder here too. In the emerging field of neuroaesthetics, researchers

Neuroscientists are measuring art's impact on the brain. At the University of Houston, in Texas, professor Jose Contreras-Vidal uses imaging to record brain waves of a painter, a dancer, and a musician. Images on the wall show each artist's brain activity. Neuroscience may one day unlock the biology of creativity.



are using brain images to better understand people's responses to art—everything from Claude Monet's water lilies to Mark Rothko's rectangles.

In one study, Edward Vessel, a neuroscientist at the Max Planck Institute for Empirical Aesthetics in Frankfurt, scanned people's brains as they ranked their reactions to more than a hundred images of artwork on a scale of one to four, with four being the most highly moving. Unsurprisingly, the participants' visual system engaged every time they looked at a painting. But only the most moving artworks—the ones that were perceived to be especially beautiful or even striking or arresting—activated the "default mode network" of the brain, which allows us to focus inward and access our most personal thoughts and feelings.

Such a balance of outward viewing and inward contemplation is unusual, Vessel says. "It's a unique brain state."

This experience creates a special relationship between viewer and art, bringing the works alive. Neuroscientist and Nobel laureate Eric Kandel, an avid art collector who owns two of Picasso's Vollard Suite etchings, says images that challenge, like Picasso's, recruit viewers into the creative process with the artist. The human brain is capable of taking incomplete clues and reconstructing fairly coherent images. "We have a tremendous ability to fill in details that are missing," he says.

But how? In an ongoing study, Kandel, co-director of Columbia University's Zuckerman Institute, is taking brain scans as participants complete a

The legacy of genius is a sweeping affair with eminence and acclaim. Picasso's works continue to draw record-breaking crowds and inspire new artists.

Picasso cultivated his reputation, relying on the influence of patrons, including Gertrude and Leo Stein. Today collectors Mera and Don Rubell are at the forefront of elevating modern talent, most recently Allison Zuckerman, whose guests at her opening are pictured here. She began posting her work on Instagram before catapulting to a solo show at the Rubell Family Collection in Miami. She uses elements of Picasso's style.

Picasso's global reach and the Internet have created a made-to-order business of knockoff paintings in Dafen, a village near Shenzhen, China. Each day, painter Yaoliang Liu produces several fake Picassos, including this likeness of Dora Maar, the photographer and artist whose tumultuous relationship with Picasso began in the mid-1930s. The Paris-based Picasso Administration, which manages rights issues related to the artist's work, says that the production and sale of such fakes are illegal under French intellectual property law.

series of exercises with figurative and abstract paintings by Rothko, Piet Mondrian, and other artists. Kandel's Columbia collaborator, Daphna Shohamy, says they are eager to see whether abstract art elicits increased activity in the hippocampus, the brain's storehouse for memories. This would suggest, at a biological level, that humans intuitively draw on their own experiences when viewing and processing complex art.

Long before brain science could corroborate it, Picasso seems to have understood this dynamic. "The picture," he once said, "lives only through the man who is looking at it."

THE JOURNEY TO GREATNESS is never a solitary pursuit. Picasso found his first creative gurus at the Quatre Gats café in Barcelona, where he hobnobbed with more experienced Spanish artists, each one contributing to "the stimulus that fueled the early stages of Picasso's rocket-like ascent," writes Picasso's longtime biographer and friend, John Richardson. In Paris, where he moved at the age of 22, Picasso immersed himself in another cluster of exuberant minds—writers Guillaume Apollinaire and Gertrude Stein and artists Henri Matisse, André Derain, and Georges Braque, the man who would become Picasso's partner in cubism. The *bande à Picasso,* as his original bevy was known, stoked the artist's creativity and competitive drive.

Still, Picasso's singular behaviors and traits stood out. He was driven by an obsession and a voracious dedication to his art, a rage to master that never subsided. "It was almost neurological, something that forced him to be very active all the time," says Diana Widmaier Picasso, an art historian and the granddaughter of Picasso and Marie-Thérèse Walter, one of Picasso's most radiant muses, with whom he had a secretive affair.

The artist found promise in everything, etching an owl or a goat onto a stone from the sea. He formed the face of a sculpted baboon using two of his son's toy cars, and crafted his famous "Bull's Head" out of a bicycle seat and rusty handlebars plucked out of a junk pile. Picasso produced incessantly—paintings, sculpture, ceramics, even jewelry. "He had the ability to renew himself constantly," Diana says. "He was so prolific, it's almost disarming." Picasso said he didn't know where his creative bursts came from, but they rampaged through his head, discrete parts becoming whole through his hands and his paintbrushes.

The artist's sharp and colossal memory served

Picasso's prodigious talent emerged in his birthplace of Málaga, where he spent his early childhood. Today references to the artist's work appear throughout the city, including this graffiti replica of a 1924 painting of Picasso's firstborn son, Paulo, dressed as a harlequin.

as a storehouse for inspiration. "He was a sponge," says Emilie Bouvard, a curator at the Musée Picasso Paris. In her office, not far from the bustle of visitors, I ask Bouvard to pick the quality that best exemplifies Picasso's prowess. "In my opinion, it's assemblage," she says, the artist's ability to sift through layered memories—a conversation with a poet, the haunting expressions in an El Greco painting, the medley of sensations from Málaga, a pot of paint in his studio. As she reflects, Bouvard calls up the French expression *faire feu de tout bois* (to make fire of all wood). "That's the genius of Picasso," she says.

Talent, nurturing, opportunity, personality: Picasso had it all. He was also lucky. The artist came of age when photography overturned the focus on traditional realism in paintings. The art world was primed for rule breaking and disruption, says András Szántó, a sociologist of art in New York City, and the media was newly equipped to celebrate it. Picasso, well aware of his stature, was masterful at branding his image. "He was so aware of his talent," says Diana's brother and Picasso's grandson, Olivier Widmaier Picasso. "He understood that he would be important in the future."

Early on, the artist shed his father's name, Ruiz, and adopted his mother's more memorable Picasso. He began dating his paintings so they could one day be assembled in chronological order. He invited photographers to capture him posing with bravado in front of his canvases, dancing bare-chested with his lover, and playing with his children on

the beach. By 1939 Picasso had vaulted onto the cover of *Time* magazine, which deemed him "Art's Acrobat." In 1968, five years before he died, *Life* magazine dedicated a 134-page double issue to him. "He was able to layer his biography over these enormous inflection points in our culture," Szántó says. "He happened to play it really well."

THE LEGACY OF GENIUS is a sweeping affair with eminence and acclaim, often tied to personal anguish. The traits that promoted Picasso's creations—his infatuation with his work and his rule breaking—led to praise and even cultlike worship. Until Leonardo da Vinci's "Salvator Mundi" sold for more than $450 million last year, Picasso's $179.4 million "Les Femmes d'Alger" was the most expensive painting ever auctioned. Picasso exhibits continue to draw record-breaking crowds: The spotlight now is on a blockbuster exhibition in London called "Picasso 1932—Love, Fame, Tragedy." His works inspire people as disparate as artist Allison Zuckerman, who made her debut at Art Basel in Miami Beach in December, and Wong Zhongjun, a Chinese media mogul who periodically paints with a cigar clamped between his teeth and the Picasso he purchased in 2015, "Femme au Chignon dans un Fauteuil," set up nearby.

These same qualities, however, also tainted Picasso's relationships, sometimes to the point of ruin. Fearful of illness and death, he cycled through women, many of them decades younger than he, perhaps in part to defy the odds of growing old. He craved women, and his charisma attracted them. Picasso had "a radiance, an inner fire," wrote Fernande Olivier, who lived with him from 1905 to 1912 in Paris, "and I couldn't resist this magnetism."

But he could be jealous and misogynistic, displaying behaviors that are now fueling a public debate about whether an artist's conduct should affect the perception of his art. "Throughout his life there was a thing of women being sacrificed to feed his art," biographer Richardson once said. Françoise Gilot, a painter in her own right and the mother of Claude and his sister, Paloma, met Picasso in a Paris café in 1943 when she was 21 and he was 61. In a memoir, she recounted Picasso holding a cigarette against her cheek and threatening to throw her over the Pont Neuf into the Seine River. His most lasting love was his art. Tragedies piled up after the artist's death with the suicides of Picasso's widow—Jacqueline—his paramour Marie-Thérèse, and his grandson Pablito.

Genius is fueled by hard work. Picasso was one of the most prolific artists in history. The elegant Musée Picasso Paris in the city's Marais neighborhood houses the world's largest public Picasso collection. Here a French visitor studies a portrait of one of Picasso's lovers, Marie-Thérèse Walter.

Picasso's surviving children and grandchildren have complex feelings about him.

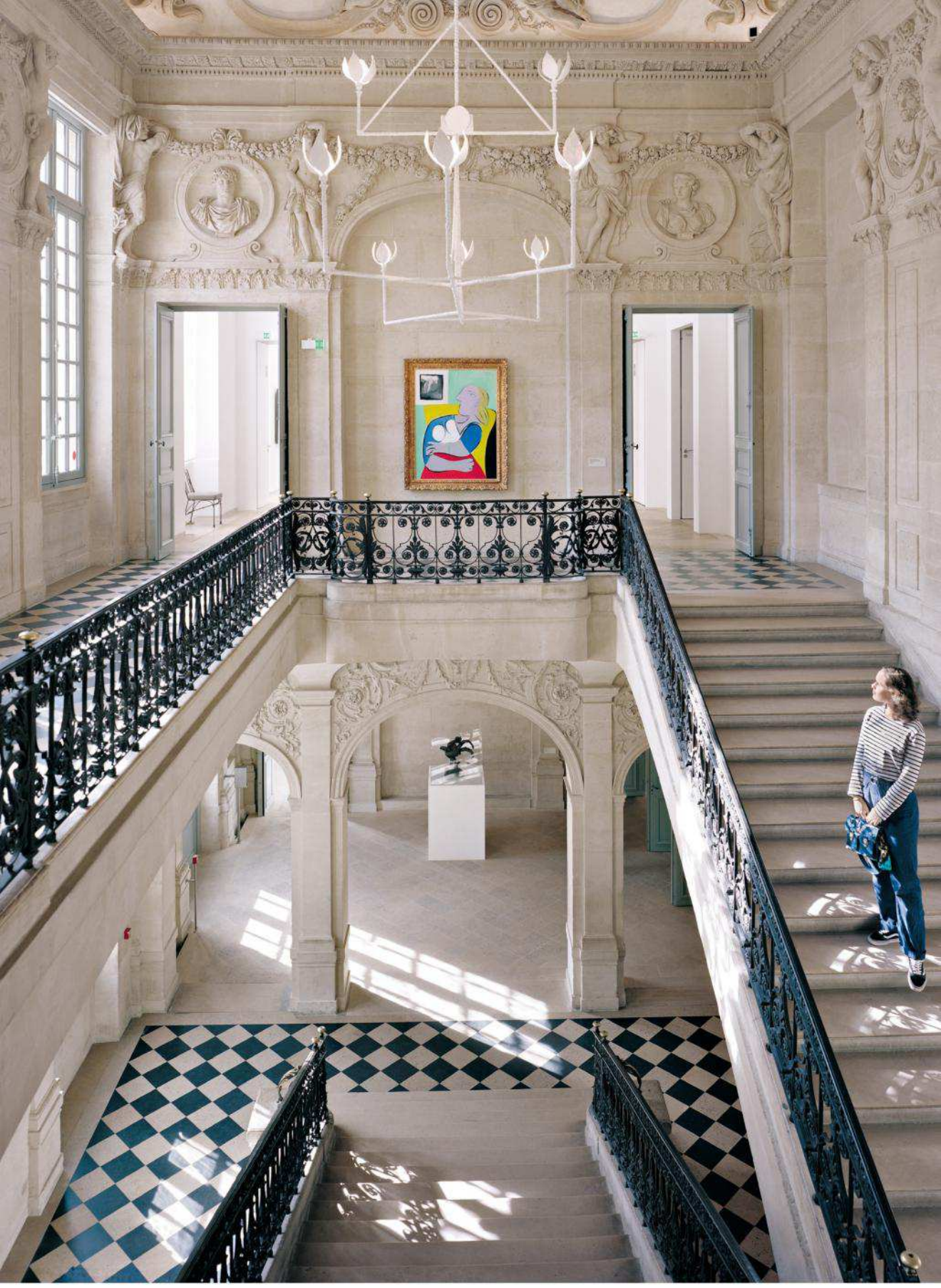
Marina Picasso, his son Paulo's daughter, has issued the harshest judgment. "His brilliant oeuvre demanded human sacrifices," she wrote in her 2001 memoir. "He drove everyone who got near him to despair and engulfed them."

But others, including Marina's half-brother Bernard, who was 14 when Picasso died, and their younger cousins Olivier and Diana, who never knew him, have processed their grandfather's life differently. While acknowledging the trauma, they also express gratitude for Picasso's work and the fortune he left behind, which has not only deeply influenced the direction of their lives but also provided financial freedom. Olivier has co-produced two documentaries and written two books about his grandfather. Diana, who feels an obligation to work with the tenacity of her grandfather, is completing a comprehensive catalog of Picasso's sculptures. And besides overseeing the Museo Picasso Málaga, Bernard and his wife, Almine Rech-Picasso, built an art foundation around his grandfather's work. "Life is full of drama. We are not the only ones," Bernard tells me. "I'm deeply grateful for what Picasso gave me."

In the end, Picasso's journey from prodigy to legacy is a story of ultimate conquest.

"He left few corners untouched and unturned," says Claude, as he sits surrounded by his father's and his mother's paintings in his home, midday sun streaming in. Still, when I ask how he explains his father's genius, he answers with the most uncomplicated reply: "How do I explain it? I don't explain it," he says. "I just understood it. It was obvious to me as a tiny child." ▯

Claudia Kalb wrote *Andy Warhol Was a Hoarder: Inside the Minds of History's Great Personalities* for National Geographic Books. Photographers **Paolo Woods** and **Gabriele Galimberti** live in Florence, Italy. This is their second story for the magazine.



DECONSTRUCTING PICASSO

STROKES OF GENIUS

From his early childhood years sketching in the dirt to his final hours at age 91, Pablo Picasso was devoted to mastering his deeply personal art. He's considered one of the most influential artists of the 20th century, and his work continues to be studied for its meaning and celebrated for its creativity. His subject matter and style, inspired by his many lovers and by other artists, were ever changing. Picasso's work is loosely divided here into 14 distinct phases, coupled with the artist's own words.

1 1889-1898 EARLY YEARS

"When I was a child, my mother said to me, 'If you become a soldier, you'll be a general. If you become a monk, you'll end up as the pope!' Instead, I became a painter and wound up as Picasso."

2 1900-1901 POSTIMPRESSIONISM

"I am not in favor of following any determined school because that only brings about similarity among adherents."

3 1901-1904 BLUE PERIOD

"I just painted the images that rose before my eyes. It is for other people to find hidden meanings in them."

4 1904-1906 ROSE PERIOD

"When it is finished, [a picture] still goes on changing, according to the state of mind of whoever is looking at it. A picture lives a life like a living creature, undergoing the changes imposed on us by our life from day to day. This is natural enough, as the picture lives only through the man who is looking at it."

5 1906-1907 IBERIAN PERIOD

"I never do a painting as a work of art. All of them are researches. I search incessantly, and there is a logical sequence in all this research."

6 1907 PROTO-

"Painting isn't a operation; it's designed as a this strange, h a way of seein form to our te our desires."

7

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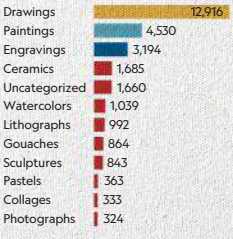
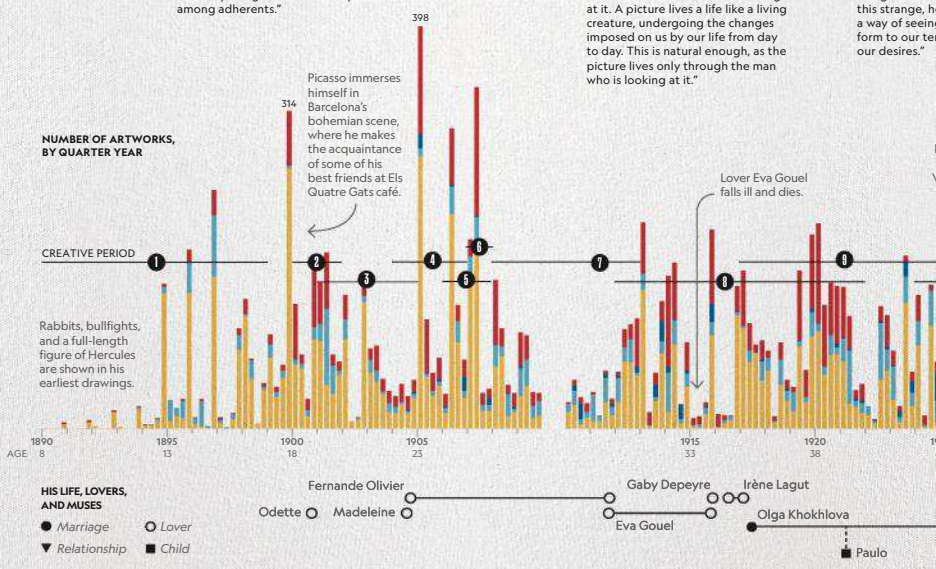
MASTER OF MANY FORMS

Picasso is most famous for his thousands of paintings, but he also created other types of art, including costume design and ballet sets.

28,743 CATALOGED ARTWORKS





1908-1912
ANALYTIC CUBISM

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CUBISM

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9 1917-1924
NEOCLASSICISM

"In my opinion, to search means nothing in painting. To find is the thing."

8 1912-1921
SYNTHETIC CUBISM

"I have never made trials or experiments ... Whenever I had something to say, I have said it in the manner in which I have felt it ought to be said. Different motives invariably require different methods of expression."

11 1936-1939
SPANISH CIVIL WAR

"Artists who live and work with spiritual values cannot and should not remain indifferent to a conflict in which the highest values of humanity and civilization are at stake."

10 1924-1937
SURREALISM

"I have reached the stage where the movement of my thought interests me more than the thought itself."

12 1939-1945
WORLD WAR II

"A work of art must not be something that leaves a man unmoved, something he passes by with a casual glance. It has to make him react, feel strongly, start creating too, if only in his imagination."

13 1945-1960
MEDITERRANEAN YEARS

"Me, I always seek a likeness ... A painter must observe nature but never confuse it with painting. It can only be translated into painting through signs."

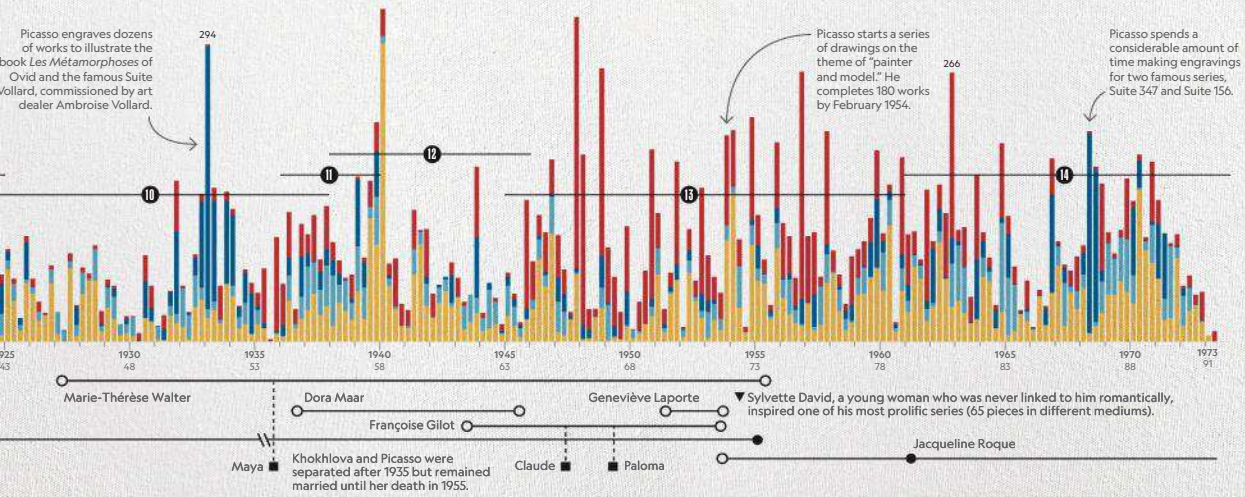
14 1961-1973
LAST YEARS

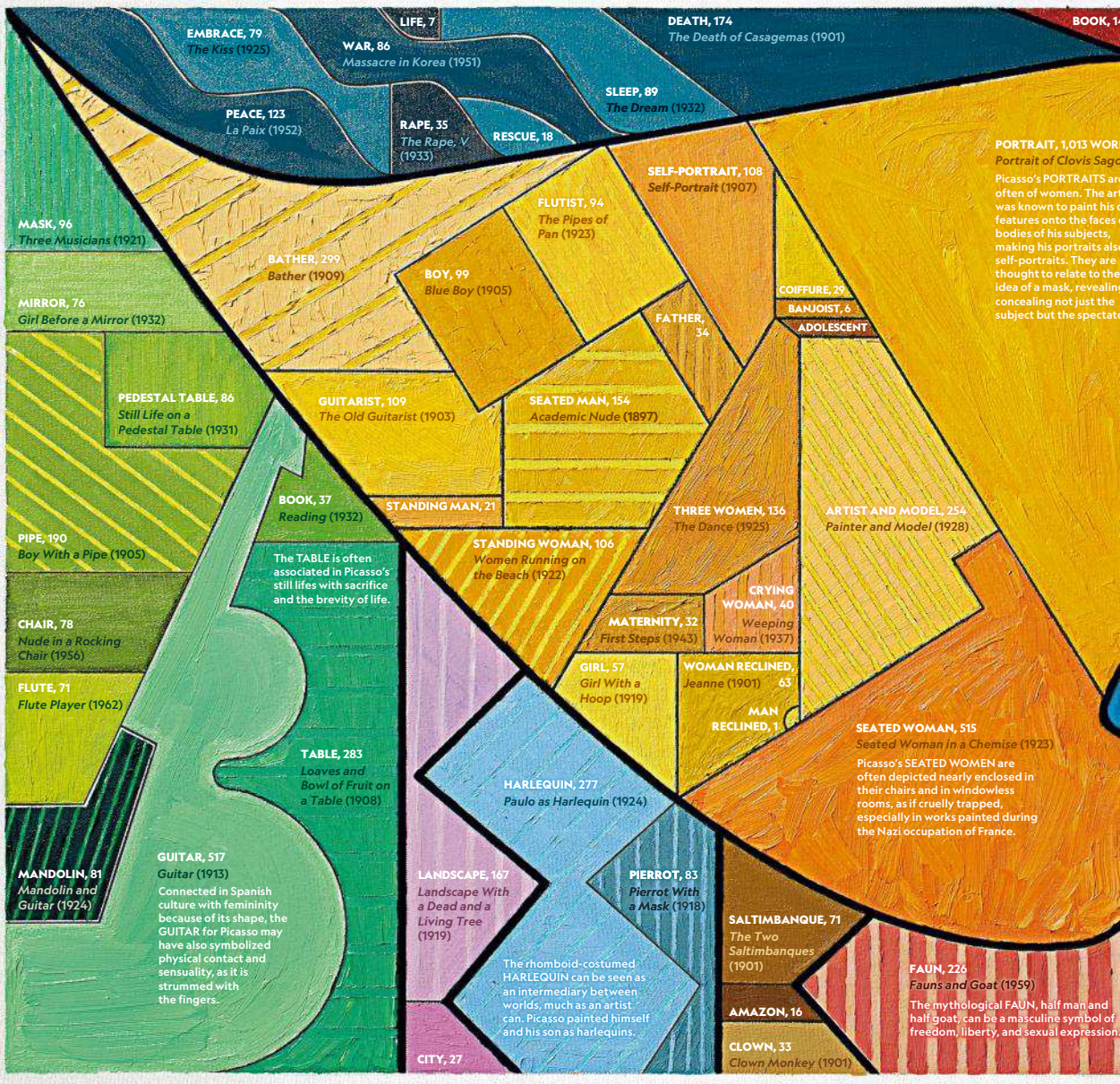
When asked what his favorite period of his career was, Picasso answered: "The next one."

ARTWORKS: 1. *SCIENCE ET CHARITÉ* (1897) 2. *LE MOULIN DE LA GALETTE* (1900) 3. *LA VIE* (1903) 4. *LA FAMILLE DE SALTIMBANQUES (LES BATELEURS)* (1905) 5. *AUTOPORTRAIT À LA PALETTE* (1906) 6. *LES DEMOISELLES D'AVIGNON* (1907) 7. *PORTRAIT D'AMBROISE VOLLARD* (1910) 8. *NATURE MORTE À LA CHAISE CANNÉE* (1912) 9. *LA FLÛTE DE PAN* (1923) 10. *LES TROIS DANSEUSES (LA DANSE)* (1925) 11. *GUERNICA* (1937) 12. *NATURE MORTE AU CRÂNE DE BOEUF* (1942) 13. *PAYSAGE MÉDITERRANÉEN* (1952) 14. *TÊTE (AUTO-PORTRAIT)* (1972)

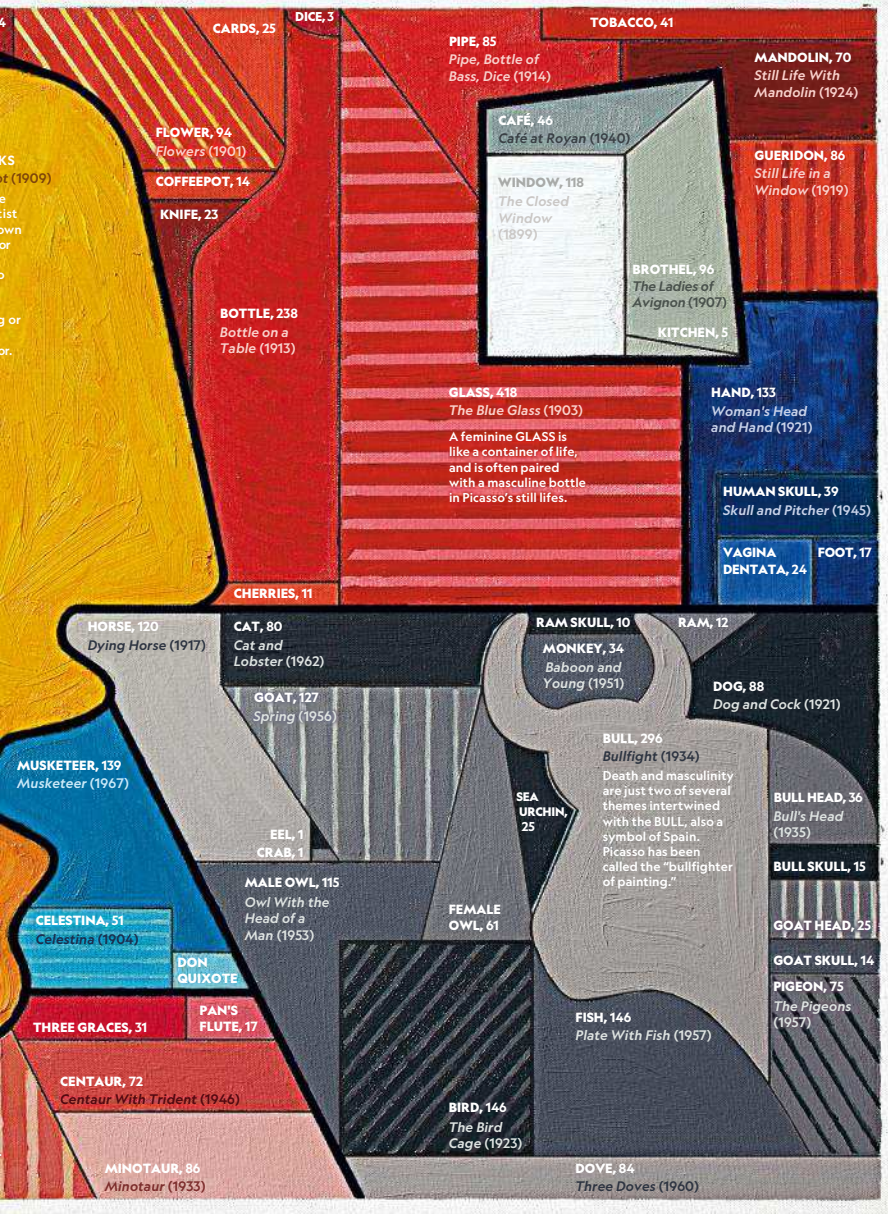
RYAN MORRIS AND EVE CONANT, NGM STAFF; ENRIQUE MALLÉN, ONLINE PICASSO PROJECT; PATRICIA HEALY

SOURCE: ONLINE PICASSO PROJECT





GRAPHIC AND ART (OIL ON CANVAS, 36 × 60 INCHES): ALBERTO LUCAS LÓPEZ, NGM STAFF. TEXT: EVE CONANT, NGM STAFF. PHOTO (PAINTING): MARK THIESSEN, NGM STAFF
SOURCES: ENRIQUE MALLÉN, ONLINE PICASSO PROJECT; *PABLO PICASSO: A RETROSPECTIVE*, MUSEUM OF MODERN ART, NEW YORK. A PIECE CAN BE INCLUDED IN SEVERAL CATEGORIES. AREA SIZES ARE APPROXIMATE.



OBJECT LESSONS

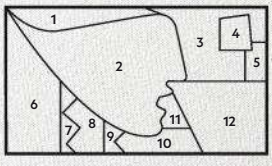
FRAMES OF MIND

'The artist is a receptacle for emotions that come from all over the place: from the sky, from the earth, from a scrap of paper, from a passing shape, from a spider's web.'

Picasso drew inspiration from mythology, from war, from those who surrounded him, even—he proclaimed—from spiderwebs. The result is tens of thousands of works that seem to touch on countless topics. But many of the subjects that fascinated him, including death and sexuality, repeatedly surface in his art throughout the decades. Those recurring themes are grouped in a sampling of some 8,000 of Picasso's works, artistically rendered here. They can be found in portraits that radically blur the line between subject and painter, and in an array of arresting symbols such as the Minotaur, bottle, and harlequin.

PICASSO BY THEME

Each of the 12 themes below is further divided into artistic subcategories, some of which include the titles of individual works. The size of each category reflects the number of artworks on a given theme.



1. ABSTRACT
2. FIGURE
3. STILL LIFE
4. ROOM
5. BODY
6. OBJECT
7. LOCATION
8. THEATER
9. CIRCUS
10. MYTHOLOGY
11. LITERATURE
12. ANIMAL

TEXT AND PHOTOGRAPHS BY

LAURENT BALLESTA

FRENZY

A RARE LOOK AT THE VIOLENT, CHAOTIC COLLISION OF **HUNGRY SHARKS** AND **BREEDING GROUPERS** IN A FRENCH POLYNESIAN CHANNEL

FIRST PHOTO

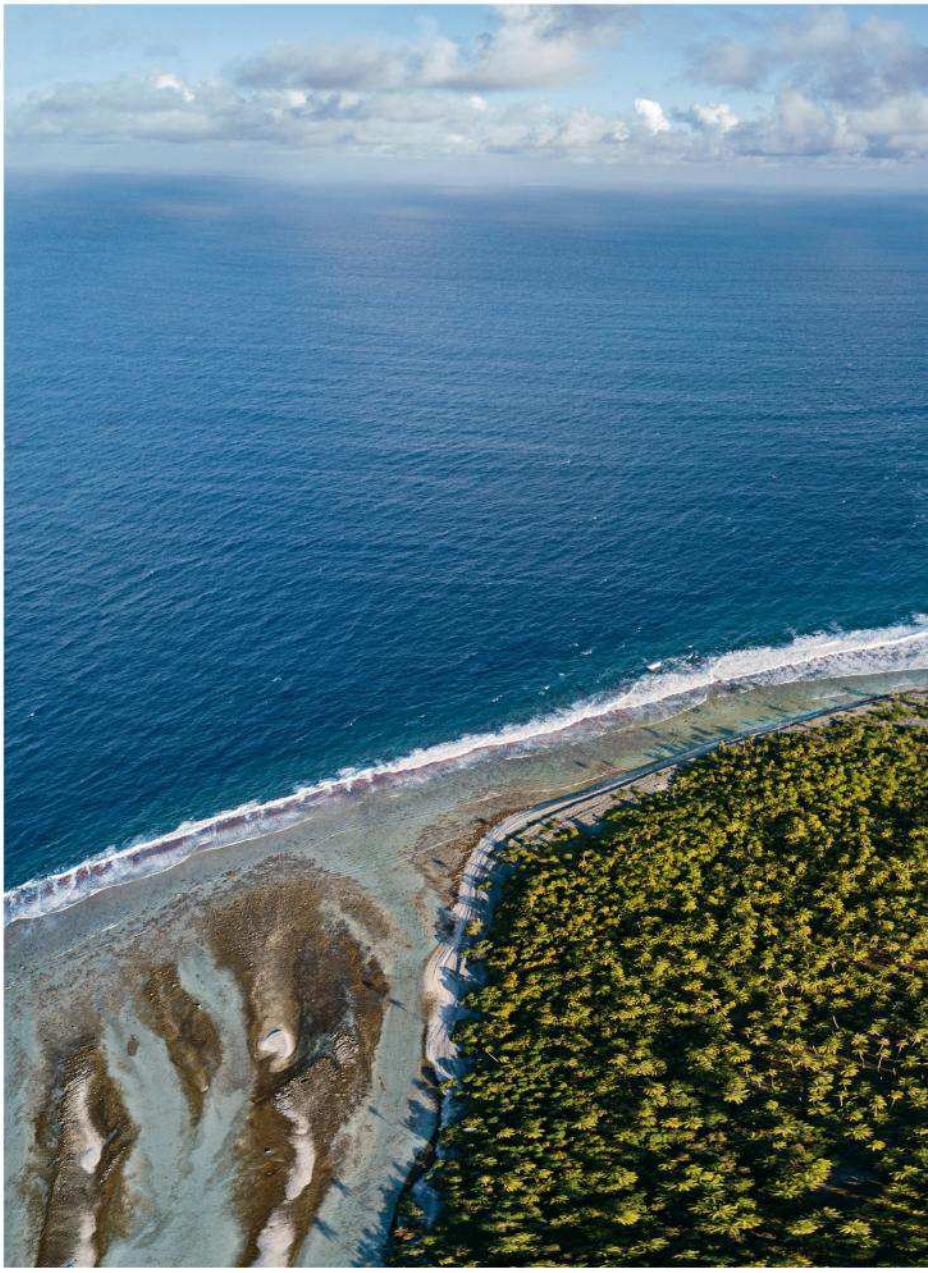
At night gray reef sharks hunt as a pack in the south channel of Fakarava Atoll, in the Tuamotu Archipelago. Laurent Ballesta's team, diving without cages or weapons, counted 700 sharks.

PREVIOUS PHOTO

The sharks' main prey, at least around the June solstice, are the 17,000 camouflage groupers that gather in the channel to spawn. The tide will sweep the fertilized eggs out to sea.

RIGHT

Here the tide rushes in through the 100-yard-wide channel, from the Pacific (far left) into the lagoon, which is enclosed by the coral atoll. Like other atolls, Fakarava formed around a volcanic island that later sank. Storm-tossed coral debris helped raise parts of it above sea level.



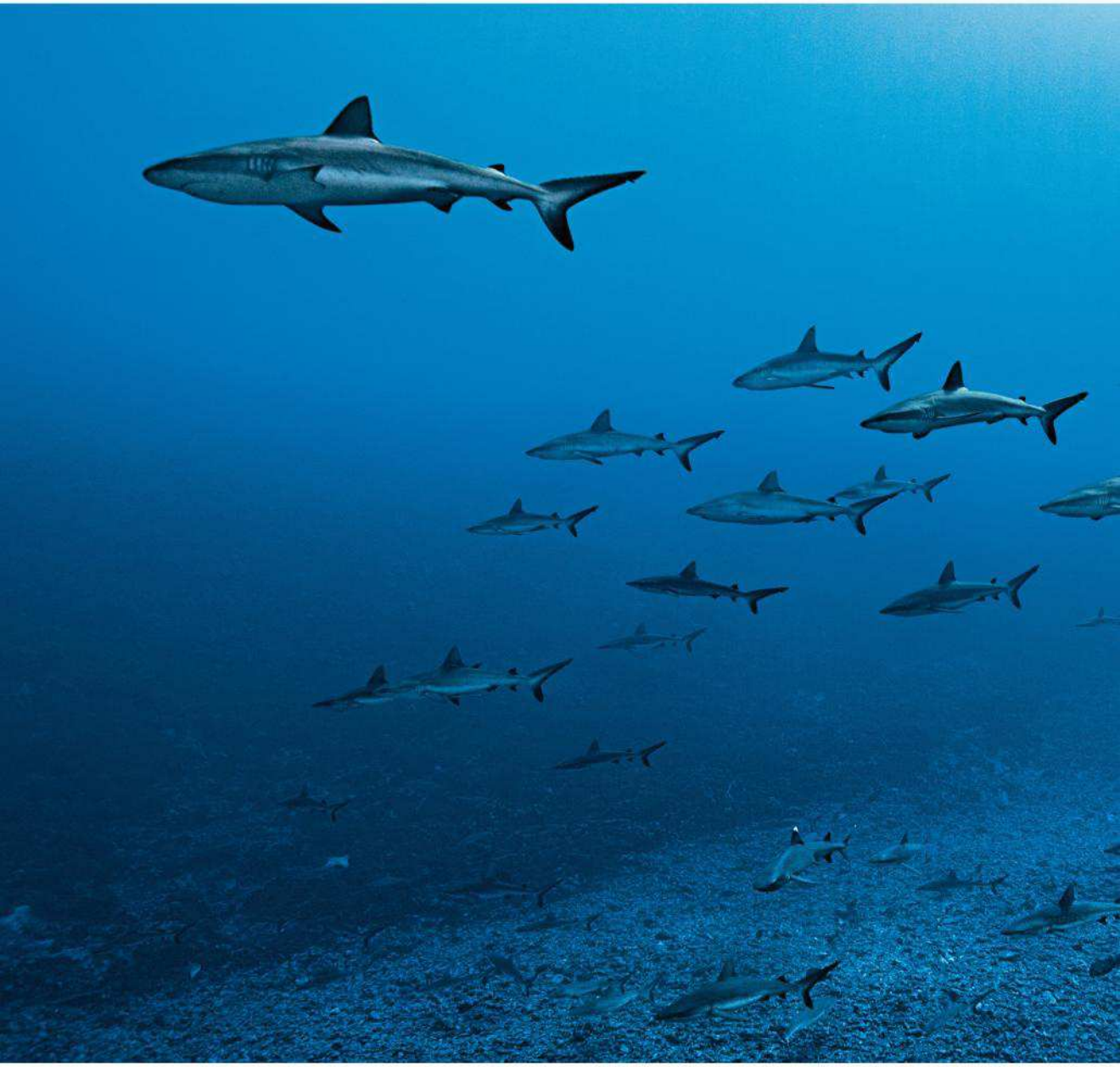
AT THE SOUTH END of Fakarava Atoll, a 35-mile-long rectangle of coral in French Polynesia, a narrow channel cuts through the barrier reef. Every June thousands of camouflage groupers congregate in that channel, in an area the size of two to three football fields, to spawn the next generation. Violent tidal currents funnel through every six hours, filling and emptying the lagoon. The groupers, fat and about two feet long, are not alone: Hundreds of gray reef sharks assemble as well, to stalk them. The female groupers, like other reef fish, spend at most a few days in the spawning grounds. Yet for some reason the males, which lead solitary lives most of the year, spend weeks crowded into this treacherous place—until finally the whole mass of fish spawn at once, releasing clouds of eggs and sperm into the water. The locals told us it happens at full moon.

My team and I have spent the past four years trying to document and understand this amazing, mysterious spectacle. For a total of 21 weeks, we've dived day and night—about 3,000 diver hours in all—into the 115-foot-deep channel. In our first year, 2014, marine biologists Johann Mourier

and Antonin Guilbert made the first accurate counts: There were some 17,000 groupers and 700 gray reef sharks in the channel. (The fish are protected here by a biosphere reserve.) That year I completed a continuous 24-hour dive—a technical feat that required the support of the whole team. The point wasn't to set a record. The point was to observe the fish the way a biologist would animals on land, uninterrupted for a long time.

At dusk on that first night, I watched crustaceans and mollusks emerge from the bowels of the reef—and then retreat at the flash of my light. I watched the camouflage groupers darken their skin and withdraw into crevices to sleep. And I watched the sharks come alive, as if they'd awaited this moment. By day they swim languidly—wakeful groupers are too quick for them. Now, after nightfall, the sharks swarmed along the seabed by the hundreds. The water was electric with them, and I realized I'd underestimated their speed. Their agitation was disturbing: Owing to the gas mixture I was breathing for this 24-hour dive, I couldn't ascend to safety whenever I wanted. I had to remain at depth with the sharks.

NGM MAPS



IN THE YEARS SINCE, I've gotten over my fear. It has given way to exhilaration—the exhilaration of learning to venture, without cages or chain mail suits or even shark billies, into a giant shark pack. That's one thing we've discovered at Fakarava: The sharks hunt in packs, a bit like wolves, but less cooperatively.

A single shark is too clumsy to catch even a somnolent grouper. A pack of them is more likely to flush the fish from its hiding place and encircle it. Then they tear it apart. Seen live, the attack is a frenzy that explodes before us. Only later, thanks to a special camera operated by Yanick Gentil that captures a thousand images a second, are we able to watch the sharks in slow motion and appreciate their efficiency and precision.

To the sharks, we humans are obstacles, not targets. When we dive at night, they approach us constantly; the slightest movement or ray of light attracts them. Sometimes they butt us hard enough to bruise. Sometimes we calm an excited shark by grabbing its tail and flipping it on its back, inducing a kind of trance. But only once since getting close to them have I worried that they might bite—when I

The sharks hunt in packs, a bit like wolves but less cooperatively. They encircle a fish, then tear it apart.

LEFT

During the day the sharks swim peacefully against the tidal current that sweeps through the channel. They spring into action at night, when the groupers rest on the seabed and are easier to catch.

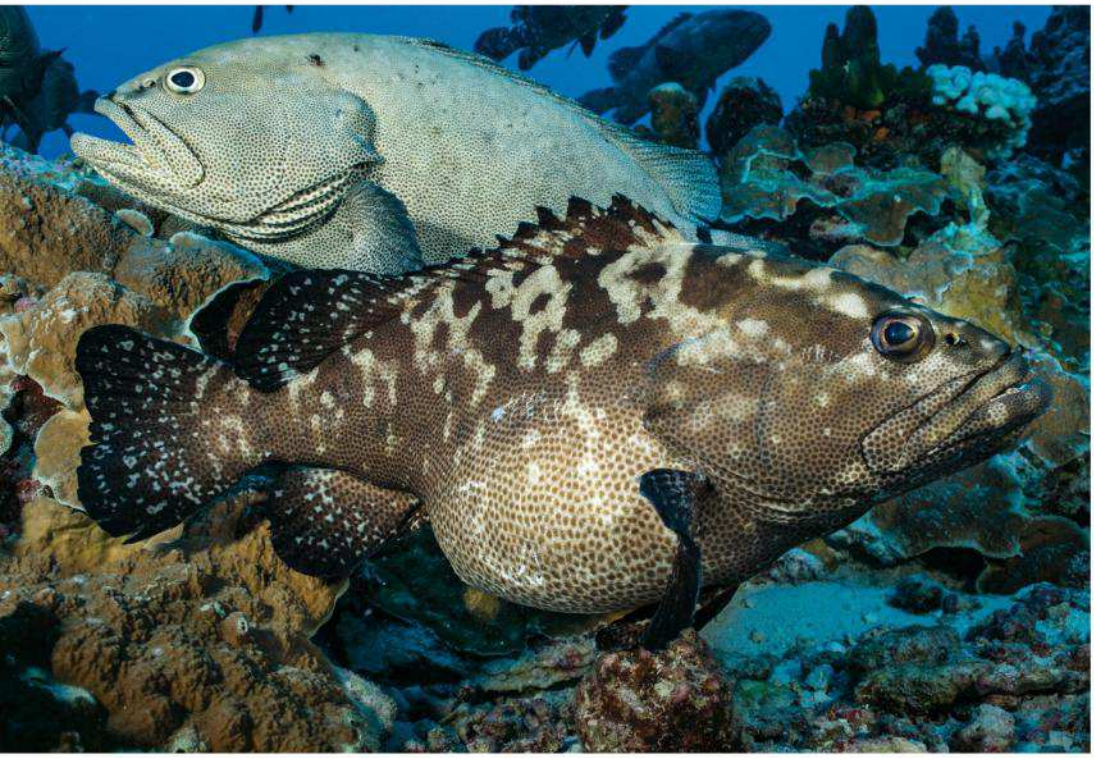
NEXT PHOTO

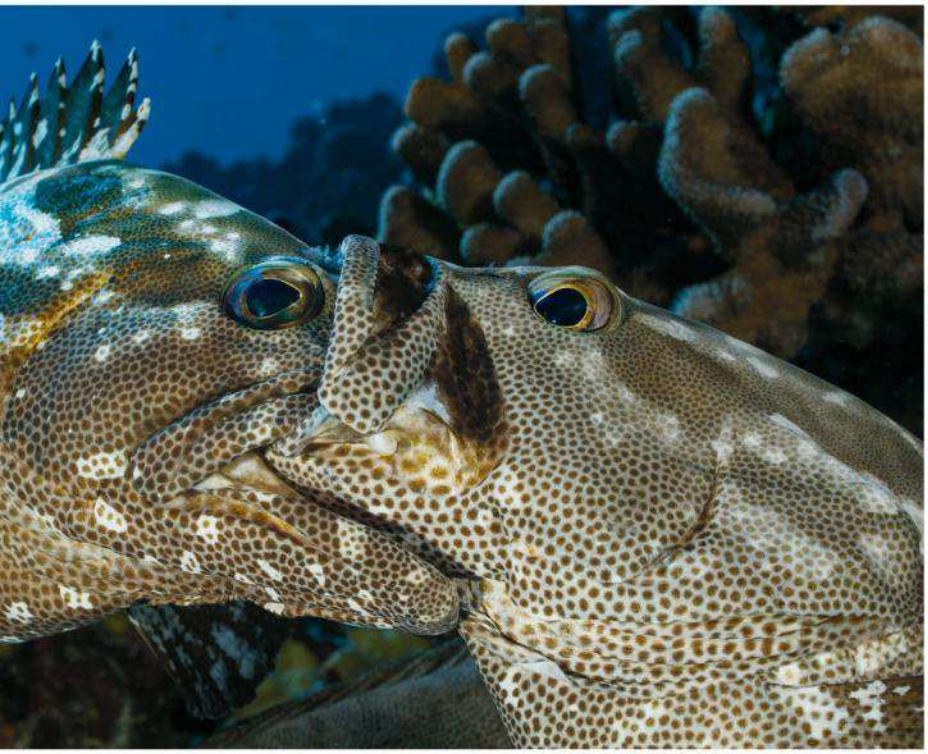
Shreds of grouper flesh fall from the jaws of two sharks as they rip a fish apart. After hunting together to roust the grouper from its hiding place in the reef, the sharks encircle it—but then compete for the spoils.

felt a sudden stinging pain on the back of my thigh. My hand found the tear in my wet suit; I could see the blood from a wound that later would require four stitches. Luckily, two cameras filmed the scene: It wasn't the shark itself but the scalpel-like spines of a large surgeonfish that sliced my skin. The shark had the fish in its jaws and was shaking it violently.

Gray reef sharks devour hundreds, perhaps thousands, of groupers during the weeks the fish congregate at Fakarava. They injure many more. The morning after my overnight dive, as the groupers began to stir, I photographed a gallery of survivors. The wounds were grave: torn fins, gill covers ripped off. But even in such a sorry state, the groupers seemed undeterred. The males challenged each other again and again, face-to-face, struggling hysterically for dominance—slaves to their reproductive instinct.

On our most recent expedition, last year, we finally got a good look at the point of it all. The day of spawning, the whole ecosystem changes: The water fills with tens of thousands of sardinelike fusiliers, which sense something is up. Female groupers, bellies swollen with eggs,





Male groupers challenge each other again and again, slaves to their reproductive instinct.

PREVIOUS PHOTO

Some fish get away: This grouper has survived a shark attack with a gaping hole in its side. Ballesta's team found many such cases of extreme resilience at Fakarava.

LEFT

Solitary most of the year, the groupers socialize intensely at Fakarava—that is, males fight to get close to females, weeks ahead of the day when they'll all spawn at once. Clockwise from upper left: Two males face off; two others bite each other in the face; a survivor of a shark attack soldiers on without the front of his upper jaw; and a victorious male stays near a female whose swollen belly suggests she'll soon release her eggs.

After nightfall the sharks swarm the seabed by the hundreds. The water is electric with them.

PREVIOUS PHOTO

In the decisive moment, the female suddenly darts off the seabed, trailing a cloud of eggs. The male that shadows her will fertilize them first, while other males rush to join in. For the couple, it's over in a second; for all the groupers at Fakarava, in less than an hour.

RIGHT

A gray reef shark devours a short-nosed unicornfish. Groupers are usually too big to be swallowed whole, but sharks kill hundreds of them at Fakarava. Yet it remains a good place for groupers to spawn: The tidal current rushing out of the channel spreads their offspring far and wide.

rest in camouflage coloring near or on the seabed. The pale gray males watch from above. At intervals a male goes down to parade before and jostle a female. He bites her belly, presumably to induce spawning.

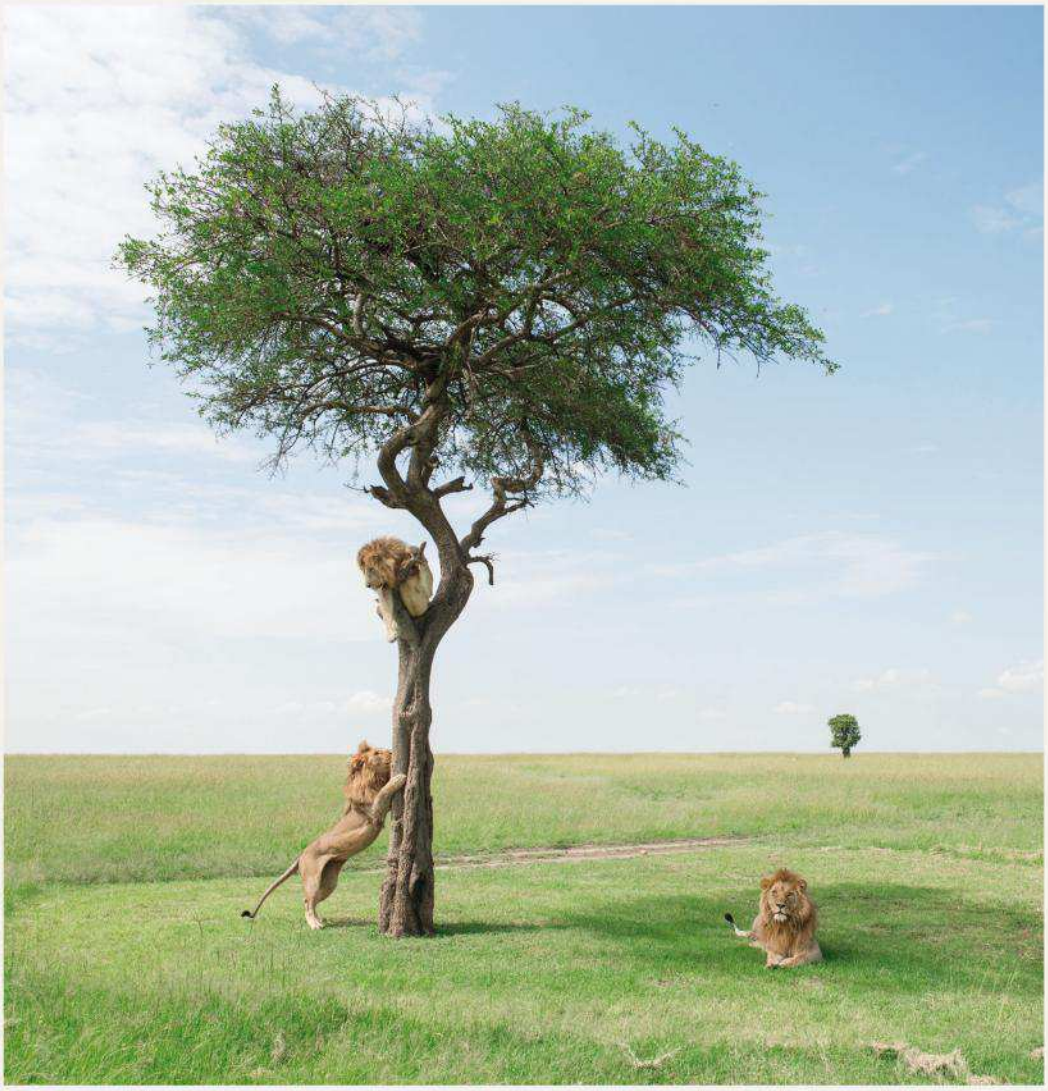
Very suddenly it begins: pandemonium. Bands of a dozen or so groupers shoot upward all around us, like fireworks. Each band consists of many males pursuing a single female. The sharks plunge into the fray, mostly without success; the groupers are too fast. The individual sex act lasts less than a second, and we can scarcely see, much less understand, what's happening. The fusiliers block our view, rushing in to swallow clouds of grouper eggs and semen as soon as they appear. The remaining cells are mixed randomly by the powerful tidal current as it carries them out to sea.

The whole anarchic spectacle is over less than an hour, and we're left wondering, what's the use? For a male grouper, what's the use of fighting other males for four weeks, at risk every night of being shredded by sharks, if in the end you don't get a female all to yourself, and to know that it's your sperm fertilizing her eggs? It seems a complete

waste of energy—which nature normally abhors.

Once again, Gentil is in the right place at the right time. His camera captures that one-second act in one grouper couple. In slow motion, everything becomes clear: The male that has earned the right to be closest to the female gets to begin breeding with her. He presses his body to hers for as long as he can. The other males are already converging on the couple; there's no exclusivity. The dominant male's hard-won prize, after four weeks of bitter battles, is just to be first in line—to have the best odds of transmitting his genes.

The locals were right: It all happens at the full moon, and just before dawn. On my 24-hour dive, before the spawning that year, I had time to appreciate the dawn, to watch the dim blue glow gradually filter from above into the inky depths, where I waited with the drowsing groupers. At that moment, I heard whales singing, probably many miles away. It reminded me of church bells. I don't know if you can get goosebumps under a thick wet suit, but it felt like I did. I don't know either for whom the whales were tolling. But I do know we'll be going back to Fakarava this June. □



YOUR SHOT

JAY RUSH

PHOTOS FROM OUR COMMUNITY

WHO

Rush, 43, a freelance photographer from Eagle, Colorado

WHERE

The Masai Mara National Reserve in Kenya, adjacent to the Serengeti

WHAT

A Nikon D800 with a Nikkor 24-70mm, f/2.8 lens

A morning photo safari had been largely fruitless for Rush and four travelers eager to see wildlife. Then right before lunch, they pulled into a clearing that seemed better suited for a picnic than for a big cat hangout. Three lion brothers, believed to be refugees of a bloody clash for dominance in their pride, were taking shelter from the midday sun under a lone tree. One began to climb the tree. "His heavy frame struggled," says Rush. The other two growled, seemingly envious of their brother's perch.

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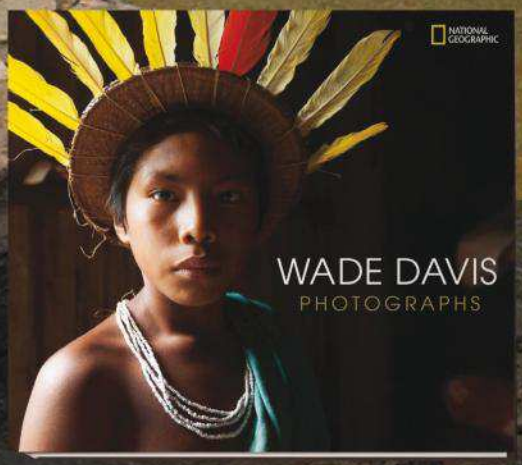
HONDA

NATIVE CULTURES REVEALED IN PICTURES



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