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RECYCLE THIS PLEASE

High-rise safety expert Jamison Walsh on the spire of One World Trade Center—more than 104 stories above New York City

PHYSICS

DON'T LOOK DOWN!

How engineers are pushing the limits of physics to build ever-taller buildings

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COVER: © JIMMY CHIN

SCIENCE NEWS

NOT FOR SALE
In April 2016, the Kenyan government burned illegal ivory destined for markets in China and other countries.

BIOLOGY: CONSERVATION

IVORY BAN

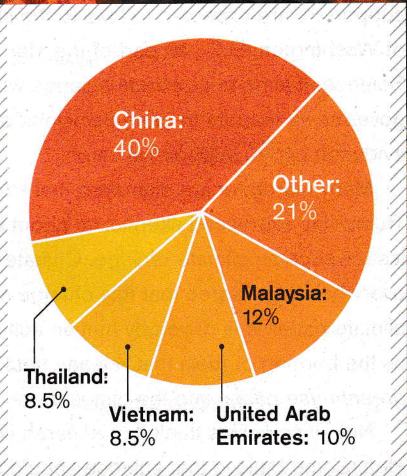
Each year, thousands of elephants are killed for their ivory tusks. Much of that ivory ends up in China. But China recently announced that it will end its ivory trade by the end of 2017. Conservationists hope the move will help save endangered African elephants.

China's policy will make it harder for traffickers to sell ivory. That should make it less profitable for *poachers*, or illegal hunters, to kill elephants. "We are very hopeful that ending the largest ivory market in the world will reduce demand," says Elly Pepper, a wildlife advocate at the Natural Resources Defense Council. But, she adds, other nations need to crack down on illegal ivory trading as well to fully protect elephants. *—Jeanette Ferrara*

HANDY TOOL Elephants use tusks to defend against predators and forage for food.

THE IVORY TRADE

Illegal ivory can sell for $500 per pound. The graph at right shows the percentage of illegal ivory shipped to various countries from 2006 to 2015. Which two countries accounted for slightly more than half of the ivory market?



SOURCE: UN OFFICE ON DRUGS AND CRIME WORLD WILDLIFE SEIZURES DATABASE

PAOLO TORCHIO/BARCROFT MEDIA VIA GETTY IMAGES (ABOVE); MITSUAKI IWAGO/MINDEN PICTURES (ELEPHANT)

CHEMISTRY: MATERIALS

Produce Protector

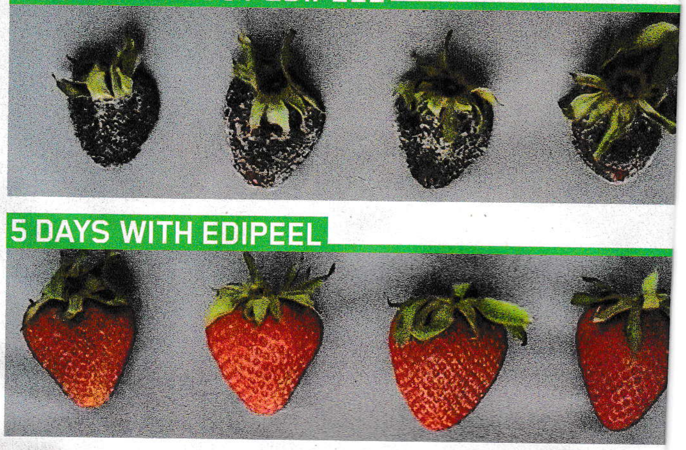
IN THE LAB Rogers inspects avocados at Apeel's headquarters.

No one wants brown bananas or moldy strawberries. A new edible coating, called Edipeel, promises to boost the shelf life of fruits and veggies. It can keep produce fresh two to five times longer than usual.

Edipeel, created by Apeel Sciences in California, is made from leaves, stems, and peels left over after produce has been picked or processed. Compounds *extracted*, or removed, from these leftovers are blended into a liquid and sprayed onto produce. It forms an invisible, tasteless barrier that helps keep water in and oxygen out. That helps prevent wilting, browning, and the growth of mold and bacteria on fruit and vegetables, says materials scientist James Rogers, Apeel's founder.

The company hopes that Edipeel will dramatically reduce food waste. Currently, 45 percent of produce harvested worldwide goes bad before it even reaches the supermarket.

—Hailee Romain



5 DAYS WITHOUT EDIPEEL

5 DAYS WITH EDIPEEL

EARTH SCIENCE: CLIMATE

Science on the March

This Earth Day, April 22, scientists and their supporters are expected to take to the streets of Washington, D.C., as part of the March for Science. It aims to celebrate science while urging government leaders to base decisions on scientific evidence and to support research.

Many marchers are dismayed that President Trump has expressed skepticism about scientific issues such as *climate change*. Climate scientists overwhelmingly agree that this change in global climate patterns is driven by human activity, such as the burning of fuels that release heat-trapping *greenhouse gases* into the atmosphere.

Not all scientists think that a march is a good idea. Some believe that science should be kept separate from politics.

—Jennifer Barone

SPEAKING OUT: The March for Science will be held in Washington, D.C., and 100 other cities around the U.S.

EARTH SCIENCE: EARTH'S WATERS

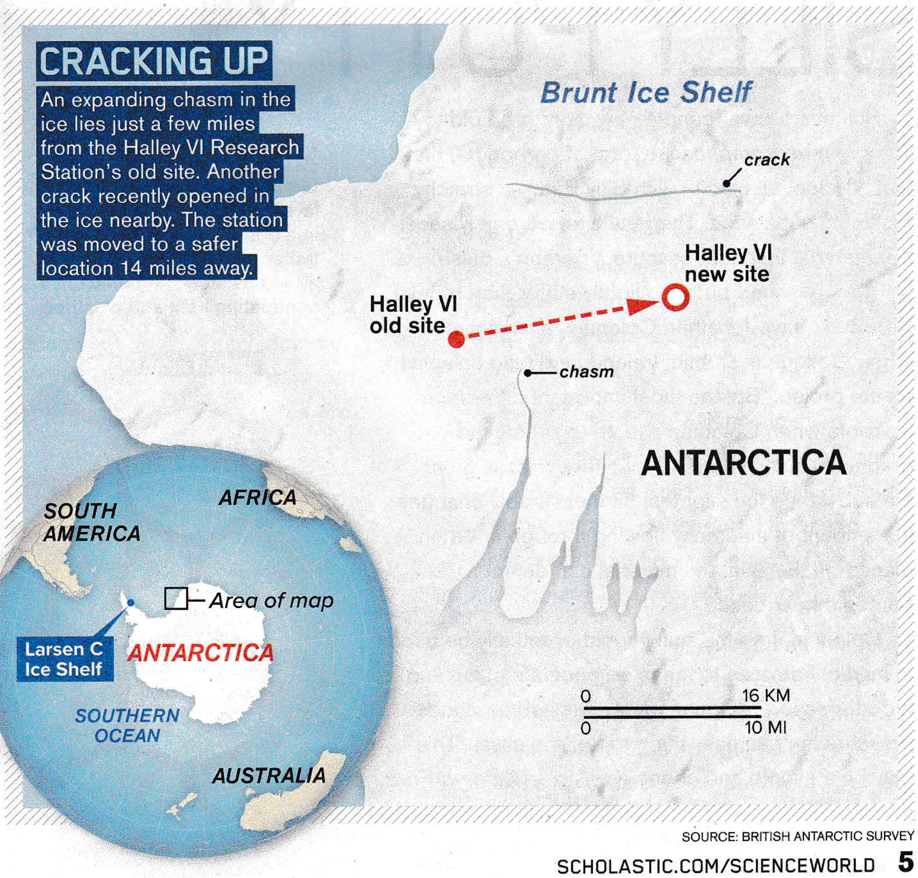
RESEARCH STATION RESCUE

This winter, scientists completed a mission to save a remote research station in Antarctica. A giant crack was creeping across the Brunt Ice Shelf, a thick slab of floating ice. The 43 kilometer (27 mile)-long fissure threatened to cut off the Halley VI Research Station. Scientists were afraid a huge chunk of ice would *calve*, or break off, and float away with the lab and its researchers. Luckily, Halley VI's eight modules stand on legs fitted with skis. Researchers shut down the station and towed the lab to a safer spot.

Elsewhere in Antarctica, a large crack has been spreading across the Larsen C Ice Shelf. Geophysicists studying the site expect a massive iceberg to break off soon. *—Hailee Romain*

CRACKING UP

An expanding chasm in the ice lies just a few miles from the Halley VI Research Station's old site. Another crack recently opened in the ice nearby. The station was moved to a safer location 14 miles away.



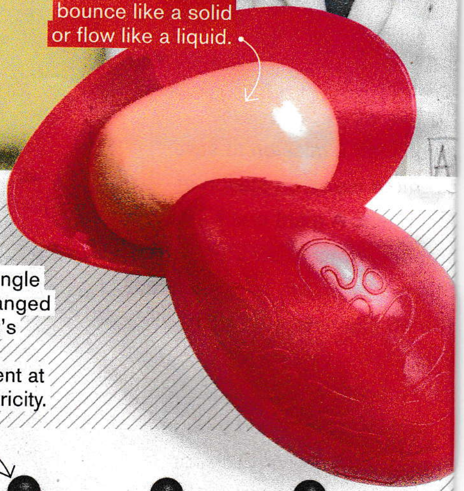
SOURCE: BRITISH ANTARCTIC SURVEY

MATHEW SCOTT/THE NEW YORK TIMES/REDUX (JAMES ROGERS); APEEL SCIENCES (STRAWBERRIES); RYAN RODRICK BEILER/ALAMY STOCK PHOTO (MARCH); BRITISH ANTARCTIC SURVEY (RESEARCH STATION AND INSET); JIM MCMAHON MAPMAN ® (MAP)

NEW PUTTY Coleman (*left*) shows off the graphene-enhanced putty.

CHEMISTRY:
PROPERTIES OF MATTER

NOT-SO SILLY PUTTY



SILLY PUTTY The original toy can bounce like a solid or flow like a liquid.

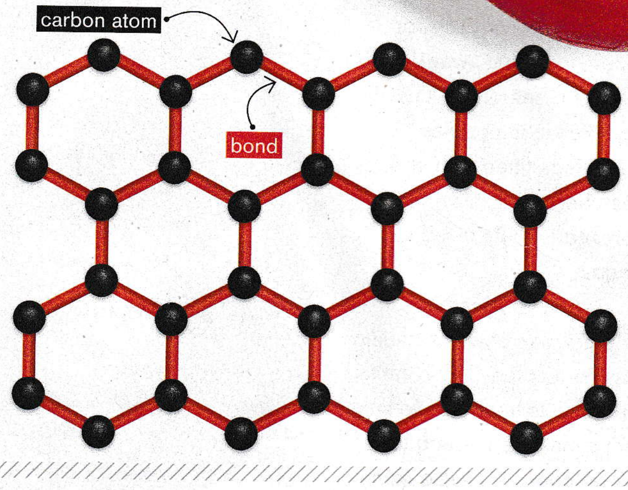
Scientists have found a new use for an old toy. They've mixed *graphene*, a form of carbon (C) that can conduct electricity, with Silly Putty—a stretchy, moldable substance. The result: an extremely sensitive material that can measure a person's pulse.

The enhanced putty is slightly stiffer than regular Silly Putty, says Jonathan Coleman, a physicist at Trinity College in Dublin, Ireland, and lead scientist on the project. But the most important difference is visible when Coleman's team connects the graphene-putty mixture to a battery. Pressing on the substance the slightest bit measurably changes the amount of electricity flowing through it. When placed on the skin, the material can detect a person's heartbeat.

Coleman says the putty could eventually be used in medical devices to measure people's pulse and blood pressure. "Continuously monitoring blood pressure isn't an easy thing to do," he says. "This may be a simple and cheap way." —*Kathryn Free*

GRAPHENE

Graphene consists of a single layer of carbon atoms arranged in a honeycomb pattern. It's transparent, 200 times as strong as steel, and efficient at conducting heat and electricity.



COLORFUL CAT Yana lives with her owner in the eastern European country of Belarus.

BIOLOGY: GENETICS

Two-Faced Cat!

Meet Yana. She might look like she's had a dye job. But genetics is responsible for this cuddly kitty's unusual looks.

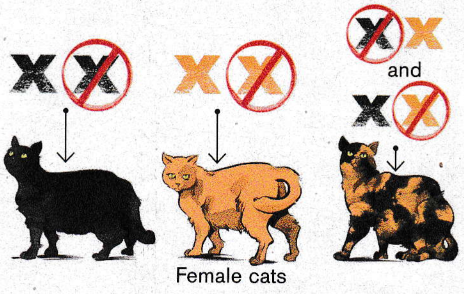
DNA, the molecule that carries genetic information, is packed into structures called *chromosomes* within an animal's cells. Mammals inherit one set from each parent. Chromosomes determine an animal's gender. Males have one X chromosome and one Y, while females have two X's.

One of the genes that influences a cat's fur color is on the X chromosome. Because females have two X chromosomes, they can have two different genes coding for fur color. But cells need only one X chromosome, so they *inactivate*, or turn off, the other one, says Leslie Lyons, an expert in cat genetics at the University of Missouri.

Yana's patchwork pattern most likely comes from different X chromosomes being switched off in different parts of her body. "This happens in people too," says Lyons. But usually it's not visible. Cats like Yana can show off this genetic phenomenon in living color. —*Kathryn Free*

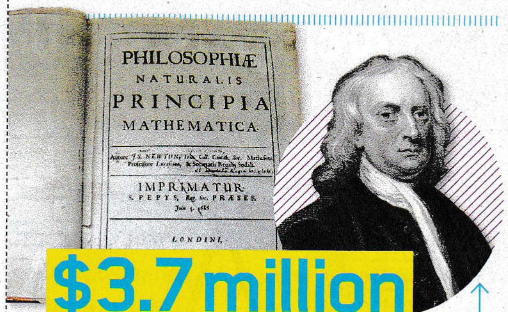
X SHUTDOWN

In cats, one of the genes for coat color is on the X chromosome. Females may have patchy coloration depending on which X chromosome is inactivated in different parts of their bodies.

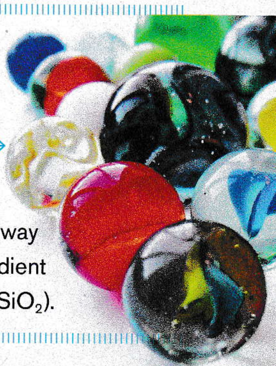


NUMBERS IN THE NEWS

30 trillion Estimated weight in tons of all the human-made objects on Earth (including buildings, vehicles, manufactured items, and garbage), according to a new study by geologists in England.



$3.7 million Price of a first-edition printing of Isaac Newton's *Principia* at a recent auction. The book, published in 1687, describes his famous three laws of motion.



38,000 Weight in pounds of marbles spilled when a cargo truck's trailer split open on an interstate highway in Indiana. The main ingredient in glass marbles is silica (SiO_2).

4,500 Distance in miles that biologist Sacha Dench paraglided from Russia to the U.K. to follow the migration of endangered swans to understand the threats the birds face.

6 Number of bonds a carbon atom forms with other atoms in a newly synthesized molecule, called hexamethylbenzene. Until now, scientists thought carbon could make a maximum of four bonds.

SKY-HIGH SCIENC

Architects and engineers tackle physics to create the tallest skyscrapers in the world

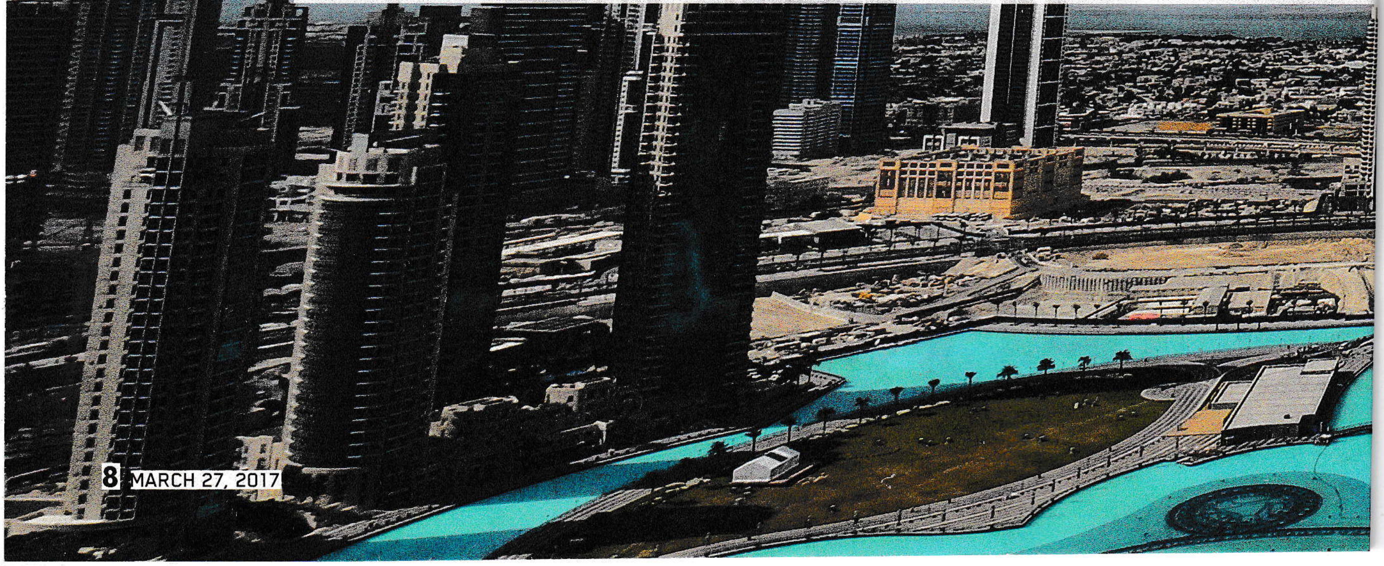
ESSENTIAL QUESTION: What are some of the challenges architects and engineers face when designing tall buildings?

All over the world, people are racing to construct taller and taller buildings. Many of today's skyscrapers are considered to be supertall—structures that stand more than 300 meters (984 feet) high. Architects and engineers have to take every last detail into account to make sure their towering creations don't topple. Their buildings must withstand everything from the downward force of *gravity* to high-speed winds that can come from just about any angle.

Unfortunately, even when architects try to consider every possible force, things can still go wrong. One example is the 279 m (915 ft)-tall Citigroup Center, a New York City skyscraper. A year after it was built, an architecture student discovered that it could collapse if a strong wind hit it from a 45-degree angle. She called the architect who designed the building to alert him to the flaw.

The Citigroup Center had a system of *braces*, or diagonal steel structures that provide extra support to the building. But something wasn't quite right. The braces were bolted instead of welded together, making them weaker than expected. To correct the error, the building's architect had workers weld them together, and the building was saved.

Find out how three other supertall skyscrapers were engineered to safely soar to amazing heights.



BURJ KHALIFA

The Burj Khalifa is currently the world's tallest building, at 828 m (2,717 ft). At 163 floors, it's almost twice as tall as One World Trade Center in New York City—the tallest building in the U.S. (*see World's Tallest Buildings, p. 10*). The building is located in Dubai in the United Arab Emirates.

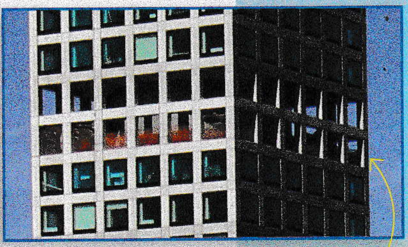
The Burj Khalifa contains a whopping 500,000 tons of steel and concrete. The building's huge mass, combined with the downward pull of gravity, puts incredible amounts of stress on the lower parts of the structure. To support this *vertical load*, architects situated the Burj Khalifa on a massive foundation. They also gave the base of the building a winged design. Arranged in a big Y formation, three wings connect to a central core. These wings *buttress*, or support, the core as it rises.

"As you go up, each wing is stepped back in a deliberate way," says Jon Galsworthy, head of the wind engineering group at RWDI, a company based in Canada that worked on the Burj Khalifa. The design reduces the weight of the building at its center and helps disperse powerful winds of up to 100 kilometers (62 miles) per hour.

Continued on the next page →

432 PARK

The tallest residential building in the Western Hemisphere towers 96 floors above Central Park in New York City. Its slender, pencil-like form reaches 426 m (1,398 ft) above city streets. Inside are some of the most luxurious—and expensive—apartments ever built.



There's a $95 million penthouse at the top of 432 Park, but that's not the real marvel of the building. It's the engineering that makes it all possible. "432 Park was a particular challenge because its slenderness made it vulnerable to wind," says Jon Galsworthy, whose engineering firm worked on this building as well as the Burj Khalifa in Dubai. "But the designers wanted it that way, so we had to develop a solution."

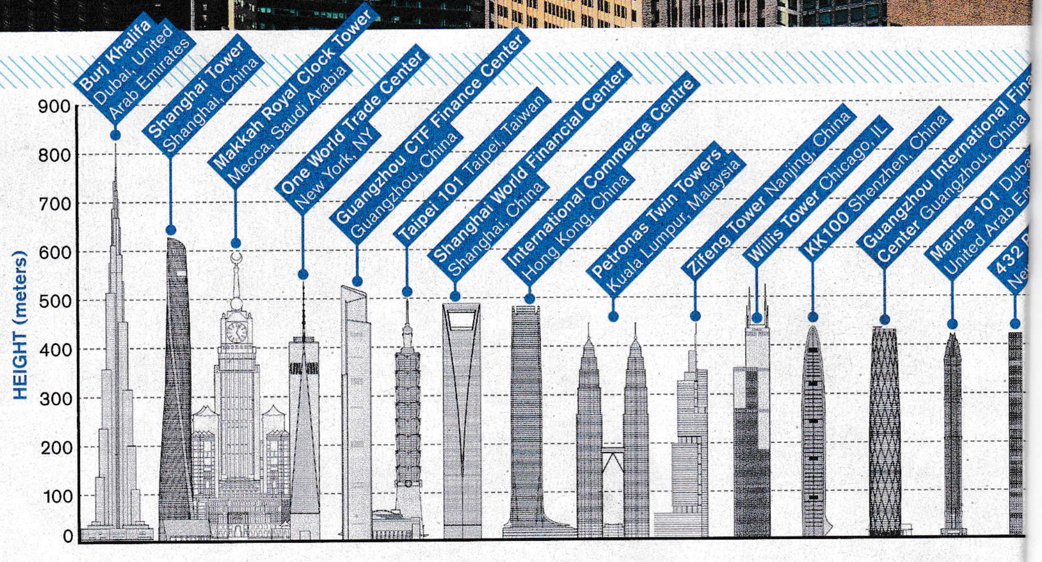
Supertall buildings are meant to sway slightly in the wind, which keeps the buildings from snapping under stress. But too much swaying—more than a foot or so in heavy winds—can cause people inside the building to experience motion sickness.

One solution was to place *blow-through floors* every dozen stories up the building. These floors are left empty and open to the elements so that wind can pass through. That reduces the *wind load*—the force caused by wind pushing on the building—and the resulting sway.

A second fix was to install two massive 650-ton *tuned-mass dampers* near the top of 432 Park. These devices reduce the size of *vibrations*, such as those caused by wind, on a structure. They have a large weight that hangs from cables and gently swings back and forth like a giant pendulum. They're designed to move in the opposite direction of the building's sway to lessen the overall movement.

WORLD'S TALLEST BUILDINGS

Supertall buildings are changing the shape of city skylines around the world. How much taller is the tallest building in the world compared with the tallest building in the U.S.?



SHANGHAI TOWER

The Shanghai Tower in Shanghai, China, is the second-tallest building in the world, standing 632 m (2,073 ft) tall. The 128-floor building's twist is its most distinctive feature.

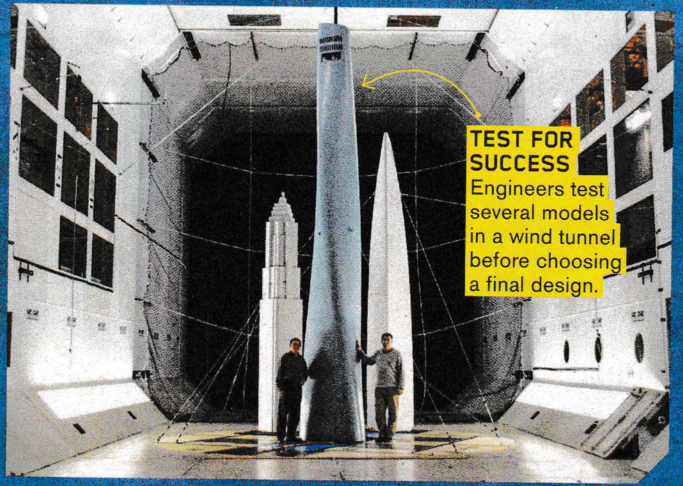
While designers chose to include a twist, it was up to engineers to determine what angle the twist should be in order to best withstand strong winds. Engineers tested various designs by placing models of the building inside a wind tunnel. Air blew over and around the models, allowing engineers to measure the buildings' wind loads. The winning design experienced 24 percent less wind load than the others. Because the building would experience less force from wind, its structure didn't need to be as strong as other designs. The builders were able to use 25 percent less steel, saving an estimated $58 million.

The ground under the Shanghai Tower presented an additional engineering challenge. The soil there is loosely packed, like sand. When a person walks on the beach, the weight of his or her foot pushes the sand particles together. That *compression* causes the person's foot to sink. The same thing would happen with the Shanghai Tower, which weighs tens of thousands of tons.

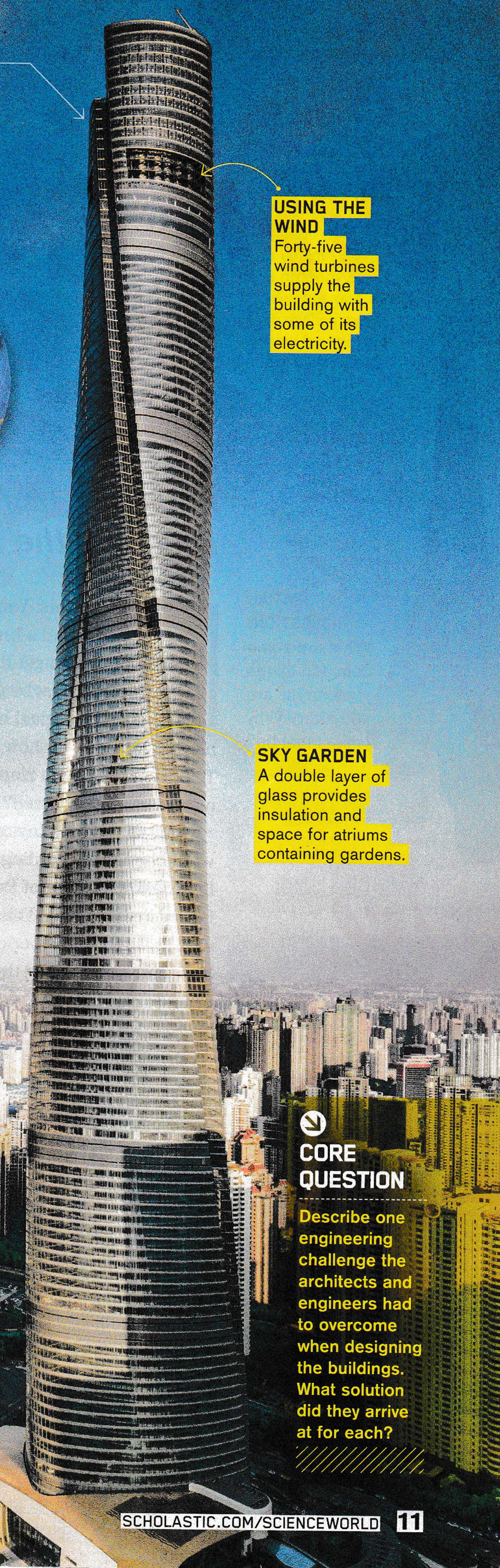
To prevent the tower from sinking, engineers drove 947 steel piles more than 60 m (197 ft) into the ground. They covered the metal columns with a 6 m (20 ft)-thick layer of concrete. This superstrong foundation helps stabilize and support the building.

"The engineer's job is to come up with the worst possible scenario and design solutions for it," says Kathy Dunne, a professor of architecture at Pratt Institute in Brooklyn, New York.

—Jacob Batchelor



TEST FOR SUCCESS Engineers test several models in a wind tunnel before choosing a final design.

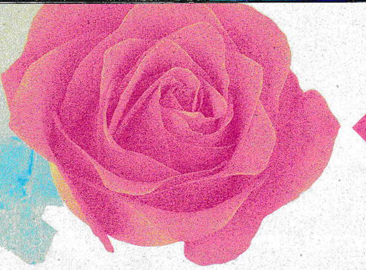


USING THE WIND Forty-five wind turbines supply the building with some of its electricity.

SKY GARDEN A double layer of glass provides insulation and space for atriums containing gardens.

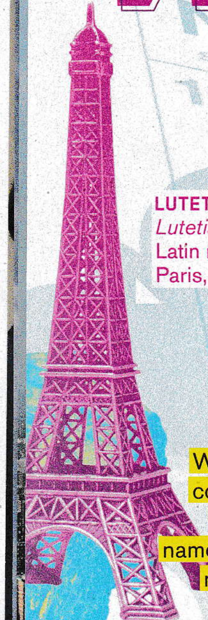
CORE QUESTION

Describe one engineering challenge the architects and engineers had to overcome when designing the buildings. What solution did they arrive at for each?



WHAT'S IN A NAME?

Four new elements have joined the periodic table. Discover the five rules used to name them.



ESSENTIAL QUESTION: What are some common things elements are named after? Why might that be?

Picture this: You're a physicist who has found a brand-new element. Now you get to decide what to call it. Maybe you'd name it after a mythological creature, something like unicornium. Or how about a state? Texasium has a nice ring to it. What about naming it after yourself?

It turns out that any of those names would be fine, according to the rules of the International Union of Pure and Applied Chemistry (IUPAC). This group oversees changes to the periodic table. It recently announced the names of four newly discovered elements: 113, 115, 117, and 118 (*see The 5 Rules of Naming, far right*). Here's what it took for scientists to find, confirm, and name them.

SMASHING SCIENCE

The periodic table contains 118 known elements. Of those elements, 94 are found naturally on Earth. But the other 24 can only be made in a lab.

Making a new element isn't easy. Scientists do it by smashing positively charged particles, called *protons*, into an atom's *nucleus*, or center, at extremely high speeds. If enough protons stick to the atom's nucleus, they can create an element that has never

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been seen before. These new elements last only from fractions of a second to minutes before they break down, though.

It can take years for IUPAC to approve a new element. That's because other researchers need time to confirm the results of the experiment that created it. In the meantime, the element gets a temporary Latin name based on its *atomic number*—the number of protons in an atom's nucleus. Element 113, for example, was called ununtrium, Latin for one, one, three.

NAME GAME

IUPAC says scientists must name new elements after one of five things: a place, a scientist, a mineral, a property of the element, or a reference to mythology.

Three of the new elements are named after the places where they were discovered. Element 113's name, nihonium (Nh), comes from Nihon, a Japanese word for Japan. Element 115, or moscovium (Mc), is named for Moscow, Russia. Element 117, tennessine (Ts), is named after Tennessee. The fourth element, 118 or oganesson (Og), is named after Yuri Oganessian, a Russian nuclear physicist who helped discover it.

Even though the names are up to the discoverers, IUPAC was flooded with suggestions from the public, says Lynn Soby, the organization's executive director. "It was great to see so many people around the world getting excited about chemistry," she says.

—Stephanie Warren Drimmer

CORE QUESTION

Explain why it takes so long for newly discovered elements to get named.

THE 5 RULES OF NAMING

An element can be named after a place, a scientist, a mineral, a property of the element, or a reference to mythology. Here's how four new elements got their names.

113
Nh
Nihonium
(284)

Nihon is Japanese for Japan, where the element was first created.

115
Mc
Moscovium
(288)

Russian scientists helped make and name this element.

117
Ts
Tennessine
(294)

Element was created by scientists at the Oak Ridge National Lab in Tennessee

118
Og
Oganesson
(294)

One of its discoverers was Yuri Oganessian, a Russian nuclear physicist.

ILLUSTRATION BY SEAN MCCABE

ALIEN LAND?

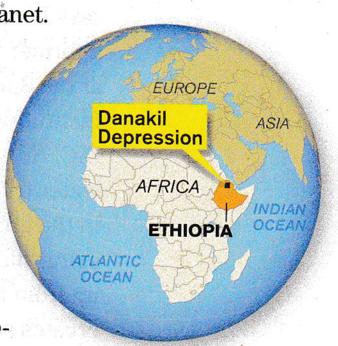
A strange land in Africa could be home to extreme life-forms

NO SWIMMING! Volcanic gases make Danakil's waters highly acidic.

EXTREME MICROBES Archaea are extremophiles that live in hot, acidic liquid environments, and could be similar to organisms that live in Danakil's ponds.

ESSENTIAL QUESTION: How might studying organisms living in extreme environments on Earth help scientists look for life on other planets?

A region in East Africa looks more like the surface of an alien planet than a landscape you'd expect to find on Earth. Scientists are drawn to its unusual features because they want to learn under what conditions life might exist beyond our planet.



Felipe Gómez is a microbiologist at the Centro de Astrobiología in Madrid, Spain. He has been to this otherworldly area of East Africa to study its *extremophiles*—microbes that live in some of the harshest places on Earth. Many scientists think alien life would likely resemble these tiny organisms.

"When you arrive at the area, it's like being on Mars—there's nothing around," says Gómez. "But as you approach, you climb to the top of a hill and look down into a basin to see colorful mineral formations and pools of water—it's really amazing."

This strange place is called the Danakil Depression, and it's found in the desert of Dallol, Ethiopia. What Gómez hopes to discover there could help scientists identify extreme environments throughout the universe where life could survive.

DANGER ZONE

Danakil is one of the most unforgiving places on Earth. During the day, for example, temperatures soar to 53°C (127°F).

Emerald-green pools dot the area. They might look beautiful, but they're filled with water so *acidic* it would start to eat away at the skin of your toe if you were to dip it in too long. The acidic ponds are caused by volcanic activity in the region. Danakil lies in an area where a *tectonic plate*—a large, slow-moving rock slab that makes up Earth's *crust*,

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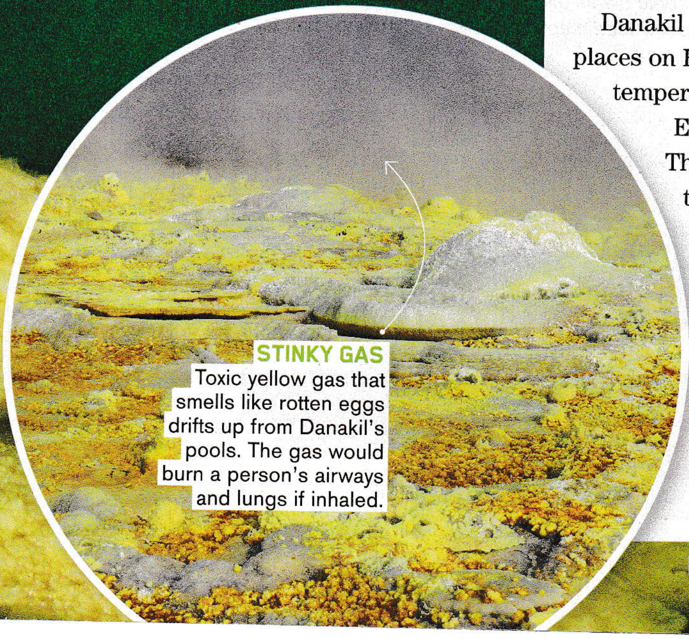


or outer layer—is being pulled apart. That allows hot rock and gases from deep underground to rise toward the surface (*see Cracking Up, below*).

“When water mixes with volcanic gases, the ponds become acidic,” says Richard Wunderman, a former volcanologist at the Smithsonian Institution in Washington, D.C. He says that pond water trickles into cracks in the ground, mixing with sulfur dioxide bubbling up from below. This creates sulfuric acid that causes a dramatic decline in the water’s *pH*—a measure of how acidic a substance is. The lower the pH of a substance, the more acidic it is.

WATCH YOUR STEP: A man walks on salt deposits to avoid stepping in Danakil’s acidic water.

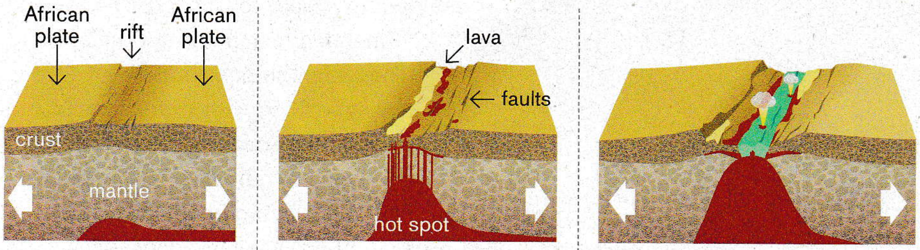
“These are not exactly ideal conditions for life,” says Gómez. He explains that the pH for all living processes is in the neutral range, a pH of 6 to 7.5. Danakil’s ponds reach extremely acidic pH levels of 0 to 2, he says. That’s about the same level of acidity as vinegar.

Not only is the water acidic, it’s also boiling hot. When water seeps deep underground, it makes contact with *magma*, or liquid rock beneath Earth’s surface. The superheated water then gushes back into the ponds through cracks called *hydrothermal vents*. This heats the ponds to about 40°C (104°F). They’re like steamy, toxic hot tubs.

You’d think nothing could survive such harsh conditions, but Gómez says Danakil’s unique geology makes it the perfect place to hunt for extremophiles. “Its heat, acidic pools, and tectonic activity mean there are several physical and chemical parameters that can be studied,” he says. “These conditions are completely

CRACKING UP

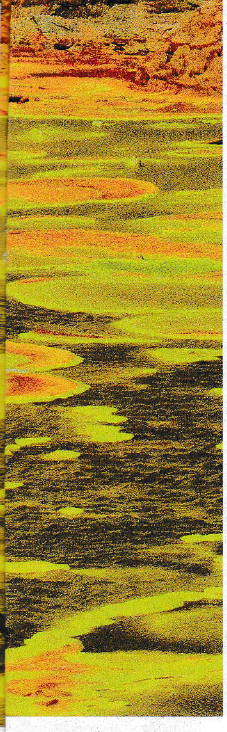
The Danakil Depression is part of a larger area in northeastern Ethiopia known as the Afar region. There, the African and Arabian *tectonic plates* (slowly moving slabs of rock that make up Earth’s *crust*, or surface) are grinding together (*see map, right*). This is causing changes to the African plate’s landscape (*see diagram, below*).



1 The collision between the African and Arabian plates is causing the African plate to form a *rift*, where the crust is splitting in two.

2 As the African Plate splits, a *hot spot* forms. This is a region where *lava*, or melted rock, spews from *faults*, or cracks formed in Earth’s crust.

3 This volcanic activity is the cause of Danakil’s unusual landscape.



different from the conditions that human beings live in, but they might be optimal for some extremophiles."

EXTREME ADAPTATIONS

Although this region has long interested scientists, Gómez and his team were among the first to research life here. Danakil has remained largely unstudied because of conflicts in the area. "We had to be escorted by soldiers with machine guns wherever we went," Gómez explains. But he says the danger was worth the risk. He was able to study a special place found nowhere else on Earth.

Gómez and his team took samples from the pools, hydrothermal vents, and mineral deposits around the Danakil region. Samples from the hot acidic pools contained extremophiles. Each has evolved specialized structures within its *cell membrane*—the protective layer that surrounds a cell. These structures act as pumps to constantly remove acidic substances from the cells so the microbes can maintain a neutral pH within. The microbes' acid pumps are more powerful and numerous than those of microorganisms that live in environments with a lower acidity, says Gómez.

He also found that Danakil's extremophiles produce more of a specific family of *proteins*—large biological molecules that carry out essential roles within organisms—than the average microbe. This family of proteins protects cells against damage when they're exposed to high temperatures or *radiation*—high-energy waves or particles—from the sun or outer space.

Gómez says that understanding these adaptations could tell scientists more about how life is possible on other planets. In these far-off places, acidity, heat, and radiation levels could exceed those on Earth.

OUT OF THIS WORLD

Scientists call places on Earth that mimic the extreme environments of other planets *extraterrestrial analogs*. "Just in the past 10 years, we've come to find that there are more and more potentially habitable environments in our solar system," says Linda Billings. She is a consultant to NASA's Astrobiology Institute, an organization that studies places in the universe that could be home to alien life. Billings explains that scientists are searching all over Earth for unique new analogs to expand the boundaries of where we believe life can exist (*see Extreme Earth, below*).

Billings says the discoveries in Danakil could help NASA identify planets with similar features that could be home to extraterrestrial life. "Some of the things we look for on other planets are plate tectonics and hydrothermal systems, like we see in places like Ethiopia," she explains. "The more we learn about the conditions in which life on Earth can survive, the more we learn about which extraterrestrial environments are worth exploring."

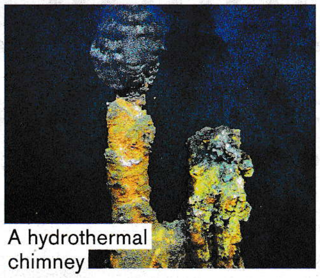
—Andrew Klein

CORE QUESTION

Based on Gómez's findings, what geological features might scientists look for on other planets to find possible alien life?

EXTREME EARTH

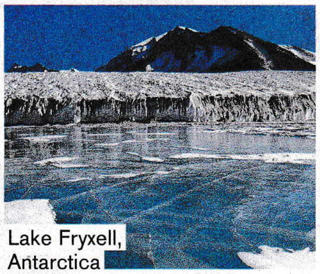
Check out these environments that are home to extremophiles.



A hydrothermal chimney

SEAFLOOR VENTS

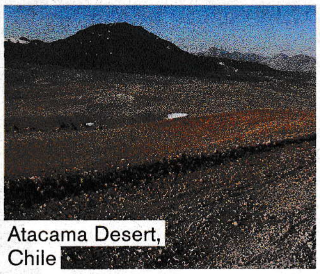
Mineral-rich fluid gushes from hydrothermal vents and chimneys on the seafloor. Microbes that live around these landforms use the minerals to make food. This might be similar to how the microbes in Danakil's hot pools make food to survive.



Lake Fryxell, Antarctica

UNDERGROUND LAKES

Thick mats of microbes live in near-freezing underground lakes in the Arctic and Antarctica. They survive by releasing gases that warm the water. NASA's Linda Billings says alien life could live in similar conditions in places like Europa—one of Jupiter's moons.



Atacama Desert, Chile

DESERTS

Microbes live in one of the driest places on Earth: the desert of Atacama, Chile, where it rains only once every other decade. Microbes called *endoliths* hide inside pores in rocks, where just enough water collects so the organisms can survive.

GAME GUYS: Danny Rivera (*left*) and Noah Rosenfield look over sketches for their game.

GAME-DESIGNING DUO

Noah Rosenfield and Danny Rivera create adventure-filled video games for mobile devices

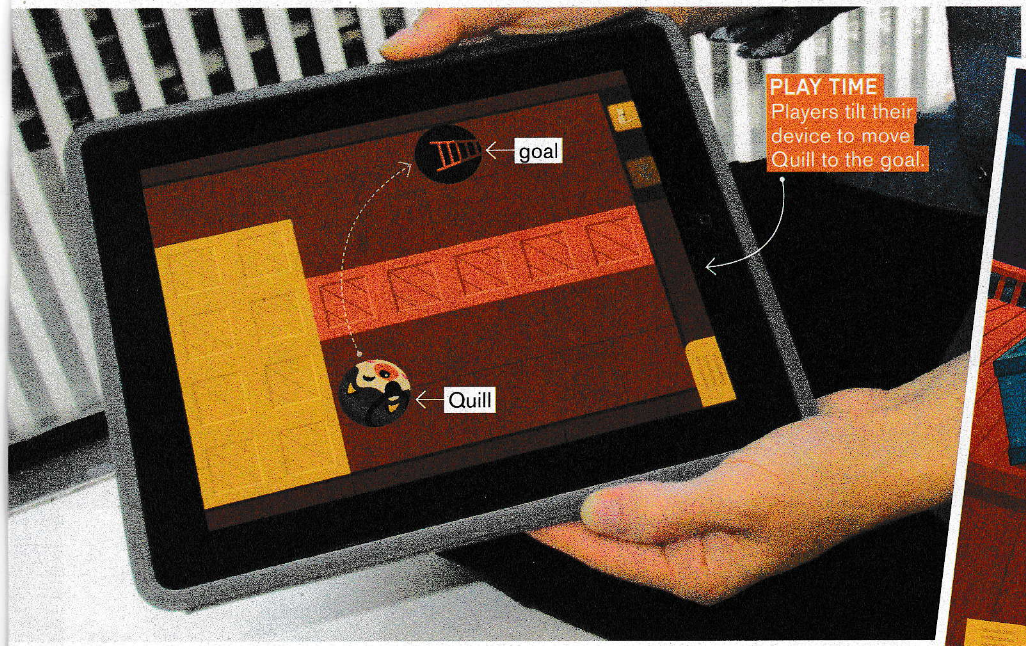
Oh no! Captain Quill has lost his hat. To get it back, the pirate hedgehog must travel between the decks of different ships. But as the boats rock on the water, crates and other objects keep sliding in his way. Quill is the hero of a video game called *Tilt: Quill's Quandary*. In the game, Quill gets around by curling up into a ball and rolling around. Players must tilt their mobile devices to move obstacles and guide the hedgehog through different challenges.

Noah Rosenfield and Danny Rivera designed the game. By day, Noah and Danny make games and videos for *Science World* and other Scholastic magazines. But in their spare time, they design mobile games like *Tilt* for smartphones and tablets.

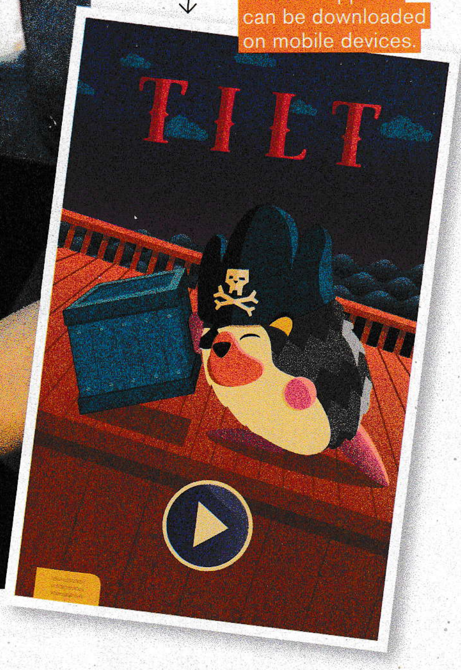
Noah and Danny had different roles creating the game. Noah is a programmer, which means that he writes *code*—the instructions that tell a computer what to do. Websites, computer programs, and apps like *Tilt* all run on code. Danny is an illustrator. He drew Captain Quill and the make-believe world Quill inhabits. *Science World* spoke with the team to find out what it's like to design video games.

How did you come up with the idea for *Tilt*?

Noah Rosenfield: In many video games, players share the point of view of a character in a virtual world. But I wanted to make something that felt like a digital version of a physical puzzle—like a game where you roll a marble through a maze to reach a goal. What I was thinking of didn't exist yet, but I really wanted to play it. That's why I decided to program the game myself.



PLAY TIME Players tilt their device to move Quill to the goal.



APP GAME *Tilt* is an app that can be downloaded on mobile devices.

What steps did you take to create the game?
Noah: Danny and I worked on *Tilt* for three years. It took two years to come up with the idea and to learn more about game design. During the final year, Danny worked on the game's illustrations and animations.

Danny Rivera: After Noah worked out the programming, he and I met for about six hours a week over six months to brainstorm and work on sketches. We decided that Quill should be a hedgehog, because this animal naturally rolls up like a ball. I made hundreds of rough sketches. Then I used a computer program to draw the final images.

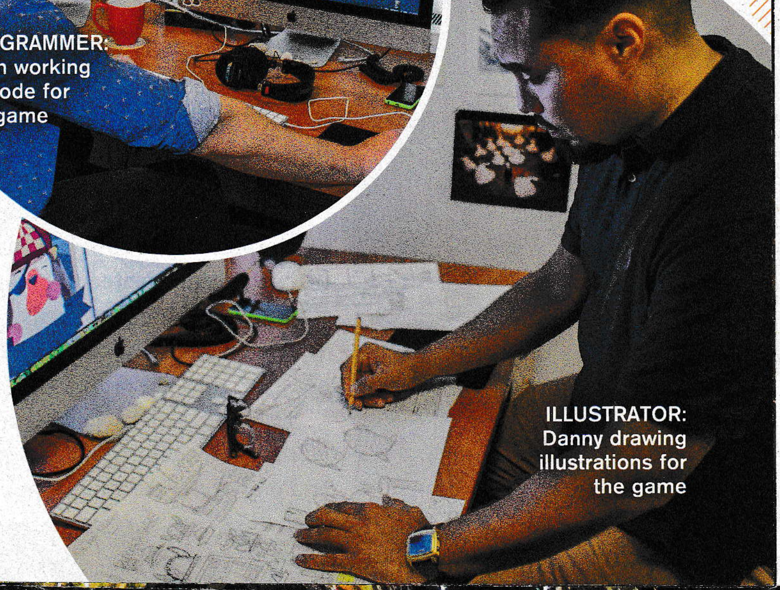
How does tilting your mobile device make Quill move?
Noah: Most mobile devices, like smartphones and tablets, contain an instrument called an *accelerometer*. It detects the device's orientation in space. For *Tilt*, I wrote code that communicates with a device's accelerometer. So when a user tilts his or her device, the code tells Quill to roll in that direction. I also wanted the *gravity* in the game to act like it would in the real world. Gravity is a force that pulls objects toward the center of Earth. The software is programmed so that when the phone is tipped all the way to one side, the pull toward that side is equal to the full force of gravity felt on Earth. When it's tipped halfway, for instance, the pull toward that side is about three-quarters the force of gravity on Earth.

Do you have any advice for aspiring game designers?
Danny: I would recommend that students take computer classes, including those that focus on digital illustration.

Noah: Playing video games is a great source of inspiration. Anytime you're playing one but wish the game did something different, take notes. Think about how you would improve it or make it more fun. Then go and make it yourself!

—Jeanette Ferrara

PROGRAMMER: Noah working on code for the game



ILLUSTRATOR: Danny drawing illustrations for the game

THE SECRET

Think plants are just a bunch of wallflowers? Think again: They network, communicate, and even care for their families.

ESSENTIAL QUESTION: How do plants interact with each other and their environments?

Let's face it: At first glance, plants don't seem to lead very interesting lives. How much can a brainless organism that's stuck in one place really do? Quite a lot, it turns out. Research shows that plants detect and respond to changes in the world around them. They maintain busy social lives, sharing resources and important news with others through complex networks. And they have highly developed senses much like our own.

"Plants can track almost everything happening in their environment," says Heidi Appel, an ecologist at the University of Toledo in Ohio. "This involves all the same basic senses we have—seeing, hearing, touch, taste, and smell—plus some others." Here's what Appel and other scientists have discovered about the secret lives of plants.

SENSITIVE BEINGS

Appel first became interested in whether plants could hear while talking with her colleague Rex Cocroft, who studies insect communication. He complained that the noisy chomping of a caterpillar was drowning out other bug sounds he wanted to record. "It was an 'Aha!' moment for us," she says. They wondered if plants could also hear and respond to the chewing.

To find out, the scientists recorded vibrations of a caterpillar eating leaves and played the recording back to some plants but not others. Plants exposed to the munching sound produced more *chemical defenses*, substances that taste bad to bugs. Many plants use these chemicals to avoid being eaten. Other sounds, such as wind blowing, had no effect. "Plants respond selectively to sounds that are important to them," says Appel. They ignore sounds that don't pose a threat.

Plants are able to sense other things besides sound. "They don't have noses or tongues, but they're very tuned in to chemicals in their environment," says Rick Karban, an ecologist at the University of California, Davis. "And they don't have eyes, but they're very sensitive to light." Plant tissues contain *photoreceptors*. These molecules allow them to tell how bright the light is and which direction it's coming from.

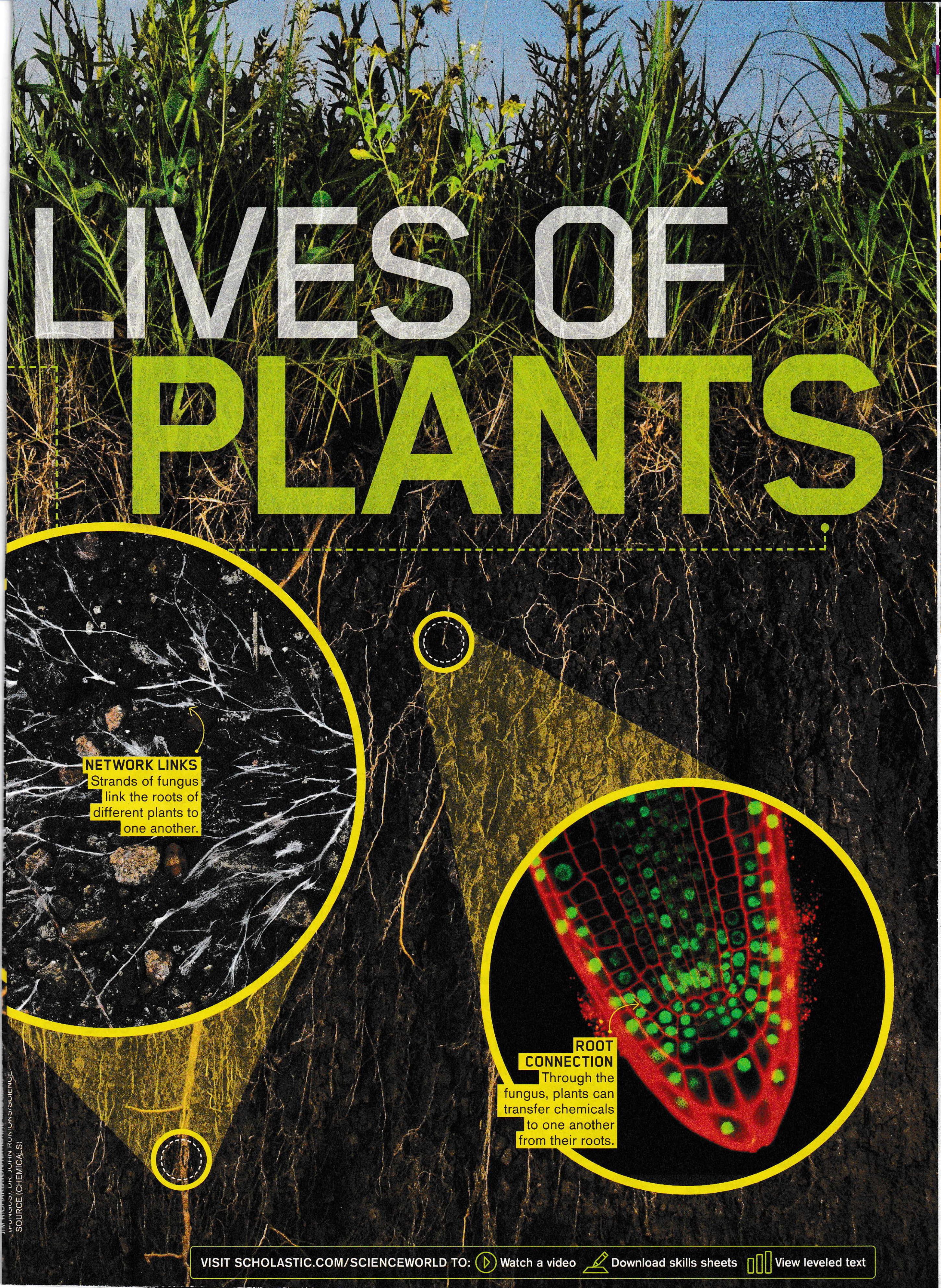
PREPARE FOR ATTACK!

We may not think of plants as chatty, but they communicate in a complex language of chemicals. Karban studies what happens when hungry insects injure sagebrush plants. "When a plant is attacked, it emits chemical cues into the air," he says. "Its neighbors detect those cues and increase their defenses."

Plants can prepare for an onslaught of bugs with not only chemical

Continued on p. 22 →

LIVES OF PLANTS



(FUNGUS); DR. JOHN RUNIONS/SCIENCE SOURCE (CHEMICALS) defenses but physical ones as well. Their tissue becomes tougher, making it harder to chew. And they can grow stiff hairs that thwart insects.

Some plants can even tell what kind of insect is eating them based on chemicals in the bugs' saliva. Depending on the attacker, plants release different alarm signals and adjust their defenses.

THE WOOD WIDE WEB

Trees may seem like the most solitary and unchanging plants of all. But they busily interact with their environment and their neighbors.

Scientists in Austria and Finland recently used lasers to map the position of tree branches (*see Tired Trees?, below*). At night, branches drooped, as if the trees were sleeping. At sunrise, the branches perked up again as trees angled their leaves to catch sunlight.

Some of trees' most interesting behavior happens underground. In the soil, tree roots partner with fungi called *mycorrhizae* (my-koh-RYE-zee). The fungi provide nutrients, like nitrogen (N) and phosphorus (P), to trees in exchange for chemicals containing carbon (C).

Strands of fungi form a dense network beneath the forest floor, which researchers have nicknamed the Wood Wide Web. It provides a physical connection linking trees and other plants to one another. "It's a highway for all kinds of chemicals," says Suzanne Simard, an ecologist at the University of British Columbia in Canada.

TREE TALK: Suzanne Simard studies chemical communication among trees.

Trees can use the network to share nutrients or water with neighbors in need. Species whose roots extend deep into the ground, like Douglas firs, collect water for shallow-rooted companions during droughts. In exchange, the firs may receive nutrients or compounds that protect against disease.

The biggest, oldest trees have the most network connections. Simard calls them "mother trees." They help youngsters grow, and they take special care of their families. Networked trees can chemically identify relatives, such as siblings or offspring. They send those seedlings extra food, nutrients, and water. If a tree in distress signals for help, nutrients or defensive chemicals arrive within hours.

"We've barely scratched the surface of the language of trees," says Simard. "Their conversations and exchanges are so complex."

PLANT SMARTS?

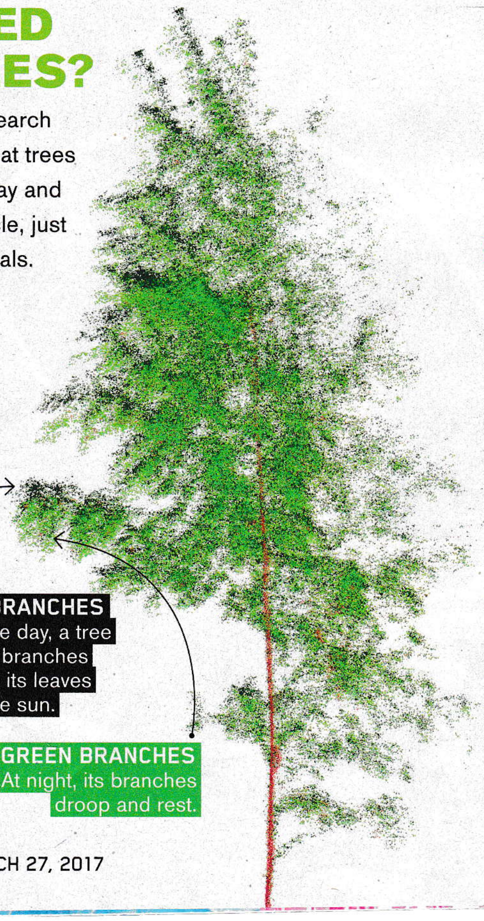
Some researchers even think plants may be intelligent, in a way. "They're collecting information about their environment and using it to make decisions that benefit them," says Karban. "If that process counts as intelligence, there's more and more evidence that plants are exhibiting it."

Some studies even suggest that plants may have a kind of memory of past events—such as bug attacks or cold snaps—that helps prepare them for future challenges. Plant scientists are still debating whether it makes sense to use terms like memory and intelligence for organisms without a brain. But there's one thing they agree on, says Appel: "Don't underestimate plants!"

—*Jennifer Barone*

TIRED TREES?

New research shows that trees have a day and night cycle, just like animals.



BLACK BRANCHES During the day, a tree raises its branches and turns its leaves toward the sun.

GREEN BRANCHES At night, its branches droop and rest.

CORE QUESTION

How do trees benefit from being linked to an underground network? Cite two examples from the text.

TINY TINKLE? Bees release excess nectar from their bodies so they can more easily fly.

BEE PEE?

Look out below! This photo seems to show a bee peeing. But the stream shooting from the bee's backside isn't pee. It's excess *nectar*—a sugary liquid collected from flowers as food.

Nectar is the primary source of energy for bees. Worker bees—all of which are female—gather the sweet fluid from flowers. At each stop, a bee unfurls its long, tube-like tongue. This organ, called a *proboscis*, works like a straw, allowing the bee to suck up nectar to bring back to its hive.

When a worker bee drinks nectar, the liquid fills an organ in the insect's *abdomen*, called the *honey stomach*. But having a tummy that's too full can weigh a bee down, making it harder for it to fly.

To lighten its load, the bee expels some of the liquid from its anus. (Bees excrete semi-solid waste in the form of *uric acid*, which exits through the same opening.) The bee pictured "is probably reducing her body weight to help with lift and flight," says Cory Sheffield, a biologist at the Royal Saskatchewan Museum in Regina, Canada. With less nectar left inside the bee's belly, the tiny insect was likely able to carry its remaining haul straight back to its hive to make into honey, explains Sheffield.

Though this behavior is not uncommon, catching it on camera certainly is. The act was caught by amateur photographer Mark Parrott in his garden in Grimsby, England. "He was set up to capture a fast-action shot at the right place and the right time," says Sheffield.

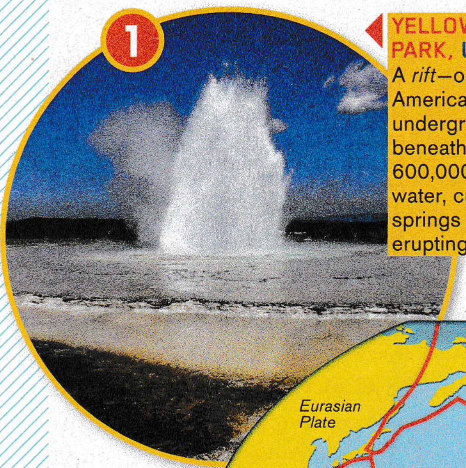
—*Spenser Mestel*

INTEGRATING VISUALS // COMPARE AND CONTRAST

SHIFTING SURFACE

In "Alien Land?" (p. 14), you learned that slowly moving *tectonic plates* cause volcanic activity. These giant slabs of rock fit together like a jigsaw puzzle, forming Earth's surface. Find out how tectonic movements cause volcanic activity around the world.

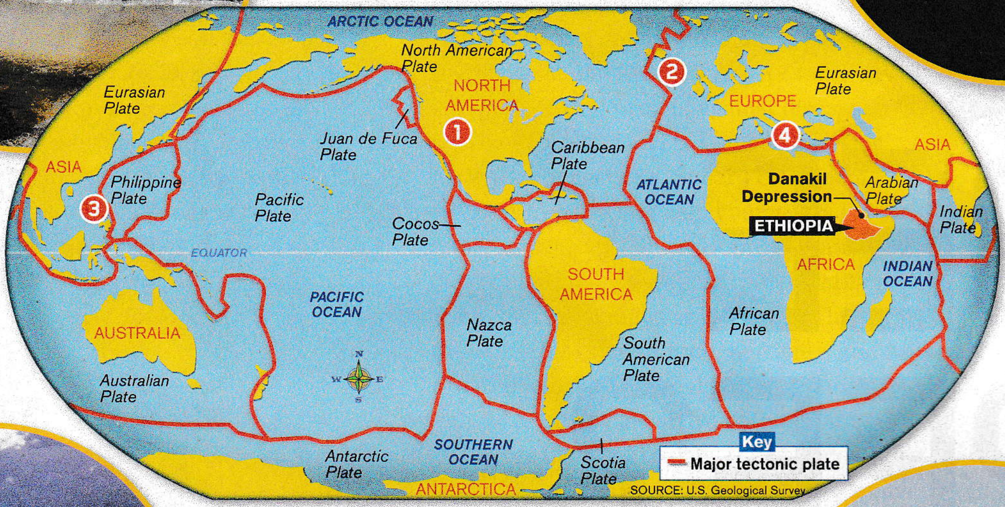
1



YELLOWSTONE NATIONAL PARK, UNITED STATES
A *rift*—or crack—in the North American plate caused a giant underground volcano to form beneath Yellowstone about 600,000 years ago. It heats water, creating the park's hot springs and *geysers*—which are erupting fountains of hot water.

2

BARDARBUNGA VOLCANO, ICELAND
The North American and Eurasian plates are sliding away from each other, causing volcanic activity like eruptions of Iceland's Bardarbunga volcano.



3

TAAL VOLCANO, PHILIPPINES
The Philippine plate is *subducting*—sliding under—the Eurasian plate, creating one of the world's most volcanically active regions. The area's Taal volcano has erupted 33 times in recorded history.

4

MOUNT VESUVIUS, ITALY
In 79 A.D., a major eruption of this volcano buried the ancient Roman city of Pompeii. Vesuvius last erupted in 1944—and could again in the near future. The African plate slipping beneath the Eurasian plate causes the volcanic activity.

ANALYZE IT Which of the four examples on this page is most similar to the volcanic activity at the Danakil Depression in Ethiopia? Explain why the location you chose is similar to Danakil.

SMITH COLLECTION/GADO/GETTY IMAGES (YELLOWSTONE); BERNARD MERIC/AFP/GETTY IMAGES (BARDARBUNGA); TED SPIEGEL/NATIONAL GEOGRAPHIC/GETTY IMAGES (TAAL); BILDAGENTUR-ONLINE/UIG VIA GETTY IMAGES (VESUVIUS); JIM MCMAHON/MAPMAN®(MAP)