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WHY WE CAN'T RESIST IT





Black-footed Albatross (*Phoebastria nigripes*)

Size: Head and body length, 68 - 74 cm (26.8 - 29.1 inches); wingspan, 193 - 216 cm (76 - 85 inches)

Weight: 2.7 - 3.7 kg (6 - 8.2 lbs) **Habitat:** Ranges widely over north Pacific; breeds in the Hawaiian Islands and Japan **Surviving number:** Estimated at 129,000 breeding individuals



Photographed by Tui De Roy

WILDLIFE AS CANON SEES IT

Balancing act. The black-footed albatross balances long sojourns at sea with family time spent at breeding colonies. At sea, it sits on the surface while foraging for food, drinking seawater and secreting salt from glands above its eyes. Back on land, monogamous breeding pairs strengthen their bonds with ritualized display postures, including bowing, preening and calling with bills pointing to the sky. But with each female laying

just one egg a year and only 6.9 out of 100 eggs becoming breeding adults, populations are barely in equilibrium. Bycatch, pollution and introduced predators could all tip the balance.

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

Canon

Survival of the
fattest: After he was
weaned, this cub,
about six months old,
would steal milk from
other mothers.

MICHAEL NICHOLS, NGM STAFF

August 2013

28 The Surprising Life of Lions

The only cat that's truly social is the lion. But why...and how? To find out, our team spent many months with the prides of the Serengeti.

By David Quammen Photographs by Michael Nichols

62 Living With Lions

Africa's lions may number no more than 35,000. In Kenya a program called Lion Guardians points to a way to save the beleaguered cats.

By David Quammen Photographs by Brent Stirton

78 Sugar Love: A Not So Sweet Tale

We were smitten 10,000 years ago on the island of New Guinea. Today the average American downs 22.7 teaspoons a day.

By Rich Cohen Photographs by Robert Clark

98 Underwater Secrets of the Maya

"I saw it, I saw it! Yes, it's true!" the archaeologist shouts: divine light at the bottom of a natural well.

By Alma Guillermoprieto

Photographs by Paul Nicklen and Shaul Schwarz

122 Cave Bravery

Technology is redefining how caves are explored.

By A. R. Williams

124 Sunita Williams: Spacewalker

The astronaut steps into the void.

By Rachel Hartigan Shea Photograph by Marco Grob

126 Behind the Painted Elephant

In India the animal is a treasure—and sometimes also a work of art.

By Rachel Hartigan Shea Photographs by Charles Fréger

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Snake Hunt

Find out what happened when Florida declared open season on pythons.

World Without Words ▶

What do the pictures to the right tell you?



Let the River Flow

Floods released from Glen Canyon Dam benefit the Grand Canyon.



Viking Mice

Many a mouse has Norse ancestry.

Recipe for Dilbit

It's a tar sands product diluted with chemicals—and it's got problems.

Carping About Carp

Asian species are invading American waters. One solution: carp cakes!

I Smell a Fly ▶

Goldenrod can sniff 'em out—and release toxins to deter egg laying.



DIGITAL EDITIONS

National Geographic is available on the iPad, the Kindle Fire, and the iPhone.



Lions **Video**

Meet the lions—and the people who study them.



Sacred Cenotes **Video**

Follow photographer Paul Nicklen into a holy Maya well.

134 **NG Connect** **The Moment** **Flashback**



On the Cover A single cupcake can contain up to 800 calories, depending on its size and gourmet credentials. There's a lot of butter in the batter and icing. And, of course, plenty of sugar.
Photo by Robert Clark

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TAKE BACK THE WEEKEND

There's nothing like a Friday-Sunday sojourn to widen the parameters of today's mile-a-minute world.

To make the most of a weekend, choose a destination where you can combine invigorating outdoor adventure with indulgent dining, shopping, and pampering. And if you need one more excuse for a getaway: **Chase Sapphire Preferred® offers 2X points on travel and dining at restaurants. Here are two award-winning ways to enjoy your weekend and explore new territories.**



Gatehouse Country Inn, Shawnee on Delaware, Pennsylvania

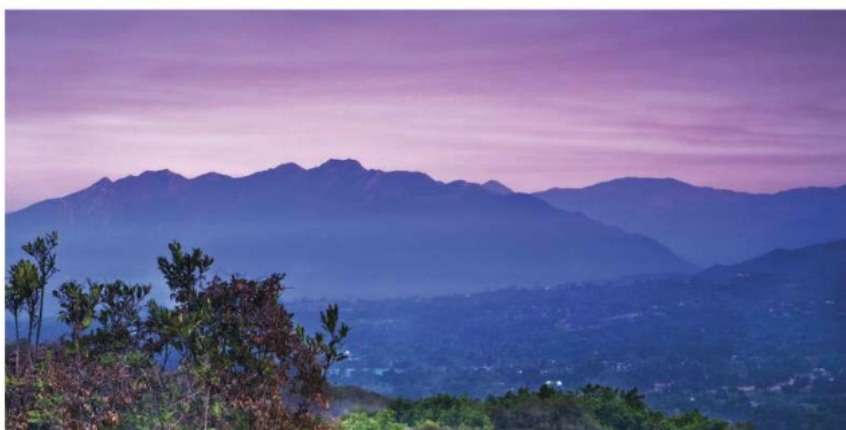
DELAWARE WATER GAP—RUGGED AND RELAXED IN PENNSYLVANIA

Just a two-hour trip from Philadelphia or New York City, the 1,000-foot-deep “gap”

is all about the magic of the Delaware River, a place of scenic wonders. Weekend warriors can enjoy the best of outdoor recreation, from angling for trout to horseback riding to trekking a stretch of the Appalachian Trail, all on nearly 70,000 acres of preserved parklands. Taking to the waters via kayak, canoe, raft, or tube is the ideal way to experience the area's dramatic and ever-changing landscapes—keep an eye out for peregrine falcons, golden eagles, and ospreys. History buffs will appreciate Native American archaeological sites and Millbrook Village, a fascinating and accurate replica—replete with mills and craft demonstrations—of a typical rural community in the late 19th century. Be sure to set aside a couple of hours to hunt for covetable antiques and linger over sophisticated cuisine in New Hope and lesser-known Lambertville (across the river, in New Jersey). When your day of adventure is done, you can rest at one of many charming country inns that range from quaint to luxurious.



Delaware Water Gap, Pennsylvania



Ojai, California



OJAI—A CALIFORNIA DREAM GETAWAY

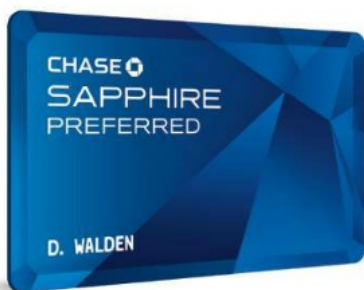
A scenic 85 miles northwest of Los Angeles—and 15 miles inland from the Pacific—Ojai is known as “Shangri-La of Southern California.” This laid-back little town is big on sustainable living, starting with

farm-to-table cuisine. Among the area's outdoor challenges, technical mountain climbing gets top billing. But Ojai's most magnetic force is something called the Pink Moment, a high-powered sunset that bathes the Ojai valley in deep pinks and lavenders. Make your way to Topatopa bluffs to witness this natural phenomenon, and then wind down at an Ojai spa hotel. On Sunday, stroll the farmers market and pick up some luscious organic produce and artisanal goods to remind you of your weekend in paradise. While you refresh and recharge, get 2x points on travel and dining at restaurants with **Chase Sapphire Preferred®**. Learn more at chasesapphire.com/preferred.



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The Truth About Lions

I met ecologist Craig Packer in 1988. I was a young photographer on assignment in the Serengeti for the first time, trying to feel my way around the craft of natural history photography. I think his first reaction to me was annoyance. He had good reason. I was green and untested in those days. Craig, who'd been director of the Serengeti Lion Project since 1978, was the scientist who knew lions. I was just beginning to learn.


Craig is not an easy man to work around. He's seen it all and isn't reluctant to tell you so. But he is rigorous in the integrity of his science. For Craig it's all about the data and getting the facts right. This made him and his team the keystone collaborators for this month's cover story on Serengeti lions, written by David Quammen and photographed by Michael (Nick) Nichols.

Craig's research provided the solid underpinning for David and Nick's work. "We sat down with him with maps," Nick says. "He told us where to go and what to look for." Craig's is a shoestring operation. His passion comes without frills. His equipment consists of five beat-up Land Rovers held together by wire, a falling-down house with no power, and a staff that works hard for the sheer love of it. "There is nothing," Nick says, "that even smells of a wasted dollar." It is all about the research—and the lions.

"Getting into Craig's head on lions," Nick continues, "was the primer that allowed me to skip the cliché of the animal we all think we know."



Members of the Serengeti Lion Project team meet by moonlight in an infrared photo made in Tanzania's Serengeti National Park. They are (from left) Daniel Rosengren, Ali Swanson, Craig Packer, Ingela Jansson, Stan Mwampeta.

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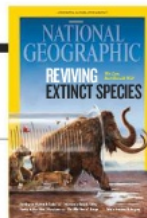
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De-Extinction

- Resurrecting extinct species just to see whether it can be done is not only impractical and wasteful but also borderline immoral. Humans continue to reduce the numbers of tigers, elephants, whales—you name it—through poaching and habitat destruction and take more and more of the planet for ourselves and leave less and less for other animals. To bring a species back only to force it to live in a zoo or research laboratory, or to release it to struggle for survival in an environment that can't support it, is cruel and unnecessary but consistent with our human-centric view of the world.

ALLISON MYERS
Freeville, New York

"What intrigues me is just that it's really cool." I wonder how many scientists on the Manhattan Project had similar sentiments. Just saying.

RANDALL WEBSTER
South Lake Tahoe, California

Reviving extinct woolly mammoths would be tremendous. But what about *Australopithecus*, *Homo habilis*, and *Homo erectus*? Do we put them in zoos? Is it murder if you kill one? Are they human or not? Are they

allowed to hold jobs, get student loans, and draw Social Security disability benefits? Still, it would be important to learn their level of capacity for abstract symbols, language, and culture.

KENNETH W. JOHNSON
Lawrenceville, Georgia

Anyone who chooses to believe in evolution and Darwin's theory of survival of the fittest clearly understands that species will come and go. Whoever decided that we humans are responsible

for this obviously has a God complex. We are merely one species in this chain. We are as vulnerable as all the other species. One chance virus, one chance astronomical event could wipe us out. Just because we believe we have higher intelligence and an understanding of this does not mean that we are arbiters. We cannot control what species live or die. If we try, we change the balance of things.

ANTHONY BERG
Madison, Wisconsin

We can never truly know the real nature, habits, and traits of these lost creatures. A resurrected animal will learn the behaviors of its adoptive parent/cousin, and therefore de-extinction can only bring back a look-alike. The true animal has been lost forever.

SAM WILLIAMS
London, England

Corrections

APRIL 2013, NEXT: CURSES, FOILED
The photograph of the tablet on page 22 should have been additionally credited to the Archaeological Museum of Bologna.

FEEDBACK Readers shared their thoughts on bringing back extinct species.



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FRIDAY AUGUST 2 • 8P

GOLD RUSH GHOST SHIPS
FRIDAY AUGUST 9 • 8P

AREA 51 DECLASSIFIED
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AMERICA BEFORE COLUMBUS
FRIDAY AUGUST 23 • 8P

GALÁPAGOS
FRIDAY AUGUST 30 • 8P



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NAT GEO
WILD



PREMIERES
SUNDAY AUGUST 18 • 10P

AMERICA THE WILD

WITH CASEY ANDERSON

I think the bigger and more fundamental questions than “Should we do this?” are “What are we doing this for?” and “What do we count as a real, biological species?” If returning extinct species to intact, natural ecosystems is the goal, that won’t be achieved by creating an animal with spliced gene fragments or by returning a long-extinct animal such as the woolly mammoth to a now alien ecosystem. All you would be doing is creating another Jurassic Park—a spectacle for humans.

MATTHEW PUDOVSKIS
Vancouver, British Columbia

I was given a completely different thought. Let’s try to save the species we still have first. Can’t we try cloning rhino horns and elephant tusks? Flood the market with the cloned products, and the value to poachers goes to zero.

TOM MOROOKIAN
North Fort Myers, Florida

In the past few years I have seen the rise of the simplistic view of man as the demon of all things environmental. “You could say an extinct species is the collateral damage of human existence” was your punch line. As a veterinarian, I see the interplay of genetics, disease, predation, food sources, reproductive choices of mating and nesting, et cetera, as having huge impact on the survival of a species. Why then does each article at some point have to point to man as the ultimate causal force for evil? If you truly are Darwinian in your scientific view, remember it

is the “survival of the fittest,” which means some species didn’t survive even when man was not on this Earth.

KENNETH ACHTERBERG
Haslett, Michigan

Reviving extinct species is a very bad idea. The reasons are clear. We do not have enough food to feed the species that are alive now. We do not have enough appropriate land for them to live on. We cannot stop people who insist that acquiring a part of a living creature is worth killing that creature. We cannot stop fishermen who use nets to kill fish in the sea that they don’t even want.

JUDITH ANTROBUS
New York, New York

Resurrecting an extinct species would certainly add biological richness to an ecosystem, but how long would it last? The author’s description of the de-extinction process would create an entire population from only a few individuals. The problem with small populations is they lack the necessary genetic variability to adapt and evolve, ultimately causing them to go the way of the dodo once again.

NATE KEIPER
Toledo, Ohio

I am greatly in favor of genetics, but the law of unintended consequences might involve reviving mammoths only to see them threatened with extinction, like elephants, for the ivory in their tusks.

ABE GRUBER
San Diego, California

I think it would be amazing to have woolly mammoths walk the Earth again.

ANDREW DAVID MOWER
Layton, Utah

Have we not learned from past experience the dangers of introducing foreign or invasive species into an ecosystem? Introducing species absent from an ecosystem for hundreds, if not thousands, of years means they are no longer native but new species, and the ecosystem likely has adapted to their absence. Also, no species are independent, as they rely on predators, prey, and other species, be they bacteria or other co-dependent species. Are the scientists planning on bringing these back as well?

GLENN C. ROTH
Calgary, Alberta

As if coolness or anything related to some concept of exploring the unknown were in any way central to this issue. Reintroducing extinct species into nature is a complex process that goes far beyond re-creating an organism in a laboratory. It involves fiscal, social, and ecological ramifications that were—to my extreme disappointment—barely if ever touched on in the article.

JONATHAN HIRSCH
Larkspur, California

Although the idea of bringing back the dead intrigues me, the possible damage to our environment, which is already unstable, makes me wary.

JULIANA KIM
Bronxville, New York

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TOUGH TERRAIN— TOUGHER CAMERA

This spring, award-winning adventure photographer **TIM KEMPLE** traveled to southern Iceland's rugged national parks, hiking trails, beaches, and glaciers to test the new Olympus Tough Series. While there, the epic landscapes were pummeled by sudden extreme weather changes, making a waterproof, freezeproof, shockproof, and crushproof camera essential. Here Kemple shares how he got these photos.

{ ALL IMAGES WERE TAKEN WITH THE OLYMPUS TOUGH. }

TRAIL RUNNING LAKI LAVA FIELDS, ICELAND



On this day ultra-runner Rory Bosio and I encountered rain and wind—but that was perfect for the images I wanted to capture. The rain had turned the moss an electric green, the waterfalls were raging in the distance, and the passing fog created another layer of depth in the imagery that was unique. And there was nobody on the trails for miles!

BOULDERING IN THÓRSMÖRK, ICELAND



We had heard rumors of bouldering potential in a particular spot in Thórsmörk, or “Thor’s Forest,” a beautiful valley below Iceland’s southern volcanic mountains. Once we found it, I started looking for an angle that allowed the climber, Blake Hendrix, to pop from the frame and show the depth of the landscape. To create a layer in the foreground that guides the eye to the subject, I had to lay the camera in the damp moss.

EXPLORING AN ICE CAVE, EYJAFJALLAJÖKULL, ICELAND



After a day of adventuring, we turned one last corner and saw a small river pouring out of a glacier. It created this giant cave at its base. We were like kids and just ran full-speed to explore the cave. It was cold inside and water was dripping everywhere. When I made it to the back of the cave, I turned and saw Rory Bosio reaching for the natural water flow. Luckily I had my camera in my pocket, and I was able to snap a couple of candid moments.

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LETTERS

Delaware

The text repeats a common misuse of the name of the stream that flows through the valley. It is Brandywine Creek, not river, as officially designated by the U.S. Board on Geographic Names. Most just call it the Brandywine. Now let's debate the proper pronunciation of “creek.”

HARRY THEMAL
Wilmington, Delaware

Though often informally referred to by the variant name Brandywine River, as it is in our text, the Brandywine was officially recognized as a creek in 1959.

Mahogany

We censure the Chinese for the slaughter of Africa's elephants and rhinos. But now it appears, since we have been its primary importer, we must censure ourselves for the slaughter of Peru's mahogany.

KENNETH BARNES
St. Petersburg, Florida

Manatees

The photo on pages 84-85 of kayakers harassing manatees is an excellent example of ignorance. Each of them ought to get the gift of three friendly black bears to live in their home. The bears' function would be to watch their every move for hours on end, plus obstruct their movements whenever possible.

JAMES R. WISIALOWSKI
Wheeling, West Virginia

Europe's Wild Men

We wanted to add another set of wild men to the list. In February 2009 we were lucky to see Hungary's version at the Busójárás festival in Mohács. The monsters, called *busó*, had a gentle demeanor but made lots of noise as they chased away winter and Ottoman Turks in a continuation of a very old festival.

DAREN AND AMY STENNES
Arvada, Colorado



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NOW'S THE TIME TO HELP PROTECT YOURSELF WITH **THE SHINGLES VACCINE**

**NO MATTER HOW
HEALTHY YOU FEEL,
SHINGLES COULD
STILL HAPPEN TO YOU.**

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Zoster Vaccine Live

Shingles is caused by the same virus that causes chickenpox. The virus stays in your body and can resurface at any time as Shingles — a painful, blistering rash. And no matter how healthy you feel, your risk increases as you get older.



Actual clinical rash image

The sooner you get vaccinated with ZOSTAVAX, the better your chances of protecting yourself from Shingles. In fact, the ACIP* of the CDC (Centers for Disease Control and Prevention) recommends that appropriate adults 60 years of age and older get vaccinated to help prevent Shingles.

*ACIP=Advisory Committee on Immunization Practices





Talk to your health care professional to see if ZOSTAVAX® (Zoster Vaccine Live) is right for you.

ZOSTAVAX is given as a single shot. ZOSTAVAX cannot be used to treat Shingles, or the nerve pain that may follow Shingles, once you have it. For more information, visit ZOSTAVAX.com or call 1-877-9 SHINGLES.

ABOUT ZOSTAVAX

ZOSTAVAX is a vaccine that is used for adults 50 years of age or older to prevent Shingles (also known as zoster).

IMPORTANT SAFETY INFORMATION

ZOSTAVAX does not protect everyone, so some people who get the vaccine may still get Shingles.

You should not get ZOSTAVAX if you are allergic to any of its ingredients, including gelatin or neomycin, have a weakened immune system, take high doses of steroids, or are pregnant or plan to become pregnant. You should not get ZOSTAVAX to prevent chickenpox.

Talk to your health care professional if you plan to get ZOSTAVAX at the same time as PNEUMOVAX®23 (Pneumococcal Vaccine Polyvalent) because it may be better to get these vaccines at least 4 weeks apart.

Possible side effects include redness, pain, itching, swelling, hard lump, warmth, or bruising at the injection site, as well as headache.

ZOSTAVAX contains a weakened chickenpox virus. Tell your health care professional if you will be in close contact with newborn infants, someone who may be pregnant and has not had chickenpox or been vaccinated against chickenpox, or someone who has problems with their immune system. Your health care professional can tell you what situations you may need to avoid.

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

Please read the Patient Information on the adjacent page for more detailed information.

BEFORE YOU GET SHINGLES, GET VACCINATED.

**Patient Information about
ZOSTAVAX® (pronounced "ZOS tah vax")
Generic name: Zoster Vaccine Live**

9989115

You should read this summary of information about ZOSTAVAX before you are vaccinated. If you have any questions about ZOSTAVAX after reading this page, you should ask your health care provider. This information does not take the place of talking about ZOSTAVAX with your doctor, nurse, or other health care provider. Only your health care provider can decide if ZOSTAVAX is right for you.

What is ZOSTAVAX and how does it work?

ZOSTAVAX is a vaccine that is used for adults 50 years of age or older to prevent shingles (also known as zoster).

ZOSTAVAX contains a weakened chickenpox virus (varicella-zoster virus).

ZOSTAVAX works by helping your immune system protect you from getting shingles.

If you do get shingles even though you have been vaccinated, ZOSTAVAX may help prevent the nerve pain that can follow shingles in some people. ZOSTAVAX does not protect everyone, so some people who get the vaccine may still get shingles.

ZOSTAVAX cannot be used to treat shingles, or the nerve pain that may follow shingles, once you have it.

What do I need to know about shingles and the virus that causes it?

Shingles is caused by the same virus that causes chickenpox. Once you have had chickenpox, the virus can stay in your nervous system for many years. For reasons that are not fully understood, the virus may become active again and give you shingles. Age and problems with the immune system may increase your chances of getting shingles.

Shingles is a rash that is usually on one side of the body. The rash begins as a cluster of small red spots that often blister. The rash can be painful. Shingles rashes usually last up to 30 days and, for most people, the pain associated with the rash lessens as it heals.

Who should not get ZOSTAVAX?

You should not get ZOSTAVAX if you:

- are allergic to any of its ingredients.
- are allergic to gelatin or neomycin.
- have a weakened immune system (for example, an immune deficiency, leukemia, lymphoma, or HIV/AIDS).
- take high doses of steroids by injection or by mouth.
- are pregnant or plan to get pregnant.

You should not get ZOSTAVAX to prevent chickenpox.

Children should not get ZOSTAVAX.

How is ZOSTAVAX given?

ZOSTAVAX is given as a single dose by injection under the skin.

What should I tell my health care provider before I get ZOSTAVAX?

You should tell your health care provider if you:

- have or have had any medical problems.
- take any medicines, including non-prescription medicines, and dietary supplements.
- have any allergies, including allergies to neomycin or gelatin.
- had an allergic reaction to another vaccine.
- are pregnant or plan to become pregnant.
- are breast-feeding.

Tell your health care provider if you expect to be in close contact (including household contact) with newborn infants, someone who may be pregnant and has not had chickenpox or been vaccinated against chickenpox, or someone who has problems with their immune system. Your health care provider can tell you what situations you may need to avoid.

Can I get ZOSTAVAX with other vaccines?

Talk to your health care provider if you plan to get ZOSTAVAX at the same time as the flu vaccine.

Talk to your health care provider if you plan to get ZOSTAVAX at the same time as PNEUMOVAX®23 (Pneumococcal Vaccine Polyvalent) because it may be better to get these vaccines at least 4 weeks apart.

What are the possible side effects of ZOSTAVAX?

The most common side effects that people in the clinical studies reported after receiving the vaccine include:

- redness, pain, itching, swelling, hard lump, warmth, or bruising where the shot was given.
- headache

The following additional side effects have been reported with ZOSTAVAX:

- allergic reactions, which may be serious and may include difficulty in breathing or swallowing. If you have an allergic reaction, call your doctor right away.
- chickenpox
- fever
- hives at the injection site
- joint pain
- muscle pain
- nausea
- rash
- rash at the injection site
- swollen glands near the injection site (that may last a few days to a few weeks)

Tell your health care provider if you have any new or unusual symptoms after you receive ZOSTAVAX. For a complete list of side effects, ask your health care provider.

Call 1-800-986-8999 to report any exposure to ZOSTAVAX during pregnancy.

What are the ingredients of ZOSTAVAX?

Active Ingredient: a weakened form of the varicella-zoster virus.

Inactive Ingredients: sucrose, hydrolyzed porcine gelatin, sodium chloride, monosodium L-glutamate, sodium phosphate dibasic, potassium phosphate monobasic, potassium chloride.

This page summarizes important information about ZOSTAVAX. If you would like more information, talk to your health care provider or visit the website at www.ZOSTAVAX.com or call 1-800-622-4477.

Rx only

Issued June 2011

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MOON LANDS ON MAN!

The skeptics said it couldn't be done... but our Moon Phase proves that one small step for Stauer is one giant leap for watch lovers!

It has always taken scientific skill and artistic wizardry to discover the Moon's secrets. When Galileo Galilei turned his telescope towards the Moon in 1609, he relied on his knowledge of light and shadow learned as a painter to understand the movements of the heavenly orb. We relied on that same pairing of art and science to create one of our most complicated and beautiful movements yet... for an unbelievable price!

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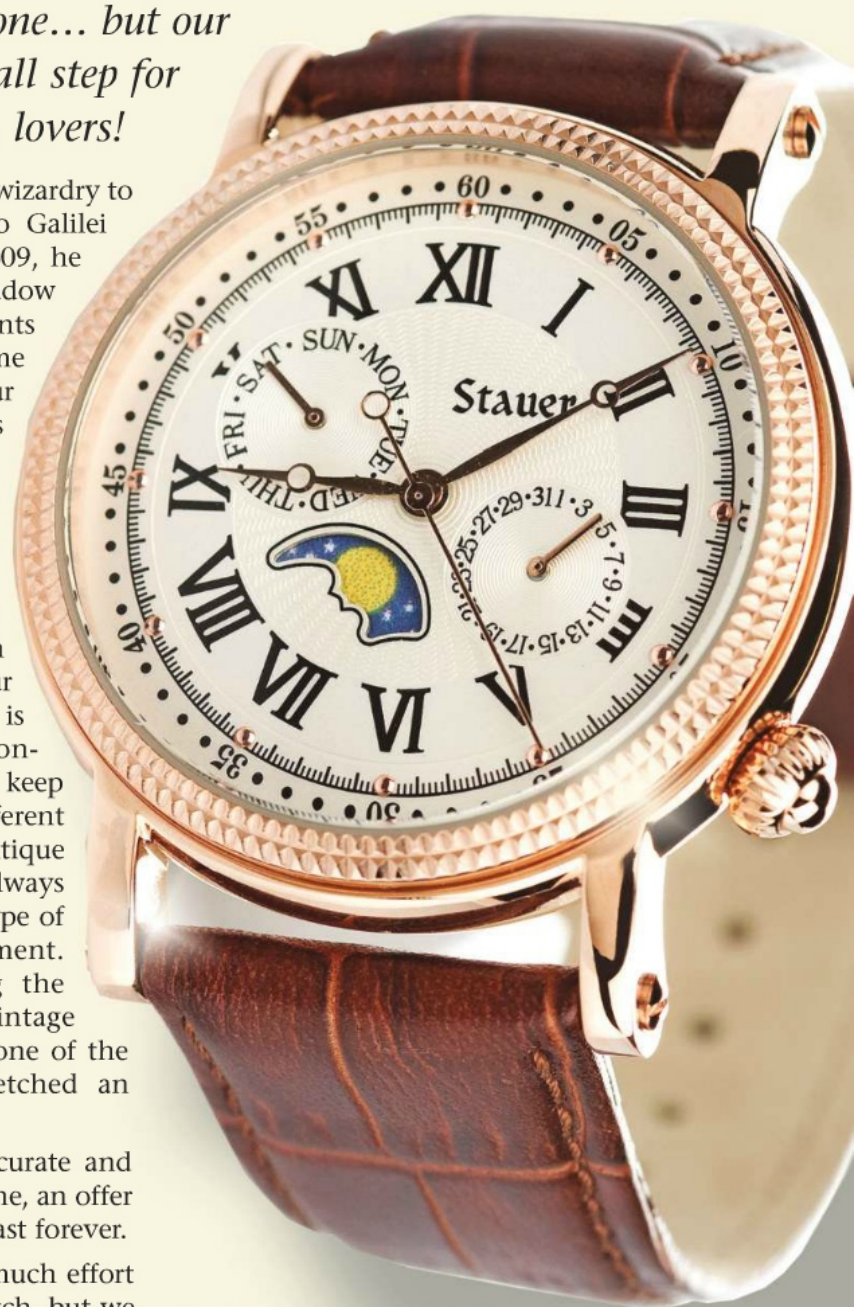
You'll find them among the rarest and most expensive vintage watches ever sold at auction. Not long ago, one of the most important moon-phase timepieces fetched an incredible \$5.7 million!

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How we captured the Moon. We put so much effort into perfecting the mechanics behind this watch, but we didn't forget the aesthetics. The *Moon Phase Watch* boasts three different complications set in the guillochéed face: a standard monthly calendar, a day of the week indicator, and the moon phase display. Its rose gold-finished case features a hobnail-pattern bezel and a crocodile-embossed, genuine brown leather strap adds the final luxurious detail.

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John Tennent
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EXPERTISE
Butterfly taxonomist

LOCATION
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Storm Tossed I was making a census of Pacific butterflies and was on the lookout for new species on the remote Lusancay Islands. There were five of us on a 23-foot dinghy I hired to move between islands—an operator, his two assistants, me, and a local Kawa chief who wanted a lift—when we were hit by a squall. Then the engine stopped. The storm was raging, and we started taking on water. We bailed out using the only thing at hand: coconut husk halves.

A dinghy is hard to maneuver. It tends to turn broadside to the waves, making it dangerously unstable. We had only two oars, and the assistants were rowing furiously to keep the bow into the wind, but as soon as they stopped, the dinghy would drift sideways again. The pilot's attempts to restart the engine weren't working.

We'd been stranded for about two hours before visibility increased and the chief recognized two rocks jutting

out of the water. The chief and I grabbed a tarpaulin, tied each side to an oar, and held the rudimentary sail up to catch the wind. Using the 20-foot stick for poling around atolls as a rudder, the operator steered us toward Kawa Island. The chief knew where it was in relation to the rocks.

With difficulty we headed to the windless side of the island so the weather wouldn't dash us against the coral island's edge. We gripped surrounding coral to pull ourselves hand over hand to shore. Freezing and with little food, we walked the mile to the nearest village to spend the night. It turned into a week, due to continuing storms. Later we learned that a passenger ferry carrying hundreds of people had been out in the same weather. A wave came over the stern, and many were lost. Thanks to a quick-thinking Kawa chief named Nelson—a good omen for any Englishman on board a ship—we were still five.



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Perfect Choice HD is NOT a hearing aid. Hearing aids can only be sold by an audiologist or a licensed hearing instrument specialist following hearing tests and fitting appointments. Once they have you tested and fitted, you could pay as much as \$5000 for the product.

Reading glasses for your ears. While some people need hearing aids, many just need the extra boost in volume that a PSAP gives them. Now, thanks to the efforts of the doctor who leads a renowned hearing institute, there is Perfect Choice HD. It's a PSAP designed to accurately amplify sounds and deliver them to your ear. Because we've developed an efficient production process, we can make a great product at an affordable price. The unit has been designed to have an easily accessible battery, but it is small and lightweight enough to hide behind your ear... only you'll know you have it on. It's comfortable and won't make you feel like you have something stuck in your ear. It provides high quality audio so sounds and conversations will be easier to hear and understand.

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VISIONS



Germany

Brandenburg is balmy if you're in Tropical Islands, a theme park housed in a 710,000-square-foot former aircraft hangar. Although the temperature in this pleasure dome is a perpetual 79°F, light levels vary due to a section of transparent roof panels.

PHOTO: REINER RIEDLER, ANZENBERGER







France

A Eurasian beaver heads for her lodge in the Loire River, hauling a poplar branch for supper. A century ago hunting had nearly wiped out this species: Just 1,200 were left. Today a million of these protected rodents thrive, mostly in Europe.

PHOTO: LOUIS-MARIE PREAU



Belgium

The chance of indoor clouds is 100 percent wherever artist Berndnaut Smilde goes. Here, one of his fleeting nimbuses—made when he mixes moisture and smoke with dramatic lighting—hovers in a centuries-old castle near Lanaken.

PHOTO: CASSANDER EEF TINCK SCHATTENKERK



Dogged Pursuit

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How Canine Genomics Influence Purina ONE Nutrition

- The diversity in the canine genome is **evidenced by the broad range in the size of different breeds.**
- One major component in this variation of sizes involves genetic expression of a cellular signal called “**Insulin-like Growth Factor**” (IGF)—a link that Purina scientists highlighted as co-authors of an article that was featured in the journal “Science.”
- To provide optimal nutrition for dogs of all sizes, **Purina ONE has formulas for all canine metabolisms.**

“Cast your mind back 15,000 years,” says Dr. Matthew Breen, Professor of Genomics at North Carolina State University’s College of Veterinary Medicine. He imagines a scenario where human encampments would be threatened by wolves looking to make a snack of their livestock. The humans may have thrown food to the wolves, launching the symbiotic relationship between man and his best friend, the dog.

Fast-forward to the Industrial Revolution in the late 18th century, when the wealthy began to breed dogs, “not solely for their function,” says Breen, “but increasingly for their appearance.” Today, the American Kennel Club recognizes 175 breeds, from massive Mastiffs to wee Chihuahuas, all with discrete instincts but descended from a common wolf ancestor. There are working dogs and companions—and now, dogs whose genetic information may help to save your life.

Purina’s longstanding partnership with the canine genomics community includes facilitating geneticists’ work and serving as the primary sponsor of the biannual Advances in Canine and Feline Genomics and Inherited Disease conference. These contributions have enabled key findings and new ways of applying dog genome mapping research to be more widely disseminated and shared.

Dr. Breen specializes in identifying genes in several canine cancers that offer hope for advancing treatments for both dogs and humans. “Human and dog genomes are incredibly similar in that we both get spontaneous genetic diseases,” he says. Moreover, it is easier to identify problematic areas in a dog’s genome because the genetic variation among dogs of the same breed is much lower than the variation in humans.

Dr. Breen explains the genome sequence as a “book,” with chromosomes as “chapters” that tell a specific story. “What we often see in cancers is that an entire chapter

is discarded, scrambled, or moved elsewhere in the book,” he says. This can drastically alter the flow and meaning of the story.

“With genome sequencing, we take the entire book and metaphorically pass it through a paper shredder.” To assemble the genome, the shreds are used to rebuild the “pages.” Each “page” is stamped with a number and a comprehensive table of contents is developed.

Another important focus of this research is nutritional genomics. Purina’s continued investment in canine genome sequencing research and the analysis of these “pages” has already provided insights that have led to breakthrough nutritional solutions for canine health and well-being.

For example, Purina has leveraged its molecular understanding of antioxidants systems that have evolved within the canine genome to protect against damaging free-radicals.

Canine genome research continues to enable scientists from many fields to pioneer advances that impact the well-being of both dogs and humans. “We are living longer and it’s having a huge effect on our healthcare,” says Dr. Breen, “and it’s the same with our pets.” By supporting canine genomic research, Purina is helping to improve the health and well-being of all types of dogs—and working to help enrich the quality of their years with proactive owners like you. ●



Wendy Savage, NC State University

DR. MATTHEW BREEN began his career over 20 years ago working on the Human Genome Project and has since been pioneering comparative aspects of cancer research with a primary focus on companion animals. He is Professor of Genomics at North Carolina State University’s College of Veterinary Medicine and member of the Center for Comparative Medicine and Translational Research.



EDITORS' CHOICE **Saori Baba** Fukuoka, Japan

During a ceremony to bless young children at Japan's Sumiyoshi Shrine in Fukuoka, Baba, a graduate student, spied this minor assault with an artificial flower. Both brothers later laughed.



READERS' CHOICE

Megan Lorenz
Etobicoke, Canada

On a photo excursion to Costa Rica, Lorenz wanted desperately to photograph red-eyed tree frogs. Just before dusk she got lucky: One approached a branch nearby. Unsteady, it grabbed a stalk of fungus to balance itself, then quickly climbed away.



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*Individual results may vary. **Clinical studies with osteoarthritis patients.

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

Important Safety Information:

All prescription NSAIDs, like CELEBREX, ibuprofen, naproxen and meloxicam have the same cardiovascular warning. They may all increase the chance of heart attack or stroke, which can lead to death. This chance increases if you have heart disease or risk factors for it, such as high blood pressure or when NSAIDs are taken for long periods.

CELEBREX should not be used right before or after certain heart surgeries.

Serious skin reactions, or stomach and intestine problems such as bleeding and ulcers, can occur without warning and may cause death. Patients taking aspirin and the elderly are at increased risk for stomach bleeding and ulcers.

Tell your doctor if you have: a history of ulcers or bleeding in the stomach or intestines; high blood pressure or heart failure; or kidney or liver problems.

CELEBREX should not be taken in late pregnancy.

Life-threatening allergic reactions can occur with CELEBREX. Get help right away if you've had swelling of the face or throat or trouble breathing. Do not take it if you have bleeding in the stomach or intestine, or you've had an asthma attack, hives, or other allergies to aspirin, other NSAIDs or certain drugs called sulfonamides.

Prescription CELEBREX should be used exactly as prescribed at the lowest dose possible and for the shortest time needed.

See the Medication Guide on the next page for important information about Celebrex and other prescription NSAIDs.



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CELEBREX
(CELECOXIB CAPSULES) 100 mg / 200 mg

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Medication Guide
for
Non-Steroidal Anti-Inflammatory Drugs (NSAIDs)
(See the end of this Medication Guide
for a list of prescription NSAID medicines.)

What is the most important information I should know about medicines called Non-Steroidal Anti-Inflammatory Drugs (NSAIDs)?

NSAID medicines may increase the chance of a heart attack or stroke that can lead to death.

This chance increases:

- with longer use of NSAID medicines
- in people who have heart disease

NSAID medicines should never be used right before or after a heart surgery called a “coronary artery bypass graft (CABG).”

NSAID medicines can cause ulcers and bleeding in the stomach and intestines at any time during treatment. Ulcers and bleeding:

- can happen without warning symptoms
- may cause death

The chance of a person getting an ulcer or bleeding increases with:

- taking medicines called “corticosteroids” and “anticoagulants”
- longer use
- smoking
- drinking alcohol
- older age
- having poor health

NSAID medicines should only be used:

- exactly as prescribed
- at the lowest dose possible for your treatment
- for the shortest time needed

What are Non-Steroidal Anti-Inflammatory Drugs (NSAIDs)?

NSAID medicines are used to treat pain and redness, swelling, and heat (inflammation) from medical conditions such as:

- different types of arthritis
- menstrual cramps and other types of short-term pain

Who should not take a Non-Steroidal Anti-Inflammatory Drug (NSAID)? Do not take an NSAID medicine:

- if you had an asthma attack, hives, or other allergic reaction with aspirin or any other NSAID medicine
- for pain right before or after heart bypass surgery

Tell your healthcare provider:

- about all of your medical conditions.
- about all of the medicines you take. NSAIDs and some other medicines can interact with each other and cause serious side effects. **Keep a list of your medicines to show to your healthcare provider and pharmacist.**
- if you are pregnant. **NSAID medicines should not be used by pregnant women late in their pregnancy.**
- if you are breastfeeding. **Talk to your doctor.**

What are the possible side effects of Non-Steroidal Anti-Inflammatory Drugs (NSAIDs)?

Serious side effects include:

- heart attack
- stroke
- high blood pressure
- heart failure from body swelling (fluid retention)
- kidney problems including kidney failure
- bleeding and ulcers in the stomach and intestine
- low red blood cells (anemia)
- life-threatening skin reactions
- life-threatening allergic reactions
- liver problems including liver failure
- asthma attacks in people who have asthma

Other side effects include:

- stomach pain
- constipation
- diarrhea
- gas
- heartburn
- nausea
- vomiting
- dizziness

Get emergency help right away if you have any of the following symptoms:

- shortness of breath or trouble breathing
- chest pain
- weakness in one part or side of your body
- slurred speech
- swelling of the face or throat

Stop your NSAID medicine and call your healthcare provider right away if you have any of the following symptoms:

- nausea
- more tired or weaker than usual
- itching
- your skin or eyes look yellow
- stomach pain
- flu-like symptoms
- vomit blood
- there is blood in your bowel movement or it is black and sticky like tar
- skin rash or blisters with fever
- unusual weight gain
- swelling of the arms and legs, hands and feet

These are not all the side effects with NSAID medicines. Talk to your healthcare provider or pharmacist for more information about NSAID medicines.

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

Other information about Non-Steroidal Anti-Inflammatory Drugs (NSAIDs)

- Aspirin is an NSAID medicine but it does not increase the chance of a heart attack. Aspirin can cause bleeding in the brain, stomach, and intestines. Aspirin can also cause ulcers in the stomach and intestines.
- Some of these NSAID medicines are sold in lower doses without a prescription (over-the-counter). Talk to your healthcare provider before using over-the-counter NSAIDs for more than 10 days.

NSAID medicines that need a prescription

Generic Name	Tradename
Celecoxib	Celebrex
Diclofenac	Cataflam, Voltaren, Arthrotec (combined with misoprostol)
Diflunisal	Dolobid
Etodolac	Lodine, Lodine XL
Fenoprofen	Nalfon, Nalfon 200
Flurbiprofen	Ansaid
Ibuprofen	Motrin, Tab-Profen, Vicoprofen* (combined with hydrocodone), Combunox (combined with oxycodone)
Indomethacin	Indocin, Indocin SR, Indo-Lemmon, Indomethagan
Ketoprofen	Oruvail
Ketorolac	Toradol
Mefenamic Acid	Ponstel
Meloxicam	Mobic
Nabumetone	Relafen
Naproxen	Naprosyn, Anaprox, Anaprox DS, EC-Naproxyn, Naprelan, Naprapac (copackaged with lansoprazole)
Oxaprozin	Daypro
Piroxicam	Feldene
Sulindac	Clinoril
Tolmetin	Tolectin, Tolectin DS, Tolectin 600

* Vicoprofen contains the same dose of ibuprofen as over-the-counter (OTC) NSAIDs, and is usually used for less than 10 days to treat pain. The OTC NSAID label warns that long term continuous use may increase the risk of heart attack or stroke.

This Medication Guide has been approved by the U.S. Food and Drug Administration. LAB-0609-1.0

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Each year, when China releases its Silver Panda coin, millions of collectors and silver lovers around the world swarm the market for these red-hot silver beauties. But even though the China Mint has raised their mintages from 600,000 to 8 million in recent years, the China Silver Pandas have still sold out each and every year. *Why?* The answer is surprisingly simple.

The Chinese silver rush is on!
The China Silver Panda has been one of the world's most popular coins for the last thirty years. But remarkably, an old 1949 law prohibited Chinese citizens from owning these coins until the law was changed in 2004. When the law was finally changed, millions of China's prosperous new middle class buyers flooded into the market. The Chinese silver rush is on!

Current prices for past-year Pandas:
Due to availability and demand, some past-year One Ounce Silver Pandas command impressive values these days:

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NEXT



SKYCAST

Overhead this month
in parts of the world



August 10-13
Perseid meteor
shower



August 26
Look for Neptune

PYTHON CHALLENGE

What happened when Florida declared open season on pythons?

FLORIDA HAS DISCOVERED something the parents of teenage boys have known for years: Snakes escape. For decades wholesalers in Florida have imported tens of thousands of pythons to supply American and international pet stores. Among the most popular has been the Burmese python, a relatively docile species found widely across South and Southeast Asia that grows to about 20 feet and can lay up to a hundred eggs in a clutch. So what makes Florida home to the python business now makes it simply home. Thousands of the snakes, perhaps multiples of that, are now permanently established as a part of the state's ecosystem. How established is yet unclear.

In January the Florida Fish and Wildlife Conservation Commission launched a Burmese python hunting tournament, the 2013 Python Challenge, awarding cash prizes to the person who brought in the most dead pythons and the largest. Nearly 1,600 people from 38 states registered in two classes: licensed snake hunter and amateur. Contestants were advised to kill the snakes using a bolt gun, a firearm, or a machete. The contest's goal, according to Frank Mazzotti, professor of wildlife ecology at the University of Florida, was to contain the snakes, gain insight into their lives, and bring attention to the invasive species issue.

Days appear numbered for the big-snake business. In 2010 Florida outlawed Burmese pythons and several other "giant" snake species as pets, and the U.S. Fish and Wildlife Service has imposed a federal ban on their importation or interstate transfer.

By the end of the month-long contest, licensed snake hunter Ruben Ramirez—captain of a group called the Florida Python Hunters—had caught the most pythons overall, an astounding 18 of the total 68 harvested. Ramirez's team members wanted to bring their catch in alive but were told they would be disqualified. Instead they shot their snakes with a pellet gun. Said one team member, "It was like shooting my own dog." —Bryan Christy

Blake Russ of the group Florida Python Hunters has his hands full. Russ won \$1,000 for catching one of the Python Challenge's longest snakes: It measured eleven feet one inch.



World Without Words

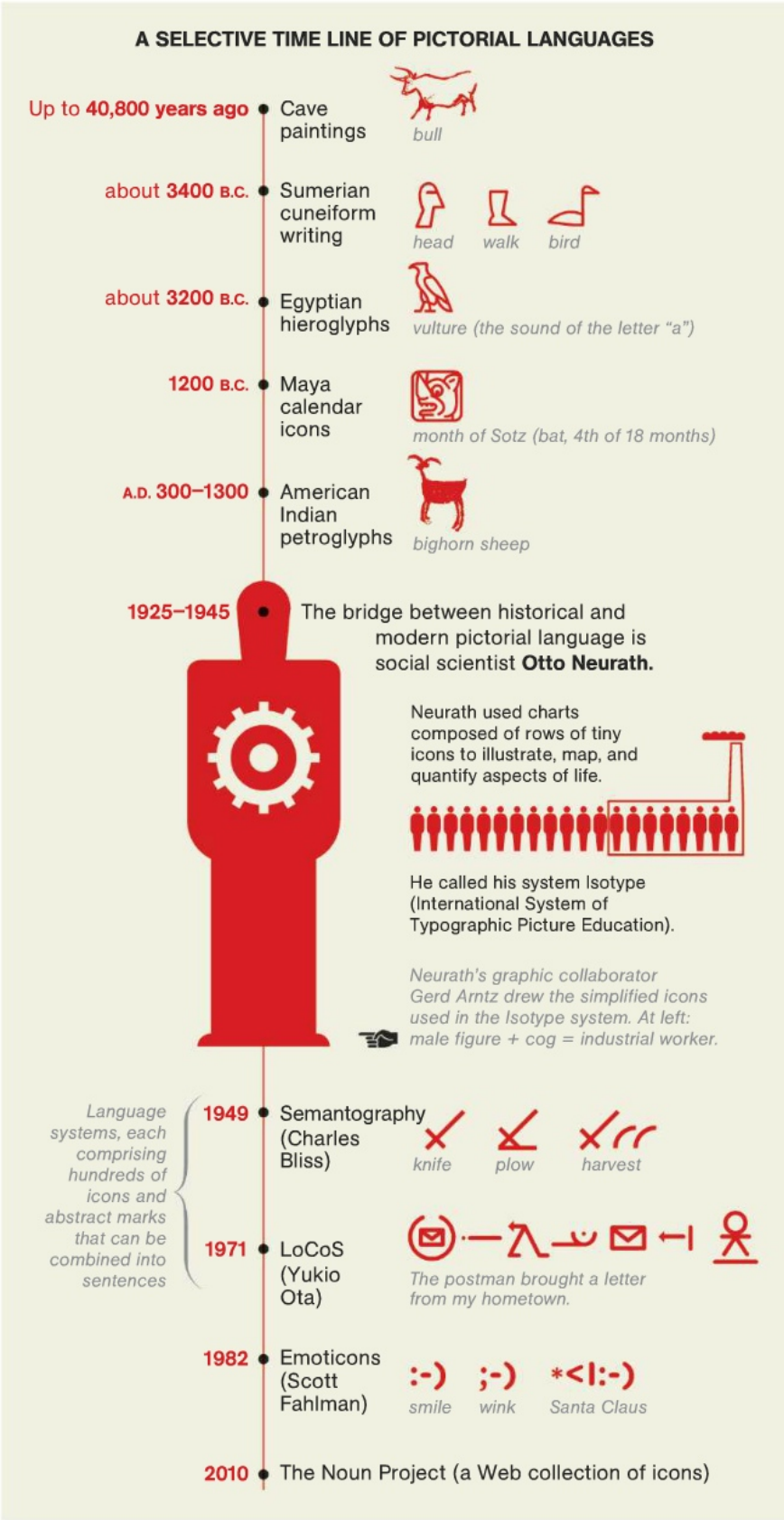
Ever since the earliest recorded paintings were made on cave walls in northern Spain, humans have used visuals to communicate. Some of these message systems are just lists or calendars. Are any of them truly universal languages—with sentences—or are they just collections of universally understood icons?

A language needs grammar. How can an organized arrangement of pictures be precise and subtle enough to convey metaphor? What do you “read” here:



Does it say, “At night, a person goes home to bed and dreams of snakes”? Or could it be, “After cutting his (or her) nails, a person goes into a house but can’t get to sleep because the thought of snakes keeps him (or her) awake”?

One problem (or one pleasure!) with pictures is that we read into them what we want. Also, both of the interpretations above assume that you are reading from left to right. How universal is that? —Nigel Holmes



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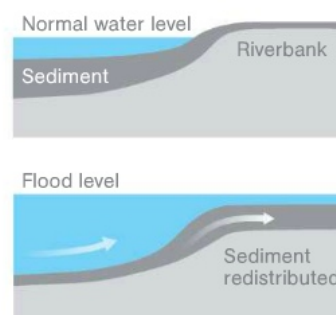
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Flooding the Canyon

Arizona's Glen Canyon Dam harnesses the Colorado River to provide electricity throughout the U.S. West—but it also blocks the 1,450-mile river from ferrying sediment downstream to the Grand Canyon. That process is vital for building the canyon's sandbars, which provide campsites and habitat that protects rare fish. So in November 2012 the U.S. Department of the Interior released a controlled flood of 44,700 cubic feet per second from the dam for three and a half days. The flow rebuilt many sandbars. But the bigger deal, notes flood manager Jack Schmidt, is a new protocol that allows opening the dam's floodgates when necessary. More frequent floods may help the Colorado, which, Schmidt says, is "a river condemned to serve many masters." —Christine Dell'Amore



Viking Mice The Norse marauded. So did their rodents. According to evolutionary biologist Eleanor Jones, there's a DNA link between modern mice living where Vikings once settled and house mice that stowed away on longships. Since house mice aren't particularly good at foraging, once they were on land, common larders tied the fates of mice and men. If Vikings abandoned outposts, leaving empty pantries, Norse mice died out and were replaced with mice brought by later settlers. —Johnna Rizzo



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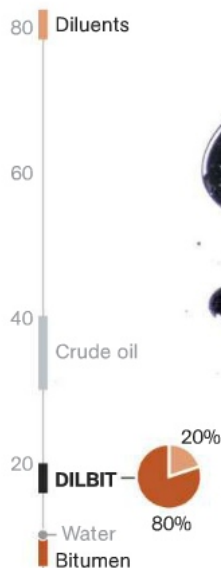
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Thick Crude

Most U.S. pipelines were designed to transport oil. What they weren't meant to carry is bitumen, a product of tar sands, like those in Canada, that can also be turned into energy. Bitumen is substantially thicker, so to make it flow through pipes, engineers dilute it with chemicals.

The resulting mixtures, called dilbit, are also cheaper than other crudes. Yet cleaning up when it spills is difficult. A leak in Michigan in 2010 of about 845,000 gallons proved more complex than oil to remove. "As the added chemicals evaporate, the thicker material stays put," says geochemist Chris Reddy. Dilbit formulas vary, complicating assessments of spills' effects on health. In pursuit of North American-based energy sources, producers say that precautionary cleanup plans can help minimize the impact of accidents. —Daniel Stone

Bitumen—about as thick as peanut butter—becomes dilbit (right, in water) when diluted for transport.



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Ant Kill Slave-making ants on the U.S. East Coast have a singular purpose: to sack neighboring ants' nests and seize the pupae to serve as their drudges. Instinct outweighs lineage, so the enslaved ants start working where they hatch, foraging food and caring for the captors' new brood and queen. They even feed the slave-makers—which are such specialized raiders that they can't feed themselves.

The captive ants are prone to periodic uprisings though, decapitating their prisoners and tossing their eggs out of the nest to die of neglect. "In theory it only takes one rebellious ant to do the job," says evolutionary biologist Tobias Pamminger. "Killing young is not hard." Still, the vicious cycle seems to favor the enslavers. At least 30 percent of the slave-making ants always survive such Spartacus-like onslaughts, enough to raid another day. —Johnna Rizzo

A slave-making ant, though larger, has been dealt a death blow by one of its potential captives.



Printable Reefs Artificial coral reefs now come with more nooks and crannies, thanks to 3-D printing technology. The new sandstone structures (left) are built layer by layer on a printer the size of a small house. David Lennon, director of Sustainable Oceans International, helped design the 1,100-pound reefs. Last fall biologists deployed two off the coast of Bahrain, in the Persian Gulf. The numerous hiding holes attract more diverse communities than do reefs formed from concrete molds. —Jane J. Lee



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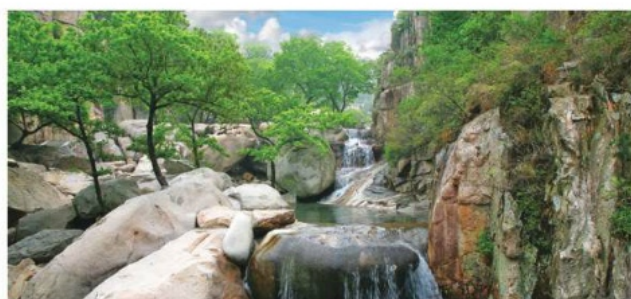
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Carp Invasion

Asian carp have been tenacious in U.S. waters. Brought to America in the 1970s to help clean sewage water, several hundred carp have spawned millions. Adept at moving between rivers during floods, escaped carp are now on the verge of spreading into all five Great Lakes. Biologists worry that the all-plankton diet of species like bighead and silver carp will disrupt the food chain and collapse fragile ecosystems.

The U.S. Fish and Wildlife Service and U.S. Geological Survey, among other agencies, are implementing a plan to manage the fish's spread. Engineers have set up electrical barriers to limit access between rivers and the Great Lakes. New laws prevent fish transport across state borders. Several companies are even working on carp-specific poisons.

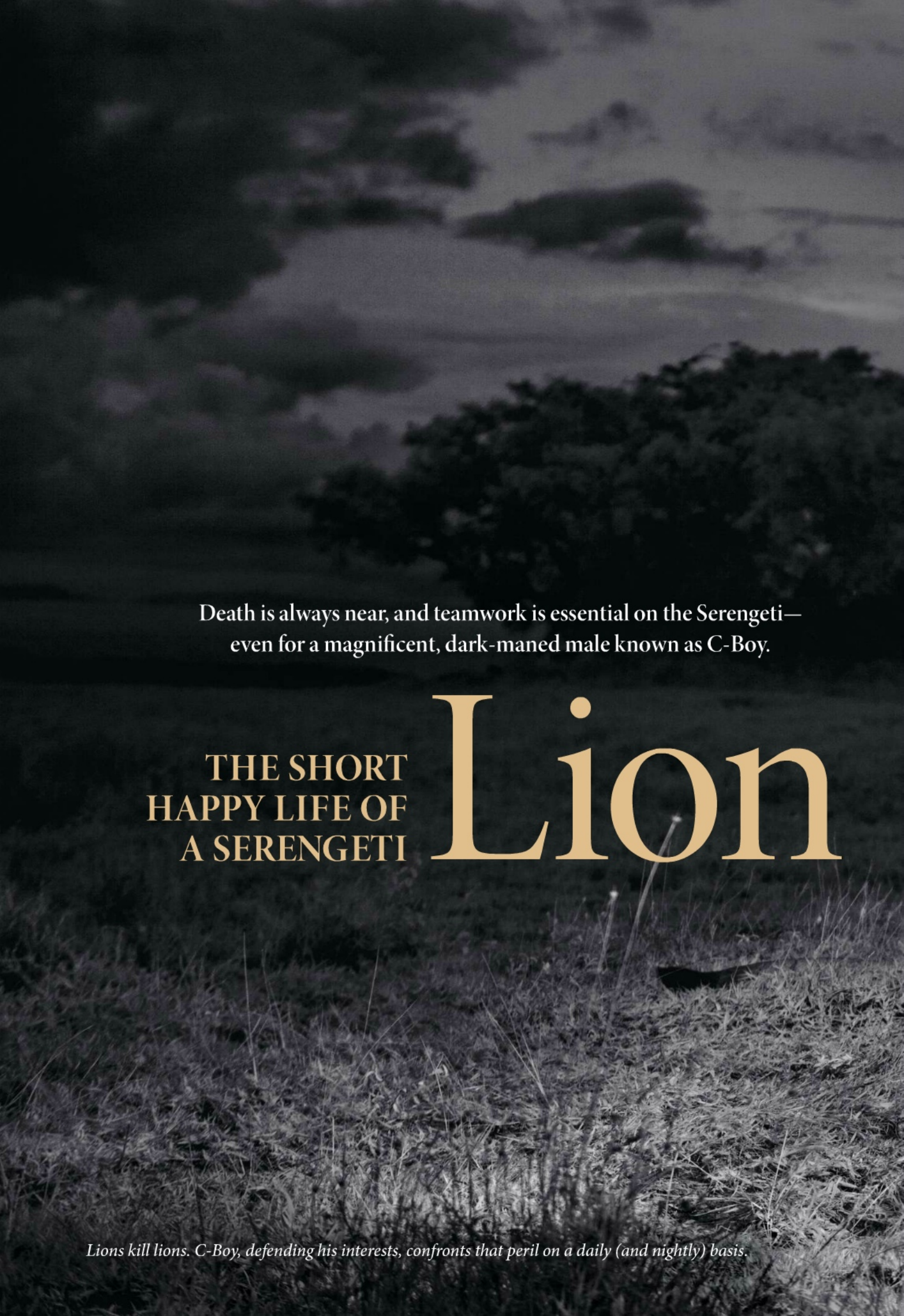
There is some good news: Carp in several rivers have shown signs of slowing population growth. "Our best chance to control these fish might be to harvest them and to use them," says Purdue University's Reuben Goforth. One option is to cook and sell the fish. A PR campaign has lobbied to shed carp's bony stigma by changing its name to "silverfin." —Daniel Stone

REPORTED BIGHEAD AND SILVER CARP SIGHTINGS



On the Scent

Tall goldenrods aren't sticking to what's expected of plants: The gallflies that perch on their leaves (left) are the ones being smelled. Entomologists say it's part of the larger arms race between plants and insects. In this case goldenrods are able to sniff out when a male fly—likely emitting mating messages—is around and produce toxins to deter egg laying. "Plants are winning mostly," says Penn State's Mark Mescher. "Insects are always trying to catch up." —Johnna Rizzo



Death is always near, and teamwork is essential on the Serengeti—
even for a magnificent, dark-maned male known as C-Boy.

THE SHORT
HAPPY LIFE OF
A SERENGETI

Lion

Lions kill lions. C-Boy, defending his interests, confronts that peril on a daily (and nightly) basis.





Large cubs of the Vumbi pride and a grown female (fifth from left) feast on a wildebeest. The darkest, moonless hours are prime hunting time because the cats can see better than their prey. These black-and-white photographs were made with infrared light to minimize disruption to the lions.







C-Boy mates with a Kibumbu pride female. After fathering cubs, a resident male can be displaced by other males. His young offspring will then be killed by the new males or left to die.





The Vumbis rest on a kopje, or rocky outcrop, near a favorite water hole. Lions use kopjes as havens and outlooks on the plains. When the rains bring green grass, wildebeests arrive in vast herds.



C-Boy and a Vumbi female relax between matings. During estrus a female may be monopolized for days by a single male consort. Dark manes correlate with robustness, and dark-maned studs like C-Boy are preferred.



By David Quammen

Photographs by Michael Nichols

T

hey say that cats have nine lives, but they don't say that about the Serengeti lion. Life is hard and precarious on this unforgiving landscape, and dead is dead. For the greatest of African predators as well as for their prey, life spans tend to be short, more often

terminating abruptly than in graceful decline. An adult male lion, if he's lucky and durable, might attain the advanced age of 12 in the wild. Adult females can live longer, even to 19. Life expectancy at birth is much lower, for any lion, if you consider the high mortality among cubs, half of which die before age two. But surviving to adulthood is no guarantee of a peaceful demise. For a certain young male, black-maned and robust, known to researchers as C-Boy, the end seemed to have arrived on the morning of August 17, 2009.

A Swedish woman named Ingela Jansson, working as a field assistant on a long-term lion study, was there to see it. She knew C-Boy from previous encounters; in fact, she had named him. (By her recollection, she had "boringly" labeled a trio of new lions alphabetically as A-Boy, B-Boy, and C-Boy.) Now he was four or five years old, just entering his prime. She sat in a Land Rover, 30 feet away, while three other males ganged up on C-Boy and tried to kill him. His struggle to survive against those daunting odds, dramatic in itself, reflected a larger truth about the Serengeti lion: Continual risk of death, even more than the ability to cause it, is what shapes the social behavior of this ferocious but ever jeopardized animal.

On the day in question, near the dry bed of the Seronera River, Jansson came to check on a pride known as Jua Kali. She was also alert for adult males, including those "resident" with the pride. (Male lions, not strictly belonging to any pride, instead form coalitions with other males and exert controlling interest over one or more prides, fathering the cubs and becoming





Cubs of the Simba East pride: too young to kill but old enough to crave meat. Adult females, and sometimes males, do the hunting. Zebras and wildebeests rank high as chosen prey in the rainy season.

THE THREE KILLERS TOOK TURNS LUNGING AT C-BOY FROM BEHIND, LASHING INTO HIS HAUNCHES, BITING AT HIS SPINE, AS HE SPUN AND ROLLED DESPERATELY TO ESCAPE.

resident, loosely associated with the pride. They also play an important role in helping kill prey—especially with larger and more dangerous animals, such as cape buffalo or hippos—thereby contributing something besides sperm and protection to the life of the pride.) The resident males of Jua Kali, Jansson knew, were C-Boy and his sole coalition partner, a golden-maned lout named Hildur. Approaching the river, she saw in the distance one male being chased by another. The fleeing lion was Hildur. Fleeing from what, and why, she didn't at first understand.

Then she found a group of four males in the grass. They had settled themselves in a squarish pattern, each about five strides away from the others. She recognized them—some of them, anyway—as members of another coalition, a group of four ambitious young adult males, notorious in her record cards as the Killers.

One lion had a bloody tooth, the lower right canine, suggesting a very recent fight. Another was hunkered flat, as though wishing he could disappear into the ground. From the flattened male came a steady, nervous growl. Driving closer, Jansson saw the dark tinge of his mane and realized this was C-Boy, wounded, isolated, and surrounded by three of the Killers.

She had also noticed a lactating female, the radio-collared lioness of the Jua Kali pride. Lactation meant young cubs, hidden somewhere in a den, the presumptive father of which was C-Boy or Hildur. So this standoff between C-Boy and the Killers was more than a pointless

rumble. It was a challenge for controlling rights to a pride. If the new males took over, they would kill the young of their rivals to bring the females quickly back into heat.

Seconds later, the fight erupted again. The three Killers circled C-Boy and took turns lunging at him from behind, lashing into his haunches, biting at his spine, as he spun and snarled and rolled desperately to escape. Close enough almost to feel the spray of spit, to smell the malice, Jansson gaped

from her car window, taking photos. Dust flew, C-Boy whirled and roared, and the Killers played their advantage, avoiding his jaws, backing off, coming at him again from the rear, sinking their teeth, scoring hurts, until the hide of his hindquarters looked like a perforated old pelt. Jansson thought she was witnessing the terminal event of a lion's life. If the immediate injuries didn't kill him, she reckoned, the later bacterial infections would.

Then it was over, as abruptly as it had begun. Maybe a minute of fighting. They separated. The Killers strolled off and positioned themselves atop a termite mound, with a commanding view of the river, while C-Boy slunk away. He was alive, for the moment, but defeated.

Jansson didn't see him for two months. He might have been dead, she guessed, or at least debilitated. In the meantime the Killers began having their way with the Jua Kali females. The small cubs of C-Boy's or Hildur's paternity disappeared—killed by the conquering males, or maybe abandoned to starvation, or neglected just enough to get eaten by hyenas. The females would go back into estrus now, and the Killers would father new litters. C-Boy was yesterday's favorite, yesterday's stud. The Jua Kalis would forget him. This is the cold arithmetic of lion society.

TIGERS ARE SOLITARY. Cougars are solitary. No leopard wants to associate with a bunch of other leopards. The lion is the only feline that's truly social, living in prides and coalitions, the size and

dynamics of which are determined by an intricate balance of evolutionary costs and benefits.

Why has social behavior, lacking in other cats, become so important in this one? Is it a necessary adaptation for hunting large prey such as wildebeest? Does it facilitate the defense of young cubs? Has it arisen from the imperatives of competing for territory? As details of leonine sociality have emerged, mostly over the past 40 years, many of the key revelations have come from a continuous study of lions within a single ecosystem: the Serengeti.

Serengeti National Park encompasses 5,700 square miles of grassy plains and woodlands near the northern border of Tanzania. The park had its origin as a smaller game reserve under the British colonial government in the 1920s and was established formally in 1951. The greater ecosystem, within which vast herds of wildebeest, zebra, and gazelle migrate seasonally, following the rains to fresh grass, includes several game reserves (designated for hunting) along the park's western edge, other lands under mixed management regimes (including the Ngorongoro Conservation Area) along the east, and a transboundary extension (the Masai Mara National Reserve) in Kenya. In addition to the migratory herds, there are populations of hartebeests, topi, reedbuck, waterbuck, eland, impalas, buffalo, warthogs, and other herbivores living less peripatetic lives. Nowhere else in Africa supports quite such a concentrated abundance of hoofed meat, amid such open landscape, and therefore the Serengeti is a glorious place for lions and an ideal site for lion researchers.

George Schaller arrived in 1966, by invitation of the director of Tanzania National Parks, to study the effects of lion predation on prey populations—and to learn as much as he could, in the process, about the dynamics of the entire ecosystem. Schaller, a legendarily tough and astute field biologist, had earlier done pioneering research on mountain gorillas. If you're making the first detailed study of any species, he told me recently, "you grab what you can." He grabbed a cornucopia of data during three and a quarter years of intensive fieldwork, and his subsequent book,

The Serengeti Lion, became the foundational text.

Other researchers followed. A young Englishman named Brian Bertram succeeded Schaller and stayed four years, long enough to begin teasing out the social factors that affect reproductive success and to explain an important phenomenon: male infanticide. Bertram documented four cases (with many others suspected) in which a new coalition of males killed cubs of a pride it had just taken over. Jeannette Hanby and David Bygott came next and assembled evidence that forming coalitions—especially coalitions of three or more—helps male lions gain and hold control of prides and thereby produce more surviving offspring. Hanby and Bygott studied some of the same prides in the same areas as Bertram and Schaller had.

Then, in 1978, Craig Packer and Anne Pusey took over the study, after having done fieldwork at the Gombe Stream Research Center (also in Tanzania) with Jane Goodall. Pusey stayed with the lion project a dozen years, co-authoring some important papers, and Packer is still on the case, leading the Serengeti Lion Project, of which Ingela Jansson's work is part. He is arguably now the world's leading authority on the behavior and ecology of the African lion. With Packer's 35 years of work added to what Schaller and the others did, the Serengeti Lion Project represents one of the longest continuous field studies of a species. Such continuity is especially valuable, allowing scientists to set events in broad context and distinguish the transitory from the essential. "If you have a long-term data set," Schaller told me, "you find out what actually happens."

One thing that happens is death. Although it's ineluctable for every creature, the particulars of timing and cause add up to patterns that matter.

AFTER HIS HARROWING experience with the Killers, C-Boy surrendered his claim on the

*David Quammen wrote about the lions of India's Gir Forest in his book *Monster of God*. Michael Nichols is the founder of the LOOK3 Festival of the Photograph. This was his first professional collaboration with his wife of 30 years, naturalist Reba Peck.*

TRACKING THE Prides

Location, location, location: High-quality habitat is crucial to a lion pride. Midsize prides generally control the best real estate and do better at holding on to their prime territories. Where rivers join, prey animals such as wildebeests and zebras become concentrated, making it easier for lions to kill them. Prides holding such territories produce more cubs that survive.

WHERE LIONS THRIVE

Prides that control the best territories produce the most cubs.

Reproductive success



High

Low

PRIDE TERRITORIES

Two to six females are optimal for prides on the plains, up to 11 in woodlands.

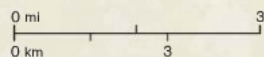
PRIDE NAME

Number of adult females

As of July 2012

LANDSCAPE

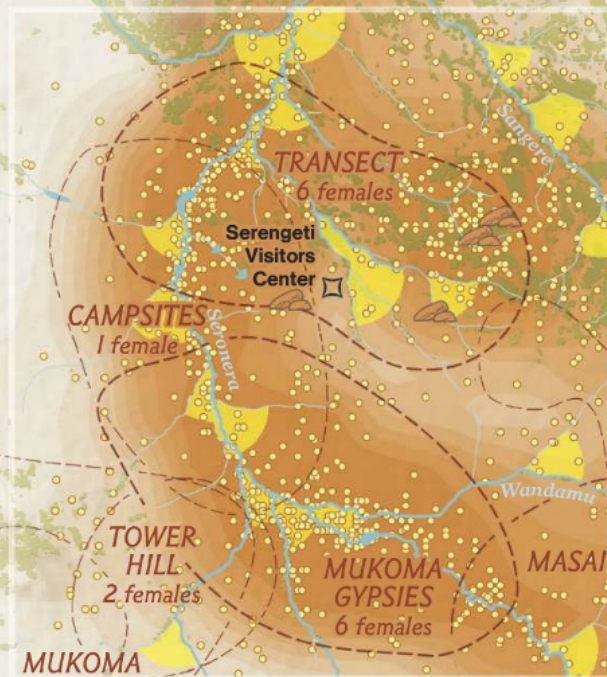
- River confluences trap prey
- Prey carcass (data collected 1966-2005)
- Kopje: a small, rocky hill used as a lookout or to hide cubs
- Plains: grassland or shrubland
- Open woodland



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VIRGINIA W. MASON, NGM STAFF

SOURCES: CRAIG PACKER, ANNA MOSSER, DANIEL ROSENGREN, AND ALI SWANSON, LION RESEARCH CENTER, UNIVERSITY OF MINNESOTA; TANZANIA NATIONAL PARKS; TANZANIA WILDLIFE RESEARCH INSTITUTE; FRANKFURT ZOOLOGICAL SOCIETY



TRANSECT
6 females

Serengeti
Visitors
Center

CAMPSES
1 female

TRANSECT
TRUANT
1 female

TOWER
HILL
2 females

MUKOMA
GYPSIES
6 females

MASAI
KOPJES
5 females

MUKOMA
MISCHIEF
2 females

Masai
Kopjes
5,240 ft
1,597 m

PRIME REAL ESTATE Abundant river confluences mark the best territory (above). When oversize prides split up, some lions migrate and create new prides.

SPURS
3 females

MUKOMA
HILL
2 females

EX-PLAINS
2 females

PLAINS

SERENGETI

Simba West
Kopjes

GIRTASHO
OUTCASTS
9 females

SIMBA
NUMBERS
9 females

SIMBA SITA
4 females







The Killers, a male coalition of four, earned their name with lethal attacks on females. They almost killed their rival C-Boy too. Because good territory is a precious resource, fighting and displacing competitors are part of the natural struggle.

THEY WERE HANDSOME DEVILS, A QUARTET OF EIGHT-YEAR-OLD MALES, RESTING IN A COMPANION-ABLE CLUSTER. THEY LOOKED FORBIDDING AND SMUG.

Jua Kali pride and shifted his attentions east. Hildur, his coalition partner, who'd been so little help in the pinch, went with him. By the time I got a glimpse of C-Boy three years later, he and Hildur had established control over two other prides, Simba East and Vumbi, whose territories lay amid the open plains and kopjes (rocky outcrops) south of the Ngare Nanyuki River. This is not the most hospitable part of the Serengeti for lions and their prey—during the dry season it can be lean and difficult—but it offered C-Boy and Hildur an opportunity to start fresh.

I was traveling through that area with Daniel Rosengren, another adventuresome Swede, who had taken over the lion-monitoring role from Jansson. Way out here, east of the main tourism area and south of the river, the great vistas of grassland rise and fall smoothly, like oceanic swells, punctuated every few miles by a cluster of kopjes. The kopjes, granitic lumps festooned with trees and shrubs, standing above the plains like garnished gumdrops, offer shade and security and lookout points for resting lions. You can drive for days in this corner of the park and not see a tourist vehicle. Along with Michael (Nick) Nichols and his photo team, who were spending months at a field camp up by the riverbed, we had the area to ourselves.

That afternoon the radio signal in Rosengren's headphones led us to Zebra Kopjes, where, amid the cover, we found the collared female of the Vumbis. Beside her was a magnificent male with a thick mane that cascaded off his neck

and shoulders like a velvet cape, shading from umber to black. It was C-Boy.

From just 40 feet away, even through binoculars, I could detect no sign of injuries to his flanks or his rear. The punctures had healed. "On lions," Rosengren told me, "most scars disappear after a while, unless they're around the nose or mouth." C-Boy had made a new life for himself in a new place, with new lionesses, and seemed to be thriving. He and Hildur had fathered

several more litters of cubs. And just the night before—so we heard from Nichols, who had seen it—the Vumbi females brought down an eland, a very large hunk of prey, after which C-Boy had laid his imperious male forepaw on the carcass, claiming first bites. C-Boy had fed on the eland alone, taking choice morsels but not too much, before allowing the lionesses and their cubs to get at it. Hildur had been elsewhere, presumably consorting with another estrous female. So they were living the good life, those two, with all the prerogatives of resident male lions. This was just 12 hours before we saw evidence suggesting that trouble had followed them east.

The trouble was male competition. Early next morning Rosengren drove us north from Nichols's camp to the river, seeking a pride known as Kibumbu, whose small cubs had been fathered by still another coalition. Those males had gone absent in recent months—departed to places unknown, for reasons unknown—and Rosengren wondered who might have supplanted them. That was his assignment, within the broader context of Packer's lion studies: to chronicle the comings and goings, the births and the deaths, the affiliations and retreats that affect pride size and territorial tenure. If the Kibumbus had new daddies, who might they be? Rosengren had a suspicion—and it was confirmed when, amid the high grass of the riverbank, we came upon the Killers.

They were handsome devils, a quartet of eight-year-old males, resting in a companionable cluster. They looked forbidding and smug.

They're probably two sets of brothers, Rosengren told me, born within months of each other in 2004. They had been dubbed "the Killers" back in 2008 by another field assistant, based on his inference that they'd killed three collared females, one by one, rather systematically, in a drainage just west of the Seronera River. Such male-on-female violence wasn't utterly aberrant—it might even be adaptive for males in some cases, opening space for prides that they control by removing competition in the form of neighboring females—but in this case it won the males a malign reputation.

Although Rosengren told me their individual names as recorded on the cards (Malin, Viking, et cetera), his preference was to call them by their numbers: 99, 98, 94, 93. Those numerals did seem somehow more concordant with their air of opaque, stolid menace. Male 99, seen in profile, had the convex nose line of a Roman senator, as well as a darkish mane, though not so dark as C-Boy's. Inspecting him through binoculars, I noticed a couple of small wounds on the left side of 99's face.

Rosengren eased the Land Rover closer, and two of the others, 93 and 94, stirred, turning toward us. In the golden light of sunrise we saw facial injuries on them too: a slice to the nose, a bit of swelling, a gash below the right ear still glistening with pus. Those are fresh, Rosengren said. Something happened last night. And not just a spat over shared food; coalition partners don't do such damage to one another. It must have been a brawl with other lions. That raised two questions. Whom had the Killers fought? And what did the other guy look like this morning?

Then, as the day progressed and we made other rounds, it seemed that C-Boy was missing.

"MOSTLY LIONS DIE because they kill each other," Craig Packer told me, in response to a question about fatalities. "The number one cause of death for lions, in an undisturbed environment, is other lions."

He broke that into categories. At least 25 percent of cub loss is owed to infanticide by

incoming males. Females too, given the chance, will sometimes kill cubs from neighboring prides. They will even kill another adult female, he said, if she unwisely wanders into their ambit. Resources are limited, prides are territorial, and "it's a tough 'hood out there."

Males operate just as jealously. "Male coalitions are gangs, and if they find a strange male that's hitting on their ladies, they'll kill him." And males will kill adult females if it suits their purposes, as the Killers had shown. You see a lot of bite wounds on lions, reflecting the competitive struggle for food, territory, reproductive success, sheer survival. With luck, the wounds heal. Less luck, and the loser is killed in a fierce leonine battle, or he limps away, losing blood, maybe crippled, maybe destined to die slowly of infection or starvation. "So the lion is the number one enemy of lions," Packer said. "It's why, ultimately, lions live in groups." Holding territory is crucial, and the best territorial locations—places he calls hot spots, such as stream confluences, where prey tend to become concentrated—serve as incentive for social cooperation. "The only way you can monopolize one of those very valuable and very scarce hot spots," he says, thinking like a lion, is as "a gang of like-sexed companions who work as a unit."

That theme has emerged strongly from Packer's research, done with various collaborators and students over the decades. It's not just the need for joint effort in making and defending kills, he has found, that drives lionesses to live in prides. It's also the need to protect offspring and retain those premium territories. His data show that, although pride size varies widely, from just one adult female to as many as 18, prides in the middle range succeed best at protecting their cubs and maintaining their territorial tenure. Prides that are too small tend to lose cubs. Periods of estrus for the adult females often are synchronized—especially if an episode of male infanticide has killed off all their young and reset their clocks—so that cubs of different mothers are born at about the same time. This allows the formation of crèches, lion nursing groups in which females suckle and

protect not just their own cubs but others too. Such cooperative mothering, efficient in itself, is further encouraged by the fact that the females of a pride are related—as mothers and daughters and sisters and aunts, sharing a genetic interest in one another’s reproductive success. But prides that are too large do poorly also, because of excessive within-pride competition. A pride of two to six adult females seems to be optimal on the plains.

Male coalition size is governed by similar logic. Coalitions are formed, typically, among young males who have outgrown the natal pride and gone off together to cope with adulthood. One pair of brothers may team with another pair, their half-siblings or cousins, or even with unrelated individuals that turn up, solitary, nomadic, and needing partnership. Put too many such males together as a roving posse, each hungry for food and for chances to mate, and you have craziness. But a lone male, or a coalition that’s too small—just a pair, say—will suffer disadvantages also.

That was C-Boy’s dilemma. With no partner other than Hildur, a handsome enough male who showed great eagerness to mate but little to fight, C-Boy confronted the Killers, in their aggressive ascendancy, virtually alone. Not even his resplendent black mane could neutralize three-against-one odds. Maybe by now he was already dead. If so, Rosengren and I realized, those minor battle injuries on the faces of the Killers might be the last evidence of C-Boy that anyone would ever see.

THAT NIGHT THE KILLERS made another move into new territory. They had rested all day by the riverbank, letting the sun cook their faces and dry their sores. About two hours after sunset, they started roaring. Their joined voices broadcast a message of some sort—maybe, Here we come!—into the distance. Then they set out, all four together, on what looked like a purposeful march. Rosengren and I got the word by walkie-talkie from Nichols, who had been keeping vigil. We jumped into Rosengren’s Land Rover and headed out through the blackness, beginning





A female wrangles her infant cubs. During the first few weeks, when they're too young for the competitive jumble among older cubs in the pride and so vulnerable to predators, she keeps them hidden away in a den. But these will soon join the group.

THE ROAR OF LIONS AT CLOSE RANGE IS AN IMPOSING SOUND: HIGH IN DECIBELS BUT THROATY AND ROUGH, AS IF SCRAPED UP FROM A BIN OF PRIMORDIAL POWER AND THREAT.

what I recall as the Night of the Long Follow.

Converging with Nichols's vehicle, we climbed in and stayed with the lions—five of us now, Nichols's wife, Reba Peck, at the wheel, easing along, headlights dimmed. There was no moon. Nichols had night vision goggles and an infrared camera. His assistant and videographer, Nathan Williamson, sat ready to capture sound or deploy the infrared floods. We were a journalistic gunship, bristling with armaments, rolling slowly along behind the lions. They showed no concern whatsoever about our presence. They had other things in mind.

We followed them up an old buffalo track, then through a tight grove of fever trees, Peck coaxing the car patiently around aardvark holes, over crunching thorn branches, across a sumpy stream bottom. Please don't get stuck, we all thought. With four Killers nearby, nobody wanted to climb out and push. We didn't get stuck. The lions walked in single file, steady, unhurried, neither waiting for us nor trying to lose us. We kept them in view with the low headlights and, where those didn't reach, a monocular thermal scope. Through the scope, as I sat atop the Rover's jouncing roof, I saw four lion bodies glowing like candles in a cave.

Suddenly another large figure swung up alongside us, its eyes shining orange when I swept it with my headlamp. It was a lioness, making herself known to the Killers. Rosengren couldn't recognize her, in this fleeting glimpse, but presumably she was in heat. So she was taking a

sex-mad risk, probably larger than she could guess, given the record of these particular males. When they noticed her, and wheeled toward her, she ran off coyly, pursued by all four, and for a moment we thought we had lost them. But only one male stayed on her tail; we wouldn't see him again all night. The other three reassembled themselves, after this flirty distraction, and continued their march.

They crossed a dirt two-track (the main east-west "road," which we used coming and going to camp) and angled south, now brazenly entering the territory of the Vumbi pride and its resident defenders, C-Boy and Hildur. They paused here and there to scent mark, rubbing their foreheads against bushes, scratching and spraying the ground. This wasn't a sneak attack; they were advertising themselves, making a statement. Too bad, Rosengren noted, that we don't have some sort of fancy scope to illuminate those smells.

By now they had turned and were headed toward Nichols's camp, so Williamson radioed ahead and warned the kitchen crew to stay in their tents. But the three lions didn't care about our little canvas compound, with its odors of popcorn and chicken and coffee, any more than they cared about us; about a quarter mile short, they bedded down to rest. During this hiatus, just before midnight, Nichols and his team went back to camp. Rosengren and I, having retrieved the other vehicle, stayed with the Killers. He took the first sleeping shift, snoring gently in the back of the Land Rover, while I sat up, keeping watch. Half an hour later the lions stood and began moving again; I woke Rosengren, and we followed.

And that's how it went—a stretch of walking, a stretch of sleeping, Rosengren and I trading duties—for the rest of the night. Occasionally, during a stop, they let their voices rise in another chorus of roars. The roar of three lions heard at close range, let me tell you, is an imposing sound: high in decibels but throaty and rough,

as though scraped up from a deep iron bin of primordial power and confidence and threat. No one answered these calls. In the wee hours the trio met a lone Thomson's gazelle; that poor gazelle must have been terrified, but as the lions made a perfunctory try, it bounded safely away. One tommy, divided three ways, was scarcely worth the trouble. As dawn came, they were back on the road after their big loop through Vumbi territory, strolling casually west toward a familiar kopje where they would find shade for the day. It was Saturday morning. Rosengren and I left them there.

The wounds on their faces, and the absence of C-Boy, were still unexplained. Lion politics along the Ngare Nanyuki River seemed to be in flux.

LATE SATURDAY AFTERNOON, we found the Vumbi pride at Zebra Kopjes, a couple of miles south of where the Killers had made that intrusive circuit. Maybe the pride had been driven down there by the minatory roaring, or maybe they had just wandered. We counted three females, resting contentedly amid the shaded lobes of granite, and all eight cubs. Another female, we knew, was off on a mating foray with lover boy Hildur. No sign of C-Boy. His absence seemed slightly ominous.

Sunday afternoon, back to Zebra Kopjes. Hildur and his female had rejoined the group, but not C-Boy. Let's try Gol Kopjes, Rosengren suggested. With luck we'll see the Simba East pride, and he might be with them. Yes, I said; that's my priority, I want to find him, dead or alive. So we drove southwest, rising and descending gently across the swales of grassland, while Rosengren listened in his headphones for the bleeps of Simba East. At a small kopje near the main Gols we located them: three females and three large cubs, lounging amid the radiant rocks. But again, no sign of C-Boy.

Rosengren, at this point, admitted to some worry. His job was not to root for favorites, of course, but to monitor events, including the natural phenomena of lion-on-lion violence and pride takeover; but he had his sympathies. It's beginning to seem, he said sadly, that

C-Boy must have fallen victim to the Killers.

With a lavender Serengeti sunset painting the horizon behind us, we drove back to Zebra Kopjes. Nichols and Peck were still there, with the Vumbis, who had hunkered together in the grass and begun roaring—one voice, then another, then three together, rumbling out across the plains beneath a now darkening sky and a small waxing crescent of moon. Lion roars can carry a range of meanings, and this chorus bore a mysterious, lonely tone. When they fell silent, we listened with them. No response.

Nichols and Peck departed for camp. Rosengren circled our vehicle into a spot just beside the reclining Vumbis. He wanted me to experience the fearsome thrill of taking lion roars point-blank in the face. This time Hildur joined in, his deep male basso rasping and thundering, almost shaking the car. Once they finished, we again listened intently. And again nothing. Now I was ready to leave. For journalistic purposes, I was prepared to list C-Boy as "missing, suspected dead."

Wait, Rosengren said. There was a scuffle in the darkness around us. Give me your headlamp, he said. Swinging the beam from left to right, across Hildur and the others, Rosengren brought it to rest on a new figure, a large one, with a very dark mane: C-Boy. He was back. He had come running to the sound of their roars.

His face was smooth. His flanks and buttocks were intact. Whomever the Killers had mugged two nights ago, it wasn't him. He settled comfortably beside the collared female. Soon he'd be mating again. He was an eight-year-old lion, healthy and formidable, commanding respect within a pride.

It was all very temporary. C-Boy's life might stretch forward a few years, beyond this moment, into infirmity, injury, mayhem, displacement, starvation, and death. The Serengeti offers no mercy to the elderly, the unlucky, or the impaired. He wouldn't always be happy. But he looked happy now. □

See more lions in The Secret Life of Predators, airing in September on the National Geographic Channel.

Older cubs like these Vumbi youngsters are raised together as a crèche, or nursery group. Pride females, united in the cause of rearing a generation, nurse and groom their own and others' offspring.







The Vumbi females—their pride name is Swahili for “dust”—kill a warthog they’ve dragged from its burrow. Such small meals help bridge the lean, hungry, dry season, when cubs may otherwise starve.







Dry season is hard on everyone. Vumbi females, stressed and fiercely protective of their young, get cross with C-Boy, though he's one of the resident fathers.





*A male often asserts his prerogatives.
C-Boy feasts on a zebra while the Vumbi
females and cubs wait nearby, warned off
by his low growls. Their turn will come.*



Hildur, C-Boy's partner, frequently makes a long run to visit the Simba East pride. A coalition that controls two prides must maintain vigilance over both.



Yusufu Shabani Difika lost his arms in a lion attack in Tanzania's Selous Game Reserve. Poor villagers farm marginal land along reserve edges, where bushpigs raid crops and lions may attack people. Here his uncle bathes Difika, a father of two.





When people
and lions collide,
both suffer.

LIVING WITH Lions



In South Africa thousands of lions are captive bred on ranches, then released for hunting within confined areas. Many people, including hunters, question whether the ranches satisfy the ethic of fair chase.





Hunters of captive lions are more certain of success than hunters of more widely ranging wild lions. This lioness was killed by bow hunter Steve Sibrel (at left) on a ranch in North-West Province, South Africa.





Legally hunted lions in South Africa yield skeletons that are exported for traditional medicines, mostly to Asia. With tigers reduced to a few thousand in the wild, lion bones are gaining popularity.

Lions are complicated creatures, magnificent at a distance yet fearsomely inconvenient to the rural peoples whose fate is to live among them. They are lords of the wild savanna but inimical to pastoralism and incompatible with farming. So it's no wonder their fortunes have trended downward for as long as human civilization has been trending up. There's evidence across at least three conti-

nents of the lions' glory days and their decline. Chauvet Cave, in southern France, filled with vivid Paleolithic paintings of wildlife, shows us that lions inhabited Europe along with humans 30 millennia ago; the Book of Daniel suggests that lions lurked at the outskirts of Babylon in the sixth century B.C.; and there are reports of lions surviving in Syria, Turkey, Iraq, and Iran until well into the 19th or 20th centuries. Africa alone, during this long ebb, remained the reliable heartland.

But that has changed too. New surveys and



By David Quammen
Photographs by Brent Stirton

upon humans, ritual killing of lions (notably within the Maasai tradition), and unsustainable trophy hunting for lions, chiefly by affluent Americans.

The new assessments, compiled by scientists from Panthera (an international felid conservation group), Duke University, the National Geographic Society's Big Cats Initiative, and elsewhere, indicate that African lions now live in nearly 70 distinct areas (map, pages 70-71), the largest and most secure of which can be considered strongholds. But the smallest contain only tiny populations, isolated, genetically limited, and lacking viability for the long term. In other words, the African lion inhabits an archipelago of insular refuges, and more than a few of those marooned populations may soon go extinct.

WHAT CAN BE DONE to stanch the losses and reverse the trend? Some experts say we should focus efforts on the strongholds, such as the Serengeti ecosystem (spanning Tanzania to Kenya), the Selous ecosystem (southeastern Tanzania), the Ruaha-Rungwa (western Tanzania), the Okavango-Hwange (Botswana into Zimbabwe), and the Greater Limpopo (at the shared corners of Mozambique, Zimbabwe, and South Africa, including Kruger National Park). Those five ecosystems alone account for roughly half of Africa's lions, and each contains a genetically viable population. Craig Packer has offered a drastic suggestion for further protecting some strongholds: Fence them, or at least some of their margins. Investing conservation dollars in chain-link and posts, combined with adequate levels of patrolling and repair, he argues, is the best way to limit illegal entry into protected areas by herders, their livestock, and poachers, as well as reckless exit from those areas by lions.

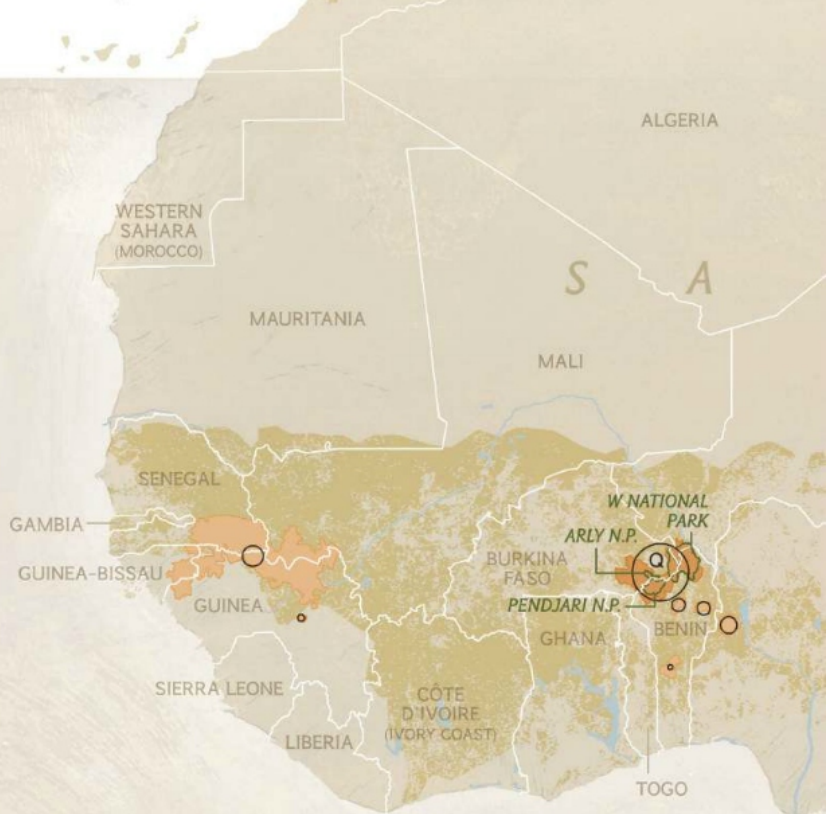
Other experts strongly disagree. In fact, this fencing idea goes against three decades of

estimates suggest that the lion has disappeared from about 80 percent of its African range. No one knows how many lions survive today in Africa—as many as 35,000?—because wild lions are difficult to count. Experts agree, though, that just within recent decades the overall total has declined significantly. The causes are multiple—including habitat loss and fragmentation, poaching of lion prey for bush meat, poachers' snares that catch lions instead, displacement of lion prey by livestock, disease, spearing or poisoning of lions in retaliation for livestock losses and attacks

Contributing writer David Quammen received the 2012 Stephen Jay Gould Prize from the Society for the Study of Evolution. Documentary photographer Brent Stirton's October 2012 elephant-ivory story won the POY Environmental Vision Award.

THE STATE OF Lions

Africa's lions—formerly widespread across the continent, although their numbers in earlier eras are unknowable—have declined severely in both distribution and abundance. Lions live in 67 distinct areas—only 10 of them large and secure enough to be called strongholds. Most areas face an uncertain future, with unstable political situations, no protected status, or too few lions. The map shows a mosaic of opportunities, fading hopes, and lion habitat emptied of lions—all surrounded by people and their impact on the landscape. Lion conservationists differ as to how best to proceed.

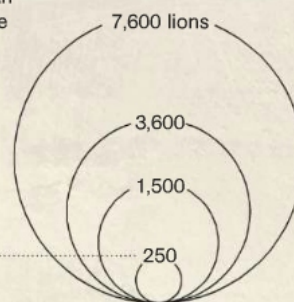


SUITABLE SAVANNA

Lions could thrive in these areas, but human pressures compromise them and their prey.

LIONS AT RISK

Fragmented populations that fall below 250 face a high probability of extinction.



HISTORIC LION RANGE (1750)

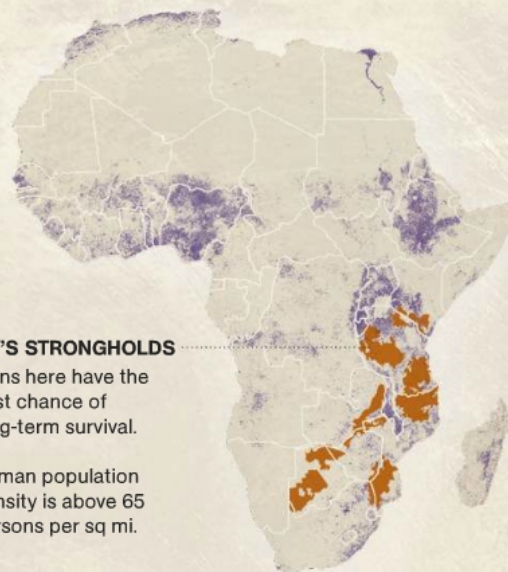
Lions have vanished from more than 80 percent of their historic range.

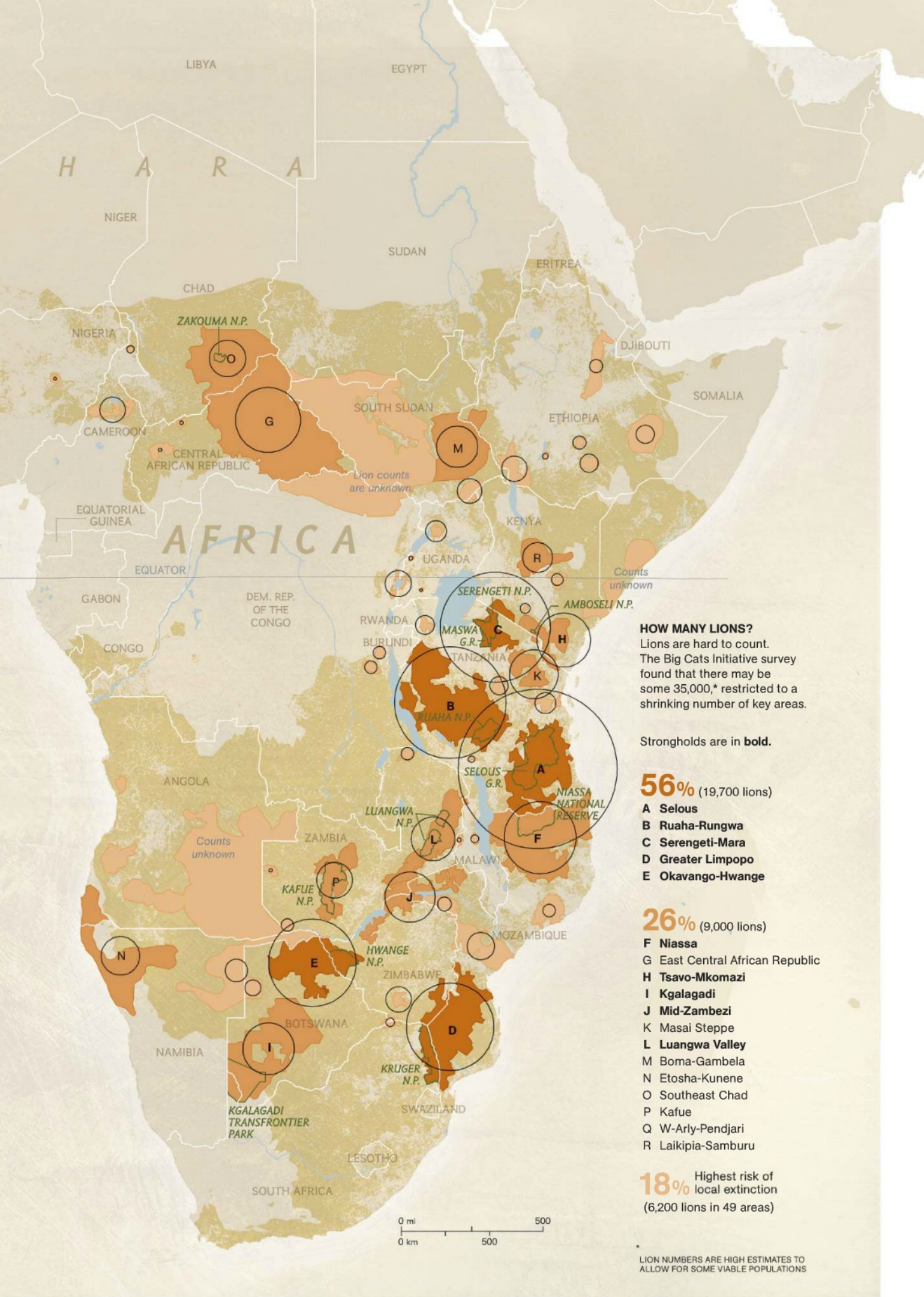


TODAY'S STRONGHOLDS

Lions here have the best chance of long-term survival.

Human population density is above 65 persons per sq mi.





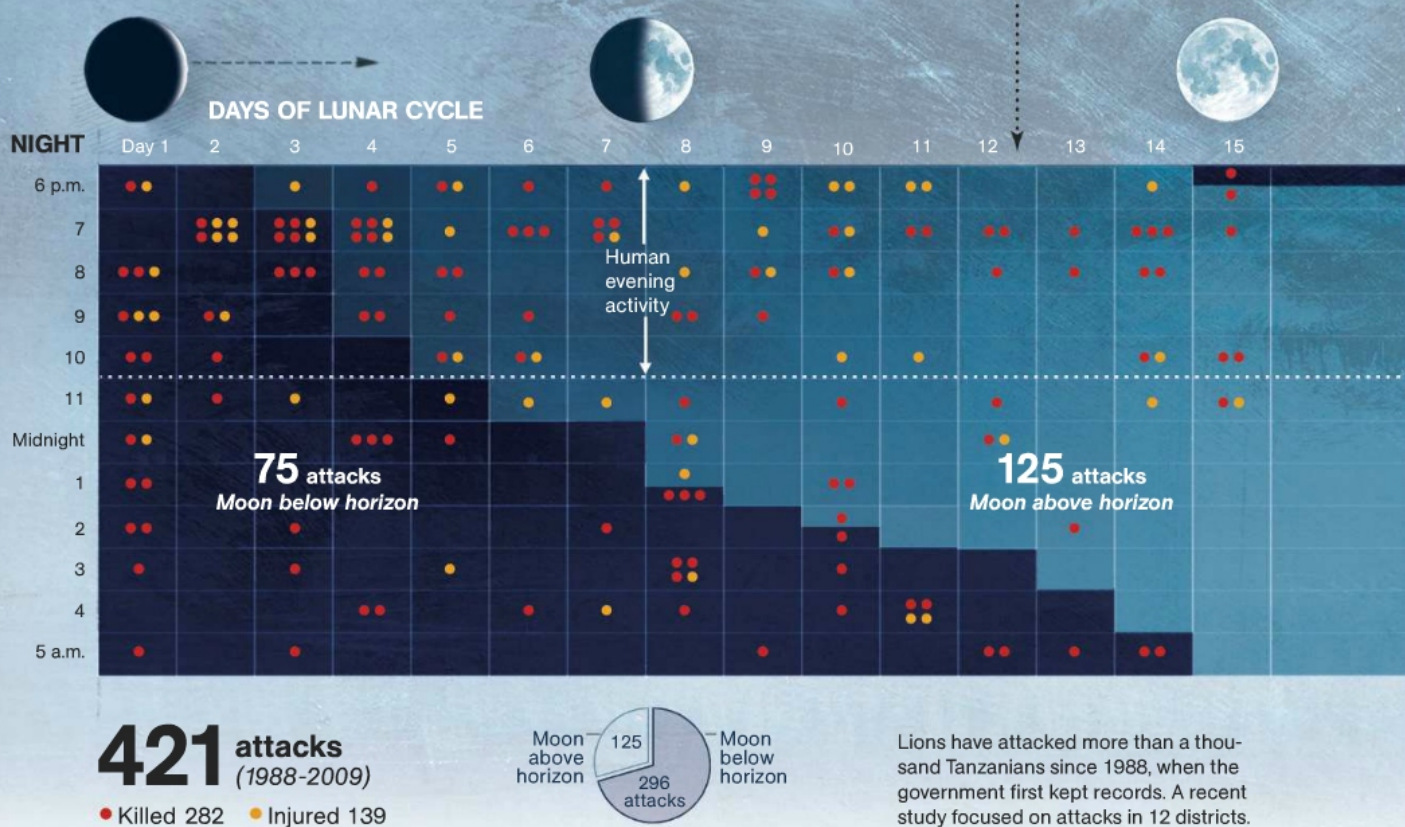
WHEN HUMANS ARE Hunted

For rural Tanzanians the threat of lion attack rises and falls with the phases of the moon (below), the nocturnal predators favoring the darkest nights. But whether the night is dark or bright, villagers living without electricity or plumbing have to walk to the outhouse or to get water and firewood. People have even been attacked inside their homes.

FEWER ATTACKS
Moon above horizon



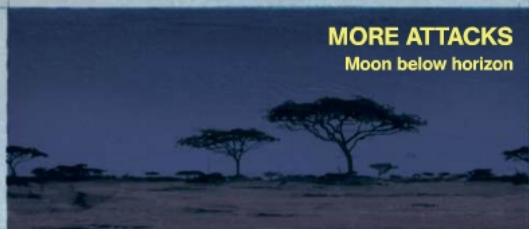
Attacks when the moon is above the horizon are usually on cloudy nights in the rainy season—just before harvesttime, when people sleep in the fields to guard crops against bushpigs.



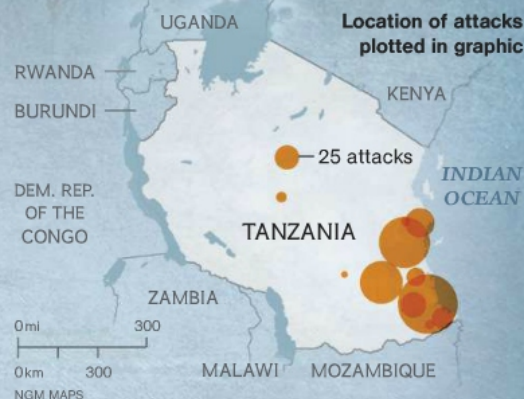
conservation theory, which stresses the importance of connectedness among habitat patches. Packer knows that, and even he wouldn't put a fence across any valuable route of wildlife dispersal or migration. But consider, for instance, the western boundary of the Serengeti ecosystem, where the Maswa Game Reserve meets the Sukuma agricultural lands beyond. If you fly over that area at low elevation, you'll see the boundary as a stark edge, delineated by the slash of a red clay road. East of it lies the rolling green terrain of Maswa, covered with acacia woodlands and

lush savanna, a virtual extension of Serengeti National Park. West of the road, in the Sukuma zone, you'll look down on mile after mile of cotton fields, cornfields, teams of oxen plowing bare dirt, paddies, and brown-and-white cows standing in pens. A fence along that boundary, as Packer asserts, could do no harm and possibly some good. It may be a special case, but it's enough to open a heated discussion.

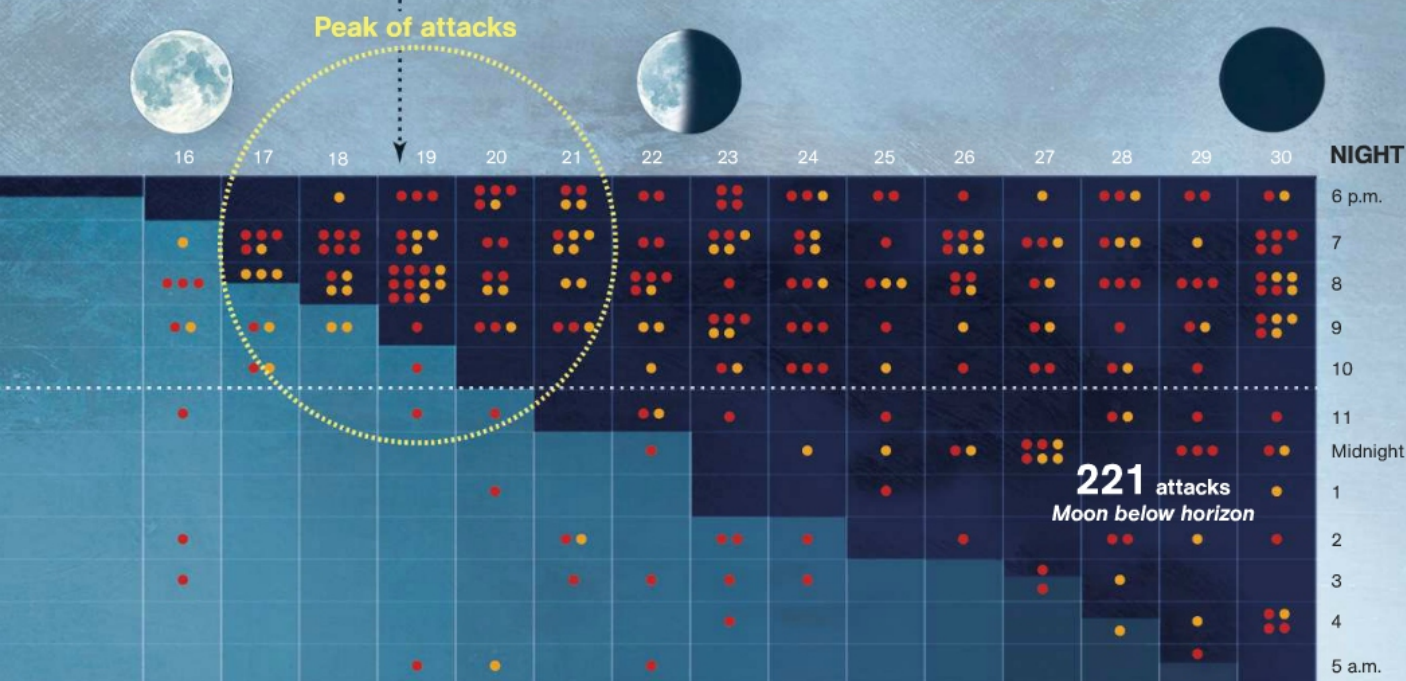
Trophy hunting is also controversial. Does it contribute to population declines because of irresponsible overharvesting? Or does it



Attacks peak on nights after a full moon when the moon doesn't rise until an hour or more after sunset. There are fewer attacks just before a full moon when the moon is already up before sunset.



Lion attacks are most numerous in areas where farming attracts bushpigs but other lion prey is scarce. In southern Tanzania religious strictures keep the largely Muslim population from eating or even killing the wild pigs.



FERNANDO G. BAPTISTA AND DANIELA SANTAMARINA, NGM STAFF; FANNA GEBREYESUS
SOURCES: CRAIG PACKER, ALEXANDRA SWANSON, AND HADAS KUSHNIR, UNIVERSITY OF MINNESOTA; DENNIS IKANDA, TANZANIA WILDLIFE RESEARCH INSTITUTE

Near the Equator, Tanzania has close to 12 hours of day and 12 of night year-round.

effectively monetize the lion, bringing cash into local and national economies and providing an incentive for habitat protection and sustainable long-term management? The answer depends—on particulars of place, on which lions are targeted (old males or young ones), and on the integrity of management, both by the hunting operator and by the national wildlife agency. Certainly there are abuses—countries in which hunting concessions are granted corruptly, situations in which little or no hunting income reaches the local people who pay the

real costs of living amid lions, concessions on which too many lions are killed. But in places such as Maswa Game Reserve—where hunts are scrupulously managed in cooperation with the Friedkin Conservation Fund, an organization that cares more about habitat protection than about revenue—the effect of a ban on hunting would be perverse.

Hunting of captive-bred lions released into fenced areas on private ranches, as now widely practiced in South Africa, raises a whole different set of questions. In a recent year 174 such



Sukuma in western Tanzania traditionally killed lions in defense of their cattle or village, dancing to claim tributes as thanks. Some Sukuma now kill innocent lions to claim the rewards.

lion-breeding ranches operated in the country, with a combined stock of more than 3,500 lions. Proponents argue that this industry may contribute to lion conservation by diverting trophy-hunt pressure from wild populations and by maintaining genetic diversity that could be needed later. Others fear it may undercut the economics of lion management in, say, Tanzania, by offering cheaper and easier ways to put a lion head on your rec-room wall.

And then there's the matter of what happens to the rest of the lion. The export of lion bones

from South Africa to Asia, where they are sold as an alternative to tiger bones, constitutes a dangerous trend that surely increases demand.

Bottom line: Lion conservation is an intricate enterprise that must now reach across borders, across oceans, and across disciplines to confront a global market in dreams of the wild.

BUT CONSERVATION BEGINS at home, among people for whom the sublime and terrifying wildness of a lion is no dream. One set of such people are the Maasai who inhabit group



ranches bordering Amboseli National Park, on the thornbush plains of southern Kenya. Since 2007 a program there called Lion Guardians has recruited Maasai warriors— young men for whom lion killing has traditionally been part of a rite of passage known as *olamayio*—to serve instead as lion protectors. These men, paid salaries, trained in radiotelemetry and GPS use, track lions on a daily basis and prevent lion attacks on livestock. The program, small but astute, seems to be succeeding: Lion killings have decreased, and

the role of Lion Guardian is now prestigious within those communities.

I spent a day recently with a Lion Guardian named Kamunu, roughly 30 years old, serious and steady, whose dark face tapered to a narrow chin and whose eyes seemed permanently squinted against sentiment and delusion. He wore a beaded necklace, beaded earrings, and a red *shuka* wrapped around him; a Maasai dagger was sheathed on his belt at one side, a cell phone at the other. Kamunu had personally killed five lions, he told me, all for *olamayio*, but he didn't intend to kill any more. He had learned that lions could be more valuable alive—in money from tourism, wages from Lion Guardians, and the food and education such cash could buy for a man's family.

We walked a long circuit that very hot day, winding through acacia bush, crossing a dry riverbed, Kamunu following lion spoor in the dust and me following him. Probably we traipsed about 16 miles. In the morning we tracked a lone adult, recognizable to Kamunu from its big pug as a certain problematic male. When we met a long line of cows headed for water, their bells clanking, attended by several Maasai boys, Kamunu warned the boys to stay clear of that lion.

Around midday he picked up a different trail, very fresh, left by a female with two cubs. We saw her flattened day bed in the herbage beneath a bush. We traced her sinuous route into a grove of scrubby myrrh trees that grew thicker as we went. Kamunu moved quietly. Finally we stopped. I saw nothing but vegetation and dirt.

They're very close, he explained. This is a good spot. No livestock nearby. We don't want to push any closer. We don't want to disturb them. No, we don't, I agreed.

"We think they are safe here," he told me. It's more than can be said for many African lions, but at that moment, in that place, it was enough. □

■ National Geographic's Big Cats Initiative is dedicated to halting the decline of lions and other big cats around the world. To learn more about the projects we support, visit causeanuproar.org.



An innovative program in southern Kenya recruits Lion Guardians among the Maasai, some former lion killers, to monitor lion movements and prevent conflicts with herders and cattle. It's working.



Sugar



THE OLYKOEK, A DUTCH FRIED BALL OF DOUGH, WAS THE DOUGHNUT'S 16TH-CENTURY PREDECESSOR. THE HOLE CAME LATER.

Love

(A not so sweet story)





A collection of petri dishes containing various colored liquids. The dishes are arranged in a circular pattern. The colors of the liquids are white, orange, pink, green, and brown. The orange liquid has many small bubbles on its surface. The pink liquid is a solid, vibrant color. The green liquid is a solid, vibrant color. The brown liquid is a solid, vibrant color. The white liquid is a solid, vibrant color.

soda

Things go better with bubbles—or so it was thought by spa-goers, who often drank sparkling mineral water as part of the cure for what ailed them. The 18th-century discovery that carbon dioxide put the fizz in fizzy water led to systems for producing soda water, then to sweet drinks like root beer, ginger ale, and cola. Today's 12-ounce soda typically contains around ten teaspoons of sugar.

BOTTOM OF THE DRINK

They had to go. The Coke machine, the snack machine, the deep fryer. Hoisted and dragged through the halls and out to the curb, they sat with other trash beneath gray, forlorn skies behind Kirkpatrick Elementary, one of a handful of primary schools in Clarksdale, Mississippi. That was seven years ago, when administrators first recognized the magnitude of the problem. Clarksdale, a storied delta town that gave us the golden age of the Delta blues, its cotton fields and flatlands rolling to the river, its Victorian mansions still beautiful, is at the center of a colossal American health crisis. High rates of obesity, diabetes, high blood pressure, heart disease: the legacy, some experts say, of sugar, a crop that brought the ancestors of most Clarksdale residents to this hemisphere in chains. “We knew we had to do something,” Kirkpatrick principal SuzAnne Walton told me.

Walton, Clarksdale born and bred, was leading me through the school, discussing ways the faculty is trying to help students—baked instead of fried, fruit instead of candy—most of whom have two meals a day in the lunchroom. She was wearing scrubs—standard Monday dress for teachers, to reinforce the school’s commitment to health and wellness. The student body is 91 percent African American, 7 percent white, “and three Latinos”—the remaining 2 percent. “These kids eat what they’re given, and too often it’s the sweetest, cheapest foods: cakes, creams, candy. It had to change. It was about the students,” she explained.

Take, for example, Nicholas Scurlock, who had recently begun his first year at Oakhurst Middle School. Nick, just tall enough to ride the coaster at the bigger amusement parks, had been 135

pounds going into fifth grade. “He was terrified of gym,” Principal Walton told me. “There was trouble running, trouble breathing—the kid had it all.”

“Of course, I’m not one to judge,” Walton added, laughing, slapping her thighs. “I’m a big woman myself.”

I met Nick in the lunchroom, where he sat beside his mother, Warkeyie Jones, a striking 38-year-old. Jones told me she had changed her own eating habits to help herself and to serve as an example for Nick. “I used to snack on sweets all day, ‘cause I sit at a desk, and what else are you going to do? But I’ve switched to celery,” she told me. “People say, ‘You’re doing it ‘cause you’ve got a boyfriend.’ And I say, ‘No, I’m doing it ‘cause I want to live and be healthy.’”

Take a cup of water, add sugar to the brim, let it sit for five hours. When you return, you’ll see that the crystals have settled on the bottom of the glass. Clarksdale, a big town in one of the fattest counties, in the fattest state, in the fattest industrialized nation in the world, is the bottom of the American drink, where the sugar settles in the bodies of kids like Nick Scurlock—the legacy of sweets in the shape of a boy.

MOSQUES OF MARZIPAN

In the beginning, on the island of New Guinea, where sugarcane was domesticated some 10,000 years ago, people picked cane and ate it raw, chewing a stem until the taste hit their tongue like a starburst. A kind of elixir, a cure for every ailment, an answer for every mood, sugar featured prominently in ancient New Guinean myths. In one the first man makes love

cotton candy

As an example of just desserts, one might point out that a dentist was co-inventor of the cotton candy machine. The fairground staple, then known as fairy floss, is nothing more than colored sugar. Its precursor—spun sugar—was practically an art form in 15th-century Venice, whose confectioners shaped it into animals, birds, and buildings for the amusement of guests.





22.7

teaspoons a day

This is how much sugar the average American eats each day. Even without dipping into a sugar bowl, it's not hard to hit that total because of the sugars in processed foods (examples below). Though sugar consumption has dropped since 1999, we're still wildly exceeding the recommended limit (right).

LIFE-SIZE ILLUSTRATION

Sugars added to processed foods enhance flavor and texture. They also act as a preservative to extend shelf life.

1 tsp = 4.2 g



Beef and pork bologna,
4 slices, 1.18 tsp sugar



Wheat bread,
2 slices, 0.66 tsp



Lucky Charms, 1 cup, 2.55 tsp



Ketchup, 3 tbsp, 1.77 tsp



Oreo cookies, 3 cookies, 2.49 tsp



Lowfat fruit yogurt, 8 oz, 6.16 tsp

TYPES OF ADDED SUGAR CONSUMED, U.S. daily average



SUCROSE (11.6 tsp, 51%)

Granulated cane or beet sugar is stirred into coffee and tea and used in baking.

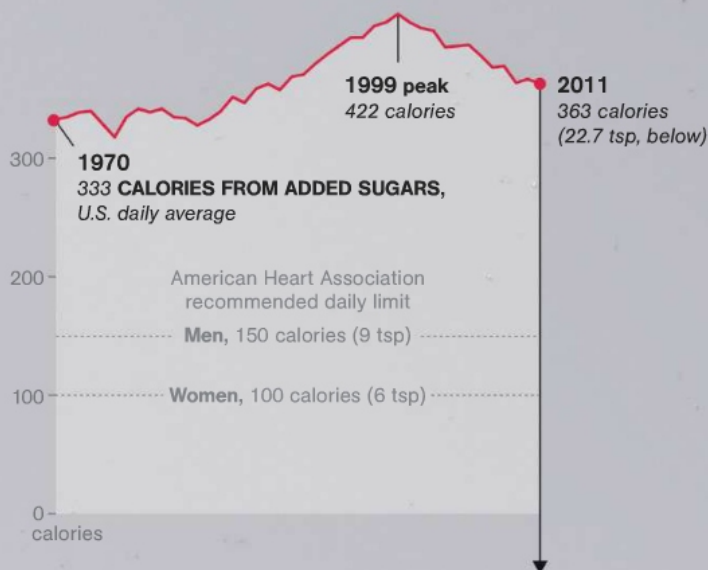
Consists of:



Fructose

Glucose

The problem with fructose Found in small amounts in fruits and vegetables—and in each type of sugar shown here—fructose in excess is a health hazard. The glucose in sugar is metabolized throughout the body. But fructose is processed mainly in the liver into fats, which can build up there and also enter the blood. The resulting risks: obesity, hypertension, insulin resistance, and type 2 diabetes.



DIAGNOSED DIABETES

Almost all the cases in this epidemic spike are type 2 diabetes, once called adult-onset diabetes.

1973

2% of the population, 4.2 million Americans

2010

7%,
21.1 million Americans

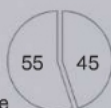
Can of cola, 12 oz, 7.93 tsp

22.7 tsp equal the natural sugar contained in each of the following:
7 red apples 454 eggs 1,135 cups of rice 27 ears of corn

HIGH-FRUCTOSE CORN SYRUP (8.2 tsp, 36%)

Made cheap by government corn subsidies, it was first added to processed food in the 1970s.

Fructose



Glucose

OTHER SWEETENERS (3 tsp,* 13%)

Honey, maple syrup, and molasses have slight traces of vitamins and minerals.

*Numbers do not equal 22.7 tsp due to rounding.

PHOTO ILLUSTRATION:
ROBERT CLARK; LAWSON
PARKER, NGM STAFF;
AMANDA HOBBS;
ALEJANDRO TUMAS
SOURCES: USDA;
CDC (DIABETES)

IT WAS LIKE THROWING PAINT AT A FAN: first here, then

to a stalk of cane, yielding the human race. At religious ceremonies priests sipped sugar water from coconut shells, a beverage since replaced in sacred ceremonies with cans of Coke.

Sugar spread slowly from island to island, finally reaching the Asian mainland around 1000 B.C. By A.D. 500 it was being processed into a powder in India and used as a medicine for headaches, stomach flutters, impotence. For years sugar refinement remained a secret science, passed master to apprentice. By 600 the art had spread to Persia, where rulers entertained guests with a plethora of sweets. When Arab armies conquered the region, they carried away the knowledge and love of sugar. It was like throwing paint at a fan: first here, then there, sugar turning up wherever Allah was worshipped. “Wherever they went, the Arabs brought with them sugar, the product and the technology of its production,” writes Sidney Mintz in *Sweetness and Power*. “Sugar, we are told, followed the Koran.”

Muslim caliphs made a great show of sugar. Marzipan was the rage, ground almonds and sugar sculpted into outlandish concoctions that demonstrated the wealth of the state. A 15th-century writer described an entire marzipan mosque commissioned by a caliph. Marveled at, prayed in, devoured by the poor. The Arabs perfected sugar refinement and turned it into an industry. The work was brutally difficult. The heat of the fields, the flash of the scythes, the smoke of the boiling rooms, the crush of the mills. By 1500, with the demand for sugar surging, the work was considered suitable only for the lowest of laborers. Many of the field hands were prisoners of war, eastern Europeans captured when Muslim and Christian armies clashed.

Perhaps the first Europeans to fall in love with sugar were British and French crusaders who went east to wrest the Holy Land from the infidel. They came home full of visions and stories and memories of sugar. As cane is not at its most productive in temperate climes—it needs tropical, rain-drenched fields to flourish—the first European market was built on a trickle of Muslim trade, and the sugar that reached the West was consumed only by the nobility, so rare

it was classified as a spice. But with the spread of the Ottoman Empire in the 1400s, trade with the East became more difficult. To the Western elite who had fallen under sugar’s spell there were few options: deal with the small southern European sugar manufacturers, defeat the Turk, or develop new sources of sugar.

In school they call it the age of exploration, the search for territories and islands that would send Europeans all around the world. In reality it was, to no small degree, a hunt for fields where sugarcane would prosper. In 1425 the Portuguese prince known as Henry the Navigator sent sugarcane to Madeira with an early group of colonists. The crop soon made its way to other newly discovered Atlantic islands—the Cape Verde Islands, the Canaries. In 1493, when Columbus set off on his second voyage to the New World, he too carried cane. Thus dawned the age of big sugar, of Caribbean islands and slave plantations, leading, in time, to great smoky refineries on the outskirts of glass cities, to mass consumption, fat kids, obese parents, and men in XXL tracksuits trundling along in electric carts.

SLAVES TO SUGAR

Columbus planted the New World’s first sugarcane in Hispaniola, the site, not coincidentally, of the great slave revolt a few hundred years later. Within decades mills marked the heights in Jamaica and Cuba, where rain forest had been cleared and the native population eliminated by disease or war, or enslaved. The Portuguese created the most effective model, making Brazil into an early boom colony, with more than 100,000 slaves churning out tons of sugar.

As more cane was planted, the price of the product fell. As the price fell, demand increased. Economists call it a virtuous cycle—not a phrase you would use if you happened to be on the wrong side of the equation. In the mid-17th century sugar began to change from a luxury spice, classed with nutmeg and cardamom, to a staple, first for the middle class, then for the poor.

By the 18th century the marriage of sugar

there, sugar turning up wherever Allah was worshipped.

and slavery was complete. Every few years a new island—Puerto Rico, Trinidad—was colonized, cleared, and planted. When the natives died, the planters replaced them with African slaves. After the crop was harvested and milled, it was piled in the holds of ships and carried to London, Amsterdam, Paris, where it was traded for finished goods, which were brought to the west coast of Africa and traded for more slaves. The bloody side of this “triangular trade,” during which millions of Africans died, was known as the Middle Passage. Until the slave trade was banned in Britain in 1807, more than 11 million Africans were shipped to the New World—more than half ending up on sugar plantations. According to Trinidadian politician and historian Eric Williams, “Slavery was not born of racism; rather, racism was the consequence of slavery.” Africans, in other words, were not enslaved because they were seen as inferior; they were seen as inferior to justify the enslavement required for the prosperity of the early sugar trade.

The original British sugar island was Barbados. Deserted when a British captain found it on May 14, 1625, the island was soon filled with grinding mills, plantation houses, and shanties. Tobacco and cotton were grown in the early years, but cane quickly overtook the island, as it did wherever it was planted in the Caribbean. Within a century the fields were depleted, the water table sapped. By then the most ambitious planters had left Barbados in search of the next island to exploit. By 1720 Jamaica had captured the sugar crown.

For an African, life on these islands was hell. Throughout the Caribbean millions died in the fields and pressing houses or while trying to escape. Gradually the sin of the trade began to be felt in Europe. Reformers preached abolition; housewives boycotted slave-grown cane. In *Sugar: A Bittersweet History* Elizabeth Abbott quotes Quaker leader William Fox, who told a crowd that for every pound of sugar, “we may be considered as consuming two ounces of human flesh.” A slave in Voltaire’s *Candide*, missing both a hand and a leg, explains his mutilation: “When we work in the sugar mills and we catch

our finger in the millstone, they cut off our hand; when we try to run away, they cut off a leg; both things have happened to me. It is at this price that you eat sugar in Europe.”

And yet there was no stopping the boom. Sugar was the oil of its day. The more you tasted, the more you wanted. In 1700 the average Englishman consumed 4 pounds a year. In 1800 the common man ate 18 pounds of sugar. In 1870 that same sweet-toothed bloke was eating 47 pounds annually. Was he satisfied? Of course not! By 1900 he was up to 100 pounds a year. In that span of 30 years, world production of cane and beet sugar exploded from 2.8 million tons a year to 13 million plus. Today the average American consumes 77 pounds of added sugar annually, or more than 22 teaspoons of added sugar a day.

If you go to Barbados today, you can see the legacies of sugar: the ruined mills, their wooden blades turning in the wind, marking time; the faded mansions; the roads that rise and fall but never lose sight of the sea; the hotels where the tourists are filled with jam and rum; and those few factories where the cane is still heaved into the presses, and the raw sugar, sticky sweet, is sent down the chutes. Standing in a refinery, as men in hard hats rushed around me, I read a handwritten sign: a prayer beseeching the Lord to grant them the wisdom, protection, and strength to bring in the crop.

THE CULPRIT

It seems like every time I study an illness and trace a path to the first cause, I find my way back to sugar.”

Richard Johnson, a nephrologist at the University of Colorado Denver, was talking to me in his office in Aurora, Colorado, the Rockies crowding the horizon. He’s a big man with eyes that sparkle when he talks. “Why is it that one-third of adults [worldwide] have high blood pressure, when in 1900 only 5 percent had high blood pressure?” he asked. “Why did 153 million people have diabetes in 1980, and now we’re up to 347 million? Why are more and more Americans (Continued on page 96)



cereal

Goldilocks adjudged the third bowl of porridge she tested just right. Anyone craving more variety may note that the U.S. Patent and Trademark Office lists 2,000 cereals. Packaged as a whole-grain health food in the late 1800s, cereal began to evolve in the 1920s into sugar-coated flakes, pops, and puffs.





syrup

From soup to soda, viscous waves of high-fructose corn syrup wash over the landscape of processed food. Called the “floozy of the sugar world” by former *Washington Post* health writer Sally Squires, HFCS is cheaper and usually sweeter than sucrose, sugar made from cane or beets. Is there any biological difference? “Not enough to fuss about,” says Marion Nestle, professor of nutrition at New York University. “Everyone would be better off eating less of either one.”

Top consumers of high-fructose syrup



Annual pounds per capita, 2011*

*In the top ten consuming nations
NGM ART. SOURCE: USDA



candy



Candy is dandy, particularly to Americans, who spent \$32 billion on sweets in 2011; per capita consumption was 25 pounds. Formerly a luxury item for the rich, candy became affordable with the decline of sugar prices and rise of mass production in the 19th century. The word itself comes from *qandi*: Arabic for a sugar confection.

CANDY ART BY VICTORIA GRANOF

cupcake

National Cupcake Day is December 15, except in New York City schools, which cracked down on baked goods in 2009 as part of a wellness policy. The downsized cake made its American cookbook debut in 1826, says food historian Andrew Smith. Cupcake gentrification spread in 2000 when *Sex and the City*'s Carrie Bradshaw nibbled one topped with pink buttercream. In the current TV series *Cupcake Wars*, dueling recipes feature ingredients like sweet tea and chocolate seltzer.

Top consumers of refined sugar

Brazil	122
Russia	88
Mexico	76
Egypt	70
European Union	70

Annual pounds per capita, 2011*

*In the top ten consuming nations
NGM ART. SOURCE: USDA





“WE HAVE A BIG PROBLEM. Our world is flooded with

obese? Sugar, we believe, is one of the culprits, if not the major culprit.”

As far back as 1675, when western Europe was experiencing its first sugar boom, Thomas Willis, a physician and founding member of Britain’s Royal Society, noted that the urine of people afflicted with diabetes tasted “wonderfully sweet, as if it were imbued with honey or sugar.” Two hundred and fifty years later Haven Emerson at Columbia University pointed out that a remarkable increase in deaths from diabetes between 1900 and 1920 corresponded with an increase in sugar consumption. And in the 1960s the British nutrition expert John Yudkin conducted a series of experiments on animals and people showing that high amounts of sugar in the diet led to high levels of fat and insulin in the blood—risk factors for heart disease and diabetes. But Yudkin’s message was drowned out by a chorus of other scientists blaming the rising rates of obesity and heart disease instead on cholesterol caused by too much saturated fat in the diet.

As a result, fat makes up a smaller portion of the American diet than it did 20 years ago. Yet the portion of America that is obese has only grown larger. The primary reason, says Johnson, along with other experts, is sugar, and in particular fructose. Sucrose, or table sugar, is composed of equal amounts of glucose and fructose, the latter being the kind of sugar you find naturally in fruit. It’s also what gives table sugar its yummy sweetness. (High-fructose corn syrup, or HFCS, is also a mix of fructose and glucose—about 55 percent and 45 percent in soft drinks. The impact on health of sucrose and HFCS appears to be similar.) Johnson explained to me that although glucose is metabolized by cells all through your body, fructose is processed primarily in the liver. If you eat too much in quickly digested forms like soft drinks and candy, your liver breaks down the fructose and produces fats called triglycerides.

Some of these fats stay in the liver, which over

long exposure can turn fatty and dysfunctional. But a lot of the triglycerides are pushed out into the blood too. Over time, blood pressure goes up, and tissues become progressively more resistant to insulin. The pancreas responds by pouring out more insulin, trying to keep things in check. Eventually a condition known as metabolic syndrome kicks in, characterized by obesity, especially around the waist; high blood pressure; and other metabolic changes that, if not checked, can lead to type 2 diabetes, with a heightened danger of heart attack thrown in for good measure. As much as a third of the American adult population could meet the criteria for metabolic syndrome set by the National Institutes of Health.

Recently the American Heart Association added its voice to the warnings against too much added sugar in the diet. But its rationale is that sugar provides calories with no nutritional benefit. According to Johnson and his colleagues, this misses the point. Excessive sugar isn’t just empty calories; it’s toxic.

“It has nothing to do with its calories,” says endocrinologist Robert Lustig of the University of California, San Francisco. “Sugar is a poison by itself when consumed at high doses.”

Johnson summed up the conventional wisdom this way: Americans are fat because they eat too much and exercise too little. But they eat too much and exercise too little because they’re addicted to sugar, which not only makes them fatter but, after the initial sugar rush, also saps their energy, beaching them on the couch. “The reason you’re watching TV is not because TV is so good,” he said, “but because you have no energy to exercise, because you’re eating too much sugar.”

The solution? Stop eating so much sugar. When people cut back, many of the ill effects disappear. The trouble is, in today’s world it’s extremely difficult to avoid sugar, which is one reason for the spike in consumption. Manufacturers use sugar to replace taste in foods bled of fat so that they seem more healthful, such as fat-free baked goods, which often contain large quantities of added sugar.

It’s a worst-case scenario: You sicken unto

Rich Cohen’s ninth book, on the 1985 Chicago Bears, will appear in October. Robert Clark’s story on the Denisovans was published last month.

fructose, but our bodies evolved to get by on very little.”

—Richard Johnson

death not by eating foods you love, but by eating foods you hate—because you don’t want to sicken unto death.

IN THE BEGINNING WAS THE FRUIT

If sugar is so bad for us, why do we crave it? The short answer is that an injection of sugar into the bloodstream stimulates the same pleasure centers of the brain that respond to heroin and cocaine. All tasty foods do this to some extent—that’s why they’re tasty!—but sugar has a sharply pronounced effect. In this sense it is literally an addictive drug.

This raises the question, however, of why our brains would evolve to respond pleasurably to a potentially toxic compound. The answer, Johnson told me, lies deep in our simian past, when a craving for fructose would be just the thing our ancestors needed to survive.

I paraphrase Johnson in a voice borrowed from the fables, for what are even the best theories, if not the old stories told again in the language of science? Some 22 million years ago, so far back it might as well be the beginning, apes filled the canopy of the African rain forest. They survived on the fruit of the trees, sweet with natural sugar, which they ate year-round—a summer without end.

One day, perhaps five million years later, a cold wind blew through this Eden. The seas receded, the ice caps expanded. A spit of land emerged from the tides, a bridge that a few adventurous apes followed out of Africa. Nomads, wanderers, they settled in the rain forests that blanketed Eurasia. But the cooling continued, replacing tropical groves of fruit with deciduous forests, where the leaves flame in autumn, then die. A time of famine followed. The woods filled with starving apes. “At some point a mutation occurred in one of those apes,” Johnson explained. It made that ape a wildly efficient processor of fructose. Even small amounts were stored as fat, a huge survival advantage in months when winter lay upon the land and food was scarce.

Then one day that ape, with its mutant gene

and healthy craving for rare, precious fruit sugar, returned to its home in Africa and begot the apes we see today, including the one that has spread its sugar-loving progeny across the globe. “The mutation was such a powerful survival factor that only animals that had it survived,” Johnson said, “so today all apes have that mutation, including humans. It got our ancestors through the lean years. But when sugar hit the West in a big way, we had a big problem. Our world is flooded with fructose, but our bodies have evolved to get by on very, very little of it.”

It’s a great irony: The very thing that saved us could kill us in the end.

THE HEALTHY CHEF

Though just 11, Nick Scurlock is a perfect stand-in for the average American in the age of sugar. Hyperefficient at turning to fat the fructose the adman and candy clerk pump into his liver at a low, low price. One hundred thirty-five pounds in fifth grade, in love with the sweet poison endangering his life. Sitting in the lunchroom, he smiled and asked, “Why are the good things so bad for you?”

But this story is less about temptation than about power. At its best, the school can help kids make better decisions. A few years ago Pop-Tarts and pizza were served at Kirkpatrick. Now, across the district, menus have improved. The school has a garden that grows food for the community, a walking track for students and the public, and a new playground.

In a sense the struggle in Clarksdale is just another front in the continuing battle between the sugar barons and the cane cutters. “It’s a tragedy that hits the poor much harder than it does the rich,” Johnson told me. “If you’re wealthy and want to have fun, you go on vacation, travel to Hawaii, treat yourself to things. But if you’re poor and want to celebrate, you go down to the corner and buy an ice-cream cake.”

When I asked Nick what he wanted to be when he grew up, he said, “A chef.” Then he thought a moment, looked at his mom, and corrected himself. “A healthy chef,” he said. □

A dramatic underwater scene inside a cave. A diver is positioned in the upper right, illuminated by a bright light source from above, creating strong rays of light that cut through the dark blue water. The cave walls are rugged and rocky, with some mineral deposits visible. The overall atmosphere is mysterious and adventurous.

SECRETS OF

A full-page background image showing a diver's perspective inside a cenote. A bright beam of light from the surface illuminates the rocky, textured walls of the underground water chamber. The water is dark, and the overall atmosphere is mysterious and ancient.

THE MAYA OTHERWORLD

Ancient Maya believed that the rain god Chaak resided in caves and natural wells called cenotes. Maya farmers today in Mexico's parched Yucatán still appeal to Chaak for the gift of rain. Meanwhile cenotes are giving archaeologists new insights into the sacred landscapes of the ancestral Maya.

A DIVER EXPLORES A CENOTE NEAR THE MAYA RUINS OF TULUM.



At the Xcaret theme park south of Cancún a mythic Maya lord of death mingles with tourists before a spectacular re-creation of ancient pilgrimages. The annual event—complete with canoe voyage—honors Ixchel, the goddess of fertility. Such ties to the past draw visitors to the Yucatán from the rest of Mexico and abroad.

SHAUL SCHWARZ



Boys from the village of Yaxuná cool off in a cenote, or limestone sinkhole. A 65-foot ladder lets them climb out after a dip. The statue is a local artist's version of a trickster spirit from Maya folklore. The villagers put it there for the tourists they hope will stop by while visiting the area's archaeological sites.

SHAUL SCHWARZ





BY ALMA GUILLERMOPRIETO

PHOTOGRAPHS BY PAUL NICKLEN AND SHAUL SCHWARZ



A pyramid 90 feet tall and a platform adorned with a feathered serpent's head testify to the former glory of Chichén Itzá, now a popular tourist destination. This once powerful city was built in about the ninth century, likely aligned with four sacred cenotes and with the sun's seasonal movements.

PAUL NICKLEN

On the edge of a small cornfield near the ruined Maya city of Chichén Itzá, in the sparse shade of

a tropical tree, a voice ricochets wildly up the mouth of a well. “¡Lo vi! ¡Lo vi!” the shout proclaims. “I saw it, I saw it!” “¡Sí, es verdad! Yes, it’s true!”

Leaning over the mouth of the well, underwater archaeologist Guillermo de Anda needs to make sure that this is what he has been longing to hear for so many months. “What is true, Arturo?” And his fellow archaeologist Arturo Montero, floating down at the bottom of the well, yells up again, “The zenith light! It really works! Get down here!” Then he whoops ecstatically.

What de Anda has been waiting anxiously for his friend Montero to determine is whether the water at the bottom of this nondescript natural well, or cenote, had acted as a sacred sundial and timekeeper for the ancient Maya on the two days of the year, May 23 and July 19, when the sun reaches its zenith. At that moment it is vertically overhead, and no shadow is cast. The fact that the cenote is directly northwest of the main staircase of El Castillo, the famous central pyramid of Chichén Itzá, and within that mysterious city’s urban limits, made de Anda’s question particularly intriguing.

Centuries earlier, had Maya priests waited in this very well to observe and correct their measurements of the sun’s angle when it reached the zenith, as it does only in the tropics? Did they come here during times of drought to deliver anxious offerings and at other times to give thanks for a plentiful harvest? Did they believe this was a place where the sun and the generous waters met and brought forth life? These and other questions involving the Maya people’s relation to their gods, their sacred city, and their extraordinarily accurate calendar were what the two archaeologists were investigating.

De Anda, renowned for his skills as an underwater archaeologist, had been able to work in the Holtún cenote only occasionally and with minimal financing. Montero, from the University of Tepeyac, was at the well on his own money. He had been in the nearby city of Mérida on May 23, leading an archaeoastronomy seminar at the University of Yucatán, where de Anda was teaching. This morning, the day after the zenith, they were at last heading for the Holtún cenote. Their start had been disastrous—a flat tire, a shortage of gasoline, and sundry other hindrances had landed them at the well just as the sun was about to reach its near-zenith position. With minutes to go, Montero and Dante García Sedano, an undergraduate student, had struggled into their diving suits, clipped themselves into harnesses, and been lowered into the well by a crew of local Maya farmers.



Now Montero was yelling and whooping, and the farmers were lowering first a rubber raft and then me into the well. De Anda, drenched in sweat in the grilling Yucatán heat, was having a hard time with his rubbery suit. But finally he too was lowered 72 feet into the well, making the four of us in all likelihood the first persons in centuries to watch the path the sun god was tracing across these waters.

Beneath the narrow mouth of the cenote, the walls opened up to become a giant dome, cathedral-like except for the roots of trees grasping through the rock for the water. Focused by the small opening—shaped into a rectangle likely to mirror the four-cornered Maya cosmos—the shaft of sunlight danced like fire on the delicate frillery of surrounding stalactites. The edge of the water too seemed to ignite when it was hit by the light, and beneath the normally dark surface the waters turned a transparent turquoise blue. The sun's rays came so close to vertical that Montero now knew that yesterday, at the zenith moment, a pillar of light

would have plunged straight into the water. One didn't have to be Maya to feel awe.

During the past couple of decades archaeologists have begun paying close attention to the role of caves, the zenith sun, and now—through de Anda—cenotes, in the beliefs and world vision of the ancient Maya of Yucatán. Archaeologists had known that the Maya regarded both caves and cenotes as mouths that opened into an otherworld inhabited by Chaak, the god of life-giving rain, but the consequences of this fact for architecture and city planning have only recently started to become clear.

In 2010 de Anda, who by then had dived in scores of cenotes, began exploring Holtún at the invitation of Rafael Cobos, a recognized archaeologist and project director who has been busy investigating and mapping the hundreds of ancient structures, promontories, and wells in the Chichén Itzá region. De Anda also had the cooperation of the National Institute of Anthropology and History. Examining the walls of the pool a few yards below the surface, he emerged from a small hollow and felt a protrusion above his head. He was astonished to find that this natural rock shelf held an offering of a human skull, pottery, the skull of a dog, deer bones, and a two-edged knife probably used for sacrifices, all neatly placed there centuries earlier. His headlamp, pointed straight down at the cenote's depths, revealed broken columns, a carved anthropomorphic jaguar, and a figure similar to one of the little stone men at Chichén Itzá's Temple of the Warriors, sculpted to look as if they were holding up the sky. This well in the middle of a cornfield was clearly a sacred site.

Now, three years later, de Anda and Montero had discovered not only a connection between the zenith sun and Holtún but apparently also the role of that sun and the cenote in the siting and orientation of Chichén Itzá's El Castillo pyramid. It was already known that at the spring equinox a snake of sunlight slithers down one side of the pyramid's central staircase—a sight witnessed every year by thousands of tourists. Some walk the short distance to the famous

KEY TO SURVIVAL

In this harsh region with no rivers the limestone sinkholes, or cenotes, are the only permanent sources of fresh water. More than 3,500 hold rainwater that has been collecting for eons.





Pleading for rain for the village of Yaxuná a kneeling shaman chants prayers at a rectangular altar, which symbolizes the four-cornered shape of the Maya universe. During this age-old ceremony, men circle with offerings of food, while crouching boys imitate the sounds that frogs make when it rains.

Sacred Cenote, which, over the centuries that Chichén Itzá was a great city-state, received in its mouth any number of human beings and other precious offerings. Early on May 23, the zenith day, Montero had gone to the central pyramid and discovered that the sun, K'inich Ajaw, rises in line with the pyramid's northeast corner. It then sets in line with the pyramid's western staircase and the nondescript Holtún well.

The Maya, to calibrate their calendar, which is justly famous to this day, had to determine the days of the year when the sun shone exactly overhead, not one fraction of a degree lower or higher. Montero and de Anda speculated that Maya astronomers waited inside the Holtún well for those two zenith moments in the year when a vertical pillar of sunlight pierces the water without reflecting onto the dome.

For the Maya, astronomy was a sacred activity, as were architecture and city planning. De Anda and Montero now think that not just Holtún but other cenotes may have played an

important role in determining where to site buildings. The Sacred Cenote lies north of El Castillo. Two other cenotes lie to its south and southeast. The Holtún cenote, directly northwest of the pyramid, may have completed the diamond configuration that allowed the Itzá people to determine where to build their sacred city and how to angle its main pyramid. If further studies corroborate all this, the most important coordinates of Chichén Itzá's overarching design will snap into place.

Such at least is de Anda's hope. But on this day he and Montero had already accomplished much. The sun drew up its spears of light and continued on its way across the face of the Earth,

Alma Guillermoprieto, a frequent contributor, won an Overseas Press Club award for her May 2010 story on Mexico's new saints. Photographer Paul Nicklen underwent extensive cave-diving training for this story. Shaul Schwarz traced Maya culture in the Yucatán above water.



Archaeologist Guillermo de Anda descends into the Holtún cenote minutes before the moment on July 19 when the sun is directly overhead. When that occurs, twice a year, light falls vertically into the water. De Anda believes the ancient Maya built a structure at the surface that caught the rays the same way.

PAUL NICKLEN



Holtún cenote

Chichén Itzá, Mexico

The Maya carved the cenote's jagged mouth into a rectangle to channel the vertical rays when the sun was directly overhead.

Sun's zenith
May 23, July 19

Before and after the sun's zenith, and on many other days, the rays slant into the cenote and are reflected onto the ceiling.

Current
water level

Shelf with offerings

When the Rains Failed

The cenote's water level fell dramatically during periodic droughts that occurred from about A.D. 770 to 1100. At the worst of times the drop may have been 20 feet or so, which left a rocky shelf high and dry.

Holtún
cenote

Additional artifacts

1.6 miles

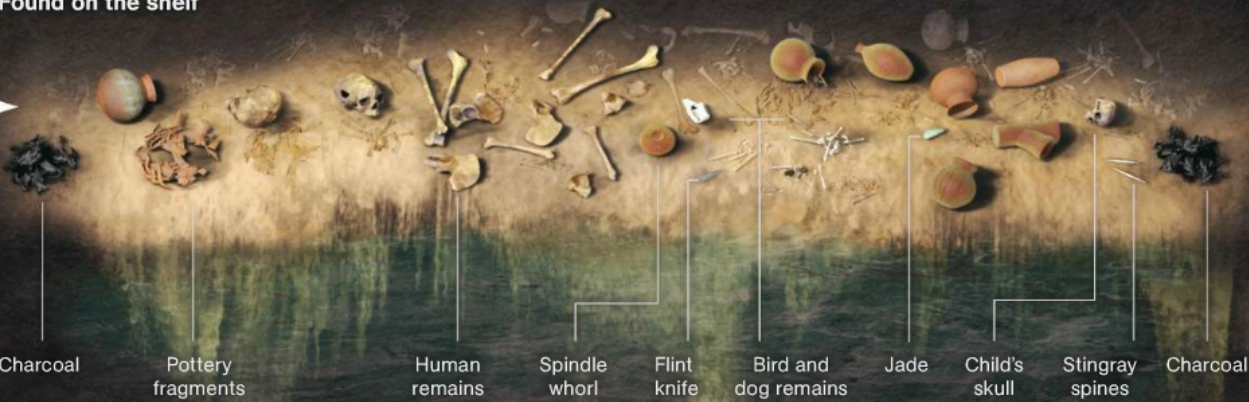
LINKS TO THE COSMOS

The pyramid at Chichén Itzá was planned with precision. Experts believe it is aligned to the March and September equinoxes, when the sun's passage makes a serpent-like shadow slither down its side. Guillermo de Anda recently discovered that the structure also stands in the middle of four cenotes (where the white lines cross, right), probably symbolizing the sacred mountain at the center of the Maya universe. It was also oriented to the moments when the sun reaches its highest point in the sky (far right), further connecting it to the cycles of the heavens.

A PLACE OF PRAYER

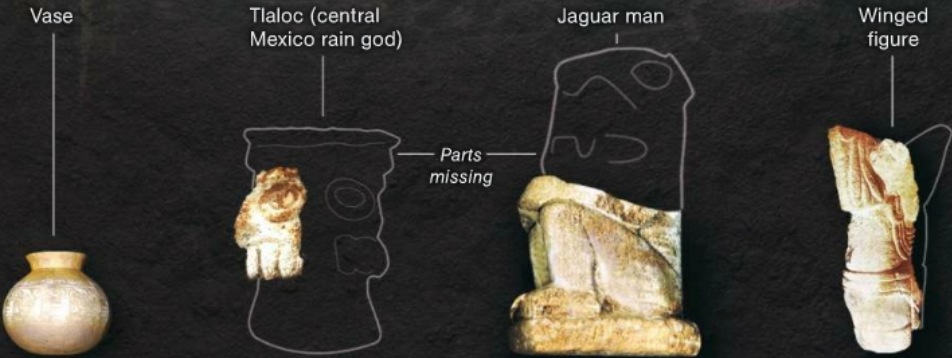
Desperate for water for their crops, the Maya petitioned the rain god Chaak from deep inside the cenote. On a rocky shelf exposed during droughts, they laid out offerings and performed rituals, which may have included bloodletting. Archaeologists found artifacts scattered on the floor of the cenote. They believe the Maya sacrificed sculptures and other objects by throwing them off the shelf. Human bones and ceramics may also have fallen to the depths on their own.

Found on the shelf



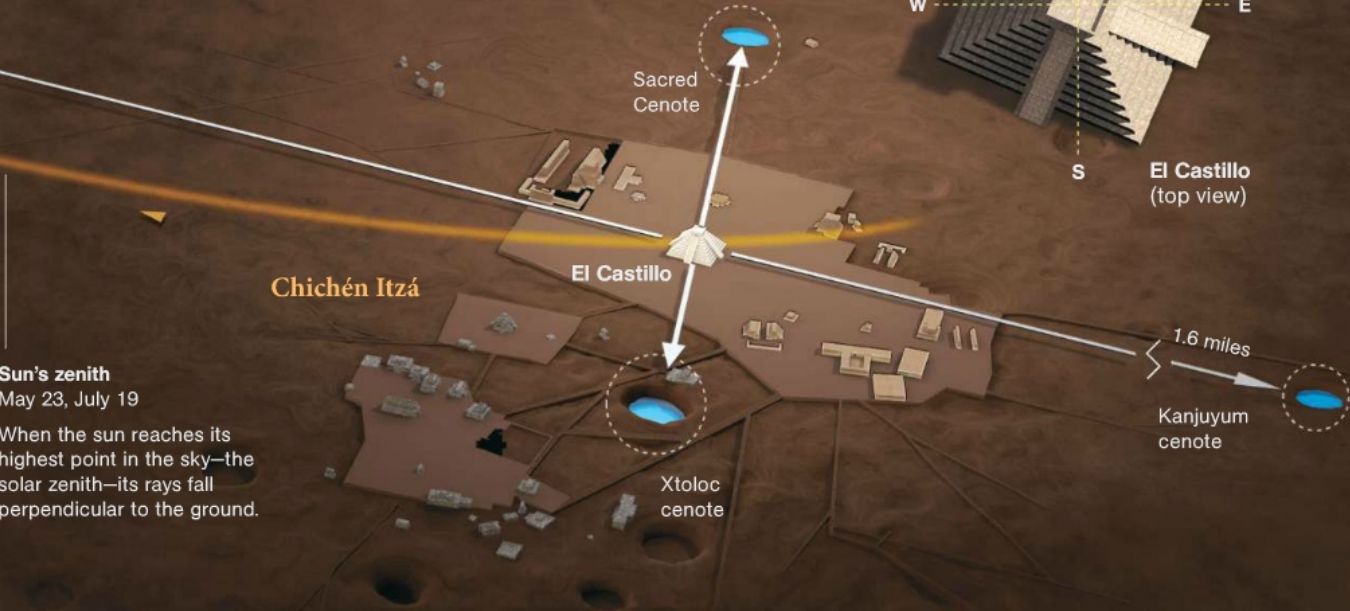
Found on the floor

(among many other artifacts)



IN LINE WITH THE SUN

Twice a year the sun rises directly to the northeast of El Castillo and travels over its peak (right). It then moves in an arc to the northwest (yellow line), where it passes over the Holtún cenote before sinking to the horizon.



Sun's zenith
May 23, July 19

When the sun reaches its highest point in the sky—the solar zenith—its rays fall perpendicular to the ground.

DE ANDA WAS ASTONISHED TO FIND THAT THE NATURAL ROCK SHELF HELD AN OFFERING OF A HUMAN SKULL.

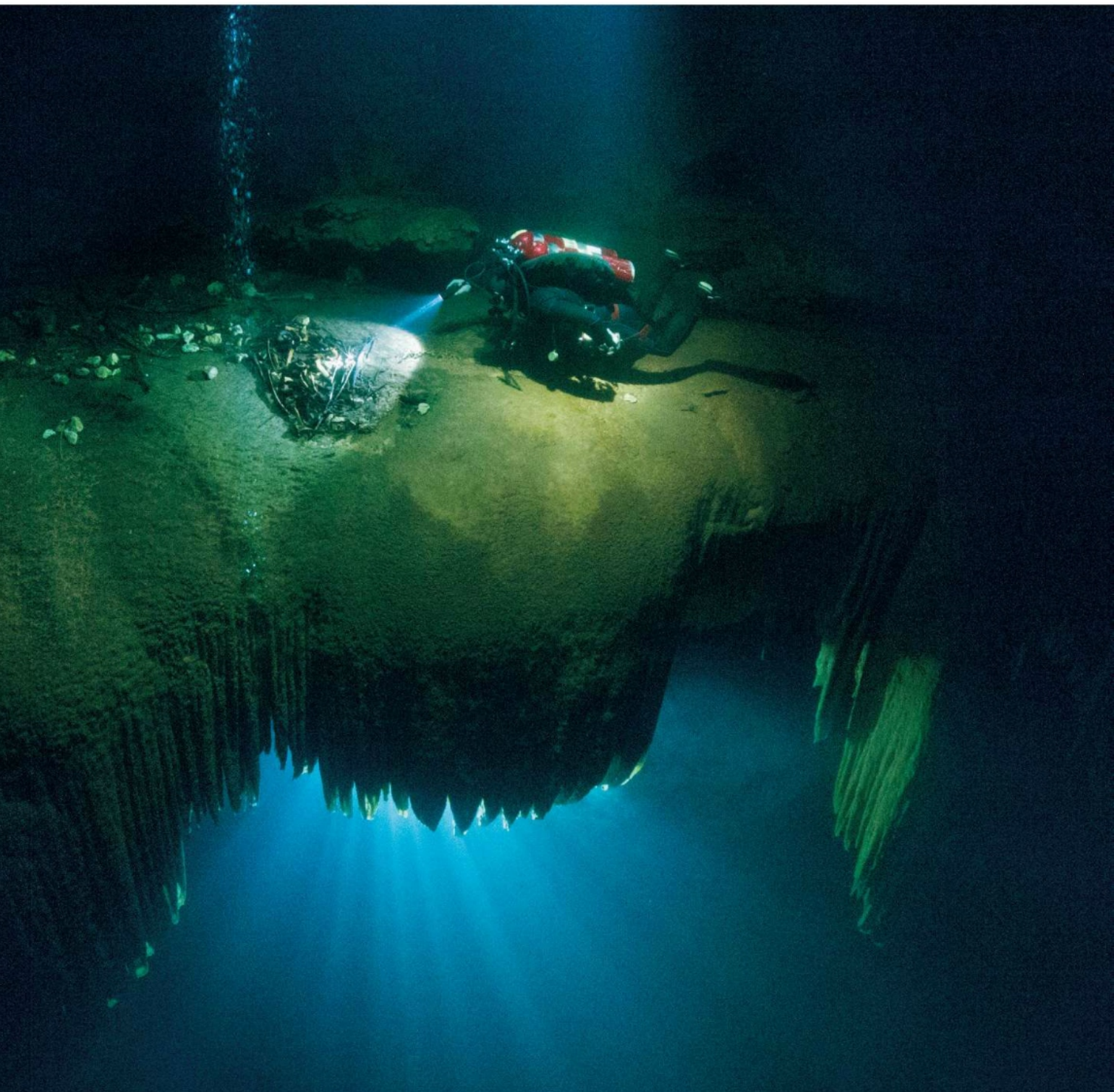
while in the renewed dark the two chattered excitedly about what they had seen and what it meant. “¡Un abrazo, hermano!” Montero exclaimed, and the two men surged toward each other in the water and flappingly embraced.

Aboveground the crew of Maya farmers, in shorts and flip-flops, had to work hard to haul the explorers up again. Around us were rustling cornfields that had been waiting for the rain too long, but team master Luis Un Ken, a smiling man respected by everyone in his nearby village, is by nature an optimist. “There was a good rain the other day,” he said, patting the sweat off his face. “The Chaak moved.”

For men like Un Ken, the old gods are still very much alive, and Chaak, ruler of cenotes and caves, is among the most important gods of all. For the benefit of living things, he pours from the skies the water he keeps in earthenware jars in caves. Chaak is one and many: Each thunderclap is a separate Chaak in action, breaking a jar open and letting the rain fall. Each god inhabits a separate layer of reality, along with dozens of alternately complacent and ferocious gods that live in the 13 otherworlds above and the 9 otherworlds below. Together, they filled the Maya people’s lives with dreams, visions, and nightmares; a complicated calendar of agricultural times and fertility rituals; and a firm sense of the way things must be done. Chaak had moved, Un Ken said, and that meant the planting season would soon arrive.

Chaak’s absence can cause the Yucatán Maya untold disasters, tragedies properly understood only when one is standing on the hard, lunar surface of their former empire, an endless shelf of karstic rock, or limestone. Rain seeps straight through the karst to groundwater levels, and as a result no river or brook runs through the land. (Cenotes are actually sinkholes that extend to the water table.) From the air one sees a green sea of dense jungle. At ground level the tropical forest is thin—spindly trees whose stubborn roots are adapted to the pockets of soil that dot the karst. Wherever the soil hollows are large enough, Maya will plant corn or a milpa, a wise





Hovering above the offering shelf in the Holtún cenote, Guillermo de Anda surveys a pile of bones. “This work is about millimeters,” says photographer Paul Nicklen. “You’re right above remains that haven’t been moved in centuries, so you have to have impeccable diving skills.”

PAUL NICKLEN

combination of the corn, beans, and squash that constitute their basic source of protein. But corn is a hungry crop; it sucks lots of nutrients from the soil. For thousands of years milpa farmers have kept their small fields productive by burning a different patch of trees every year and planting in the corn-friendly ashes. We call this deforestation, but to the Maya it means survival.

As for water for the fields...well, that's where Chaak comes in. Only seasonal rains can make the corn grow, and they must arrive in an excruciatingly accurate pattern: no rain in winter, so that the fields and forest will be dry enough to burn by March; some rain in early May to soften up the soil for planting; then very gentle rain to allow the planted seeds to sprout and the young corn god to make his appearance in the shape of a barely formed corn ear; finally plenty of rain to send the cornstalks shooting skyward and fatten the kernels on the mature corn. At any point in the yearly cycle irregular rains mean a smaller ration of food for a family.

The unsolved archaeological question is why the great Yucatán Maya city-states collapsed one after another. The miracle is that they survived at all, fed by corn grown in such a harsh environment.

Yet they did survive—and prospered too—sometimes reaping a plentiful harvest and sometimes, as Guillermo de Anda believes happened at the Holtún well, placing offerings inside a cenote during a prolonged drought, when the water table could sink by 20 feet. With a population estimated in the millions a thousand years ago, the northern Maya built so many cities—in the dry north, always next to a life-giving cenote—that one starts to think the Yucatán forest is an archaeologist's do-it-yourself: Anyone can trip over an untouched ruin. In fact a couple of days after the Yucatán zenith day, I was trudging down a path between milpas and forest a few miles from Chichén Itzá with archaeologist and cave explorer Donald Slater, when he nodded toward our right and said, "There it is." There what was? I looked around and saw cornfields to our left



A ceramic flute displays a human face (at left) beneath a curved bird's beak. Archaeologist Donald Slater and colleague Sabrina Simón found the offering near a natural stone altar deep in a cave.

and forest to our right. "There," Slater insisted. Just skinny trees, and behind those, more trees. Then what looked like a blurry thickening of the forest about 50 yards off the path turned out to be a steeply pitched hill. Of course there are no steep hills anywhere in the neighborhood. But there are pyramids. This was a particularly tall one, and directly facing its southwest corner was a very big cave.

To the Maya the cave would have been a mouth, the gaping jaws of a devouring Earth deity or one of the dwelling places of Chaak. Slater was hoping to document his claim that this cave was a sacred observation point from which to greet the arrival of the sun on its zenith day and that this pyramid—which has been known about but never fully explored—was built or at least oriented specifically in relation to the cave.

Before our visit Slater had asked a crew of Maya farmers to clear the jungle growth covering the structure's western face so that the zenith sun's track could be observed more clearly.



Illuminating his discovery, Guillermo de Anda shows off the only known *sacbe*, or sacred path, inside a cave. At the rock column this stone walkway turns west, toward a cenote's shimmering pool. The ancient Maya believed that was the direction leading to the underworld, a stop on the journey to heaven.

At the cave's lip Slater pointed out the remains of a set of stairs rough-hewn centuries before, perhaps to give shamans access to this terrifying maw of the Earth. Slater speculates that the solar priests would have spent the night before the zenith sun fasting, dancing, and chanting to the sound of drums and double-chambered clay flutes like those he found deep inside the cave, praising the sun god for bringing the zenith day around once more, and with it, the rains.

As we stood where the holy men once might have, the entire pyramid loomed before us. We waited. At 8:07 a.m. a fat, orange globe bobbled up behind the pyramid, appeared to pause for a second or two, and then displayed itself in blinding glory as it cleared the top, filling our cave with its fiery light. Centuries ago on the two zenith days, Slater explained, it would have performed its bobble dance on what are now the ruins of a platform on the top southwest corner of the structure.

To the sky-gazing Maya, the pyramids in the

Yucatán, others of which were aligned with the rising and setting suns of equinox and zenith days, would have seemed not landbound piles of stone but cosmic timekeepers—upward-yearning structures in constant interaction with the heavens. And the interaction of K'inich Ajaw, the sun, and the sacred waters of Chaak was the dance of life that made the cornfields possible.

I was on my own modest search for Chaak. Roaming the Yucatán Peninsula, I was looking for rituals and beliefs held by modern Maya that might help me understand their link to their glorious ancestors. Most Maya today live in poor farming communities, and Chaak, who remains so important to them, is celebrated seasonally in an extended rain-calling prayer known as a Cha Chaak.

Some 80 miles southeast of Chichén Itzá, approaching the area now known by the misleading, if glamorous, name of the Maya Riviera, lies the village of Chunpón. It is part of



Scattered handprints, some from children, mark the walls of a cave next to the shadows cast by Dante García Sedano, Guillermo de Anda's assistant. This cave likely was part of a ritual landscape that included four cenotes, where the Maya left more handprints, human bones, and offerings of ceramics.

a government-designated Zona Maya that covers a sizable portion of the Yucatán Peninsula. I visited Chunpón in the company of a man named Pastor Caamal. During work hours he is a proudly independent tour guide, and like many of his neighbors and Luis Un Ken, he is a Cruzoob, or believer in the Talking Cross, a relic from the 19th-century uprising known as the Caste War. A descendant of Maya warriors who fought government troops, he still does round-the-clock guard duty at the cross's sacred garrison two weeks out of every year.

"The Cruzoob are basically the Maya who survived," Caamal said to me on a summer afternoon as we zipped down a flat highway in the Zona Maya toward his hometown. That was something of an exaggeration: The Caste War was a strictly local affair, and there are approximately five million Maya living in an area

that encompasses the lower third of Mexico, as well as most of Belize and Guatemala, western Honduras, and western El Salvador. But it is true that in the Yucatán, the war touched nearly every village.

I asked Caamal how he bridged the difference between the old Maya gods and Jesus Christ, whom the Maya frequently invoke, sometimes calling him Our Lord Most Holy Cross Three Persons. "We are polytheists," Caamal answered. Strikingly, there is virtually no Catholic presence in the zona; instead there are *hmem*—shamans, healers, and enchanter who usually discover their vocation in dreams, then mediate between the gods and their needy worshippers.

In answer to my increasingly desperate queries about where I might be able to witness a Cha Chaak rain ritual, Caamal said his own *hmem* might know of a Cha Chaak coming up somewhere, although it was late in the season.

In the bruising heat of midday we made a brief stop in Chunpón at Caamal's family

■ **Society Grant** This research was funded in part by your National Geographic Society membership.

FOR MEN LIKE UN KEN, THE OLD GODS ARE ALIVE, AND CHAAK IS AMONG THE MOST IMPORTANT GODS OF ALL.

compound. In the oval kitchen hut was strung a row of hammocks, each cradling a Caamal relative who lay chatting and rocking gently. It would have been cooler without the hearth—three large stones on the dirt floor with embers glowing beneath a large iron griddle—but the kitchen embers are always stoked. Caamal's fierce, tiny mother glared at me, a "Spanish," or non-Maya, visitor, but she made some tortillas, offering them with meat and chilies. Later she would pointedly ask her son when I was planning to get out of her hammock and leave, but the rules of hospitality, as set as the movement of the stars, dictated that food be offered.

Back on the road, we saw slender trees shooting up from the bone-white, bone-hard surface of the karst. We stopped at the village of Chun-Yah, which, like many in the Zona Maya, has no land or cellular phone communication with the outside world and only rudimentary schools. In his own dusty compound of oval thatched-roof huts, Caamal's mentor and hmem, Mariano Pacheco Caamal, greeted me with a broad smile.

Don Mariano said he knew how to use 40 different kinds of plants to cure illnesses and heal fractures and snakebites. At a particularly fragile time for Pastor, Don Mariano had built a protective ring of invisible fire around his friend. In dreams he had learned what to ask each god and on which day of the week. He knew where to find the sacred caves.

Don Mariano wore cutoffs and flip-flops and seemed to have remarkably few possessions for a man of his age and prestige. He spoke only elementary Spanish, and because my Mayan is nonexistent, Pastor had to translate my questions a few different ways to get the meaning across. I asked Don Mariano how he knew he was Maya. The mild-mannered hmem blinked behind his thick glasses. "Because we are poor," he said. I asked again. "Because of what we eat, our skin color, our height," came the reply, and then he thought of a better answer. "Because here there are no factories, machines, smoke. At night we have peacefulness, silence. In the morning I say, Today I will do this or that. Our work is our own.

When one works for outsiders, they say, Give me your time. But Maya are their own rulers."

Did he know of a Cha Chaak coming up? Alas, Don Mariano could only confirm that I was late. In Chun-Yah as elsewhere, the time for planting and rain invoking had already passed. Then he graciously explained how a Cha Chaak offering is set up in his small part of the Maya universe. A rectangular altar, or offering table, about three feet wide and made of saplings and a few boards, represents the world. The various foods for Chaak are placed on it in a strict order, along with half-gourd cups of a sacred fermented drink, *balché*, made from tree bark, and gourds filled with holy water taken from a hidden cenote or cave. The special food offering consists of 13 loaves of "bread," thick tortillas made of 13 layers of masa, or corn dough, representing the 13 layers of the otherworld above. The bread is wrapped in leaves of *bakaalché*, a local vine, and baked in a coffin-size pit, or *pib*, dug out near the altar. A cross is placed at the center back of the table to oversee the whole.

I ventured that I had heard about *sapitos*, small boys who crouch at the base of the altar table and encourage Chaak to arrive by imitating the call of frogs during the rainy season. Pastor and the hmem looked at each other and smiled.

"You heard about that [near Chichén Itzá], right?" Pastor said. He imitated the boys imitating the frogs: "They go *lek lek lek*." He smiled again. "*Muy bonita costumbre*. A very pretty custom." He grinned. "We don't do that here."

In Yaxuná, a little town in the middle of the peninsula—on yet another parchingly hot morning, the rains overdue, not a cloud in sight—where a late season ceremony was being held for the laggard Chaak, they most certainly do. Yaxuná is some 12 miles south of Chichén Itzá, and in this part of Yucatán many people still depend on milpa, making them the anxious subjects of Chaak.

The ceremony in Yaxuná had almost ended by the time I caught up with it. For going on two days rain-desperate villagers and their hmem had toiled without rest or sleep to persuade Chaak to come to them. They had walked



In the once sacred waters of a cenote Karla and Justin Petraitis pose for photos after a wedding ceremony infused with Maya and New Age themes. The event was only symbolic, so the couple had married back home in Tennessee beforehand. Their wedding planner arranges a dozen such celebrations a year.

SHAUL SCHWARZ





A snorkeling tourist floats in a cenote called Las Calaveras—“the skulls”—near Tulum. Local Maya got their drinking water here until about 30 years ago, when divers found bones. Archaeologists have recorded the remains of more than a hundred people, usually shrouded by the water’s primordial darkness.

PAUL NICKLEN

THE RAIN STARTED—A SIGN THAT CHAAK HAD RECEIVED HIS OFFERING AND WAS PLEASED.



a long way through the forest to a secret cave and scrabbled down to its center on a scary rope system to bring up the water the ceremony required. They had raised the altar, dug the pib, gone to enormous expense to provide 13 fat hens for the ritual meal, guarded the altar overnight while praying and drinking balché, patted out the stacks of 13-layer corn-and-squash-seed breads that no women had been allowed to touch, cooked them in the pib, and brought them out of their fiery bed again, leaving the pit open so that the steam could rise directly to the rain god as an offering.

And now the hmem, Hipólito Puuc Tamay, a slow-moving, leathery man in a red baseball cap and much washed shirt, was standing in front of the altar praying to Chaak, to Jesus Christ, to all the saints, to San Juan Bautista, to the forces of the Earth and sky, and to Chaak again, to let the holy blessing of rain fall on them and on all the surrounding Maya communities so that they might survive one more full cycle of the sun. On instructions from the hmem, one of the villagers crouched on a rock behind and to one side of the altar, keeping very still, only blowing from time to time into one of the gourds in which Chaak stores the wind. He was just one of the neighbors, but he was also the rain god, and he sat with his eyes closed so as not to harm the ceremony with his terrible glance. Two other participants brought him to the altar, facing backward, to receive the hmem's neutralizing blessing.

And there the little frogs were too, five slightly abashed boys crouching at the foot of the world altar, one boy at each corner and one at the center, four of them saying, *hmaa, hmaa, hmaa*, and the fifth, *lek lek lek lek lek*, a blended sound remarkably like that of frogs in the evening rain.

Out of nowhere a wind came up in the clearing. Thunder rolled in the blue distance.

As the ceremonial meal of chicken and the corn-and-seed bread was being distributed to the exhausted men, the rain started—a light, refreshing summer shower. A sign, the hmem said, that Chaak had received his offering and was pleased with his people's prayer. Soon, perhaps, the Earth would be ready for planting. □

Braving Caves

DARK AND MYSTERIOUS, deep caves have attracted explorers since the 1800s. Caving pioneer Édouard-Alfred Martel, a French lawyer, investigated more than a thousand caverns in Europe and the U.S. for three decades. A self-taught scientist, he measured, mapped, and photographed as he went. He also promoted caving as a hobby in his vivid lectures and reports. After an 1889 visit to a French cave called Rabanel, he likened one chamber to a church's nave with "stalactites that hang like crystal tears."

To probe these cracks in the Earth, Martel relied on a rope rigged with pulleys, a winch, and a collapsible canvas boat (for subterranean rivers). By the 1950s most cavers were using cumbersome ladders made of steel cables. But Bill Cuddington, caving in the eastern U.S., worked out a simpler way: rappelling down and climbing up a single rope anchored to a rock. The technique slowly caught on and revolutionized the sport, earning him the nickname "Vertical Bill." Today similar rope work allows cavers to explore the depths of extreme chasms like Krubera (right), in the republic of Georgia.

As caving has pushed into such otherworldly realms, it has inspired a new generation of scientists. Hazel Barton is a University of Akron microbiologist. To get to her research sites hundreds of feet below the ground, she rappels down shafts, squeezes through cracks, and tiptoes along ridges just inches wide. Beyond the reach of the sun's energy, the bacteria she studies feed off rocks—and each other. There could be similar life hidden far beneath the surface of Mars, Barton says. "I'd be shocked if there isn't." —A. R. Williams

KRUBERA CAVE

Expeditions have pushed ever deeper into this chasm in the Caucasus Mountains, setting a series of records.

★ Current world record

★ Previous world record





HAZARDS

With the right gear, explorers can conquer caves that were once off-limits.

EXTREME HEAT

Cave of Crystals

Chihuahua, Mexico

An ice-cooled suit and air supply prevent heatstroke in temperatures that can hit 113°F, allowing visits of up to an hour.



TOXIC GAS

Cave of the Lighted House

Tabasco, Mexico

A respirator protects against hydrogen sulfide, which frequently reaches lethal levels.

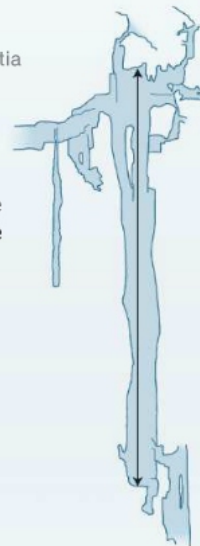


SHEER DROP

Velebita Cave

Rožanski Kukovi, Croatia

This vertical pit cave has the longest straight drop, at 1,683 feet. Rope designed to minimize stretch allows for safe rappelling.



Feet

0

-1,000

-2,000

-3,000

-4,000

-5,000

-6,000

-7,000

By Rachel Hartigan Shea Photograph by Marco Grob

Spacewalker

SUNITA WILLIAMS assumed as a kid that *The Jetsons* and *Star Trek* signaled a future where space travel would be routine. She never dreamed she'd be one of the pioneers. The former Navy pilot, age 47, has spent 322 days in space and 50 hours walking in space—the most spacewalking of any female astronaut. She first met astronauts two decades ago during test pilot school—and discovered that with her flying experience, she could join them. Now, as a member of the astronaut corps, she draws upon her Navy background. Walking in space, she says, is like flying a helicopter with a battle group: You focus on your job but always know where the other guy is.

What's the most impressive thing about a space walk?

The view—being way, way high looking down and seeing the northern lights below.

Is it scary?

On my first walk [in 2006] there was a problem with a solar array that we needed to look at. As I started going up [the arm connecting the array to the station], I felt like I was climbing a skyscraper. I had to tell myself, It's OK. You're not going to fall. I clipped on a local tether and let my hands go to prove to myself, Hey, you're OK. In space if you close your eyes for a second, you can twist the frame of reference. I remembered how we trained in the pool climbing this piece [while it lay] on its side, so I said to myself, OK, I'm on its side. I'm not climbing up; I'm climbing sideways.

Are there things you do to keep yourself grounded while living in space?

On my first flight I would float down to the [Russian] end of the space station because there was only one bathroom at the time. [Cosmonaut] Misha Tyurin would always say, "Would you like some tea?" We would sit or float or whatever for five or ten minutes drinking tea and just talk about life.

You did a space triathlon: treadmill, stationary bike. How'd you swim?

[To mimic] the swim, I had 15 exercises. It lasted about 20 minutes, my usual swim time.

What next?

Eventually I might like to teach seventh-grade science. But I'd love it if the U.S. could get the next spacecraft going. I'd jump at the chance to be a test pilot.





OPENING HATCH

- 1. PRESSURE EQUALIZATION VALVE - OPEN
- 2. CRANK HANDLE - Engaged position
- 3. RATCHET - UNLATCH position
- 4. CRANK HANDLE - Turn to UNLATCH direction
- 5. INDICATOR - UNLATCHED
- 6. CRANK HANDLE - Shoved position
- 7. PRESSURE EQUALIZATION VALVE - CLOSED
- 8. RATCHET - LATCH position
- 9. TOP HANDLE - Push in
- 10. BOTTOM HANDLE - Pull up. Move
- 11. BASE TO REMOVE HATCH OPERATOR
- 12. STOWAGE LATCH BUTTON - Push
- 13. STOWAGE LATCH HANDLE - Pull

CLOSING HATCH

- 1. STOWAGE LATCH BUTTON - Push
- 2. STOWAGE LATCH HANDLE - Pull
- 3. HATCH - Pull down
- 4. PRESSURE EQUALIZATION VALVE - CLOSED
- 5. RATCHET - LATCH position
- 6. CRANK HANDLE - Engaged position
- 7. CRANK HANDLE - Turn to LATCH direction
- 8. INDICATOR - LATCHED
- 9. CRANK HANDLE - Shoved position





Parade of the Painted Elephants

*Adorning pachyderms
is elevated to an art form
at an annual festival
in Jaipur, India.*

Held in high esteem, elephants have played an outsize role in India's history and culture.



THE ROYALTY OF INDIA—HINDU AND MUSLIM—UNDERSTOOD LONG ago that power was best wielded from the back of an elephant. Kings appeared before their dazzled subjects on elephants whose ivory tusks glittered with gold and silver and whose bodies shimmered in silk and velvet. “An elephant mounted by a king is radiant; a king mounted on an elephant is resplendent,” proclaims one historical manuscript.

Tourists are now king, and so at the Elephant Festival in Jaipur, Rajasthan, instead of pomp there are elephant polo, elephant tug-of-war, and an elephant beauty contest. The participants in the festival are working animals, which spend most days ferrying tourists up to the Amber Palace, a historic site above the city that attracts visitors from all over the world. For the annual festival the elephants are garbed in their finest costumes. Last spring photographer Charles Fréger traveled to Jaipur to capture the elephants in their glory—bright with paint, bangles, and drapes. He was drawn to the elephants because in India they are “sacred sometimes and being used sometimes.” But they also have strong personalities, he says, “playing and moving all the time.” He got the pictures, but then the festival was canceled, reportedly because animal rights groups raised concerns about how the animals were treated.

The elephant has long been revered by Indians. And that has “helped massively” to protect them, says Rachel Dwyer, a British scholar researching the cultural history of Indian elephants. “India’s elephants have survived in larger numbers than other elephants in Asia.” The elephant-headed god Ganesh, the remover of obstacles, is invoked before every new endeavor. Elephants add to the aura of temples and bestow blessings on the devoted. Beautiful women are said to walk with an elephant’s gait.

But the animals face an uncertain future. An estimated 3,500 to 4,000 elephants are held in captivity, and according to Suparna Bakshi Ganguly, a former member of India’s Task Force on Elephants, “almost all are part of the huge illegal trafficking in wildlife.” Some steps have been taken to improve their welfare. The elephants photographed here dwell in Hathi Gaon, a village near the Amber Palace designed specifically for elephants and their mahouts. Tall enclosures that shelter the elephants are scattered among ponds where the mahouts bathe the great beasts at the end of the day. “Tradition has no meaning if it results in suffering and exploitation,” says Ganguly, yet “all Indians, culturally, have love, respect, and great devotion for the elephant.” —Rachel Hartigan Shea

Elephants once carried soldiers into battle. Now grooms ride them in splendid wedding processions.







Asian elephants lack the grand tusks of their African cousins, and many males don't have tusks at all. Females have tushes, long teeth hidden by their upper lips. Some mahouts screw long plastic tusks into the tushes (left and upper right) to make their elephants look more dramatic.





The elephants are decorated with the same kinds of pigments that are used during Holi, the Hindu festival in which celebrants splash each other with bright colors. Professional artists paint the elephants in advance of the festival in Jaipur, which is held on the eve of Holi.





LECTURE

Joel Sartore

Photographer Joel Sartore's work for the *Geographic* has brought him face-to-face with animals of all stripes, like this veiled chameleon. Now he's on a quest to photograph every endangered species on Earth. For his speaking dates in Canada, Australia, and New Zealand visit nglive.org.

PHOTOS

NATIONAL GEOGRAPHIC ON INSTAGRAM Follow *National Geographic* magazine's official Instagram feed and see what our globe-trekking photographers are up to. Daily updates include dispatches from the field and unpublished images. Search for the user name @natgeo.

TRIPS



ADVENTURE TRAVEL Our adventure trips are designed for travelers eager to explore off the beaten path—on foot or on horseback, by kayak or even by dogsled. Find action-packed itineraries for Patagonia, Mount Kilimanjaro (left), and destinations closer to home at nationalgeographicadventures.com.

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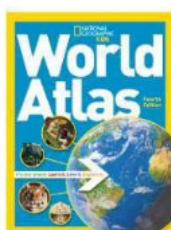
THE BEAUTIFUL DAYS This photography exhibit, now touring South Korea, showcases the diversity of life on the land, in the air, and under the sea. Amy Toensing's portrait of a Papua New Guinean (right) is just one of 180 images on display. See ngphoto.co.kr for more.



GAME

PLAN IT GREEN How would you do as a city mayor? This free game allows kids of all ages to plan their own energy-efficient cities—complete with parks and power plants—and compete for the best city ranking. Start building your eco-friendly metropolis at planitgreenlive.com, and use code GREEN2013 for a special bonus.

Book of the Month



National Geographic Kids World Atlas

Our award-winning maps now come in a fresh, kid-friendly design. This updated atlas has a new games section with crosswords and puzzles that incorporate the latest statistics and country information. Classic National Geographic maps, rich graphics, and more than 200 illustrations round out the volume. Available now (\$14.99).

Eyes on the Pride Nighttime was the right time for veteran *National Geographic* photographer Michael Nichols to take pictures of lions. The cats sleep most of the day, preserving energy for hunts after dark. To capture a pride's pursuit of prey—or the sharing of bounty (below)—he used infrared light that is not disruptive to lions and produces black-and-white images. For close-ups, he affixed a camera to a small robot. “We never wanted to use equipment that would startle them or deny them a meal,” Nichols says. “We tried to treat them with honor.” —Daniel Stone



BEHIND THE LENS

You really did get up close and personal with the lions.

MN: We did. We had incredible intimacy. Our car was closer than close, just a few feet away. We saw cubs when they were tiny and watched them grow up. I never thought I'd find so much family support among them. Lions are different from house cats, which can live individually. Being there, you really see how much they depend on each other to survive.

Were you afraid of getting hurt?

Psychologically, it's very strange. You have to take the leap of faith that they have no desire to hurt you. But if you make a mistake, like putting your arm or leg outside the car, all of that

could change. One swipe and you'd be done. One time a lion three feet away almost walked into our vehicle.

Did you sense that they felt threatened by you?

They were nervous at first but quickly

got habituated to us. They see the car as one entity, not understanding that humans are in it. Lions are very efficient animals, so they won't expend energy unless they see you as a threat. We got very close, but we never interacted.



Glove Story A metal-mesh glove “like a crusader’s gauntlet” protected photographer Luis Marden’s hand while he changed flashbulbs during a shoot in Mexico’s Yucatán. “Up From the Well of Time,” the longtime *Geographic* staffer’s story on the region’s Dzibilchaltún cenote, appeared in the January 1959 issue of the magazine. Marden learned the hard way that such an accessory was necessary when working in the deep. (His dives at Dzibilchaltún reached depths of 144 feet.) According to notes that accompany the photo: “Once while Marden was diving in the Mediterranean, a flashbulb imploded under water pressure and nearly cost him his thumb.” —Margaret G. Zackowitz

📌 **Flashback Archive** Find all the photos at [ngm.com](https://www.nationalgeographic.com/flashback).

PHOTO: LUIS MARDEN, NATIONAL GEOGRAPHIC CREATIVE

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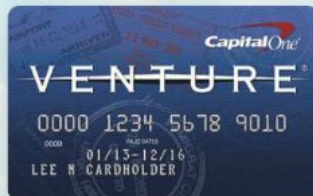
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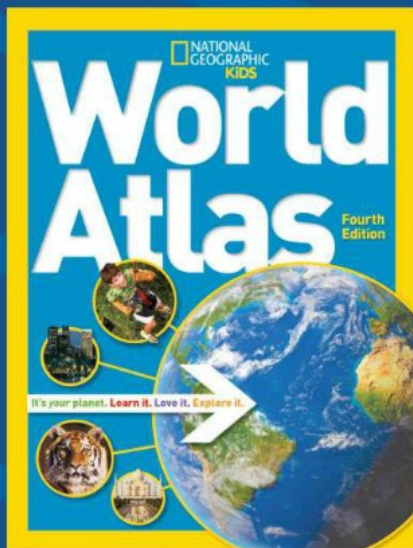
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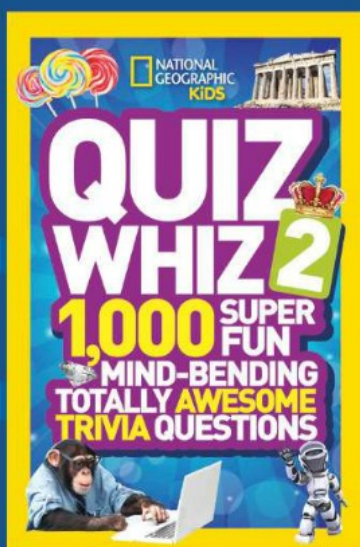
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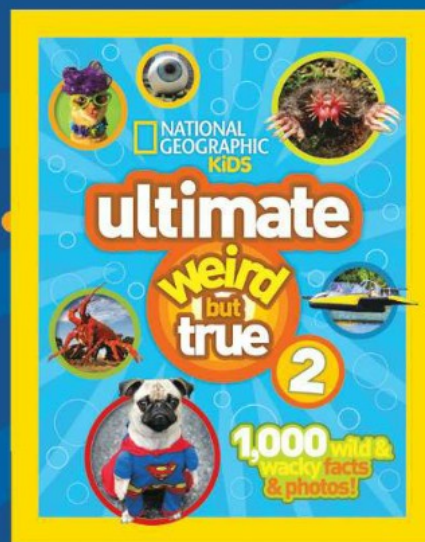
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