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EARTH SCIENCE

THE BIG DIG

Geologists attempt to drill
the world's deepest hole

INSIDE

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Seriously
Strange Animals

CHEMISTRY
Can Science
Save a Historic
Spacesuit?

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2 MARCH 21, 2016

BIOLOGY: INFECTIOUS DISEASES

ZIKA OUTBR

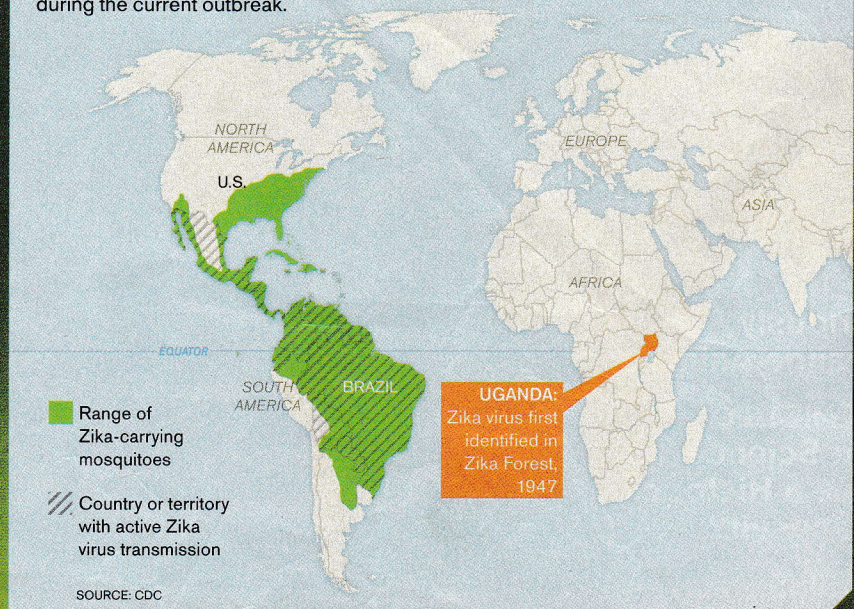
Concern is growing over a mosquito-borne disease called *Zika virus* that is rapidly spreading across Central America and South America. Infected people often have no symptoms or mild flu-like ones. Scientists are more worried about a possible link between the virus and a birth defect called *microcephaly*. Affected babies are born with an abnormally small head and incomplete brain development.

In May 2015, Brazil confirmed the first case of Zika in the Americas. Since then, more than 4,000 Brazilian newborns have been diagnosed with microcephaly. The disorder may be caused by a Zika infection during pregnancy. Some countries are also reporting a rise in muscle paralysis in patients of all ages that might be associated with Zika.

The Zika virus has spread to more than 20 countries (see map, below). Since mosquitoes transmit it, governments are spraying insecticides; removing standing water where mosquitoes breed; and encouraging people to wear repellent to try to control the outbreak. Officials are warning pregnant women to avoid visiting Zika-affected countries.

"We aren't sure why the virus is suddenly infecting millions," says David Morens, an epidemiologist (scientist who studies disease outbreaks) at the National Institute of Allergy and Infectious Diseases in Maryland. "Right now, there are more questions than answers."
 —Cody Crane

ZIKA'S SPREAD Two species of mosquito are thought to spread Zika virus: *Aedes aegypti* and *Aedes albopictus*. This map shows the mosquitoes' ranges in the Americas as well as areas where Zika had been transmitted as of February 2016 during the current outbreak.



EAK

HAVING A DRINK
An *A. aegypti* mosquito takes a blood meal through her needle-like *fascicle*.

ABOUT MOSQUITOES



Most mosquitoes are active in the evening, but the mosquitoes that transmit Zika bite during the day.



Only female mosquitoes bite—they need blood to nourish their young. Males feed on plant nectar.



Experts expect to see some transmission of Zika virus in the U.S. as the weather warms and mosquitoes become more active.

725,000

Number of human deaths caused by mosquito-borne diseases each year.

THE VICTIM
The mosquito is feeding on biomedical photographer James Gathany at the Centers for Disease Control and Prevention.

FULL BELLY
Blood is visible in the mosquito's abdomen through her translucent exoskeleton.

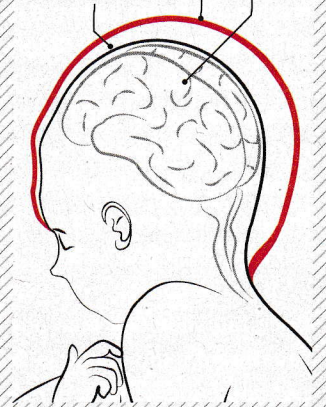
MICROCEPHALY

Infants whose mothers had a Zika infection during pregnancy may be born with this condition.

Typical head size

Abnormal head circumference measuring less than 12.6 in. at birth

Smaller brain



MORE SCIENCE NEWS
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BIOLOGY: PALEONTOLOGY

DINO DANCE

Paleontologists recently unearthed dozens of bathtub-sized gouges in 100-million-year-old rocks in Colorado. They say the grooves were probably created by dinosaurs performing mating dances to attract partners, just like many birds—the descendants of dinosaurs—do today.

“Some dinosaurs had feathers and crests and large eyes,” says Martin Lockley, a paleontologist at the University of Colorado in Denver who led the excavations. “Put together, those traits are a recipe for a mating display. But there was no physical evidence for that until now.”

Lockley says scientists have likely uncovered several of these grooves over the years but never knew what they were. “I expect we’re going to find a lot more of these now that we’re aware of them,” he says.

—Lizzy True



DINO ROMANCE: Meat-eating dinos called theropods may have danced to attract mates.

PHYSICS: FORCES AND MOTION

A REAL HOVERBOARD!

This spring, the Arca Space Corporation in New Mexico will begin selling a real-life hoverboard, called the ArcaBoard. Riders can steer by leaning with their bodies or navigate automatically with a smartphone app. The board hovers 0.3 meters (1 foot) in the air with the help of 36 fans. The fans produce enough *thrust* (pushing force) to carry the weight of an adult and can move the board over any surface, including water.

But even buyers who can afford the \$14,900 price tag shouldn’t plan any long trips: The ArcaBoard’s top speed is 20 kilometers (12.5 miles) per hour, and its battery runs out in just six minutes.

—Hailee Romain



FLY RIDE: An ArcaBoard in flight

XING LIDA/CU DENVER (DINOSAURS); ARCA SPACE CORPORATION (HOVERBOARD); XINHUA/VEVINE/REDX (FUTURE FARM); JOSHUA CORBETT/THE NEW YORK TIMES/REDX (BABY PLANTS)



GROWING INSIDE: This vertical farm in Vancouver, Canada, produces 150,000 pounds of veggies per year.

EARTH SCIENCE: RESOURCES

FUTURE FARM

FarmedHere, located in a warehouse just outside Chicago, Illinois, isn't your typical farm. It's a *vertical farm*, where tall stacks of crops are grown within a building. With their efficient use of resources, vertical farms could be the wave of the future for agriculture.

Experts determine how much light and water each plant receives. As a result, vertical farms use "95 percent less water, 90 percent less land, and 90 percent less fuel than traditional farms," says Megan Klein, president of FarmedHere. Also, because vertical farms are indoors, they aren't affected by things like drought, frost, environmental pollution, or climate change.



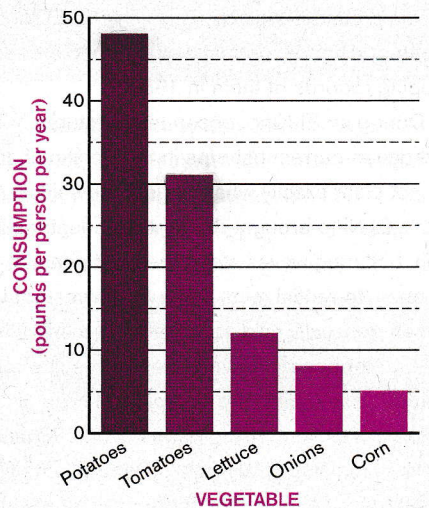
LET IT SHINE: Special lights emit the colors that best help plants grow.

The company's Chicago headquarters, which produces greens and herbs, is the largest vertical farm in North America. It's so successful that FarmedHere plans to open new farms in 18 cities across the U.S.

—Hailee Romain

AMERICA'S FAVORITE VEGGIES

Which is the most commonly consumed vegetable in the U.S.?



SOURCE: USDA, 2013



☉ **STRANDED:** A driver hangs out of his flooded car after an El Niño-strengthened storm in Los Angeles, California.

EARTH SCIENCE: CLIMATE

RECORD EL NIÑO

This winter, California got drenched with record-breaking rainfall, which brought floods and mudslides to cities like Los Angeles. The rains were due in part to *El Niño*, a climate pattern in the Pacific Ocean that occurs once every several years with far-reaching effects around the globe. This winter's El Niño is one of the most dramatic since people began keeping records of them in 1950.

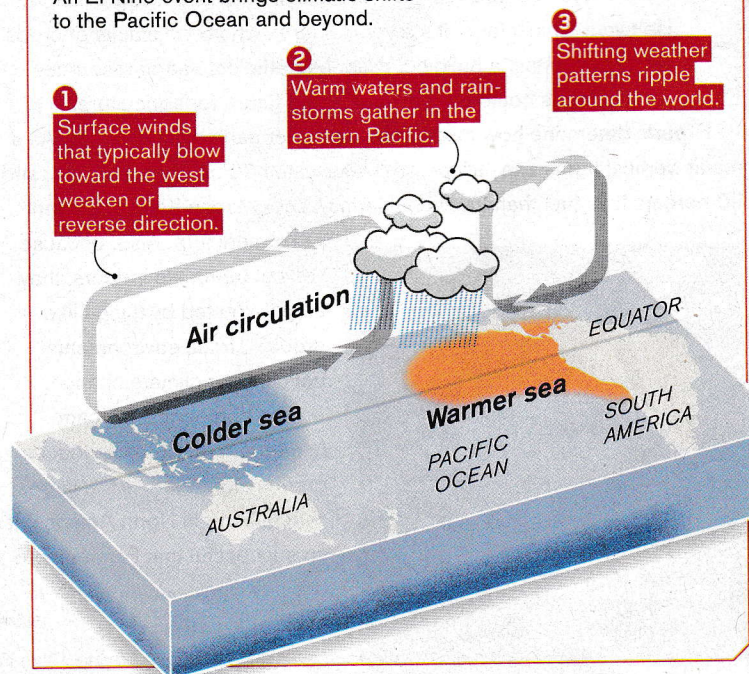
During an El Niño, ocean temperatures, winds, and ocean-current patterns in the Pacific change. It's not clear exactly what triggers the shift, but this year's El Niño brought droughts to countries in Asia, battering waves along the west coast of South America, torrential rains in the Southwestern U.S., and an unusually mild early winter in the Northeast.

Warmer ocean temperatures—a result of climate change—could be turbo-charging El Niño. If temperatures keep rising, says Michael Anderson, a climatologist for California's Department of Water Resources, we could see more extreme weather in the future.

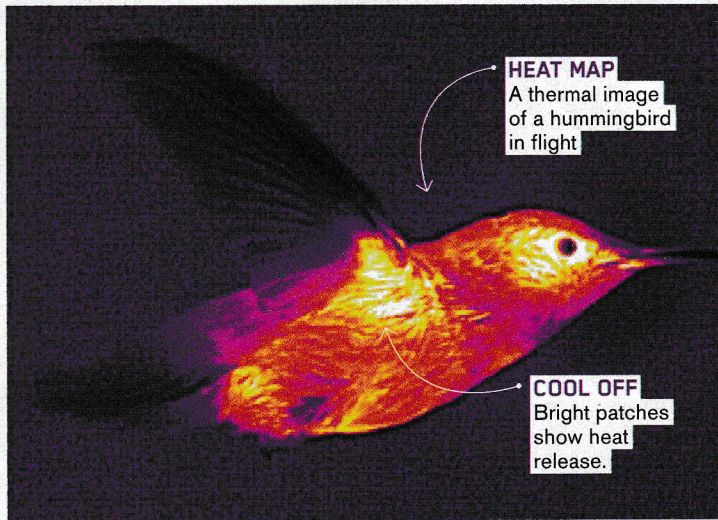
—Hanneke Weitering

WHAT IS EL NIÑO?

An El Niño event brings climatic shifts to the Pacific Ocean and beyond.



NUMBERS IN THE NEWS



BIOLOGY: THERMOREGULATION

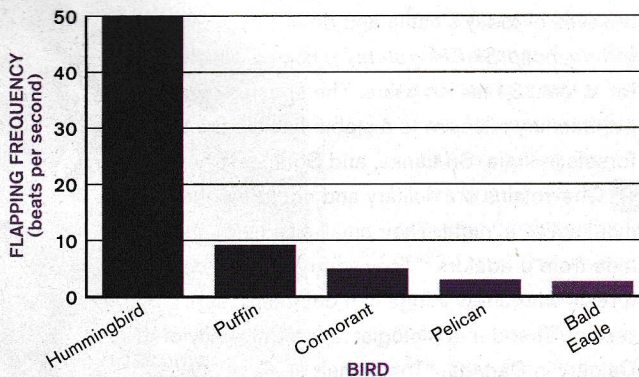
KEEPING THEIR COOL

Hummingbirds are some of the most energetic creatures in the animal kingdom. As they flutter their wings up to 70 times a second, their muscles generate a lot of heat. Scientists now understand how the birds avoid overheating during flight.

Researchers observed hummingbirds in flight using a thermal imaging video camera. They discovered that heat escapes the birds' bodies from areas around the eyes, shoulders, and feet. While most hummingbird plumage is thick and insulating, the feathers in these areas are less dense, allowing heat to flow away. Don Powers, an ecologist at George Fox University in Oregon who led the study, hopes that learning how the birds deal with heat will help scientists understand how they might be affected by climate change. —Hanneke Weitering

FAST FLAPPERS

About how many more times does a hummingbird typically flap its wings each second compared to a cormorant?



SOURCE: PENNYCUICK, J. EXP. BIOL., 1990

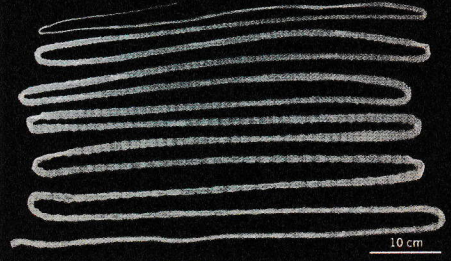
22,338,618 Number of digits in a newfound *prime number* (divisible only by 1 and itself) discovered in January. A printout of the number would fill more than 6,000 pages.

80,000 Number of people who lost power when two Ukrainian power companies were hacked this past winter. The outages are the first known blackouts caused by cyberattacks.

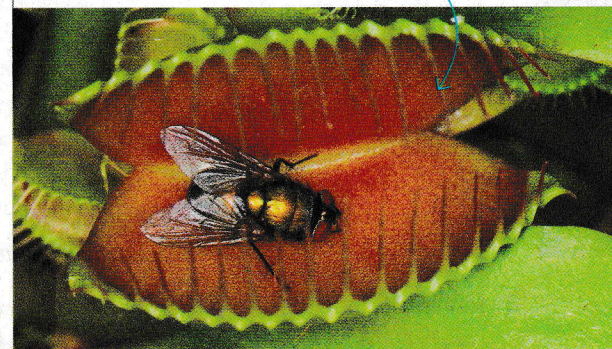
1,175 Number of rhinos illegally killed in South Africa in 2015—that's 40 fewer than in the previous year. This is the first drop in rhino poaching since 2007.



20 Length, in feet, of a tapeworm removed from the small intestine of a man in China. Doctors believe he acquired the tapeworm by eating raw beef.



2 Number of prey movements needed to trigger a Venus flytrap to close. Requiring multiple movements prevents the carnivorous plant from wasting energy by accidentally chomping down on nonliving debris.



BARELY EVOLVED

Meet four animals that look just like they did millions of years ago

How would you like to get a rare glimpse of how animals looked millions of years ago—even before dinosaurs roamed Earth? Many people don't realize it, but a few types of animals alive today survived mass extinctions and outlasted many other creatures.

These animals, sometimes called *living fossils*, appear to have barely changed over time. Though they've undergone genetic and physical changes, their skeletons and outward appearances remain remarkably primitive.

Species change, or *evolve*, over many generations, as an animal's most successful traits are inherited by offspring and less-successful traits fade away. This process fine-tunes organisms to thrive in their environment. In some cases, the external features of a species hardly change. Today, the skeletons of these animals look very similar to fossils of their ancestors that lived millions of years ago.

Scientists aren't sure why certain species haven't changed much over time. In some cases, they're so well adapted to their environment that they didn't need to. Others had little competition for food. It's possible that luck also played a role—these animals happened to be in the right place at the right time.

"Living fossils' allow us to look back in time, to gain an impression of distant relatives of animals living today," says British paleontologist Richard Fortey. "It's almost like meeting up with your great-great-great-grandparents and asking them about the world they lived in." ❁

—Alessandra Potenza

Big eyes allow chevrotains to see in the dark and move around at night, when few predators are out.

Males use elongated teeth as weapons when competing with other males for a mate.

1

CHEVROTAIN

Also known as mouse deer, these tiny creatures are relatives of today's cattle and deer. The chevrotain (pronounced SHEH-vroh-tayn) has barely changed for at least 34 million years. The species owes its evolutionary success to a stable habitat: the tropical forests in India, Sri Lanka, and Southeast Asia.

Chevrotains are solitary and *nocturnal*—they're most active at night. Their small size helps them hide from predators. "They scurry through dark forests where few things can get them," says Jessica Theodor, a biologist at the University of Calgary in Canada. "That's their strategy."

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4 BONUS
SKILLS
SHEETS

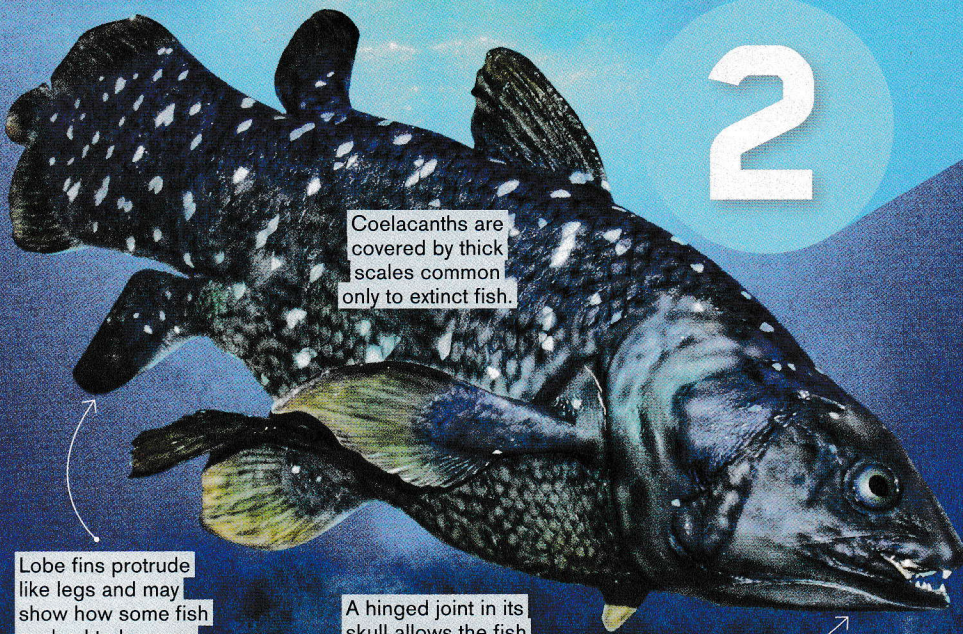
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Adults are
20 to 30
inches long
and about
12 in. tall.

Slender legs and
a tiny body
allow
chevrotains to
move
quickly and
hide
from predators.

ANUP SHAH/INFLUENCING PICTURES (CHEVROTAIN); GERARD LACZ/FLOP/AMINDEN PICTURES (SWIMMING); GEORGE MULALA/REUTERS (TABLE)

2



Coelacanths are covered by thick scales common only to extinct fish.

Lobe fins protrude like legs and may show how some fish evolved to become land animals.

A hinged joint in its skull allows the fish to widen its mouth to ingest large prey.

Coelacanths can grow to 6.5 feet and weigh more than 198 pounds.



This coelacanth was caught by Kenyan fishermen in 2001.

COELACANTH

No animal has been called a “living fossil” more often than the coelacanth (*pronounced SEE-lah-kanth*). Fossils of the fish date back 400 million years. Coelacanths were long thought to have gone extinct with the dinosaurs 65 million years ago. But in 1938, a living coelacanth was caught off the coast of South Africa—and it looked remarkably similar to its ancient ancestors.

The strange fish retains many primitive features, including paired *lobe fins* that extend away from its body like legs and move in a motion similar to that of a trotting horse. The coelacanth’s lobe fins provide a glimpse into an early stage in the evolution of fish to walking, four-limbed land animals.

No one knows why the fish retained so many ancient features, but scientists have guesses: Coelacanths live in secluded marine areas, sometimes about 700 meters (2,300 feet) underwater, where they may have experienced few environmental changes or little competition for food, says paleontologist and National Geographic explorer Nizar Ibrahim. Today’s coelacanths do have some genetic and anatomical differences from their ancient ancestors. “Evolution never sleeps!” says Ibrahim.

3

OPOSSUM

Species of opossum diverged from other *marsupials* (pouched mammals) about 65 million years ago. Since then, opossums haven't changed much. Their recipe for success is adaptability. Opossums are food *generalists*—they'll eat almost any food. They feed on bugs, fruit, and roadkill and will even raid garbage cans.

They've also adjusted well to humans, using people to their advantage. Until recently opossums lived only in warm climates, but they've expanded their range to colder areas of North America in part by living in heated basements. Usually, opossums nest in tree holes or dens. The mammals are found in Australia, New Zealand, the island of New Guinea, and North America. "They can handle a variety of conditions, so they've survived for a very long time," says Samantha Hopkins, a geologist at the University of Oregon.



The opossum's long *prehensile* tail can grip. It's used as an extra limb and helps the animal climb trees.

Opossums use their sharp claws to dig into bark as they climb trees. They nest in tree holes or in dens made by other animals.

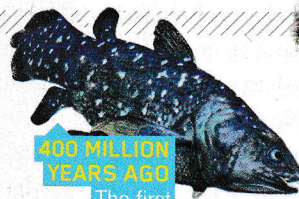
They're the only marsupial that lives in North America. Like kangaroos, female opossums carry their babies in a pouch until they're big enough to survive on their own.

WHEN ANIMALS EVOLVED

Check out this timeline to see when some animals—including dinosaurs and people—first emerged.



3.5 BILLION YEARS AGO
The first traces of life on Earth appear.



400 MILLION YEARS AGO
The first coelacanths swim in the ocean.



375 MILLION YEARS AGO
Land animals emerge.



230 MILLION YEARS AGO
Dinosaurs appear.

SAD&K MASLOWSKI/PA/MINDEN PICTURES (OPOSSUM); DAVE WATTS/NP/UMINDEN PICTURES (PLATYPUS); TIMELINE: EYE OF SCIENCE/SCIENCE SOURCE; GERARD LACZ/FILM/MINDEN PICTURES; DE AGOSTINI/GETTY IMAGES; SCIENCE PICTURE CO/SCIENCE SOURCE; JIM BRANDENBURG/MINDEN PICTURES; JOEL SARTORE/NATIONAL GEOGRAPHIC PHOTO ARK/NATIONAL GEOGRAPHIC CREATIVE (MOUSE DEER; PLATYPUS); SCIENCE PICTURE CO/SCIENCE FACTION/CORBIS

4

PLATYPUS This ancient water-loving creature looks like a mix of several different animals. It has a bill and webbed feet like a duck, a tail like a beaver, and a body and fur like an otter. It's also one of the world's five remaining *monotremes* (egg-laying mammals)—the other four are species of a spiky creature called the *echidna*.

The platypus emerged some 61 million to 125 million years ago, and it hasn't changed much in the past 2 million years. That's because the animals are well-suited to their environment and have little competition for food. Native to Australia, they're one of the few mammals there that hunt underwater for insects, shellfish, and worms. Platypuses live pretty much undisturbed by competition or predators.

Australia is an island that's been isolated for millions of years. That's protected the platypus. "They swim around and eat bugs. No animal has come along that's better at that," says Hopkins.

They keep their eyes, ears, and nostrils shut while swimming to keep water out.

Like reptiles, they lay eggs in underground burrows.

Thick fur keeps them warm and dry.

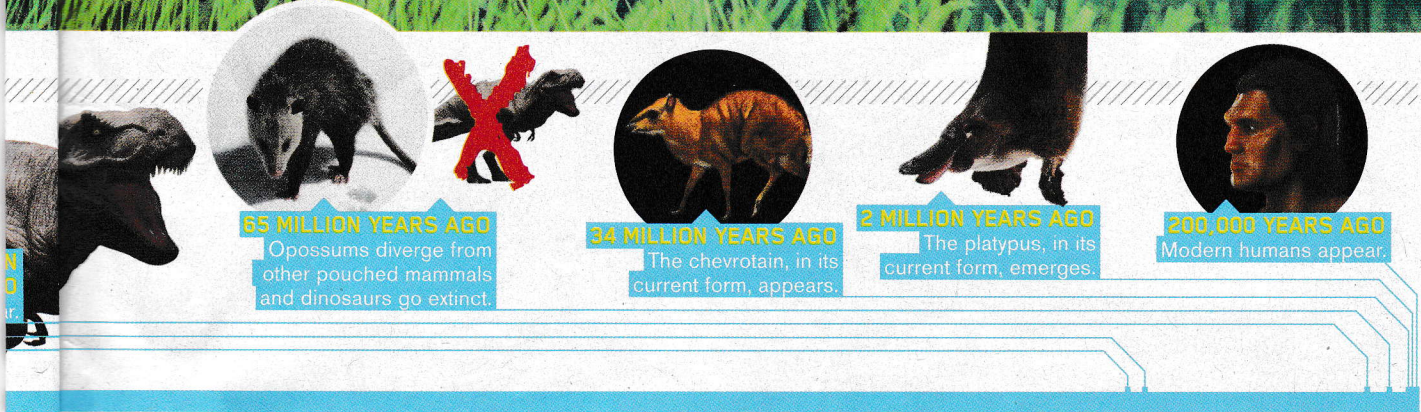
Webbed feet help platypuses swim and dive.

Male platypuses can shoot poison out of their hind feet to paralyze males competing for a female.

Their rubbery bill has *electroreceptors*, sensory cells that allow them to detect the movement of prey. This is especially important since platypuses shut their ears, nostrils, and eyes while swimming.

CORE QUESTION

What is a living fossil? Explain in your own words.



MISSION to the MANTLE

Geologists drill deeper into Earth than ever before

What lurks miles below the street where you live? Geologists have dreamed of breaking through the crust that covers Earth, into the hot mantle below it. But drilling that deep is a huge challenge: It means grinding through more than 5 kilometers (3 miles) of extremely hard rock. It's a feat that many have tried—and failed.

In December 2015, a team of scientists found what they hope is the perfect site: a rocky hill on the floor of the Indian Ocean. Erosion has thinned the crust in this region by about 1.5 km (1 mi), which may allow for easier access to the mantle. Still, the

project will take several years to complete. "The drill bit is attached to a long steel pipe suspended from a ship. As we go deeper, the pipe will be over a mile long and weigh 75

tons," says geologist Henry Dick of the Woods Hole Oceanographic Institution in Massachusetts. Water is continuously pumped down the hole through the drill bit to flush out debris that's been cut away. The team is hunting for the

scientists think separates the crust from the mantle. The team also hopes to answer big questions about Earth, such as how molten rock (hot, liquid rock) rises from the planet's interior and cools to form new crust. The scientists might even

find organisms living deeper inside Earth than ever found before. "That would be exciting," says Henry Dick. The farther they drill, the more they will discover about the layers that make up our planet.



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4 BONUS SKILLS SHEETS
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EARTH'S LAYERS

CRUST:

4.4 billion years ago, Earth was born from a mass of rubble and gases swirling through space. As the pull of gravity brought this material together, heavier materials like iron sank to the center, and lighter materials like granite ended up toward the outside. Like an eggshell, Earth's crust is thin: only about 3 to 5 miles thick beneath the ocean.

MOHO BOUNDARY:

Scientists have never seen this border, thought to separate the crust from the mantle. They've detected it by studying seismic waves caused by earthquakes and volcanic eruptions. If the drilling project is successful, scientists will get a first-ever look at the Moho boundary.

UPPER MANTLE:

This layer contains rocks made of elements like silicon, magnesium, and aluminum. The region can reach scorching temperatures of 5,000°F—hot enough to melt rock. As rock melts, it moves upward. This motion is critical to how the ocean flows and how air in the atmosphere circulates, says Henry Dick.

LOWER MANTLE:

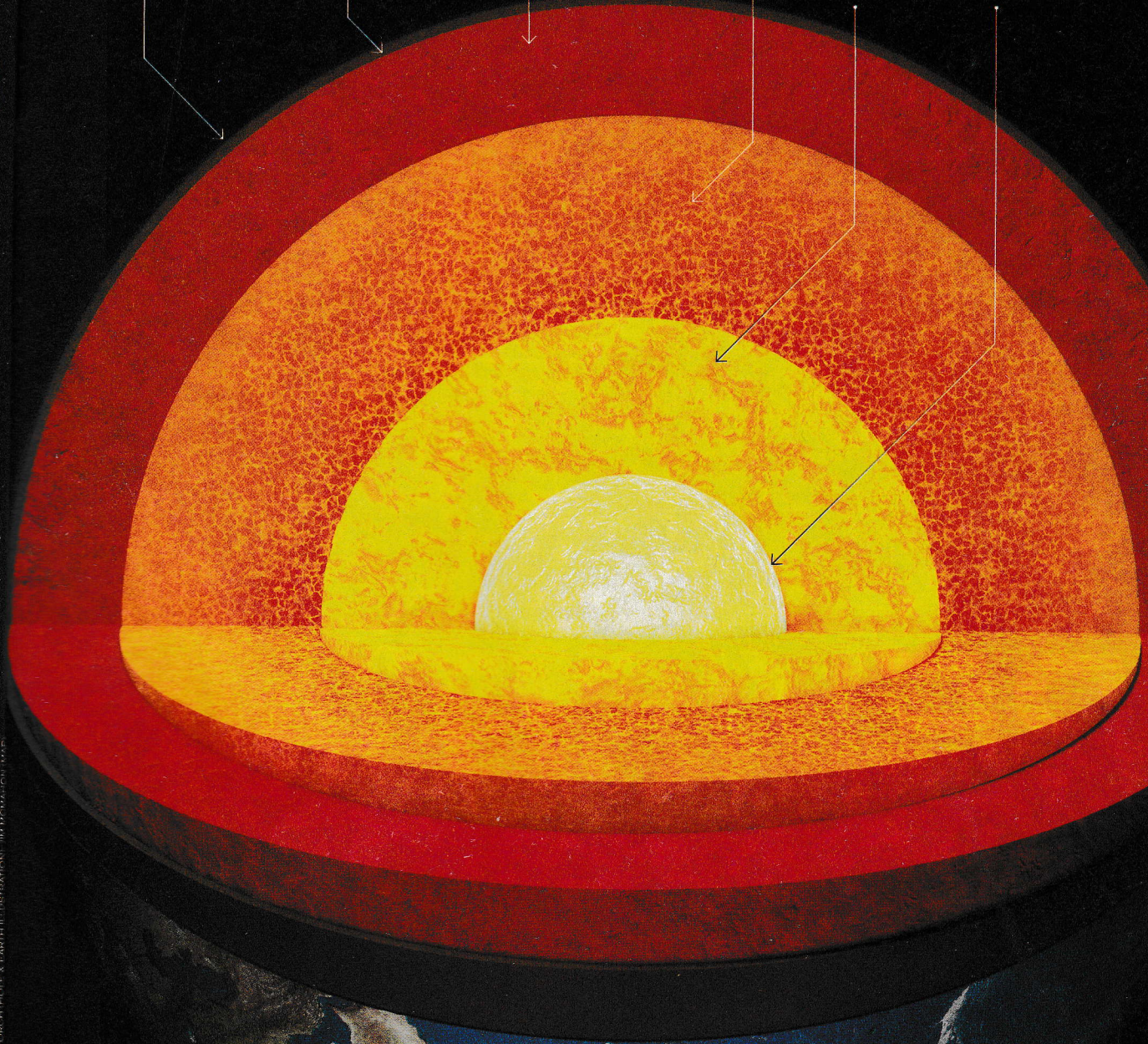
The lower mantle is a solid layer of rock from 400 to 2,000 mi thick.

OUTER CORE:

Temperatures of 4,000° to 9,000°F melt the iron and nickel that make up the outer core. The liquid metal flows around Earth's center, creating the planet's magnetic field.

INNER CORE:

The pressure here is so great that it squeezes the iron and nickel in the inner core into a solid metal ball 1,500 mi wide.



➦ CORE QUESTION What are two reasons that scientists want to drill through Earth's crust?



ENGINEERING: Design // **PHYSICS:** Radiation
BIOLOGY: Ecology // **CHEMISTRY:** Chemical Reactions

HIGH AND DRY:
A sophisticated ventilation system will keep the interior dry to prevent rust.

STEEL GIANT:
A stainless steel exterior resists corrosion.

UP WE GO!
Massive jacks were used to lift the arch as it was being built.

REVISITING CHERNO

30 years after a nuclear catastrophe, engineers are building a giant tomb to bury the past

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THE NEW CHERNOBYL ARCH

This giant structure will seal up the remains of the Chernobyl disaster.

GROUND ZERO:

The completed arch will slide into place over the sarcophagus covering the exploded reactor.

On April 26, 1986, the nuclear power station at Chernobyl, Ukraine (then part of the Soviet Union), experienced a massive meltdown. One of the reactors exploded and caught fire, burning for 10 days.

Following the disaster, workers rushed to contain the *radiation* leaking from the facility. They had to act quickly, because radiation consists of energy or particles that can be dangerous to people. Exposure to high doses can cause cancer, birth defects, or even death.

Workers entombed the damaged reactor in a concrete and steel structure nicknamed the *sarcophagus* (pronounced sar-KOFF-uh-gus). Even today, a person standing inside, near the reactor, for just a few minutes would be exposed to a deadly dose of radiation.

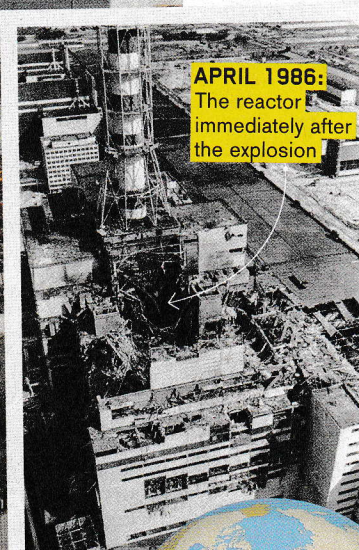
The sarcophagus has an estimated lifespan of 30 years—an anniversary that will pass this spring. Its roof is riddled with cracks and holes, and the structure could collapse at any moment. But if it can hold for just a little longer, a new containment structure will be ready to take over the job: Technicians are nearing completion of a \$1.5-billion giant steel arch that will seal the ruined reactor for a century or more. Taller than the Statue

of Liberty and spanning an area the size of eight football fields, it's one of the most spectacular engineering projects ever.

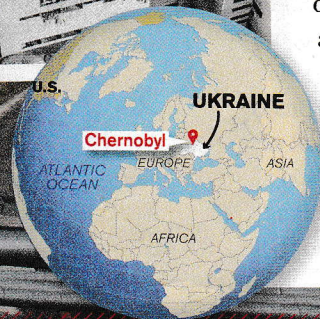
NUCLEAR TRAGEDY

Nuclear reactors transform one chemical element into another, releasing large amounts of energy in the process. That energy can be used to generate electricity. The Chernobyl disaster happened during a test of how one of the power station's reactors would respond in the event of a power outage. The reactor

Continued on the next page →



APRIL 1986:
The reactor immediately after the explosion



became unstable and exploded. The blast killed one worker immediately and fatally injured another. Dozens of employees and emergency responders attempting to contain the burning reactor received lethal doses of radiation. They died within a few months.

Radioactive debris ejected by the explosion landed in the surrounding area, which included Pripjat—a city of 50,000 people—and smaller farming villages. Over the next few days, emergency crews in helicopters poured sand and other material over the ruined reactor to extinguish the fire and limit the release of radiation. More than 100,000 residents had to be evacuated from the region.

A few weeks later, construction began on the sarcophagus in an effort to contain the hundreds of tons of radioactive fuel, dust, and meltdown by-products remaining at the reactor site. “It was built in very difficult circumstances,” says Nicolas Caille, the engineer who is the project director on the new arch. The sarcophagus was hastily constructed in a few months, since it wasn’t safe for workers to remain near the reactor for long.

BUILT TO LAST

After years of planning, construction of the new arch—officially known as the Chernobyl New Safe Confinement—began in 2012. Because radiation levels at the sarcophagus are still unsafe, the arch is being built about 300 meters (roughly 1,000 feet) away from the damaged reactor. “We’re not in a dangerous environment at this distance,” says Caille. When the arch is finished around November, workers will slide it on tracks into place over the old sarcophagus and seal it up.

To help protect workers, contractors put up a concrete wall between the work site and the sarcophagus to act as a radiation shield.

Additionally, “everybody is equipped with a *dosimeter* [a device that measures radiation],” says Caille, “so we know exactly the dose everyone receives, and we can make sure it is always well below international safety limits.”

When completed, the arch will weigh more than 36,000 tons—about as much as 240 blue whales. Because it will slide into position, engineers consider it to be the largest movable structure ever made. It has double walls of steel designed to withstand tornadoes, earthquakes, and extreme temperatures. “Even if the existing sarcophagus collapses,” says Caille, “everything will remain confined.”

CHERNOBYL TODAY

1 An abandoned amusement park that opened just a few hours before evacuation

2 The new arch under construction



BERT KAUFMANN PHOTOGRAPHY/MOMENT OPENING/GETTY IMAGES (TOP); LAURENT ZYLBERMAN/GRAPHIX IMAGES (BOTTOM)
ANTON PETRUS/MOMENT OPENING/GETTY IMAGES (HORSE); TIMMY DUBINIOLU/ANZENBERGERHARREDDUK (TURTLE); SERGEI SUPINSKY/AF/GETTY IMAGES (CHICKENS)

3
Rare wild horses in the evacuation area

4
A tortoise in the remains of an abandoned house

5
Some residents have illegally returned to their homes in the evacuation area.

Many steel structures, including the Eiffel Tower, have stood strong for more than 100 years—the minimum lifespan of the arch. But maintaining an object on top of a nuclear disaster takes some ingenuity. “With any metallic structure, you have to protect against rust,” says Caille. “Usually that means painting it every 10 years or so. But this arch will be over an exploded reactor. We can’t just send in a painter.”

To get around that problem, the arch’s *cladding*, or outer layer, is made of stainless steel, which contains the element chromium and resists corrosion better than regular steel. A ventilation system will keep the air between the two steel walls very dry—lower than 40 percent humidity. “When the air is that dry, rust can’t form,” says Caille.

The steel structure will be equipped with remotely operated cranes that could someday be used to remove the radioactive

waste inside, if anyone can come up with a safe way to dispose of it. Or officials may simply decide to let the arch protect the site for the next hundred years or so and deal with the question of disposal a century from now.

RESILIENT LANDSCAPE

As workers prepare to seal the heart of the power plant beneath the new arch, wildlife scientists are studying the effects of the 1986 disaster on animal populations nearby. They’ve found some encouraging signs.

After people were evacuated, “nature really took over,” says environmental scientist Jim Smith of the University of Portsmouth in England. Smith visits the area regularly. “It’s like a forest with some buildings in it,” he says.

By examining animal tracks and analyzing data from helicopter surveys, Smith and his colleagues have found that in the absence of humans, populations of elk, deer, boars, and wolves are thriving. They’re doing as well as or better than those in uncontaminated nature reserves elsewhere in the region.

“People think of Chernobyl as a radioactive wasteland,” he says. “But it’s not that simple.”

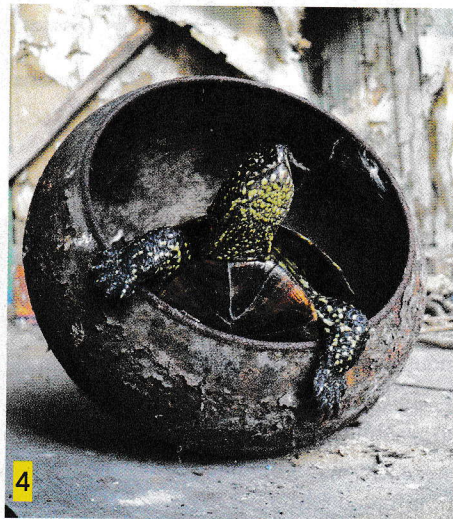
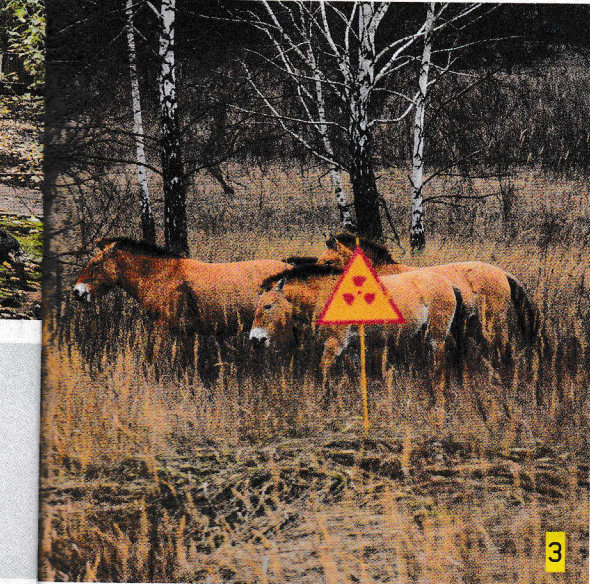
Levels of radiation in the environment dropped rapidly in the months after the explosion. Even so, “it’s still too contaminated for humans,” says Smith. Radiation limits for people are very strict, so it could be centuries before the area is declared safe.

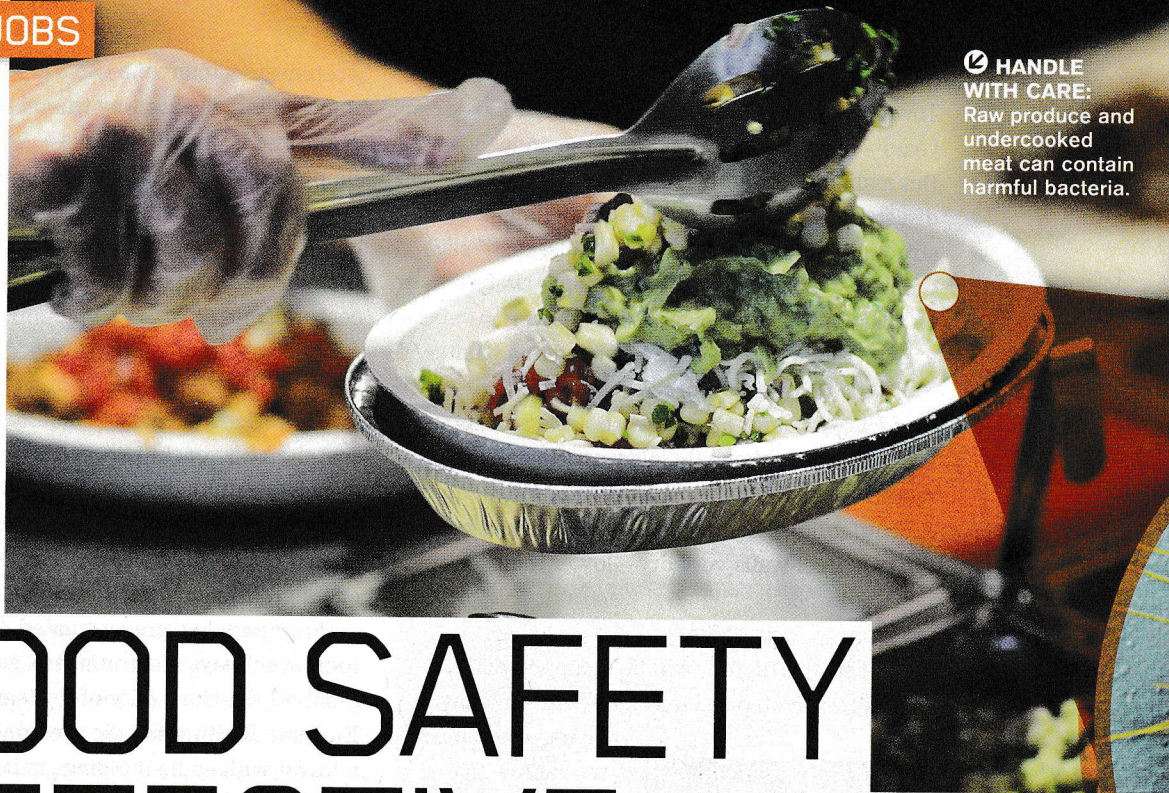
Meanwhile the world will be watching—and hoping the old sarcophagus holds together—as the new arch is completed. If all goes well, Chernobyl’s most toxic remains will stay safely buried for a long time to come. ❁

—Jennifer Barone

CORE QUESTION

What are some features of the new arch that will help it last for 100 years? Cite evidence from the text.





HANDLE WITH CARE: Raw produce and undercooked meat can contain harmful bacteria.

FOOD SAFETY DETECTIVE

Beth Melius investigates foodborne diseases like the *E. coli* outbreak that sickened Chipotle customers

Every year, one in six Americans get sick from food poisoning. When many people in one region fall ill with the same symptoms, scientists like Beth Melius get to work figuring out why. Melius is a foodborne disease *epidemiologist* at the Washington State Department of Health. When dozens of people in Washington and Oregon were infected with *E. coli* last fall, she and her team had to figure out where and why they contracted the gut-wrenching stomach bug.

E. coli is a common kind of bacteria. Harmless *E. coli* strains live in your intestines and help digest food. But dangerous forms can cause stomach problems or even death in severe cases. Harmful *E. coli* can exist in raw produce and undercooked meats. Melius says that one of those was probably the culprit in the Chipotle outbreak.

In February, the Centers for Disease Control and Prevention declared the *E. coli* outbreak and investigation over. *E. coli* isn't the only foodborne illness that has plagued Chipotle recently. Last year, more than 300 cases of *norovirus*, which can cause severe vomiting, were reported in connection with Chipotle restaurants in Simi Valley, California, and Boston, Massachusetts. *Science World* spoke with Melius about how she tracks an outbreak to its source.



Beth Melius tracks cases during an outbreak.

What do you do when you learn about a potential outbreak?

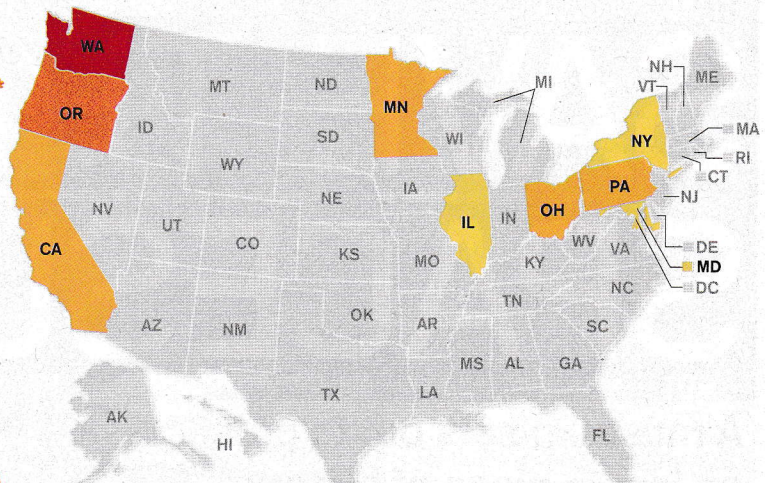
We're disease detectives. When an unusual number of people become ill with similar symptoms, we call the patients and ask about foods they have eaten and restaurants they visited before they became ill to find what they all have in common. Then we generate hypotheses about what may have caused the illness. In Washington, almost all of the people had eaten at the same restaurant within a few days of each other.

How do outbreaks happen?

For foodborne diseases, an outbreak happens when two or more people have eaten a common source of contaminated food. If the food item

MAPPING THE E. COLI OUTBREAK*

NUMBER OF ILL PEOPLE



Alaska and Hawaii are not drawn to scale or placed in their proper geographic positions.

SOURCE: CDC
*as of December 2015



E. coli bacteria are a common cause of food-borne illness.

is produce, contamination could have occurred at the site where it was grown, or it could have happened during transport or at the restaurant with improper food handling.

If meats are the cause, it could be that the meat wasn't cooked thoroughly.

In the Chipotle outbreak, we still don't know the source or exactly where the contamination happened. We know the outbreak was

caused by something served at Chipotle, but we're not sure what. Although the people who got sick ate different menu items, those items were made with the same ingredients. So it's been difficult to pin down the exact food that was responsible for the outbreak.

How are outbreaks managed?

Once we have an idea that an outbreak may be stemming from a particular restaurant or chain, then we call our environmental health partners. Colleagues from

there go out and inspect the relevant restaurants.

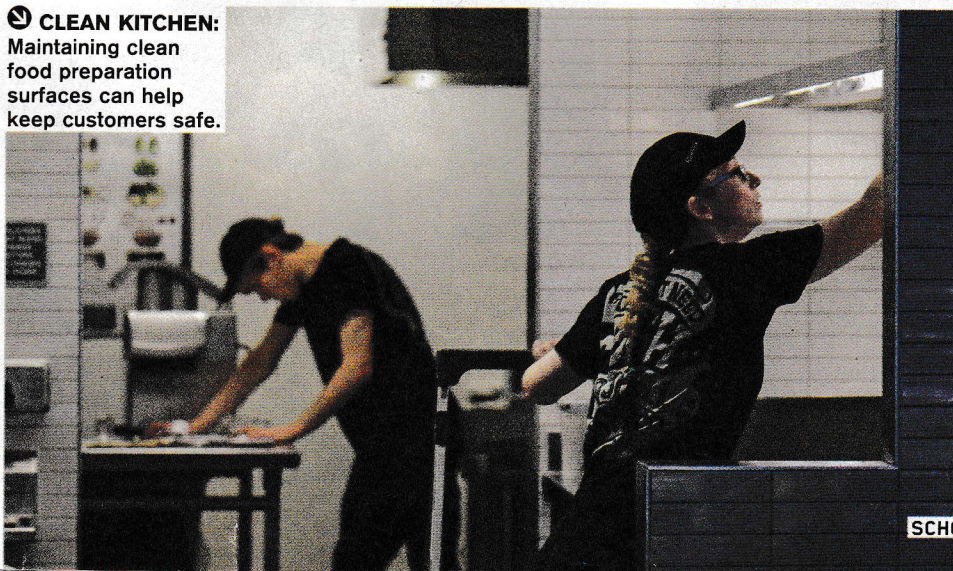
If the outbreak is traced to a specific food item, we talk to the Centers for Disease Control and Prevention, the Food and Drug Administration [FDA], and the Department of Agriculture. If we find out that a produce item is to blame, then the FDA traces it back to the farm. Health inspectors also check to make sure restaurant employees are using safe food practices.

How can outbreaks be prevented?

Safe food handling is the best way to prevent foodborne illness. Washing hands thoroughly, washing produce, and cooking food to the right temperature are the most important things to do. Consumers can often look up health scores from inspections if they're concerned about the practices at a particular restaurant. ❄

—Hanneke Weitering

CLEAN KITCHEN: Maintaining clean food preparation surfaces can help keep customers safe.



SAVE THIS SPACESUIT!

A museum sets out to preserve an iconic piece of history



LUNAR LEGACY: A museum worker examines Neil Armstrong's spacesuit at a National Air and Space Museum storage space.

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4 BONUS SKILLS SHEETS
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MOON WALK: Neil Armstrong took this photo of astronaut Buzz Aldrin in July 1969, when they became the first people to walk on the moon.



TO THE MOON: Apollo 11 astronauts Neil Armstrong (left) and Michael Collins shortly before launching to the moon

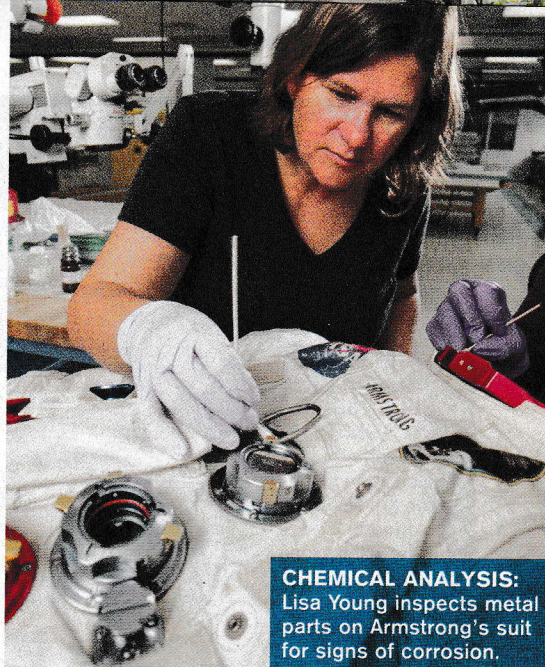


n July 20, 1969, millions of people around the world sat glued to their televisions. They watched as American astronaut Neil Armstrong stepped out of the Apollo 11 spacecraft and onto the moon. He was the first person to ever set foot on the lunar surface. Now the National Air and Space Museum in Washington, D.C., is on a mission to save one of the artifacts that made this achievement possible—Armstrong's spacesuit.

The spacesuit was designed to withstand the harsh environment of space. But after decades back on Earth, the materials used in its construction have started to *degrade*, or break down. "The suit was made to last only long enough to get an astronaut to the moon and back," says Lisa Young, a *conservator* at the museum who is responsible for the preservation of its spacesuit collection.

Last summer, Young teamed up with *curator* Cathleen Lewis, who oversees the museum's spacesuit collection. Together, they helped launch a campaign called "Reboot the Suit" on Kickstarter, a website where people can donate money to help fund different types of creative projects. By reaching out to the public, the museum hoped to raise \$500,000 to preserve Armstrong's spacesuit. The campaign met its goal in just five days.

With the money, Young and Lewis plan to use high-tech imaging tools to analyze the condition of the many parts that make up Armstrong's suit. Their work will help them prepare the artifact to go on display at the National Air and Space Museum in 2019—in time for the 50th anniversary of the moon landing. The suit will also be permanently featured in the museum's "Destination Moon" gallery set to open in 2020.



CHEMICAL ANALYSIS: Lisa Young inspects metal parts on Armstrong's suit for signs of corrosion.



SUIT SCAN: Museum workers use 3-D imaging to view hidden layers inside Armstrong's suit.

SUIT BREAKDOWN

One of the first steps to "reboot" Armstrong's suit is for Young and Lewis to learn about its past. They'll research everything from its creation to its handling postflight, when it went on a 50-state tour and was later displayed at the museum. That will help them determine how and when changes to the suit took place (*see Spacesuit Wear and Tear*, p. 22).

Part of the research process includes talking to engineers and companies that contributed

to making the suit, which was tailor-made to fit Armstrong's body. The suit has 21 layers made of 24 different materials. The outermost layer is called *Beta cloth*. It's made of fiberglass fabric woven with threads dipped in *Teflon*—a tough chemical compound used for coating nonstick pans. The Beta cloth was designed to resist tears and punctures, like those that can be caused by tiny particles of rock that

hurtle through space at up to 16 kilometers (10 miles) per second. Beneath that are several layers of insulating materials. They protected Armstrong from the -150°C to 120°C (-250°F to 230°F) temperature swings on the moon. They also blocked *radiation*—energy or particles that can be dangerous at high doses—from the sun.

But the most important layer of the suit, says Young, is its inner *pressure bladder*. It squeezed around Armstrong's body to create pressure like we feel on Earth from the weight of the atmosphere pushing down on us. This *air pressure* is absent in the empty *vacuum* of space. Without air pressure, liquids and gases inside Armstrong's body would have expanded and quickly killed him. The bladder is made of rubber, a type of *polymer*, or molecule made up of repeating units. Over the years, exposure to light,

Continued on the next page →

oxygen, and temperature changes have caused the rubber to become brittle. “The rubber bladder has started cracking in certain places and changed shape,” says Young.

INSIDE AND OUT

The next big undertaking in the preservation of Armstrong’s suit will be to carefully examine it inch-by-inch. Young and Lewis will take high-resolution photographs and precise measurements of all the suit’s components. They’ll also photograph the suit using *infrared* and *ultraviolet light*, which can reveal changes undetectable to the human eye.

Young and Lewis have previously examined the suit’s internal layers by putting it through a *CT scanner*. They’ll use the machine again to take updated cross-sectional X-ray images. A computer will piece together these images to create a 3-D view of the suit’s interior.

Based on what Young and Lewis uncover, they’ll devise ways to treat problem areas on the suit to prevent further deterioration. But the goal isn’t to make the suit look like new. “The important part is preserving anything related to its use on the moon,” says Lewis. The team might clean fabric discolored by age, for instance, but they wouldn’t remove particles of moon dust, which still cling to the suit’s surface.

ON DISPLAY

The main way Young and Lewis plan to slow the suit’s degradation is by placing it in a special display case that controls light, humidity, and temperature. It will have a ventilation system to remove gaseous chemicals that are released as materials in the suit break down. When rubber degrades, for example, it gives off acidic *hydrogen chloride* gas, which can damage parts of the suit.

The precise measurements taken by Young and Lewis will be used to design a mannequin to wear the suit and provide the right amount of support for fragile parts. Once the suit is

SPACESUIT WEAR AND TEAR

Neil Armstrong’s Apollo 11 spacesuit has undergone many changes throughout its history. Conservators want to preserve changes related to the suit’s mission and repair any damage caused by time.


CORRODING GASKETS:

The red and blue aluminum fittings on the suit have started to *oxidize* (react with oxygen), causing the metal to break down.



FADING FLAG:

Exposure to light has caused the colors of the flag to fade and its silk fibers to become thin and brittle.



STAINED FABRIC:

A pocket has orange stains on it from an unknown source. If the stains happened after the moon mission, they will be removed.



PAST REPAIRS:

Repairs, like this hand-stitched one, are found throughout the suit. Research will help determine when and why they were made.



EMBEDDED DUST:

Sharp bits of moon dust are stuck in the suit. Conservators will clean the suit without removing the dust. They’ll see if the dust is creating tiny tears in the fabric and find ways to keep it in place.

upright, museum staff will scan it and *digitize* the image, creating a 3-D computer model that people can examine online.

“Landing a person on the moon was one of the greatest technological accomplishments humans have ever made,” says Lewis. “Preserving Armstrong’s suit is important to remind us and future generations about what it really took to visit another world.” And, adds Young, “it also gets us thinking about where we’ll go next.” ❁

—Cody Crane

CORE QUESTION

According to the text, why don’t museum staff want to make Neil Armstrong’s suit “look like new”?

WORLD'S LONGEST FINGERNAILS



The last time Shridhar Chillal, from Pune, India, clipped the nails on his left hand was when he was 15 years old. That was 64 years ago. Today, the combined length of those fingernails is about 9 meters (30 feet). Chillal, a retired photographer, recently earned the Guinness World Record title for “longest fingernails on a single hand ever.”

On average, fingernails grow 3 millimeters (0.1 inches) per month. In 2004, Chillal’s longest nail—his thumbnail—measured

158 centimeters (62 in.). Now it’s 197.8 cm (78 in.) long. Do the math—it’s grown right on schedule.

As Chillal’s nails grew, so did his troubles. He struggled with simple, everyday tasks, like doing laundry. Over time, the weight of his nails began to cause pain in his wrist, elbow, and shoulder. He says that he hardly sleeps. “I can’t move much, so every half an hour or so I wake up and move my hand to the other side of the bed,” Chillal told Guinness.

While his feat has earned him fame, Dana Stern, a dermatologist

in New York City who specializes in fingernail health, doesn’t recommend trying to beat his record. “Having long nails is bad hygiene,” she says. “It’s a challenge to keep them clean.”

She explains that infectious bacteria can hide under long nails. Even fingernails of average length can collect bacteria, so she recommends keeping them short.

Chillal has no immediate plans to trim his nails, but he says that someday he’ll clip them off and give them to a museum.

—Hanneke Weitering

SPACESUIT EVOLUTION

Check out some of the weirdest and most important styles developed for the space age

 DENOTES A SUIT FLOWN IN SPACE



LATE 1950s

Pressurized suit worn by U.S. Navy pilots; served as a model for early spacesuits



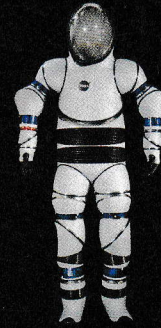
1961 

Suit worn by Alan Shepard on the first American manned spaceflight, the Mercury-Redstone 3 mission



1965 

Gus Grissom's suit from the Gemini 3 mission, which tested a new maneuverable spacecraft; recorded biomedical data from the wearer



1968

AX-2 prototype suit with a hard body to protect the wearer from small space rocks



1969 

Suit worn by Neil Armstrong during the Apollo 11 moon landing



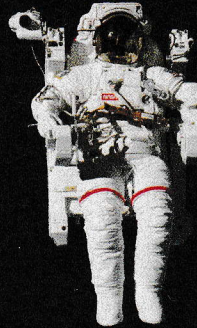
1973 

Suit worn by Alan Bean on a mission to the Skylab space station; allowed Bean to move freely when working outside the station



1974

AX-3 prototype suit used to test different types of spacesuit joints



1984 

Extravehicular Mobility Unit suit worn by astronaut Bruce McCandless on the world's first untethered spacewalk



1994 

Advanced Crew Escape Suit used on space shuttle missions; designed to prevent blood from pooling in the lower body during descent



2013

Z-2 prototype suit currently under development by NASA for exploration of Mars; has a hard torso for durability on long missions

ANALYZE IT Why do you think so many different suits were developed during the 1960s? // // // // //

SCI-TRIV		HOW TO RESTORE GAME		TEAM 1: 60	TEAM 2: 20
10 POINTS	20 POINTS	30 POINTS	40 POINTS	SCORE	QUESTIONS
CORRECT	?	?	CORRECT		
?	CORRECT	?	?		
INCORRECT	?	INCORRECT	?		
?	CORRECT	?	?		

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