NATIONALGEOGRAPHIC.COM/MAGAZINE | JANUARY 2010

NATIONAL GEOGRAPHIC

Merging Man and Machine

THE BIONIC AGE

Macaroni Penguin *(Eudyptes chrysolophus)*
Size: Head and body length, 65 - 75 cm (25.6 - 29.5 inches); wingspan, approx. 70 cm (28 inches)
Weight: 3.1 - 6.6 kg (6.8 - 14.6 lbs) **Habitat:** Found mainly in the southern Atlantic; nests on rocky slopes, often amid tussock grass **Surviving number:** Estimated at 18,000,000 - 22,000,000

Photographed by Art Wolfe

WILDLIFE AS CANON SEES IT

Clean and preened. The macaroni penguin spends a great deal of time caring for its plumage, even making trips to the sea expressly to wash off dirt and parasites. Mates preen each other, too, which helps strengthen pair bonds. Despite all this effort, every year it must still replace its feathers in order to remain properly insulated and waterproof. During the molt, the penguin can't forage and, as a result, it can lose up to 40% of its body weight. Packing weight back on depends on an ample supply of marine life, which is being disrupted by commercial fishing and climate change. The question is: How much longer will the penguin preen?

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

Canon

NATIONAL GEOGRAPHIC

JANUARY 2010 · VOL. 217 · NO. 1

DAVID DOUBILET

Clownfish can't flourish without a host anemone, whose stinging tentacles keep predators away. Story on page 120.

NATIONAL GEOGRAPHIC

DEPARTMENTS

CONSERVATION

Backing Big Cats

The NGS Big Cats Initiative aims to keep top felines from sliding toward extinction.

SPACE

Wanted: Moon Rocks

NASA has a cache. Samples are sold on eBay. Then there's the black market.

HEALTH

The Cost of Care

Which country leads the world in health care spending per person?

TECHNOLOGY

Mummies Bare All

Lady Hor was really a sir. That's one of many surprises from high-tech scans.

ENVIRONMENT

Quashing Kudzu

The vine covers eight million U.S. acres—and counting. A killer fungus aims to take it down.

THE BIG IDEA

A radical new strategy could outwit the wily, ever mutating parasites.

ngm.com

Replacing Your Parts

Maybe you need an artificial retina or a "spring ankle with regenerative kinetics." Our interactive illustration shows the latest in substitute devices.

ART: BRYAN CHRISTIE

On the Cover

This revolutionary prosthetic limb can match the real thing. With 20 motors, it is nearly as strong and dexterous.

Photo by Mark Thiessen

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iavi
International AIDS Vaccine Initiative

The International AIDS Vaccine Initiative (IAVI) is a global nonprofit organization searching for safe, effective, preventive and accessible HIV vaccines for use throughout the world. IAVI evaluates vaccines through its network of state-of-the-art laboratories and clinical research centers globally. To learn more, visit www.iavi.org.

BD

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The statistics are staggering. Over 33 million people are estimated to be living with HIV. Last year alone there were 2.5 million new infections, and another 2 million died as the result of AIDS.[1]

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BD – *Helping all people live healthy lives.*

[1]UNAIDS, *2007 AIDS Epidemic Update,* [2]*FORTUNE,* March 2009, [3]*Ethisphere™ Magazine,* April 2009

Please visit www.bd.com

Photo ©Richard Lord

EDITOR'S NOTE

Amanda Kitts tests a bionic arm in the prosthetics lab at the Rehabilitation Institute of Chicago.

Four years ago an automobile accident robbed Amanda Kitts of her arm and the ability to do things most of us take for granted, like making a sandwich. "I felt lost," the teacher from Knoxville, Tennessee, tells writer Josh Fischman in this month's cover story on bionics.

Then Amanda met Todd Kuiken, a physician and biomedical engineer who knew that the nerves in an amputee's stump can still telegraph brain signals. He fitted her with a bionic arm.

Bionics is technology at its most ingenious and humane. Most of us first encountered the word in science fiction books or television shows like *The Six Million Dollar Man*. In that 1970s series, pilot Steve Austin is injured in a crash. His rebuilt body, which includes a bionic arm, eye, and legs, is nothing short of superhuman. But the bionics of modern medical engineering has little to do with enabling someone to run at 60 miles an hour or use an eye like a zoom lens. It is more about the quiet miracle of holding a fork or seeing the silhouette of a tree. It's about allowing people like Amanda to reclaim what they've lost.

A year ago Ray Edwards, a quadruple amputee, was one of the first people in the United Kingdom to be fitted with a bionic hand. When he flexed his new hand for the first time, he cried. "It made me feel I was just Ray again," he said. The restoration of one's normal self is a powerful gift.

PHOTO: MARK THIESSEN, NG STAFF

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NATIONAL GEOGRAPHIC

Inspiring people to care about the planet

The National Geographic Society is chartered in Washington, D.C., as a nonprofit scientific and educational organization "for the increase and diffusion of geographic knowledge." Since 1888 the Society has supported more than 9,000 explorations and research projects, adding to knowledge of earth, sea, and sky.

It takes more than a financial company to save something this precious.

Less than 1% of earth's water is fit for human consumption. That's why the Royal Bank of Canada supports more than 150 organizations around the globe that promote water stewardship and the protection of fresh water. Learn more about what we're doing with partners like the National Geographic Society at www.nationalgeographic.com/bluewaterproject.

Create a Blue Water future.

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LETTERS

September 2009

Plugging Into the Sun

While the pessimists are saying of solar energy, we've heard it all before, the optimists are busy taking advantage of free energy. I installed solar thermal and solar electric on my home. My utility bills have dropped by more than two-thirds, my home value has increased substantially, and after subsidies, my systems will pay for themselves in less than four years at current utility rates. I'll get free energy for the remainder of the system's 25-year (minimum) life span. Solar is not only inevitable, it's a no-brainer.

WILLIAM SAROKIN
Mount Kisco, New York

Last year I looked into installing a photovoltaic system on my house here in southern California. Then I found out that I would have to sell any excess power back to Southern California Edison for less than Southern California Edison sells it to me. Plus I would have to use a special meter, I would not be permitted to install the equipment myself (although I'm an industrial electrician with more than 20 years of experience), and I would have to pay an approved contractor for the system installation. Lastly, if there is a power credit at the end of the year (if I produce more power than I use), the credit is forfeited! Why bother?

KENNETH JOHNSON
Beaumont, California

Your coverage of solar energy omitted Israel's solar achievements. Israel leads the world in use of solar water heaters. Use of these devices, visible on virtually every building in the country, has been law since the early 1990s. Israel is a leader in solar technology as well. In fact, an Israeli company has been contracted to build in California's Mojave Desert what will become the world's largest solar-collection facility in both capacity and land size. Israel deserves credit for its leadership in solar energy development and generation.

ZVI HOLLAND
Phoenix, Arizona

There is a piece missing from your article, and that is that North America's electrical system is able to provide for today's requirements. The generation and delivery systems are dated but adequate. Updating and improvements always need to be continued, as is the case with any mechanical system. However, the main thrust does not have to be "Big Electric." What we need is self-sufficiency at the point of consumption. Your article's coverage on Germany shows what can happen when individual homes and businesses each produce power. We all live under roofs. If each user produces only 50 percent of what he or she consumes, already we have off-loaded the demand on the generating system.

PETER VANDERBURG
Ottawa, Ontario

Before New York

You can go back to 1609 to rediscover the wilderness sacrificed to create an urban center, or you can go to photos taken in 2005 of wilderness raped to create one-acre, landscaped plots with five-bedroom monstrosities to house couples who don't even have children yet.

CHRISTINA SORMANI
New York, New York

José the beaver was right to come to the Bronx. The New York Botanical Garden, just north of the Bronx Zoo, has the largest stand of original forest left in New York City, about 50 acres. The Bronx is also home to the largest city-run park in New York City, Pelham Bay Park, which is three times the size of Central Park. I live just outside the park's border and from my kitchen window can see snowy egrets and herons picking their way through the tidal flats of the Hutchinson River. The park is also home to rabbit, raccoon, skunks, turkeys, hawks, and the occasional coyote.

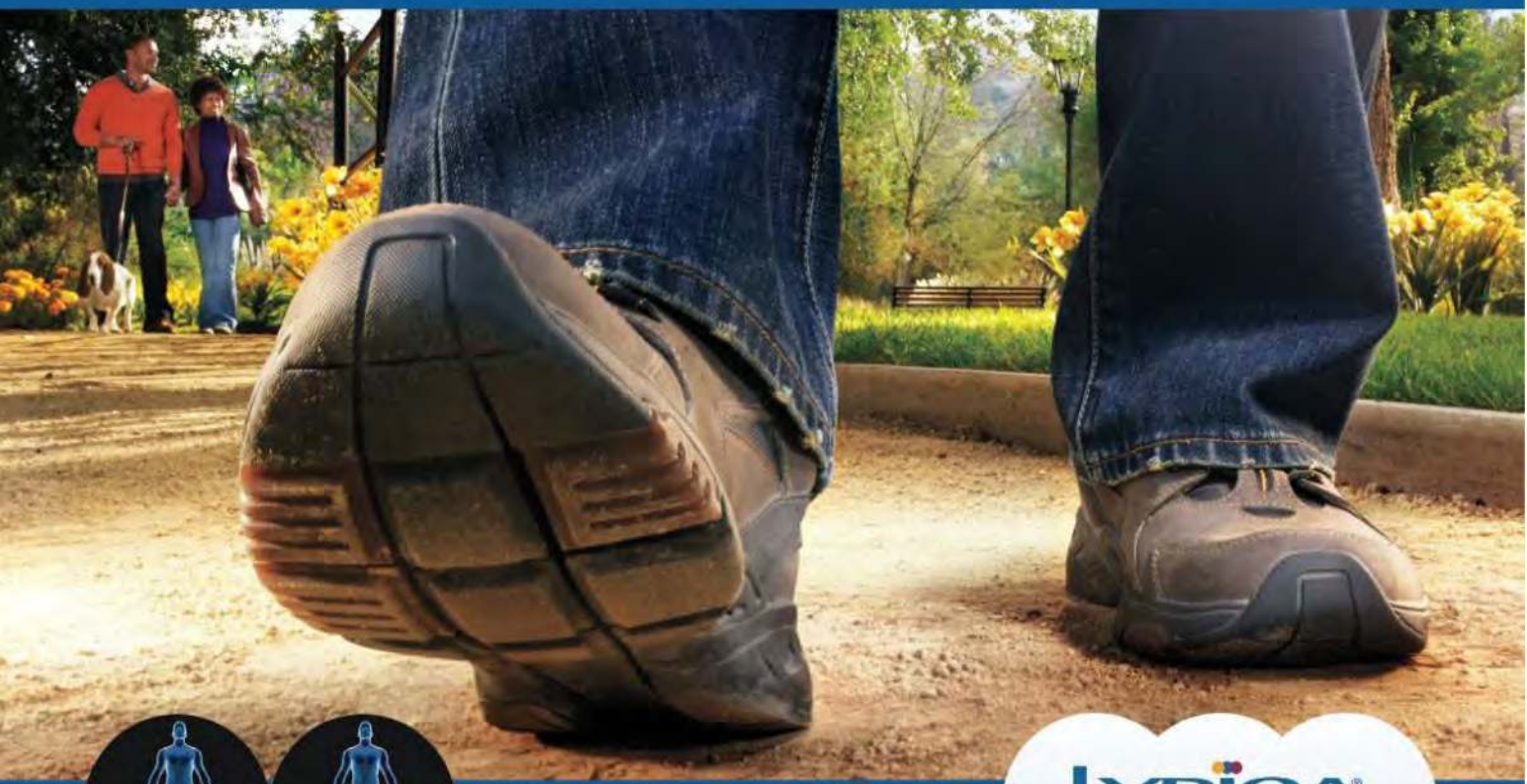
PETER A. GEIGER
New York, New York

Corrections, Clarifications

September 2009:
Science: Who's Number Two?
São Paulo was misspelled.
We regret the error.

Email ngsforum@ngm.com
Write National Geographic Magazine, PO Box 98199, Washington, DC 20090-8199. Include name, address, and daytime telephone. Letters may be edited for clarity and length.

This is no walk in the park if you have Diabetic Nerve Pain.



*Nerves damaged by diabetes can send too many signals that cause pain.**

Lyrica is believed to help calm the damaged nerves† – reducing the signals and the pain.

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Unlike some common over-the-counter pain relievers, Lyrica is FDA approved specifically to treat the **shooting, stabbing, burning sensations** of diabetic nerve pain. Lyrica is believed to help calm the damaged nerves† and help ease this pain – so a walk in the park can be just that.

Ask your doctor if Lyrica can help you.

*Diagram is illustrative of diabetic nerve pain.

† Exact mechanism of action and relevance to humans are unknown as studies were conducted on animal models.

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 or neck or any trouble breathing or that affects your skin. Lyrica may cause suicidal thoughts or actions in a very small number of people. Call your doctor right away if you have new or worsening depression, suicidal thoughts or actions, or unusual changes in mood or behavior. Lyrica may cause swelling of your hands, legs and feet. Some of the most common side effects of Lyrica are dizziness and sleepiness. Do not drive or work with machines until you know how Lyrica affects you. Other common side effects are blurry vision, weight gain, trouble concentrating, dry mouth, and feeling "high." Also, tell your doctor right away about muscle pain along with feeling sick and feverish, or any changes in your eyesight including blurry vision or any skin sores if you have diabetes. You may have a higher chance of swelling, hives or gaining weight if you are also taking certain diabetes or high blood pressure medicines. Do not drink alcohol while taking Lyrica. You may have more dizziness and sleepiness if you take Lyrica with alcohol, narcotic pain medicines, or medicines for anxiety. If you have had a drug or alcohol problem, you may be more likely to misuse Lyrica. Tell your doctor if you are planning to father a child. Talk with your doctor before you stop taking Lyrica or any other prescription medication.

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LETTERS

I wish you had devoted a couple of paragraphs to the broader role of the beaver, a species that moved onto the rocky, partially barren island that would someday be Manhattan soon after the retreat of the glaciers about 11,000 years ago. Layer upon layer, it was the beaver-dam silting process that would ultimately create the marshes and meadows that support such a rich assortment of vertebrate life identified in the Muir web.

RAY PAWLEY
Arabela, New Mexico

It's unfortunate that your foldout map cropped out one of the only swaths of Manhattan that still resembles the island in its natural state. Inwood Hill Park, 196 forested acres at the northern end of Manhattan, contains native flora and fauna not found elsewhere on the island. Inattention to this special, timeless place, which contains huge cliffs, caves, freshwater springs, and one of Manhattan's only salt marshes, has contributed to its disrepair. Its absence from the article is a missed opportunity to educate the public about this last Manhattan wilderness.

GABE KIRCHHEIMER
New York, New York

Sea levels around Manhattan Island have risen by one to two feet since the 1780s, when the "British Headquarters Map" was drawn. One would expect that large areas of the late 1700s-era shoreline would have been gradually submerged by now. However, the overlaid maps of ancient and current areas clearly show that there are now high-rise buildings sitting on land that was then off the shoreline of Manhattan. This says volumes about how humans, using the technologies of the 19th and 20th centuries, were able to withstand over 18 inches of sea level rise—which is approximately the amount that sea levels are projected to increase over the next century.

CHRIS WALCEK
Albany, New York

Shattered Somalia

I was twice deployed to Somalia while serving in the U.S. Marine Corps in the early 1990s. The parts of your article most relevant to my observations of the country were the passages

that relay the hope that exists in Somalia. It has been ravaged by power struggles and inter-clan rivalries. Yet its people are as proud of their land and heritage and are as optimistic as any on the planet. A number of lessons can be learned from Somalia, including the human capacity for hope.

MICHAEL R. PICK, JR.
Arroyo Grande, California

The people of Somaliland have set a wonderful example. They are the best chance for Somalia and other nearby countries. They deserve some support from the international community to bolster their stability so that in time they can reach out to Somalia.

J. McFARLAND
Stanfield, Oregon

Orchids

Michael Pollan's review of the orchid family's deviant deceptions was delightfully written, and I will never view their blossoms in the same way again. My wife loves orchids, and when an appropriate response to a holiday, birthday, or anniversary is warranted, I visit our local orchid shop for a sure thing. I am eager to see the shop's reaction when I request a "prostitute orchid." Or perhaps, a "whorchid"?

TOM BULLOCH
Woodland Park, Colorado

Culture: Facing Beggars

Buskers also feel the burn of anti-begging laws. In many countries great artists stay off the street for fear of being fined or arrested. Luckily there are still places where street entertainers are supported—if not by the government, then at least by the people.

JEDEDIAH CALLEN
Manitoba, Canada

History: Saved By the Belt

I was very surprised at the omission of the 1903 invention of laminated glass by French chemist Édouard Bénédictus. Horrific disfigurements and deaths from broken windshields were common in early automotive history.

WILLIAM B. HARBERT
Spokane, Washington

Automobile windshields were just being introduced in 1903, but safety glass was not employed in them until the 1920s.

Rare Air They fall and soar at different altitudes, one slicing into water, the other carving air. But a diver and a jet have something in common: Both present amazing picture possibilities. So take your best shot and send it to us—the sky's the limit for how far it'll go. Every month this page features two photographs: one chosen by our editors, one chosen by our readers via online voting. For more information, go to *ngm.com/yourshot.*

EDITORS' CHOICE

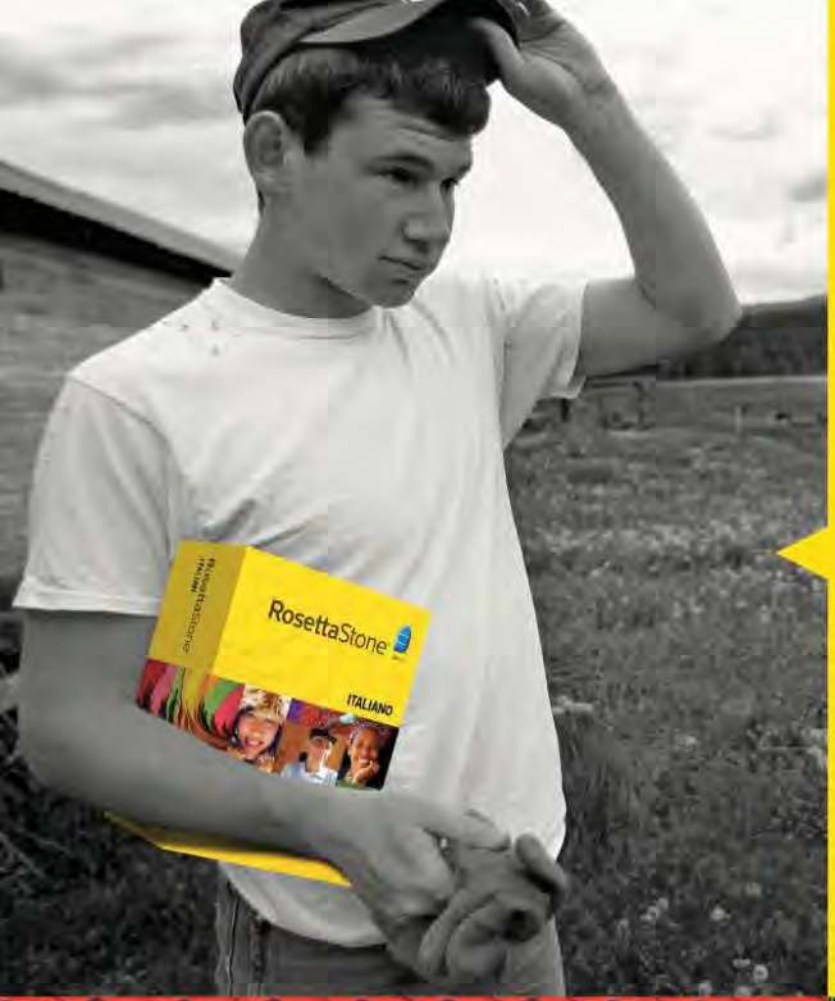
Erik Guzowski New York, New York

A wedding photographer in Manhattan, Guzowski, 38, took a different kind of picture in Tempe, Arizona. Perched atop a 33-foot platform, he captured two high schoolers warming up on springboards before a state diving competition.

Kirk McMenamin Grosse Ile, Michigan

The back of an F/A-18F Super Hornet is consumed by a vapor cone during an exhibition. McMenamin, 38, a quality and engineering manager, says, "It had been raining that morning, so the air was filled with moisture. Conditions were perfect."

READERS' CHOICE



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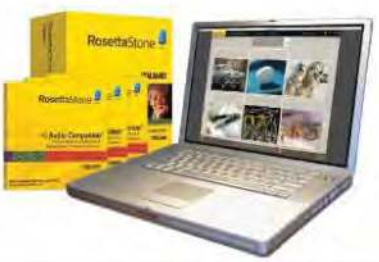

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St. Maarten Landing at Princess Juliana International Airport, a looming 747 thrills those on Mahó beach. The white-sand stretch on the Caribbean island's Dutch side—the rest is French—is a famous plane-watching perch.

PHOTO: FABI FLIERVOET

Spain Sliding headlong through a tomato-juice torrent, a young man celebrates La Tomatina in Buñol on August 26, 2009. The event is a one-hour food fight that last year used 275,000 pounds of tomatoes.

PHOTO: BIEL ALINO, EPA/CORBIS

Portugal Near the Azores, just below the sunlit Atlantic surface, sperm whales float in vertical repose. Scientists think "drift dives" are a form of communal slumber. This species may sleep the least of any mammal.

PHOTO: MAGNUS LUNDGREN, WILD WONDERS OF EUROPE

Backing Big Cats

Majesty alone can't save them. The world's top felines—including lions, cheetahs, and leopards—are slipping toward extinction. But an emergency effort to fund on-the-ground conservation projects may help put them back on their feet.

The Big Cats Initiative, recently launched by the National Geographic Society and led by Society Explorers-in-Residence Dereck and Beverly Joubert, is uniting governments, conservation groups, corporations, scientists, and local villages to find ways to reverse big-cat declines. In Africa burgeoning human populations have swallowed up wild habitat, leading to increased poaching and retaliatory killings by farmers when cats prey on cattle—a top threat. Part of the solution: programs offering financial incentives to those who spare the predators, say the Jouberts. Lions will be the initiative's first priority, with a goal of boosting their numbers to sustainable levels by 2020. *—Jennifer S. Holland*

Lions have declined to as few as 20,000 animals from about 450,000 just 50 years ago. Other population estimates:

7,500 cheetahs
6,000 snow leopards
4,000 tigers

Learn more about the Big Cats Initiative at **nationalgeographic.com/bigcats.**

PHOTO: BEVERLY JOUBERT, NATIONAL GEOGRAPHIC STOCK

TREASURE IN TEXAS

SECRET HOARD OF 110-YEAR-OLD SILVER STUNS COIN EXPERTS!

Larger than actual size of 30.6 mm

AUSTIN, Texas, Tuesday 8:55 AM — For years stories have circulated about a huge cache of U.S. silver half dollars that had been accumulated and stashed away in an unknown location by an old-time collector. But it was not until our firm was summoned to a tiny farm outside Austin, Texas that hearsay suddenly became startling fact.

There, spread before us on a dining room table, was a small mountain of silver half dollars. But as we began to inspect each coin, one by one, our surprise turned to shock. For these were not just any old silver coins, but rather the very first United States commemoratives, the legendary 1893 Columbian Exposition Half Dollars — over a thousand of them! What's more, each and every coin was preserved in Very Fine condition. The old-timer knew his stuff, and had kept only the better coins in collectible grade.

FIRST EVER, LAST EVER?

This is the first hoard of authentic original 1893 Columbian silver halves we've ever seen of this magnitude, and perhaps the last as well. The United States ceased issuing 90% silver coins 40 years ago. Since then, millions upon millions have vanished forever into the melting pot. It is doubtful we will ever chance upon a hoard of this size and quality again. Due to our private purchase of this major find, this may be your last opportunity to acquire this historically important and valuable collectors coin through a public offering such as this. The Columbian Half Dollar was issued to celebrate the World's Columbian Exposition in Chicago. It was one of the great world's fairs of the 19th century. Situated on almost 700 acres bordering Lake Michigan, the Expo grounds held 150 buildings with exhibits from all the nations of North and South America. At the fair one could ride the world's first Ferris Wheel, or take in such sights as a 22,000 pound brick of Canadian cheese or a 30,000 pound temple crafted entirely of chocolate!

Thousands of visitors attended the fair during 1892-93. The official U.S. Mint Columbian Silver Half Dollar was sold at the fair for the premium price of one dollar — equal to about a full day's wages back then.

THE COLUMBIAN EXPOSITION HALF DOLLAR

Designers: Charles Barber (obverse) and George Morgan (reverse)
Diameter: 30.6 mm
Weight: 12.5 grams
Composition: .900 fine silver
Status: Legal-Tender Commemorative
Date: 1893

SILVER LEGACY OF LASTING VALUE

Relatively few Silver Columbian Half Dollars survived the last century, and fewer yet in Very Fine condition. These coins retain their full designs in bold relief with complete dates. Columbus' ship the Santa Maria sails across the reverse side of the coin, with the two hemispheres representing the world beneath it. This is your chance to acquire a family heirloom that will be the cornerstone of any collection. The Columbian Exposition Silver Half Dollar will always be sought-after by collectors for its historic importance as our nation's FIRST commemorative coin. Act today to become one of the few who has the chance to own a coin from this major find before they are gone forever. Get one for yourself, your friends and loved ones. It will make a gift of lasting value that they will treasure for a lifetime.

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ACCREDITED BUSINESS

A 4.7-ounce moon rock at National Geographic headquarters is on loan from NASA.

Wanted: Moon Rocks

Earth may get more moon rocks in 2018, when NASA plans a manned lunar landing. Until then, as scientists and collectors know, supply and demand are worlds apart. The only sources? Rare lunar meteorites, soil from Soviet probes, and the 842 pounds of rubble carted back by Apollo astronauts from 1969 to 1972. NASA keeps most of its 1,500-rock cache in Houston, lending out 400 samples a year for research and display. Presidents Nixon and Ford gave pea-size "goodwill" slivers to 134 countries, 50 states, and Puerto Rico. For other interested parties, auctions can be a legal option—if the rock for sale isn't U.S. government property. At Sotheby's in 1993, a Soviet sample fetched $442,500. On eBay, a meteorite cut can go for $40 to $100,000, depending on size, quality, and authentication. Then there's the black market. Joseph Gutheinz, a former NASA investigator, says Apollo rocks that have vanished over the years can turn up with five-million-dollar tags. "They simply mean more and more as the years go by." *—Jeremy Berlin*

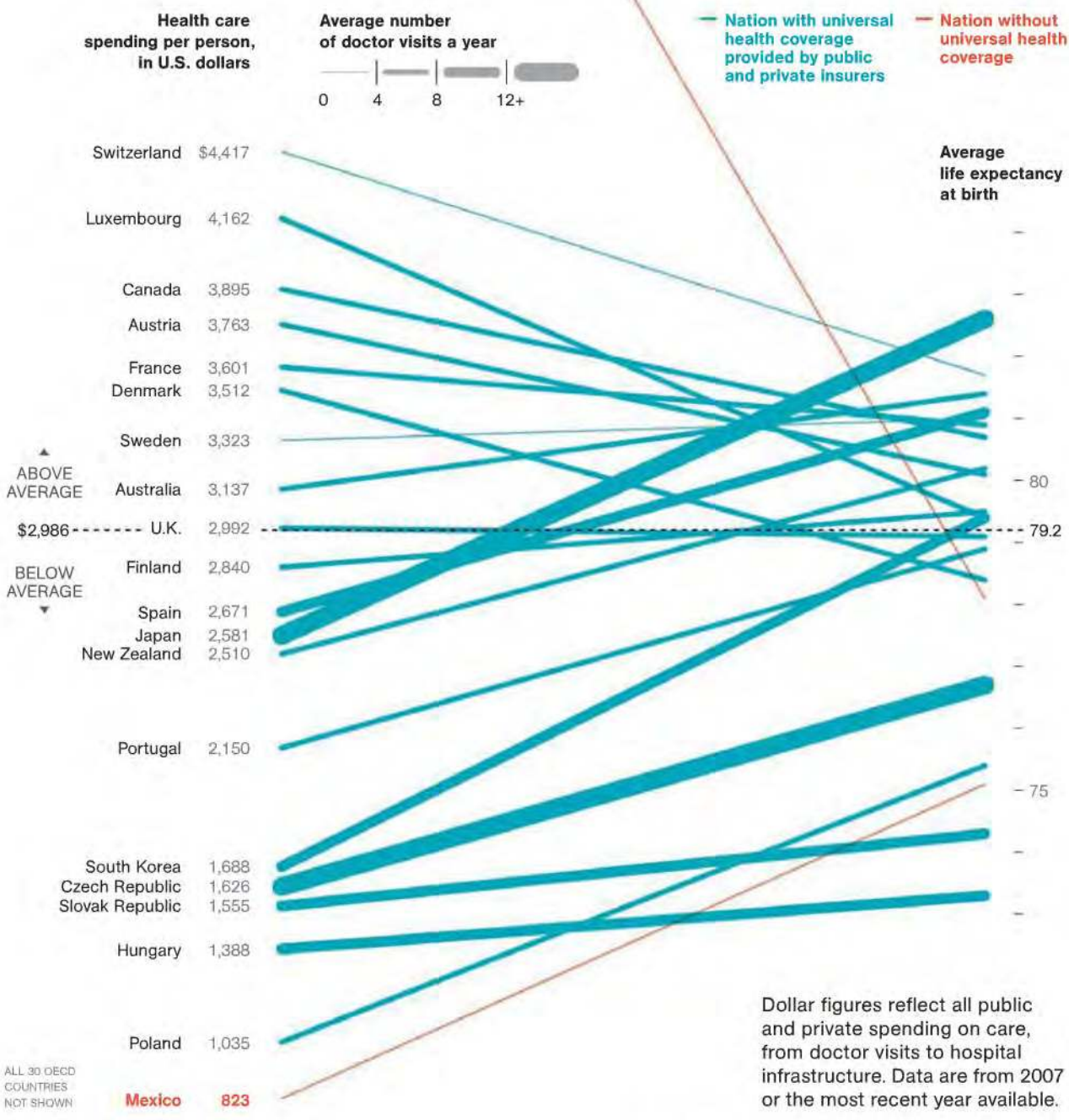
PHOTO: TYRONE TURNER

United States $7,290

HEALTH

The Cost of Care

The United States spends more on medical care per person than any country, yet life expectancy is shorter than in most other developed nations and many developing ones. Lack of health insurance is a factor in life span and contributes to an estimated 45,000 deaths a year. Why the high cost? The U.S. has a fee-for-service system—paying medical providers piecemeal for appointments, surgery, and the like. That can lead to unneeded treatment that doesn't reliably improve a patient's health. Says Gerard Anderson, a professor at Johns Hopkins Bloomberg School of Public Health who studies health insurance worldwide, "More care does not necessarily mean better care." *—Michelle Andrews*



Dollar figures reflect all public and private spending on care, from doctor visits to hospital infrastructure. Data are from 2007 or the most recent year available.

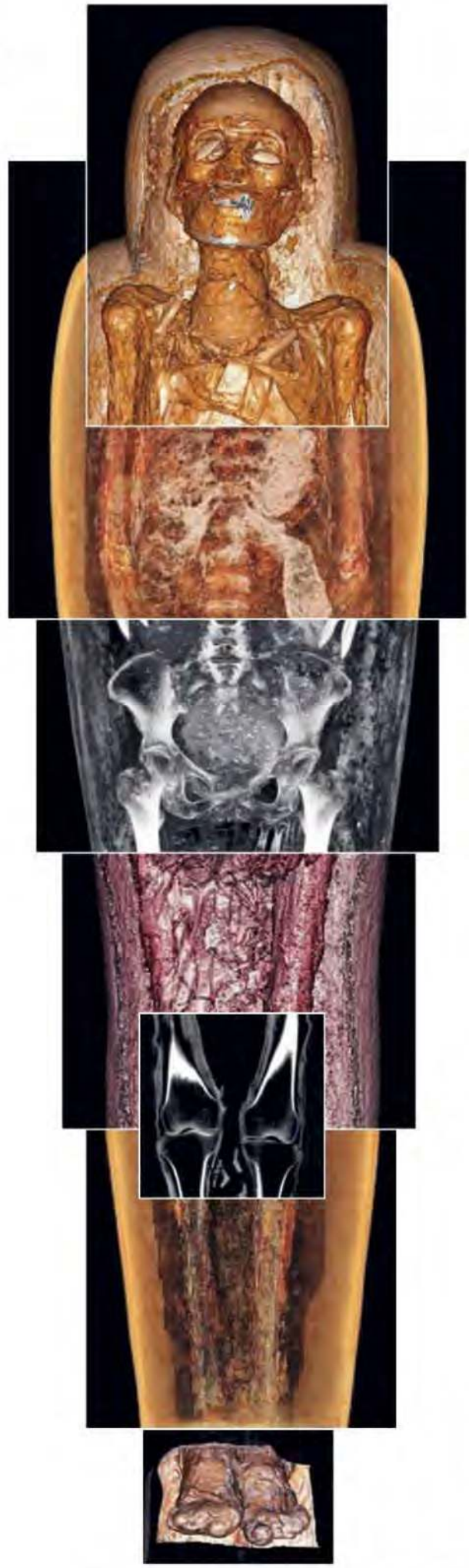
GRAPHIC: OLIVER UBERTI, NG STAFF. SOURCE: "OECD HEALTH DATA 2009," ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Mummies Bare All

The plump neck on mummy Meresamun (right) made scientists think she had a goiter. Then they examined her with a high-resolution computed tomography (CT) scan and learned the truth: Her mummifiers had inserted a bit of stuffing to enlarge the Theban priestess' neck.

Opening a sealed sarcophagus can destroy the mummy inside, but medical technologies allow experts to peer in without risk. X-rays have long been used for this purpose, though results aren't always reliable. CT scans, now so powerful they can reveal 3-D slices half a millimeter thick, are clearing up years of uncertainty. Scientists have been able to pinpoint mummies' ages at death and see how status resulted in higher quality mummification. Medical imaging has turned up evidence of an ancient gallstone (once thought to be a scarab), cancer, even teeth grinding.

Nothing was as surprising as the outcome of the high-tech analysis of a 2,700-year-old mummy from the Brooklyn Museum. "You told me this one was a woman!" the radiologist at New York's North Shore University Hospital said. Just like that, the mummy known for 80-plus years as the Lady Hor became a sir. *–Hannah Bloch*



No Cavities
A CT scan showed cavity-free teeth. Stones or faience pieces cover her eyes.

Childbearing Hips?
Scan results are inconclusive as to whether she had children.

Good Legs
Strong bones are evidence of her healthy diet and active lifestyle.

Foot Trouble
A 2,800-year-old bunion showed up on her right big toe.

INSIDE THE COFFIN
Thirty billion CT measurements are uncovering details about the priestess Meresamun (right), who died around age 30 in 800 B.C.

PHOTOS: COURTESY ORIENTAL INSTITUTE OF THE UNIVERSITY OF CHICAGO

Quashing Kudzu An Asian vine with flowers that smell like grape drink, kudzu enticed Americans at a Philadelphia exhibition in 1876. In the 1930s Southerners started planting it to halt soil erosion. They stopped in the '50s, when they realized that the hardy perennial, which can spread up to 60 feet a year, was out of control. Since then, the vine has swallowed 150,000 acres a year—eight million U.S. acres total. Eliminating it would require a constant war waged by scythes, grazing cattle, and potent herbicides. That's not likely to happen.

Researchers have been studying a fungus that can help: *Myrothecium verrucaria.* A morning spritz turns leaves and stems brown by afternoon. Keep on spraying and roots will die. USDA scientist Douglas Boyette says the fungus will be mixed with herbicides to create a product safe enough for homeowners to use. Someday soon, people in kudzu-besieged suburbs will have a powerful new ally in the fight to reclaim yards and porches. *—Karen E. Lange*

Kudzu blankets an Alabama building. A killer fungus could become the latest anti-weed weapon.

PHOTO: WILLIAM CHRISTENBERRY, HEMPHILL FINE ARTS
NGM MAPS. SOURCE: JOHN KARTESZ, BIOTA OF NORTH AMERICA PROGRAM

Hit Them Where They Live

Viruses that infect us can't spread without us. Finding their helpers inside human cells may yield drugs that stop pandemics.

WITHIN A FEW MONTHS of the outbreak of swine flu last spring, public health officials reported the first cases resistant to Tamiflu. It was no surprise. The previous winter most cases of seasonal flu had also proved resistant to the drug. Why don't we have antivirals as good as antibiotics are against bacteria? Viruses are wilier; they mutate so fast that they slink from the grasp of even the best designed drugs. But researchers are now working on a radical new strategy that just might help ward off future pandemics and produce the antiviral equivalent of amoxicillin. The idea is simple: Instead of attacking viruses directly, target the human cells they infect.

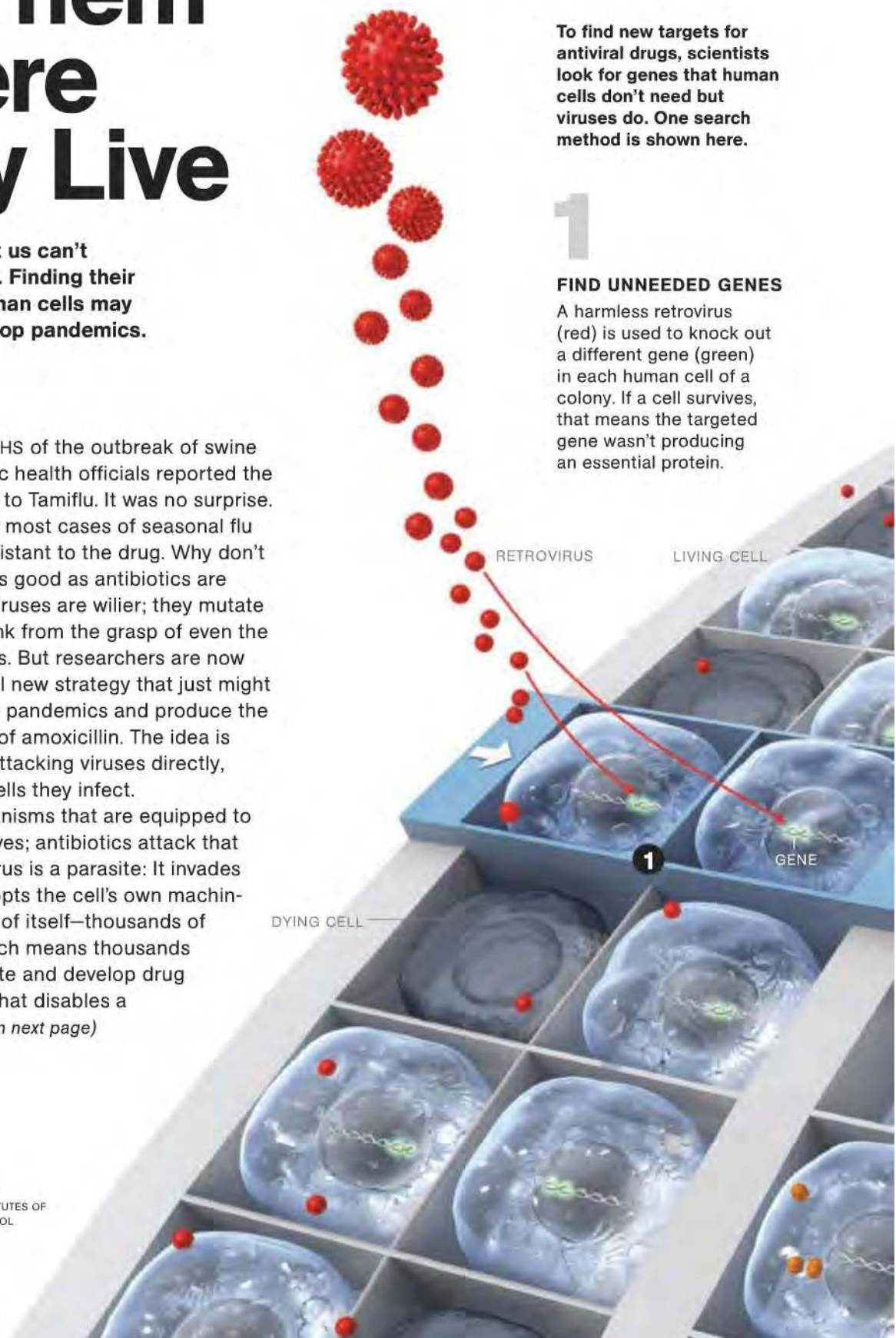
Bacteria are organisms that are equipped to reproduce themselves; antibiotics attack that machinery. But a virus is a parasite: It invades a host cell and co-opts the cell's own machinery to make copies of itself—thousands of copies at once, which means thousands of chances to mutate and develop drug resistance. A drug that disables a part of *(Continued on next page)*

To find new targets for antiviral drugs, scientists look for genes that human cells don't need but viruses do. One search method is shown here.

1

FIND UNNEEDED GENES

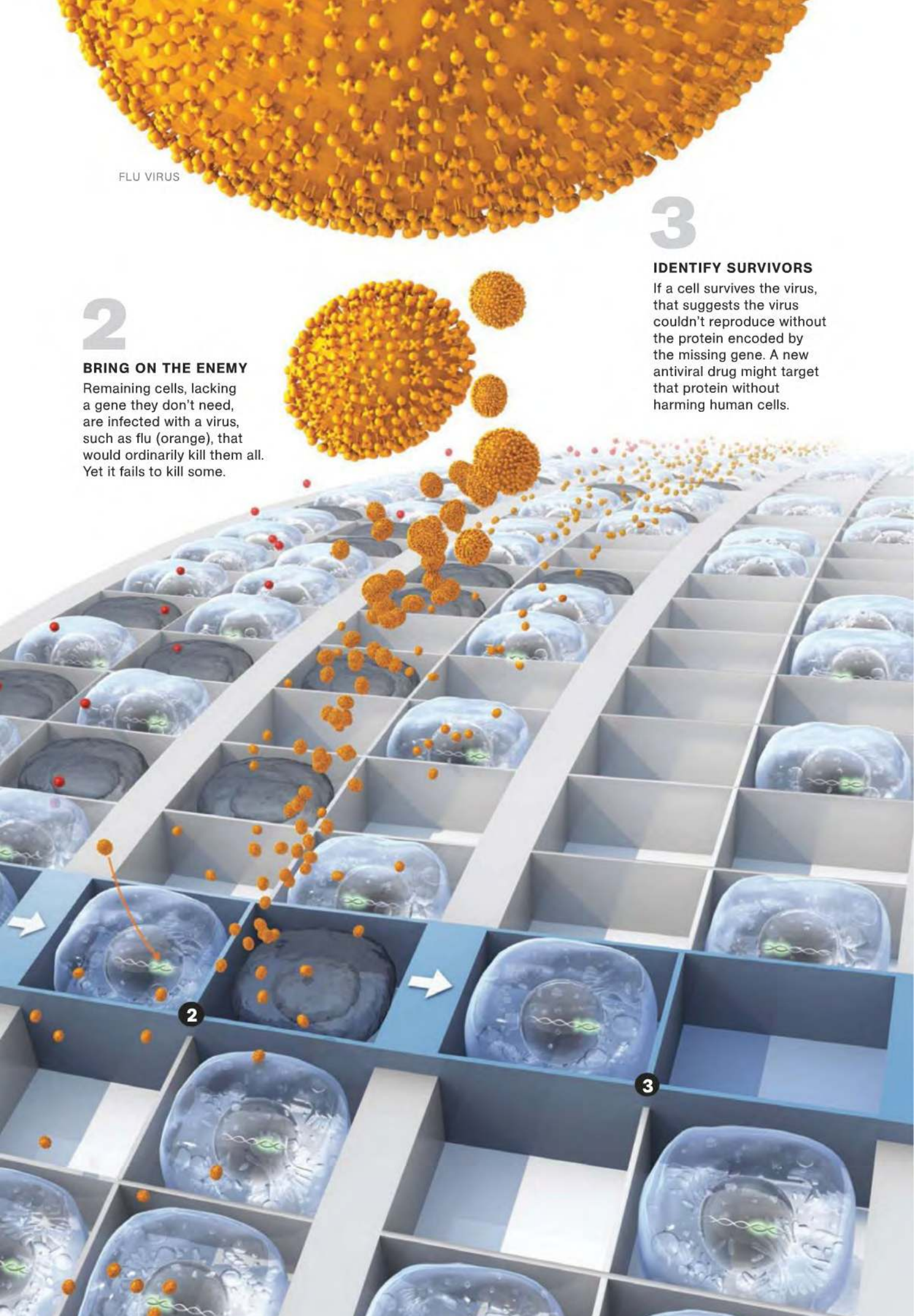
A harmless retrovirus (red) is used to knock out a different gene (green) in each human cell of a colony. If a cell survives, that means the targeted gene wasn't producing an essential protein.



ART BY BRYAN CHRISTIE

REPORTING BY FARHANA HOSSAIN

SOURCES: ZIRUS; NATIONAL INSTITUTES OF HEALTH; HARVARD MEDICAL SCHOOL


FLU VIRUS
2
BRING ON THE ENEMY
Remaining cells, lacking a gene they don't need, are infected with a virus, such as flu (orange), that would ordinarily kill them all. Yet it fails to kill some.
3
IDENTIFY SURVIVORS
If a cell survives the virus, that suggests the virus couldn't reproduce without the protein encoded by the missing gene. A new antiviral drug might target that protein without harming human cells.
2
3

John-Joseph van Haelewyn

John and Shirley Spinelli included National Geographic in their estate plans.

Support the Future

"We believe in the work of National Geographic and wanted to be involved," says John Spinelli. He and his wife Shirley grew up reading *National Geographic* magazine and passed that love on to their children and grandchildren. Now retired, they enjoy in-line skating, tennis and bird watching.

The Spinellis set up a charitable gift annuity which provides them with steady income and tax savings while supporting the Society's efforts worldwide. "National Geographic is an important source for solutions to the challenges facing our planet," says John. "We want the world to be in good shape for our grandchildren."

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

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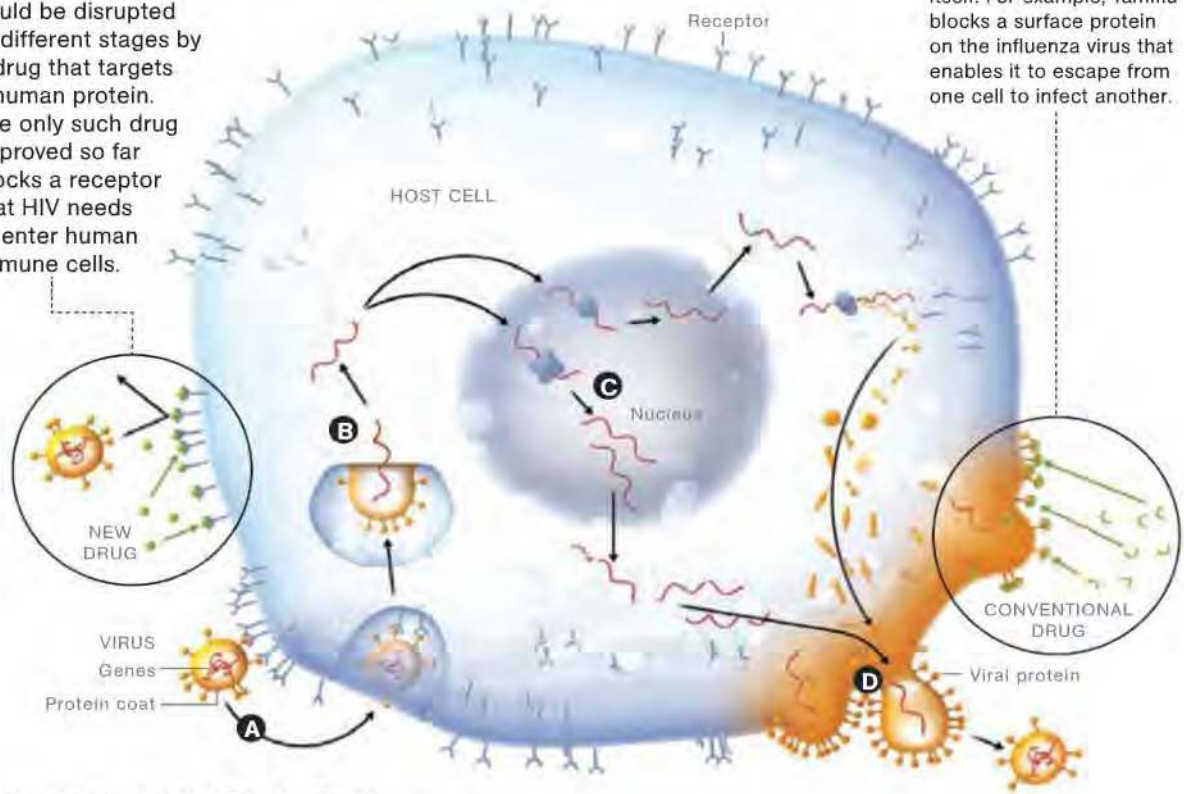
4 BREAK THE CYCLE

A virus's life cycle could be disrupted at different stages by a drug that targets a human protein. The only such drug approved so far blocks a receptor that HIV needs to enter human immune cells.

Conventional antiviral drugs target the virus itself. For example, Tamiflu blocks a surface protein on the influenza virus that enables it to escape from one cell to infect another.



How viruses use a host cell to replicate

A INVADE CELL
Proteins on the surface of the virus bind to receptors on the host cell. The virus fuses with the cell.

B UNCOAT
Human enzymes dissolve the virus's protein coat, releasing the genes in its core.

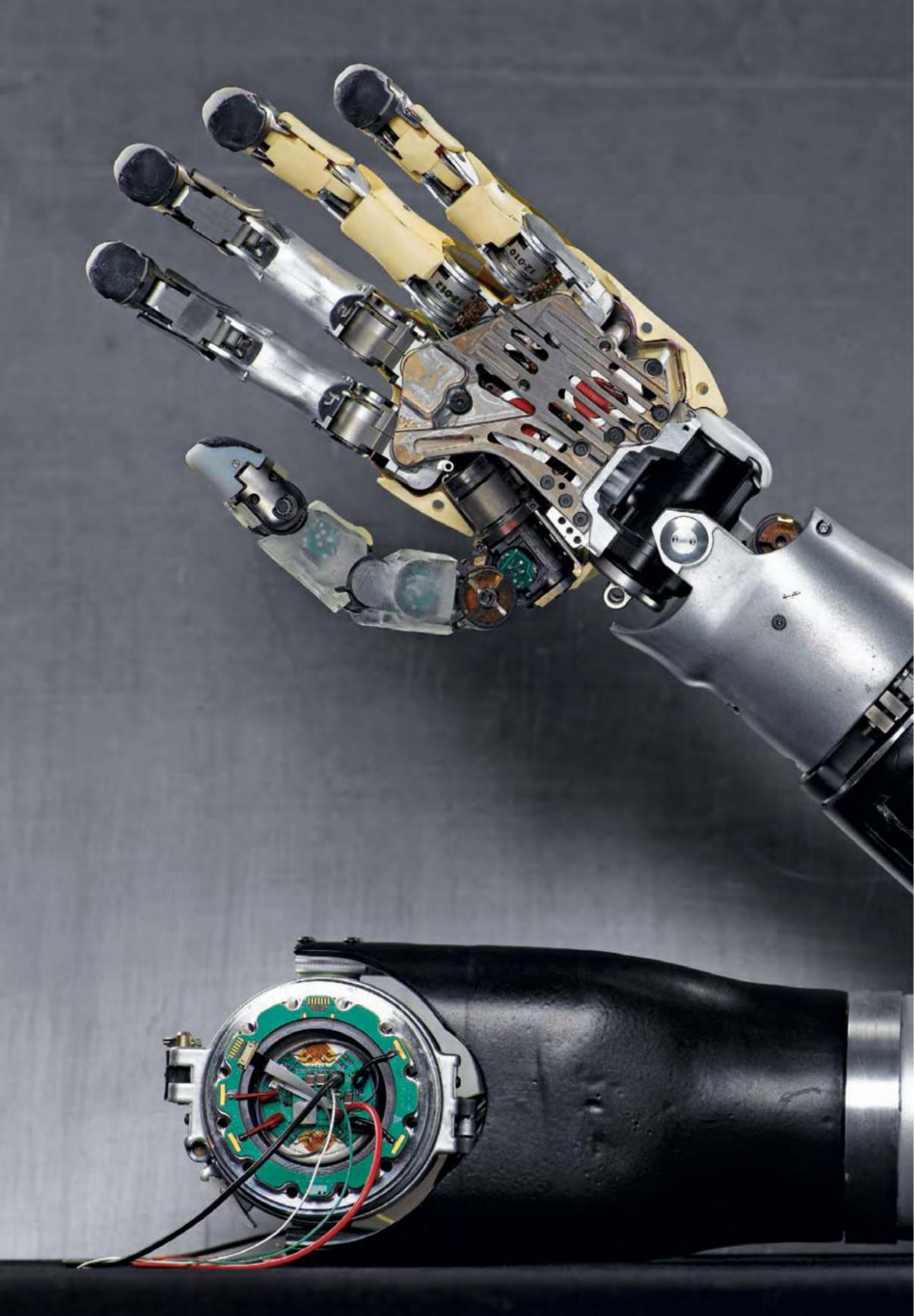
C MULTIPLY
The virus takes over the host cell's machinery to make copies of its genes and proteins.

D GO FORTH
The genes and the proteins form new viruses, which bud from the cell and seek new hosts.

the human cell that helps the virus reproduce, though, could stop it with little risk of resistance. "And if you can identify a host function that HIV, flu, and Ebola all require, you can have one drug that is active against all three—a broad-spectrum antiviral," says Michael Kurilla of the National Institute of Allergy and Infectious Diseases (NIAID).

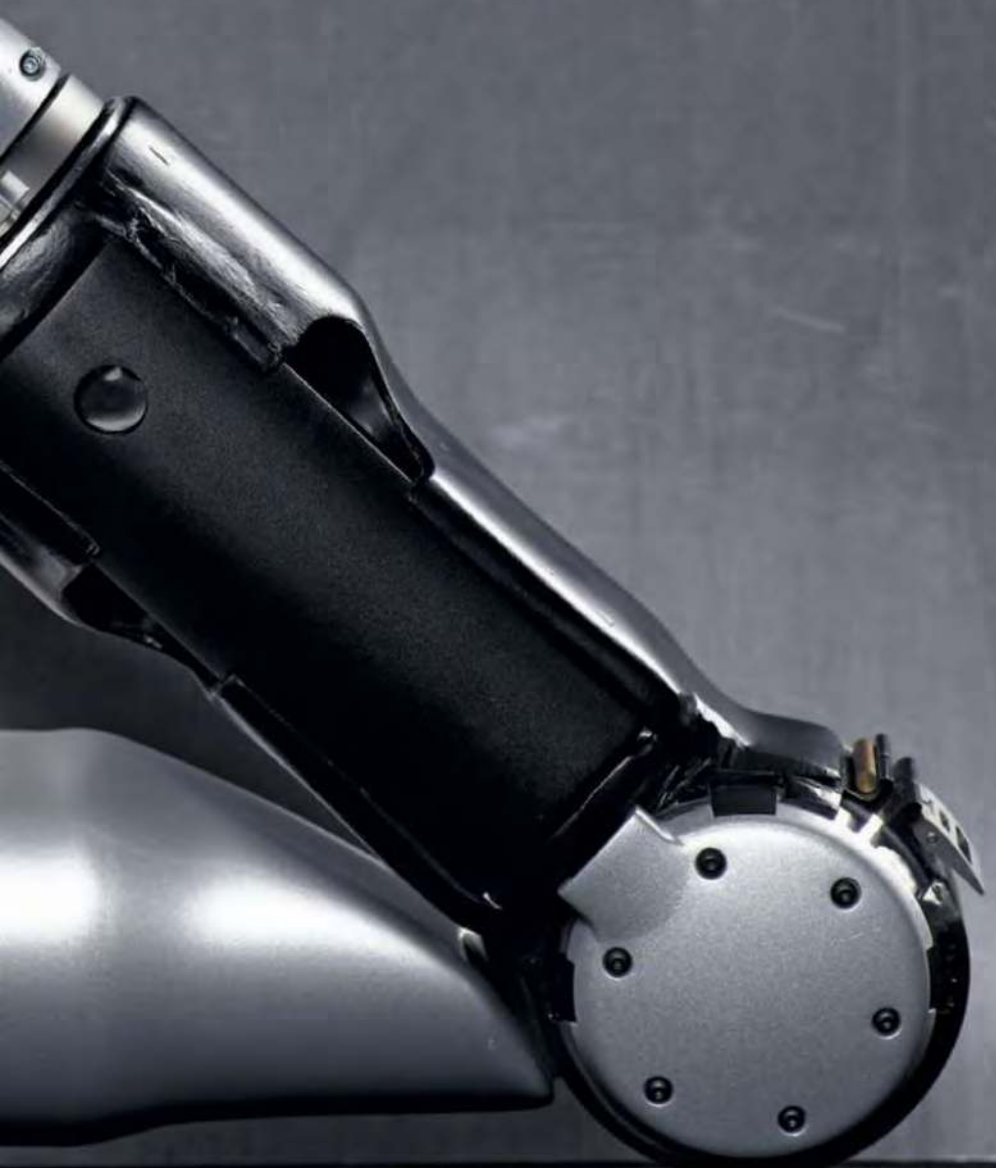
The key is finding the right target—a gene, and the protein it encodes, that the human cell doesn't need but the virus does. Human DNA contains more than 20,000 genes, but in any given cell at any given time, many are dormant; some, for instance, are only switched on during embryonic development. With the human genome now fully decoded, investigators can search for targets systematically by disabling individual genes in many cells and seeing what happens. Zirus, a company in Buford, Georgia, uses a three-step process (see opening illustration); it begins by infecting cells with a harmless retrovirus, which splices itself randomly into human DNA, knocking out any gene it interrupts. Other groups are disabling selected genes with matching bits of RNA. If the cell survives without a particular gene and is now resistant to infection, that gene-protein combo is a promising target for a drug.

The first such drug, Pfizer's Maraviroc, is already being used to treat HIV infections; it blocks a cell-surface protein that acts as a receptor for the virus. San Diego–based NexBio has recently begun clinical trials of a compound called Fludase that inactivates the receptors through which both swine flu and seasonal flu enter respiratory cells. NIAID is vigorously supporting such research. "Over the next 20 to 30 years there will be a paradigm shift in the way we approach infectious diseases," Kurilla says. "I think this will be emblematic of 21st-century medicine." *—Josie Glausiusz*

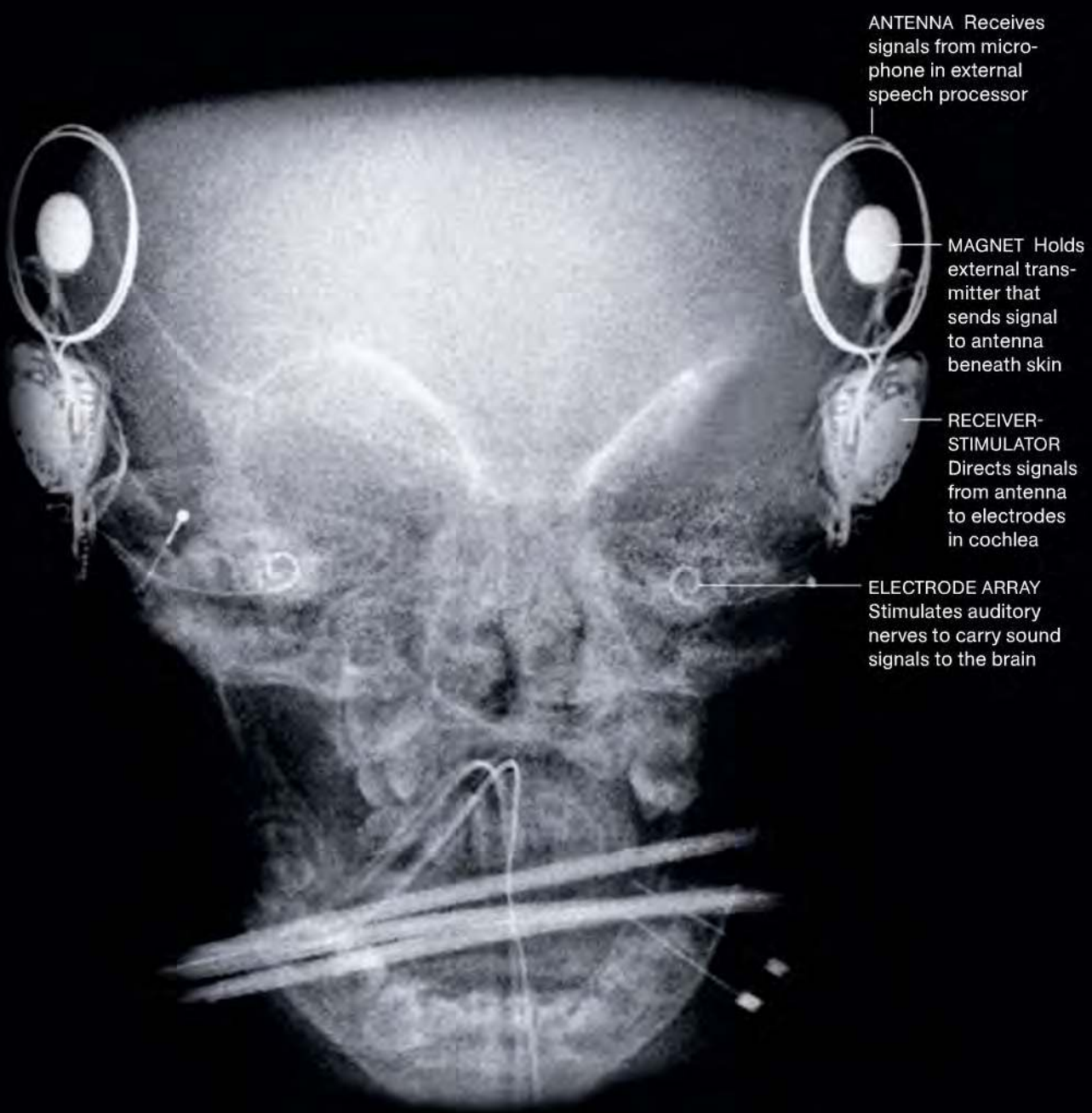


bi-on-ics

Etymology: from bi (as in "life") + onics (as in "electronics"); the study of mechanical systems that function like living organisms or parts of living organisms



BODY REDUX Twenty motors animate a cutting-edge bionic arm that mimics a flesh-and-blood limb with unprecedented accuracy. Users control it via nerve impulses. It even has sensors that register touch.



Wired for Sound

Aiden Kenny got two cochlear implants when he was ten months old. Bypassing parts of his ears that don't work, the implants—visible in an x-ray (above)—carry electronic signals to his auditory nerves. Within months of the surgery, a child who'd grown increasingly quiet spoke the words his hearing parents longed for: Mama and Dada. "You're looking at a real bionic kid," says Johns Hopkins University surgeon John Niparko.

ABOVE: JOHNS HOPKINS HOSPITAL (COMPOSITE X-RAY IMAGE MADE DURING SURGERY)

BY JOSH FISCHMAN

PHOTOGRAPHS BY MARK THIESSEN

Amanda Kitts is mobbed by four- and five-year-olds as she enters the classroom at the Kiddie Kottage Learning Center near Knoxville, Tennessee. "Hey kids, how're my babies today?" she says, patting shoulders and ruffling hair. Slender and energetic, she has operated this day-care center and two others for almost 20 years. She crouches down to talk to a small girl, putting her hands on her knees.

"The robot arm!" several kids cry.

"You remember this, huh?" says Kitts, holding out her left arm. She turns her hand palm up. There is a soft whirring sound. If you weren't paying close attention, you'd miss it. She bends her elbow, accompanied by more whirring.

"Make it do something silly!" one girl says.

"Silly? Remember how I can shake your hand?" Kitts says, extending her arm and rotating her wrist. A boy reaches out, hesitantly, to touch her fingers. What he brushes against is flesh-colored plastic, fingers curved slightly inward. Underneath are three motors, a metal frame, and a network of sophisticated electronics. The assembly is topped by a white plastic cup midway up Kitts's biceps, encircling a stump that is almost all that remains from the arm she lost in a car accident in 2006.

Almost all, but not quite. Within her brain, below the level of consciousness, lives an intact image of that arm, a phantom. When Kitts thinks about flexing her elbow, the phantom moves. Impulses racing down from her brain are picked up by electrode sensors in the white cup and converted into signals that turn motors, and the artificial elbow bends.

"I don't really think about it. I just move it," says the 40-year-old, who uses both this standard model and a more experimental arm with even more control. "After my accident I felt lost, and I didn't understand why God would do such a terrible thing to me. These days I'm just excited all the time, because they keep on improving the arm. One day I'll be able to feel things with it and clap my hands together in time to the songs my kids are singing."

Kitts is living proof that, even though the flesh and bone may be damaged or gone, the nerves and parts of the brain that once controlled it live on. In many patients, they sit there waiting to communicate—dangling telephone wires, severed from a handset. With microscopic electrodes and surgical wizardry, doctors have begun to connect these parts in other patients to devices such as cameras and microphones and motors. As a result, the blind can see, the deaf can hear, and Amanda Kitts can fold her shirts.

KITTS IS ONE OF "TOMORROW'S PEOPLE," a group whose missing or ruined body parts are being replaced by devices embedded in their nervous systems that respond to commands from their brains. The machines they use are called neural prostheses or—as scientists have become more comfortable with a term made popular by science fiction writers—bionics. Eric Schremp, who has been a quadriplegic since he shattered his neck during a swimming pool dive in 1992, now has an electronic device under his skin that

MIND AND MACHINE An array of sensors tracks muscle movements that Amanda Kitts produces in her residual arm thanks to surgically rerouted nerves. Next-generation prostheses obey relayed signals, increasingly working like her original limb.

lets him move his fingers to grip a fork. Jo Ann Lewis, a blind woman, can see the shapes of trees with the help of a tiny camera that communicates with her optic nerve. And Tammy Kenny can speak to her 18-month-old son, Aiden, and he can reply, because the boy, born deaf, has 22 electrodes inside his ear that change sounds picked up by a microphone into signals his auditory nerve can understand.

The work is extremely delicate, a series of trials filled with many errors. As scientists have learned that it's possible to link machine and mind, they have also learned how difficult it is to maintain that connection. If the cup atop Kitts's arm shifts just slightly, for instance, she might not be able to close her fingers. Still, bionics represents a big leap forward, enabling researchers to give people back much more of what they've lost than was ever possible before.

"That's really what this work is about: restoration," says Joseph Pancrazio, program director for neural engineering at the National Institute of Neurological Disorders and Stroke. "When a person with a spinal-cord injury can be in a restaurant, feeding himself, and no one else notices, that is my definition of success."

When Kitts thinks about flexing her elbow, the phantom moves, and the artificial elbow bends. "I don't really think about it. I just move it," she says.

A HISTORY OF BODY-RESTORATION attempts, in the form of man-made hands and legs and feet, lines the shelves in Robert Lipschutz's office at the Rehabilitation Institute of Chicago (RIC). "The basic technology of prosthetic arms hasn't changed much in the last hundred years," he says. "Materials are different, so we use plastic instead of leather, but the basic idea has been the same: hooks and hinges moved by cables or motors, controlled by levers. A lot of amputees coming back from Iraq get devices like these. Here, try this on." Lipschutz drags a plastic shell off one of his shelves.

It turns out to be a left shoulder and arm. The shoulder part is a kind of breastplate, secured across the chest by a harness. The arm, hinged at the shoulder and elbow, ends in a metal pincer. To extend the arm, you twist your head to the left and press a lever with your chin, and use a little body English to swing the limb out. It is as awkward as it sounds. And heavy. After 20 minutes your neck hurts from the odd posture and the effort of pressing the levers. Many amputees end up putting such arms aside.

"It's hard for me to give people these devices sometimes," Lipschutz says, "because we just don't know if they will really help." What could help more, he and others at RIC think, is the kind of prosthesis Amanda Kitts has volunteered to test—one controlled by the brain, not by body parts that normally have nothing to do with moving the hand. A technique called targeted muscle reinnervation uses nerves remaining after an amputation to control an artificial limb. It was first tried in a patient in 2002. Four years later Tommy Kitts, Amanda's husband, read about it on the Internet as his wife lay in a hospital bed after her accident. The truck that had crushed her car had also crushed her arm, from just above the elbow down.

"I was angry, sad, depressed. I just couldn't accept it," she says. But what Tommy told her about the Chicago arm sounded hopeful. "It seemed like the best option out there, a lot better than motors and switches," Tommy says. "Amanda actually got excited about it." Soon they were on a plane to Illinois.

Todd Kuiken, a physician and biomedical engineer at RIC, was the person responsible for what the institute had begun calling the

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Josh Fischman is a senior editor for research and technology at the Chronicle of Higher Education. *Mark Thiessen is a* Geographic *staff photographer.*

BIONIC WOMAN Kitts imagines a hand movement, and muscle activity in her residual arm—decoded by a computer on her back—causes the actual motion. When she straps on the experimental Johns Hopkins–developed arm at the Rehabilitation Institute of Chicago, she says, "often it feels like I'm not missing anything."

"bionic arm." He knew that nerves in an amputee's stump could still carry signals from the brain. And he knew that a computer in a prosthesis could direct electric motors to move the limb. The problem was making the connection. Nerves conduct electricity, but they can't be spliced together with a computer cable. (Nerve fibers and metal wires don't get along well. And an open wound where a wire enters the body would be a dangerous avenue for infections.)

Kuiken needed an amplifier to boost the signals from the nerves, avoiding the need for a direct splice. He found one in muscles. When muscles contract, they give off an electrical burst strong enough to be detected by an electrode placed on the skin. He developed a technique to reroute severed nerves from their old, damaged spots to other muscles that could give their signals the proper boost.

In October 2006 Kuiken set about rewiring Amanda Kitts. The first step was to salvage major nerves that once went all the way down her arm. "These are the same nerves that work the arm and hand, but we had to create four different muscle areas to lead them to," Kuiken says. The nerves started in Kitts's brain, in the motor cortex, which holds a rough map of the body, but they stopped at the end of her stump—the disconnected telephone wires. In an intricate operation, a surgeon rerouted those nerves to different regions of Kitts's upper-arm muscles. For

Closing In on a Lifelike Limb

THE ABILITIES OF TODAY'S PROTO 1 BIONIC ARM WILL TRIPLE IN THE NEXT PROTOTYPE.

HUMAN ARM

22+ MOVEMENTS

From the shoulder to a finger's last joint, an arm has at least 22 points of movement. Nerves carry the brain's instructions from the spinal cord to the muscles.

TRADITIONAL PROSTHESIS

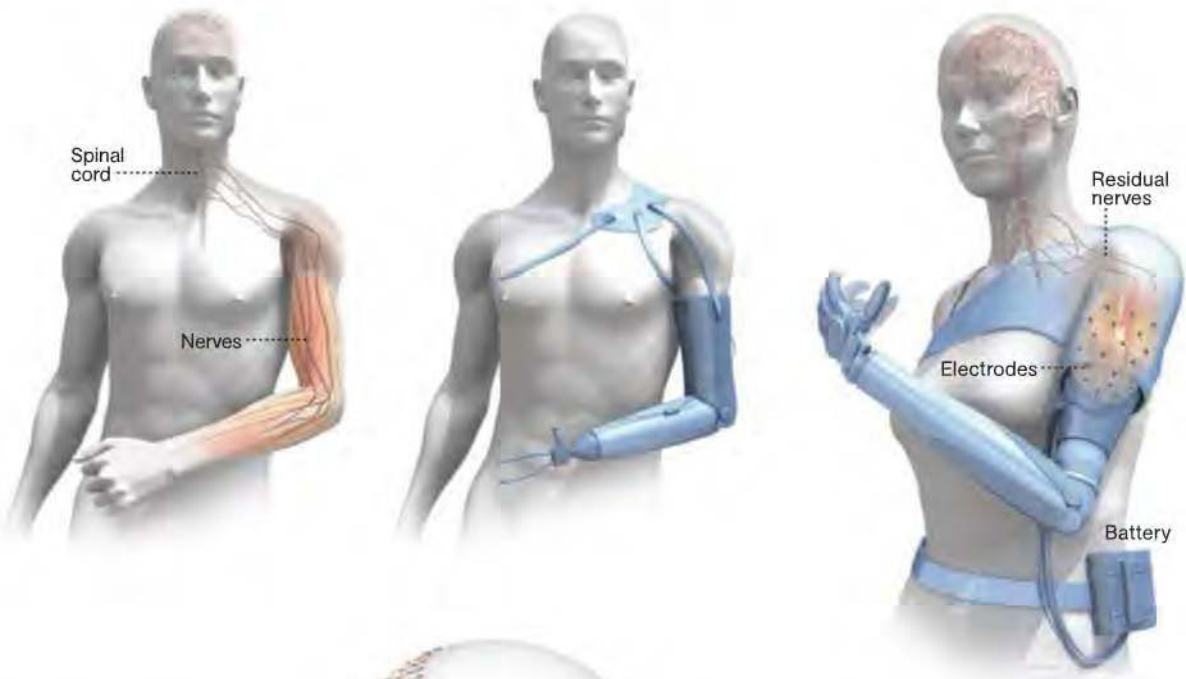
3 MOVEMENTS

Still the only device available to most amputees, the pincer-hand prosthesis relies on cables moved by pressing levers on a harness with the chin or other arm.

PROTO 1

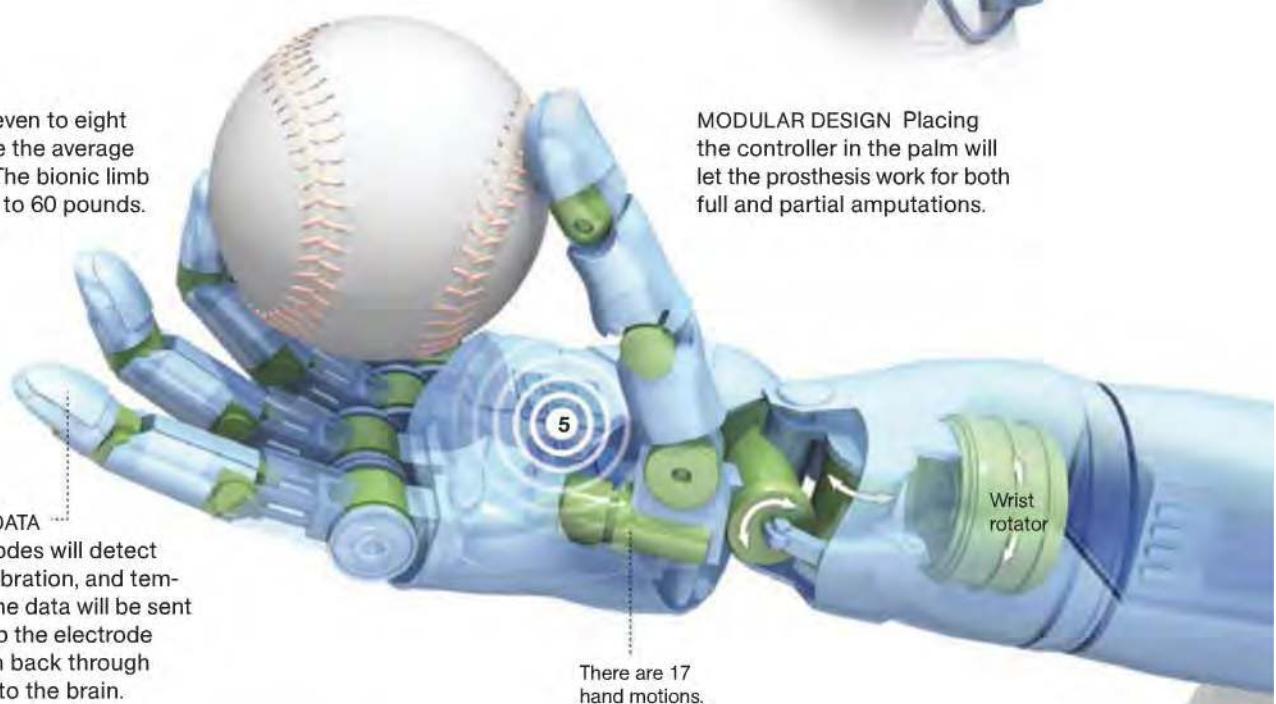
7 MOVEMENTS

Nerves that once reached the lower arm are rerouted into other muscles. Electrodes placed on those muscles capture the brain's commands and relay them by wires in the prosthesis.



WEIGHT Seven to eight pounds, like the average adult arm. The bionic limb can curl up to 60 pounds.

MODULAR DESIGN Placing the controller in the palm will let the prosthesis work for both full and partial amputations.

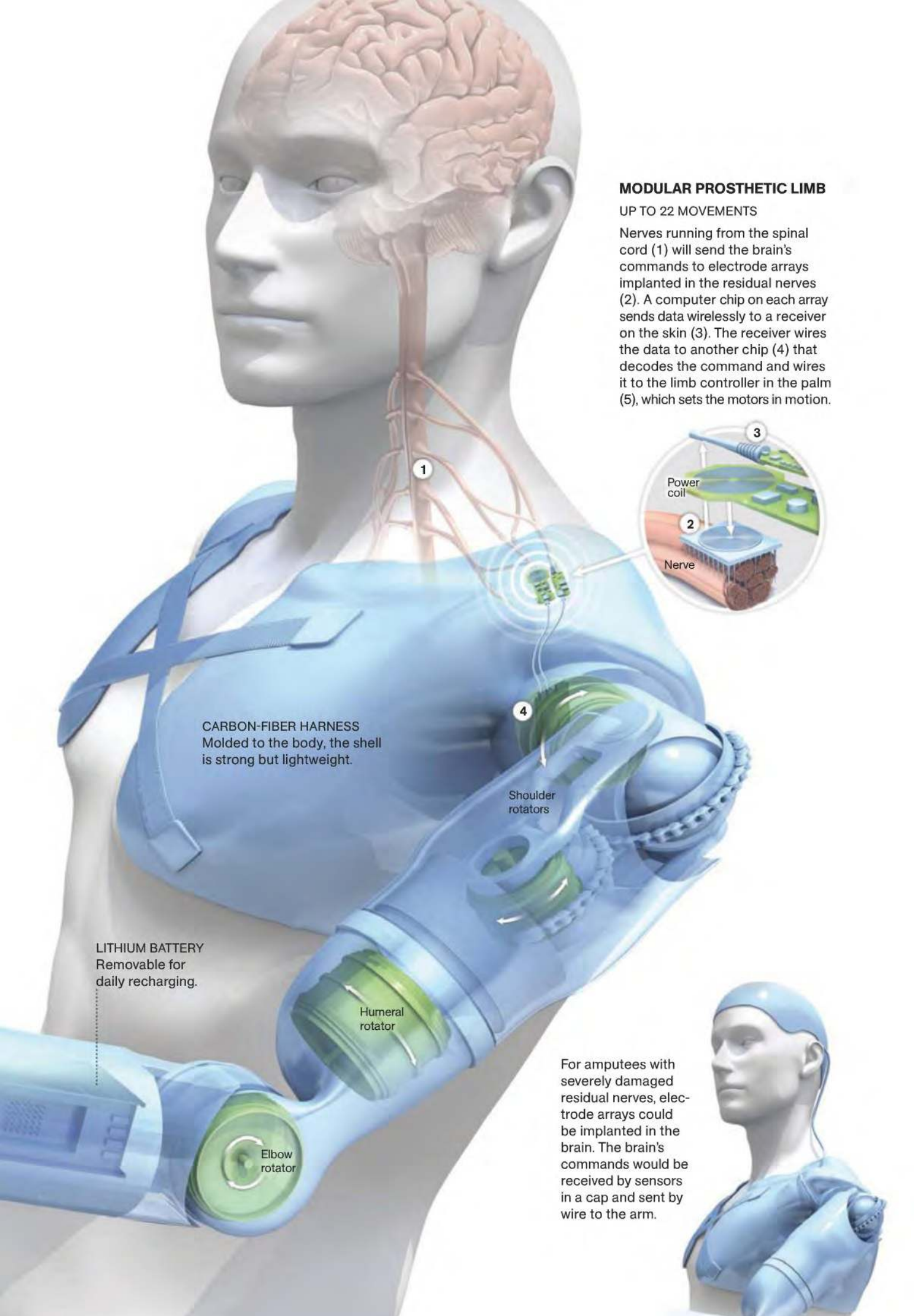


SENSORY DATA Fingertip nodes will detect pressure, vibration, and temperature. The data will be sent wirelessly to the electrode arrays, then back through the nerves to the brain.

There are 17 hand motions.

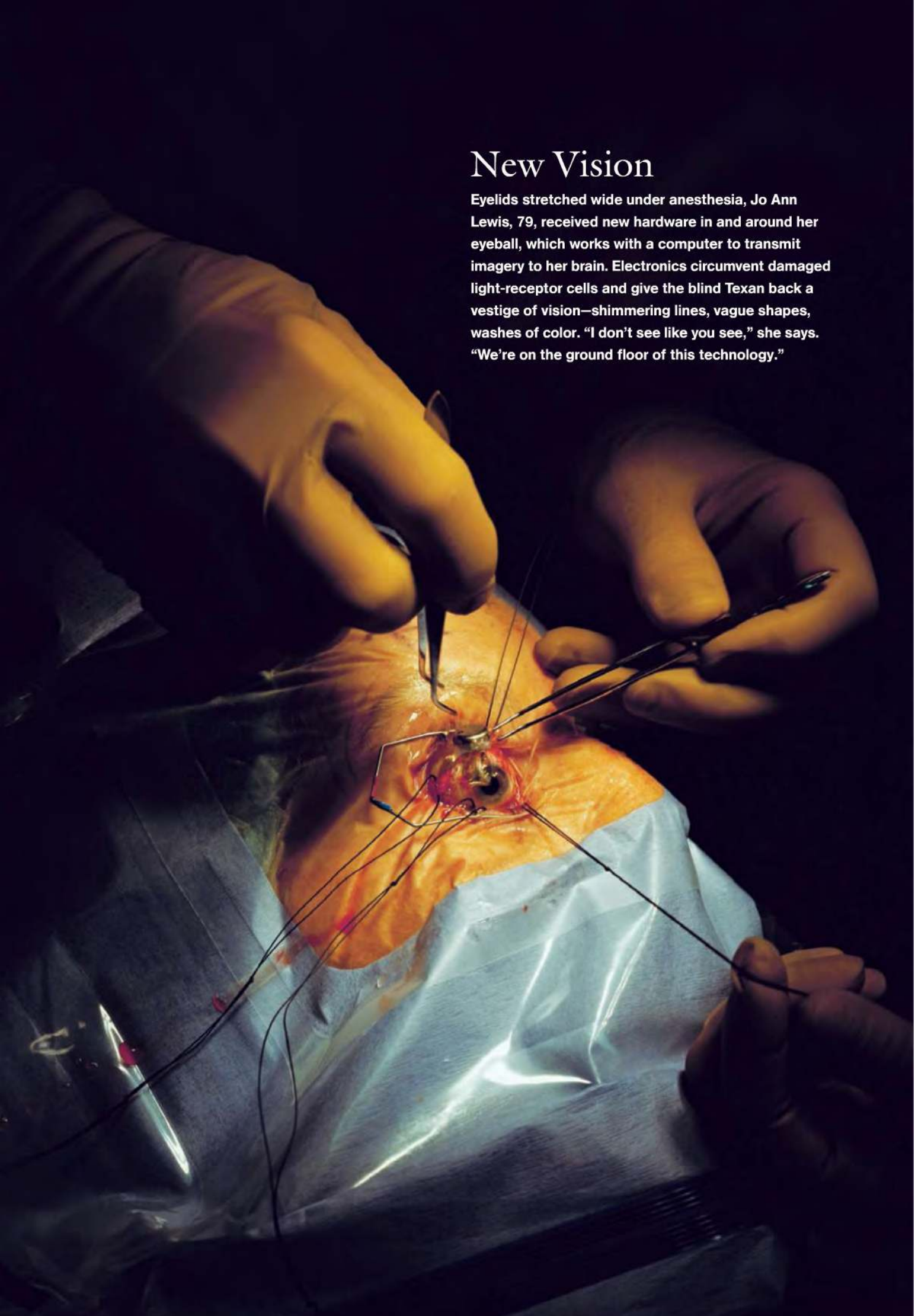
HIRAM HENRIQUEZ, NG STAFF; JENNY WANG. ART BY BRYAN CHRISTIE

SOURCES: REHABILITATION INSTITUTE OF CHICAGO; JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY; UNIVERSITY OF UTAH

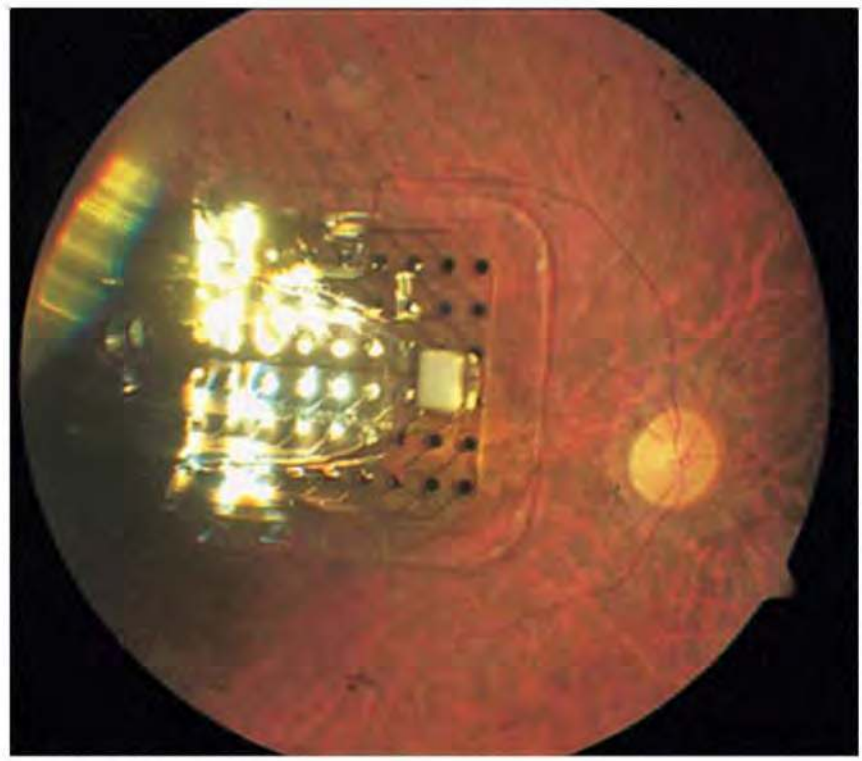

MODULAR PROSTHETIC LIMB
UP TO 22 MOVEMENTS
Nerves running from the spinal cord (1) will send the brain's commands to electrode arrays implanted in the residual nerves (2). A computer chip on each array sends data wirelessly to a receiver on the skin (3). The receiver wires the data to another chip (4) that decodes the command and wires it to the limb controller in the palm (5), which sets the motors in motion.
1
2
3
Power coil
Nerve
4
CARBON-FIBER HARNESS
Molded to the body, the shell is strong but lightweight.
Shoulder rotators
LITHIUM BATTERY
Removable for daily recharging.
Humeral rotator
Elbow rotator
For amputees with severely damaged residual nerves, electrode arrays could be implanted in the brain. The brain's commands would be received by sensors in a cap and sent by wire to the arm.

New Vision

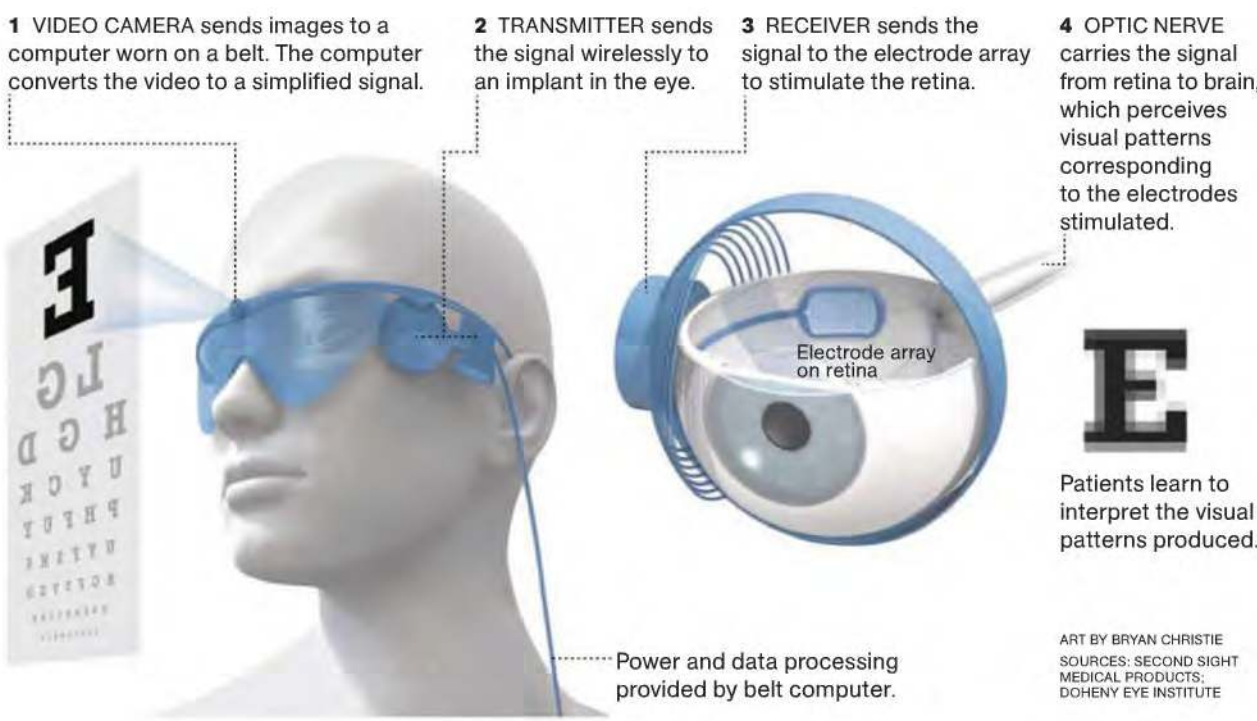
Eyelids stretched wide under anesthesia, Jo Ann Lewis, 79, received new hardware in and around her eyeball, which works with a computer to transmit imagery to her brain. Electronics circumvent damaged light-receptor cells and give the blind Texan back a vestige of vision—shimmering lines, vague shapes, washes of color. "I don't see like you see," she says. "We're on the ground floor of this technology."



Each dot on an array tacked to a patient's retina (right) is an electrode that sends visual stimuli to the optic nerve, visible as a white circle at far right. Built by the U.S. company Second Sight, the one-third-inch-wide array has 60 electrodes. An older model had just 16. As with digital camera pixels, more electrodes capture more detail. The company is now developing implants with hundreds, even thousands, of electrodes.



SECOND SIGHT MEDICAL PRODUCTS



ART BY BRYAN CHRISTIE

SOURCES: SECOND SIGHT MEDICAL PRODUCTS; DOHENY EYE INSTITUTE

MAX AGUILERA-HELLWEG

FAMILIAR SIGHT Using her new bionic vision, Jo Ann Lewis recognizes objects she knew before losing her sight, though they're blurry and vague. With practice, and her brain's natural learning ability, objects should be more recognizable.

months the nerves grew, millimeter by millimeter, moving deeper into their new homes.

"At three months I started feeling little tingles and twitches," says Kitts. "By four months I could actually feel different parts of my hand when I touched my upper arm. I could touch it in different places and feel different fingers." What she was feeling were parts of the phantom arm that were mapped into her brain, now reconnected to flesh. When Kitts thought about moving those phantom fingers, her real upper-arm muscles contracted.

A month later she was fitted with her first bionic arm, which had electrodes in the cup around the stump to pick up the signals from the muscles. Now the challenge was to convert those signals into commands to move the elbow and hand. A storm of electrical noise was coming from the small region on Kitts's arm. Somewhere in there was the signal that meant "straighten the elbow" or "turn the wrist." A microprocessor housed in the prosthesis had to be programmed to fish out the right signal and send it to the right motor.

"Now I'm able to see silhouettes of trees again," says Jo Ann Lewis. "That's one of the last things I remember seeing naturally. Today I can see limbs sticking out this way and that."

Finding these signals has been possible because of Kitts's phantom arm. In a lab at the RIC Blair Lock, a research engineer, fine-tunes the programming. He has Kitts slide off the artificial arm so that he can cover her stump with electrodes. She stands in front of a large flat-panel TV screen that displays a disembodied, flesh-colored arm floating in blue space—a visualization of her phantom. Lock's electrodes pick up commands from Kitts's brain radiating down to her stump, and the virtual arm moves.

In a hushed voice, so as not to break her concentration, Lock asks Kitts to turn her hand, palm in. On-screen, the hand turns, palm in. "Now extend your wrist, palm up," he says. The screen hand moves. "Is that better than last time?" she asks. "Oh yeah. Strong signals." Kitts laughs. Now Lock asks her to line up her thumb alongside her fingers. The screen hand obliges. Kitts opens her eyes wide. "Wow. I didn't even know I could do that!" Once the muscle signals associated with a particular movement are identified, the computer in the arm is programmed to look for them and respond by activating the correct motor.

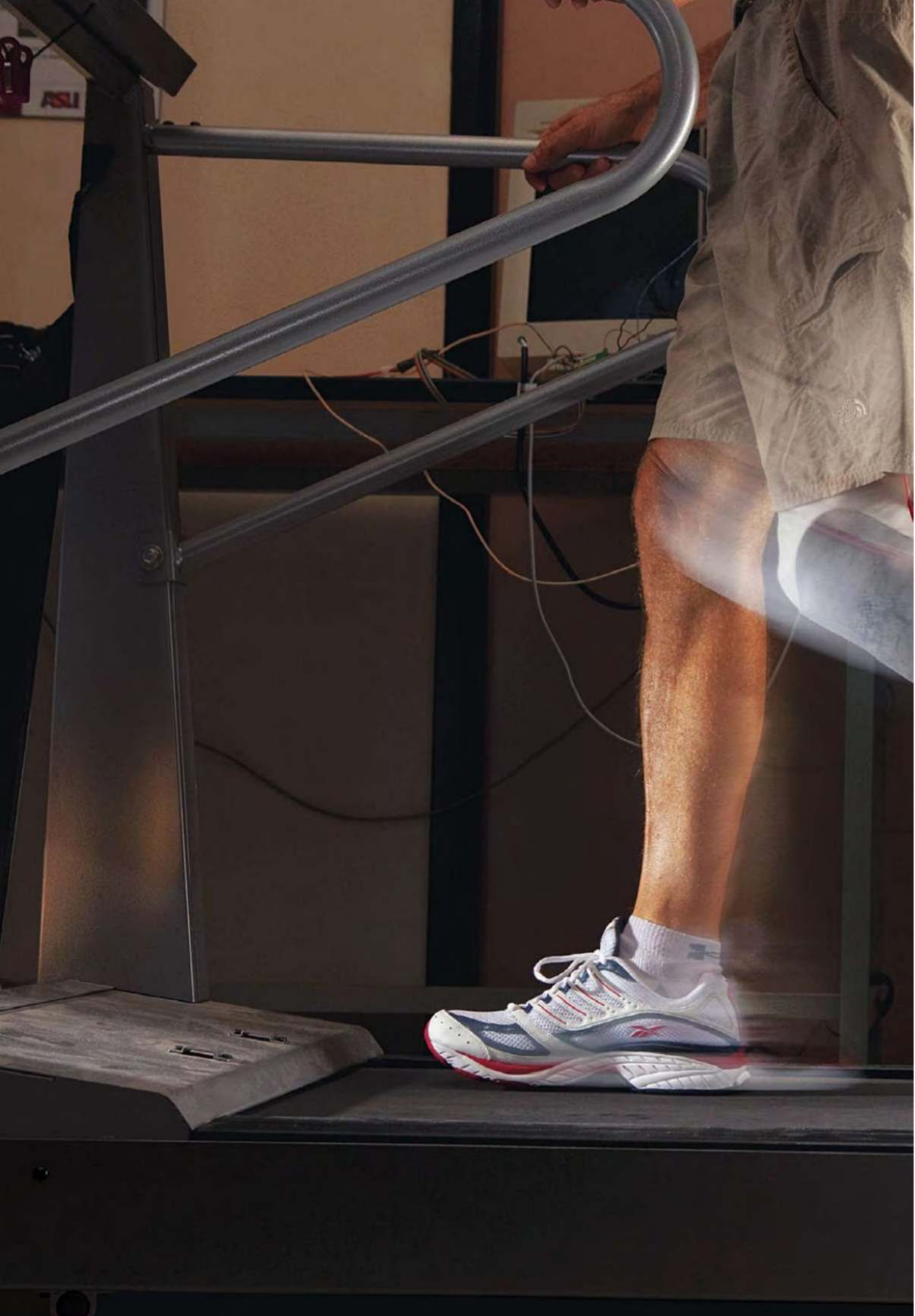
Kitts practiced using her arm one floor below Kuiken's office in an apartment set up by occupational therapists with everything a newly equipped amputee might ordinarily use. It has a kitchen with a stove, silverware in a drawer, a bed, a closet with hangers, a bathroom, stairs—things people use every day without a second thought but that pose huge obstacles to someone missing a limb. Watching Kitts make a peanut butter sandwich in the kitchen is a startling experience. With her sleeve rolled back to reveal the plastic cup, her motion is fluid. Her live arm holds a slice of bread, her artificial fingers close on a knife, the elbow flexes, and she swipes peanut butter back and forth.

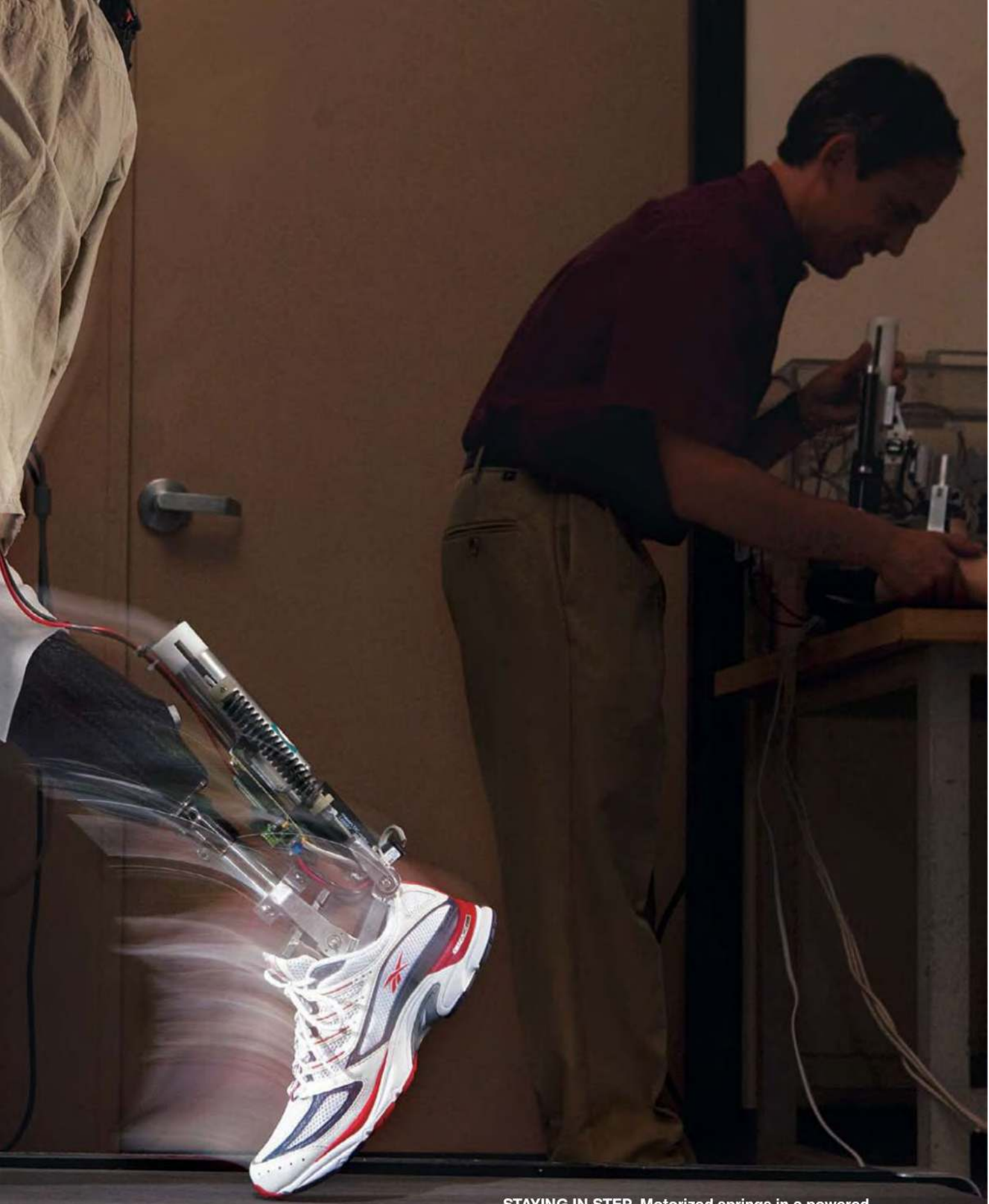
"It wasn't easy at first," she says. "I would try to move it, and it wouldn't always go where I wanted." But she worked at it, and the more she used the arm, the more lifelike the motions felt. What Kitts would really like now is sensation. That would be a big help in many actions, including one of her favorites—gulping coffee.

"The problem with a paper coffee cup is that my hand will close until it gets a solid grip. But with a paper cup you never get a solid grip," she says. "That happened at Starbucks once. It kept squeezing until the cup went 'pop.'"

There's a good chance she'll get that sensation, says Kuiken, again thanks to her phantom. In partnership with bioengineers at the Johns Hopkins University Applied Physics

MAX AGUILERA-HELLWEG





STAYING IN STEP Motorized springs in a powered ankle push off like a real leg, saving energy and easing joint problems. "Military amputees are young and athletic," says designer Tom Sugar (at right), an Arizona State University engineering professor. "They want back all the function they had."

Laboratory, RIC has been developing a new prototype for Kitts and other patients that not only has more flexibility—more motors and joints—but also has pressure-sensing pads on the fingertips. The pads are connected to small, pistonlike rods that poke into Kitts's stump. The harder the pressure, the stronger the sensation in her phantom fingers.

"I can feel how hard I'm grabbing," she says. She can also tell the difference between rubbing something rough, like sandpaper, and smooth, like glass, by how fast the rods vibrate. "I go up to Chicago to experiment with it, and I love it," she says. "I want them to give it to me already so I can take it home. But it's a lot more complicated than my take-home arm, so they don't have it completely reliable yet."

ERIC SCHREMP, UNLIKE KITTS, doesn't need artificial hands. He just needs his natural ones to work. They haven't done that on their own since Schremp broke his neck in 1992, leaving him a quadriplegic. Now, however, the 40-year-old Ohio man can grip a knife or a fork.

He can do this because of an implanted device developed by Hunter Peckham, a biomedical engineer at Case Western Reserve University in Cleveland. "Our goal is to restore hand grasping," Peckham says. "Hand use is key to independence."

Schremp's finger muscles and the nerves that control them still exist, but the signals from his brain have been cut off at the neck. Peckham's team ran eight micro-thin electrodes from Schremp's chest under the skin of his right arm, ending at the finger muscles. When a muscle in his chest twitches, it triggers a signal that's sent via a radio transmitter to a small computer hanging from his wheelchair. The computer interprets the signal and radios it back to a receiver implanted in his chest, where the signal is sent by wires down Schremp's arm to his hand. There the signal tells his finger muscles to close in a grip—all within a microsecond.

"I can grab a fork and feed myself," Schremp says. "That means a lot."

About 250 people have been treated with this technique, which is still experimental. But another bionic device has shown that the marriage of mind and machine can be both powerful and enduring, having been implanted in nearly 200,000 people around the world during the past 30 years. That device is the cochlear implant, and Aiden Kenny is among the latest recipients. Tammy Kenny, his mother, remembers when, a year ago, she learned that her baby was beyond the help of hearing aids.

"I would just hold him in my arms and cry," she says, "knowing he couldn't hear me. How would he ever get to know me? One time, my husband banged pots together, hoping for a response." Aiden never heard the noise.

He hears banging pots now. In February 2009 surgeons at Johns Hopkins Hospital snaked thin lines with 22 electrodes into each cochlea, the part of the inner ear that normally detects sound vibrations. In Aiden, a microphone picks up sounds and sends signals to the electrodes, which pass them directly to the nerves.

"The day they turned on the implant, a month after surgery, we noticed he responded to sound," Tammy Kenny says. "He turned at the sound of my voice. That was amazing." Today, she says, with intensive therapy, he's picking up language, quickly catching up to his hearing peers.

"The day they turned on the implant, a month after surgery, we noticed he responded to sound," says Aiden's mother, Tammy Kenny. "He turned at the sound of my voice."

BIONIC EYES MAY SOON FOLLOW bionic ears. Jo Ann Lewis lost her sight years ago to retinitis pigmentosa, a degenerative disease that destroys light-detecting cells in the eyes called rods and cones. Lately, however, she has partially regained her vision as a result of

research by Mark Humayun, an ophthalmologist at the University of Southern California and a company called Second Sight.

As is common with this disease, part of an inner layer of her retina had survived. This layer, filled with bipolar and ganglion cells, normally gathers signals from outer rods and cones and passes them to fibers that fuse into the optic nerve. No one knew what language the inner retina spoke or how to feed it images it could understand. But in 1992, Humayun began laying, for a short time, a tiny electrode array on the retinas of RP patients undergoing surgery for other reasons.

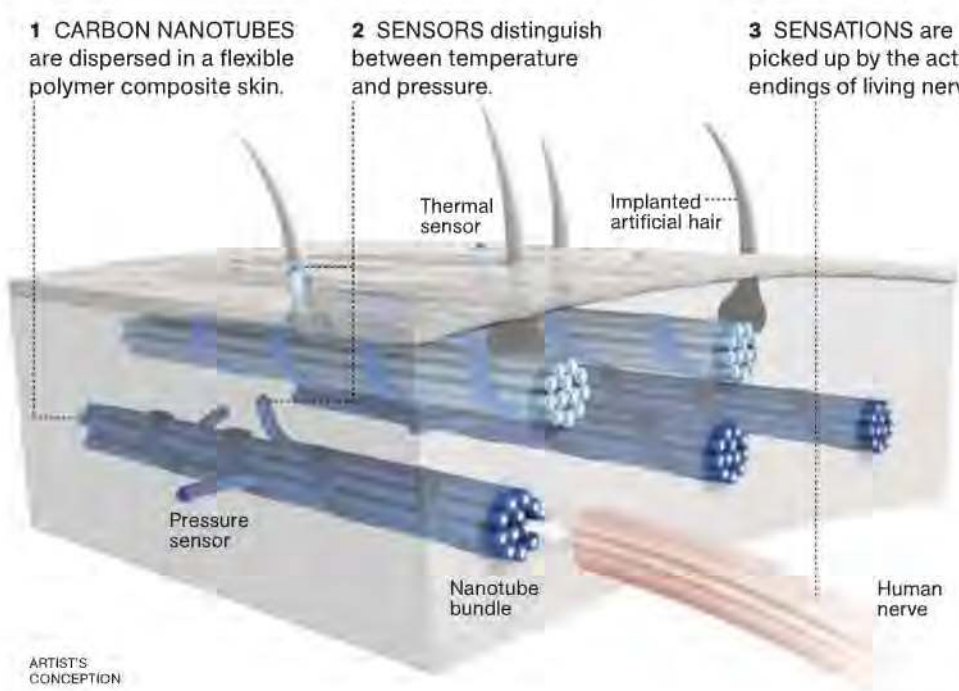
"We asked them to follow a dot, and they could," he says. "They could see rows, and they could see columns." After another decade of testing, Humayun and his colleagues developed a system they dubbed Argus. (Greek mythology. A giant. Hundreds of eyes.) Patients got a pair of dark glasses with a tiny video camera mounted on them, along with a radio transmitter. Video signals were beamed to a computer worn on a belt, translated to electrical impulse patterns understood by ganglion cells, and then beamed to a receiver resting behind the ear. From there a wire took them inside the eye, to a square array of 16 electrodes gently attached to the retinal surface. The impulses triggered the electrodes. The electrodes triggered the cells. Then the brain did the rest, enabling these first patients to see edges and some coarse shapes.

In the fall of 2006 Humayun, Second Sight, and an international team increased the electrodes in the array to 60. Like a camera with more pixels, the new array produced a sharper image. Lewis, from Rockwall, Texas, was among the first to get one. "Now I'm able to see silhouettes of trees again," she says. "That's one of the last things I remember seeing naturally. Today I can see limbs sticking out this way and that."

Pushing the neural prosthetic concept further, researchers are beginning to use it on the brain itself. Scientists behind a project called BrainGate are attempting to wire the motor cortex of completely immobilized patients directly into a

Engineering Bionic Skin

WITHIN 20 YEARS, ARTIFICIAL LIMBS COULD HAVE SKIN THAT SENSES TEMPERATURE AND TOUCH.



ARTIST'S CONCEPTION

- Carbon nanotubes—1/10,000 as thick as a human hair—are the most efficient thermal and electrical conductors known.
- Nanotechnology will be used to create the water-resistant skin composite, shaped by lasers to be lifelike.
- FILMskin, a joint project of Oak Ridge National Laboratory and NASA, may also benefit burn victims.

ART BY BRYAN CHRISTIE

SOURCES: OAK RIDGE NATIONAL LABORATORY; NASA


GADSON
U.S.ARMY

WARRIOR'S FOCUS A roadside bomb in Iraq took his legs in 2007. Now Lt. Col. Greg Gadson tests powered limbs meant to restore mobility to the growing ranks of injured troops. On a track at Ft. Belvoir, Virginia, his computerized PowerKnees transfix young and old. He's regaining his balance, Gadson says, "by meshing my 43-year-old body with a machine."

computer so that patients can move remote objects with their minds. So far, test subjects have been able to move a cursor around a computer screen. Researchers are even planning to develop an artificial hippocampus, the part of the brain that stores memories, with the intent of implanting it in people with memory loss.

Not everything will work perfectly. One of the four initial BrainGate patients decided to have the plug removed because it interfered with other medical devices. And Jo Ann Lewis says her vision isn't good enough for her to safely cross a street. Today, however, Kitts has a new, more elastic cup atop her arm that better aligns electrodes with nerves that control the arm.

"It means I can do a lot more with the arm," she says. "A new one up in Chicago lets me do lots of different hand grasps. I want that. I want to pick up pennies and hammers and toys with my kids." These are reasonable hopes for a replacement part, Kuiken says. "We are giving people tools. They are better than what previously existed. But they are still crude, like a hammer, compared with the complexity of the human body. They can't hold a candle to Mother Nature."

Still, at least the people using the tools can grab the candle. And some can even see it flicker in the dark. □

On Skye's Trotternish Peninsula, basalt pinnacles loom over the Sound of Raasay. Rising from the debris of an ancient landslide, they bear witness to the geologic upheavals that shaped these lands.

Edge of the World

Scotland's Hebrides, islands both stern and sublime, have taught centuries of artists, scientists, poets, and travelers to treasure the wild.

Callanish, Lewis Cut from rocks three billion years old, the Callanish stones likely stood before the Great Pyramid was finished. Humans had already settled here 5,000 years ago, farming, hunting,

fishing—and building. Outer stones rise about 11 feet, the central stone more than 15 feet. Like Stonehenge far to the south, the 40-foot circle was an important ritual center visible for miles around.

Michael Robson fell in love in 1948—with a place he'd never been.

An illustrated magazine swept the young boy's imagination from the familiar domesticity of his English home to the wild islands that rise in jagged ranks off Scotland's northwest coast. As soon and as often as he could, first on school holidays and later on breaks from work, Robson surrendered to the call of the Hebrides, making long journeys from the mainland by steamer and bus, by small boat and on foot, venturing from the mountains of Skye to the moors and sea lochs of Lewis and Harris and even farther, across miles of ocean to a rocky speck of land where the last permanent settlement had been abandoned a century before.

More than 500 islands and islets make up the Inner and Outer Hebrides. Often cloaked in mist and rain and nearly always wind-scoured, they're surrounded by waters temperamental enough to test the most skilled captain, seas that can vary in a day from a silken ripple of improbably tropical blue to a roiling assault of gunmetal and spume. For thousands of years humans have struggled to survive here. Even so, Celts and Vikings, then Scots and English, fought to rule these shores. Today only a few dozen of the Hebrides are inhabited. "The islands are a challenge," Robson says. "Some visitors call them bleak, but that just means they're not really paying attention."

Between battles the isles got precious little attention. The famously cranky 18th-century London intellectual Samuel Johnson declared that mainlanders to the south knew no more of them than they did "of Borneo or Sumatra." What little was written focused on "improving" the islands: What crops could be grown? What resources exploited? How large a population could the various islands support, and what sort of rents could they generate for their landlords? Johnson mostly filled the journal of

By Lynne Warren *Photographs by Jim Richardson*

Boreray, St. Kilda

Fog lifts to reveal an island perched far out in the Atlantic. Humans survived on St. Kilda for millennia, but the last residents gave up their isolated homes nearly 80 years ago.

LEFT

Red Cuillin, Skye

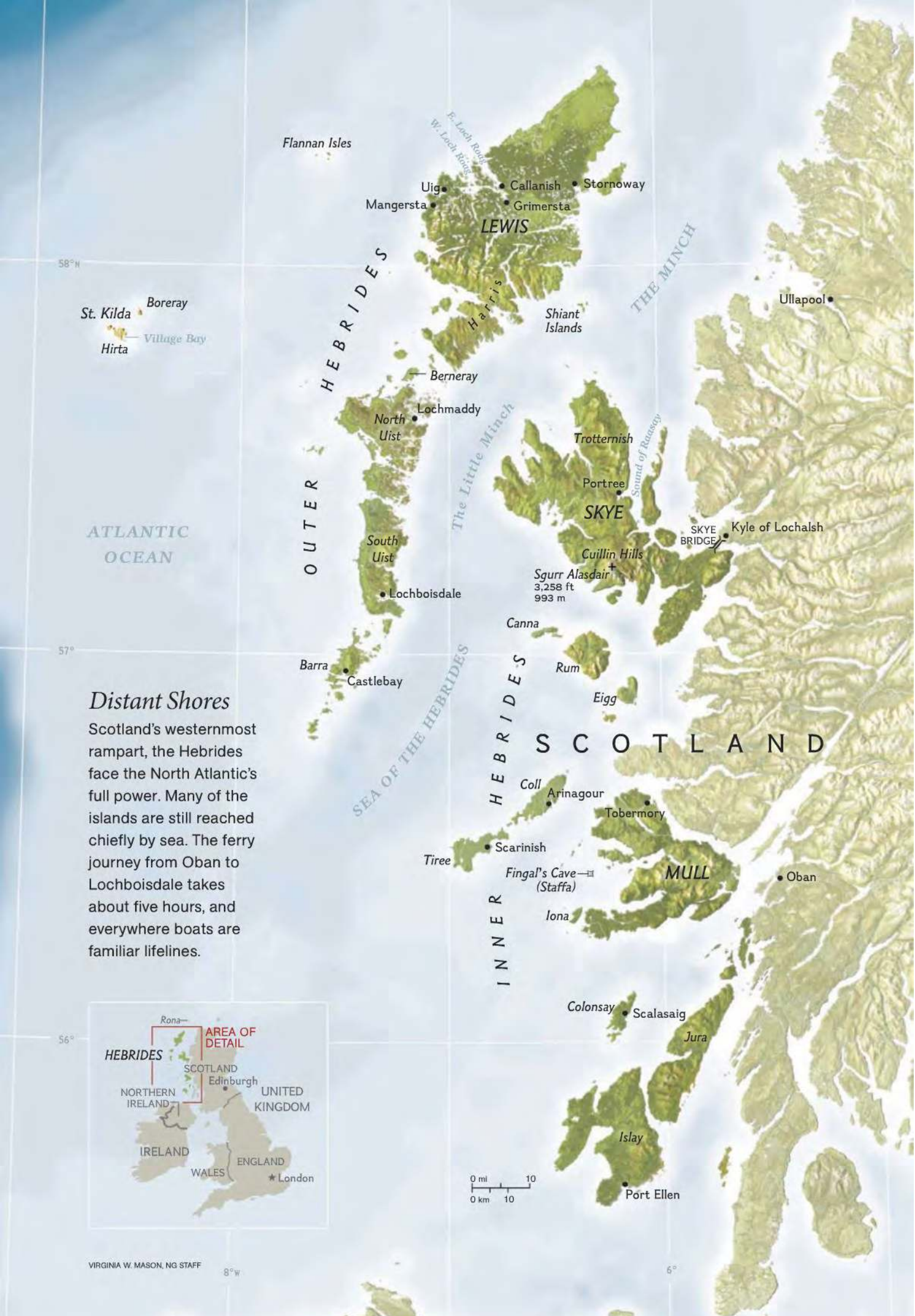
Tranquil waters and a drift of morning mist belie the power that carved these granite hills. Born as the roots of great volcanoes, over millions of years they have been deeply eroded by wind and water and rounded by the grinding weight of glacial ice.

RIGHT

Uig Bay, Lewis

Sheltered more than a mile and a half from Atlantic breakers, high tide mirrors a summer sky. A century ago some 3,400 people lived in Uig district. The casualties of two world wars, dwindling prospects for small farmers and fishermen, and the lure of urban opportunity have reduced the local population to just a few hundred.

BOTH PANORAMAS ARE COMPOSITES OF THREE IMAGES EACH.



Distant Shores

Scotland's westernmost rampart, the Hebrides face the North Atlantic's full power. Many of the islands are still reached chiefly by sea. The ferry journey from Oban to Lochboisdale takes about five hours, and everywhere boats are familiar lifelines.

VIRGINIA W. MASON, NG STAFF

his Hebridean journey with complaints about the difficulties of travel and the rustic accommodations that he endured.

But even as Johnson grumbled, a different set of ideas about the value of rugged places was gaining importance. Scottish Enlightenment thinkers, particularly philosopher David Hume and geologist James Hutton, unshackled intellect from piety, insisting that the ways of the world be learned by direct experience, rather than by reference to ancient and sacred authorities. To these men nature was not merely a wilderness to be tamed; it was the Earth's own textbook.

Nature was the Earth's own textbook, and some of its most dramatic pages could be read on the Hebrides.

Some of its most dramatic pages were read on the Hebrides. In 1800 geologist Robert Jameson (who later served as Charles Darwin's professor at the University of Edinburgh) published *Mineralogy of the Scottish Isles* in two volumes, offering detailed descriptions of hundreds of Hebridean sites. On Islay, Jameson noted shell deposits far from the highest tides: "proofs," he wrote, "of the retiring of the sea from the land." Scientists now know that these fossil beaches, elevated as much as 115 feet above the present waterline, record the passing of the last great ice age. As glaciers blanketing the island began to melt 15,000 years ago, relieving it of the huge weight of ice, the land began to rebound, eventually lifting the coastline high and dry from the sea.

On Skye, Jameson declared that "this island appears, at some former period, to have been very much exposed to violent convulsions." The spiky arc of the Black Cuillin range, rising more than 3,000 feet above sea level, is indeed the remains of a volcano. The outer structures have long since disappeared, revealing the stark and convoluted shape of the deep magma chamber that seethed here 60 million years ago.

Jameson stopped short of the westernmost isles, so he missed the chance to catalog the striped and mottled rock that forms the foundation of the Outer Hebrides. Named for the Isle of Lewis, where it was first described, Lewisian gneiss was born from volcanic activity deep in the crust more than three billion years ago. Intensively and repeatedly altered, lifted up by complex tectonic shifts, and revealed by massive erosion, it is the oldest rock in the British Isles and among the oldest in Europe.

Perhaps the most evocative place to encounter Lewisian gneiss is in the great stone circle at Callanish, overlooking Loch Roag on Lewis. Erected between 4,500 and 4,900 years ago, the Callanish stones may have been standing longer than the central ring at Stonehenge. Little is known for certain of the builders beyond their obvious engineering prowess, but it seems fitting that one of the earliest monuments to the human occupation of the Hebrides should have been crafted of this immensely old rock. Other standing stones dot the isles, along with Bronze Age burial cairns and stout Iron Age fortifications—most likewise built from Lewisian gneiss. The crumbling remains summon up the spirits of mighty warriors, the terror of villagers attacked from the sea, and the determination of farmers, shepherds, and fisherfolk to make their homes on the edge of the world.

The romance of these brooding ruins speaks powerfully to Michael Robson. The old tales, he says, "however extravagant and impossible at times, often have a measure of authenticity about them." Like the Enlightenment zeal

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Author Lynne Warren is a senior editor for the magazine. Photographer Jim Richardson is at work on a book about Scotland's whisky country.

Mangersta, Lewis

Their crumpled layers as old as the continents, the sea stacks and cliffs of the Outer Hebrides offer jagged reminders of the forces that drove Europe, North America, and Greenland apart as the North Atlantic began to open 60 million years ago.

for observation, the Romantic sensibility is an inheritance from the 18th century, and the Hebrides were among its touchstones. British inventiveness had fueled a nascent industrial revolution—and generated brutal levels of noise, pollution, and crowding. For an increasingly mechanized, urbanized world, nature became a refuge, a place for contemplation and inspiration with sublime power to transform emotions as well as thoughts. "Every valley has its battle, and every stream its song," declared Sir Walter Scott, whose novels and poems gave voice to wild Scotland. Even resolutely rational Robert Jameson assured readers that he was not "insensible to the emotions which naturally arise from the retired and striking scenes which often burst upon me."

West Coast, Berneray

Late spring twilight settles over pale crushed-shell sands and thick dune grasses that stretch for miles along Berneray's Atlantic shore, turning the rugged hills of Harris, some six miles away to the northeast, to blue shadows on the far horizon.

The scene widely regarded as the most striking in all the isles was discovered in 1772 by English naturalist Joseph Banks. On his way to Iceland via the Hebrides, Banks had visited the diminutive island of Staffa and found in its southwest part "the most remarkable pillars." Now known to be the remains of colossal volcanic eruptions that began to tear open the North Atlantic Ocean Basin some 60 million years ago, the towering columns of basalt formed one magnificent spectacle after another as the explorer's party moved along the shore. Grandest of all was the great sea cavern Banks called the Cave of Fingal. Fingal was the hero of an epic poem that Scotsman James Macpherson claimed he had translated from verses written by an ancient Gaelic bard

For a mechanized world, nature became a refuge, a place for contemplation with sublime power to transform.

named Ossian—Britain's own Homer. Evoking a mythic past, the epic—eventually revealed to be largely Macpherson's composition—had ignited a romantic fascination with the misty landscapes of Britain's north.

With its entrance more than six stories high, the columned hollow of Fingal's Cave extends back some 230 feet and resounds with the rush of the sea. "Compared to this," Banks declared, "what are the cathedrals or the palaces built by men!" Of course, the Englishman had not truly discovered anything: Gaelic-speaking islanders knew how the cavern echoed the thunder of the waves and called it Uamh Binn, the "melodious cave." But Banks's own prominence assured his report wide attention, and by linking the geologic wonder to the popular Ossian poems, Banks helped make the cavern a must-see.

The moment was right. Illustrated travel books became cheaper as durable steel engraving plates replaced softer copper ones, making larger print runs possible. New roads and steamboat services made island journeys easier. Years of Napoleonic Wars made travel on the Continent nearly impossible for Britons, but the Hebrides were exotic and—with an adventurous dash of effort—accessible.

Fingal's Cave was on the itinerary of the German composer Felix Mendelssohn and his companion Karl Klingemann in the summer of 1829. The Hebrides affected the young musician "extraordinarily," he wrote home to his family in Berlin. On August 8, the two travelers sailed from Mull to Staffa. They'd seen the cave "in all the picture books," Klingemann noted, but the real thing still had the power to amaze: "A greener roar of waves never rushed into a stranger cavern," he went on, "its many pillars making it look like the inside of an immense organ, black and resounding, absolutely without purpose, and quite alone, the wide gray sea within and without." In his *Hebrides Overture,* begun on the journey, Mendelssohn created what Duke University music historian R. Larry Todd

calls "romantic tone painting at its purest."

The sea was not in a collaborative mood the day celebrated English painter J. M. W. Turner took ship for Fingal's Cave in August 1831. "It is not very pleasant or safe when the wave rolls right in," Turner wrote. The steamer *Maid of Morven* could not land her passengers, so a few hardy souls, Turner included, rode a small pilot boat to the cave's entrance and leaped from the deck to slippery rocks. In the painting that records Turner's wild journey, the cave and its great basalt columns are barely visible.

Fingal's Cave, Staffa

Rank upon rank of basalt pillars line this sea cavern, lit from within by the photographer. The natural precision of the columns and the echoes of lashing waves have captivated travelers since the late 18th century.

Hirta, St. Kilda On rough slopes above the haunting remnants of St. Kilda's main settlement, drystone walls still girdle plots of built-up topsoil. These enclosures once sheltered crops of oats and

barley from salt-laden winds and grazing livestock. Beehive-shaped *cleitean* protected stores of food as well as the dried peat that islanders relied on for fuel; hundreds survive, many with turf roofs still intact.

Boreray, St. Kilda Legions of seabirds throng the sky and stipple narrow ledges with their nests. Often hidden in cloud, the northern end of the island juts 1,260 feet above the ocean, and 60,000 pairs of

gannets—the world's largest colony—breed here and on nearby sea stacks. Barefoot St. Kildans used to scale these crags, harvesting birds and eggs that helped sustain their remote community.

Grimersta, Lewis

In a seaward rush, fresh water sluices and clatters from upland lochs and streams down broad, rocky terraces. "On the island it's easy to escape any human sound," Lewis native Alice Starmore says, "but it's never silent."

The canvas is all heaving waves and incandescent sky, with the ship steaming determinedly but nearly overwhelmed by the elements.

There are some places so wild, it seems, that even the sturdiest humans cannot always endure their challenges. St. Kilda, a tiny cluster of islands and sea stacks perched in the North Atlantic 40 miles west of North Uist, was occupied for more than 4,000 years. A small community once huddled around the curve of Village Bay on Hirta, the largest island. Sheep grazed steep slopes all around. Modest crops

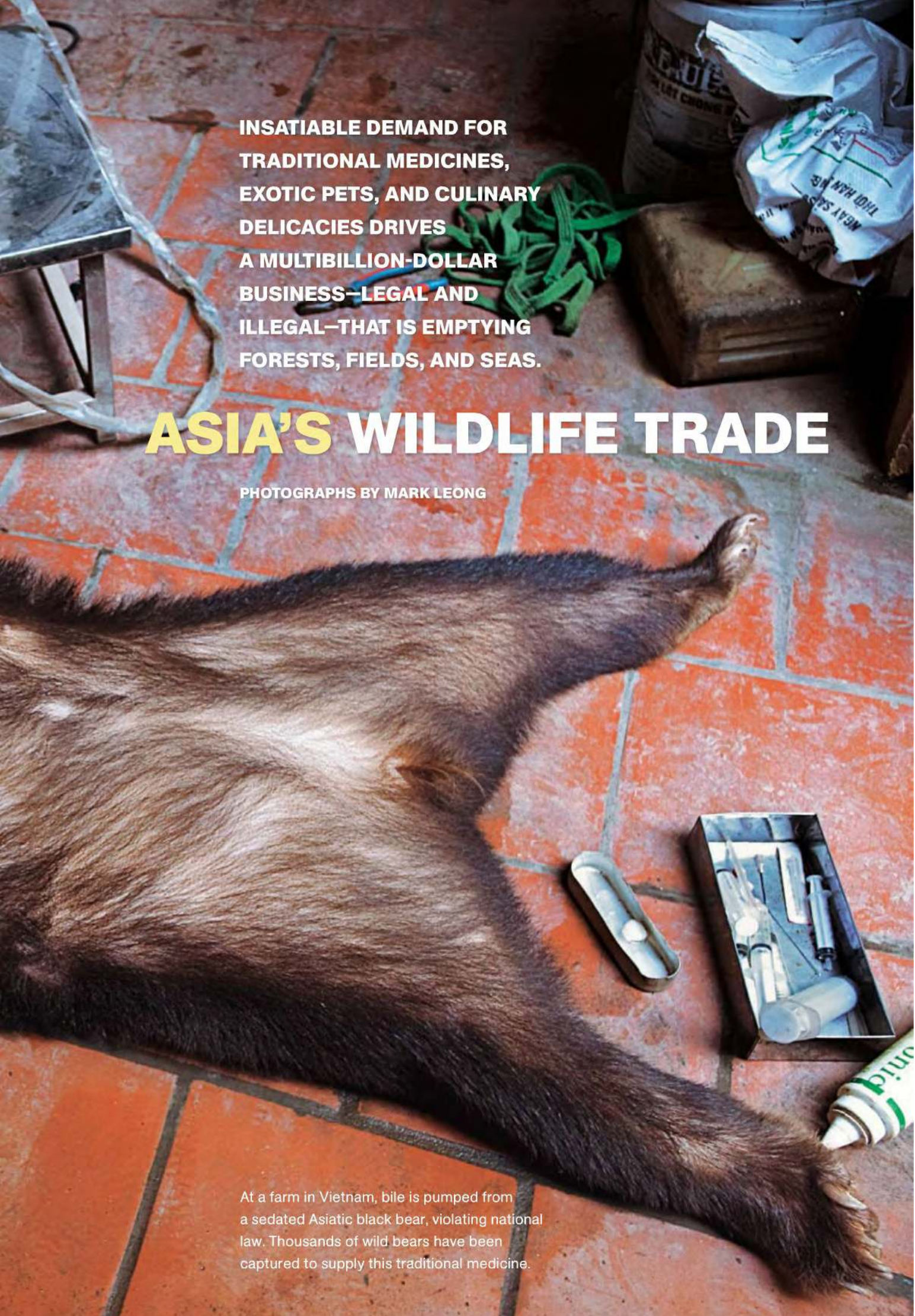
There are some places so wild, it seems, that even the sturdiest humans cannot always endure their challenges.

of barley, oats, and potatoes were grown in raised beds, where thin soil was carefully augmented with applications of mineral-rich seaweed. Winter storms, rolling unchecked across thousands of miles of open ocean, struck the islands with almost unimaginable ferocity. In 1852, 36 islanders—roughly a third of the population at that time—chose a long and arduous journey to Australia over remaining on St. Kilda. Many perished at sea.

By 1930, the 36 remaining residents had had enough. They petitioned the government to evacuate them from their homes. On August 29, the St. Kildans and most of their livestock took ship for the Scottish mainland. Declared a UNESCO World Heritage site in 1986, the islands now belong to the birds that sweep and soar along their plunging cliffs, and people are the migratory visitors.

As a young man, Michael Robson crossed the 40-odd miles of open North Atlantic from Lewis to the lone island of Rona, another abandoned outpost. Lying in the open in the bright summer nights, he listened to the cries of seabirds that nest by the thousands on Rona each year. He came on signs of long-vanished human occupants, from ruined stone huts that had sheltered eighth-century Christian hermits to worn stones that later occupants had used to grind grain. None of Rona's settlements lasted: The harsh conditions overcame each isolated group in turn.

Robson finally settled on Lewis 16 years ago and has opened his collection of Scottish history and lore—books, manuscripts, and maps—to the public. He retains the lean frame of the self-sufficient outdoorsman, his blue-eyed gaze direct and his prodigious memory sharp. But he is no longer young. His hands tremble sometimes as he gestures, telling a Hebridean tale. His journeys are less rigorous now, but he has not stopped seeking places, bleak to some, that for him are steeped in meaning. "The essence of the islands is something you only discover over a long period," he says at last. "I won't have time to learn it all." □



INSATIABLE DEMAND FOR TRADITIONAL MEDICINES, EXOTIC PETS, AND CULINARY DELICACIES DRIVES A MULTIBILLION-DOLLAR BUSINESS—LEGAL AND ILLEGAL—THAT IS EMPTYING FORESTS, FIELDS, AND SEAS.

ASIA'S WILDLIFE TRADE

PHOTOGRAPHS BY MARK LEONG

At a farm in Vietnam, bile is pumped from a sedated Asiatic black bear, violating national law. Thousands of wild bears have been captured to supply this traditional medicine.


PORKAB-IV
KARAWANG

ANIMALS FOR SALE at the Jatinegara market in Jakarta, Indonesia, include crickets in bamboo tubes and species taken illegally from the wild to become pets—a spotted wood owl in a cage and a wreathed hornbill perched next to its seller.

IN AN INDONESIAN SLAUGHTERHOUSE workmen slit open wild-caught blood pythons, pumped full of water and air for ease of skinning. Reptile skins that will be turned into luxury leather goods are the world's top legally traded animal part.

On September 14, 1998, a thin, bespectacled Malaysian named Wong Keng Liang walked off Japan Airlines Flight 12 at Mexico City International Airport. He was dressed in faded blue jeans, a light-blue jacket, and a T-shirt emblazoned with a white iguana head. George Morrison, lead agent for Special Operations, the elite, five-person undercover unit of the U.S. Fish and Wildlife Service, was there to greet him. Within seconds of his arrest, Anson (the name by which Wong is known to wildlife traffickers and wildlife law enforcement officers around the world) was whisked downstairs in handcuffs by Mexican *federales,* to be held in the country's largest prison, the infamous Reclusorio Norte.

To Morrison and his team, Anson Wong was the catch of a lifetime—the world's most wanted smuggler of endangered species. His arrest, involving authorities in Australia, Canada, Mexico, New Zealand, and the United States, was a hard-won victory, the culmination of a half-decade-long undercover operation still widely considered the most successful international wildlife investigation ever.

For too long in too many countries (including the U.S.), placing the word "wildlife" in front of the word "crime" had diminished its seriousness. U.S. federal prosecutors wanted Anson's conviction to show the world that wildlife smugglers are criminals. In addition to charging him under the American wildlife-trafficking law known as the Lacey Act, they indicted him for conspiracy, felony smuggling, and money laundering.

For nearly two years Anson fought extradition to the U.S., but eventually he signed plea agreements, admitting to crimes carrying a maximum penalty of 250 years in prison and a $12.5-million fine. On June 7, 2001, U.S. District Judge Martin J. Jenkins sentenced him to 71 months in U.S. federal prison (with credit for 34 months served), fined him $60,000, and banned him from selling animals to anyone in

THE KINGPIN

BY BRYAN CHRISTY

AN EXPOSÉ OF THE WORLD'S MOST NOTORIOUS WILDLIFE DEALER, HIS SPECIAL GOVERNMENT FRIEND, AND HIS AMBITIOUS NEW PLAN

ART BY JILLIAN TAMAKI

the U.S. for three years after his prison release.

If the judge thought a ban on Anson Wong would work, he was mistaken. Shortly after his arrest, Anson's wife and business partner, Cheah Bing Shee, established a new company, CBS Wildlife, which exported wildlife to the U.S. while Anson was in prison. His main company, Sungai Rusa Wildlife, continued to ship despite the ban. Now that he's free, Anson has launched a new wildlife venture, a zoo that promises to be his most audacious enterprise yet.

NUMBERS GAME

It is almost impossible to name an animal or plant species anywhere on the planet that has not been traded—legally or illegally—for its meat, fur, skin, song, or ornamental value, as a pet, or as an ingredient in perfume or medicine. Every year China, the U.S., Europe, and Japan purchase billions of dollars' worth of wildlife from biologically rich parts of the world, such as Southeast Asia, emptying out parks and plundering wildlands, often newly accessible along logging roads.

The path to market typically begins when poor hunters or farmers catch animals for local traders, who pass them up the supply chain, though some traffickers—Anson Wong among them—have even dispatched their own poachers, posing as tourists. In Asia, wildlife ends up on the banquet table or in medicine shops; in Western countries, in the living rooms of exotic-animal fanciers. The economics are as easy to understand as an art auction: the rarer the item, the higher the price. Around the globe, nature is dying, and the prices of her rarest works are going up.

While no one knows exactly how large the illegal wildlife trade is, this much is certain: It's extraordinarily lucrative. Profit margins are the kind drug kingpins would kill for. Smugglers evade detection by hiding illegal wildlife in legal shipments, they bribe wildlife and customs officials, and they alter trade documents. Few are ever caught, and penalties are usually no more severe than a parking ticket. Wildlife trafficking may very well be the world's most profitable form of illegal trade, bar none.

Smugglers also exploit a loophole in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). With 175 countries as members, CITES is the world's primary treaty to protect wildlife, categorized into three groups according to how endangered a species is perceived to be. Appendix I animals, such as tigers and orangutans, are considered so close to extinction that their commercial trade is banned. Species in Appendix II are less vulnerable and may be traded under a permit system. Those in Appendix III are protected by the national legislation of the country that added them to the list. The CITES treaty has one gaping exception: Specimens bred in captivity do not receive the same protection as their wild counterparts. CITES, after all, applies to *wild* life.

Proponents of captive breeding argue that it takes pressure off wild populations, decreases crime, satisfies international demand that will never go away, and puts money in the pockets of those willing to commit to "farming" wildlife. But these benefits only hold in countries with enforcement policies strong enough to deter rule breakers. In practice, smugglers establish fake breeding facilities, then claim that animals and plants poached from the wild are captive bred. Fake captive breeding is just one of the techniques Anson Wong used in running a secret front operation for one of the world's largest wildlife-smuggling syndicates.

Now the world's most notorious convicted reptile trafficker is about to move in a new direction, with potentially shattering consequences for one of the most revered, charismatic—and endangered—animals on the planet: the tiger.

OPERATION CHAMELEON

Special Operations began its hunt for Anson Wong in the fall of 1993. Ops prided itself on tackling large-scale commercial traffickers. The group's work on exotic-bird trafficking had resulted in the breakup of smuggling operations

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Bryan Christy's reporting for this story grew out of work for his book, The Lizard King. *Mark Leong, a frequent contributor, is based in Beijing.*

around the world—involving dozens of convictions in U.S. courts—and had contributed to passage of the Wild Bird Conservation Act of 1992, which banned the import of many vulnerable bird species. Overnight, imports of macaws, African gray parrots, and other psittacines had dropped from hundreds of thousands a year to hundreds.

By the 1990s illegal reptiles were pouring into the U.S. Prices were skyrocketing—$20,000 or more for a rare tortoise or a Komodo dragon. Reptiles smuggle well: They're small (at least as babies), durable, and with cold-blooded metabolisms, can go for long periods without food or water. Valuable and portable, reptiles were the diamonds of wildlife trafficking.

Informants had been raising Anson Wong's name for years, and Ops suspected he was the global kingpin of the illegal reptile trade. Anson was already wanted in the U.S. for smuggling rare reptiles to a Florida dealer in the late 1980s. He was said to be acutely aware of his status as an outlaw. There would be no "stinging" Anson Wong, no tricking him with a onetime transaction in a hotel room or catching him personally bringing reptiles through an airport. To get him, Ops would have to come up with something clever.

Special Agent Morrison—six foot five, a lifelong hunter, the son of a lawyer—was given the lead. He and his boss, Special Agent Rick Leach, leased a unit in a business complex outside San Francisco, not far from Lawrence Livermore National Laboratory, the nuclear weapons facility. They filled their new wholesale enterprise, called Pac Rim, with the only saleable merchandise they had, a truckload of seashells and corals left over from previous investigations: fluted clamshells, spiraling Trochidae shells, hard corals, the sort of white and pink junk sold by aquarium supply stores and beachside tourist shops. They advertised their confidence items in magazines, and when legitimate orders came in, the seasoned crime fighters boxed and labeled seashell orders themselves.

As a complement to Pac Rim, Ops opened a retail business called Silver State Exotics outside Reno, Nevada. The combination gave the agents a circle of economic life—they could import animals in wholesale quantities through Pac Rim and retail what they didn't need for evidence through Silver State Exotics, giving Pac Rim the appearance of a thriving global operation (and an income).

HE HAD ACCESS TO EXTRAORDINARY BIRDS, INCLUDING THE ROTHSCHILD'S MYNAH. HE BRAGGED ABOUT HIS SPIX'S MACAWS, A BIRD BELIEVED TO BE EXTINCT IN THE WILD, CLAIMING HE'D RECENTLY SOLD THREE.

On October 19, 1995, Morrison sent a fax to Anson's company, Sungai Rusa Wildlife, explaining that he was a wholesaler of shells and corals interested in expanding into reptiles and amphibians. Anson replied with a one-page price list offering low-end frogs and toads for under five dollars and house geckos for 30 cents (items known in the pet industry as trash animals), listed by their Latin names. In one case Anson used his own name for a subspecies: *ansoni*. Two animals on the list stood out—the Fly River turtle (also known as the pig-nosed turtle) and the frilled lizard, protected throughout their ranges in Papua New Guinea, Indonesia, and Australia. So in his first contact with Morrison, a complete stranger, Anson had offered a taste of illegal wildlife.

Soon Anson was soliciting Morrison with the planet's scarcest, most valuable Appendix I reptiles: Komodo dragons from Indonesia, tuatara from New Zealand, Chinese alligators, and Madagascan plowshare tortoises, rarest of the rare. Using a corrupt employee in the FedEx

facility in Phoenix, Arizona, Anson express mailed protected species—including a Southeast Asian false gharial and Madagascan radiated tortoises, both Appendix I—to fake "drop" addresses. He flew Komodos directly to Morrison from Malaysia, hidden in suitcases wheeled by his American mule, James Burroughs. He sent Madagascan radiated tortoises, their legs taped inside their shells, bundled in black socks and packed at the bottom of legal reptile shipments.

Morrison marveled at Anson's dexterity. He could broker turtles out of Peru without ever touching them. He contracted out poaching hits on a wildlife sanctuary in New Zealand. He owned a wildlife business in Vietnam. And he boasted an ability to enforce his deals using Chinese muscle.

Significantly, he exploited the CITES captive-breeding exception, claiming that wild animals he exported were captive bred. Under one ruse, Anson shipped large numbers of Indian star tortoises through Dubai, claiming they'd been bred in captivity there. When investigators checked on the facility, they found a flower shop.

Anson assured Morrison that they had nothing to fear from Malaysian authorities. Wildlife smuggling in Malaysia is policed both by customs and the Department of Wildlife and National Parks, or Perhilitan. Referring to his American courier, Anson told Morrison, "I have the second man of the customs bring him out of the airport and drive him to my office."

In one instance Anson offered Morrison 20 Timor pythons for $15,000. Morrison said he was interested but worried that the snakes would lack CITES paperwork. "They'll definitely be coming with papers," Anson said. "I will have a fall guy and he will get arrested. Plus the goods will be confiscated, and the goods will be sold to me by the department."

Then Anson offered Morrison horns of Sumatran and Javanese rhinoceroses, both forbidden Appendix I animals. He talked openly about getting *shahtoosh,* the "king of wool," from the Tibetan antelope. He had access to extraordinary birds, including the Rothschild's mynah, whose wild population was estimated to number fewer than 150. He bragged about his Spix's macaws, a bird now believed to be extinct in the wild, claiming he'd recently sold three. The black market rate for a Spix's macaw was $100,000. His expanding list of astonishing illegal rarities included panda skins and snow leopard pelts.

Perceiving Anson Wong as only a reptile smuggler had been a terrible mistake, allowing him to maneuver freely across the globe. Reptiles were repulsive, repulsive was invisible, invisible was money. If Anson could deliver on his offers, cheap, legal reptiles shipped to pet stores around the world were a front for a vast, illegal wildlife-smuggling empire.

"I can get anything here from anywhere," he wrote Morrison. "It only depends on how much certain people get paid. Tell me what you want, I will weigh the risks, and tell you how much it'll set you back.

"Nothing can be done to me," he boasted. "I could sell a panda—and, nothing. As long as I'm here, I'm safe."

Finally, after five years and half a million dollars' worth of illegal trade, Morrison was ready to breach Fortress Malaysia, as he called Anson's base. He proposed that Anson partner with him in a new venture, a kind of Endangered Species, Inc., specializing in the rarest animals on the planet. "Top dollar, hard-to-find things," Anson responded. "I've put myself in that position where people will offer me things first before they go elsewhere." He was in.

Morrison suggested they start out by smuggling bear bile, an ingredient in traditional Chinese medicine. Anson agreed that there was high demand for bear bile in China and South Korea, and he said he had a client willing to pay up to a hundred dollars an ounce for the liquid. "Please remember," he wrote Morrison, "I am not selling direct—too dangerous." Instead, he would use a middleman.

Morrison said he too had a partner, who could arrange for the bile from Canada, but she wouldn't work with Anson until she met him in person. Anson was reluctant. Because of the outstanding warrant on him, he couldn't enter U.S. territory, he *(Continued on page 94)*

FISHERMEN OFF-LOAD a requiem shark at a market in Indonesia. The carcass will sell for about a hundred dollars at a seaside auction. Two-thirds of that represents the value of the fins, a legal commodity destined for Hong Kong or Taiwan.


WEEKEND

EXOTIC TASTES

Shark-fin soup symbolizes wealth and status at a wedding banquet in Shanghai, China (top left). In the past only a few could afford this delicacy. Today the appetite of the expanding middle class is causing a catastrophic decline in shark populations. In Tibet wearing ceremonial robes, or *chubas,* trimmed with furs such as snow leopard (above, at left) and otter (at right) was an accepted sign of prosperity until the Dalai Lama denounced the practice in 2005. Many people then burned their chubas on this sacred hill above Lhasa. Carving elephant ivory has occupied 83-year-old Chen Jipin (left) since he was a teenager. The 1989 international ivory-trade ban put many masters of the ancient art out of work, but China has tapped legal African stockpiles, and Chen is now training two apprentices.

13,356,588

LIVE ANIMALS AND **30,309,815 ANIMAL PARTS** WERE LEGALLY EXPORTED FROM SOUTHEAST ASIA, 2000-2007

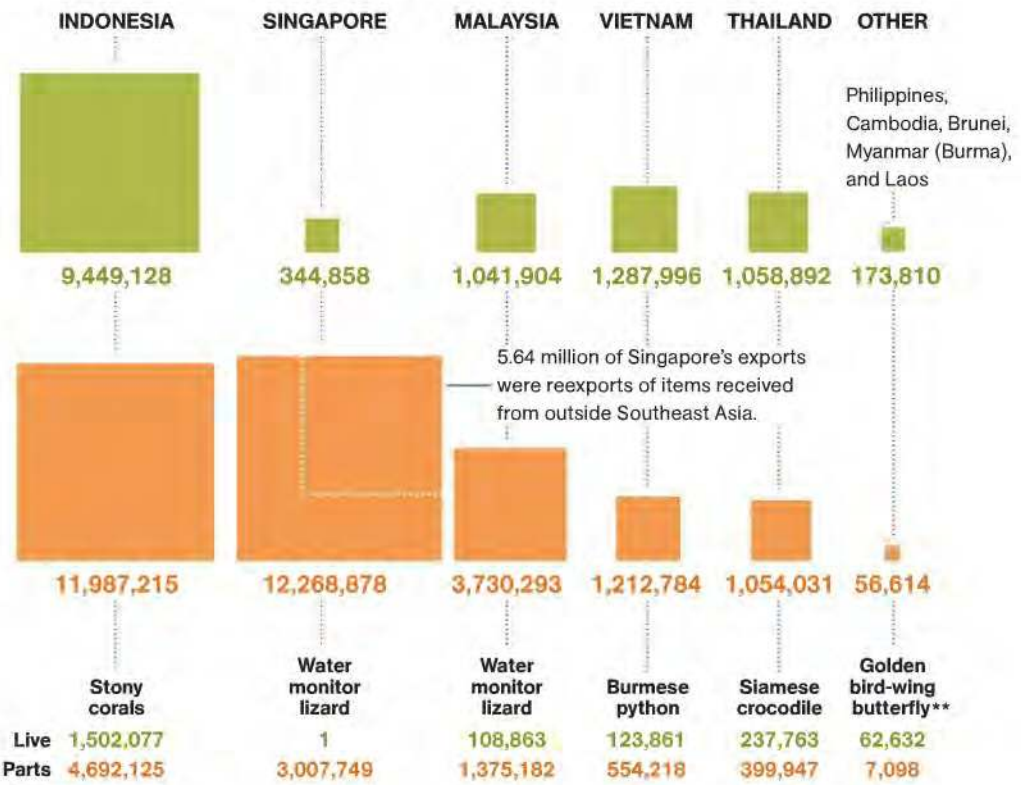
SUPPLY TOP FIVE EXPORTING COUNTRIES*

Live animals

Corals for marine aquariums dominate live animal exports, followed by reptiles for the pet trade.

Animal parts

Singapore is a transshipment point for animal parts, chiefly reptile skins, from other Southeast Asian countries.



Top species traded by each country		Stony corals	Water monitor lizard	Water monitor lizard	Burmese python	Siamese crocodile	Golden bird-wing butterfly**
	Live	1,502,077	1	108,863	123,861	237,763	62,632
	Parts	4,692,125	3,007,749	1,375,182	554,218	399,947	7,098

SPECIES TRADED

Stony corals A variety of reefbuilding species make up this top-traded category, sold for aquariums or as curios. A fraction are propagated on coral farms; most are collected wild.

Water monitor lizard The largest lizard after the Komodo dragon is common in the wild but heavily hunted for its skin and meat. Trade in rarer monitor species is banned.

Reticulated python Exquisitely patterned skin makes it the top-traded snake for leather fashions. Nearly all are wild caught. Though aggressive as pets, thousands are traded live.

LIVE

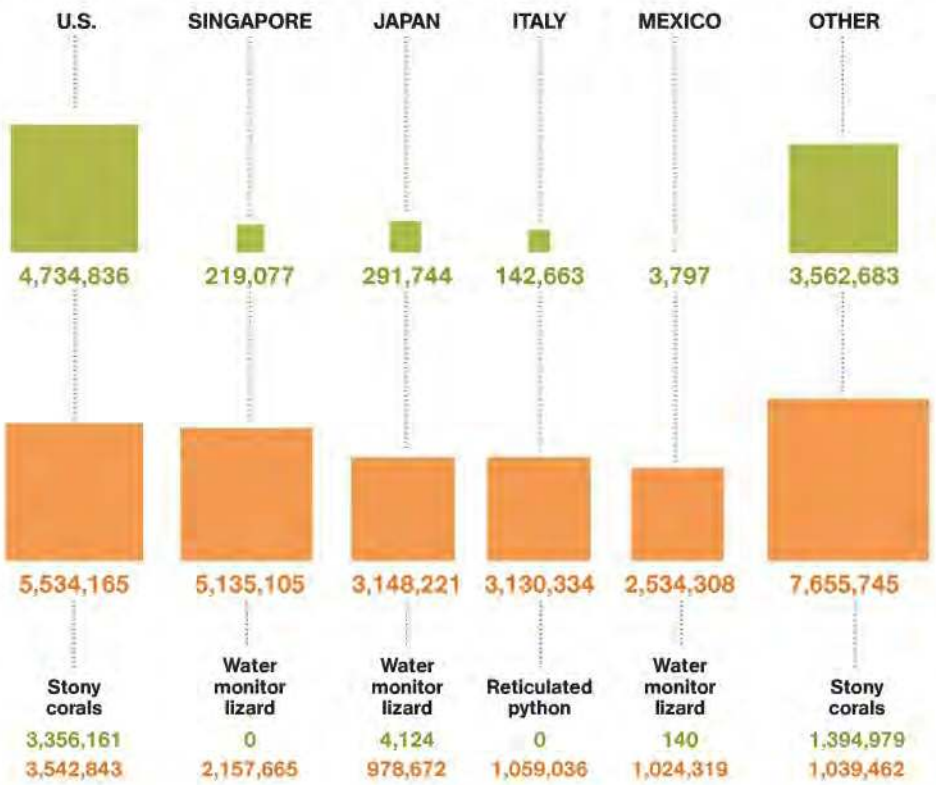
Corals 8,619,442 • Reptiles 2,597,594 • Fish 890,058 • Mollusks 729,295 • Birds 311,600
Mammals 105,876 • Insects 102,582 • Amphibians 141 • **Total 13,356,588**

HIRAM HENRIQUEZ AND AMANDA HOBBS, NG STAFF. ART BY JILLIAN TAMAKI. DATA ANALYSIS: ROBERT THOMASON.
SOURCE: CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES OF WILD FAUNA AND FLORA (CITES)

SOUTHEAST ASIA'S LEGAL WILDLIFE TRADE

This chart covers legal trade in protected species that require permits to be traded internationally. Biologically rich Southeast Asia is the top exporter, with the U.S. as its biggest customer. Legal trade in both protected and unprotected animals dwarfs the profitable illicit trade that operates in its shadow.

DEMAND TOP FIVE IMPORTING COUNTRIES*



Top three among 57 other importers: China (top live import, Siamese crocodile), Hong Kong (South Asian box turtle), and the United Kingdom (stony corals)

Top three among 57 other importers of parts: Germany (reticulated python), China (brown spectacled caiman), and Hong Kong (water monitor lizard)

*RANKED BY TOTAL LIVE ANIMALS AND PARTS

Burmese python Found across Southeast Asia, most exported for pets are captive bred. Cast-off pets have become an invasive species in Florida's Everglades.

Siamese crocodile Almost extinct in the wild, it is legally raised for trade by crocodile farms. Demand for its skin and prized meat has skyrocketed during this decade.

Golden bird-wing butterfly Like most butterflies, this wide-ranging species is exported mainly as live, farm-raised pupae. Adults are shipped as mounted specimens.

PARTS

Reptiles 24,782,857 ▪ Corals 4,770,046 ▪ Mammals 516,745 ▪ Insects 168,526 ▪ Mollusks 49,484
Fish 19,533 ▪ Birds 2,624 ▪ Amphibians (frog legs, measured by weight) ▪ **Total 30,309,815**

** TOP EXPORT AMONG ALL SPECIES TRADED BY THESE COUNTRIES. NOTE: EXPORT AND IMPORT TOTALS DO NOT MATCH BECAUSE OF VARYING METHODS OF ACCOUNTING. EXPORT NUMBERS MAY BE BASED ON PERMITS ISSUED. IMPORT NUMBERS ARE BASED ON ARRIVALS.

(Continued from page 87) told Morrison, and he was leery of Canada.

"We can meet anywhere here in Asia," Anson wrote. Argentina, South Africa, Peru, France, and England were all OK too. "No New Zealand," he stipulated, "or Australia."

They settled on Mexico.

THE MALAYSIAN PHOENIX

With Anson Wong's arrest that September day in 1998, the U.S. Fish and Wildlife Service accomplished its mission, but it may have lost a war. "We focused everything on one climax," George Morrison told me. Exhausted, he left full-time undercover work. Rick Leach, the group's supervisor, retired, and soon Special Operations had all but shut its doors.

Six years later, on November 10, 2003, Anson went free. Reporters flocked to Malaysia. They parked in front of his headquarters on Penang, a tiny island off the west coast, and tried to take his photograph. He refused to speak to the press.

At the time, Malaysia was embroiled in a smuggling scandal involving western lowland gorillas, a critically endangered species. Traffickers had used Nigeria's University of Ibadan Zoological Gardens as a front to smuggle four infants, snatched from the forest in Cameroon, to Malaysia's Taiping Zoo. The Taiping Four incident had sparked international outrage. In the midst of this commotion, Anson sat down at his computer and typed a one-line message on *Vorras .net,* a commercial message board frequented by international wildlife traders: "we need Nigerian primates. pls quote CnF Malaysia."

Anson was back in business.

In truth he had never really stopped. During his imprisonment, Cheah Bing Shee continued to run the operation. Now Anson began to frequent Internet message boards, seeking reptiles from India, Madagascar, and Sudan; insects from Mozambique; and "10 tons a month" of sheep horns. He has offered to sell an array of wildlife, including Malaysian reptiles, mynah birds, parrots, and half a million dollars' worth of wild agarwood, prized for its aromatic qualities. To a request for dead birds and mammals, he replied, "We have always specimens."

MALAYSIA WAS EMBROILED IN A SCANDAL INVOLVING CRITICALLY ENDANGERED WESTERN LOWLAND GORILLAS. TRAFFICKERS HAD USED NIGERIA'S IBADAN ZOO AS A FRONT TO SMUGGLE FOUR INFANTS TO MALAYSIA'S TAIPING ZOO.

Since his release he's had only one brush with the law. On March 16, 2006, Manny Esguerra, an alert Thai Airways cargo employee stationed in Manila, questioned a shipment of reptiles en route from the Philippines to Sungai Rusa Wildlife in Malaysia. The consignment lacked export permits, in violation of Philippine law. Esguerra, as required by his airline, telephoned the intended recipient, which confirmed the shipment. Esguerra referred the case to Philippine authorities. Then the Philippine supplier named in the shipping records evaporated. The seized reptiles themselves vanished before authorities had a chance to investigate further, turning up later at a remote Philippine rescue center. Local news articles presented the case as a success, but no one was arrested. The only identifiable person who could be connected to the illegal shipment was safe in Fortress Malaysia—Anson Wong.

What initially drew my attention to Anson was an offhand comment by Mike Van Nostrand, owner of Strictly Reptiles in South Florida, among the world's largest reptile import-export wholesalers and one of Anson's biggest customers. I was writing a book about Van Nostrand's past as a reptile smuggler. "Two weeks after he got out," Van Nostrand told me in the summer

of 2004, "Anson offered me something he really shouldn't have." It was a Gray's monitor, a fruit-eating Philippine lizard thought to have been extinct until the late 1970s and one of the animals Anson had gone to prison for smuggling. Van Nostrand, who had done jail time himself for smuggling reptiles and wanted to avoid a repeat, was shocked. "Boy, you never quit," he replied.

In September 2006 I rented an apartment in South Florida and went to work for Strictly Reptiles. I spent three months in the warehouse sweeping floors, cleaning snake cages, and unpacking reptile shipments—including ones from Anson—working toward a single question for Van Nostrand: "Would you introduce me?" Employees repeatedly accused me of being a federal agent. They photographed me. They wrote down my license plate number. I was threatened with a baseball bat and had a .357 aimed at my head. But eventually Van Nostrand and I became friends. A few days before my lease ran out, I asked my question. "Sure," he answered. "Anson'll talk to you. He loves to talk about himself."

INSIDE THE FORTRESS

Situated in the trendy Pulau Tikus ("rat island") section of Penang, Sungai Rusa Wildlife might easily be mistaken for a hair salon. No wider than a family garage and unidentified, it's one of dozens of units along a quiet strip of retail shops offering tummy reduction, skin care, and spa treatments. When I walked in on March 2, 2007, a black BMW and a windowless delivery van bearing the address of Anson's Penang-based reptile farm were parked out front. Next door was Xie Design, an interior furnishings business Anson's wife operates.

Anson shook my hand with that significant extra squeeze some men give you just before the release. He led me past stacks of live tarantulas in deli cups, scattered paperwork, and shipping boxes to his private office, a cramped, windowless room. Although he'd advertised his company on the Web as doing "U.S. $50 million to U.S. $100 million" in annual sales, the fanciest item in the room was the cell phone on his desk.

After I sat down, Anson pointed to three sets of photographs laminated in plastic and taped to his office door. "My wife put those up to remind me to ask myself if it was worth it," he said. "Beautiful, huh?"

They were evidence photos of Indian star tortoises he'd smuggled, each page stamped by the Northern District of California federal court. They may have been a reminder to Anson from his wife, but they were also a warning to every person who stepped through his door: I, Anson Wong, have run the toughest legal gantlet in the world, and I am here.

He was deceptively boyish-looking. He wore large, round glasses and had a ponytail, which was flecked with gray. At 49, his face was without stress. He had the cultured air of a successful artist, a sculptor maybe, and he spoke with a pleasant British curl to his perfect English. Behind his head was a map of the world. Behind me slept a reticulated python, the world's longest python.

Anson said he'd started in the wildlife trade in the 1980s, with a company called Exotic Skins and Alives. Back then, he said, Malaysia gave legal protection only to indigenous wildlife, so he traded freely in endangered species from around the world. Anson smiled. "Anything," he said.

I said I was writing a book about his U.S. customer Mike Van Nostrand, who had also played a cat-and-mouse game with the U.S. Fish and Wildlife Service. "You're the main guy in Asia," I said. "Mike told me that if it wasn't for Anson Wong, there would be no reptile industry in the United States."

Anson named a rival trader in Indonesia and another in Madagascar. Then he laughed and shook his head. "Well, I guess there aren't that many of us."

Wildlife is an integral part of every Asian economy, I said, and I'm interested in the line between man and nature.

"Ahhh," he said. Anson raised his arms and put his fists together. "Always in conflict."

FUTURE SHOCK

"I'm building another zoo," he said, pointing to a 30-page document on his desk titled "Anson

RESCUED ORPHANS learn the ways of the forest at a Borneo Orangutan Survival Foundation facility in Indonesia so they can eventually live on their own. In many cases workers on oil palm plantations shot their mothers and sold the babies as pets.

Wong, Flora and Fauna Village." "The plans were approved yesterday." I began thumbing through the architectural drawings.

Anson's partners were his wife and Michael Ooi, an internationally renowned orchid dealer. (Michael's brother Gino operates Malaysia's largest rare bird facility, Penang Bird Park.) For years the Wongs and Michael Ooi had run a zoo on Penang called Bukit Jambul Orchid, Hibiscus and Reptile Garden.

Zoos make good cover. Smugglers in control of a zoo can move endangered species with CITES paperwork, and a zoo can use its breeding program to explain the appearance of a new animal. CITES generally doesn't monitor what happens to an animal after a zoo imports it: A gorilla can be sold domestically, or if it dies (or is killed), can be cut up for meat, or parts, or even stuffed. Anson's portion of the zoo was called Bukit Jambul Reptile Sanctuary, and it had enabled him to host nature lovers and wildlife experts from around the world while he secretly smuggled rare animals through his other company.

Anson told me his new zoo would far surpass Bukit Jambul. He would still display reptiles, and he would charge visitors next to nothing to get in, but this time he expected to make a lot of money. He had a new focus: big cats. "I love tigers," he said.

"Captive breeding," Anson smiled, "that is the future."

I looked up with an adrenaline jolt. Tigers are all but extinct in the wild, with only about 4,000 left. Now Anson Wong was planning to make tigers his specialty.

There's a valuable black market for tigers. Tibetans wear tiger-skin robes; wealthy collectors display their heads; exotic restaurants sell their meat; their penis is said to be an aphrodisiac; and Chinese covet their bones for health cures, including tiger-bone wine, the "chicken soup" of Chinese medicine. Experts have put the black market value of a dead, adult male tiger at $10,000 or more. In some Asian countries, tourist attractions called tiger parks secretly operate as front operations for tiger farming—butchering captive tigers for their parts and offering a potential market for wild-tiger poachers too. (Keeping an adult tiger costs $5,000 a year in food alone, but a bullet costs only a dollar.)

THERE'S A VALUABLE BLACK MARKET FOR TIGERS. WEALTHY COLLECTORS DISPLAY THEIR HEADS, EXOTIC RESTAURANTS SELL THEIR MEAT, AND CHINESE COVET THEIR BONES FOR HEALTH CURES, INCLUDING TIGER-BONE WINE.

Anson has a dark history with big cats. During Operation Chameleon he had asked Morrison's help to have tigers he was raising mounted for sale as trophies. He has offered to smuggle a cougar out of the U.S., and he wanted to sell Morrison an Appendix I marbled cat. After his prison release, tiger cubs he owned were found on display at a Kuala Lumpur pet store. Anson was practiced at circumventing Malaysian prohibitions on keeping tigers and other endangered species by securing "special permits"—licenses granted on the recommendation of Perhilitan, the wildlife department, to private individuals, theme parks, and zoos.

He glanced at my shoulder bag. "George Morrison recorded everything," he said, and stood up. He rapped his knuckles against his wall calendar. "I'm busy," he said, indicating forthcoming commitments: Taipei, Hong Kong, Thailand.

"I'm here this weekend," I offered.

"Weekends are for family," he replied. "We'll talk, but not this trip."

He walked me to the door. "When you're done with your book, we should talk about my story," he said.

That's when I made a mistake. I told him I'd written an article exposing a questionable agreement between the U.S. government and a British coin dealer to sell the world's most valuable—and stolen—coin and split the profit. Normally, telling an ex-felon you'd given the government a black eye was a sure bet to improve your relationship. But momentarily I'd forgotten the premise for Operation Chameleon: Anson and his government were friends.

Anson stared at me. "So, you're a journalist," he said, stiffening.

Apparently, he had mistaken me for a biographer. I started to reply, but he interrupted. "Journalists who uncover what people want left alone can get killed," he said, his voice very calm.

KECIK-KECIK CILI PADI

One day in late December 2007, Anson's black Mercedes-Benz pulled into Penang International Airport and picked up two of Malaysia's top wildlife enforcement officials, Perhilitan's law enforcement division director, Sivananthan Elagupillay, and his boss, Deputy Director General Misliah Mohamad Basir. The officers had flown in from Kuala Lumpur for a press conference launching Flora and Fauna Village, now a joint venture between Penang's forestry department and Anson Wong and Michael Ooi's enterprise. It would be a five-acre zoo carved out of the Teluk Bahang Forest Reserve, and to help finance it, the Penang state government was contributing 700,000 ringgit (U.S. $200,000). A photograph in Malaysia's newspaper *The Star* showed government officials inspecting the zoo's new tiger den.

"The price will be very affordable as our aim of setting the village is also to help conserve the endangered species," Ooi told reporters.

Anson had long boasted his government influence. Now he had the open support of both the Penang government and Malaysia's wildlife department. Misliah's presence was ironic. During Operation Chameleon Misliah had been the wildlife official in charge on Penang. She signed his CITES permits. Within four years of Anson's arrest, she was promoted to director of Perhilitan's law enforcement division, and by 2007 she'd been given the department's number two job.

I wondered what Misliah thought of the man who had smuggled so much endangered wildlife right under her nose.

"He is my good friend," Misliah giggled, sitting behind her desk in her spacious office at Perhilitan headquarters. She was a plump little woman, hardly more than a round head wrapped in a Muslim's white *tudung* scarf. She was swaddled in a sky blue shawl over a *baju kurung,* a long blouse and sarong, and wore petite brown sandals. Her voice was honestly the sweetest I'd ever heard.

I'd been warned that Misliah had two prejudices: She disliked Americans, and she thought all Americans were obsessed with Anson Wong.

"You know," I said, "I'm an American. And when it comes to Malaysia and wildlife, all we ever hear about in the U.S. is one story."

"What is that?" she asked pleasantly.

I smiled. "Anson Wong."

Misliah giggled. She had joined Perhilitan in the early 1980s, about the same time Anson started in the reptile business, and had been posted to Penang for much of her career. "I spent more than ten years inspecting his shipments," she said. I tried to picture Misliah, crowbar in hand, prying open Anson's wooden shipping crates, reaching into boxes crammed with biting Tokay geckos, venomous mangrove snakes, and other discouragingly aggressive animals Anson called cover species, because he put them on top of illegal animal shipments.

She hadn't known much about reptiles when she started, she said, but now she did. "Everything I know about them I learned from opening Anson's boxes." Misliah turned to look at her bookshelves. Though she hadn't seen him much since her move to Kuala Lumpur, she still borrowed Anson's books on bird identification from time to time. When her officers can't identify an animal, she tells her people to call Anson. "He's better than anyone in the department at identifying wildlife, so why not go to him," she said. "He's the most knowledgeable in the country."

I noticed that Misliah rarely blinks.

"He is very smart," she continued, explaining

that Anson does all his deals over the phone. "In Malaysia you must catch someone with the animals. Not like the U.S. with the Lacey Act," she said contemptuously.

The Lacey Act makes it a federal crime to violate wildlife laws, even those of a foreign country, and a wildlife smuggler doesn't have to be caught in possession of an animal to face felony prosecution. Misliah considers Anson's conviction under the Lacey Act illegitimate and has publicly accused the U.S. Fish and Wildlife Service of framing him.

"They said he had Komodos, but he never handles animals himself—he has runners everywhere," Misliah said. "When he was in prison, Anson wrote me letters. He bribed his way. They treated him like a king!" She explained that his business had gone down while he was in prison and his wife was in charge. "But," she said, "now it is going up."

Malaysia's second highest wildlife law enforcement officer speaks of her country's most notorious illegal trafficker like a doting aunt.

"People say, 'How can you give him his license?'" A smile wreathed Misliah's face. "He was a very bad boy, but if we don't give him a license, he would just do it anyway." This way, she said, they could keep their eye on him.

To this day Misliah vouches for Anson. "Anson Wong has carried out his business legally and complying [*sic*] the needs and requirements under the domestic law. He and his business in peninsular Malaysia have been monitored closely by this department," her office asserted in a written statement to the press in 2008.

She was also in favor of legalized tiger and bear-bile farming. "Why not?" she asked me.

Misliah Mohamad Basir, so inconspicuous, seemingly so benign, is one of the most powerful wildlife decision-makers on the planet. On her watch Malaysia has become a global trafficking hub.

I kept coming back to how delightful she seemed in person. "Isn't Misliah the sweetest little woman you ever met?" I asked a senior Perhilitan officer.

The officer studied me for a moment, then smiled. "In Perhilitan we have a saying about her: *Kecik-kecik cili padi.*"

A park ranger standing nearby nodded.

"The smallest chilies are always the hottest."

CASES DO WELL IN THE PRESS ONLY IF THEY INVOLVE ICONIC ANIMALS. NOT IF THEY'RE THE FISH CALLED HUMPHEAD WRASSE, OR THE 14 TONS OF TURTLES, MONITOR LIZARDS, AND PANGOLINS FOUND FLOATING IN A BOAT OFF THE COAST OF CHINA.

SHERIFF WANTED

Misliah had mentioned an adversary named Chris Shepherd, an intrepid investigator who has drawn attention to black market wildlife operations throughout Southeast Asia. "He says we're just a transit country," Misliah told me, with obvious disdain. "He says we do nothing to stop smuggling."

Shepherd, a Canadian, works for TRAFFIC, the trade-monitoring arm of the World Wildlife Fund and the International Union for Conservation of Nature. Based in Cambridge, England, with offices around the world, TRAFFIC's investigators monitor crime and pass what they learn to host country law enforcement agencies. Shepherd is the lead investigator in the Southeast Asia headquarters, in Petaling Jaya, Malaysia. Over the past decade he's published a mountain of reports covering illegal trade in bear parts, elephants, civets, Indonesia's laughing thrushes, the Indian star tortoise, the serow, the Roti Island snake-necked turtle, the Sumatran

tiger, and more. He is widely considered among the region's best investigators, and his reports benefit conservationists and law enforcement around the world.

When I visited Shepherd and asked if he would show me his Anson Wong file, he looked at me blankly. He opened a file cabinet and removed a thin folder from a half-empty drawer. After scanning a few pages, he shook his head.

Not one NGO investigator I met in Southeast Asia, Shepherd included, had ever laid eyes on Anson Wong. Time and again I found experts eager to take me to see atrocities: bear cubs in Vietnam dipped in boiling water to intensify the "life force" in bear-paw soup, orangutans chained in the backyards of Indonesian generals, endangered birds openly for sale in Asian markets. But when I asked what connections could be made between a scene and a criminal organization, no one had a single example of a syndicate being mapped out the way one would expect to see on any low-budget cop show.

"Their brains all work like a camera," George Morrison told me. NGOs, their donors, and the media tend to focus on wildlife crimes they can see, while multinational criminal syndicates operate hidden behind thickets of corporate records, CITES permits, and trade data.

NGO staff have many demands on their time: fund-raising and species reports, press interviews, market surveys, donor meetings, and bill paying. NGOs are not police. They have no enforcement authority, their employees depend for their visas on the wildlife officials they might investigate, and if NGOs push too hard, they invite trouble. In 2008, TRAFFIC issued a report on the Sumatran trade in tiger parts and urged Indonesia to increase its enforcement. In response, Indonesia froze TRAFFIC's activities, a move tantamount to expulsion. Tonny Soehartono, the Ministry of Forestry official responsible for Indonesia's action, explained his reasoning: "TRAFFIC attacked my country."

TRAFFIC itself has just three investigators covering Southeast Asia and only a hundred staff worldwide. The CITES secretariat employs only one—that's right, one—enforcement officer. Interpol likewise employs one person to manage its wildlife-crime program. Other countries have useful tools, such as wiretap authority, but they don't have the long reach of the Lacey Act, and now U.S. Special Operations has dwindled to three or fewer agents.

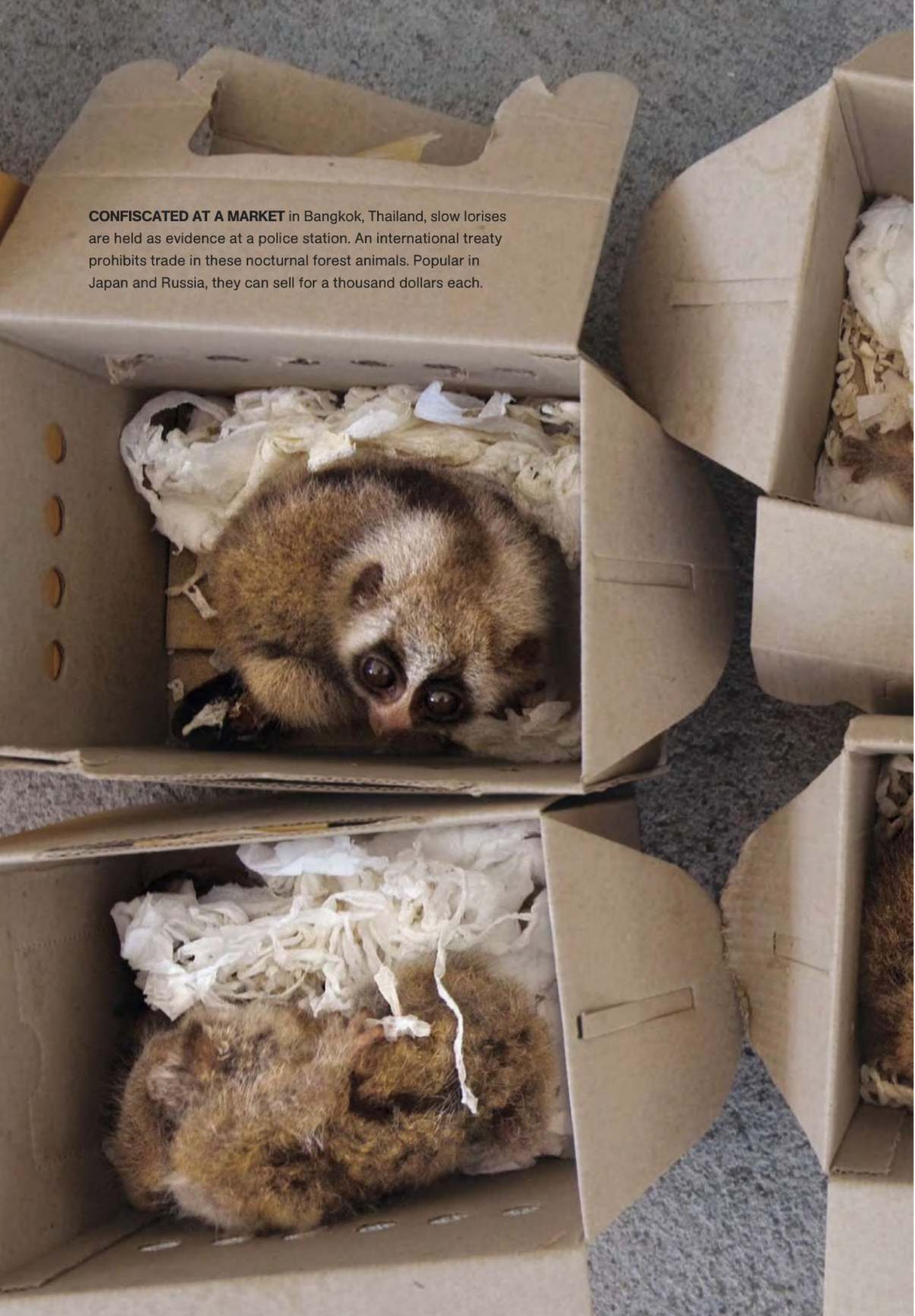
At a U.S. congressional committee hearing on the links between national security and wildlife trafficking, I met a woman with a Ph.D. in veterinary science who had helped prepare some of the informational material. "I want to go work undercover in Southeast Asia," she told me. I was impressed: a bright young professional eager to take on the undercover agent's life. "I have some vacation time coming up," she said, "and I'm going to do it."

Is there any other area of law enforcement where a private citizen could even imagine doing undercover work on her vacation?

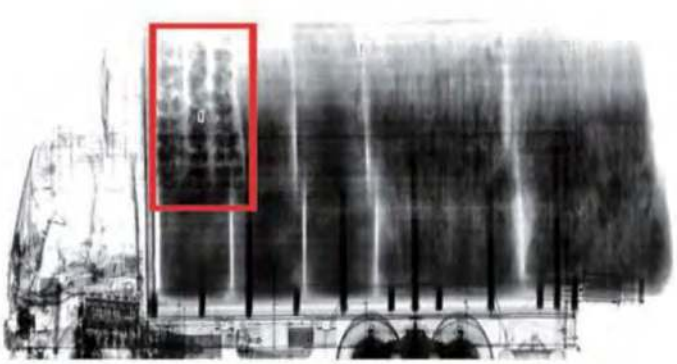
Misliah dislikes Shepherd because his criticisms appear in the news, but cases do well in the press only if they involve iconic animals that garner catchy names like Taiping Four or Bangkok Six (smuggled orangutans). They don't do well if they're the simple fish called humphead wrasse, or the 14 tons of turtles, monitor lizards, and pangolins found floating in a deserted boat off the coast of China.

One cause for hope may be a new regional organization—the Association of Southeast Asian Nations' Wildlife Enforcement Network (ASEAN-WEN). Established four years ago, ASEAN-WEN brings together customs agents, wildlife officers, prosecutors, and police from each of its ten member countries. Australia, New Zealand, and the U.S. are also involved, with much of ASEAN-WEN's funding provided by the U.S. Agency for International Development. It's a testament to ASEAN-WEN's potential that Anson Wong subscribes to its newsletter.

Last August Misliah responded to allegations of a corrupt relationship between her department and Anson Wong: "As far as Malaysia is concerned, he abides by local laws and has the necessary licenses," she said. "What he does outside the country is not our concern." □



CONFISCATED AT A MARKET in Bangkok, Thailand, slow lorises are held as evidence at a police station. An international treaty prohibits trade in these nocturnal forest animals. Popular in Japan and Russia, they can sell for a thousand dollars each.



ROYAL THAI CUSTOMS (BOTTOM)

FRONT LINES OF ENFORCEMENT

Tipped off by an informant, Thai police discover a slow loris at the Chatuchak market in Bangkok (top left). Three dealers were arrested during the raid. In a discouraging outcome for conservationists, two were let go, and the third paid a light fine of about $600. Forestry police in Medan, Indonesia, store an array of contraband at their headquarters (above). None of these mounted animals—including a tiger, a clouded leopard, and hawksbill sea turtles—can be sold legally, alive or dead. Saws and spare chains came from illegal logging. An x-ray of a truck at a highway checkpoint in Thailand reveals a hundred live pangolins (left, in red box) smuggled behind piles of paper. Also known as scaly anteaters, the creatures were likely on their way to China to be sold as food or for traditional medicine.

TOURISTS FEED TIGERS at a private zoo in Guilin, China. Owners of such animals are pushing to legalize sales of captive-tiger products. Conservationists fear that any form of legal tiger trade would further endanger the few cats that still roam free.

Restless Spirits

In China, ancient human sacrifice has given way to modern tomb-tending ceremonies, but the dead still make demands.

TANG TOMB GUARD
A.D. 618–906 • 26 INCHES

Ghost warriors, sculpted 2,200 years ago to accompany China's first emperor into eternity, were to serve in a carefully planned afterlife—along with bureaucrats, beasts, and entertainers.

Restless Spirits

In China, ancient human sacrifice has given way to modern tomb-tending ceremonies, but the dead still make demands.

TANG TOMB GUARD
A.D. 618–906 • 26 INCHES

HAN CERAMIC VESSEL
206 B.C.–A.D. 220 • 18.7 IN

Grave goods served the needs of the dead; elaborate
from above: A wine container, a cauldron supported by
vessel let ancestors perform afterlife ceremonies. An o
jade adorned a queen's grave. Far left: A spiky-crowne

SHANG JADE DRAGON
CA 1250 B.C. • 2.3 IN

NORTHERN WEI CERAMIC OX
A.D. 386–534 • 7 IN

WESTERN ZHOU BRONZE CAULDRON
1045–771 B.C. • 8 IN

design signaled status. Clockwise
fantastical birds, and a plump-legged
x did otherworldly plowing; cherished
d tomb guard kept evil at bay.

LONGSHAN CERAMIC VESSEL
2700–2500 B.C. • 9.6 IN

BY PETER HESSLER • PHOTOGRAPHS BY IRA BLOCK

IN THE VILLAGE OF SPRING VALLEY, PEOPLE RARELY SPOKE OF THE DEAD, AND THEY DIDN'T LIKE TO reminisce. "This place was always so poor," villagers said if I asked about the old days, and then they fell silent. They had few old photographs and only a handful of written records. The Great Wall stood nearby, but even those impressive ruins didn't inspire much interest. In 2001, I began renting a home in the village, partly because I was curious about the region's history, but soon I realized that glimpses of the past were fleeting. Like most Chinese of the current generation, the villagers focused on today's opportunities: the rising prices for local crops, the construction boom that was bringing new jobs to Beijing, less than two hours away.

There was only one day each year when they looked backward, in April, during the festival of Qingming. The Chinese name translates as "day of clear brightness," and for more than a millennium it's been celebrated in various regional forms across China. Ancestor worship goes back even further. More than 5,000 years ago, the cultures of northern China were venerating the dead through highly systemized ceremonies. Echoes of these traditions still survive today, and during my first year in the village, when the holiday came around, I accompanied my neighbors on their ritual journey to the cemetery.

An oracle bone (wrongly) assured a Shang dynasty king he would be safe from harm.

Only men were allowed to participate. All of them were named Wei, and a dozen members of this extended clan left before dawn, hiking up the steep mountain behind the village. They wore simple work clothes and carried flat wicker baskets and shovels on their shoulders. They didn't make small talk, and they didn't stop

Peter Hessler's forthcoming book is Country Driving: A Journey Through China From Farm to Factory. *Ira Block has photographed more than 30 stories for* NG.

O. LOUIS MAZZATENTA (JADE DRAGON, CENTER LEFT); RICHARD SWIECKI, ROYAL ONTARIO MUSEUM/CORBIS (ORACLE BONE, RIGHT)

to rest. They had the determined air of a work crew—tools at the ready, trudging past apricot trees whose fresh buds glowed like stars in the morning half-light. After 20 minutes we reached the village cemetery. It was located high on the mountain, where simple piles of dirt had been arranged in neat rows. Each row represented a distinct generation, and the men began their work on the front line, tending the graves of the most recently dead—the fathers and mothers, uncles and aunts. They weeded the mounds and piled fresh dirt atop. They left special gifts, such as bottles of alcohol or packs of cigarettes. And they burned paper grave money for use in the afterlife, the bills bearing a watermark that said, "The Bank of Heaven Co., Ltd."

Each villager paid special attention to his own close relatives, working through the rows from father to grandfather to great-grandfather. Almost none of the graves had markers, and as the men moved back in time, from row to row, they became less certain of identities. At last the work was communal, everybody pitching in for every mound, and nobody knowing who was buried beneath. The final grave stood alone, the sole representative of the fourth generation. *"Lao zu,"* one villager said. "The ancestor." There was no other name for the original clan member, whose details had been lost over the years.

By the time they finished, morning light glowed behind eastern peaks. A man named Wei Minghe explained that each mound represented a house for the dead, and local tradition called for them to complete the Qingming ritual before dawn. "If you pour dirt on the grave before the sun comes up, it means that in the afterlife they get a tile roof," he said. "If you don't make it in time, they get a thatched roof."

Wei Minghe was in his late 60s. He still had the rawboned build of a farmer, but now he lived in a retirement apartment in the nearby city of Huairou, although he returned faithfully each year for Qingming. Later that day, I gave him a ride back to the city. When I asked him if he missed Spring Valley, he said, "Before this apartment, I never lived in a place with good heat." His view of progress made perfect sense, just like the wishes of the ancestors—tile roofs versus thatched.

Wearing brass bridle fittings, a horse (above) was killed and placed in the grave of a Shang noble some 3,000 years ago, when such sacrifices were common. Clay bowls and jars (right) that four females may have used in life were included in a rare group burial some 6,000 to 7,000 years ago.

O. LOUIS MAZZATENTA (ABOVE)

THE CHINESE VIEW of the afterlife has always been marked by qualities many Westerners would perceive as earthly. In ancient times the vision of the next world tended to be pragmatic, materialistic, even bureaucratic—values that are apparent in today's archaeological discoveries. When royal tombs are opened, they're usually characterized by meticulous organization and impressive wealth. The tradition of burying bodies with precious goods goes back at least as far as the fifth millennium B.C., when some tombs contained jade and pottery.

It's not until the Shang, a culture that flourished in northern China from roughly 1600 to 1045 B.C., that we have written evidence of how people viewed the afterlife. The earliest known Chinese writing appears on Shang oracle bones —ox scapulae and turtle shells used in rituals at the royal court. Cracked and interpreted, the

bones were a means of communicating with the unseen world, including passing messages to ancestors of the royal family. "We ritually report the king's sick eyes to Grandfather Ding." "As to the coming of the Shaofang [an enemy], we make ritual-report to Father Ding."

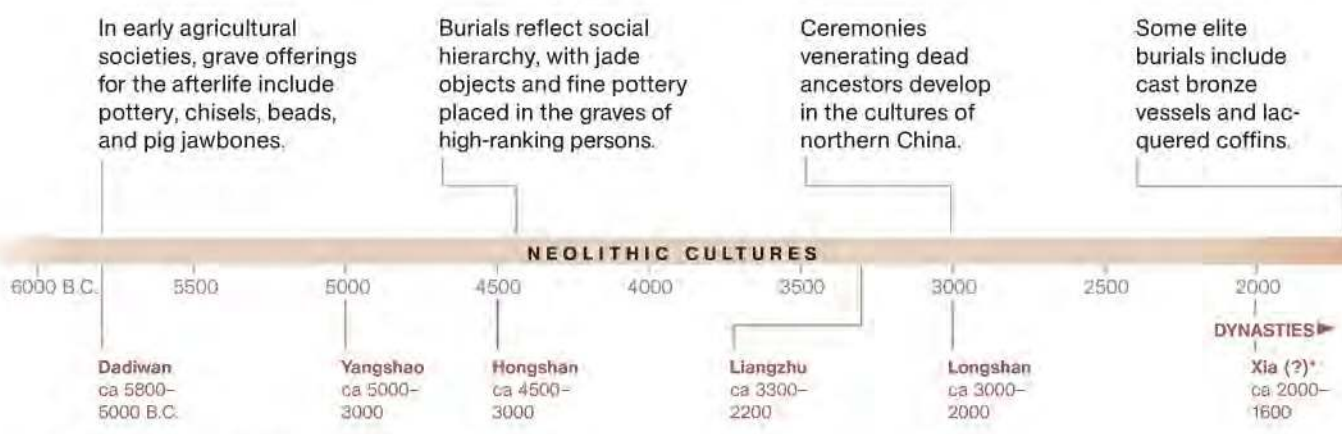
The dead were believed to have great power over daily events. Unhappy ancestors could cause illness or disaster among the living, and many oracle bones refer to human sacrifices meant to appease these spirits. At one complex of tombs in Henan Province, excavations have uncovered more than 1,200 sacrificial pits, most of which contain human victims. An archaeologist once told me that he had counted 60 different ways a person could be killed during a Shang ceremony. But he also reminded me that these were rituals, not murder and mayhem. From the Shang perspective, human sacrifice was simply part of a remarkably well organized system. The Shang kept a strict calendar, with certain sacrificial days devoted to certain ancestors. They were meticulous almost to the point of scientific inquiry. In one instance, a diviner patiently made 70 individual oracle-bone cracks in order to determine which ancestor was responsible for a living king's toothache.

As for the dead, they functioned in an extensive bureaucracy. Royal names were changed after death to mark the transition to new roles. The purpose of ancestor worship was not to remember the way people had been in life. Instead, it was about currying favor with the departed, who'd been given distinct responsibilities. Many oracle-bone inscriptions request that an ancestor make an offering of his own to an even higher power.

David N. Keightley, a historian at the University of California, Berkeley, told me that he's particularly struck by how oracle-bone inscriptions convey a sense of hierarchy and order. "The more recently dead deal with the small things; the ones who have been dead for longer deal with the bigger things," he said. "This is a way to organize the world."

After the Shang collapsed in 1045 B.C., divination using oracle bones was continued by

Chinese Burial Traditions

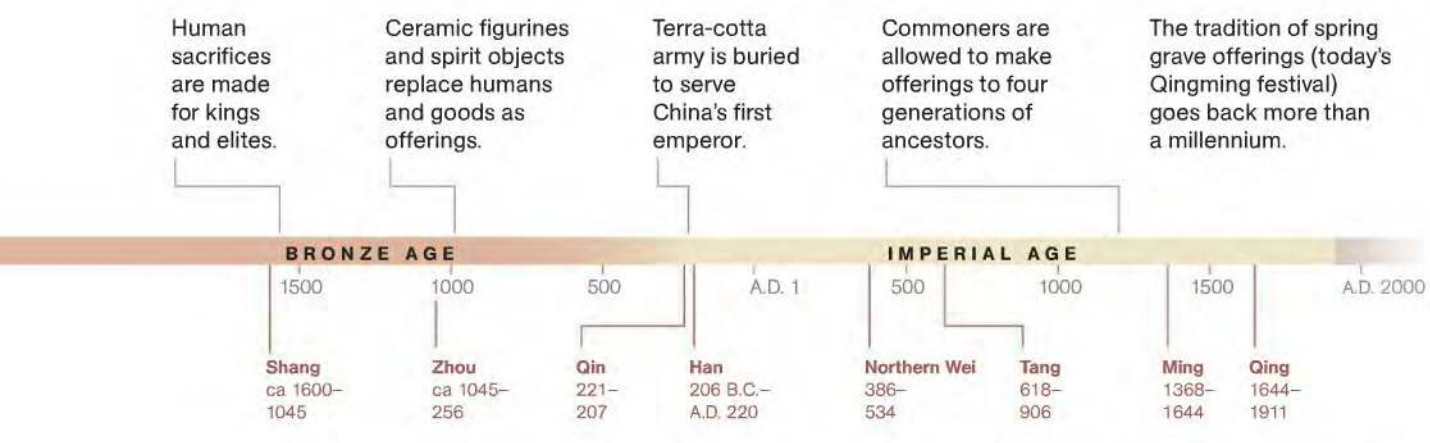


SELECTED CULTURES AND DYNASTIES SHOWN
*CHINA'S LEGENDARY FIRST DYNASTY

Dressed in mourning white, the family of farmwife Zhang Guilan buries her in her Shaanxi Province village. Outside the crypt, youngest son Sun Lin Hu reaches for foil-wrapped ingots, symbols of wealth to meet afterlife needs. In cities the dead are typically cremated.

the Zhou, a dynasty that ruled parts of northern China until the third century B.C. But the practice of human sacrifice gradually became less common, and royal tombs began to feature *mingqi*, or spirit objects, as substitutes for real goods. Ceramic figurines took the place of people. The terra-cotta soldiers commissioned by China's first emperor, Qin Shi Huang Di, who united the country under one dynasty in 221 B.C., are the most famous example. This army of an estimated 8,000 life-size statues was intended to serve the emperor in the hereafter.

The next dynasty, the Han, left a collection of funeral goods that is less military in character. The tomb of Han Jing Di, who ruled



NGM MAPS. NG ART. SOURCES: PATRICIA EBREY, UNIVERSITY OF WASHINGTON; ROWAN FLAD, HARVARD UNIVERSITY; LOTHAR VON FALKENHAUSEN, UCLA

from 157 to 141 B.C., has yielded an amazing array of spirit goods designed to reflect the needs of everyday life: reproductions of pigs, sheep, dogs, chariots, spades, saws, adzes, chisels, stoves, measuring devices. There are even official chops, or ink stamps, to be used by netherworld bureaucrats.

In a culture as rich and ancient as China's, the line from past to present is never perfectly straight, and countless influences have shaped and shifted the Chinese view of the afterlife. Some Taoist philosophers didn't believe in life after death, but Buddhism, which began to influence Chinese thought in the second century A.D., introduced concepts of rebirth after death. Ideas of eternal reward and punishment also filtered in from Buddhism and Christianity.

Yet many elements of early cultures such as the Shang and the Zhou remained recognizable across the millennia. The Chinese continued to worship their ancestors, and they continued to imagine the afterlife in material and bureaucratic terms. Near-death experiences gave rise to popular legends about how some low-level clerk in the netherworld miswrote a name on a ledger of the dead, nearly cutting a life short before the mistake was discovered.

David Keightley told me that the traditional Chinese view of death impressed him as optimistic. There's no concept of original sin, so entering the afterlife doesn't require a radical change. The world isn't fatally flawed; it provides a perfectly adequate model for the next stage. "In the West, it's all about rebirth, redemption, salvation," he said. "In the Chinese tradition, you die, but you remain what you are."

Keightley believes that such ideas contributed to the stability of Chinese society. "Cultures that engage in ancestor worship are going to be conservative cultures," he said. "You're not going to find new things attractive, because that will be a challenge to the ancestors."

CHINA'S CURRENT CHANGES are anything but conservative, and they are hard on the dead. Cemeteries are often destroyed by building projects, and many rural Chinese have migrated to cities, making it impossible to return home for Qingming. Some try alternative forms of grave care—there are websites that allow descendants to tend "virtual tombs." But it's difficult to think about the past in a fast-changing country, and many traditions simply fade away.

Wooden attendants stood watch in a Zhou king's tomb in Liangdai centuries before the terra-cotta army was created. Today mourners burn paper effigies (right) to ensure that relationships live on after death.

Each year in Spring Valley it seems that fewer people turn out to celebrate Qingming. Yet the holiday survives, and some elements still recall ancient rituals. Village graves are organized with bureaucratic precision, each generation in its own row. Material concerns remain important: cigarettes, alcohol, and grave money for the dead. Perhaps someday even these traditions will be abandoned, but for now they still

provide a link between past and present.

Three years after my first Qingming, only seven villagers made the journey up the mountain to the cemetery. At the top, a new grave stood in the first row, decorated with a candle that said, "Eternally young." I asked my neighbor who was buried there.

"Wei Minghe," he said. "You gave him a ride home a few years ago. He died last year. I don't remember which month."

Another man spoke up. "This is the first time we're marking his grave."

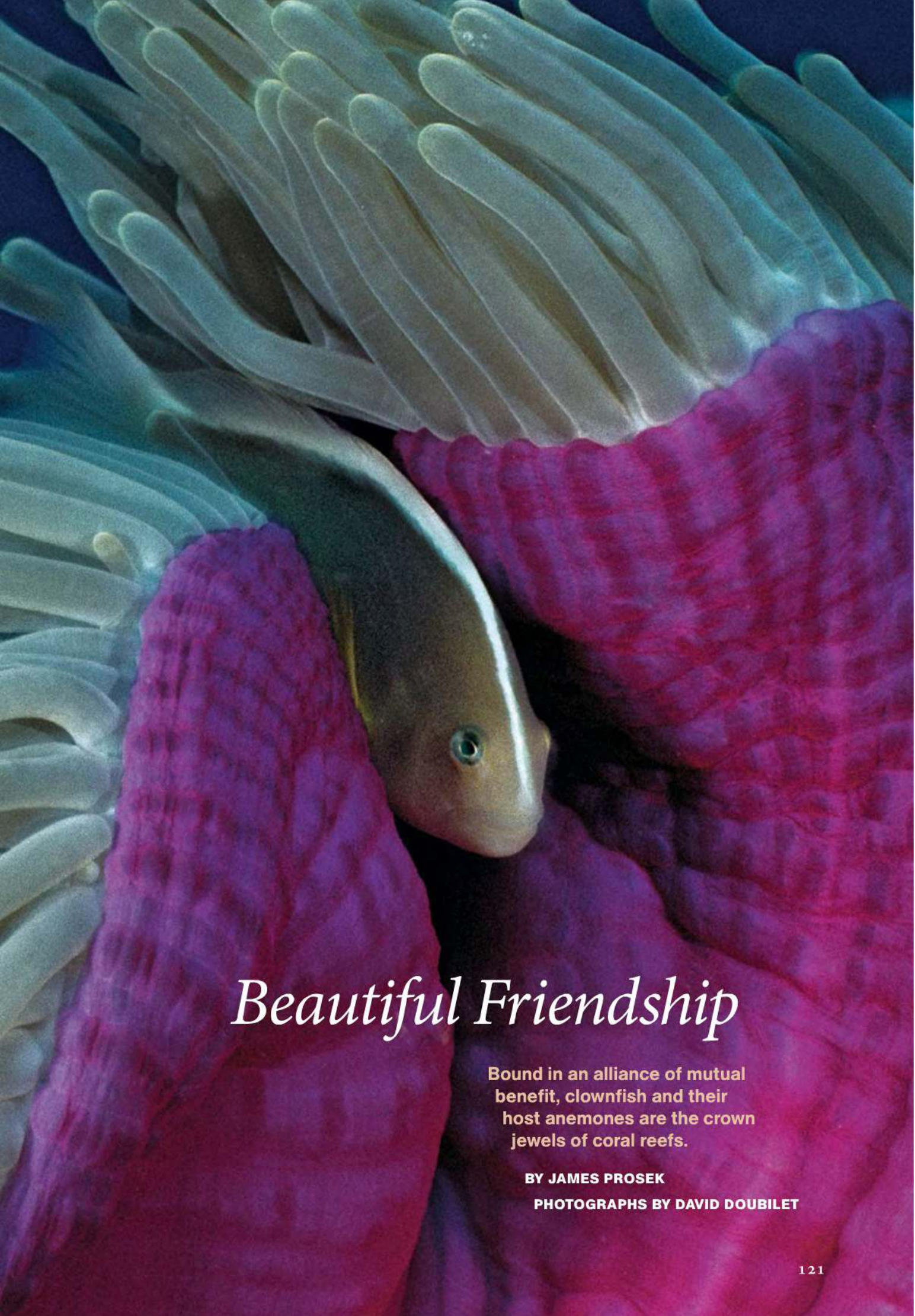
"Last year he poured dirt on other people's graves," somebody else said. "This year we pour dirt on his."

I picked up a shovel and contributed to the mound. Somebody lit a Red Plum Blossom cigarette and stuck it upright in the dirt. Wei Minghe would have liked that touch, and he would have appreciated the timing. We were gone before dawn—the ancestors, at least for another year, could enjoy their roofs of tile. ▯

Stand face-to-face with life-size soldiers, charioteers, and acrobats from Qin Shi Huang Di's tomb complex. **Terra Cotta Warriors: Guardians of China's First Emperor,** an exhibition at the National Geographic Museum in Washington, D.C., is open now through March 31. Purchase tickets at **warriorsdc.org.**

GREG GIRARD, CONTACT PRESS IMAGES (TOP); WANG DA GANG (RIGHT)

AMPHIPRION AKALLOPISOS (SKUNK CLOWNFISH); *HETERACTIS MAGNIFICA* (MAGNIFICENT SEA ANEMONE); PHOTOGRAPHED IN SEYCHELLES



Beautiful Friendship

Bound in an alliance of mutual benefit, clownfish and their host anemones are the crown jewels of coral reefs.

BY JAMES PROSEK

PHOTOGRAPHS BY DAVID DOUBILET

Tucking themselves in for the night among the stinging tentacles of their anemone, orange-fin clownfish (male at left, female at right) find refuge from predators, such as groupers.

AMPHIPRION CHRYSOPTERUS; STICHODACTYLA MERTENSII (MERTENS'S CLOWNFISH ANEMONE); PAPUA NEW GUINEA

WHEN ANDREW STANTON set out to make an animated children's movie set in the ocean and faithful to "the real rules of nature," all he needed was the perfect fish for his main character. Combing through coffee table books on sea life, his eye landed on a photo of two fish peeking out of an anemone. "It was so arresting," Stanton says. "I had no idea what kind of fish they were, but I couldn't take my eyes off them." The image of fish in their natural hiding place perfectly captured the oceanic mystery he wanted to convey. "And as an entertainer, the fact that they were called clownfish—it was perfect. There's almost nothing more appealing than these little fish that want to play peekaboo with you."

So a star was born. *Finding Nemo,* the Pixar movie Stanton wrote and directed, won the 2003 Academy Award for best animated feature and remains one of the highest grossing G-rated films of all time, taking in over $850 million dollars to date. Nemo—a clownfish of the species *Amphiprion percula*—introduced millions of children around the world to a wondrous tropical ecosystem: the coral reef and its denizens.

Clownfish get their name from the bold color strokes on their body (from rich purplish browns to bright oranges and reds and yellows), often divided by stark lines of white or black, quite like the face paint on a circus clown. Seeing clownfish darting among the tentacled folds of an anemone is like watching butterflies flitting around a flowering plant in a breeze-blown meadow—mesmerizing.

Twenty-nine species of clownfish live among the reefs from East Africa to French Polynesia and from Japan to eastern Australia, with the greatest concentration of diversity on the north coast of New Guinea in the Bismarck Sea (where with a little luck and a competent guide you can see seven species on one reef). On a recent diving trip to Fiji, Gerald Allen—a research associate at the Western Australian Museum and the world's clownfish authority—discovered the 29th species, *Amphiprion barberi.* That brought his lifetime total to seven clownfish (and nearly 500 species of reef fish). "I still get a huge buzz when I find something new," Allen says. "*Amphiprion barberi* is a beautiful clown, orange and red like a blazing ember on the reef."

AMONG SCIENTISTS and aquarists, clownfish are also known as anemonefish because they can't survive without a host anemone, whose stinging tentacles protect them and their developing eggs from intruders. Of the roughly thousand species of anemones, only ten host clownfish. It's still a mystery exactly how a clownfish avoids being stung by the anenome, but a layer of mucus—possibly developed by the clownfish after it first touches an anemone's tentacles—may afford protection. "It's a slime that inhibits the anemone from firing off its stinging cells," Allen says. "If you ever watch a new little anemonefish coming into an anemone, it makes these very tentative touches. They have to make contact to get this chemical process going." Thus shielded, the clownfish, in effect, becomes an extension of the anemone—another layer of defense against anemone-eating fish, such as the butterflyfish. What's good for the clownfish is good for the anemone, and vice versa.

Clownfish spend their entire lives with their host anemone, rarely straying more than a few yards from it. They lay their eggs about twice a month on the nearest hard surface concealed by the fleshy base of the anemone, and they aggressively protect the developing embryos. Just after a clownfish hatches, it drifts near the surface for

James Prosek's book about eels will be published in September by HarperCollins. David Doubilet has photographed sea life in 55 Geographic *articles.*

As dusk falls, a magnificent sea anemone contracts, resembling a terra-cotta pot. Enough of its tentacles are exposed for the resident percula clownfish, which can grow to about three inches long, to burrow in for safe haven. The color of this anemone species' body varies from orange to pink, blue, green, red, or white.

AMPHIPRION PERCULA (PERCULA CLOWNFISH); *HETERACTIS MAGNIFICA*; GREAT BARRIER REEF, AUSTRALIA

a week or two as a tiny, transparent larva. Then it metamorphoses into a miniature clownfish less than half an inch long that descends to the reef. If the young fish doesn't find an anemone and acclimatize to its new life within a day or two, it will die.

A dozen or more clownfish of the same species, from juveniles to mature adults up to six inches long, can occupy a single anenome. (Allen has seen as many as 30 on specimens of *Stichodactyla haddoni*.) Cruising around their anemone, they snag plankton, algae, and tiny creatures such as copepods, often hiding within the folds of their host to eat the larger food items. In the wild, where grouper or moray eels threaten, clownfish rarely live past seven to ten years, but in the safety of captivity they can go much longer. My neighbor keeps a spry 25-year-old, which used to bite my knuckles when I cleaned out his reef tank years ago as a kid.

Clownfish may or may not become sexually mature adults. A strict hierarchy exists among the occupants of each anemone, which hosts only one dominant pair at any time. The female is the largest in this "family," followed by the male and the adolescents. A mature pair assure their continued dominance by chasing the juveniles, causing stress and reduced energy for food foraging. "During courtship especially, there's a lot of chasing between the dominant pair," Allen says. The female occasionally reminds the male who's boss by nipping at his fins.

Many reef fish have the ability to change from one sex to another. Most, such as wrasses and

CLOWNFISH RANGE
Throughout the Indian Ocean and western Pacific, 29 clownfish species live symbiotically with 10 species of anemones. Degradation of some reef habitats threatens their survival.

JEROME N. COOKSON AND LISA R. RITTER, NG STAFF
SOURCE: GERALD ALLEN, WESTERN AUSTRALIAN MUSEUM

parrotfish, change from female to male. But the clownfish is one of the few known to change from male to female: If a dominant female dies, the dominant male will become the dominant female, and the largest remaining juvenile will assume the role of dominant male. No one has yet identified the hormones responsible for this sexual plasticity. "It's a really good adaptive strategy to make sure the species is perpetuated," Allen says. "There will always be a breeding pair at any given anemone."

THE CLOWNFISH and the anemone—their relationship has captivated home aquarists since the 1970s, when improvements in the shipping of fish and in tank design and filtration caused a boom. But never before has a fish had a bigger boost than the clownfish in the wake of *Finding Nemo* (unlike the notoriety of a very large mechanical killer with teeth). At first, fear spread through the aquarium industry that the story line would cause a backlash: Nemo is captured and held in a tank in a dentist's office, and his father spends the rest of the time trying to rescue him. "I'm here to tell you the opposite happened," says Vince Rado of Oceans, Reefs and Aquariums (ORA), a hobby-fish hatchery and wholesaler in Fort Pierce, Florida, whose sales of *A. ocellaris*—a Nemo look-alike species—jumped by 25 percent. "Thank God for little Nemo!"

Stardom has been a mixed blessing for clownfish themselves. For years it has cost much less to catch and ship wild-caught clownfish than to raise the fish in captivity. Breeding them in tanks presents certain challenges—getting the larvae to feed, for one—and it takes at least eight months to grow them to marketable size.

But the economics of wild clownfish have been changing: Rising fuel costs have made shipping them more expensive, and populations have been declining. Overharvesting and invasive collection methods, such as the use of cyanide to stun and capture fish, are destroying reefs and their inhabitants. In the Philippines and Indonesia, for instance, clownfish have been severely depleted. Loss of clownfish leaves anemones exposed and vulnerable to predation. When reefs go bad, one of the first things to disappear is anemones—and their clownfish. "They're a really good indicator group," Allen says.

Besides spurring demand for clownfish, *Finding Nemo* helped fuel the explosion of websites and chat rooms devoted to raising reef fish in captivity. ORA breeds 13 clownfish species, as well as designer exotics such as the Picasso clown. Rado says he sells some 300,000 clownfish a year—"that's several hundred thousand that won't be taken from the wild."

Despite the reef degradation Allen has witnessed during his 40-year career, he says that in some areas "there's incredible hope. Many reefs are almost pristine and very healthy." His focus now, as a consultant for Conservation International, is "to identify these areas and help with their preservation before it's too late."

Although the movie may have harmed native populations, Stanton's colorful little character also created a new group of nature lovers, eager to preserve clownfish and their reef homes. "I hope it increased awareness," Stanton says. "I know it's precarious out there." □

Bleached by high water temperatures, this bubble-tipped anemone is largely devoid of the algae that provide color as well as energy from photosynthesis. Though stressed, it will likely survive and continue to serve its clownfish.

PREMNAS BIACULEATUS (SPINE-CHEEK CLOWNFISH); *ENTACMAEA QUADRICOLOR*; PAPUA NEW GUINEA

A male tomato clownfish tends his field of developing eggs like a gardener, scooping away ones with dead embryos. He oxygenates the eggs by fanning them with his pectoral fins.

AMPHIPRION FRENATUS; PHILIPPINES

AMPHIPRION POLYMNUS; STICHODACTYLA HADDONI (HADDON'S CARPET ANEMONE); PAPUA NEW GUINEA

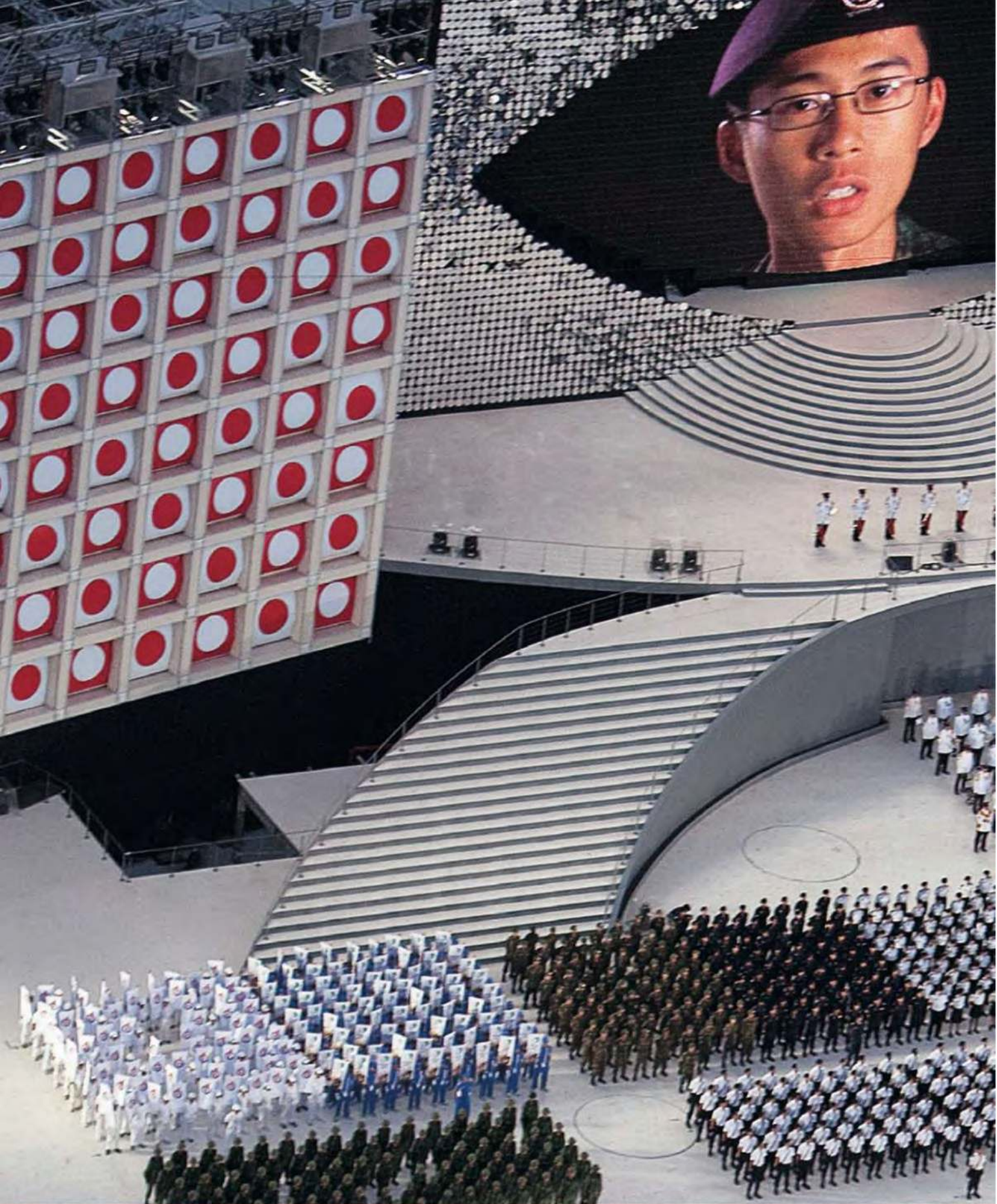
When under attack, the saddleback clownfish (above) will sometimes dive into its host anemone's mouth for protection. Since this species of anemone lives on sand, the saddleback must lay its eggs on a nearby hard object, such as a shell fragment. A raft of juvenile Maldives clownfish (below) holds steady against the current. The largest two in the group will become the anemone's breeding pair.

AMPHIPRION NIGRIPES; HETERACTIS MAGNIFICA (MAGNIFICENT SEA ANEMONE); MALDIVES

AMPHIPRION PERIDERAION; HETERACTIS MAGNIFICA (MAGNIFICENT SEA ANEMONE); PAPUA NEW GUINEA

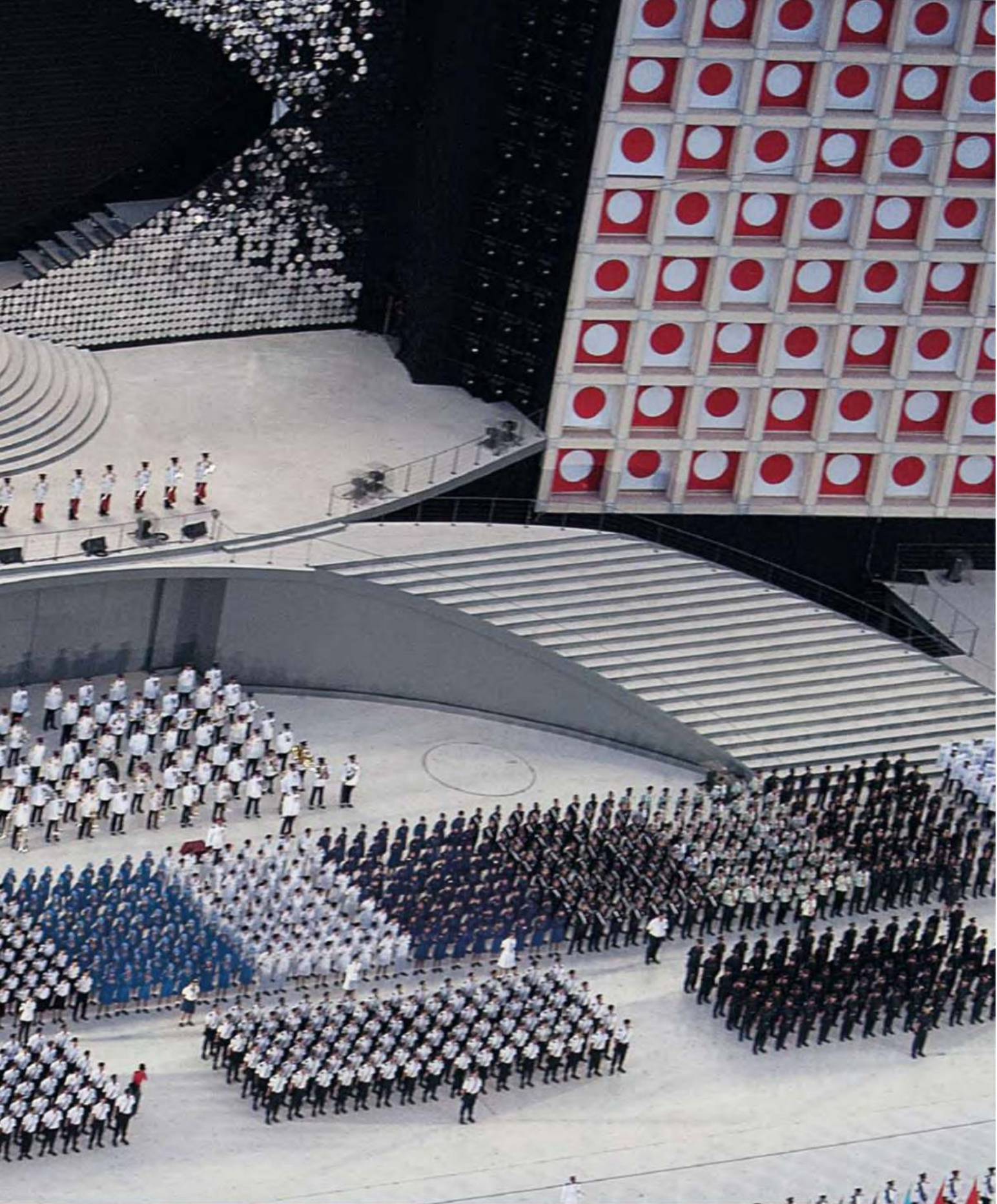
A female pink clownfish (above, at upper left) asserts her dominance over a mature male (foreground) as he chases off a young interloper. An anemone can host many clownfish but only one breeding pair at a time. The bubble-tipped anemone (below) is home to more species of clownfish—14—than any other. Here a tomato clownfish floats among tentacles colored by algae, a sign of good health.

AMPHIPRION FRENATUS; ENTACMAEA QUADRICOLOR; OKINAWA, JAPAN



THE SINGAPORE

HOW DID A SLEEPY LITTLE ISLAND TRANSFORM INTO A HIGH-TECH



A SOLDIER'S IMAGE LOOMS OVER MILITARY CONTINGENTS REHEARSING FOR SINGAPORE'S NATIONAL DAY PARADE.

SOLUTION

POWERHOUSE IN ONE GENERATION? IT WAS ALL IN THE PLAN.

On alert during the swine flu epidemic, a hostess checks a would-be patron's temperature outside a nightclub. Singapore is among the world's most tightly controlled societies, ever vigilant against any threat to the tiny nation's hard-earned prosperity.

BY MARK JACOBSON

PHOTOGRAPHS BY DAVID McLAIN

IF YOU WANT TO GET A SINGAPOREAN TO LOOK UP

from a beloved dish of fish-head curry—or make a harried cabdriver slam on his brakes—say you are going to interview the country's "minister mentor," Lee Kuan Yew, and would like an opinion about what to ask him. "The MM? *Wah lau!* You're going to see the MM? Real?" You might as well have told a resident of the Emerald City that you're late for an appointment with the Wizard of Oz. After all, LKY, as he is known in acronym-mad Singapore, is more than the "father of the country." He is its inventor, as surely as if he had scientifically formulated the place with precise portions of Plato's *Republic,* Anglophile elitism, unwavering economic pragmatism, and old-fashioned strong-arm repression.

People like to call Singapore the Switzerland of Southeast Asia, and who can argue? Out of a malarial swamp, the tiny island at the southernmost tip of the Malay Peninsula gained independence from Britain in 1963 and, in one generation, transformed itself into a legendarily efficient place, where the per capita income for its 3.7 million citizens exceeds that of many European countries, the education and health systems rival anything in the West, government officials are largely corruption free, 90 percent of households own their own homes, taxes are relatively low and sidewalks are clean, and there are no visible homeless people or slums.

If all that, plus a typical unemployment rate of about 3 percent and a nice stash of money in the bank thanks to the government's enforced savings plan, doesn't sound sweet to you, just travel 600 miles south and try getting by in a Jakarta shantytown.

Achieving all this has required a delicate balancing act, an often paradoxical interplay between what some Singaporeans refer to as "the big stick and the big carrot." What strikes you first is the carrot: giddy financial growth fueling never ending construction and consumerism. Against this is the stick, most often symbolized by the infamous ban on chewing gum and the caning of people for spray-painting cars. Disruptive things like racial and religious disharmony? They're simply not allowed, and no one steals anyone else's wallet.

Singapore, maybe more than anywhere else, crystallizes an elemental question: What price prosperity and security? Are they worth living in a place that many contend is a socially engineered, nose-to-the-grindstone, workaholic rat race, where the self-perpetuating ruling party enforces draconian laws (your airport entry card informs you, in red letters, that the penalty for drug trafficking is "DEATH"), squashes press freedom, and offers a debatable level of financial transparency? Some people joke that the government micromanages the details of life right down to how well Singapore Airlines flight attendants fill out their batik-patterned dresses.

They say Lee Kuan Yew has mellowed over the years, but when he walks into the interview

A custodian plucks a bit of trash off the gleaming floor of a downtown parking garage. Armies of cleaners keep the city nearly litter free. Tough laws help: Get caught dropping a cigarette butt or candy wrapper, and you'll be fined $200. Repeat the offense, and you'll be forced to pick up other people's litter.

wearing a zippered blue jacket, looking like a flint-eyed Asian Clint Eastwood circa *Gran Torino,* you know you'd better get on with it. While it is not exactly clear what a minister mentor does, good luck finding many Singaporeans who don't believe that the Old Man is still top dog, the ultimate string puller behind the curtain. Told most of my questions have come from Singaporeans, the MM, now 86 but as sharp and unsentimental as a barbed tack, offers a bring-it-on smile: "At my age I've had many eggs thrown at me."

Few living leaders—Fidel Castro in Cuba, Nelson Mandela in South Africa, and Robert Mugabe in Zimbabwe come to mind—have dominated their homeland's national narrative the way Lee Kuan Yew has. Born into a well-to-do Chinese family in 1923, deeply influenced by both British colonial society and the brutal Japanese occupation that killed as many as 50,000 people on the island in the mid-1940s, the erstwhile "Harry Lee," Cambridge law degree in hand, first came to prominence as a leader of a left-leaning anticolonial movement in the 1950s. Firming up his personal power within the ascendant People's Action Party, Lee became Singapore's first prime minister, filling the post for 26 years. He was senior minister for another 15; his current minister mentor title was established when his son, Lee Hsien Loong, became prime minister in 2004.

Lee masterminded the celebrated "Singapore Model," converting a country one-eighth the size of Delaware, with no natural resources and a fractured mix of ethnicities, into "Singapore, Inc." He attracted foreign investment by building communications and transportation infrastructure, made English the official language, created a superefficient government by paying top administrators salaries equal to those in private companies, and cracked down on corruption until it disappeared. The model—a unique

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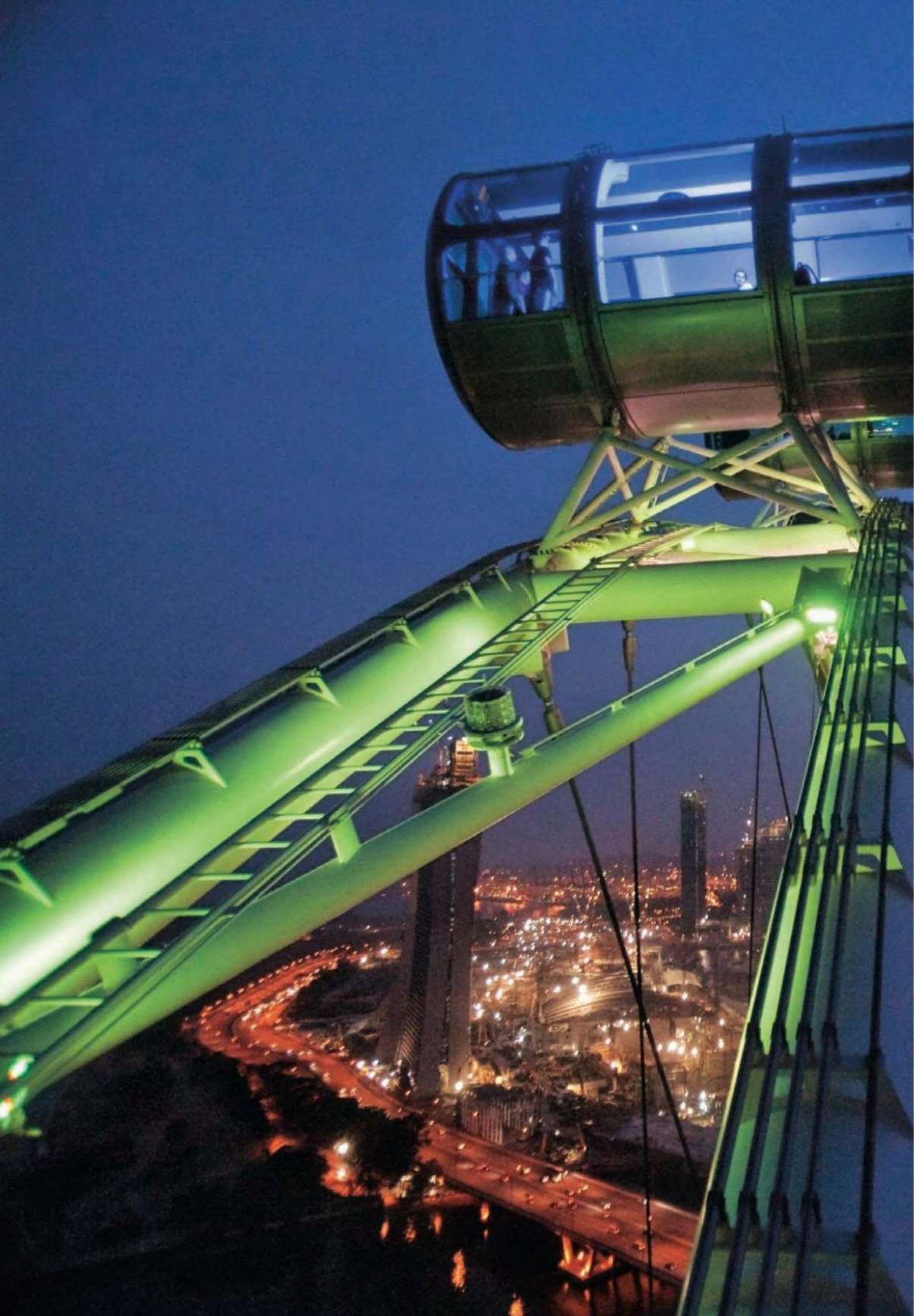
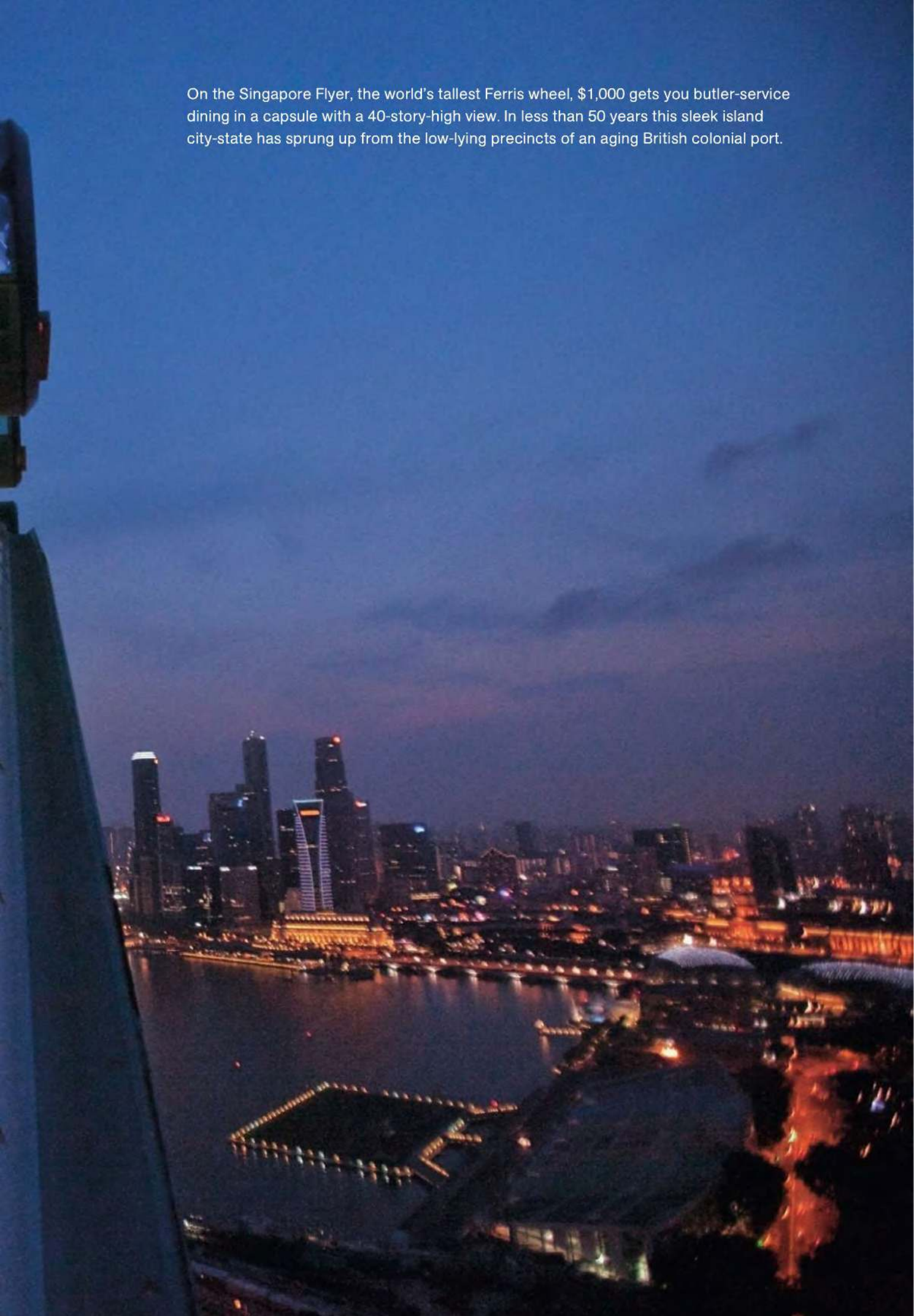
Mark Jacobson reported on a Mumbai slum in the May 2007 issue. David McLain was hospitalized in Singapore for a virus that turned out not *to be swine flu.*





On the Singapore Flyer, the world's tallest Ferris wheel, $1,000 gets you butler-service dining in a capsule with a 40-story-high view. In less than 50 years this sleek island city-state has sprung up from the low-lying precincts of an aging British colonial port.

mix of economic empowerment and tightly controlled personal liberties—has inspired imitators in China, Russia, and eastern Europe.

To lead a society, the MM says in his precise Victorian English, "one must understand human nature. I have always thought that humanity was animal-like. The Confucian theory was man could be improved, but I'm not sure he can be. He can be trained, he can be disciplined." In Singapore that has meant lots of rules—prohibiting littering, spitting on sidewalks, failing to flush public toilets—with fines and occasional outing in the newspaper for those who break them. It also meant educating his people—industrious by nature—and converting them from shopkeepers to high-tech workers in a few decades.

Over time, the MM says, Singaporeans have become "less hard-driving and hard-striving." This is why it is a good thing, the MM says, that the nation has welcomed so many Chinese immigrants (25 percent of the population is now foreign-born). He is aware that many Singaporeans are unhappy with the influx of immigrants, especially those educated newcomers prepared to fight for higher paying jobs. But taking a typically Darwinian stance, the MM describes the country's new subjects as "hungry," with parents who "pushed the children very hard." If native Singaporeans are falling behind because "the spurs are not stuck into the hide," that is their problem.

IF THERE IS A SINGLE WORD that sums up the Singaporean existential condition, it is *kiasu,* a term that means "afraid to lose." In a society that begins tracking its students into test-based groups at age ten ("special" and "express" are the top tiers; "normal" is the path for those headed for factory and service-sector work), kiasu seeps in early, eventually germinating in brilliant engineering students and phallic high-rises with a Bulgari store on the ground floor. Singaporeans are big on being number one in everything, but in a kiasu world, winning is never completely sweet, carrying with it the dread of ceasing to win. When the Singapore port, the busiest container hub in the world, slipped behind Shanghai in 2005 in total cargo tonnage handled, it was a national calamity.

One day, as part of a rehearsal for the National Day celebration, I was treated to a veritable lollapalooza of kiasu. Singapore armed forces playacted at subduing a cabal of "terrorists" who had shot a half dozen flower-bearing children in red leotards, leaving them "dead" on the stage. "We're not North Korea, but we try," said one observer, commenting on the rolling tanks, zooming Apache helicopters, and earsplitting 21-gun salutes. You hear it all the time: The only way for Singapore to survive being surrounded by massive neighbors is to remain constantly vigilant. The 2009 military budget is $11.4 billion, or 5 percent of GDP, among the world's highest rates.

You never know where the threat might come from, or what form it will take. Last summer everyone was in a panic about swine flu. Mask-wearing health monitors were positioned around the city. On Saturday night, no matter how *stylo milo* your threads, there was no way of getting into a club on trendy Clarke Quay without a bouncer pressing a handheld thermometer to your forehead. It was part of the unending Singaporean state of siege. Many of the newer public housing apartments come with a bomb shelter, complete with a steel door. After a while, the perceived danger and excessive compliance with rules get internalized; one thing you don't see in Singapore is very many police. "The cop is inside our heads," one resident says.

Self-censorship is rampant in Singapore, where dealing with the powers that be is "a dance," says Alvin Tan, the artistic director of the Necessary Stage, which has put on dozens of plays dealing with touchy issues such as the death penalty and sexuality. Tan spends a lot of time with the government censors. "You have to use the proper approach," he says. "If they say 'south,' you don't say 'north.' You say 'northeast.' Go from there. It's a negotiation."

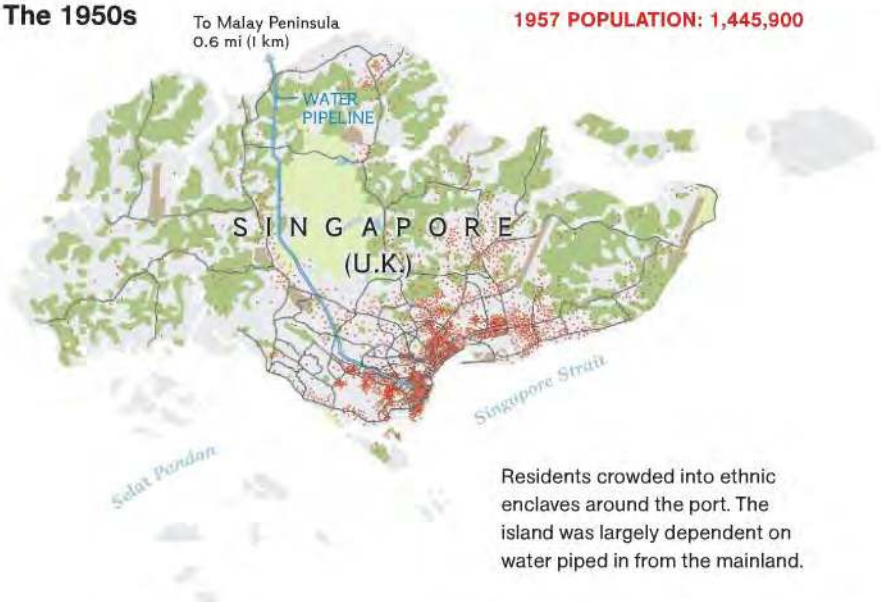
Those who do not learn their steps in the dance soon get the message. Consider the case of Siew Kum Hong, a 35-year-old Singaporean who thought he'd be furthering the cause of openness by serving as an unelected NMP, or nominated member of parliament. With only

THE MASTER'S PLAN

Starting in 1965, as slums teemed with the jobless, island leader Lee Kuan Yew (below) crafted plans that reshaped the economy and even the land itself (maps, right). His ideas continue to drive Singapore's endless transformation.

The 1950s

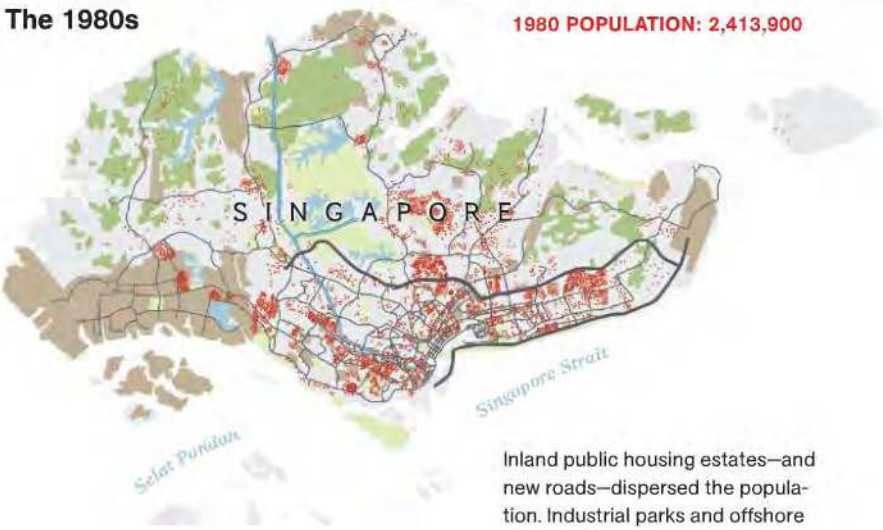
1957 POPULATION: 1,445,900



Residents crowded into ethnic enclaves around the port. The island was largely dependent on water piped in from the mainland.

The 1980s

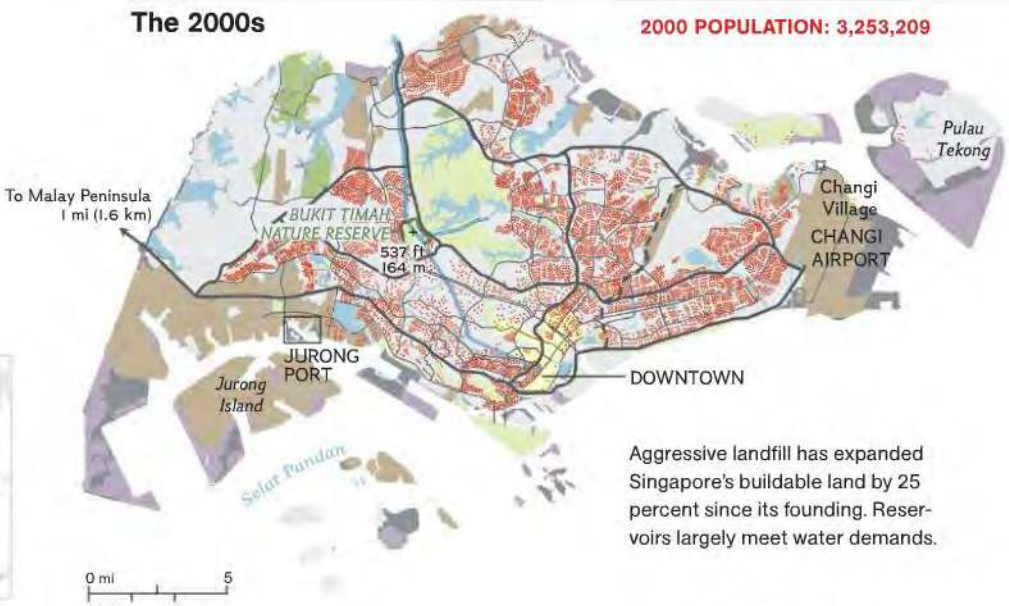
1980 POPULATION: 2,413,900



Inland public housing estates—and new roads—dispersed the population. Industrial parks and offshore oil facilities sped development.

The 2000s

2000 POPULATION: 3,253,209



Aggressive landfill has expanded Singapore's buildable land by 25 percent since its founding. Reservoirs largely meet water demands.

- Population
  1 dot equals 500 persons
- Reservoir
- Expressway/road
- Agricultural
- Park or green space
- Developed/industrial
- Landfill
- Future expansion

POPULATION INCLUDES CITIZENS AND PERMANENT RESIDENTS.

VIRGINIA W. MASON, NG STAFF

SOURCE: RODOLPHE DE KONINCK, JULIE DROLET, AND MARC GIRARD, *SINGAPORE, AN ATLAS OF PERPETUAL TERRITORIAL TRANSFORMATION*, NATIONAL UNIVERSITY OF SINGAPORE

Birdcages dangle from poles in a public housing estate, hoisted aloft so their occupants can enjoy cool morning air. Though much of Singapore's past has vanished, the custom of training birds for singing competitions continues. One dove may cost as much as $60,000.

CONTROL Singapore uses corporal punishment to fight the drug trade: Scars from a court-ordered caning mark a man who sold small amounts of heroin. Rules governing foreign workers brought in to fill low-paying jobs are equally strict. Trained for placement as maids, Filipino and Indonesian women (opposite) will be deported if they get pregnant.

four opposition MPs elected in the history of the country, the ruling party thought NMPs might provide the appearance of "a more consensual style of government where alternative views are heard and constructive dissent accommodated." This was how Siew Kum Hong told me he viewed his position, but he was passed over for another term.

"I thought I was doing a good job," a surprised Kum Hong says. What it came down to, he surmises, were "those 'no' votes." When he first voted no, on a resolution he felt discriminated against gays, his colleagues "went absolutely silent. It was the first time since I'd been in parliament that anyone had ever voted no." When he voted no again, this time on a law lowering the number of people who could assemble to protest, the reaction was similarly cool. "So much for alternative views," Kum Hong says.

THE SINGAPORE GOVERNMENT is not unaware of the pitfalls of its highly controlled society. One concern is the "creativity crisis," the fear that an emphasis on rote learning in Singapore's schools is not conducive to producing game-changing ideas. Yet attempts to encourage originality have been tone-deaf. When Scape, a youth outreach group, opened a "graffiti wall," youngsters were instructed to submit graffiti designs for consideration; those chosen would be painted on a designated wall at an assigned time.

Similarly, the government has maintained a campaign against the use of "Singlish," the multiculti gumbo of Malay, Hokkien Chinese, Tamil, and English street patois that is Singapore's great linguistic achievement. As you sit in a Starbucks listening to teens saying things like "You blur like *sotong, lah!*" (roughly, "You're dumber than squid, man!"), Singlish seems a brilliantly subversive attack on the very conformity the government claims it is trying to overcome. Then again, one of Singlish's major conceits is the ironic lionization of the flashy, down-market "Ah Beng" culture of Chinese immigrant thugs

and their sunglass-wearing Malay counterparts. You know that won't fly in a world where the MM ("minister de-mentor" in Beng speak) has advocated "assortative mating," the idea that college graduates should marry only other college graduates so as to uplift the national stock.

Perhaps the most troubling problem facing the nation is a result of its overly successful population control program, which ran in the 1970s with the slogan "Two Is Enough." Today Singaporeans are simply not reproducing, so the country must depend on immigrants to keep the population growing. The government offers baby bonuses and long maternity leaves, but nothing will help unless Singaporeans start having more sex. According to a poll by the Durex condom company, Singaporeans have less intercourse than almost any other country on Earth. "We are shrinking in our population," the MM says. "Our fertility rate is 1.29. It is a worrying factor." This could be the fatal error in the Singapore Model: The eventual extinction of Singaporeans.

But there is an upside to all this social engineering. You could feel it during the "We Are the World" production numbers in the National Day show. On stage were representatives of Singapore's major ethnic groups, the Chinese, Malays, and Indians, all wearing colorful costumes. After riots in the 1960s, the government installed a strict quota system in public housing to make sure that ethnic groups did not create their own monolithic quarters. This practice may have more to do with controlling the populace than with true multiracial harmony, but at the rehearsal, as schmaltzy as it was, it was hard not to be moved by the earnest show of brotherhood. However invented, there is something called Singaporean, and it is real. Whatever people's grumbles—and as the MM says, "Singaporeans are champion grumblers"—Singapore is their home, and they love it despite everything. It makes you like the place too, for their sake.

The kicker is that things are about to change. In a famous quote, Lee Kuan Yew said, "If you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A transit station is slated for the cemetery where his great-grandmother was buried, so Jerry Chua removes her remains, shading the bag holding her bones so the sun won't harm her spirit. The family isn't upset, says brother Joe. "There aren't many graves left in Singapore."

are going to lower me into the grave, and I feel something is wrong, I will get up." But this is beyond even him. "We all know the MM will die someday," says Calvin Fones, a psychiatrist who runs a clinic at Gleneagles Hospital on Orchard Road. Fones likens his homeland to a family. "When the country was young, there was a need for wise oversight. A firm hand. Now we are in adolescence, which can be a questioning, troublesome period. Coming into it without the presence of the patriarch will be a test."

The great engine of cultural change, of course, is the Internet, that cyber fly in the authoritarian ointment. Lee acknowledges the threat. "We banned *Playboy* in the sixties, and it is still banned, that's true, but now, with the Internet, you get much more than you ever could from *Playboy*." Allowing pornography sites while banning magazines may seem contradictory. But attempting to censor the Internet, as has been tried in China, would be pointless, Lee says. It is an exquisitely pragmatic reply.

And so bloggers, like the satirist Mr. Brown and the urbanely pugnacious Yawning Bread, are free to broadcast opinions unlikely to be found in the pages of the government-linked *Straits Times*. As a result, more and more young people are questioning the trade-off between freedom and security—and even calling for freer politics and fewer social controls.

Last August, a wide-ranging speech by new NMP Viswa Sadasivan created a lot of buzz on the blogosphere: "I do lament our lack of freedom to express ourselves, and the government's seemingly unmitigated grip on power and what appears to be an inconsistent willingness to listen to public sentiment that does not suit it," Viswa said before parliament. "Accountability requires the government to go beyond lip-service in addressing the call for greater democracy… If not, people are likely to feel increasingly alienated."

Irked by Viswa's criticisms of the way some ethnic groups are treated in Singapore, LKY interrupted a medical treatment to angrily refute

AMBITION Under construction in the city center (left), a casino will lure foreign tourists but allow citizens to place bets only after they pay a $70 charge meant to discourage gambling. Contemplating the showroom amenities of a $1,000-a-square-foot condo (complete with fake skyline view), a couple (below) is ready to invest in the Singapore dream.

the "highfalutin" speech in a rare appearance on the parliament floor. The patriarch, in case anyone needed reminding, was not yet in his grave.

SINGAPORE CAN BE a disconcerting place, even to the people who call it home, though they'd never think of leaving. As one local put it, "Singapore is like a warm bath. You sink in, slit your wrists, your lifeblood floats away, but hey, it's warm." If that's so, most Singaporeans figure they might as well go down the tubes eating pepper crabs, with a couple of curry puffs on the side. Eating is the true national pastime and refuge. The longer I stayed, the more I ate. It got so I'd go over to the marvelously overcrowded Maxwell Road Food Centre, stand in the 20-minute queue for a plate at the Tian Tian food stall, eat it, then line up again.

On my last day, I climbed the hill in the Bukit Timah Nature Reserve, at 537 feet the highest point on the island and the closest thing in Singapore to the jungle it once was. In the unexpected quiet, I returned to what the MM had said about Confucius's belief "that man could be perfected." This was, the MM said with a sigh, "an optimistic way of looking at life." People abuse freedom. That is his beef with America: The rights of individuals to do their own thing allow them to misbehave at the expense of an orderly society. As they say in Singapore: What good are all those rights if you're afraid to go out at night?

When I got to the top of the hill, I thought I might be rewarded with a view of the entire city-state. But there was no view at all—only a rusting communication tower and a cyclone fence affixed with a sign saying "Protected Place" and showing a stick figure drawing of a soldier aiming a rifle at a man with his hands raised.

Later I mentioned this to Calvin Fones, the shrink. "See, that shows the progress we've made," he said. "Until a few years ago, we had the same sign, except the guy was lying on the ground, already shot." And then, being a Singaporean, living a life he didn't believe possible anywhere else in Asia, he laughed. □

Justin Tesmer (top, at right) and other creators of the Modular Prosthetic Limb photograph its hand, resting in the palms of engineer Eric Faulring.

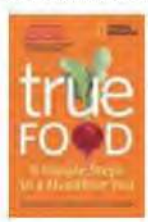
ON ASSIGNMENT **Arm Race** The photo shoot of the bionic arm called Proto 2 was wrapping up when HDT Engineered Technologies, one of the arm's makers, shared news. "We're about to do the next arm," said engineer Tom Van Doren. He was referring to the Modular Prosthetic Limb, the next-generation appendage his team had been building for over a year. The closest yet to the real thing, this "next arm" is crammed with motors, gears, microprocessors, and sensors, yet has roughly the size, weight, and strength of a human arm. Deadlines loomed for this month's cover story, but Director of Photo Editing Kurt Mutchler agreed to wait five weeks for the final product. Eager to see their work in the issue, the crew pushed hard. "The forearm piece literally did not exist the day before this picture was taken," recalls Van Doren. When staff photographer Mark Thiessen returned, the arm's coat of paint was barely dry.

ARM DEVELOPMENT TEAM: JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY; HDT ENGINEERED TECHNOLOGIES; KINEA DESIGN; BIOMECHATRONICS DEVELOPMENT LABORATORY, REHABILITATION INSTITUTE OF CHICAGO; OTTO BOCK HEALTHCARE; VAN DOREN DESIGNS; CIELO SOLUTIONS; ORTHOCARE INNOVATIONS

Society Updates

NG CHANNEL
Nogales, Arizona, is home to one of the United States' busiest border crossings. Patrol agents Thomas Pittman (foreground) and Jonathan Carlson are part of the team on nonstop watch. Follow more men and women who are on the lookout for smugglers and terrorists as well as illegal immigrants in *Border Wars,* a new series airing Mondays at 9 p.m. on the National Geographic Channel.

NG BOOKS
Just in time for that New Year's resolution to eat better, National Geographic offers *True Food,* an authoritative but fun guide to creating a healthy diet. This handy how-to distills notions of the current food revolution into eight practical steps, with recipes, anecdotes, and sidebars. Find *True Food* in bookstores December 29 ($26).



GeoPuzzle Answers

PHOTOS: MARK THIESSEN, NG STAFF (LEFT, BOTH); KEVIN CUNNINGHAM, NATIONAL GEOGRAPHIC TELEVISION

Explore the Dynamic Web of Life on Our Planet

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6. Human Society as Ecological Driver
7. Movement of Energy through Living Systems
8. Humans as Energy Consumers
9. Nutrient Cycling in Ecosystems
10. The Challenges of Waste and Disposal
11. The Water Cycle and Climate
12. Human Water Use and Climate Change
13. Rain and Heat—Forces That Shape Climate
14. The Ecology of Global Climate Change
15. How Living Organisms Acquire Food
16. The Ecological Consequences of Agriculture
17. Food, Energy Flows, Biomagnification
18. The Human Ecology of Biomagnification
19. The Ecological Community as a Living Mosaic
20. Wildlife Adaptation to Human Landscapes
21. Biodiversity, Disturbance, Invasive Species
22. Biodiversity Decline and Restoration Ecology
23. Microevolution and Biological Variation
24. Human Impacts on Ecological Space and Time
25. Population Growth and Its Natural Limits
26. The Human Shift to an Urban Lifestyle
27. The Ecology of Dispersal and Migration
28. Human Impacts on Animal Migration
29. Ecology and Economy of Sex and Reproduction
30. Cities and the Human Demographic Transition
31. Coevolution among Species
32. The Coevolution of Human Diseases
33. Strategies for Reversing Ecosystem Decline
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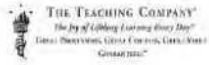

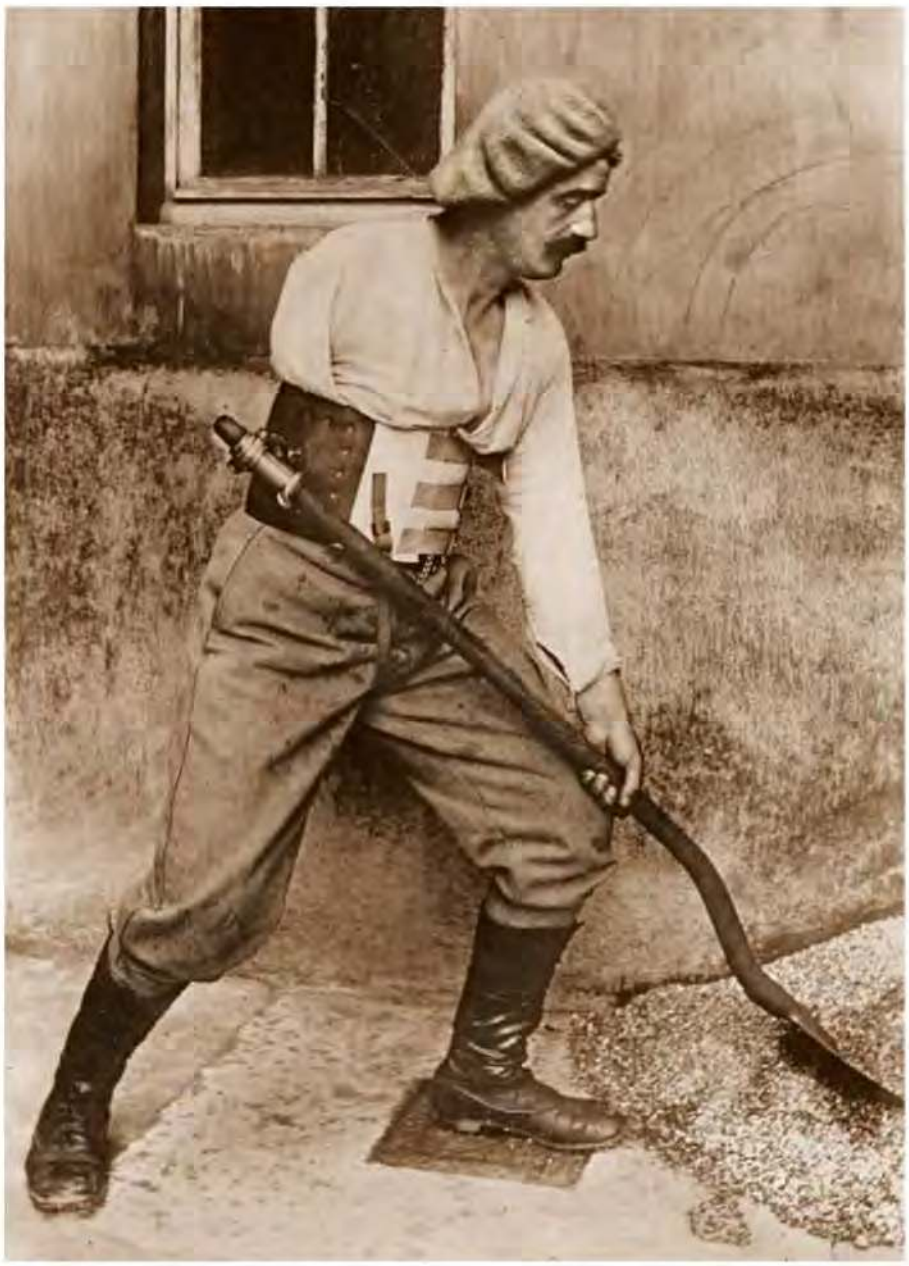

Digging In Some 8.5 million French were mobilized to fight in World War I. Following the conflict, the wounded were mobilized to work. A 1918 Red Cross report put it bluntly: "Disabled men will have no difficulty in obtaining employment immediately after the war when there will be the greatest good-will...the difficulty will come...when the way in which the disabilities were acquired has been forgotten." Amputees like this man fitted with a shovel belt were trained to compensate for their lost limbs. Noted the report, "Ingenuity quickly devises appliances for making easy operations which a mutilation has made difficult." *—Margaret G. Zackowitz*

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

PHOTO: AMERICAN RED CROSS/NATIONAL GEOGRAPHIC STOCK

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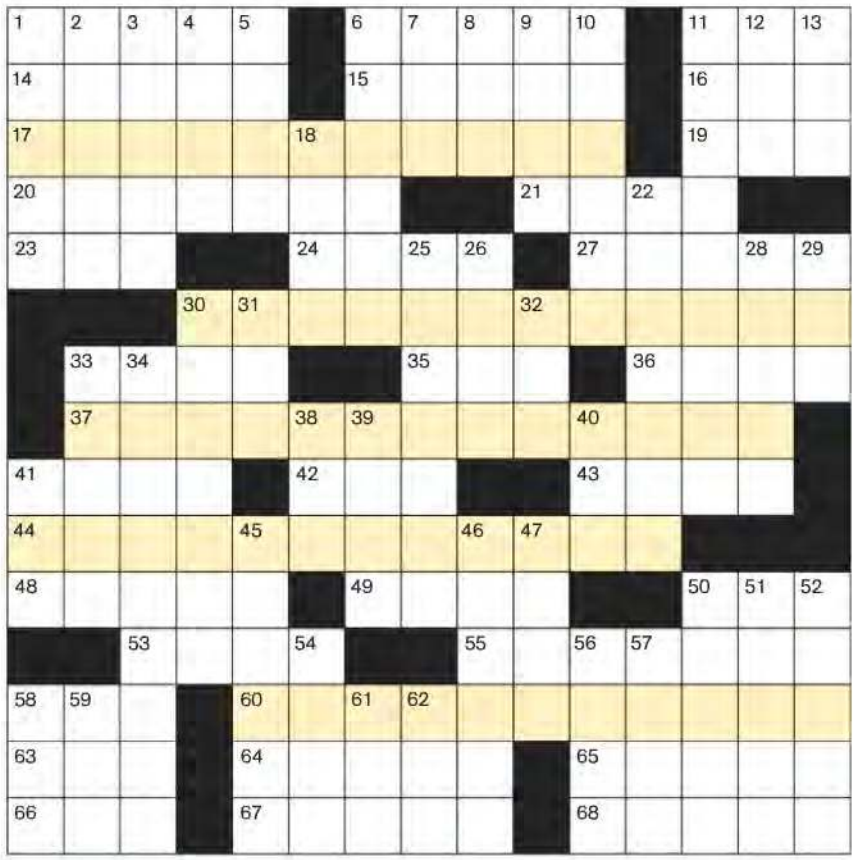

Limber Limb

Puzzle by Cathy Allis

Amanda Kitts, profiled in the story on bionic replacements for lost or damaged body parts (page 34), has a robotic arm she can move with brainpower. One of "tomorrow's people," she is the key to solving the tinted clues in this puzzle.

ACROSS

1 Whitman wrote one in honor of Lincoln
6 Marx with a horn
11 Quite some gum
14 "I swear it!"
15 Liquid in fats
16 Teamwork deterrent
17 What pressure-sensing pads in her prosthetic fingers will help Amanda Kitts do?
19 Be in a bee, maybe
20 Did some logging
21 Fruit-crate part
23 Pinky without a prosthesis?
24 Minimalist Mies's "more"
27 According to
30 What her prosthesis could help Kitts do in her office?
33 Tree, source of "butter" in soaps
35 Bern's river
36 Reformer-journalist Jacob
37 What Kitts's neural prosthesis enables her brain to do?
41 Handel oratorio king
42 *Wheel of Fortune* request
43 Pack of lifesavers?: abbr.
44 What Kitts hopes her prosthesis can do someday?
48 Termini of Greek temple walls
49 "Unto us __ is given": Isaiah
50 *Cheers* : Sam :: *The Simpsons* : __
53 Romance lang.
55 Weather-map lines
58 Pops, e.g.
60 What Kitts's prosthesis could do when she's tying kids' shoes?
63 Ticker test, for short
64 Wear away
65 Aquarium growth
66 "All right!"
67 Transactions
68 Is inclined

DOWN

1 Devil's opposite, in Deutschland
2 *Bonanza* actor Greene
3 Lift way up
4 Razz
5 Annum
6 Like cobras and parkas
7 1936 election loser Landon
8 One who OKs KOs
9 Their shells are edible
10 Quarter mile, often
11 Home of the Army's Black Knights
12 Word after new or old
13 Stock index inventor
18 Neuron, e.g.
22 Hindu hermitages
25 Cholesterol-controlling drugs
26 Persian for "king"
28 Bagnold, Blyton, and Markey
29 Abbr. seen near bus.
30 Fighter plane of WWII
31 Chardonnay flavor, often
32 Afore
33 Furniture finish
34 Unwelcome home happenings
38 Emulate Mumble in *Happy Feet*
39 Draft status
40 Laugh half
41 It's spring-loaded?
45 Put in a pile
46 Poltergeists make them
47 Part of RIC, where Kitts has been "armed"
50 Japanese comic book genre
51 Generous donation
52 Trio of prosthetists?
54 Bait
56 Thermometer type
57 Choler
58 Kind of grip employed in theaters
59 U-2 incident prez
61 Mauna __ (Hawaiian "long mountain")
62 "Bad" cholesterol, for short

Answers in Inside Geographic

PHOTO: MARK THIESSEN, NG STAFF

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

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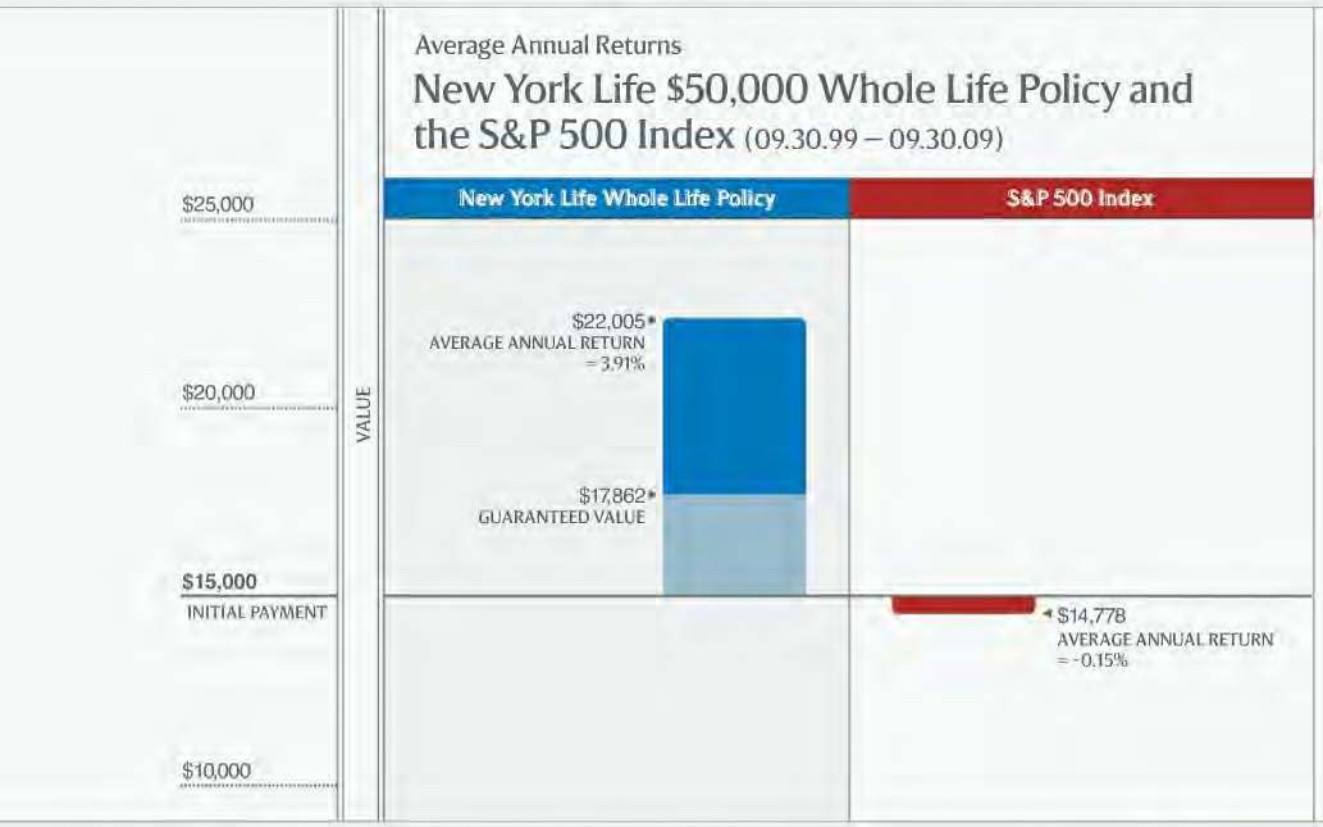

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The chart shows the difference in accumulation after ten years' time of the cash value of the whole life product versus the index's rate of return. The whole life policy was purchased in 1999 for a 35-year-old, non-smoking male; $648 annual premium plus $14,352 lump sum payment for paid up additional insurance. Return is net of annual premium obligation. Results may vary depending on age, class and gender. The 3.91% average annual rate of return and $22,005 cash value shown reflect the increase in the policy's total cash value. "Guaranteed growth" refers to the sum of the guaranteed cash value of both the base policy and the paid up additional insurance minus the initial payment ($2,862). Dividends are not guaranteed. Cash value is accessible through loans, which accrue interest, and surrenders. Both reduce the total cash value and death benefit, and unpaid loan interest could result in the policy lapsing. Cash value of a whole life insurance policy begins accumulating at the end of the first policy year. Guarantees are dependent upon the claims paying ability of the issuer. This chart also shows the hypothetical historical performance of a $15,000 investment which tracks the returns of the S&P 500 index. S&P 500® is a trademark of the McGraw-Hill Companies, Inc. The S&P 500 is an unmanaged index and is widely regarded as the standard for measuring large-cap U.S. stock market performance. Returns reflect reinvestment of all income and capital gain distribution, and an investment cannot be made directly into an index. Past performance is not indicative of future results. (Exp. 1/10)