NATIONAL GEOGRAPHIC

RACE TO THE RED PLANET

NOVEMBER 2016

Red-shanked Douc Langur *(Pygathrix nemaeus)*
Size: Head and body length, 49 - 63 cm (19.3 - 24.8 inches); tail, 42 - 66 cm (16.5 - 26 inches) **Weight:** 6 - 11.6 kg (13.2 - 25.6 lb) **Habitat:** Subtropical and tropical evergreen and semi-deciduous broadleaf forest, bamboo forest, montane forest and forested karst **Surviving number:** Unknown

Photographed by Cyril Ruoso

WILDLIFE AS CANON SEES IT

Living it up. The red-shanked douc langur spends most of its time in the forest canopy, where it forages for leaves, leaf buds, fruit, seeds and bark. The colorful langur feeds in the morning and afternoon, and uses the middle of the day to rest, socialize and play. Vocalizations and gestures – ranging from threatening growls and distress squeals to submissive open-mouthed grimaces – help it communicate with group members. But these close-knit groups face an uncertain future due to widespread hunting and habitat loss.

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


EOS System

Canon

NATIONAL GEOGRAPHIC
NOVEMBER 2016 • VOL. NO. 5

See video of the camouflage tricks and getaway moves of octopuses—like this southern keeled octopus—at *natgeo.com/octopus.*

On the Cover The four images in this composite were captured on October 4, 2014, by India's Mars Orbiter Mission probe, circling at an altitude of about 47,650 miles. *Image: Indian Space Research Organisation*

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

Beyond the Magazine

Your guide to National Geographic TV programs, online exclusives, videos, books, and more

TELEVISION

Countdown to *MARS* Launch

A six-part series that blends documentary footage, scripted drama, and computer-generated visuals, *MARS* is the creation of award-winning filmmakers Brian Grazer and Ron Howard.

Premieres Monday, November 14, at 9/8c on National Geographic

TELEVISION

Join a Botswana Safari

Safari Brothers follows the adventures of a family-run expedition company in Botswana.

Fridays at 10/9c starting October 14, on Nat Geo WILD

NATGEO.COM/PHOTOCONTEST

Win a Trip to the Galápagos

Submit your best nature images at *natgeo.com/photocontest* for a chance to win a Galápagos trip for two and be named Nat Geo Nature Photographer of the Year.

NATGEO.COM VIDEO

Meet the Deep's Dexterous Denizen, the Octopus

A remarkably complex nervous system operates those characteristic eight legs.

Watch videos throughout the article at ngm.com/Nov2016.

TELEVISION

Tales of the Emperor's Tomb

Learn what terra-cotta warriors were guarding in the ruler's funerary complex, in *China's Megatomb Revealed.*

Sunday, October 23, at 9/8c on National Geographic

BOOKS

National Geographic Greatest Landscapes

Stunning photos take you to the world's most beautiful places.

Available at shopng.com/landscapes

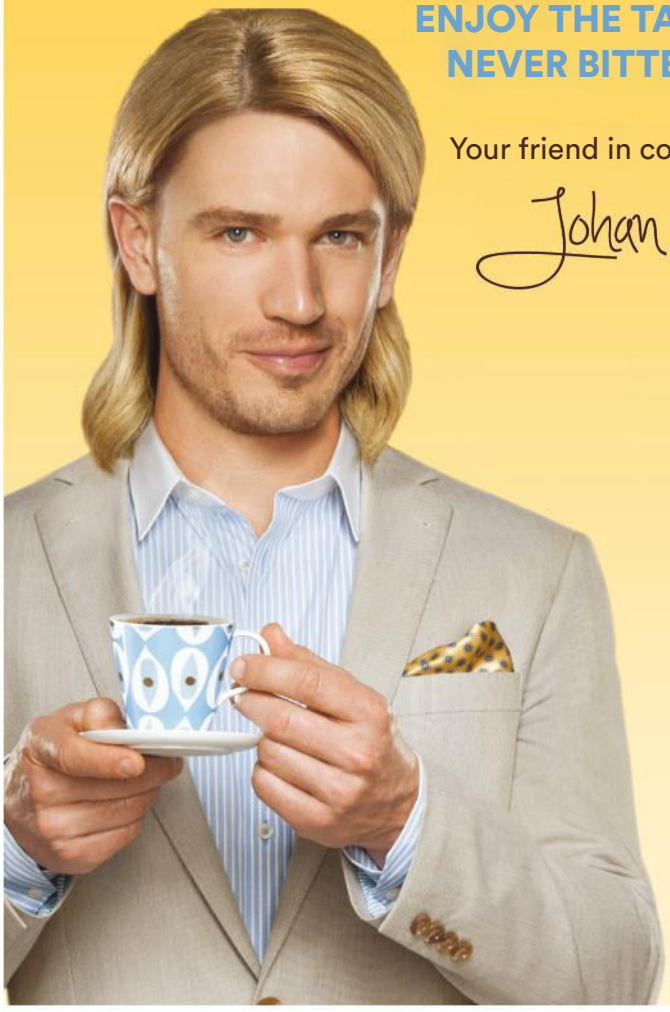
PHOTO ILLUSTRATION: ROBERT VIGLASKY, NATIONAL GEOGRAPHIC CHANNELS (TOP).
PHOTOS: NATIONAL GEOGRAPHIC CHANNELS/SYMBIO STUDIOS (LEFT); TOMÁS MUNITA

DON'T BE BITTER, STARBUCKS.

MORE PEOPLE PREFER THE TASTE OF GEVALIA.

With over 150 years of experience making rich, never bitter coffee, it's no wonder **more people prefer the taste of Gevalia House Blend to your house blend,** Starbucks. But don't feel bad. We might have better taste in coffee. But you have better taste in artisanal cheese plates.

ENJOY THE TASTE OF RICH, NEVER BITTER GEVALIA.



Your friend in coffee,

Johan

Based on a January 2016 national taste test of coffee drinkers conducted by an independent third party comparing Gevalia House Blend and Starbucks House Blend.

To Mars, by Multimedia

In winter the temperature at the poles of Mars can reach 200° below zero Fahrenheit. But make no mistake: The red planet is the hottest topic in space.

Astronauts might begin a mission to explore Mars in 2024, as SpaceX company founder Elon Musk projects. Or, as NASA contends, it may take longer: The space agency puts the date in the 2030s, and then not to land on Mars but just to orbit it.

At National Geographic, exploration of new frontiers is in our DNA. As far as Mars goes, we've already launched—and landed. This month:

- National Geographic will unveil a six-part television series, *MARS,* blending documentary footage of today's efforts to reach the planet with a scripted story focused on how we might eventually build a new civilization there. It premieres November 14.
- Our book division is publishing *Mars: Our Future on the Red Planet,* featuring incredible space photography and comprehensive explanations of the science that may ultimately enable Mars colonization.
- In our *Kids* magazine a handy guide gives answers to questions that Mars-bound youngsters might have, from "How will I go to the bathroom?" to "What will I eat?"
- Our social media efforts include a series on Snapchat Discover in which we invite our audience to take Mars quizzes on topics such as "Could you survive on Mars?"
- Finally we have "Mars: The Race to the Red Planet," this magazine's cover story, by Joel Achenbach. It examines our long-held fascination with Mars—18,300 people applied for the eight to 14 slots in NASA's next class of astronauts—and what it would take to actually pull off a mission.

March 2016: Russian cosmonaut Sergey Volkov is greeted after returning from six months on the International Space Station.

Everything about sending astronauts to Mars is hard: safeguarding them against radiation from cosmic rays, preventing bone loss in a zero-gravity environment, keeping them psychologically stable during what would be, at a minimum, roughly a two-year journey there and back.

"This is not a business trip to a different city, when you miss your apartment, your home, family," said Russian cosmonaut Mikhail Kornienko, who spent nearly a year on the International Space Station. "This is about missing the Earth as a whole. It is a completely different emotion. There is a shortage of greenery, for real, like not enough forest, summer, winter, snow."

It will be a brave person indeed who ultimately lands on Mars. You can count on National Geographic to document that journey—and maybe even plant a flag.

Thank you for reading.

Susan Goldberg, *Editor in Chief*

PHOTO: PHILLIP TOLEDANO

FROM EXECUTIVE PRODUCERS

BRIAN GRAZER AND RON HOWARD

MARS

WE WENT TO THE MOON BECAUSE WE WANTED TO.

WE WENT TO MARS BECAUSE WE HAD TO.

MONDAYS 9/8c | PREMIERES NOV 14

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NATIONAL GEOGRAPHIC

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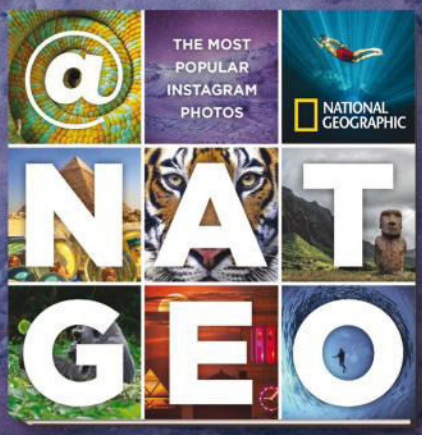
We believe in the power of science, exploration, and storytelling to change the world.

The National Geographic Society is a global nonprofit membership organization committed to exploring and protecting our planet.



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NATIONAL GEOGRAPHIC

Why the Climate Gets Top Billing

Leonardo DiCaprio likes to say that he makes his living in made-up worlds. The Oscar-winning actor, 41, has played an 1820s frontiersman, a 1920s tycoon, and a 1960s con man. Now DiCaprio, a UN messenger of peace, has produced a documentary about a very real concern: climate change, and the need for government action. He shot *Before the Flood* all over the world—this time playing himself.

Before the Flood airs Sunday, October 30, at 9/8c on National Geographic.

Whom do you hope to reach with the film?
We all have a role to play in saving our planet. This film is meant to educate everyone, from global leaders to everyday citizens, on the threat of climate change. There are practical steps we all must take—today—to hasten the adoption of renewable and clean-energy technologies across the planet. For the film we interviewed inspiring figures, from Pope Francis and President Obama—who both have the ability to galvanize millions of people—to activists like Sunita Narain, a tremendous voice in India who's calling for her country to be part of a global solution.

How can an issue like climate change attract more sustained attention?
There is no issue this important—because the future of the planet is at stake. We have no planet B. The energy we focus on solving climate change and the pressure we place on global leaders to lead on the question will help create a sustainable and livable environment for the long term.

You traveled around the world for this film. What message do people have for Americans?
We need to vote for leaders who understand the serious issues impacting our climate—and for leaders who believe in the undeniable truth of science. No nation or society is immune from the symptoms of climate change. America is in many places already feeling the impacts of it: droughts in California, rising seas in Miami, more extreme storms in the Gulf of Mexico. We can still prevent these crises from becoming a widespread challenge in the future of our country. We have an opportunity to lead the world on one of the most crucial issues of all time.

THIS INTERVIEW WAS EDITED FOR LENGTH AND CLARITY.

PHOTO: PROVIDED BY JOHN RUSSO, *BEFORE THE FLOOD*

BOOKS
Always a great idea!

NATIONAL GEOGRAPHIC

AVAILABLE WHEREVER BOOKS AND EBOOKS ARE SOLD
and at shopng.com/books

NatGeoBooks @NatGeoBooks

VISIONS

Myanmar
At a brick factory on the outskirts of Yangon, a swaddled baby sways in a makeshift hammock. The child's mother works at the kiln, where she's paid for each brick she manufactures. Many families work—and live—at the site.

PHOTO: SOE ZEYA TUN, REUTERS

Turkey
A dusty pastoral scene unfolds in Bitlis Province, where shepherds guide their flocks toward grazing areas near Nemrut Mountain. This arid part of eastern Turkey—with its harsh climate and scant arable land—is heavily reliant on livestock.

PHOTO: ABDULLAH METIN

Order prints of select *National Geographic* photos online at **NationalGeographicArt.com.**

United States
In the Sonoran Desert near Red Rock, Arizona, a fast-moving electrical storm and a rainbow share the sky in this composite image. Several ranges in this part of Arizona—including the nearby Tortolita Mountains—help spawn thunder and lightning.

PHOTO: JACK DYKINGA, NATURE PICTURE LIBRARY

For people with a higher risk of stroke due to
Atrial Fibrillation (AFib) not caused by a heart valve problem

I won't accept going for less than my best.

ELIQUIS® (apixaban) is a prescription medicine used to reduce the risk of stroke and blood clots in people who have atrial fibrillation, a type of irregular heartbeat, not caused by a heart valve problem.

IMPORTANT SAFETY INFORMATION:

- **Do not stop taking ELIQUIS for atrial fibrillation without talking to the doctor who prescribed it for you. Stopping ELIQUIS increases your risk of having a stroke.** ELIQUIS may need to be stopped, prior to surgery or a medical or dental procedure. Your doctor will tell you when you should stop taking ELIQUIS and when you may start taking it again. If you have to stop taking ELIQUIS, your doctor may prescribe another medicine to help prevent a blood clot from forming.
- **ELIQUIS can cause bleeding, which can be serious,** and rarely may lead to death.
- **You may have a higher risk of bleeding if you take ELIQUIS and** take other medicines that increase your risk of bleeding, such as aspirin, NSAIDs, warfarin (COUMADIN®), heparin, SSRIs or SNRIs, and other blood thinners. **Tell your doctor about all medicines, vitamins and supplements you take.**

While taking ELIQUIS, you may bruise more easily and it may take longer than usual for any bleeding to stop.

- Get medical help right away if you have any of these signs or symptoms of bleeding:
  - unexpected bleeding, or bleeding that lasts a long time, such as unusual bleeding from the gums; nosebleeds that happen often, or menstrual or vaginal bleeding that is heavier than normal
  - bleeding that is severe or you cannot control
  - red, pink, or brown urine; red or black stools (looks like tar)
  - coughing up or vomiting blood or vomit that looks like coffee grounds
  - unexpected pain, swelling, or joint pain; headaches, feeling dizzy or weak
- **ELIQUIS is not for patients with artificial heart valves.**

Now I'm going for something better than warfarin. ELIQUIS.

Reduced the risk of stroke better than warfarin.

ELIQUIS® (apixaban)

Had significantly less major bleeding than warfarin.

No routine blood testing.

ELIQUIS and other blood thinners increase the risk of bleeding which can be serious, and rarely may lead to death.

Ask your doctor if switching to ELIQUIS is right for you.

- **Spinal or epidural blood clots (hematoma).** People who take ELIQUIS, and have medicine injected into their spinal and epidural area, or have a spinal puncture have a risk of forming a blood clot that can cause long-term or permanent loss of the ability to move (paralysis). This risk is higher if, an epidural catheter is placed in your back to give you certain medicine, you take NSAIDs or blood thinners, you have a history of difficult or repeated epidural or spinal punctures. Tell your doctor right away if you have tingling, numbness, or muscle weakness, especially in your legs and feet.
- **Before you take ELIQUIS,** tell your doctor if you have: kidney or liver problems, any other medical condition, or ever had bleeding problems. Tell your doctor if you are pregnant or breastfeeding, or plan to become pregnant or breastfeed.
- **Do not take ELIQUIS if you** currently have certain types of abnormal bleeding or have had a serious allergic reaction to ELIQUIS.

A reaction to ELIQUIS can cause hives, rash, itching, and possibly trouble breathing. Get medical help right away if you have sudden chest pain or chest tightness, have sudden swelling of your face or tongue, have trouble breathing, wheezing, or feeling dizzy or faint.

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

Please see additional Important Product Information on the adjacent page.

Individual results may vary.

Learn about savings and offers.

Visit ELIQUIS.COM or call 1-855-ELIQUIS

Eliquis®
(apixaban) tablets 5mg 2.5mg

IMPORTANT FACTS about ELIQUIS® (apixaban) tablets *(Continued)*

- treat blood clots in the veins of your legs (deep vein thrombosis) or lungs (pulmonary embolism), and reduce the risk of them occurring again.

It is not known if ELIQUIS (apixaban) is safe and effective in children.

Who should not take ELIQUIS?

Do not take ELIQUIS if you:

- currently have certain types of abnormal bleeding
- have had a serious allergic reaction to ELIQUIS. Ask your doctor if you are not sure

What should I tell my doctor before taking ELIQUIS?

Before you take ELIQUIS, tell your doctor if you:

- have kidney or liver problems
- have any other medical condition
- have ever had bleeding problems
- are pregnant or plan to become pregnant. It is not known if ELIQUIS will harm your unborn baby
- are breastfeeding or plan to breastfeed. It is not known if ELIQUIS passes into your breast milk. You and your doctor should decide if you will take ELIQUIS or breastfeed. You should not do both

Tell all of your doctors and dentists that you are taking ELIQUIS. They should talk to the doctor who prescribed ELIQUIS for you, before you have **any** surgery, medical or dental procedure. **Tell your doctor about all the medicines you take, including** prescription and over-the-counter medicines, vitamins, and herbal supplements. Some of your other medicines may affect the way ELIQUIS works. Certain medicines may increase your risk of bleeding or stroke when taken with ELIQUIS.

How should I take ELIQUIS?

Take ELIQUIS exactly as prescribed by your doctor. Take ELIQUIS twice every day with or without food, and do not change your dose or stop taking it unless your doctor tells you to. If you miss a dose of ELIQUIS, take it as soon as you remember, and do not take more than one dose at the same time.

If you have difficulty swallowing the tablet whole, talk to your doctor about other ways to take ELIQUIS (apixaban). **Do not run out of ELIQUIS. Refill your prescription before you run out.** When leaving the hospital following hip or knee replacement, be sure that you will have ELIQUIS available to avoid missing any doses. **If you are taking ELIQUIS for atrial fibrillation, stopping ELIQUIS may increase your risk of having a stroke.**

What are the possible side effects of ELIQUIS?

- See **"What is the most important information I should know about ELIQUIS?"**
- ELIQUIS can cause a skin rash or severe allergic reaction. Call your doctor or get medical help right away if you have any of the following symptoms:
  - chest pain or tightness
  - swelling of your face or tongue
  - trouble breathing or wheezing
  - feeling dizzy or faint

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

These are not all of the possible side effects of ELIQUIS. For more information, ask your doctor or pharmacist. Call your doctor for medical advice about side effects. You may report side effects to FDA at 1-800-FDA-1088.

This is a brief summary of the most important information about ELIQUIS. For more information, talk with your doctor or pharmacist, call 1-855-ELIQUIS (1-855-354-7847), or go to www.ELIQUIS.com.

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July 2016
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Sights and Sounds

Assignment Music is something most of us hear. But how do we *see* it? We challenged the Your Shot community to show the spectacle of sound.

EDITOR'S NOTE

'There's nothing easy about photographing music. The scene, the framing, the lighting all need to align for one fleeting moment. Line them up, and you can almost hear the notes.'

Matt Adams, *Your Shot assignment editor*

Igor Ivanko
Moscow, Russia

Ivanko, a photojournalist, knew there would be fireworks and a band at Moscow's International Military Music Festival. "I drew this picture in my head in advance," he says. After he found the best angle, he framed the shot—with a slight tilt—to include the full bursts of the fireworks.

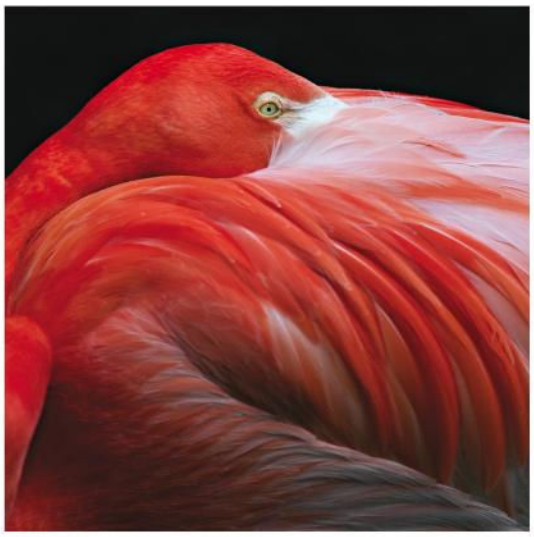
A World of Beauty

For over a century National Geographic photographers have returned from their assignments with thousands more photographs than we can include in the magazine. Today Instagram, the web and mobile platform, helps us share more of those wide-ranging images: people, places, and events on all seven continents.

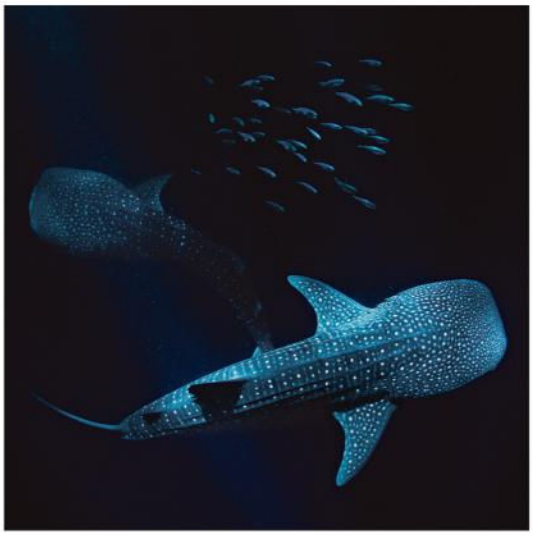
A new book titled *@NatGeo* features 255 popular images across several themes. The images below appear in the chapter on beauty. Join us on Instagram—*@natgeo*—for more.

The book @NatGeo *is available at* shopng.com/natgeobook *or wherever books are sold.*

@ARGONAUTPHOTO An ensemble of Svan youths in the republic of Georgia revives traditional folk dances.



@ROBERTCLARKPHOTO An elegant flamingo preens during a photo shoot.



@THOMASPESCHAK Subadult whale sharks gather off the coast of Djibouti to feed on plankton blooms.

@LUCALOCATELLIPHOTO Man-made "supertrees" can be seen in Singapore's ecotourism hub Gardens by the Bay.

CLOCKWISE FROM TOP LEFT: AARON HUEY; ROBERT CLARK; LUCA LOCATELLI; THOMAS P. PESCHAK

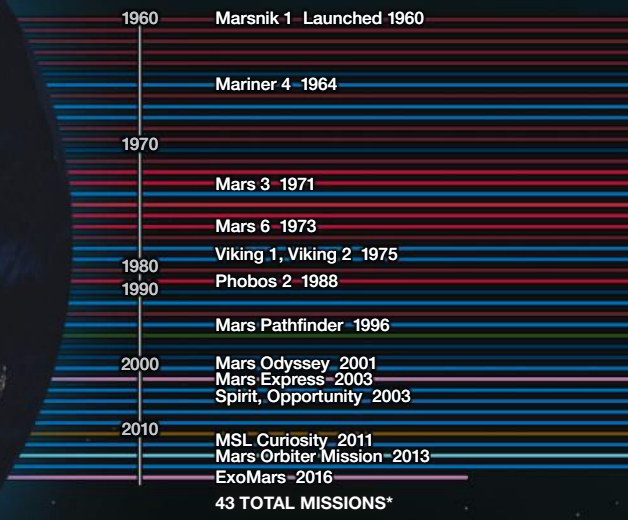
EXPLORE

Science

50 Years of Martian Invasions

Even before humans landed on Earth's moon, we'd been sending spacecraft to our closest planetary neighbor, Mars. As these craft have flown past, orbited around, landed on, and driven over the surface of Mars, there have been utter failures and spectacular successes. As NASA sets its sights on a manned Mars mission in the 2030s, we look back on mission history.

MISSIONS TO MARS
Each line below is color-coded to represent one mission that reached Mars or failed in the attempt; the type of mission; and the country of origin.



NOTABLE MISSIONS

Mariner 4
U.S. *1964*
This flyby provided the first close-up photos of Mars.

Mars 3
U.S.S.R. *1971*
This was the first successful lander, though it stopped transmitting after 20 seconds.

Viking 1 & 2
U.S. *1975*
The first U.S. landers on Mars returned color images from the surface.

*All Mars missions launched as of August 2016

FAILURE TO LAND
Many missions launch with several stages planned. While an orbiter might be successful, its lander can fail; that's been the case with Mars 2, Mars 6, Phobos 2, and Mars Express.

2001 Mars Odyssey
U.S. *2001*
The orbiter is the longest serving Mars spacecraft.

Mars Express
ESA *2003*
The lander was lost, but the orbiter keeps making images.

Mars Orbiter Mission
India *2013*
India's first Mars probe carries imaging and scientific instruments.

GRAPHIC: MATTHEW TWOMBLY
SOURCES: NASA; EUROPEAN SPACE AGENCY; INDIAN SPACE RESEARCH ORGANISATION

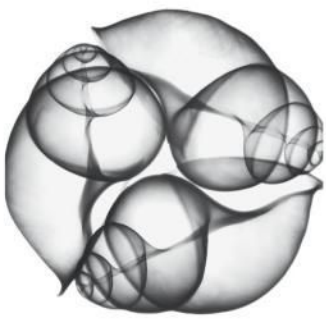
Sahara's Coolest Ants

Most animals seek shade when temperatures in the Sahara soar to 120 degrees Fahrenheit. Saharan silver ants (above) seek lunch, skittering from underground lairs into the sun's brutal rays to scavenge animal carcasses. In 2015 they were joined by scientists from two Belgian universities, who spent a sweltering month tracking the ants and digging out their nests. The goal: to discover how the species adapted to the kind of heat that can melt shoes.

Back in Belgium, the scientists looked at the ants under an electron microscope and found that their dense, triangular hair reflects light like a prism, giving them a metallic glint and shielding them from the sun's heat. When Ph.D. student Quentin Willot shaved an ant with a tiny scalpel and put it under a heat lamp, its temperature jumped. He says the ants' method of staying cool is unique among animals. Could this reflective type of hair protect people? Willot says companies are interested in reproducing it. *—Nina Strochlic*

SNAIL SHELLS REVEAL SECRET TO ASYMMETRY

On the outside, your body is symmetrical: two legs, two arms—roughly the same on each side. But your innards are mostly an asymmetrical mess. In contrast, snails "wear their asymmetry on the outside," says Angus Davison, an evolutionary geneticist. Davison and his team identified the gene in pond snails that makes their shells spiral clockwise—and it turns out to be the same crucial gene that determines cell structure in vertebrates, including humans. What if it mutates? In snails, shells spiral left; in humans, mutations of this gene tend to be fatal. *—Rachel Hartigan Shea*



PHOTOS: NORMAN NAN SHI AND NANFANG YU, COLUMBIA UNIVERSITY (TOP); ALBERT KOETSIER

IF YOU HAVE DIABETES AND SHOOTING BURNING PINS AND NEEDLES PAIN IN YOUR FEET OR HANDS,

ASK YOUR DOCTOR ABOUT LYRICA® (pregabalin).

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

*Individual results may vary.

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

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

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

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

LYRICA® PREGABALIN © capsules

IT'S SPECIFIC TREATMENT FOR DIABETIC NERVE PAIN

IMPORTANT FACTS

LYRICA® PREGABALIN ©
capsules

(**LEER**-i-kah)
(pregabalin)

IMPORTANT SAFETY INFORMATION ABOUT LYRICA

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

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

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

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

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

ABOUT LYRICA

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

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

BEFORE STARTING LYRICA

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

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

BEFORE STARTING LYRICA, continued

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

POSSIBLE SIDE EFFECTS OF LYRICA

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

If you have any of these symptoms, tell your doctor right away.
The most common side effects of LYRICA are:
- Dizziness
- Blurry vision
- Weight gain
- Sleepiness
- Trouble concentrating
- Swelling of hands and feet
- Dry mouth

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

HOW TO TAKE LYRICA

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

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

NEED MORE INFORMATION?

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

PARKE–DAVIS, Division of Pfizer Inc., New York, NY 10017

Version March 2016

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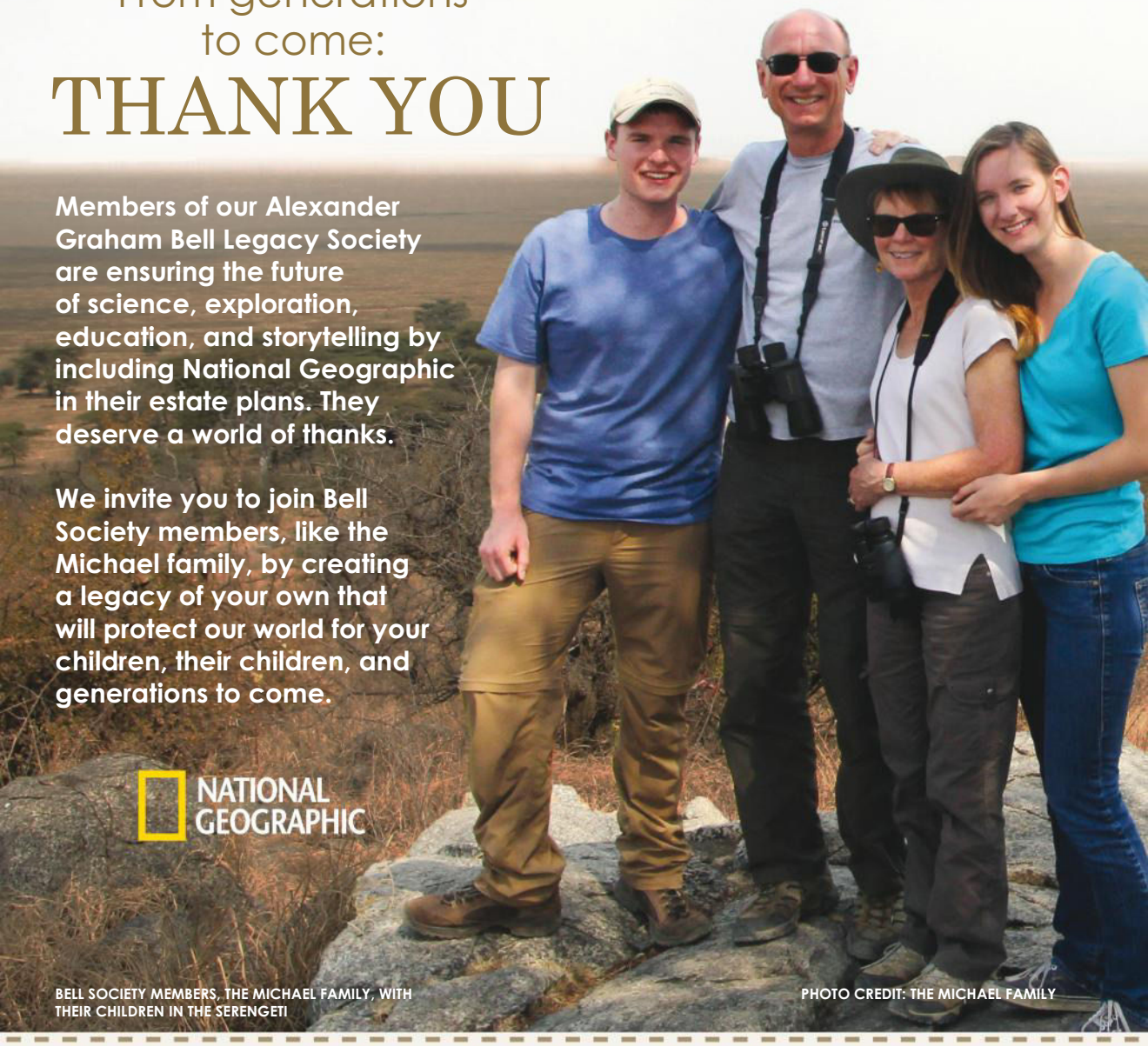

BELL SOCIETY MEMBERS, THE MICHAEL FAMILY, WITH THEIR CHILDREN IN THE SERENGETI

PHOTO CREDIT: THE MICHAEL FAMILY

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Secrets of the Terra-Cotta Warriors

In 1974 farmers uncovered strange terra-cotta figures while digging a well near the old Chinese capital of Xianyang. Excavations revealed a virtual army of warriors, presumably meant to eternally protect China's first emperor, Qin Shi Huang Di, after his death in 210 B.C. But an account from about 89 B.C. makes no mention of those figures. Instead, it tells of the next emperor sacrificing concubines to be buried with the deceased ruler and entombing craftsmen to keep them from talking about the lavish burial they had created. Was that historian wrong?

Perhaps not. Over the past four decades, archaeologists have discovered various mass burials in the emperor's funerary complex—the 20-plus square miles around his tomb, partly illustrated here. The emperor's final resting place remains untouched. But in light of these discoveries, it seems entirely possible that the burial chamber may include the bronze coffin, replicas of palaces, rivers of mercury, and "rare utensils and wonderful objects" that the first-century B.C. text describes. *—A. R. Williams*

Tour the tomb site with National Geographic, airing October 23 at 9/8c.

Workers' Burials
Artisans, craftsmen, and laborers who died during the 36 years it took to build this complex were buried here. Some were identified by a ceramic tile fragment (right) that served as a tombstone.

Additional Finds
Excavations revealed many pits within and outside the walls of this complex. Bronze chariots, stone suits of armor, and terra-cotta figures such as acrobats came to light, along with the remains of real horses and other animals.

The Emperor's Tomb
Historical records say Qin Shi Huang Di created a replica of his realm as his final resting place. Archaeologists have not yet dug here, fearing that exposure might damage any buried treasures.

Murdered Princes
One of the first emperor's many sons killed his brothers to gain the throne. Those royals may lie here. The skeletons are mostly male, and the tip of an arrow splits one of the skulls.

DAISY CHUNG AND ANDREW UMENTUM, NGM STAFF; MANYUN ZOU. SOURCES: ZHANG WEIXING AND XIUZHEN LI, ARCHAEOLOGY DEPARTMENT, EMPEROR QIN SHI HUANG'S MAUSOLEUM SITE MUSEUM; ROBERTO CIARLA, "GIUSEPPE TUCCI" NATIONAL MUSEUM OF ORIENTAL ART

Sumatra, Indonesia

Riding in a Rickshaw With a Hostage Orangutan

PANUT HADISISWOYO *Conservationist*

Sumatra's orangutan population has declined 85 percent since 1900. Hadisiswoyo (top) and his team work to protect those remaining, including returning illegally traded animals to the wild.

Orangutans that live in Sumatra usually make their nests in palm forests. But one day in 2014, Panut Hadisiswoyo caught sight of an orangutan riding around the streets of Medan, the island's largest city, in a rickshaw. Hadisiswoyo runs the Orangutan Information Centre, an Indonesian NGO devoted to saving endangered apes, and so he gave chase, on foot, through traffic. "I jumped in the rickshaw and made the driver stop," he says. Then he put the orangutan's chaperone, a wildlife trader, under citizen's arrest and called for backup from his staff. The police arrived three hours later.

His work is not often that exciting. It's also rarely easy. The National Geographic emerging explorer spends most of his time trying to stop deforestation by palm oil and other commodity companies in the Leuser ecosystem, one of Asia's largest lowland rain forests. He has worked with drone photographers to identify sensitive areas to protect, not only for orangutans but also for rhinos and tigers.

Unlike elephants or rhinos, whose body parts are trafficked, orangutans tend to be trafficked themselves (their docile demeanor makes them attractive as pets). Few offenders have been prosecuted in Indonesia and even fewer convicted. Yet Hadisiswoyo and his group do make progress. Since 2001, they've returned more than 2,500 acres of forest to habitat land. And that orangutan from the rickshaw? The police questioned the trader, and the animal was reintroduced into the wild. *—Daniel Stone*

PHOTO: CRAIG JONES, ORANGUTAN INFORMATION CENTRE. NGM MAPS


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Egypt

The Anti-Indiana Jones Measures the Pyramids

YUKINORI KAWAE *Nat Geo explorer*

When Yukinori Kawae explores the Great Pyramids at Giza, he isn't after treasure or lost chambers—he's looking for dimensions. For all that the pyramids have been dug, scanned, and photographed, the exact measurements of many are still unknown.

Kawae builds precise 3-D models of the pyramids using photographs and videos. Here, he stands on the top of a pyramid for the best view.

Kawae first saw the pyramids in 1992 as a 19-year-old traveling from Japan to study them. He was disappointed: They were much smaller than he'd imagined. Today, as an archaeologist, he values every inch of the pyramids in his mission to preserve their unique stone construction.

For the past decade Kawae has been recording the sites in precise detail. He creates digital 3-D models of the pyramids using laser scanners and photogrammetry, a method that stitches together photographs and videos captured from different vantage points. He also mapped the unusual cave-like indentation on the side of Khufu, the largest pyramid, and made a model of the oldest pyramid before restoration work began.

With this information, he hopes to illuminate how the pyramids were built. Then he wants to enlist muography—an imaging technique that uses cosmic rays to scan a structure's density and create a blueprint of its interior. Kawae compares his detailed examinations to a "crime scene investigation."

Laser scans, cosmic ray detectors, and 3-D models have unearthed Indiana Jones-style mysteries and opened archaeological sites to researchers of all ages and nationalities across the world. Last year an archaeologist studying laser scans found hints of hidden chambers in King Tut's tomb. In February a class at Harvard University "toured" a virtual reality version of Giza's complexes built from scans and photographs. Crowdsourcing this information, Kawae says, "may solve the mysteries of the pyramids"—but walking the site "is equally important to sitting in front of the data."

In high school Kawae became obsessed with the pyramids after watching a TV documentary. Now he's quick to say that sweating under the Egyptian sun isn't as glamorous as Hollywood portrays it.

His most exciting find so far? A pile of trash, unearthed a decade ago, which provided a glimpse into the daily lives of ancient people. The purpose of archaeology, Kawae says, is "to record everything about the past and to understand human beings. We are not treasure hunters. We need information rather than treasure." *—Nina Strochlic*

PHOTO: MOMEN BADR. NGM MAPS

MY INCOME WILL INCREASE 20% WITH EVERY YEAR I STAY IN SCHOOL.

Globally, 62 million girls are not in school and even more are fighting to stay there. Girls empowered with an education will delay marriage, have fewer children, earn a higher income, and are more likely to invest in their families and communities. When girls gain skills, knowledge, and confidence, they break the cycle of poverty and help strengthen societies.

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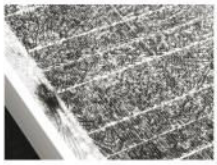
LEGAL NOTICE

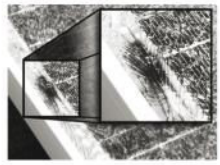
You may be entitled to replacement solar panels and/or a new inverter from a BP Solar Settlement

Para una notificación en Español, llamar 1-844-360-2767 o visitar nuestro website www.BPSolarSettlement.com

A Settlement has been reached in a class action lawsuit against BP Solar and Home Depot involving solar panels manufactured between 1999 and 2007 with an S-type junction box ("Class Panels"). You may be entitled to benefits from a $45.33 million common fund or a separate, $20 million claims-made settlement.

The lawsuit claims these panels are defective and prone to junction box failures, which could cause burn marks at the junction box, shattered glass, and be a potential fire hazard. BP and Home Depot deny these claims.





Who's Included? The Settlement includes anyone in the United States who: (1) purchased certain BP solar panels for installation on a property, or (2) currently owns a property on which these panels are installed and, in either case, who still owns some or all of the BP solar panels.

The panels were sold through various distributors and retailers, including but not limited to Solar Depot and Home Depot.

What does the Settlement provide? Subject to Court approval, a $45.33 million fund will be created to pay for the removal and replacement of a subset of Class Panels (Category 1), and to pay administration, attorneys' fees and costs, and Class Representative awards. A separate $20 million fund will be established for the remaining Class Panels (Category 2), which have a lower failure rate. Category 2 claimants will be entitled to a free visual inspection to identify any failed panels, replacement of failed panels, replacement of all panels if over 20% of panels have failed and, if not all panels are replaced, a free inverter with arc fault detection. Non-residential class members with 400 or more Class Panels will be invited to commercial negotiations. Complete details are found on the website.

How can I receive benefits? You must file a claim to receive benefits. You can file a claim online at www.BPSolarSettlement.com or call 1-844-360-2767. Category 1 claims will be paid until the Fund is spent. Category 2 claims will last for three years after it starts or until the $20 million fund is spent.

What are my rights? If you want to keep your right to sue the Defendants yourself, you must exclude yourself from the Settlement Class by **November 28, 2016**. If you exclude yourself you will not receive benefits from the Settlement. If you stay in the Settlement Class, you may object to the Settlement by **November 28, 2016**. If you do nothing, you will not receive any benefits but you will still be bound by the Court's decisions.

The Court will hold a hearing on **December 22, 2016 at 3:00 p.m. PST** to consider whether to approve the Settlement and a request for attorneys' fees of up to $11 million, plus reimbursement of attorneys' costs and expenses up to $600,000. The motion for attorneys' fees and costs and class representative service awards will be posted on the website after they are filed. You or your own lawyer may appear at the hearing at your own expense. This is only a summary, so please visit the website for complete information.

1-844-360-2767
www.BPSolarSettlement.com

Did you own property near and downwind from the former Rocky Flats Nuclear Weapons Plant (in Jefferson County, northwest of Denver, Colorado) on June 7, 1989? Are you an heir of someone who did? If so, you could get money from a proposed $375 million class action settlement.

A $375 million Settlement has been proposed in a lawsuit against the former operators of the Rocky Flats Nuclear Weapons Plant. The lawsuit claims that Rockwell International Corp. and The Dow Chemical Co. caused the properties owned by the Class Representatives and the other class members in the Property Class Area (see map at www.RockyFlatsSettlement.com) to be contaminated with plutonium, a hazardous radioactive substance, which caused the properties' values to be less than they otherwise would have been and which substantially interfered with Class Members' use and enjoyment of their property. The case is *Cook et al. v. Rockwell International Corp. and The Dow Chemical Co.*, Civil Action No. 90-00181-JLK (D. Colo.). The parties have agreed to settle to avoid additional delay and uncertainty in a case that already is over 26 years old but, before any money is paid, the proposed settlement must be approved by the Court.

Who is a Class Member?

The Property Class (or "Class") includes all persons and entities that owned an interest (other than mortgagee and other security interests) in real property within the Property Class Area **on June 7, 1989 (one day after a famous FBI raid of the plant site)**. If you are an heir of someone (or the successor of an entity) who owned property on June 7, 1989 in the Property Class Area, you may also file a claim.

What Does the Settlement Provide?

Defendants will pay $375 million (the "Settlement Fund") to pay Class Members and to pay attorneys' fees (not to exceed 40% of the Settlement Fund) and costs and expenses. Also, Class Counsel will ask for service awards totaling $780,000 to the Class Representatives for their efforts during over 26 years of litigation. Additionally, the Settlement Fund will pay for the cost of Notice and settlement administration. The remainder (the "Net Settlement Fund") will be divided among Class Members.

What are my options?

To get a share of the Net Settlement Fund, you must file a claim by June 1, 2017. Payments will be calculated as a percentage of the property owned and located within the Class Area as of June 7, 1989. You may opt out of the Class and Settlement by March 1, 2017. If you opt out you will **not receive any money** if the Settlement is approved, but you retain your right to pursue your own lawsuit with your own lawyer. Your own lawyer can advise you about whether your claims may be barred by the statute of limitations. If you do not opt out, you can object to any part of the Settlement on or before March 1, 2017. If you do not opt out, you will remain in the Class and be bound by the terms of the Settlement.

A public hearing will be held on April 28, 2017 at 11:00 a.m. MDT, in Courtroom A802 at the United States District Court for the District of Colorado, Alfred A. Arraj United States Courthouse, 901 19th Street, Denver, CO 80294. The Court will consider whether the Settlement is fair, reasonable and adequate. If there are objections, the Court will consider them. If the hearing time/date changes, it will be posted at www.RockyFlatsSettlement.com. After the hearing, the Court will decide whether to approve the Settlement. You or your attorney may attend the hearing at your own expense, but you don't have to.

This is a summary only. For more information, including a longer Notice, the Settlement, the claim form, the proposed Plan of Allocation, the motion for attorneys' fees, reimbursement of costs and expenses and for service awards, and a list of important deadlines, visit www.RockyFlatsSettlement.com or call 1-844-528-0187.

1-844-528-0187
www.RockyFlatsSettlement.com

All Moms, No Dads

In sexual reproduction—the way most life-forms procreate—each parent provides half an offspring's chromosomes. Over generations, this mating and procreating shuffles the DNA deck, giving sexual reproducers a genetic diversity that helps them adapt to changing environments.

By contrast, asexual reproducers—some 70 vertebrate species and many less complex organisms—"use all the chromosomes they have" to solitarily produce offspring that are genetic clones, says molecular biologist Peter Baumann. Because the organisms are genetically identical, they're more vulnerable: A disease or an environmental shift that kills one could kill all.

But there's a twist in the case of the genus *Aspidoscelis,* the asexually reproducing whiptail lizards that Baumann and his colleagues have been studying at the Stowers Institute for Medical Research in Kansas City, Missouri. The lizards are all female and parthenogenetic, meaning their eggs develop into embryos without fertilization. But before the eggs form, Baumann's team discovered, the females' cells gain twice the usual number of chromosomes—so the eggs get a full chromosome count and genetic variety and breadth (known as heterozygosity) rivaling that of a sexually reproducing lizard.

Why does this occur? Because long ago, Baumann says, lizards of the genus *Aspidoscelis* had "a hybridization event"—that is, females of one species broke form and mated with males of another species. Those outlier liaisons gave whiptails robust heterozygosity, which has been preserved by the identical replication—essentially, cloning—that occurs in asexual reproduction. It's a genetic-diversity advantage that today's females still enjoy and propagate. *—Patricia Edmonds*

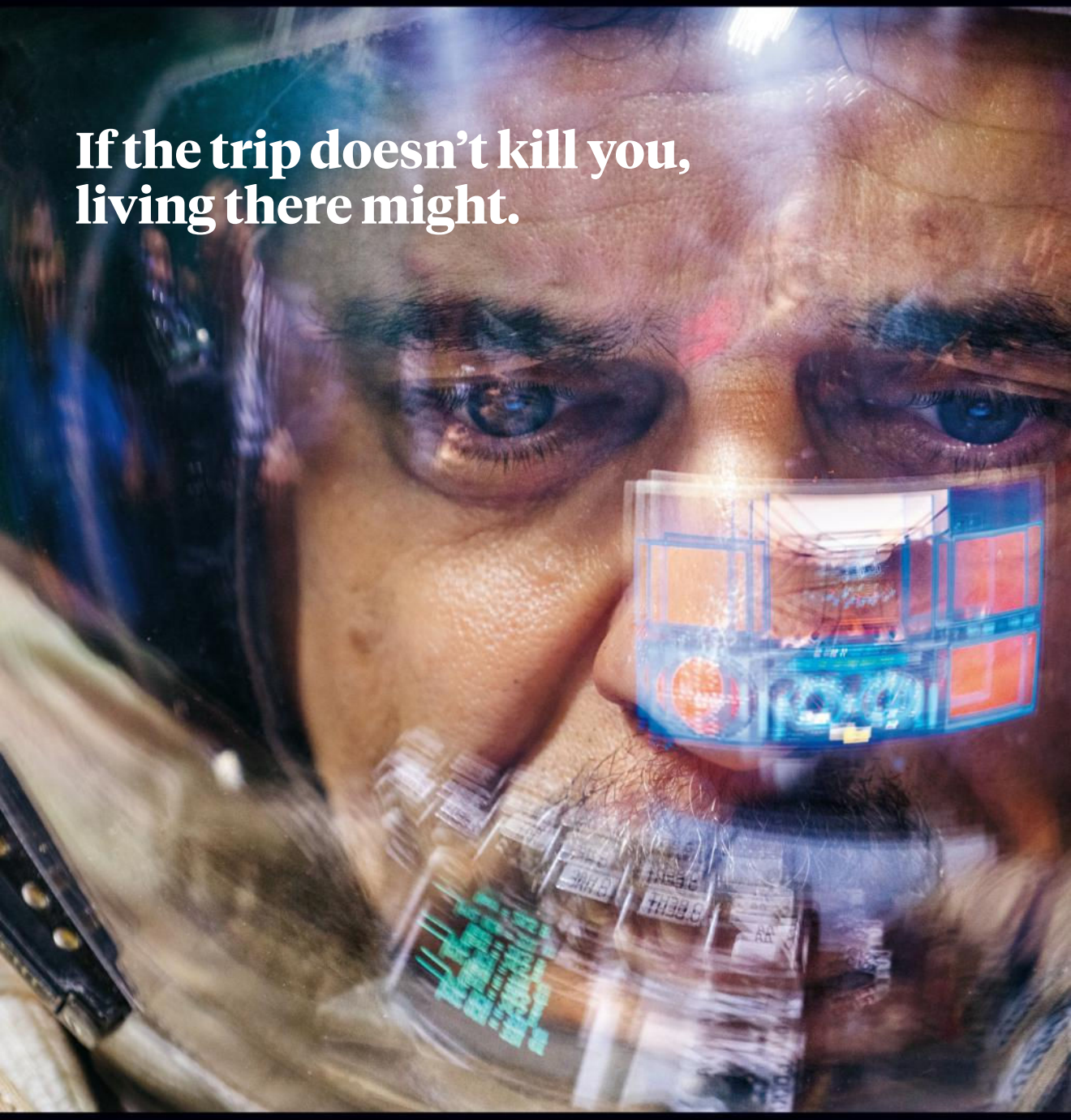
Aspidoscelis neomexicana

HABITAT/RANGE
Desert-grassland transition zones in the southwestern U.S. and northern Mexico

CONSERVATION STATUS
Most of the 50-some *Aspidoscelis* species are rated of least concern. Four are rated near threatened. Another four are rated vulnerable.

NATIONAL GEOGRAPHIC
PHOTO ARK
JOEL SARTORE

This New Mexico whiptail lizard *(Aspidoscelis neomexicana)* was photographed at the Henry Doorly Zoo and Aquarium in Omaha, Nebraska.


If the trip doesn't kill you,
living there might.

Mars

The race to the red planet

Four days after returning from nearly a year on the International Space Station – a dry run for a Mars voyage – Mikhail Kornienko drives a simulated Mars rover at Star City, the Russian cosmonaut training center. How well Mars explorers would perform on arrival is uncertain: Hazards of the trip include bone loss and brain damage.

PHOTO: PHILLIP TOLEDANO (LEFT). MARS MOSAIC COMPOSED OF 102 IMAGES: VIKING PROJECT, USGS/NASA


SPACEX

Landing softly, so as to fly again

Aerospace company SpaceX is developing a technology it says may one day enable humans to land on Mars: reusable rockets. Here a Falcon 9 rocket lifts off (far left) from Cape Canaveral, Florida, to deliver supplies to the space station. After a few minutes the booster separates from the second stage, which continues toward orbit. Instead of falling into the ocean, the booster flips over and fires its engines twice more to slow and guide it to a soft landing at a nearby pad (right). A long exposure (center) captures the whole sequence; the straight light streak at right is the booster's return path.

PHOTOS: SPACEX (FAR LEFT); MICHAEL SEELEY (CENTER); SPACEX

Dressed for Mars, University of North Dakota space engineer Pablo de León tests a prototype space suit in the "regolith bin" at NASA's Kennedy Space Center. Inside the chamber, fine soil and fans simulate the dust storms that could bedevil astronauts on Mars.

PHOTO: PHILLIP TOLEDANO


AC SUPPLY
Valkyrie Safety
Valkyrie Safety
If Valkyrie falls, don't worry! She is tethered such that she will not collide with the ground.
However, it may be very loud and surprising, so please be alert.
FOR YOUR SAFETY
Please remain behind the yellow stanchions

The first footprints on Mars might be those of robots like Valkyrie, being tested by Northeastern University engineers Taskin Padir (right) and Velin Dimitrov. Robots could build a base before humans arrived. Later they'd do chores, such as cleaning dust off solar panels.

PHOTO: MAX AGUILERA-HELLWEG. PHOTOGRAPHED AT THE NEW ENGLAND ROBOTICS VALIDATION AND EXPERIMENTATION CENTER, UNIVERSITY OF MASSACHUSETTS, LOWELL

This past May a South Carolina tree briefly framed the second stage (left) and the returning booster of a Falcon 9. "It really quite dramatically improves my confidence that a city on Mars is possible," SpaceX founder Elon Musk said after an earlier soft landing.

PHOTO: ZACH GRETHER

By Joel Achenbach

Photographs by Phillip Toledano, Robert Clark, Max Aguilera-Hellweg, and Mark Thiessen

Elon Musk wants to go to Mars.

He has said, famously, that he wants to die on Mars, just not on impact. A technology that might help prevent such a mishap passed a crucial test one night last December, when a Falcon 9 rocket built by Musk's company SpaceX lifted off from Cape Canaveral in Florida, carrying 11 communications satellites.

A few minutes into the flight the booster separated from the rest of the rocket, as thousands of spent boosters have done since the dawn of the space age; normally they burn up in the atmosphere, and their fragments rain into the ocean. But this booster wasn't spent. Instead of falling, it flipped over, and its engines reignited to slow and guide its descent toward a nearby landing pad. Essentially it flew backward. From the ground it looked as if the launch movie were being rewound.

Inside the launch control center on the cape,

Everyone seems to agree: If humanity has a next great destination in space, Mars is it. But how attainable is it?

and inside SpaceX mission control in Hawthorne, California, hundreds of young engineer faces watched the approaching ball of light on video screens, transfixed. At launch control Musk ran outside to get a direct look. Seconds later there was an ominous boom. No one had ever succeeded in landing an orbital-class booster rocket like this; the first couple of times SpaceX had tried, the rocket had exploded. But this noise turned out to be merely a sonic boom from the booster's rapid descent through the atmosphere. It reached Musk's ears just as the booster was landing—gently, safely, and successfully at last. In front of their screens the engineers were whooping.

SpaceX had just achieved a milestone in the quest for reusable rockets. Musk figures the technology could cut launch costs by a factor of a hundred, giving SpaceX a competitive advantage in its business of launching satellites and delivering supplies to the International Space Station. But that has never been the point for Musk. The first soft landing of a booster rocket, he said during a news teleconference that night, was "a critical step along the way toward being able to establish a city on Mars."

Elon Musk doesn't just want to land on Mars, the way Apollo astronauts landed on the moon. He wants to build a new civilization there before some calamity, possibly self-inflicted, wipes us out on Earth. SpaceX employees in Hawthorne often wear "Occupy Mars" T-shirts. Just around the corner from Musk's no-frills desk, twin images of Mars hang on a wall: One shows the red, parched planet today, and the other shows a blue Mars, "terraformed" by engineers, with seas and rivers. Musk imagines colonizing Mars with a flotilla of interplanetary *Mayflowers,* each carrying a hundred settlers, like the original, except that many of these pilgrims would be ponying up $500,000 or more for a berth on the spaceship.

SpaceX, founded in 2002, has yet to launch a single human into space, though it hopes to change that next year by carrying NASA astronauts to the space station on a Falcon 9. It has been building a larger rocket, the Falcon Heavy, but even that won't be large enough to carry humans to Mars. Musk promised to unveil details of his Mars plans in late September, after this story went to press (and just weeks after another SpaceX rocket exploded on the launchpad). But in advance there was no indication that SpaceX had developed, much less tested, the other technologies necessary to keep humans alive and healthy on Mars or on the long journey. Nevertheless, Musk announced this past June that SpaceX aims to dispatch its first astronauts to Mars in 2024. They'd land (softly, he hopes) in 2025.

"There'll be fame and that kind of thing for them," Musk says. "But in the grander historical context, what really matters is being able to send a large number of people, like tens of thousands if not hundreds of thousands of people, and ultimately millions of tons of cargo." That's why he thinks reusable rockets are so important.

NASA, which landed men on the moon in 1969 and began exploring Mars with robotic probes even before that, says it plans to send astronauts to Mars too—but not until the 2030s, and then only to orbit the red planet. The dangerous, tricky feat of actually landing a large craft on the surface, NASA says, is a "horizon goal" that it would achieve only in a later decade. NASA doesn't talk about Martian cities.

Everyone seems to agree on one thing: If humanity has a next great destination in space, Mars is it. But clearly there are conflicting visions of how attainable it is. Legendary NASA astronaut John Grunsfeld, who fixed the Hubble Space Telescope three times and retired this past spring as the agency's science chief, remembers being told, back in 1992, that he was in the class of astronauts that would someday go to Mars. This year, thanks in part to the success of *The Martian,* a best-selling book and blockbuster movie, NASA received 18,300 applications for its next class—in which there are at most 14 openings. Grunsfeld still wants humans to go to Mars, but he also stands by the advice he gave a few years ago to NASA administrator and fellow

astronaut Charles Bolden. It was about talking to new recruits. "Don't tell these folks they're going to Mars, because there's no chance," Grunsfeld said. "They'll be in their 70s or 60s."

What NASA has been doing, besides designing its own rocket to go to Mars, is a lot of work on how to take care of the passengers. In March, for example, astronaut Scott Kelly and Russian cosmonaut Mikhail Kornienko returned to Earth after 340 days on the space station. On their "One-Year Mission" they served as guinea pigs for studies of what long stints in space (a round-trip to Mars might take nearly three years) do to the human body and mind. As they plunged back into the atmosphere, Kornienko recalls, their Soyuz capsule was rattling like a car on a cobblestone road, and fist-size sparks from the flaming heat shield were flying past the portholes. He and Kelly could barely breathe: After a year of weightlessness their lungs and chest muscles were weak. And once they landed on the steppes of Kazakhstan, they could barely walk. The ground crew carried them from the capsule, for fear they might stumble and break a bone. In May, Kelly was still saying that his feet hurt.

Hollywood movies convey the fun of weightlessness. Interviews with Kelly and Kornienko from the space station hint at the other side. Their faces are puffy, because fluid doesn't drain out of them. Their arms are folded across their chests, lest they extend straight ahead in the dreaded "zombie pose." Astronauts can get used to strapping themselves onto a suction toilet and even, Kornienko says, to a whole year of wiping off with a wet washcloth, for lack of a shower. On a much longer, much more hazardous Mars journey, in which Earth is not 250 miles but millions of miles away, with no option to turn back or bail out, what space can do to a human body could be a huge problem. "They're going to be sick when they get there," says Jennifer Fogarty, deputy chief scientist for the Human Research Program at NASA's Johnson Space Center, in Houston.

Bones waste away in zero gravity: The rule of thumb is you lose one percent of your bone mass per month. Vigorous exercise helps, but the jumbo equipment used on the space station weighs too much for a Mars mission. Some astronauts on the station have also experienced serious vision impairment, apparently because fluid collects in the brain and presses on their eyeballs. The nightmare scenario is that astronauts land on Mars with blurred vision and brittle bones and immediately break a leg. Theoretically the risk could be reduced by spinning the spacecraft rapidly, replacing gravity with centrifugal force. But NASA engineers see that as adding too much complexity to an already challenging mission.

Radiation is another hazard. The astronauts on the space station are still mostly protected by Earth's magnetic field. But on a journey to Mars they'd be vulnerable to radiation from solar flares and cosmic rays, which are high-energy particles coming from across the galaxy at nearly the speed of light. The latter especially can damage DNA and brain cells—which means astronauts could arrive on Mars a little dimmer, as well as blurry eyed and brittle boned. One possibility would be to line the habitat module with a thick layer of water, or even plants growing in soil, as a partial radiation shield. But so far nothing has been proved to solve the problem.

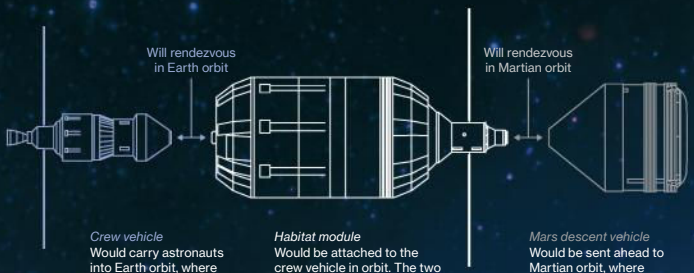
Just keeping astronauts supplied with drinkable water and breathable air is a challenge. One day at Johnson Space Center I met Kenny Todd, whose title is operations integration manager for the space station. He looked weary. It was midmorning, but he'd been at the office for many hours, working overnight to supervise one of the unheralded but critically important cargo flights. A conversation between the station and mission control squawked quietly from a speaker on his desk as we talked about urine, among other things.

Some of the water on the space station comes from filtering and recycling urine and sweat. But those filters can get clogged with calcium—from the astronauts' dwindling bones—and the water sometimes gets contaminated by microbes. "Working with urine—it's very finicky," Todd said. The scrubbers that remove carbon dioxide from air break down too—like nearly every other device on the station. In low Earth orbit, that's not critical; NASA can send up spare parts. A Mars-bound spacecraft would have only the spares it could carry with it. All the life-support equipment, Todd said, would need to be much more reliable than it is now, essentially unbreakable.

That doesn't mean he doesn't want to send people to Mars. Nor does he criticize the dreamers who are ready to blast off tomorrow morning. "You gotta start somewhere. You gotta start with dreaming," Todd said. "And sometime in there,

SURVIVING THE VOYAGE

Mars is never less than 34 million miles away – more than 140 times farther than the moon. To send astronauts would require a new kind of spacecraft that could house them comfortably for months, shield them from cosmic radiation, and carry enough supplies for the voyage home. This artist's conception, based on a NASA study, shows one possible scheme.



Crew vehicle
Would carry astronauts into Earth orbit, where they'd rendezvous with a habitat module.

Habitat module
Would be attached to the crew vehicle in orbit. The two vehicles would make the long voyage to Mars together.

Mars descent vehicle
Would be sent ahead to Martian orbit, where it would ferry arriving crew to the surface and back.

Living in Space

The crew vehicle would get astronauts into
too cramped for six people – NASA's baseli
to Mars – to live in comfortably for long stre
module, perhaps an inflatable one, could be
Earth orbit for the long interplanetary missi

Getting There

Getting to Mars would require a lot of fuel. Getting back could require making chemical fuel – and the oxygen to burn it – on Mars. Nuclear or solar power might help.

CHEMICAL
Traditional rockets would be needed at least for liftoff: They burn fuel so fast that their exhaust generates huge thrust. But they're inefficient.

NUCLEAR
A nuclear reactor can create thrust more efficiently by heating and expelling hydrogen. But putting a reactor on a rocket raises safety concerns.

SOLAR
In this system, solar electricity ionizes a gas, which is then expelled by a magnetic field. The thrust is weak but may be enough for a slow cargo ship.

1 MORALE
Having enough space and good food would help keep the crew comfortable and positive. Crops from "green walls" could supplement a space-food diet.

2 PROTE
Cosmic radi
hazard to ar
Earth's mag
filled green
shield astro

space, but it would be
ne number for a mission
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e assembled in low
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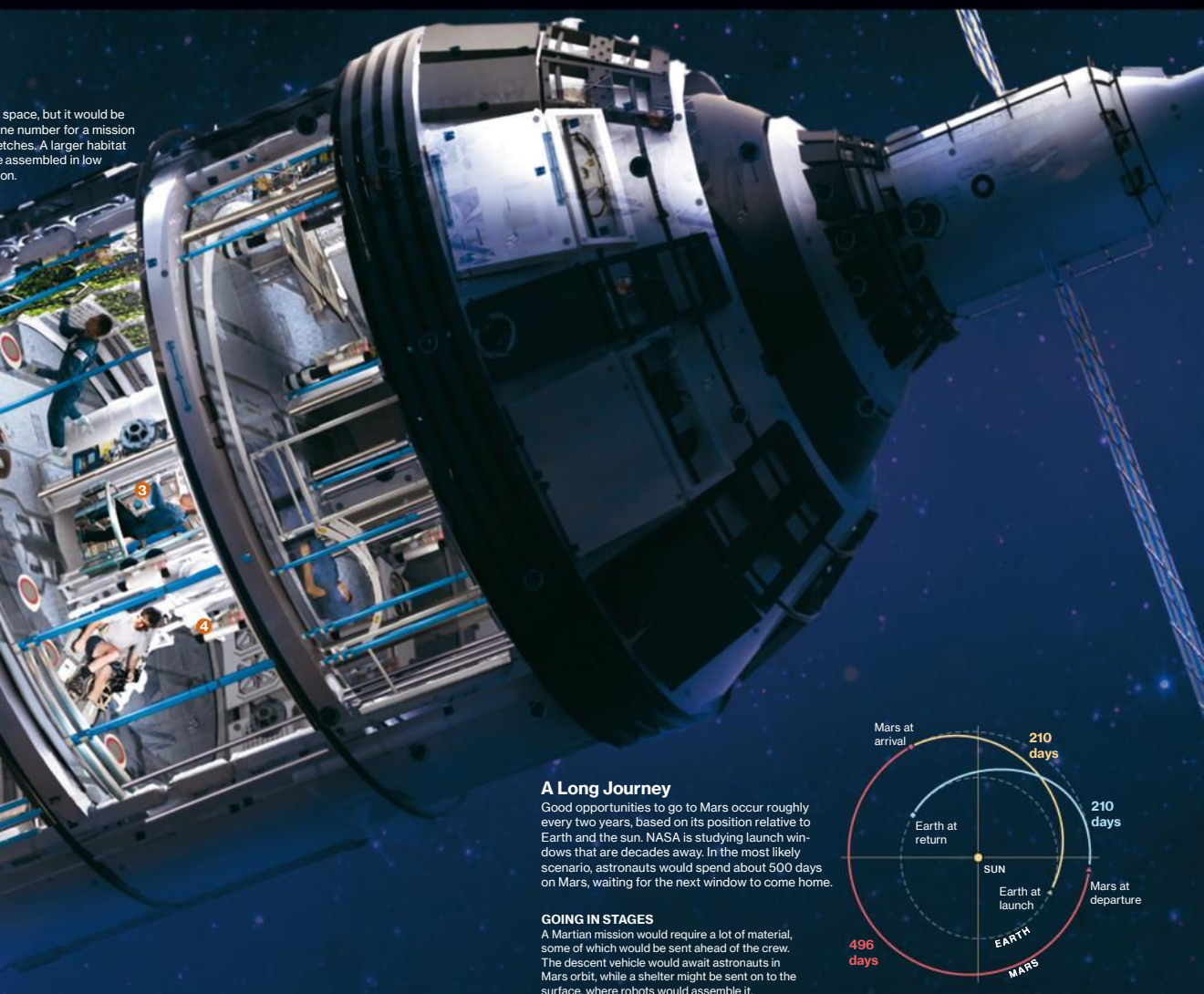


A Long Journey

Good opportunities to go to Mars occur roughly every two years, based on its position relative to Earth and the sun. NASA is studying launch windows that are decades away. In the most likely scenario, astronauts would spend about 500 days on Mars, waiting for the next window to come home.

GOING IN STAGES

A Martian mission would require a lot of material, some of which would be sent ahead of the crew. The descent vehicle would await astronauts in Mars orbit, while a shelter might be sent on to the surface, where robots would assemble it.

CTION
ation is a constant
nyone outside
netic field. Water-
walls would help
nauts from it.

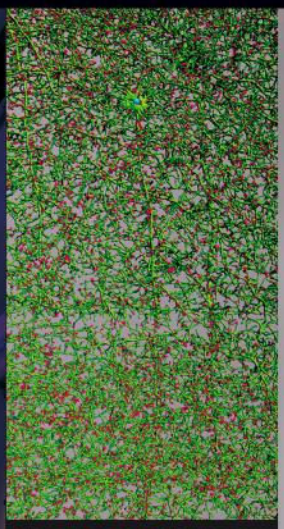
3 REPAIRS
Critical systems for navigation and for recycling air and water would be kept in the core of the habitat module, making repairs and maintenance convenient.

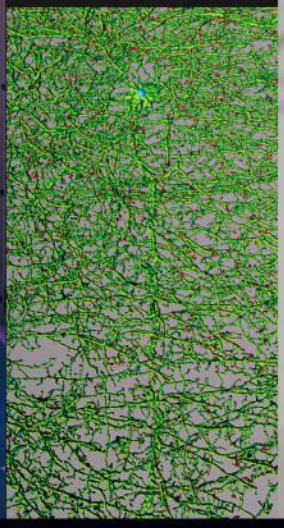
4 EXERCISE
Living in zero gravity for long periods would take a major toll on the human mind and body. Exercise would be critical for mental and physical health.

JASON TREAT, NGM STAFF; TONY SCHICK. ART: STEPHAN MARTINIERE

SOURCES: JAMES B. GARVIN, NASA GODDARD SPACE FLIGHT CENTER; JASON C. CRUSAN, NASA HUMAN EXPLORATION AND OPERATIONS MISSION DIRECTORATE; BRET G. DRAKE, THE AEROSPACE CORPORATION; MARIA BANKS, PLANETARY SCIENCE INSTITUTE

Water tanks lining a spaceship could partially shield astronauts from radiation while boosting their mood and diet by letting them garden. Bob Morrow of NASA-funded Orbitec shows off lettuce ripened in a prototype system.





COSMIC RAYS AND BRAINS Astronauts leaving Earth's protective magnetic field would be vulnerable to fast-moving particles called cosmic rays. Compared with a healthy mouse brain (top), a mouse hit by "space-relevant" radiation (bottom) has fewer nerve-cell branches (green) and connections (red) in its prefrontal cortex. Such mice explore less and have worse spatial memory – "a cause for concern" for Mars explorers, says Charles Limoli of the University of California, Irvine.

PHOTOS: ROBERT CLARK (LEFT); CHARLES LIMOLI, DEPARTMENT OF RADIATION ONCOLOGY, UNIVERSITY OF CALIFORNIA, IRVINE (MOUSE BRAINS); PHILLIP TOLEDANO

Russian cosmonaut Sergey Volkov undergoes a battery of physical tests at Star City after returning from six months on the International Space Station. Long stays in space – a trip to Mars might take seven months each way – can affect the body profoundly.

No experiment on Earth can quite simulate the feeling of being locked in a small can millions of miles away.

things become actual." Which means a lot of things have to be figured out.

That includes more complicated things like human psychology. "We've done so well with robotic missions, we think we've got the hardware part of it figured out," says Fogarty. "But now we're going to throw in self-aware, self-deterministic individuals that are part of this team. Have we truly understood all the risks they bring and given them the tools to handle it?"

NASA works on that problem by conducting analog missions on Earth. At Johnson Space Center I visited one. Inside a cavernous, windowless warehouse, beyond a DO NOT ENTER sign, sat a three-level, domed structure, also windowless, that was covered in soundproofing material—like a chunk of space station specially wrapped for a long and dangerous journey. Inside were four volunteers, each making $160 a day to be sealed up for a month, physically cut off from the outside world. Thirteen cameras inside their habitat allowed researchers in "mission control," a few strides away, to watch their every move and see how they dealt with the isolation, individually and as a crew.

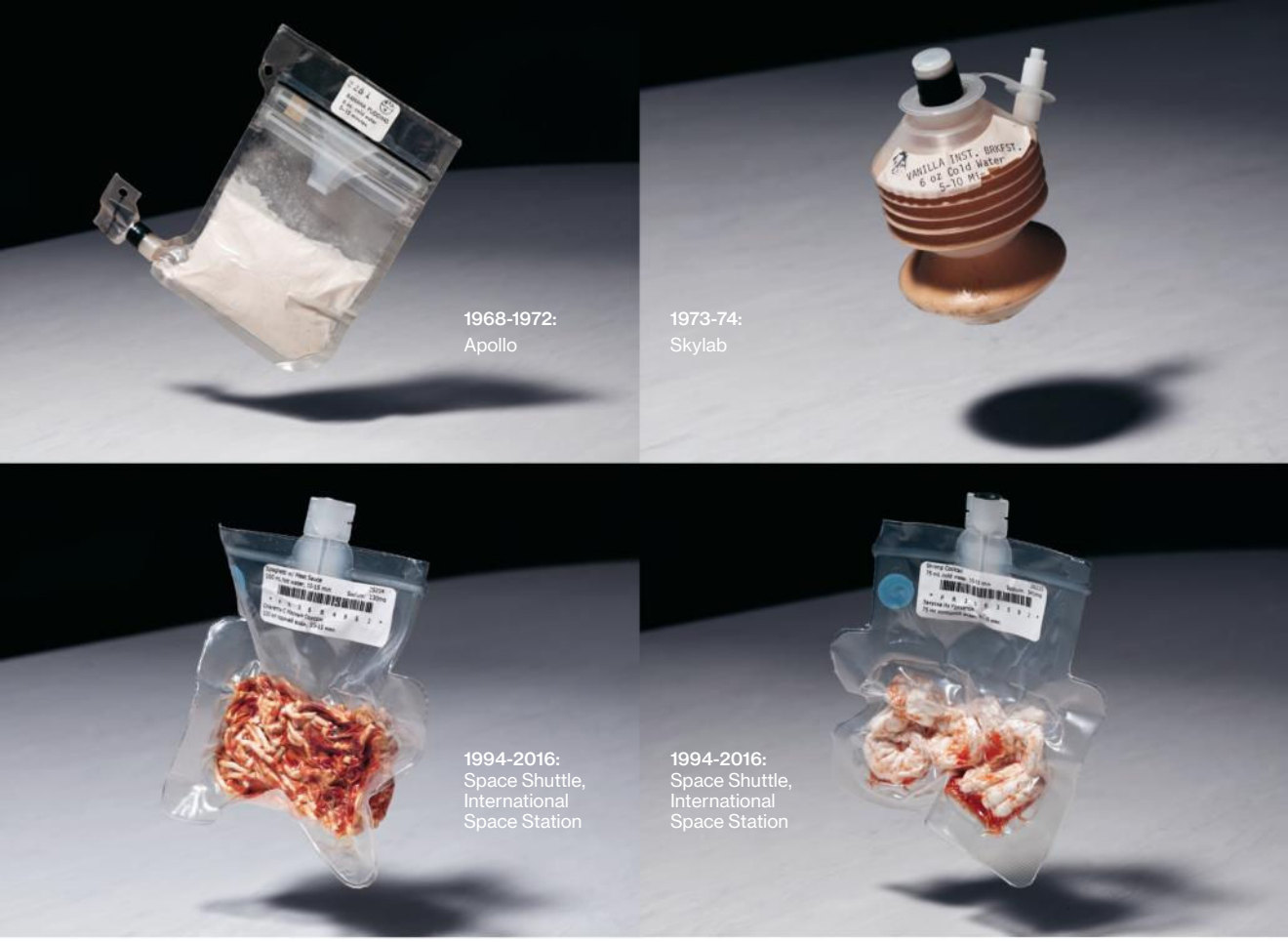
The simulation has its limits. "Obviously we don't have a zero-g switch," said project manager Lisa Spence; these astronauts get to enjoy a flush toilet and a shower. But Spence and her colleagues strive for as much verisimilitude as possible. As we watched two volunteers huddled in a darkened air lock, wearing virtual reality visors and experiencing a simulated space walk, we spoke in hushed voices, lest they hear us. A huge storm had just blown through, a real toad-strangler, with booming thunderclaps; if anyone inside the module asks about thunder, Spence said, "we make up a cockamamy story about space weather."

A certain kind of personality is needed for a Mars mission, the experts say: someone who can tolerate isolation and boredom during the long transit, then shift into overdrive on Mars. Someone who's mentally resilient and has excellent social skills. These traits may or may not correlate with the ability to pay $500,000, which is the SpaceX criterion. "We select very low-drama people. Nonetheless, there's bound to be conflict," says Kim Binsted of the University of Hawaii at Manoa, who directs other NASA-funded analog missions. In the most recent one, six volunteers were sealed for a year into a mock Mars habitat halfway up the side of a volcano. They could exit only if they donned space suits.

No experiment on Earth, however, can quite simulate the feeling that will come from being locked in a small can millions of miles away. William Gerstenmaier, NASA's chief of human spaceflight, has noticed something about astronauts on the space station. "They tweet a lot of pictures of their hometown," he told me. "They take pictures of their college football stadiums. There's still a really strong tie back to the Earth."

Kornienko felt it. "This is not even nostalgia, you understand; this is not a business trip to a different city, when you miss your apartment, your home, family," he said, shortly after he returned from his year in orbit. "This is about missing the Earth as a whole. It is a completely different emotion. There is a shortage of greenery, for real, like not enough forest, summer, winter, snow."

In June, six months after SpaceX triumphantly landed its booster, NASA held its own rocket test in the hills of northern Utah. This was a "ground test" of a solid-fuel booster that will be an integral element of the Space Launch System, the blandly named rocket that NASA says will someday take humans into deep space. Thousands of people gathered a mile away, intently watching through the clear desert air as an announcer went through the countdown. At zero, the booster, lying on its side and bolted fast to the ground, ignited ferociously. The announcer reminded everyone that this was part of NASA's "Journey to Mars." The jet of flame roared for more than two minutes as a great pillar of smoke



NASA menus have progressed from banana pudding (top left) through vanilla instant breakfast (top right) to recognizable spaghetti (bottom left) and even shrimp cocktail. But foodies should think twice before signing up for a Mars trip.

rose into the sky and onlookers cheered.

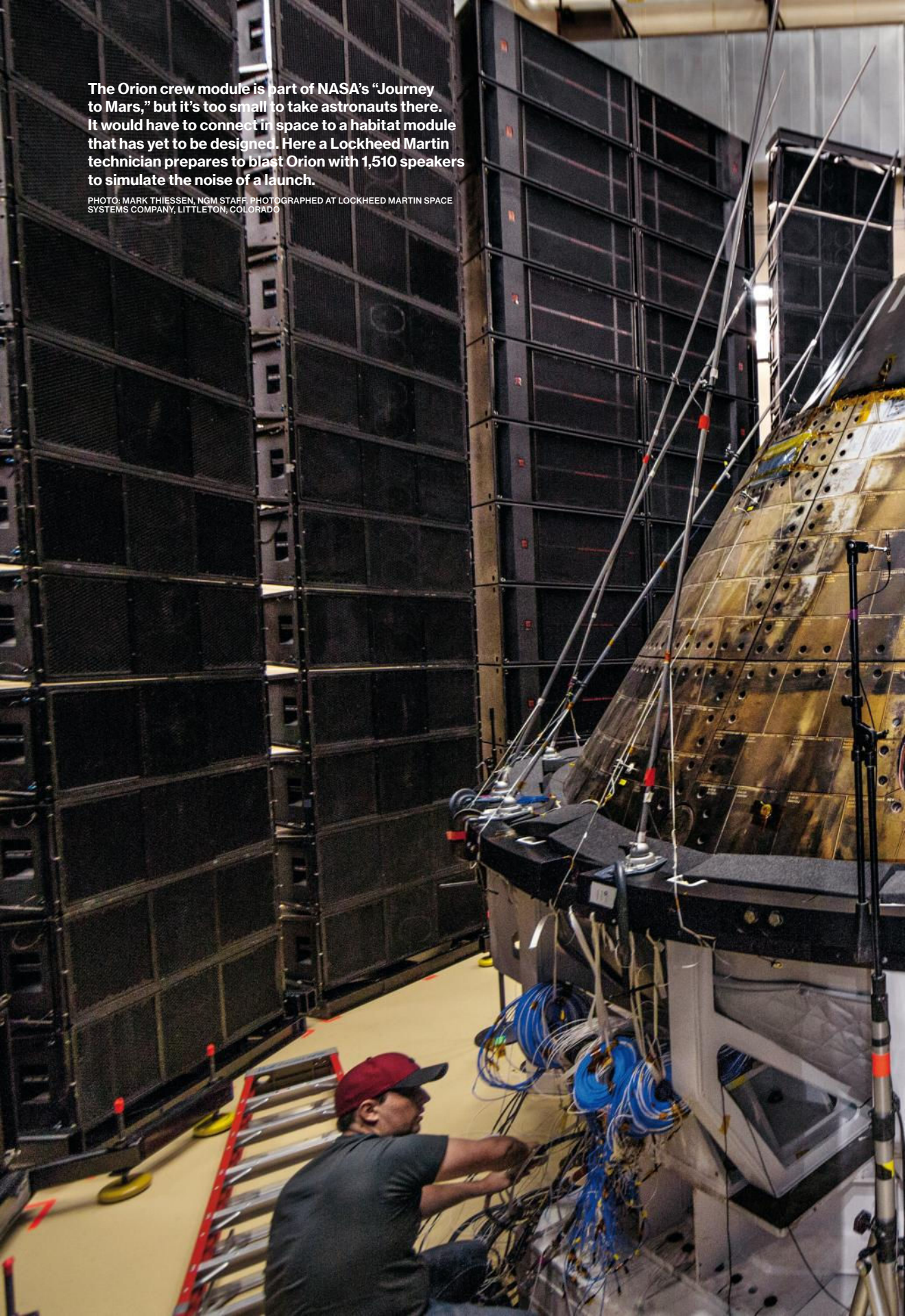
"What an absolutely amazing day today!" Gerstenmaier said at a news conference afterward. And the test was indeed spectacular—as spectacular as it could possibly be, given that the rocket didn't actually fly.

"We are closer than ever before to sending American astronauts to Mars than anyone, anywhere, at any time has ever been," NASA Deputy Administrator Dava Newman wrote in a blog post this past April. To some of NASA's critics, it doesn't feel that way. It certainly wouldn't have felt that way to Wernher von Braun, builder of the Saturn V moon rocket. In 1969, in the euphoria after the first moon landing, von Braun pitched a plan to President Richard Nixon to land men on Mars in 1982. Nixon ordered NASA to build the space shuttle instead.

Since then grand plans for breaking out of low Earth orbit have come and gone. Gerstenmaier, who's been at NASA for decades, has survived the strategic lurches imposed by politicians. He was told to send astronauts back to the moon, then to send them to an asteroid instead, then to capture an asteroid and have astronauts visit it in lunar orbit. In news media coverage of NASA, "lost in space" has become a cliché. Gerst, as he's known, remains unruffled. He's a low-key engineer, kind of an anti-Musk, someone who doesn't want to overpromise. He'd like to go to Mars slowly, methodically, and sustainably.

That means glacially, some critics would argue. "To say NASA has a strategy [for going to Mars] is really an insult to the word 'strategy,'" declares Robert Zubrin, founder of the Mars Society, which advocates the settlement of Mars as "the greatest cause of our generation." Michael Griffin, who served as NASA administrator under President George W. Bush, believes a Mars mission would be hard, but no harder than the

PHOTOS: PHILLIP TOLEDANO. PHOTOGRAPHED AT NASA JOHNSON SPACE CENTER



The Orion crew module is part of NASA's "Journey to Mars," but it's too small to take astronauts there. It would have to connect in space to a habitat module that has yet to be designed. Here a Lockheed Martin technician prepares to blast Orion with 1,510 speakers to simulate the noise of a launch.

PHOTO: MARK THIESSEN, NGM STAFF. PHOTOGRAPHED AT LOCKHEED MARTIN SPACE SYSTEMS COMPANY, LITTLETON, COLORADO

Test dummies in an Orion model suit up for a drop test in a pool at NASA's Langley Research Center in Virginia. Like the Apollo modules, Orion will splash down in the ocean. One day it may take astronauts near the moon again but probably not before 2021.

PHOTO: DAVID C. BOWMAN, NASA

FIRST STEPS

The first humans to walk on Mars would be stepping into a harsh, unforgiving environment. The thin atmosphere would partially protect them from solar radiation, but they'd need to shield themselves from cosmic rays. They'd also have to utilize scant Martian resources for their oxygen and water.

Potential Landing Sites

Nearly 50 possibilities have been identified. They're in areas of scientific interest, with resources such as water-rich deposits – and within 50 degrees of the equator, where it's easiest to launch a rocket home.

1

TEMPORARY SHELTER
NASA is testing a flexible life-support structure that recycles all water, air, and waste. It would house working astronauts while permanent shelters were assembled.

2

LONG-TERM SHELTER
Shipping resources to Mars would be onerous and expensive. One option for creating permanent shelters involves using the soil found on Mars to create building materials.

3

THE Z-2 SUIT
Astronauts would slide into and out of this flexible space suit through a "suit port" in the back, which would attach directly to the outside of a pressurized shelter or rover.

4

GETTING AROUND
Pressurized rovers – able to support two people for a fortnight and travel about 60 miles at a time – could be used to aid exploration missions on the surface.

JASON TREAT AND MATTHEW W. CHWASTYK, NGM STAFF; TONY SCHICK
ART: STEPHAN MARTINIERE

SOURCES: JAMES B. GARVIN, NASA GODDARD SPACE FLIGHT CENTER; JASON C. CRUSAN, NASA HUMAN EXPLORATION AND OPERATIONS MISSION DIRECTORATE; BRET G. DRAKE, THE AEROSPACE CORPORATION; MARIA BANKS, PLANETARY SCIENCE INSTITUTE; LINDSAY E. HAYS, NASA/JPL

When and whether we go to Mars depends on technology, money, and what we consider an acceptable risk.

Manhattan Project or the Apollo program: "We're closer to Mars in terms of the technology required to do it today than we were to the moon when President Kennedy set that goal in 1961. We are far closer."

We aren't closer to paying for a Mars trip, though—and it's the expense that killed the grand plans of the past. The Apollo moon landings cost about $140 billion in today's dollars. Experts assume a realistic journey to Mars would cost at least that much; a fully loaded plan put forward under President George H. W. Bush had a price tag of $450 billion. But NASA's annual budget for all human spaceflight is around nine billion dollars. To get to Mars before the 2040s would take a lot more money and a president with Kennedy-like commitment. During the moon race with the Soviet Union, NASA got more than 4 percent of the federal budget; now it gets about half a percent. If there were truly a "Mars race" with China, say, that might help, but the Chinese don't appear in a rush to get there.

When and whether we go to Mars doesn't just depend on technology and money. It depends on what we consider an acceptable level of risk. Advocates of an early landing say that NASA is too risk averse, that true explorers accept the possibility of failure or death, that the people who first tried to reach the poles or cross the oceans knew they might not make it—and often didn't. NASA could send people to Mars a lot sooner if it didn't worry so much about whether they'd arrive alive and eventually make it home.

At the end of Gerstenmaier's news conference in Utah, a local reporter stood up. He was 49 years old, he said, and he just wanted to know one thing: Would he live to see a man on Mars?

"Yes," Gerstenmaier said. He hesitated for a moment and then added: "'Man' may be the wrong word. You will see a human being."

Then, after the applause and appreciative laughter had subsided, Gerstenmaier proceeded to explain why it was going to take until the 2040s. NASA needed to begin its return to deep space with missions to the "Proving Ground," he said, meaning around the moon and nearby points in space. That would lead in the 2030s to putting astronauts in orbit around Mars. "When I look at challenges of getting a crew on the surface, it adds another order of magnitude of complexity to what we're trying to do," Gerstenmaier had told me earlier. "That's what drives me out of the 2030 time frame."

But that's where SpaceX might help. Mars is a much harder place than the moon to land a spacecraft softly. Its gravity is stronger, and its atmosphere—while too thin to be much help in slowing a spacecraft or to support life as we know it—is thick enough to cause overheating. Many unmanned probes have crashed on Mars. NASA has landed a one-ton rover, Curiosity, but a payload big enough to carry humans and keep them supplied would have to be the size of a house and weigh at least 20 tons. A parachute wouldn't work—it would have to be as big as the Rose Bowl, and it would never open quickly enough.

The most promising solution at the moment is the technology that SpaceX is developing: supersonic retropropulsion. When the Falcon 9 booster descends at supersonic speed through Earth's thin upper atmosphere, it's in Mars-like conditions. The success at Cape Canaveral last December, and subsequent landings on a ship offshore, are why so many people are now saying that sending humans to Mars is plausible—if far from a slam dunk. SpaceX has shared its data with NASA.

At Kennedy Space Center, SpaceX has leased Launch Pad 39A, where the Apollo 11 astronauts blasted off for the moon. The company is young, nimble, and daring, as NASA was then; NASA has grown slow, bureaucratic, and cautious. But the two aren't competitors, and they're not in a race. They're partners. SpaceX already delivers supplies to the space station in a Dragon capsule carried on a Falcon 9. In April, Musk announced

Since 2012, NASA's Curiosity rover has been looking for chemical evidence that Mars might once have supported life. "The most sophisticated robot ever sent to another planet," according to former chief scientist John Grotzinger, it needs no food or water and never gets lonely. It even takes selfies.

that SpaceX wants to send an unoccupied Dragon capsule to Mars as early as 2018. To do that, he'd need NASA's technical support, in particular its huge radio antennas, which allow spacecraft to communicate with Earth.

To send people to Mars, SpaceX would need far more help—those $500,000 tickets won't cover much of the costs, and it will take NASA know-how to keep the travelers alive. NASA, on the other hand, could benefit from SpaceX's rockets, capsules, and enthusiasm. The two will likely go to Mars together if they go at all. (Musk himself has suggested as much.) When will they go? If it's a partnership, it seems more likely to follow NASA's more cautious schedule. What will they do when they get there? It's a lot easier to imagine a few scientists spending a year or two at a small Martian research station, like the ones in Antarctica, than it is to imagine thousands of people emigrating permanently to a Martian metropolis.

"Those people who think they want to live on Mars—I would encourage them to spend a summer, or better yet a year, on South Pole station," says Chris McKay, a NASA scientist and Mars expert who has worked in Antarctica. Suggesting that humans might find refuge on Mars after messing up Earth is "ethically and technically absurd," says McKay. "I think we need to take the view that failure is not an option. The notion of Mars as a lifeboat makes the *Titanic* look like a happy ending."

Mikhail Kornienko recommends a long stay on the space station as a way to winnow out the enthusiasts who think they'd like to go on a one-way journey to Mars. Soon after he came back from space this year, he recalled the moment the ground crew opened the hatch on the Soyuz capsule. "The air of the steppe comes into the cabin after all the bustle of descent, and you understand that everything is over," he said. "And you can't get enough of this air. It's possible to cut it with a knife and spread it on bread." □

To learn more about colonizing the red planet, tune in to National Geographic's six-part series, *MARS*, on November 14 at 9/8c.

PHOTO: NASA/JPL/MALIN SPACE SCIENCE SYSTEMS; COMPOSITE OF 58 PHOTOS

“No nobler cause has ever been,” declared the founders of the Mars Society in 1998. They advocated sending humans to Mars “within a decade.” The society runs a research station in Utah where crews practice in a landscape that resembles Mars, but with breathable air.

PHOTO: PHILLIP TOLEDANO

An astonishing diversity of octopus species inhabits the oceans from the tropics to the poles. *Wunderpus photogenicus,* aka the wunderpus, lives in the warm, shallow waters of the Indo-Pacific.

PHOTOGRAPHED AT CALDWELL LAB, UC BERKELEY

The Power of Eight

Octopuses change shape and color at will, squirt ink, vanish through tiny cracks, and taste with their suckers. So why do they remind us of ourselves?

This female – from a species yet to be scientifically described – is tending her eggs. Soon after they hatch, she will die: In most octopus species, females reproduce just once in their lives. This means that young octopuses must fend for themselves from the get-go.

PHOTOGRAPHED AT CALDWELL LAB, UC BERKELEY

By Olivia Judson
Photographs by David Liittschwager

You're sitting on the seabed, just off the coast of the Indonesian island of Lembeh. You're not deep—20 feet or so—and there's plenty of light. As you'd expect in such a tropical place, the water is warm. All around, you see ripples of a fine gray-black sand, covered, in places, with a kind of greenish scum. As you explore, you notice a conch shell. Stoutly made, it has six heavy spikes coming off it. Perhaps the maker is within. Or perhaps the maker is long dead, and the shell now belongs to a hermit crab. Curious, you flip it over. A row of suckers. A pair of eyes.

An octopus. In particular, *Amphioctopus marginatus,* also known as the coconut octopus. Its common name comes from its habit of hiding in discarded coconut shells (sometimes it even picks them up and carries them about, for use as an emergency shelter). But in fact, any big shell will do—such as a conch.

With a few of its suckers, this octopus is holding two halves of a clamshell. As you watch, it drops them and hoists itself up a little. It gives the impression of evaluating the situation. You make like a statue. After a moment, the octopus climbs out of the shell. Its body is the size of your thumb, its arms perhaps

Stocky, with a large body and shortish arms, the pale octopus *(Octopus pallidus)* lives in the waters off southeastern Australia, where it emerges at night to feed on shellfish.

three times that. As it moves onto the sand, it turns a matching shade of dark gray. Is it leaving? No. It snakes several of its arms over the sand, and the rest over the shell. With a single heave, it flips the shell back over and flows inside.

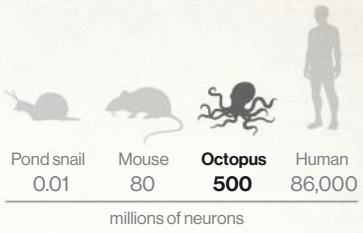
Not wanting to disturb it further, you're about to swim off, when you notice a small movement. The animal has squirted a jet of water, clearing sand from beneath the lip of the shell. There's now a small gap between shell and seafloor. In the gap, the eyes reappear. You bring your mask close, and for a moment, you look at each other. Of all the invertebrates—animals that lack a backbone—octopuses are the ones that seem the most like us. In part, it's the way they return your gaze, as if they're scrutinizing you. (This sets them apart from plenty of vertebrates too: Most fish don't appear to stare at you.) In part, it's their dexterity. Their eight arms are lined with hundreds of suckers; this allows them to manipulate objects, whether it's to open clamshells, dismantle the filtration system of an aquarium tank, or unscrew lids from jars. This distinguishes them from mammals like dolphins, which, for all their smarts, are limited by their anatomy and can't easily unscrew anything.

This algae octopus, *Abdopus aculeatus,* has just inked. Octopuses release ink when they feel threatened; the ink swirls into a dark cloud that distracts predators. The adaptation is ancient: Ink sacs are present in fossils of octopus ancestors that are more than 300 million years old.

PHOTOGRAPHED AT DIVE GIZO, SOLOMON ISLANDS

Armed With Intelligence

In number of neurons, octopuses and their relatives far exceed other invertebrates and put rodents, frogs, and many other vertebrates to shame. An octopus's nervous system processes information not just in the brain but also throughout all eight arms and the suckers that line them.



Nervous system chain of command

35 percent
Brain

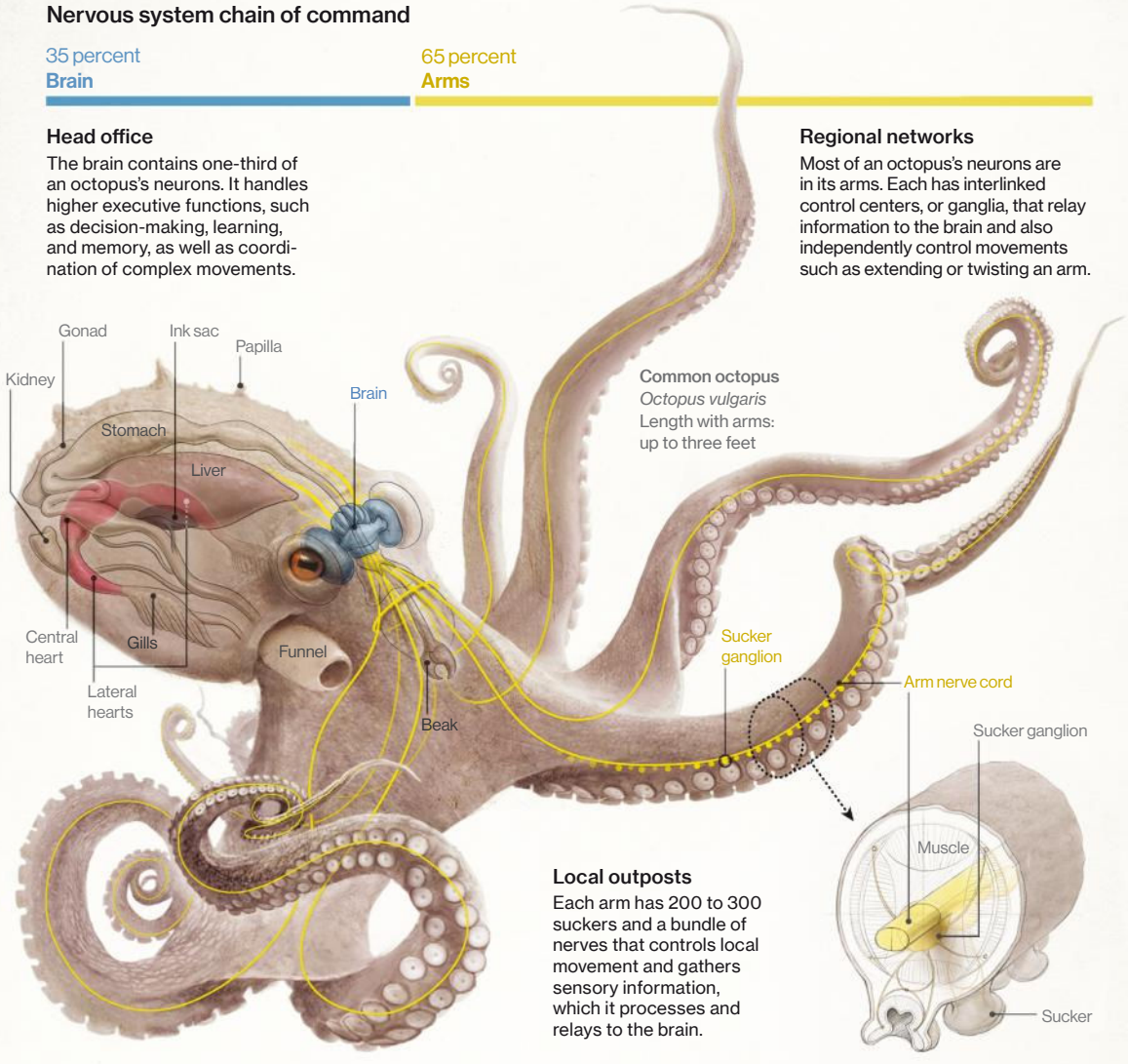
65 percent
Arms

Head office

The brain contains one-third of an octopus's neurons. It handles higher executive functions, such as decision-making, learning, and memory, as well as coordination of complex movements.

Regional networks

Most of an octopus's neurons are in its arms. Each has interlinked control centers, or ganglia, that relay information to the brain and also independently control movements such as extending or twisting an arm.

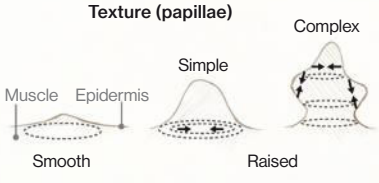


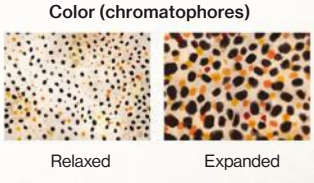
Local outposts

Each arm has 200 to 300 suckers and a bundle of nerves that controls local movement and gathers sensory information, which it processes and relays to the brain.

Hidden in plain sight

Octopuses can vary their appearance to match their surroundings nearly instantaneously. The brain signals muscles to raise nipple-like papillae, making smooth skin bumpy and expanding networks of chromatophores, changing the animal's color and texture.





FERNANDO G. BAPTISTA, NGM STAFF. SHIZUKA AOKI; MESA SCHUMACHER

SOURCES: ROGER HANLON, MARINE BIOLOGICAL LABORATORY; GUY LEVY AND BENNY HOCHNER, HEBREW UNIVERSITY OF JERUSALEM; CLIFF RAGSDALE, UNIVERSITY OF CHICAGO

At the same time, octopuses are as alien as any extraterrestrial you might dream up. For starters, they have three hearts and blue blood. When feeling under threat, they squirt a cloud of ink and jet off in another direction. They have no bones. The only hard parts of their bodies are a parrot-like beak and a nub of cartilage around their brain. This makes it easy for them to vanish through tiny cracks—an ability that allows them to escape, Houdini-like, from all but the most octopus-proofed aquarium. Not only can all of their suckers be moved independently; each one is covered with taste receptors—imagine your body covered with hundreds of tongues. Their skin is embedded with cells that sense light. Most otherworldly of all—but let's wait on that. First, let's meet another octopus.

YOU'RE STANDING IN A SMALL, windowless office in the Natural History Museum in London. In front of you, on a desk crowded with files, lies a slab of pale, fine-grained stone. Beside you, Jakob Vinther, a burly Dane with blond hair and a ginger beard, is pointing at it.

"That thing there is the ink sac," says Vinther, an expert on fossil invertebrates at the University of Bristol, in Great Britain. "That's actually pigment—chemically preserved melanin."

You lean forward to look. The stone is clearly marked with the impression of an octopus. It's not large: In life the animal would have been perhaps 10 inches long. You can trace the mantle—the baglike structure that housed its gills, hearts, and other vital organs. Ah yes. That dark stain in the middle there—that's the ink sac. The arms hang down, loosely grouped together, each marked with rows of circles. "And those little round structures," says Vinther, "those are the suckers."

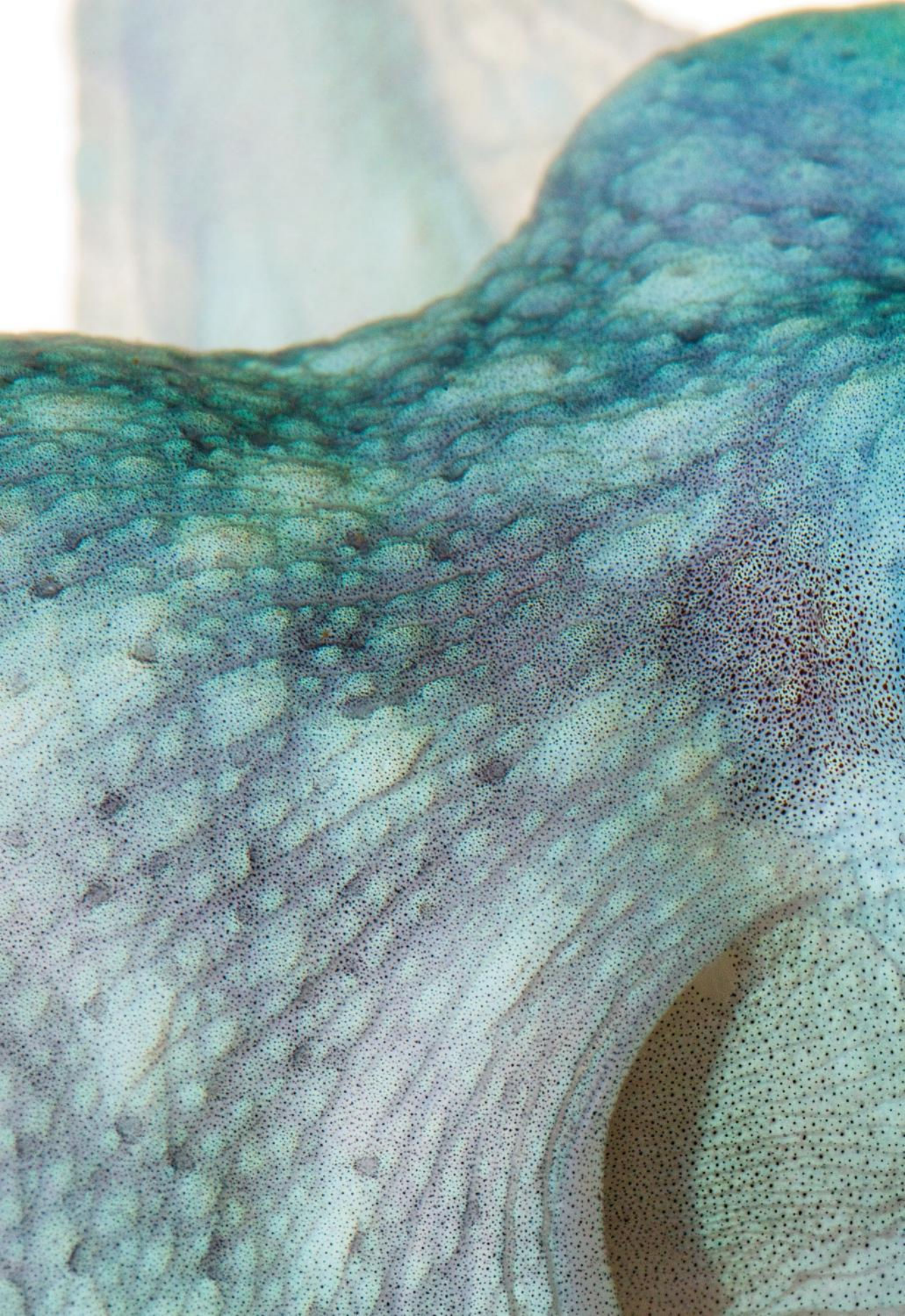
Of all the animals that lack a backbone, octopuses are the ones that seem the most like us. In part, it's the way they return your gaze, as if they're scrutinizing you.

Octopus fossils are rare; animals with soft bodies generally leave no trace. This fossil is about 90 million years old, which makes it one of the oldest known octopuses. When this animal lived, the extinction of the dinosaurs was still 25 million years in the future. "It comes from a locality in Lebanon where you find all kinds of wonderfully preserved soft-bodied creatures," Vinther says. Lampreys. Fire worms. All entombed, long ago, in fine, chalky mud on the floor of a long-vanished sea.

Just as humans are mammals, octopuses are cephalopods. The word is Greek for "head-foot" and refers to their weird anatomy, by which their arms are attached directly to one side of their head while their "torso"—the baglike mantle—is on the other. Cephalopods, in turn, are a type of mollusk—a group that includes snails and slugs as well as clams and oysters.

Cephalopods were among the first predatory animals to hunt in the ancient seas. They evolved more than 500 million years ago—long before fish got going—from a small animal with a shell like a witch's hat. Indeed, if you were to travel back in time 450 million years, some of the fiercest predators in the oceans would have been shell-wearing cephalopods. Some of these were apparently enormous: The shell of the long-extinct *Endoceras giganteum* may have been more than 18 feet long.

Today there are more than 750 known living species of cephalopods. Besides



Octopuses are masters of disguise, rapidly shifting their looks to blend in with their surroundings. The speckles on this Capricorn night octopus, *Callistoctopus alpheus,* are cells full of pigment. If the animal were to open them all, it would appear red with white polka dots.

PHOTOGRAPHED AT QUEENSLAND SUSTAINABLE SEALIFE, AUSTRALIA

A Capricorn night octopus jets away (top), using muscles in its mantle to force water through the tubular funnel visible below the eye. The southern keeled octopus, *Octopus berrima* (middle), is particularly fond of crabs. All octopuses have venom, but that of the blue-ringed octopuses, such as this southern blue-ringed, *Hapalochlaena maculosa* (bottom), is powerful enough to kill a human. All three of these octopuses are from Australia.

PHOTOGRAPHED AT: QUEENSLAND SUSTAINABLE SEALIFE, AUSTRALIA (TOP); PANG QUONG AQUATICS, VICTORIA, AUSTRALIA (BOTTOM)

around 300 species of octopus, these include an array of squid and cuttlefish (both of which have 10 limbs) and a few species of nautilus—peculiar animals that have 90 tentacles and live in shells.

Modern octopuses are a diverse bunch. The giant Pacific octopus, *Enteroctopus dofleini,* is, as its name suggests, gigantic. Each arm of a large individual can be 6.5 feet long, and the whole animal can weigh more than 200 pounds. Others, such as the star-sucker pygmy octopus, *Octopus wolfi,* are teensy, weighing just a fraction of an ounce. Some octopuses have a tiny mantle but immensely long arms; others are more evenly proportioned. Most clamber around on corals, mud, or sand, swimming only to get from A to B or to escape from a predator, but a few have taken to cruising the ocean currents. You can find octopuses from the tropics to the poles, from coral reefs to sand flats, from tide pools to the abyss. At least you can if you can spot them.

BACK IN LEMBEH, it's a sunny morning. You're swimming over a shallow reef. Your guide—a man named Amba—makes a hand sign that shows he's seen an octopus. A big octopus. Where? You look around. No octopus. Just rocks, covered with corals and sponges of different colors. Amba gestures insistently: big octopus! You look where he's pointing. Nope: nothing. Wait. Look again. That patch of dark, velvety coral, that one over there. That's no coral. That's a day octopus, *Octopus cyanea*. Astonishing to have missed it: It's as big as a dinner plate.

Octopuses and cuttlefish that live in shallow water and hunt during the day are the world champions of disguise. Of course, disguise is not unusual: Many creatures have evolved to look like something they're not. That orange sponge over there, for example, is not a sponge but a frogfish, lying in wait for an unwary fish. That leaf you see drifting above the sand is not a leaf; it's a fish that's evolved to look like a leaf. That leaf—that one there, scuttling over the sand—really is a leaf, but it is also really scuttling. A crab has taken it and stuck it to its shell. That small anemone is a sea slug that has evolved to impersonate an anemone. And everywhere you look, patches of sand get up and walk about (tiny crabs with sand-colored shells) or swim off (sand-colored flatfish).

What makes octopuses and cuttlefish (and to a lesser extent, squid) different is that they can disguise themselves on the fly, now looking like coral, now like a clump of algae, now like a patch of sand. It's as if they use their skin to make three-dimensional images of objects in their surroundings. How do they do it?

Octopus disguise has three main elements. One is color. Octopuses generate color through a system of pigments and reflectors. The pigments—usually tones such as yellows, browns, and reds—are kept in thousands of tiny sacs in the top layer of the skin. When the sacs are closed, they look like minute speckles. To show the pigment, an octopus contracts the muscles around the sac, thus pulling it open and revealing the color. Depending on which sets of sacs an

A Pacific red octopus, *Octopus rubescens* (above), shows its suckers. Each one can be controlled independently, bending and twisting to provide not just suction but also formidable strength and surprising dexterity. The greater blue-ringed octopus, *Hapalochlaena lunulata* (top right), flashes its rings to warn of its poisonous bite. Many young octopuses, like the juvenile day octopus *(Octopus cyanea)* at bottom right, grow extremely fast.

PHOTOGRAPHED AT DIVE GIZO, SOLOMON ISLANDS (OPPOSITE, BOTH)

The nervous system of this common octopus, *Octopus vulgaris,* is far larger and more complex than that of most invertebrates. Can it think? Is it conscious, as some scientists and philosophers suggest? How will we ever know?

PHOTOGRAPHED AT FLORIDA KEYS MARINE LIFE

octopus opens or closes, it can instantly produce patterns such as bands, stripes, or spots. The reflecting cells come in two types. The first type reflects back the light that arrives—thus causing the skin to appear white in white light, red in red light, and so on. The second type is like a living soap bubble that presents different colors when seen from different angles. Together, the reflectors plus the pigment organs allow an octopus to create a huge variety of colors and patterns.

The second element of disguise is skin texture. By contracting special muscles, octopuses can change their skin from smooth to spiky. The effect can be extreme. The algae octopus, *Abdopus aculeatus,* generates temporary wispy structures that give the impression that the animal is just a piece of seaweed. The hairy octopus, a creature yet to be scientifically described, has evolved a permanently wispy look and is hard to tell apart from a scrap of red algae.

The third part of disguise is posture. The way an octopus holds itself can make it more or less conspicuous. Some octopuses, for example, will ball themselves up like a lump of coral and, using just two of their arms, creep slowly across the seafloor. (No, no, don't look at me—I'm just a rock...)

An octopus on the hunt is an impressive sight—every arm stretched out over the sand, each one exploring, probing into holes. If one arm startles a shrimp, two more can reach out to catch it.

How did octopuses get so good at this? The short answer is: evolution. Through tens of millions of years, individuals that were better at disguise were more likely to evade predators and leave offspring. And plenty of animals—including eels, dolphins, mantis shrimps, cormorants, many fish, and even other octopuses—are enthusiastic eaters of octopuses. Because octopuses have no bones, predators can eat the whole animal. As Mark Norman, a world expert on living cephalopods at Museum Victoria, in Melbourne, Australia, puts it, "These animals are pure meat walking around—they're filet mignons."

NOW LET'S TURN TO THE MATTER of the octopus's nervous system. A typical pond snail has just 10,000 neurons; lobsters have around 100,000; jumping spiders, perhaps 600,000. Honeybees and cockroaches, which after cephalopods have a claim to be the planet's most neuronally rich invertebrates, have around a million. So the 500 million neurons of the common octopus, *Octopus vulgaris,* put the animals into a completely different league. In terms of their neuron count, they are better endowed than a mouse (80 million) or rat (200 million) and almost on a par with a cat (around 700 million). Yet while vertebrates keep most of their neurons in their heads, two-thirds of an octopus's are in its arms. What's more, nervous systems take a lot of energy to run and can evolve to be large only when the benefits outweigh the costs. So what's going on?

Peter Godfrey-Smith, a philosopher turned octopus biologist at City University of New York and the University of Sydney, in Australia, suggests that several forces may have helped the octopus develop a complex nervous system. The first is its body. Nervous systems, after all, evolve in tandem with bodies, and the octopus body has evolved to be unusually complex. Being boneless, an octopus can extend any arm in any direction at any point; unlike you or me, it's not limited to moving at shoulder, elbow, or wrist. This gives

the octopus an enormous range of possible movements; also, each arm can be doing something different. An octopus on the hunt can thus be an impressive sight. It can have every arm stretched out over the sand, each one exploring, rummaging, probing into holes. If one arm startles a shrimp, two more can reach out to catch it. Octopuses also have all those suckers that can be moved independently, not to mention the structures and mechanisms for controlling skin color and texture. At the same time, the animal has evolved the capacity to receive and process a huge amount of incoming sensory information: taste and touch from the suckers, gravity sensed by structures called statocysts, as well as all the information that its sophisticated eyes collect.

On top of this, many octopuses live in spatially complicated environments—they must navigate on, around, and through reefs. Having no body armor, they need to keep a sharp lookout for predators, and in case camouflage is not enough, they need to know where to hide. Finally, octopuses are fast, agile hunters that catch and eat a wide variety of animals, from oysters to crabs to fish. Boneless bodies, complex environments, diverse diets, avoiding predators—all factors, Godfrey-Smith suggests, that can drive the evolution of intelligence.

Yet while octopuses clearly have complex nervous systems, are they, in fact, smart? Evaluating the intelligence of other animals is tricky at the best of times, and sometimes tells us more about ourselves than about the animal in question. Markers of intelligence in birds and mammals, such as the ability to use tools, often don't make much sense for an octopus: Its whole body is a tool. It doesn't need a tool to reach into crevices—it can just reach in—or to pull oysters apart.

That being said, experiments starting in the 1950s and 1960s showed that common octopuses are good at tasks involving learning and memory—two attributes that we associate with intelligence. Indeed, a particular part of the octopus brain, the vertical lobe, is dedicated to such tasks. I'm stressing the common octopus here because it has been studied the most, by far. Octopus species do differ somewhat in the organization of their brains, and as only a few have been studied, no one knows whether all of them are equally gifted. Roy Caldwell, an octopus researcher at the University of California, Berkeley, says, "Some that I've had in the lab seem to be as dull as toast." Name names? "*Octopus bocki,* a tiny little octopus." What makes it dull? "It just doesn't seem to do much."

But perhaps whether they are smart or dull—whether they are pondering philosophy or lunch, or not thinking anything at all—is less important than the fact that they are just all around astonishing. Enchanting.

Let's go on one final dive. It's dusk in Lembeh. You're kneeling by a rocky slope. In front of you, swimming cheek to cheek, a pair of small fish are spawning. An eel is curled in a hole. A large hermit crab, in its borrowed shell, comes clunking past. And there, sitting on a rock, is a small algae octopus.

As you watch, it starts to move. One moment it seems to float, levitating like an eight-armed yogi. Another moment it appears to glide. Now it starts to crawl over the rocks—but whether it pulls itself with the arms in front or pushes with the arms behind, you cannot say. As it moves down the slope, one arm finds a tiny hole, and, one arm after another, the animal streams into it. Gone. No—not quite. The tip of an arm reaches out of the hole, feels around, grabs some small stones, and pulls them over the entrance. There. All secure for the night. □

To photograph the octopuses for this story, **David Liittschwager** put them in custom-fitted aquariums placed in front of white backgrounds.
SUZIE RASHKIS

A curiosity, a portent, a looming symbol of the impending change: This May, for the first time in nearly four decades, an American cruise ship sailed into Havana Bay.

Here

CHANGING CUBA

A warming relationship with the U.S. has an upbeat but wary Cuba bracing for an onslaught of tourists from its Cold War adversary.

Comes the Wave

By Cynthia Gorney
Photographs by David Guttenfelder

The first Cuba sighting came Monday morning, just after sunrise. The island is almost 800 miles tip to tip, and for a while there was a horizon shimmer, then hilly outlines against pink sky, and finally: rooftops. A domed shape, maybe a cupola.

The ship's topmost deck was jammed with television crews; the rest of us mashed up against the railings on the next deck down. Somebody handed out little Cuban and American flags. Now we could make out the Malecón, the seawall and walkway that serves as a collective front porch for people seeking fresh air or respite from overcrowded households. On warm evenings Cubans always populate the Malecón, but this was something new—nine in the morning, and crowds seemed to have gathered, lofting flags of their own, waving. Cheering!

None of us had known what to expect; as we left Miami on Sunday afternoon, there'd been speculation that the first U.S. cruise ship to dock in Cuba in nearly four decades might fire up anti-Castro hostilities. A lone protest motorboat had chugged around with *"Democracia"* painted in defiant red along the hull, but that was all. And now in Havana the celebrations were so exuberant, once we made our way into the city's passenger ship terminal, that the currency exchange booth clerk and I shouted at each other in Spanish through the glass.

Me: "IS IT ALWAYS THIS LOUD IN HERE?" Exchange clerk: "WHAT?" Me: "THE DRUMS, THE MUSIC, THE DANCERS? THEY ALWAYS GREET THE SHIPS?" Exchange clerk: "WHAT?" She slid me a pen, and I wrote on the back of a receipt: "IS THIS SPECIAL FOR THE AMERICANS?" She nodded, smiling ruefully, and rolled her eyes. The female dancers' ensembles consisted of high heels, Cuban flag swimsuits, and big silver stars affixed to their hair. We watched two of them snuggle up, beaming and posing, to a disembarking male passenger in shorts. Something flickered across the clerk's face—distaste, I think—and she lowered her gaze and went on counting pesos. Those cell phone photos of the local beauties with their torsos wrapped in the national colors were going to spread remarkably fast, and make trouble.

"*AMIGA,* COME SIT BETWEEN US," Javier and Lydia demanded. They are neighbors in a sagging Havana building not far from the terminal; Lydia had heard so much on the news about the *histórico* ship arrival that they walked over to see it for themselves. They brought a spool of line and some shrimp pieces for bait, and they were side by side on the crowded seawall with their fishing line in the water, gazing at the docked ship, when they shoved over to make room for me.

From out here, surrounded as we were by Cubans holding up tablets and smartphones to mug for selfies with the *Adonia,* the ship looked to me like the biggest object on the whole Havana seafront. Above the water we could count nine layers of portholes and plate glass (photographer David Guttenfelder and I had rooms on board for the week, somewhere on level four), and I thought that from a Cuban perspective the whole gleaming white hulk must loom like a massive billboard: Here Come the Americans. Brace Yourselves.

In a way everything important about this inaugural trip from Miami to Cuba—everything *histórico*—lay in the visuals, and the anticipation of what comes next. Cruise ships aren't new to Cuba; giant floating hotels under the flags of other nations have visited for decades. Tourism in general isn't new to Cuba, in fact. After the Soviet Union collapsed, ending its economic support and kicking off a brutal depression, state ministries approved new beach resorts that have become popular with Canadians and Europeans.

And although the U.S. embargo still prohibits U.S. residents from traveling to Cuba for what the Treasury Department calls "tourist

From the Malecón, Havana's seawall, the closest tip of the United States (la Yuma, as it's called in Cuban slang) is some 90 miles away. A common refrain, heard among Cubans studying the docked American ship: Pretty vessel. Wish I could travel like that – and go back and forth, between la Yuma and home.

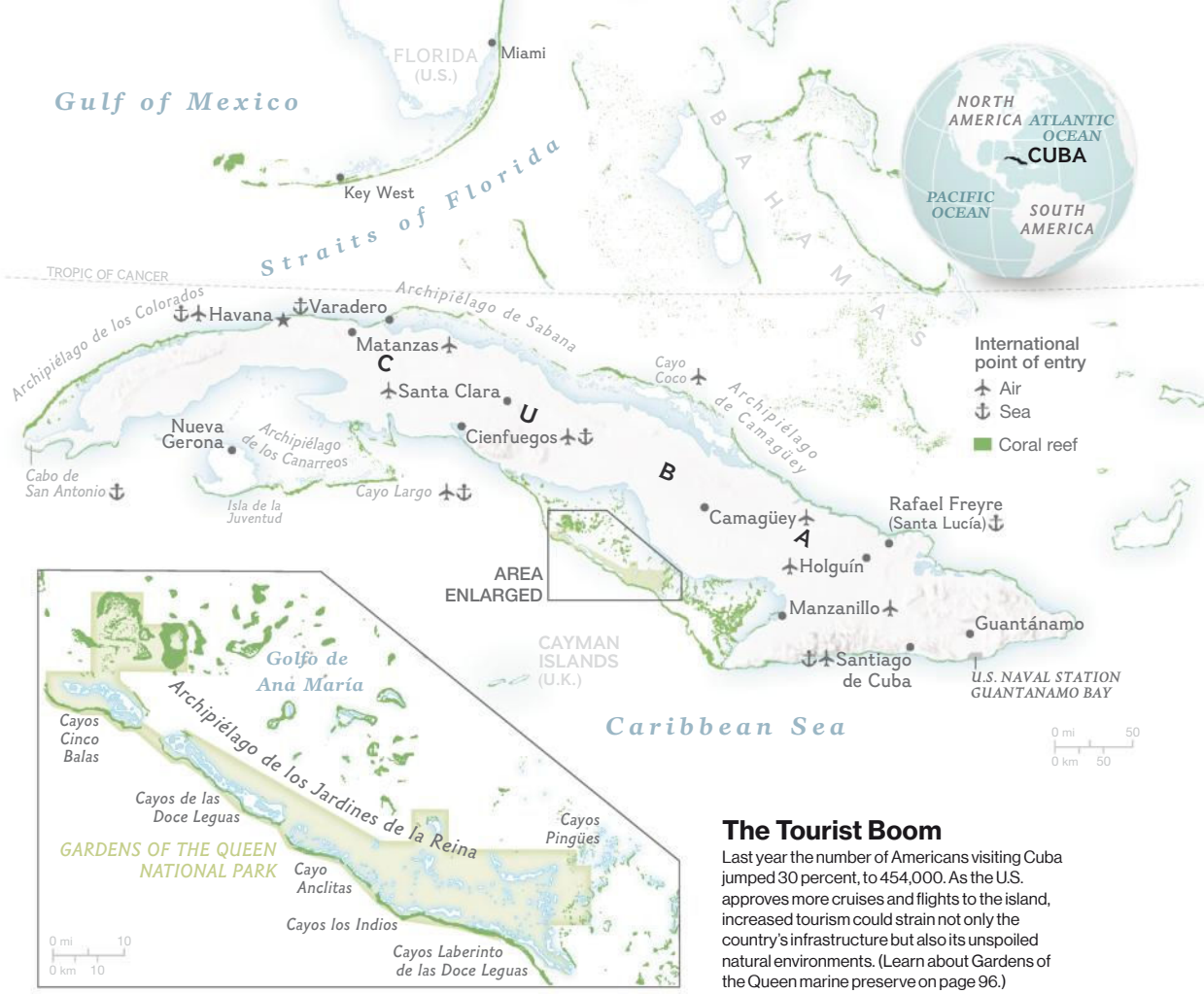
Havana's crumbling buildings charm tourists, who rarely glimpse life on the inside. Like many structures there, the two-story tenement where Caridad Gonzalez lives with her 82-year-old mother and other family members is badly in need of repair. The building has partially collapsed, which is not unusual in the city.

Crowded around the terminal as the *Adonia* docks in Havana, Cubans cheer as though the Americans were rock stars. "A ship like this, straight from the U.S. – what an immense joy," a man says as he high-fives disembarking passengers. "I'm 50 years old and have never seen such a thing."

activities," Americans started arriving in noticeable numbers about five years ago. Even before the December 2014 announcement that diplomatic relations would resume, the Obama Administration was approving tours for "people-to-people educational travel," a Cuba-specific category that continues to evolve. No lying on beaches all day with rum drinks is the idea, but you may visit the school that teaches violin to the rum-drink mixer's kids, and it's become increasingly common to see phalanxes of Americans following guides along beautifully restored streets in Old Havana or into private restaurants or organic farms.

Then this March the administration declared that Americans could start people-to-people traveling on their own, provided they sign affidavits promising to abide by embargo rules. Less than a week later U.S.-based Starwood Hotels and Resorts announced a deal to run three Cuban hotels—"the beginning of the luxury market in Havana," a company official told me. In late August the first regularly scheduled flights to Cuba began. Even before that, charter flights were leaving Florida so frequently that Miami International Airport departures boards listed Cienfuegos, Cuba, right up there between Chicago and Cincinnati.

Cienfuegos isn't even one of the biggest cities in Cuba. It now maintains an international airport and a cruise ship terminal, though, and was the second of the *Adonia*'s three stops in its circumnavigation. All week David and I kept trailing passengers off and on the ship, and everywhere we went, we studied Cubans as they studied the *Adonia*—or what the *Adonia* was delivering into their midst. Seven hundred tourists at once makes for a lot of shepherding around a smallish city like Cienfuegos, and it was useful to keep remembering the way Javier had elbowed me, his new yanqui acquaintance, and told me he was pretty confident his country could manage



The Tourist Boom

Last year the number of Americans visiting Cuba jumped 30 percent, to 454,000. As the U.S. approves more cruises and flights to the island, increased tourism could strain not only the country's infrastructure but also its unspoiled natural environments. (Learn about Gardens of the Queen marine preserve on page 96.)

the coming tsunami, a word I heard more than once from Cubans as they contemplated what's en route. "It's going to change. But little by little," Javier said. "This is going to be good for the whole country, you'll see. We'll figure it out."

PRODUCE MARKET, CIENFUEGOS: Yanet, the vegetable seller, leans on her counter in amusement as Americans troop steadily by outside, some stopping just long enough to peer in and photograph. ("They stay on the ship. They eat in the restaurants. They don't buy anything from *me*.") Bed-and-breakfast, Havana: Señora Martha, the landlady, says cruise ship passengers are no use to her, either, but the country needs more business desperately. ("Bring on the Americans! Just don't let any of them privatize the water system.") Taxi stand, Santiago de Cuba: Jorge, the former civil engineer who is now driving tourists around in an old Russian-made Lada because he makes so much more than he did at his former state job, says he's heard people worry that the influx will eventually bring drugs, exploitation, a surge in prostitution. ("I don't think so. I have faith in our government, in our values—and in the morality of *norteamericanos*.")

In Cuba *resolver* is a crucial verb. In its most Cuban sense it means to manage with creative dexterity the challenges of modern Cuban life, *improvisando* as you go. Among ordinary citizens, it's a point of national pride that so many have resolved and improvised their way through the post-Soviet crash, through the mismanagement and overreach of their own state ministries, and through the extraordinarily long U.S. embargo. Fishing with a baited piece of line, because your custodian salary won't cover the price of a rod, is a tiny way to *resolver*.

And so is cannibalizing parts to keep an ancient car running, not because foreigners love looking at it but because there is nothing else to

JON BOWEN, NG STAFF. SOURCES: IUCN AND UNEP-WCMC, WORLD DATABASE ON PROTECTED AREAS (2016); WORLDFISH CENTER; WORLD RESOURCES INSTITUTE; NATURE CONSERVANCY

Until recently, limited Wi-Fi was a source of intense frustration for Cubans. Now every city offers public hotspots, like this Havana plaza, to anybody with by-the-hour access cards. At about two dollars each, the cards are still costly for people on state salaries – but the outdoor spaces bustle, especially after work.

drive. The paradoxes of tourism are especially loud and perplexing in Cuba now, during these tentative seasons before the tsunami truly rolls. Set aside for a moment political quarrels about whether the American embargo or the Cuban Communist Party is at fault; one of the standard enticements, in tour brochures aimed at Americans, is the islandwide absence of material modernity, of familiar commerce, of Americanness. No McDonald's—it's true. No billboards, except those exhorting socialism and good civic behavior. "Frozen in time" is a popular phrase in the brochures; so is "long forbidden." "Ninety-nine percent of Americans planning to visit Cuba say the same," Havana architect Miguel Coyula told me. "'I want to see Havana *now.*'"

Before "the urban Jurassic Park," as Coyula likes to joke, becomes…what? Coyula's not hostile to tourism; accommodating Americans seems to him one obvious growth industry for the biggest island in the Caribbean. The perils of overadoration by visitors are plain to him, and in fact, as the *Adonia* was rounding Cuba, several dozen academics and officials were meeting at a conference called Turismo Sostenible y Responsable—Sustainable and Responsible Tourism. Among the presentations: A clip from *Bye Bye Barcelona,* a documentary making the case that hordes of tourists, especially the thousands pouring into the streets from as many as four docked cruise ships at once, have rendered the Spanish city nearly unlivable for its own residents. "A theme park," complains one angry local.

For an enormous, beachy island 90 miles from the United States, this is not an implausible comparison. Some of the ships now plying the Caribbean can hold six times as many passengers as the *Adonia;* Carnival Corporation, which owns the ship, has Cuba plans in the works, as does every American touring company with an interest in the Caribbean (including National Geographic Expeditions, which routinely runs people-to-people Cuba trips). On board I asked a Carnival official to guess at the potential of a fully tourist developed Cuba. Well, he replied, Carnival last year delivered nearly a million people to the Caribbean's Grand Turk Island, which is seven square miles. "Cuba is a few hundred times bigger," he said. "You can calculate the answer."

At least three million Americans a year, eventually, is what economists project. Cuba's population is 11 million, and many still *resolver* their way to enough powdered milk for the children, a toilet that flushes, a balcony that won't collapse. How to bring in all those Americans in a way that actually improves Cubans' lives?

"I've thought about this," said Rafael Betancourt, an economics professor at a Havana university who helped arrange the tourism conference. "There's always a risk. But I'm basically an optimist. I believe we have a tradition, a very solid culture and history of our own."

One other thing, he said: The Cuban flag bathing suits. Some of the dismay they set off, once the photos began to circulate, was magisterial in its invocation of Cuban dignity and decorum in a public space. Flags of any nation should be treated with more respect than that, essayists wrote. One in particular spoke of *vergüenza,* shame, and invoked the revered nationalist writer Nicolás Guillén, who in the 1930s—long before the Cuban Revolution—wrote a poem about obsequious maracas shakers scurrying to yanqui cruise ships in search of dollars.

Betancourt sighed, when I asked him about that essay, and said nobody he knew was angry with the swimsuit dancers themselves. "They didn't do it to insult the Cuban flag," he said. The whole noisy production was just somebody's idea of Welcoming, Exuberant, Friendly, Dancing Cuba, he said, and a flap like this can have a certain usefulness. "It unleashed the discussion," he said. "It was like a switch. And we have got to watch out. We have to be very careful. This is a country that will not have its identity torn away." □

MARK THIESSEN, NGM STAFF

Cynthia Gorney wrote the November 2012 cover story, "Cuba's New Now." This was her fourth trip to Cuba. She would like to point out that **David Guttenfelder** had a window in his berth on the *Adonia,* and she didn't.

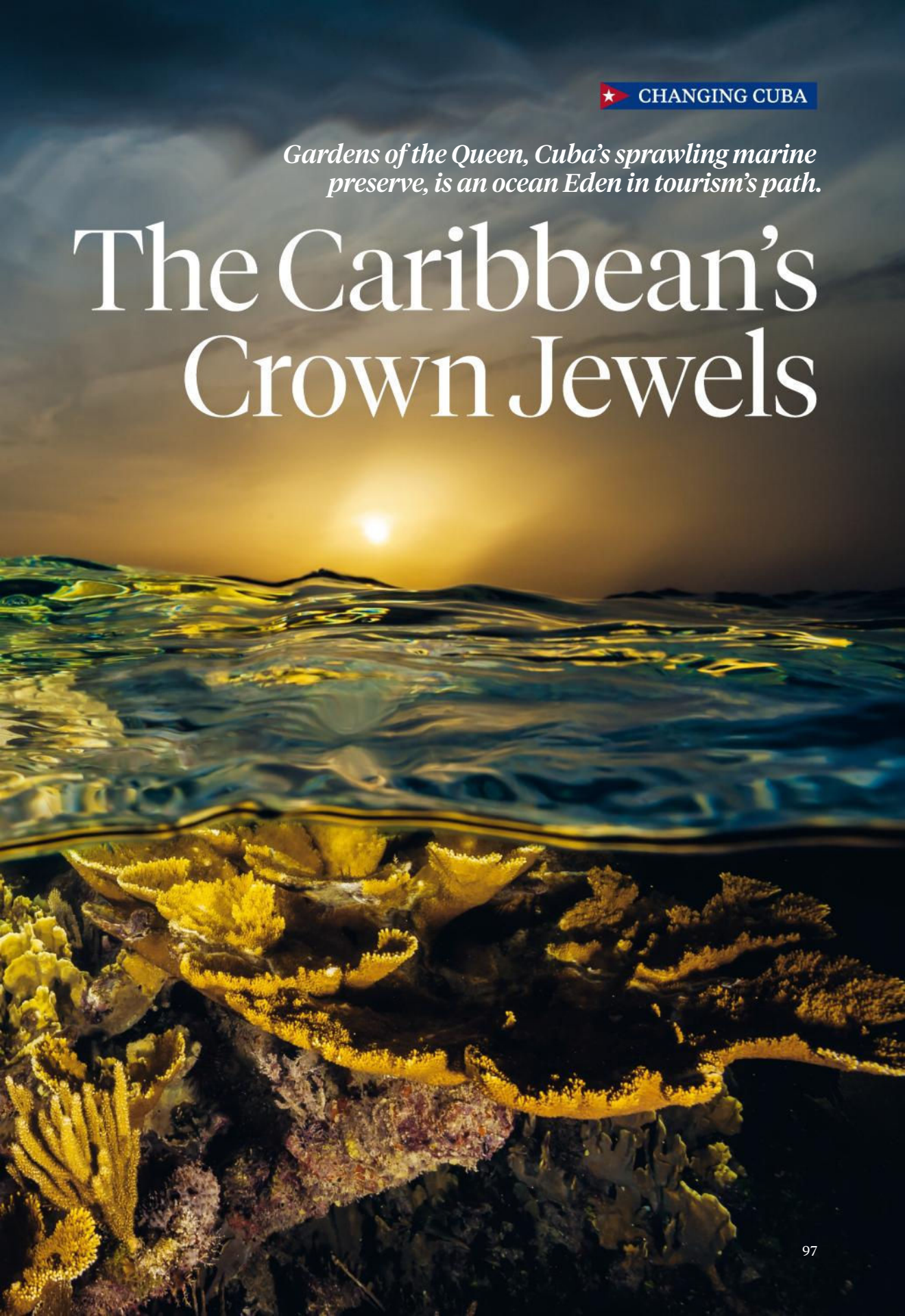
"Tourism is a double-edged razor," says Cuban architect Miguel Coyula, who thinks the U.S. embargo has filtered out conventional tourism to Cuba. "The people who come now want to understand," he says. "But I know that's about to change, when everybody comes. That's my fear."

"You say you're from New York, and they say, 'America!' and embrace you," one passenger recounted, still moved by his encounters with Cubans on the street. He resolved to learn "Guantanamera," the 1930s folk song that has become a kind of international anthem of Cuba, as the *Adonia* headed out of Havana Bay.

Sunset casts a golden glow over corals flourishing off the country's southern coast. Named by Christopher Columbus in honor of Queen Isabella, this remote set of keys, mangroves, and reefs appears nearly unchanged by time and human hand.

Gardens of the Queen, Cuba's sprawling marine preserve, is an ocean Eden in tourism's path.

The Caribbean's Crown Jewels



Silversides swirl through mangroves like a river in the sea. The dense forest of roots offers welcome shelter for the finger-size fish, which form large schools to try to confuse predators. Mangroves enhance reefs by providing a nursery area for vulnerable creatures and by trapping sediment that can smother coral. They also store carbon that might otherwise contribute to global warming.

Fifteen years had elapsed since we last explored the Gardens of the Queen. In the necklace of keys, mangrove islets, and reefs about 50 miles off Cuba, we had discovered a marine wilderness that astonished us with its vibrant life.

We returned to Cuba anxious about what we would see in the wake of time and climate change in this national park now covering about 850 square miles. On our first dive we descended into a large stand of elkhorn coral, a critically endangered species diminished throughout the Caribbean. We found ourselves in a dense thicket, amazed as we watched grunts and snappers jostle for space among the broad branches, as if in a game of musical chairs. This is exactly what we hoped to see; we were inside a liquid time capsule, transported back to a world of coral draped in fish, what the Caribbean looked like to our eyes decades ago.

Noel López, a dive master who has observed these waters for two decades, guided us to a deeper reef where we encountered four species of grouper, including a goliath the size of a stove. The reef seemed even

David Doubilet and **Jennifer Hayes,** who work as a team, have photographed the oceans from the Equator to polar regions.

Story and Photographs by
David Doubilet and Jennifer Hayes

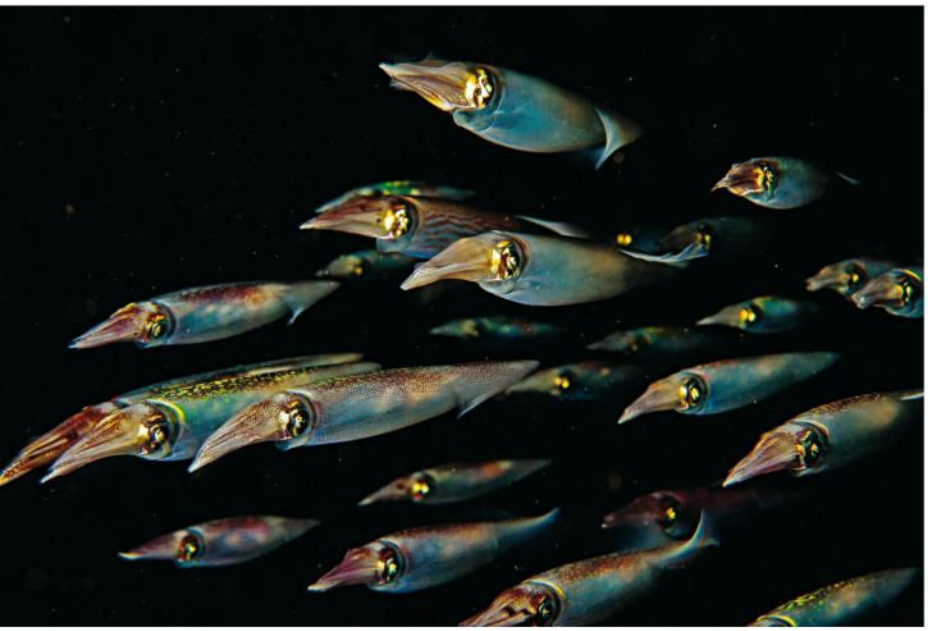
more crowded with large fish and sharks than on our first visit.

One morning we entered the mangroves and swam through a flooded forest filled with clouds of silversides. We ventured out to open water to dive with dozens of sleek silky sharks, which formed a perfect carousel around us. At dusk we returned to the mangroves and submerged into the dark water with powerful lights. We followed an American crocodile, hunting silent as a submarine. To encounter such abundant prey and super predators in a single system, let alone a single day, was incredible.

This oasis in the ocean flourishes, marine scientist Fabián Pina Amargós emphasizes, because Cuba actively protects the preserve, where tides and currents help retain nutrients and larvae. So far the marine ecosystem has proven resilient to coral bleaching, but it faces the same threat that other reefs do as the ocean warms, acidifies, and rises.

As the U.S. embargo draws to an end, the romance of Cuba's waters is sure to lure more Americans. There's an urgent need to strike a balance between ecotourism and conservation. Cubans know what's at stake: the living crown jewels of the Caribbean.

A trio of silky sharks *(Carcharhinus falciformis)* gleams against the blue Caribbean Sea. Healthy reefs support a food chain that links plankton to predators. Besides silky sharks, predators include Caribbean reef sharks and large fish such as the black grouper *(Mycteroperca bonaci)*, seen above consuming a snapper.



For a detailed map of Cuba and Gardens of the Queen National Park, see page 89.

The night sea pulsates with life unseen during the day. Marine worms attracted to an underwater light form a living veil (top left). A squadron of Caribbean reef squid *(Sepioteuthis sepioidea),* known for their voracious appetites and ability to communicate by rapid changes in skin color and patterns, hunts for a meal (bottom left). A critically endangered hawksbill sea turtle hatchling *(Eretmochelys imbricata),* about three inches long, paddles away from shore under the protective cover of dusk. Cuba banned the harvest of sea turtles in 2008.

Schools of bluestriped grunts *(Haemulon sciurus)* and schoolmaster snappers *(Lutjanus apodus)* fill the space between broad branches of elkhorn coral *(Acropora palmata)*. Fast growing but fragile, elkhorn coral is a critically endangered species. It has virtually disappeared throughout most of the Caribbean – but populations of it remain in the Gardens of the Queen.

A submerged American crocodile *(Crocodylus acutus)* rises from an evening slumber in a bed of turtle grass to return to the labyrinth of mangrove roots that offer near-impenetrable shelter. Scientists consider crocodiles the engineers of the mangrove ecosystem because they create pathways that improve nutrient circulation. Increasing numbers of super predators, such as crocodiles and sharks, are key indicators of a balanced ecosystem.

Fragile Peace

Seven years after the end of a brutal civil war, Sri Lanka is beginning to reckon with the aftermath: the tens of thousands homeless and tens of thousands still missing.

A military color guard lowers the national flag on Galle Face Green, a popular park in Colombo. The country's largest city shows few signs of the strife that divided the Sinhalese and Tamils for 26 years.


SPECIAL TASK FORCE

Scouts prepare to sing for the president as a policeman in his security detail stands watch. The national jamboree was held this year in Jaffna, the first time it has been in the Northern Province.

At a camp for displaced Tamils, a man hides behind his child. The memory of the war, which ended in a bloody attack, looms large. Tens of thousands of Tamils are still waiting to be resettled.

By Robert Draper
Photographs by Ami Vitale

The photograph the young woman holds is barely the size of a postage stamp. But it is the only one of her husband she could find here in her parents' house. They had not approved of her marriage, given that he was just a fisherman from the coastal town of Mannar, while her family has lived in Jaffna, the capital of Sri Lanka's Northern Province, for generations. But as the photo attests, her husband, a Tamil like herself—is broad-faced and confident. Staring at the tiny image of the man who went missing a decade ago, her mahogany eyes brighten as she loses herself in memories.

They'd fallen in love at a refugee camp in southern India in 1999, when she was 17. Both had escaped Sri Lanka's wantonly vicious civil war, pitting the army, controlled by the majority Sinhalese, against Tamil rebels. She had fled Jaffna with her family, leaping over the corpses of neighbors as the military's bombs plummeted from the sky. He had escaped Mannar after he saw an army officer shoot his youngest sister to death in their home. They had married under the withering glare of her mother.

They returned in 2002 to Mannar, where he could take his boat and his nets out to sea. They had a boy, then a girl. To supplement his modest income, he sold canisters of gasoline to Tamil resistance fighters. She saw little risk to this practice, which was common among Tamil men in Mannar. And when he said to her, "If something ever happens to me, you shouldn't try to look for me—go back to your mother," the words simply did not register, until December 27, 2006, when he took his motorcycle out and didn't come back that evening or in the days that followed.

A rooster zigzags past her bare feet. Stirred from reverie, the fisherman's wife puts down the photo and returns to the cooking chores with the other women in the ramshackle, barely lit house. Today her family has gathered to memorialize her mother's sudden death from stomach cancer a month ago. One brother couldn't make it. He's in Paris, illegally and without a job. The Sri Lankan military had tortured him, and if he were to return home, he fears he might well be apprehended from the streets, as the fisherman was, as thousands of Tamil men have been—without warning, justification, paper trail, or even official acknowledgment.

Somehow the 34-year-old woman with the waist-length braided hair that sways as she serves a traditional vegetarian feast—chickpeas, eggplant, beans, tapioca—is not swallowed by grief. "I know my husband is alive," she says, with simple finality. This belief is what preoccupies her. Not her mother's death. Not that she earns almost

Tamil children return from school in Mannar, a town on the northwest coast where many Tamil men vanished during the civil war. Sri Lankans highly value education, a constitutional right. It's not unusual to see children studying by candlelight late into the night. The country has an adult literacy rate of more than 95 percent.

nothing at the roadside kiosk where she sells rice and telephone cards. What matters most to the fisherman's wife—who asked not to be identified out of fear for her safety and that of her family—is that she believes her husband remains a ghostly prisoner of a war that concluded seven years ago.

As it happens, the very same conundrum applies to Sri Lanka. In a sense it too has fallen off the map. Once seen as an emerging South Asian powerhouse, the island nation squandered its opportunity for international legitimacy when it descended into a spiral of violence fomented by long-nurtured ethnic grievances. Now, with a new government pledging to unite the country, that opportunity has returned. This April, Samantha Power, the U.S. ambassador to the United Nations, applauded the administration led by President Maithripala Sirisena for its "extraordinary progress" in working toward "a durable peace, an accountable democracy, a new relationship with the outside world, and expanded opportunities for all."

But it's not Power or other foreign officials whom the government needs to win over. Far more crucial is the Tamil minority that feels left behind by the country's postwar progress and embittered by the Sinhalese majority's seeming indifference to its plight. And this is where the

‘We want the world to know that we’re different—that we’re going to do what we say we’re doing.’

Harsha de Silva,
deputy minister of foreign affairs

young woman with the tiny photograph comes in. The inescapable reality is that Sri Lanka will not fully reappear until men like her husband do.

TWO-THIRDS OF THE WAY down the west coast of the teardrop-shaped island from Jaffna lies Colombo, Sri Lanka’s administrative capital. It’s a well-groomed, galloping metropolis that bears no visible scars of war. The city’s population of some 700,000 is more or less equally divided among Sinhalese Buddhists, Tamil Hindus, and Muslims, who live and work together with only occasional displays of hostility. For those who come to Sri Lanka full of questions about its future, Colombo offers reassuring answers.

The city maintained a surprising show of composure on the night of January 8, 2015, when Sri Lanka astonished the world by ousting the autocratic regime of Mahinda Rajapaksa through a largely peaceful and untainted election. Since that pivotal day, the nation’s new leaders have been eager to show the world that Sri Lanka can behave like a modern democracy. The Sirisena Administration has begun to reform the corrupt judiciary system, privatize bloated agencies, and reckon with immense debt incurred from dubious infrastructure contracts awarded to Chinese companies. “We’re not the same guys who used to tell you various things and then forget about it three days later,” said Harsha de Silva, the deputy minister of foreign affairs. “We want the world to know that we’re different—that we’re going to do what we say we’re doing.”

It’s entirely possible for a visitor to fly into Colombo, pursue the country’s myriad tourist pleasures—the ancient temples at Dambulla and Polonnaruwa, the elephants and leopards in its wildlife parks, the sumptuous tea plantations, the surfing mecca of Arugam Bay—and then depart a week or two later without the slightest awareness that for 26 years Sri Lanka was an epicenter of horrific ethnic bloodshed. But geography tugs the visitor away from seeing the lingering aftermath. Colombo is in the south—a region dominated by the Sinhalese, who are mostly Buddhists and constitute around 75 percent of the country’s population. Nearly all the country’s main attractions are also concentrated in the south. By contrast, the Northern Province is visually unremarkable, a mostly flat and arid expanse of agrarian terrain. It also happens to be the homeland of the Sri Lankan Tamils, who are mostly Hindu and make up about 11 percent of the population.

The north and east are where the militant Liberation Tigers of Tamil Eelam (Eelam is the Tamil name for Sri Lanka) ran a de facto state until they were finally crushed. The battlefields across the north today are consecrated with towering memorials celebrating the defeat of “the terrorists.” But for these gaudy new spectacles, few tourists—including Sri Lankans living elsewhere on the island—would ever bother to visit the north. As one Tamil banker put it, with evident bitterness, “They come only to see the victory.”

“IT’S A HISTORY of missed opportunities,” said Sri Lanka’s second most powerful government official, Prime Minister Ranil Wickremesinghe.

He was referring to the country’s as yet unfulfilled economic potential. Geographically situated at the busy trading crossroads between China and India, blessed with fertile land and an educated populace, the nation was positioned after World War II to compete with Singapore for the spoils of Japan’s momentary industrial demise.

Instead, the country known as Ceylon until 1972 proceeded to bungle its chances under a series of governments, including a failed experiment with socialism and, more recently, the cronyism of Rajapaksa, who ruled for a decade. His agriculture-based model purported “to be very

Healing Sri Lanka

The country is taking steps to mend ethnic divisions after nearly three decades of civil war between a government controlled by the Sinhalese majority and the Liberation Tigers of Tamil Eelam.

THE DISPLACED
When the war ended in 2009, there were 44 centers for Tamils who had fled the fighting. Since then, the number has continued to decline as Tamils return home.

ETHNIC TENSIONS
A product of colonial policies, the resentment between Sinhalese and Tamils drove the civil war and has stymied reconciliation efforts needed to create lasting peace.

MINE REMOVAL
More than a million mines and other unexploded ordnance, from both sides of the conflict, have been removed, allowing resettlement in cleared areas.

TEA AND TOURISM
Many Sri Lankan industries, such as its tea trade, are growing. Tourism revenue has more than quadrupled since the war ended.

CHARLES PREPPERNAU, NGM STAFF

SOURCES: ESRI; USGS; NASA; MINISTRY OF DEFENCE, SRI LANKA; NATIONAL MINE ACTION CENTER; UN OFFICE FOR THE COORDINATION OF HUMANITARIAN AFFAIRS; INTERNAL DISPLACEMENT MONITORING CENTRE; INTERNATIONAL RESEARCH INSTITUTE FOR CLIMATE AND SOCIETY; FOUNDATION FOR ENVIRONMENT, CLIMATE, AND TECHNOLOGY; DEPARTMENT OF CENSUS AND STATISTICS, SRI LANKA

Women pick tea in the Central Province near St. Clair Falls, known as the Little Niagara of Sri Lanka. A major source of foreign currency, tea exports bring at least $1.5 billion a year to the economy.

A worker with HALO Trust, a British nonprofit, removes land mines in Jeyapuram, once a Tamil Tigers stronghold south of the Jaffna Peninsula. The organization hires mostly Tamils – about half war widows – and has removed more than 212,000 mines. The government is aiming to clear most remaining mines by 2020.

populist," Wickremesinghe said, "but wasn't really giving anything to the people and was really meant to consolidate family rule."

But Sri Lanka's missed opportunities have not been limited to economic policy. Time and again, ethnic division has undone the country's progress. For 133 years British colonizers tended to award upper-income jobs to Tamils while consigning Sinhalese to semiskilled labor. In 1948, when Sri Lanka won its independence, the new leaders didn't try to unite the country. Sinhalese politicians nurtured the nationalist pride of the majority, who had arrived on the island around 500 B.C. and established what is now the world's oldest continually Buddhist nation. They also stoked the majority's abiding belief that Tamils had been awarded a disproportionate share of government jobs.

Systematically, the Sri Lanka government began to marginalize the Tamils: stripping the right to vote from those whose ancestors had been brought over from India to work in the tea plantations, reassigning university jobs to Sinhalese academics, and diluting the Tamil majority in the Eastern Province by offering land grants to Sinhalese. In 1956 the Sinhalese-dominated parliament made Sinhala the official language. While export-import licenses were preferentially

granted to Sinhalese businessmen in the south, the government showed little interest in the Northern Province's development.

In the 1970s the thought of secession began to take hold in the north, and the Tamil Tigers were born. In 1983 the Tigers ambushed and killed 13 army soldiers, spurring a backlash of ethnic riots in which thousands of Tamils were murdered. The Tigers retaliated with suicide bombers and massacres of civilians. Sri Lanka descended into civil war. Foreign investors fled the country, as did some three-quarters of a million skilled and semiskilled Sri Lankans.

Rajapaksa, who became president in 2005, escalated the war against the Tigers, and four years later government forces cornered the fighters and tens of thousands of Tamil civilians in a slender strip of land near a lagoon. By mid-May 2009 they had slaughtered the last remnants of the Tamil Tigers, along with thousands of the trapped civilians. The war was over. In the end as many as 100,000 people may have been killed.

The atrocities were by no means limited to one side. The Tamil Tigers infamously expelled more than 70,000 Muslim residents from the Northern Province in 1990. They forcibly conscripted thousands of Tamil youths. Their bombings of temples, trains, buses, and airplanes amounted to unambiguous acts of terrorism. After the Tamils were defeated, the triumphalist Rajapaksa regime continued its humbling of them. The government held Tamil political activists indefinitely without formal charges. It would "use the army to colonize the entire Tamil region and give it to the Sinhalese," according to D. M. Swaminathan, a Tamil, who is the new government's minister in charge of resettling Tamils forced into displaced persons camps. And it would refuse to acknowledge any role in the ongoing disappearances.

Rajapaksa's tyranny-of-the-majority vision for Sri Lanka was not sitting well with the international community. In 2010 the European Union halted the country's benefits from certain sustainable-development and good-governance incentives on human rights grounds. Dissatisfied with the Rajapaksa Administration's halfhearted war crimes investigation, the UN Human Rights Council commissioned one of its own in 2014. Under a withering spotlight, Sri Lanka seemed on the brink of yet another disappearing act.

I FIRST WENT to the Northern Province at the end of 2014, just three weeks before Rajapaksa was voted out. The regime had grown annoyed with how journalists and UN investigators were depicting postwar conditions in the north and had effectively sealed it off. Gaining permission to travel there required months of haggling with the defense ministry. Finally, after obtaining authorization, my guide, interpreter, and I drove out of Colombo one early morning and, six and a half hours later, reached the first checkpoint, in the dusty village of Omantai, once the beginning of rebel-held territory. The army officers studied our papers, made calls, asked questions, examined

Fishermen in Nagarkovil, on the north-east coast, haul in nets filled with sprats. Since 2011 nearly 34,000 mines have been cleared from the beach; now more than a thousand people live there.

our van, murmured among themselves, and at last grudgingly motioned us forward.

Throughout our 10-day stay, we encountered checkpoints nearly every hour. Soldiers demanded my guide's home address and my (female) interpreter's cell phone number. One officer called me late at night, sounding drunk, to inquire about my itinerary. Advised by confidants that those who spoke to us would likely be harassed by the military, we staged interviews furtively, in churches and in hotel rooms and in the van on the side of a desolate road. The Tamil homeland remained a thoroughly militarized zone.

Nearly a year later, 10 months after Sirisena became president, I returned. This time, no papers were required and no checkpoints greeted us after Omantai. Soldiers drove past us with disinterest. They did not linger on street corners, staring at Tamil passersby. In Jaffna there were no reports of newspapers being threatened or political demonstrations being quashed. Sri Lanka's occupied territory felt, to a visitor anyway, more like a free society.

The Tamils I spoke with soon disabused me of my optimism. "There's been some breathing space," a Jaffna civic leader told me. "But it's not a drastic change, I'm afraid." Members of the government's Criminal Investigation Department, or CID, still photographed participants at public meetings, he said. Similarly, Vallipuram Kaanamylnathan, editor of the leading Tamil newspaper, *Uthayan,* told me, "The press in the north doesn't feel confident that they can carry out their job the way the media in the south does. The military is still keeping our office under surveillance."

Today three-fourths of the country's 200,000 armed forces remain stationed in the Northern Province. "That number won't be reduced for a long time, because the threat isn't 100 percent over," said Gen. Daya Ratnayake, the former commander of the Sri Lankan Army. Many of the soldiers, Ratnayake pointed out, were now removing mines from the countryside, building temples and schools, and planting trees. But, as I would learn, they also operate the largest hotels in the Jaffna area. They run a golf course and a yogurt factory. They breed dairy cows and sell produce in the markets. "They're getting free land and fertilizer, so they can sell for three rupees what a Jaffna farmer charges 20 rupees," noted Swaminathan, the government minister. "So we have told the military very precisely that they have to give this land back over to the public."

But the military—which until the 2015 election was headed by Rajapaksa's brother Gotabaya—has been slow to respond to the new administration and continues to occupy some of the roughly 12,000 acres that it confiscated during the war.

"We have no confidence that we'll get our land back," said a 46-year-old Tamil woman who has lived in a squalid camp since the army seized her land in 1990. "They've built a hotel on my property. They're earning revenue there. Are you telling me they'll just hand it back over to us?"

A Buddhist monk cares for a spotted deer he rescued when he found it alone in the forest near the ruins of Ritigala Monastery, in the center of the country. A few monks still live near the archaeological site, which has inscriptions from the first century B.C. Sri Lanka is considered the oldest continually Buddhist nation.

The woman told me that her 20-year-old son was born in the camp. The rickety shack with the leaky roof and dirt floor is the only home he has ever known. "As you can see, this is no place to raise a family," she said.

When I asked about her husband, she paused for a moment before replying, in a distant voice, "I lost my husband eight years ago. He was abducted in a white van."

WHEN THE FISHERMAN failed to return home, his wife's first thought was that he must have taken his boat out—though it was odd that he wasn't answering his phone. A few days later she found his motorcycle, and she went to the police. "If we hear of something," they told her, "we'll let you know."

The fisherman's wife began to hear about more Tamil men disappearing from the streets of Mannar. Some had been snatched in public and deposited in unmarked white vans. In September 2008 her cousin was abducted at gunpoint while riding his motorbike. His mother says a naval officer admitted the navy was behind his kidnapping.

The fisherman's wife, other women in Mannar, and women throughout the Northern Province whose men had disappeared decided to make themselves heard. They hectored the police.

Tamil Hindus celebrate Masi Magam at Point Pedro, on the Jaffna Peninsula. During the festival, temple idols are carried to the sea for a ceremonial bath, and devotees wash away their sins.

A nurse greets a mother in the maternity ward of Jaffna Teaching Hospital. In 1987, during the civil war, Indian soldiers who were in Sri Lanka as peacekeepers killed more than 60 patients and staff. Today the hospital has returned to normalcy and is a place where people of all ethnicities and religions are treated.

They visited every prison they could find. They traveled to Colombo and demanded an audience with government officials. They found nothing. Not a body, living or dead. Not an answer, or even a clue. And without formal acknowledgment that the men were dead, the women were not entitled to inheritances or bereavement benefits.

When the war ended, the women braced for answers. But none of the abducted men were released. Instead, the disappearances continued.

The fisherman's wife wrote letters to Rajapaksa and Pope Francis. *My husband has been missing since 2006, from an area controlled by the army. I have two young children. Please help me.* Reports circulated of mass graves, of secret military camps. By 2015 the UN was estimating the number of Tamil disappearances at more than 15,000. Others in Sri Lanka suggested that this number was far too conservative. The Rajapaksa government, for its part, maintained that all the missing persons had simply fled overseas—a claim that it didn't back up with any evidence.

In September 2015 the UN released a comprehensively damning assessment of war crimes in Sri Lanka, citing "years of denials and cover-ups" on the part of the Rajapaksa regime. By not protesting the findings, the new government implicitly signaled it was ready to confront the truth.

"We will get a second chance—we're already working on it," Wickremesinghe, the prime minister, told me. Crucial to this, he acknowledged, was an earnest attempt to make Tamils feel like part of a new Sri Lanka. "They just want to lead a normal life like everyone else," he said.

I wondered how a normal life was possible for the 10 Tamil women I met whose loved ones had disappeared. They feared speaking openly, even under the new regime. The aunt of the fisherman's wife has faced intimidation from state officials for filing a writ of habeas corpus on behalf of her missing son. Others have been threatened with arrest for staging protests. Meanwhile, dozens of Tamils in the north were rounded up this past spring and jailed without formal charges. The government's continued surveillance of Tamil Hindus has coincided with the reemergence of Buddhist extremist groups thought to have been associated with the Rajapaksa Administration. This was, distressingly for many Tamils, still "normal life" in Sri Lanka.

A few days before meeting with the prime minister, I had seen the fisherman's wife in Jaffna. There was now a new photograph of her missing husband, she had told me, from a newspaper story. It was of 168 men, all in white prison uniforms, seated and solemn-faced—taken at a penitentiary somewhere near Colombo during the annual Tamil harvest festival known as Pongal, which would have occurred 10 months earlier.

The men's eyes were blacked out, and in the grainy copy the Tamil inmates seemed impossible to differentiate. But to a woman's longing eyes, it was not impossible. "My husband is in that picture," she had told me. "I can definitely identify him. Three other women from my neighborhood have recognized some of the men. Many of the men look like they have come from Mannar." Seeing the doubt in my face, she had insisted, "I can identify him. He was my husband."

But the prison was located. Her husband was not there. Nor were any of the other missing men from Mannar. And so I asked the prime minister if, as rumored, such men had been hidden in sites guarded by the military.

"There are no such places," he said. "We spoke to the military. And that is what they said."

"Meaning…"

"They're all dead," he said.

In June the Sri Lankan government acknowledged that more than 65,000 people have been reported missing since 1994. It also announced plans to create an office to investigate the disappearances and to issue "certificates of absence" to families of the missing so they can collect benefits and, hopefully, move on with their lives. Assuming it does so, perhaps Sri Lanka will also move forward—consigning its ghosts to memory. ☐

SARAH ISAACS

For the August 2016 issue, **Ami Vitale** photographed China's efforts to breed giant pandas and release them into the wild. **Robert Draper,** a contributing writer, wrote about Virunga National Park in July 2016.

Consecrated in Mexico

In these monasteries, the lives of cloistered nuns are rooted in tradition, devotion—and rock-and-roll.

At a Catholic convent in Puebla, Mexico, 23-year-old Sister Reina Maria, a novice in the Order of the Discalced Carmelites, plays volleyball. Recreation gives the nuns a chance to recharge during a long day of work and devotion.

Story and Photographs by
Marcela Taboada

I always want to know what goes on backstage. Whether I'm photographing baseball or ballet, I like to peek behind the curtain and see what people's lives are really like. So when I got a grant to spend three years documenting Roman Catholic nuns cloistered in Mexican monasteries, I jumped at the chance.

In Puebla, Mexico, where I grew up, some Catholic churches are more than 400 years old. The first sisters here helped the Spanish spread Catholicism in Mexico. But many of the nuns stay secluded in their convents, forbidden to engage with the world. When I was a kid they seemed like legends to me.

Gaining access to their world wasn't easy. When I'd knock on a convent door, they'd tell me to go away—then slam the door in my face. But I was stubborn and persistent, and eventually they let me in.

When I asked the nuns why they'd taken their vows, some told me they'd received a calling. Others said they wanted to avoid marriage. And then there were two sisters who used to play in a rock band—they became nuns to find spiritual meaning.

Each morning I'd start my day when they did—at 4:30. Their devotional singing was my alarm clock. Then I'd shadow them as they did their daily prayers and chores, washing and cleaning and cooking.

I soon learned that they have fun. They laugh and dance, play cards and games. They listen to rock-and-roll.

One nun I met is a big soccer fan. She'd watch TV and follow the teams she liked, praying for the players and jumping for joy when they won.

My aim with this series is to show the daily lives of people whose seclusion makes them invisible. I want everyone to see how alive they are, how human and feminine. Maybe one day their centuries-old way of life will be extinct. But it's not yet. ▯

Before Mass, nuns arrange the priest's cincture into a liturgical word on the altar cloth (above). Their work hasn't always been well documented. I made this image of Sister Emma (right), wearing a crown and holding a staff, when the nuns told me that no current portraits of them exist.


40
Aniversario

When I began this project, I thought of nuns as always dour and serious. But they love to laugh and be festive too. Here, Mother Maria del Carmen (at left) and Sister Virginia stand by a dessert table at a meeting of nuns from nine monasteries of the Conceptionist Order.

Cloistered Catholic nuns perform duties throughout the day. Their chores include (clockwise from top left) decorating altars with flowers, washing and drying clothes, ironing laundry with starch, and stowing away banquet tables after an event.

A procession of nuns – permitted to leave their convent for a day and visit a Franciscan monastery – walk past a sunny wall in Cholula, Mexico. Cloistered nuns may also go out for a doctor's or dentist's appointment, but must always travel in pairs.

In the Loupe

With Bill Bonner, National Geographic Archivist

Family Flock

Turkey farming helped countless families weather the Great Depression—and it was often farm wives who ran the cottage industry. This Idaho woman (inset), camouflaged within an impressive flock in 1940, was likely one such businesswoman.

Hatching time could be chaotic: "Turkeys in the parlor, turkeys on the chair, turkeys in the dishpan, turkeys everywhere," exclaimed an Emmett, Idaho, newspaper in 1933. But the birds didn't just have the run of the house. They had the hills too.

Before commercial farming overtook the family enterprise by the mid-century, says Idaho historian Madeline Buckendorf, farm kids herded the birds "much like sheep." She still cherishes the bell her grandfather would place on the "lead" turkey's neck so the flock could be heard "when turned out to graze on the sagebrush-covered hillsides of the canyon." *—Eve Conant*

PHOTO: ANSGAR E. JOHNSON, NATIONAL GEOGRAPHIC CREATIVE

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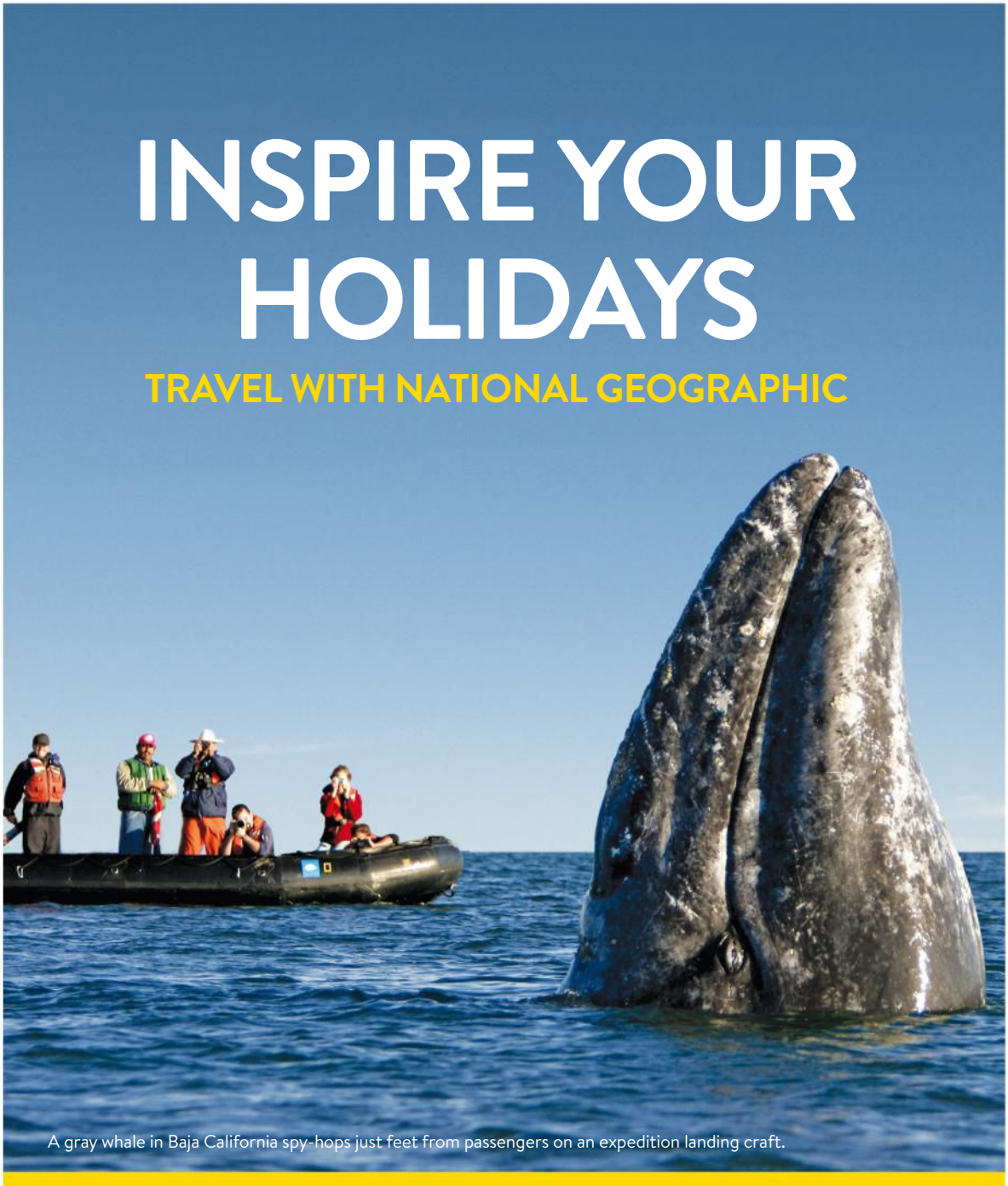

A gray whale in Baja California spy-hops just feet from passengers on an expedition landing craft.

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