

muise

JANUARY 2016

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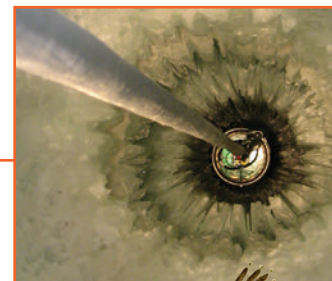
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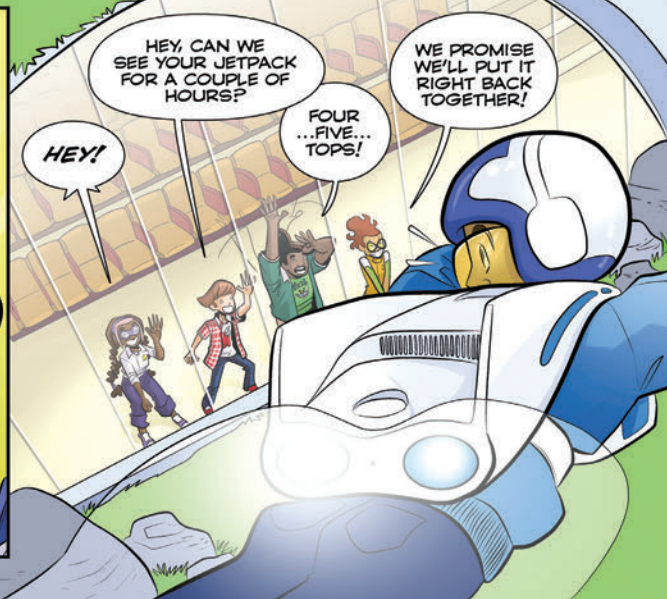
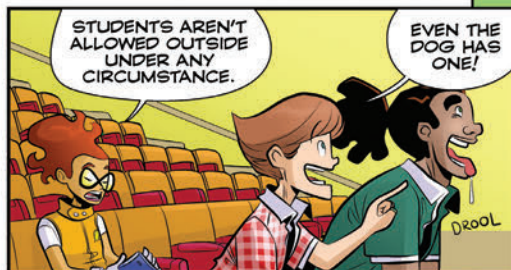
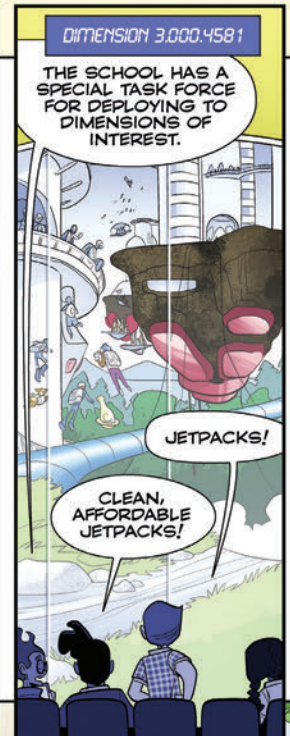
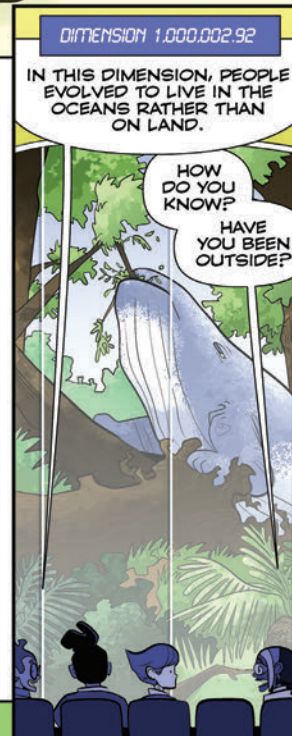
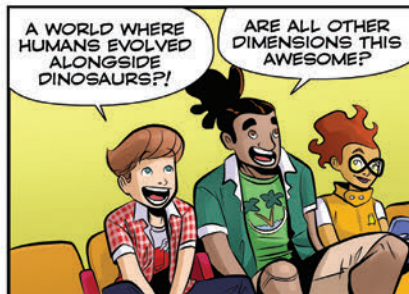
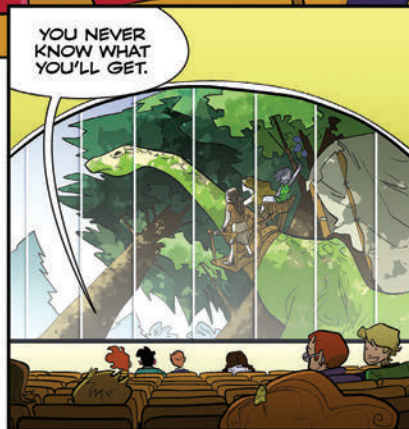
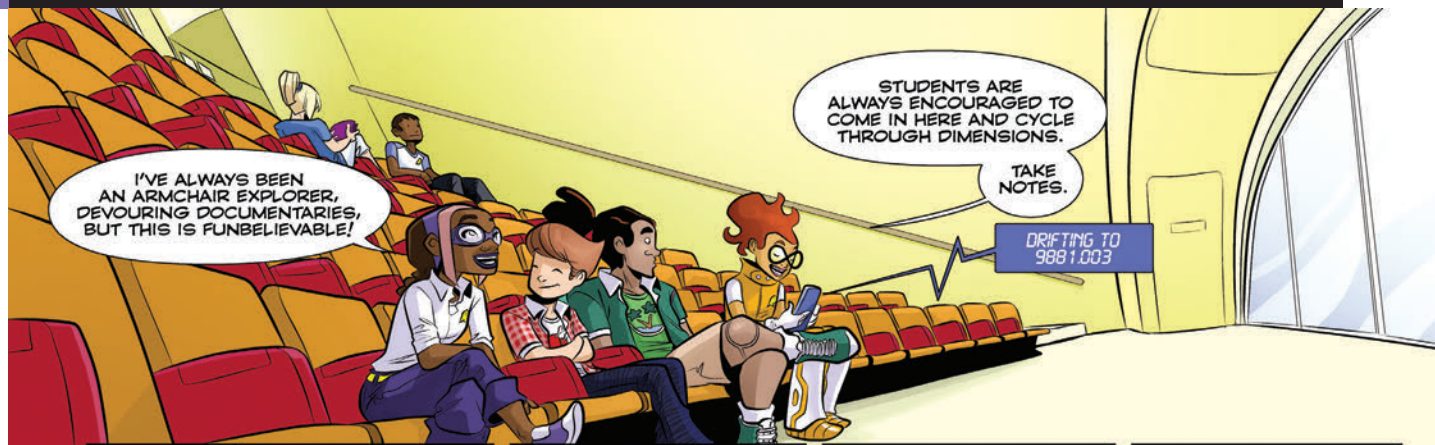
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Dear Muse

Namely the Nine New Old Muses, and Whatsi, O, and Aarti. And the Editors, but they aren't as important until the end.

LETTER
of the
MONTH

I am just wondering what happened to the Nine New Old Muses! I don't know why they would leave, but my best guess is that they were able to create each of their paradises and went to them and never came back. Oh well. Welcome, Whatsi, O, and Aarti. I like S.T.E.M. and all, but S.T.E.A.M. is MUCH better! Because there's art! NEVER LEAVE OUT ART!

Editors, it would be nice if you guys could do an article on different emotions and how to deal with them. Also, I would be very thankful if you guys did an article on Latin and the Ancient Romans, and/or the care and keeping of livestock such as pigs or cows (as pets). I love animals, mint green, and HOME DESIGN!

Love love love

—**MAEGAN ESTELLE YOSHIKO F. AND GOODBOY SAGEBRUSH F.**
(MY CAT) / California

P.S. The pink bunnies at Mnemosyne are an AWESOME touch.

P.P.S. I invite all of the Muses to vacation at my house, where there is a zip line, slackline, and rope to climb. Please come Old New Muses ... I'm sure you'll like it.

P.P.P.S. I will send GoodBoy to hack into your system if you don't publish this letter, and he will make you send all copies of *Muse* magazine to me! Mwahahahahahahaha!



Hi Maegan! Thanks for the welcome! I agree with you 100 percent about adding the A! Art totally fits between engineering and math. Plus ... don't art and design make life SOOO much more beautiful and interesting?

—**AARTI**

P.S. GoodBoy Sagebrush, if you're reading this, could you send notes on your hacking strategy? I usually prefer programming because it's more elegant and constructive, but how could I pass up tips on cathacking?

Yes: Stay Tuned

Could you do an issue on CRISPR? It's an amazing new gene-altering technology.

—**KAI B.**

P.S. I send no threats with this letter. I probably won't even open the cage of the editor-eating laser cats if you put it in the FMP.

Weird in a Good Way

Could you do an article on synesthesia? I think it is interesting how two of the five senses can be combined to make one and how it's related to autism. By the way, to prove how awesome your magazine is, my mom (who is an English teacher) reads *Muse* before I do, and whenever I read *Muse* to my college-aged sister, she gives me an I-did-not-know-that weird look (which is a good sign).

—**ADELINE, THE UKULELE, PIANO, AND FLUTE MANIAC** / age 10 / USA

Happiness Is a Super Tall Stack

I will not lie. Way before I started on Muse, my parents got me a lot of magazines.

Like, a lot, a lot. I got *Ladybug*, *Cricket*, *Ask*, even some *Spider*. I read them all (mostly my parents read them to me). My brother and sister read them too, so we had a super tall stack. As each of us got older, my parents subscribed to other magazines: *Faces*, *Appleseeds*, *Calliope*, *Dig*, etc. I actually discovered *Muse* when they sent us a *Muse* instead of an *Odyssey*! I read the first one and was like "HOLY CHEESEBEARDS. THIS STUFF IS GOOD!" I'm hooked!

—**SOPHIA S.** / age 11 (SOOOO close to 12 but not there yet) / San Francisco, California



A calico kitten approximately 10 years and 10 months younger than Jingle. Letter-writing ability not yet evident.

Order: Carnivora;

Family: Felidae

My name is Jingle. No, I am in fact NOT a *Homo sapiens*. I am a *Felis catus*, or domesticated house cat. Will you do an article on the system of classification, scientific names, or the *Puma concolor*? Also, in your Viral Video How-To [July/August 2015], I very much agree. We kittens are the cutest! I have borrowed this mag from the *Homo sapiens*. It is the cat's meow!

—JINGLE CALICO / age 11

P.S. Please publish this letter or I shall send my friends, the big cats.

Tips and Tricks

I have become my school's newspaper's editor, so can you give me some tips? I've decided not to be mad at you anymore because my mom said that sometimes people like you (The Editors) don't have a choice about it.

If you do put this in the

magazine, could you write back on how to pronounce "Mnemosyne" because I am having a really hard time pronouncing it? I am not going to threaten to send my army of Hot Pink Bunnies to attack you or anything IF you promise to put this in the next *Muse*.

—KLARA (PRONOUNCED KL-ARE-UH), THE (NEW) QUEEN OF HAMSTERS



Hi Klara. Apparently I'm the expert on pronouncing "Mnemosyne." (Keep this to yourself, but the Editors get tongue-tied every time they try to say it out loud. It's awkward.) Anyway, I don't speak Greek (yet) but to me it sounds like NE-MOSS-UH-NEE. Or you could say "No moss on knee" really fast with Pop Rocks in your mouth. Hope that helps. Your fellow hamster aficionado,
—O

P.S. Oh, and the Editors said: "Congrats on editing your school paper! We suggest learning to love your style guide and delegating tasks when necessary."



Clandestine Activities

I am a member of the Hungers, the secret group who protects awesome magazines like this one from weird thieving psychos.

I can't really specify on where headquarters is, but I'll tell you it's in the scenic city of Over the Rainbow in the country Hamati. I REALLY love your magazine. I'm interested in the brain, so maybe you could do an article on how the brain works and what the different parts of it do?

If you don't publish this . . . uhhh . . . I'll . . . throw a hot-pink-bunny-shaped moldy pie at you? Yeah, that's what I'll do. I just got to make that pie . . .

—RAVEENA P., MEMBER OF THE HONGERS, GUARDIAN OF THE GARGOYLE GATES / age 11 / Arizona

Dragons Among Us

You are probably wondering how a dragon gets your magazine.

Well, we have our ways. Usually when someone, a someone being a human, finishes reading your mag, and sets it down on a park bench somewhere or puts it in the recycling, we go out and snatch it. When it's left on a park bench it is relatively easy to get it back, but when . . .

You know what, skip that. Your mag is SO SO SO COOL that NOBODY would DARE to throw it out!

—HANNAH "FLAME" W. / Atlantis

P.S. My dragon name is not Hannah. It is Ermin, but don't tell anyone.

P.P.S. Loch Ness monster has a peculiar taste that takes some getting used to.

Skeptics from Far, Far Away

I am from M1 Galaxy. My name is (translated) William. I am the nerd in the third class.

But enough with the introduction. *Muse* magazine is the official magazine in M1. Nobody believes there is life where you are. They think *Muse* is created by gases mixing together.

I would love it if you wrote an article about galaxies other than the Milky Way. It would be nice if you mentioned M1, if you wrote it.

—KEILORB-VALDIMEZ
(PRONOUNCED KEY-LORB VAL-DI-MES) / age 9



Hey William. (Can I call you William?) I took a look at your rough map and think I may have pinpointed your galaxy. Is it in the cluster Abell 520? I drew an arrow to my best guess for M1. Looks like your galaxy is more than 2 billion light-years away. That's too far for my transgalactic radio frequency to reach, but I'm still making adjustments. Please stand by! Talk soon (hopefully),

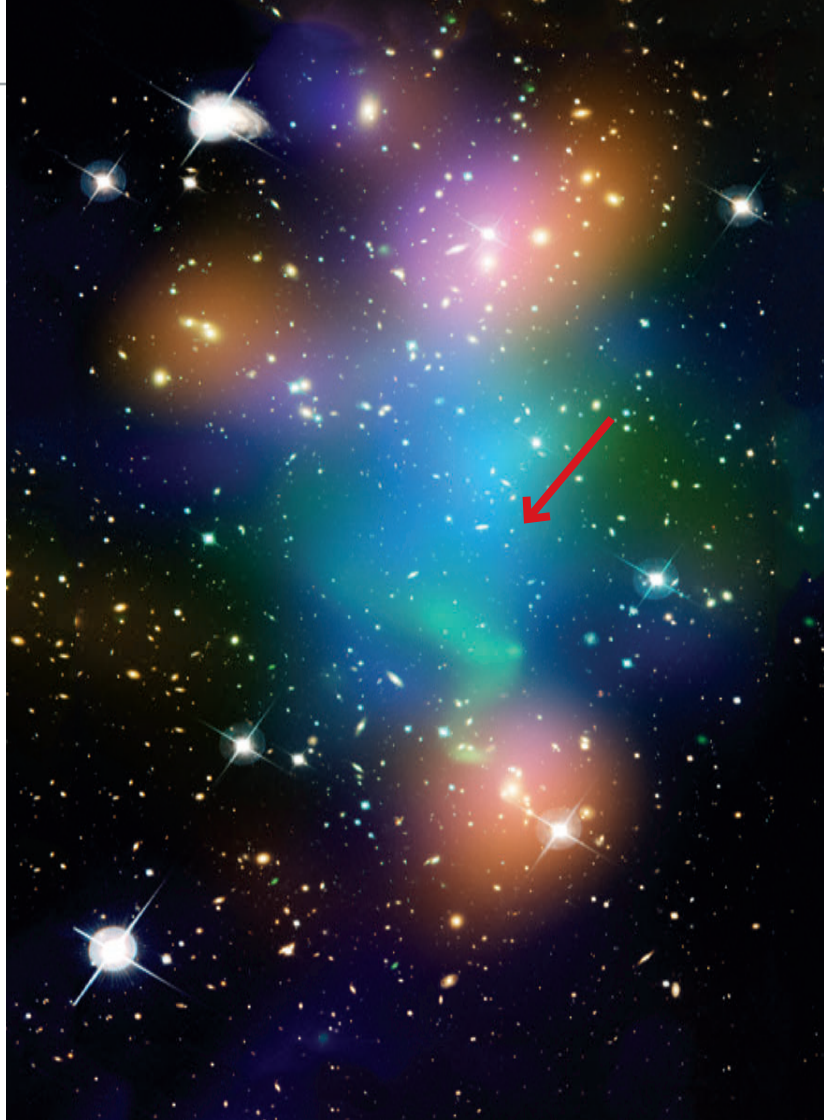
—WHATSI

A Question of Language

There was one problem, no, error, in a letter I want to correct. In her [July/August 2015] letter, Tara, age 9, says, "There are three major dialects of Chinese: Mandarin, Taiwanese, and Cantonese."

How is this wrong? These are not "dialects," but languages. There is no one Chinese language. The official language, Mandarin, is often called "Chinese," but it is not the first language of all Chinese people.

Examples of Chinese languages are: Mandarin, Wu, Cantonese, Hakka, Yue, Min Bei, Gan, Jin, Xiang, and Pu-Xian. There may be others I have forgotten. The point is that Chinese languages have as much diversity as Romance languages. This may sound like I have way too much free time, but I think that Americans



should know more about things outside their country.

—PHILIP N. / New Mexico

Crawling This Way

I have only had your mag for a few months, AND IT'S AMAZING!!! You see I'm on this quest to know everything and I mean EEEVVVEEERRYYY-TTTHHHIIINNNGGG!!!

Did you know poison dart frogs are only poisonous because of the bugs they eat; did you know pizza was actually made in Pisa, Italy, by a boy whose sisters made pie; did you know ice cream is great? D-d-d-did you know Nicola Tesla is amazing and you should do an article on him?

Also this letter is robotic and will crawl out of the fan mail pit. And if you still ignore it I will send my three chinchillas that will chew your cords, a bearded dragon that will make you all grow beards, Peg Leg Percy (our pet rooster), who will peck your feet till you pet him, and a mouse in my room that steals my chocolate, but will be stealing yours.

—GABE / age 13 / not from northern New York

Something to say?

Send letters to *Muse Mail*,
70 E. Lake St., Suite 800,
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or email them to
muse@cricketmedia.com

»» One of these stories is false. Can you spot which one? The answer is hidden in this issue.



»» HEALTH

Friends Keep You from Feeling Blue

SURE, YOU can catch a cold from your friend, or the flu from your lab partner. But can you catch feelings?

Researchers in the United Kingdom say yes: friends with healthy moods can protect you from becoming depressed.

After teens answered questions about

their moods, researchers rated each teen as having either a healthy mood or symptoms of depression. The teens answered the same questions again 6 to 12 months later. They also listed their friends at school. By looking at the results from every student within a school, researchers were able to map whole networks of friends.

They saw that depression doesn't spread like a disease. But healthy moods do. Depressed teens have a better chance of recovering if they have a lot of healthy friends. And someone with five healthy friends is half as likely to become depressed as someone with none. (If your cheerful friend gives you a stomach bug, though, you can still be mad at her.)



>> GEOGRAPHY

Undiscovered Island Is Pretty Boring

AMATEUR EXPLORERS have found what may have been the last undiscovered place on Earth. Disappointingly, it's very dull.

The island is round and about three quarters of a mile wide. It sits in the northern Pacific, where temperatures are not tropical but not too cold. It's almost completely flat and rocky. The island's only distinguishing feature is a slight hill on the eastern side. Some grasses and low bushes grow on the island, and its only resident animals are a few common flies and other insects.

After spotting the hidden piece of land in what first looked like a Google Earth glitch, the group of friends set out in a boat to confirm what they'd found. They're now running an online contest to name the island. They hope its name will be interesting, even if nothing else about it is.

>> ZZZZZ

SCHOOL STARTS TOO EARLY, SAYS GOVERNMENT

Think your school day starts too early in the morning? So does the Centers for Disease Control and Prevention (CDC). The government agency surveyed almost 40,000 middle and high schools around the country. It found that most schools start at an unhealthy time.

Doctors in the American Academy of Pediatrics say school shouldn't start before 8:30. Teens need a lot of sleep, and skimping on rest is tied to health problems and bad grades. Yet the CDC survey found that fewer than 1 in 5 schools started at 8:30 or later.

Your best odds of sleeping late are in Alaska, where the average school start time is 8:33. The worst? Louisiana, where kids have to be in class at 7:40 on average.



>> BOTANY

How Many Trees?

USING SATELLITE images and other tools, researchers estimated that there are more than three trillion trees on Earth—seven times more than earlier estimates, but about half as many trees as there were at the beginning of human civilization.

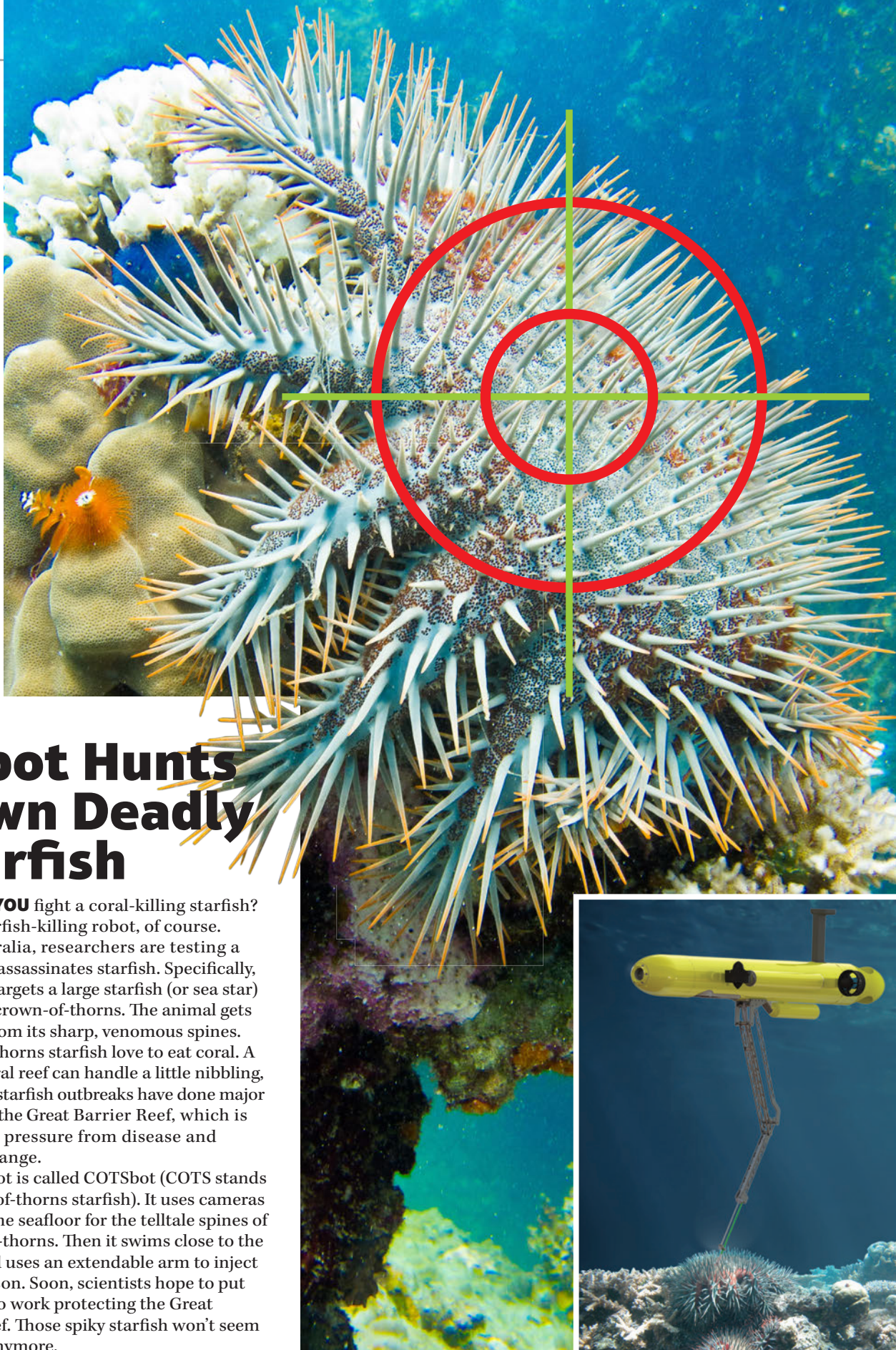
>> PALEONTOLOGY

Ancient Sea Scorpion Was Big Enough to Ride

Pentacopterus decorahensis roamed the seas long before humans—or even dinosaurs—existed. But don't feel too sad that you never met one. This eurypterid, also called a sea scorpion, was nearly six feet long.

Pentacopterus lived about 467 million years ago, making it the oldest eurypterid ever discovered. Scientists found fossils of the new species in Iowa. They named it after the penteconter, an ancient Greek warship, because of the animal's long body and predatory nature. *Pentacopterus* used its grasping arms to trap prey—and it probably wouldn't have appreciated you sitting on it.





» TECH DESK

Robot Hunts Down Deadly Starfish

HOW DO YOU fight a coral-killing starfish? With a starfish-killing robot, of course.

In Australia, researchers are testing a robot that assassinates starfish. Specifically, the robot targets a large starfish (or sea star) called the crown-of-thorns. The animal gets its name from its sharp, venomous spines. Crown-of-thorns starfish love to eat coral. A healthy coral reef can handle a little nibbling, but recent starfish outbreaks have done major damage to the Great Barrier Reef, which is also under pressure from disease and climate change.

The robot is called COTSbot (COTS stands for crown-of-thorns starfish). It uses cameras to search the seafloor for the telltale spines of a crown-of-thorns. Then it swims close to the animal and uses an extendable arm to inject it with poison. Soon, scientists hope to put the robot to work protecting the Great Barrier Reef. Those spiky starfish won't seem so tough anymore.

Breathtaking CRYSTALS

Secrets in the Naica mine

by Linda Zajac



Time is ticking deep inside a sweltering mine in Mexico. If Dr. Juan Manuel García-Ruiz lingers longer than ten minutes, the extreme heat and humidity could kill him. Beads of sweat trickle down his face. When his steamed-up glasses clear, his eyes widen with astonishment. The light from his headlamp shines on a spectacular site—enormous crystals! Some are as tall as telephone poles.



Protective gear helps researchers and filmmakers stay cool in the Cave of Crystals. Too bad Dr. Juan Manuel García-Ruiz didn't have similar gear!

CRYSTALS GALORE

García-Ruiz is a researcher and professor at Spain's National Research Council at the University of Granada. He studies crystals. "The main challenges were to measure the temperature and rate at which these crystals grew," says García-Ruiz.

Crystals are three-dimensional solid objects constructed from repeating patterns of molecules. They come in many different shapes, colors, and sizes. For most people, the word "crystals" conjures up images of snowflakes, fancy jewelry, and rock candy, but there are many other crystals. You eat salt and sugar all the time. These are both made of tiny crystals. Other crystals that form inside the body can lead to medical problems, such as kidney stones or cataracts. The soft colors and swirling curves found in seashells, eggshells, coral, and pearls come from crystals of calcium carbonate. Your bones contain crystals of calcium phosphate. When you brush your teeth, you're cleaning tooth enamel made of crystals.

The giant crystals are in the Naica Mine near Chihuahua, Mexico. They're the largest naturally occurring gypsum crystals in the world. The site is about 200 miles (322 kilometers) south of the Texas border.

AN INCREDIBLE SECRET

More than 20 million years ago, a magma chamber beneath Naica Mountain rumbled, shaking and shaping the land. In

1794, prospectors discovered ore in the dusty rock. While miners chipped away at the surface to extract precious silver, zinc, and lead, an incredible secret was brewing deep beneath their feet.

Mining operations expanded over centuries. These operations pumped out magma-heated groundwater that had coursed through the mountain. In April 2000, brothers Eloy and Javier Delgado were blasting around 1,000 feet (305 meters) down in the mine. When Eloy scrambled through a small hole in the rock, he stumbled upon the extraordinary "Cave of Crystals."

THE CAVE OF CRYSTALS

Rust-colored iron oxide deposits coat the walls and ceiling of the limestone chamber. Enormous columns crisscross, like crystal rafters, gleaming in the light. The most immense pillars weigh up to 55 tons—more than an 18-wheeler loaded with cargo. They look stunning against a backdrop of red. The smooth contour and glassy luster of the crystals deceive the eye. Although they look like great columns of ice, in reality they're as hot as a furnace.

García-Ruiz treks deeper into the stifling cave. He is careful as he steps. One fall on small, razor-sharp formations on the cave floor could prove deadly.

The crystals are selenite, a colorless, transparent mineral that can be split neatly into sheets. Selenite is a form of gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$), which you can also find in cement



The breathtakingly beautiful cave is making it hard to breathe. If his body heats up too much, he may get to the point of no return, when organs start to fail. He has to get out now!

“I was exhausted, drained, almost cooked by the hot and wet atmosphere,” says García-Ruiz, “but I was euphoric. I knew this wonderful picture of crystal harmony was possible—that crystals could grow this size in nature—but I never dreamed I could watch it.”

One bubble isn’t enough. To learn how the crystals formed, he needs to find more, but that’s not easy with these pure crystals. It means he and his colleagues have to enter the deadly, but mesmerizing, cave again and again.

GROWING MASSIVE CRYSTALS

After dozens of research trips to the cave, García-Ruiz analyzed 33 fluid samples. He learned the crystals got their start when the cave was filled with scalding groundwater—hotter than a hot tub. This scorching hot cauldron slowly cooled to 136.4°F (58°C), dissolving anhydrite rock. Gypsum crystallized in water saturated with calcium and sulfates. In the quiet darkness of this hidden inferno, the temperature remained constant for thousands of years.

To find out the giant crystals’ age, García-Ruiz collected small minerals and 14 water samples from various deep zones in the mine. In a lab, scientists who work with García-Ruiz placed the crystals in hot water from the mine to allow them to grow. With a high-tech microscope, they measured the minerals’ growth rates.

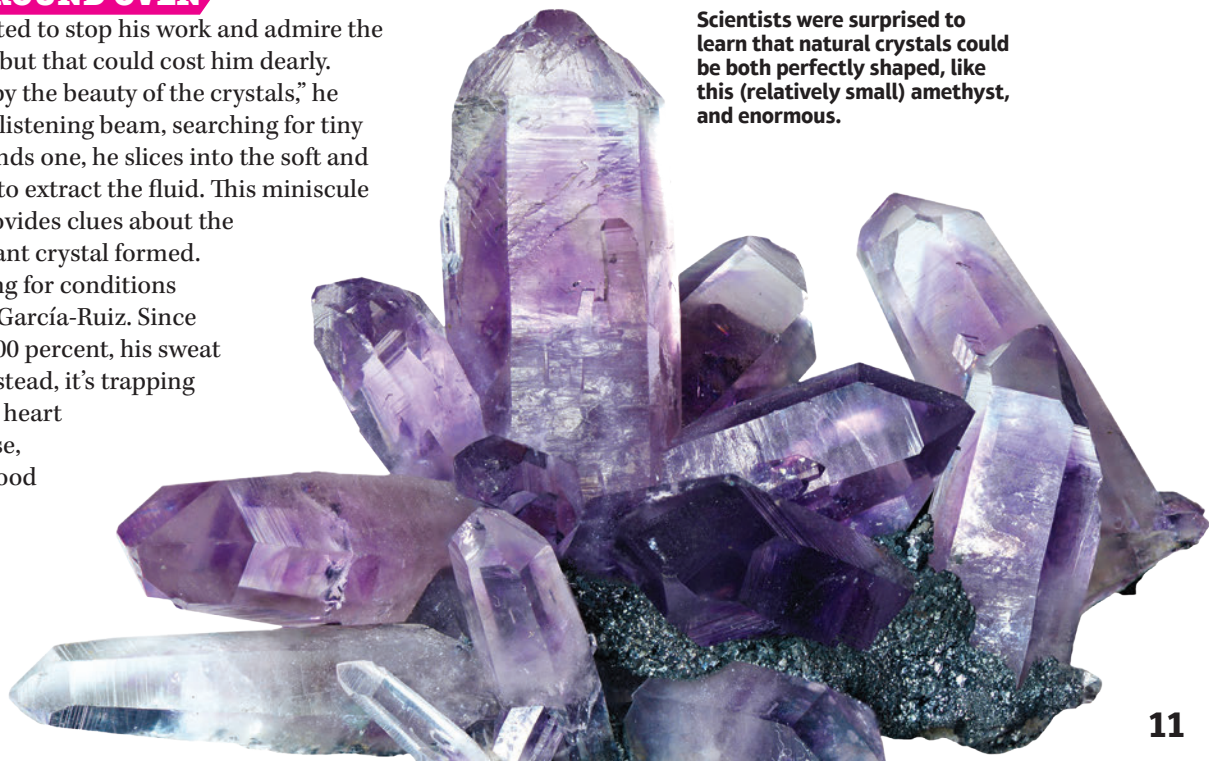
and plaster-of-Paris. Gypsum board, or drywall, covers the walls and ceilings in many homes. It could very well be in yours. Anhydrite, or calcium sulfate (CaSO_4), is gypsum minus water molecules in its chemical structure. Below 787 feet (240 meters), bluish anhydrite deposits are abundant in the mine.

THE UNDERGROUND OVEN

García-Ruiz is tempted to stop his work and admire the sparkling spectacle, but that could cost him dearly. “I was mesmerized by the beauty of the crystals,” he says. He inspects a glistening beam, searching for tiny bubbles. When he finds one, he slices into the soft and shimmering crystal to extract the fluid. This miniscule amount of liquid provides clues about the climate when the giant crystal formed.

It doesn’t take long for conditions in the cave to affect García-Ruiz. Since humidity is nearly 100 percent, his sweat isn’t evaporating. Instead, it’s trapping heat in his body. His heart beats faster. His pulse, temperature, and blood pressure rise. Sweat soaks his shirt and pants. It drips down his face and neck.

Scientists were surprised to learn that natural crystals could be both perfectly shaped, like this (relatively small) amethyst, and enormous.





Crystal specimens from the Naica mine on display

They were the slowest-growing crystals ever measured. García-Ruiz calculated that it would take a century for them to grow the width of a strand of hair. Now he could calculate the age of the crystals. They had grown undisturbed for around half a million years!

The slower a crystal grows, the better the quality. “The way the temperature changed is critical. The crystals are few and huge because the water cooled very slowly and there was a small, but continuous, supply of calcium sulfate from the rocks,” explains García-Ruiz. If the water had cooled faster, the cave would have been filled with many small crystals. His team developed new techniques and used advanced microscopes to measure the extremely slow growth rate of the crystals and the temperature at which they grew.

THE CRYSTAL CAVE'S FUTURE

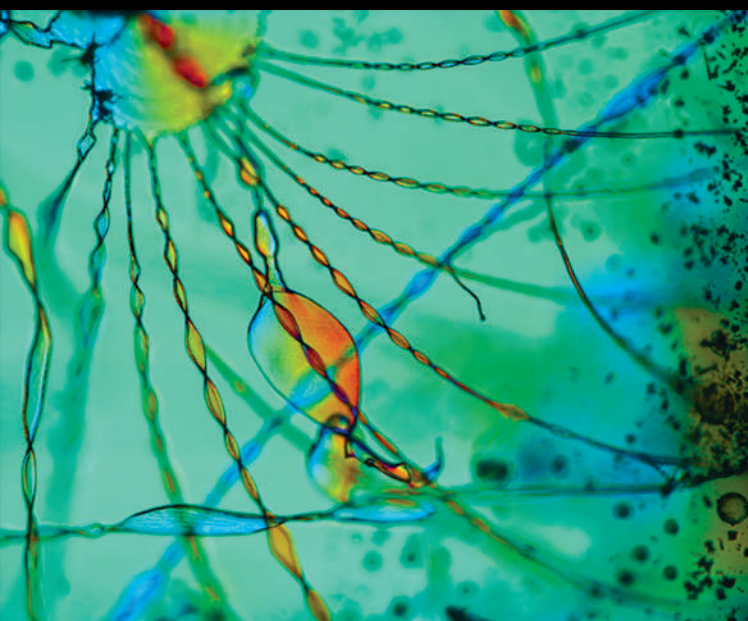
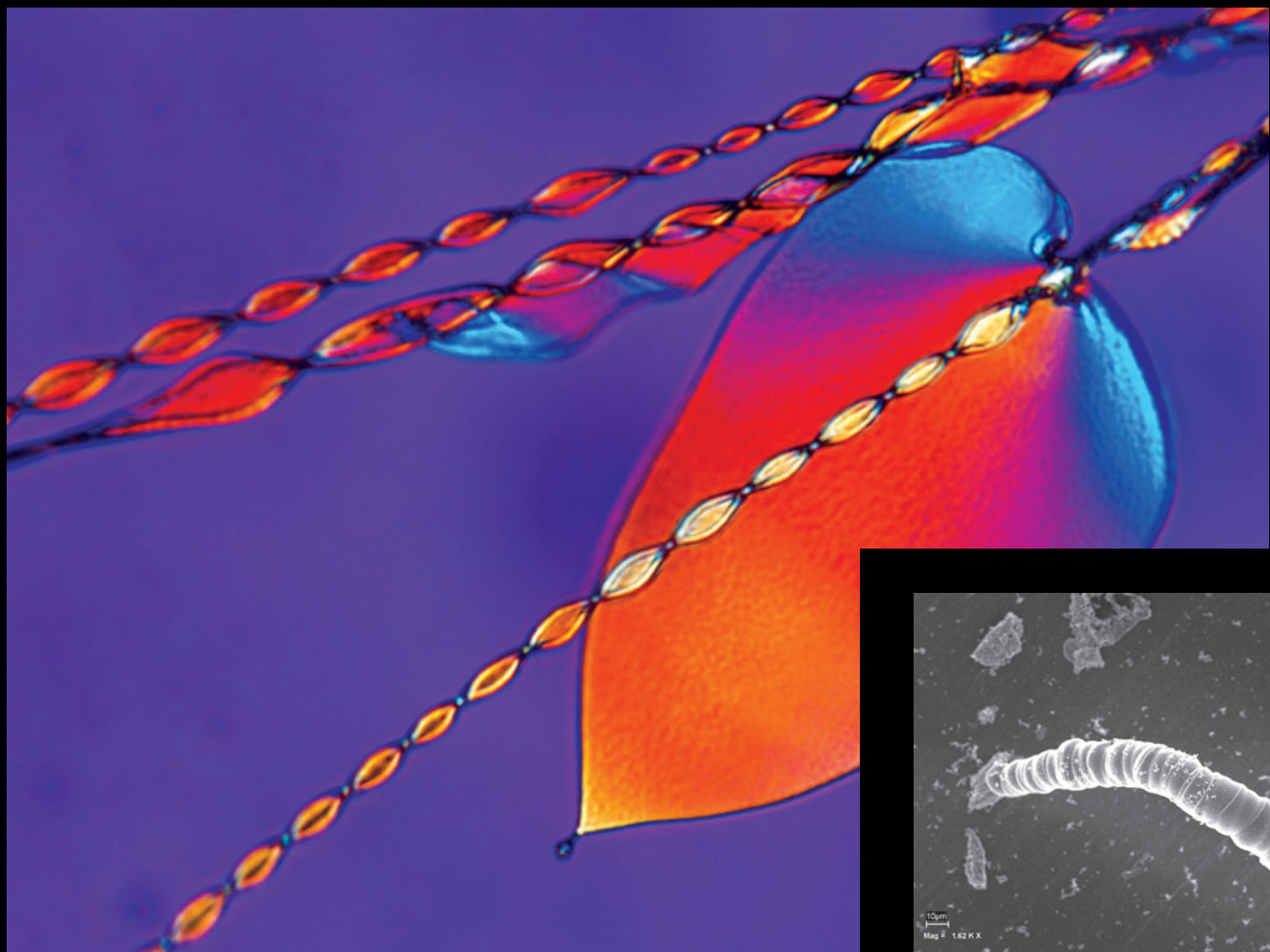
The future of the crystals is uncertain. They’re no longer growing because the mineral-rich water that nourished them continues to be pumped out. Eventually, they’ll erode

and collapse.

García-Ruiz has more questions about the crystals, but he may never get answers. The mining company may stop pumping water when it has finished its work. Then the groundwater would rise and fill the cave again. The crystals would thrive, soaked in magma-heated water, but Naica Mountain would become an inaccessible tomb for a magnificent work of nature.

García-Ruiz doesn’t want that to happen. He explains that these conditions are very difficult to re-create because it takes time to grow crystals this size. “Naica is still an ‘alive’ natural laboratory . . . from which many things can still be learned. . . . [It’s] a unique natural setting that should be preserved the same way we preserve archaeological heritage or biological diversity.”

Linda Zajac is a science writer. She enjoys nibbling on crystals of cocoa butter in the form of chocolate. Although chocolate has six different crystal structures, only one produces glossy chocolate with a great snap. Nom nom.



The beautiful shapes seem lifelike, but researchers used nonliving materials to grow these crystals in a lab.

PRIMITIVE LIFE ON EARTH

Crystals in living things grow in gentle swirls and graceful spirals. In nonliving things, they form edges and angles, lines and planes. “It was thought that living organisms and crystalline minerals belonged to two separate worlds,” says Dr. Juan Manuel García-Ruiz.

When investigating whether a fossil was once living, scientists typically look at how the organism formed. Curved crystal structures indicate a living thing. Based on this definition, the 3.5-billion-year-old Warrawoona fossils from Australia are hailed as among the oldest remnants of life on the planet.

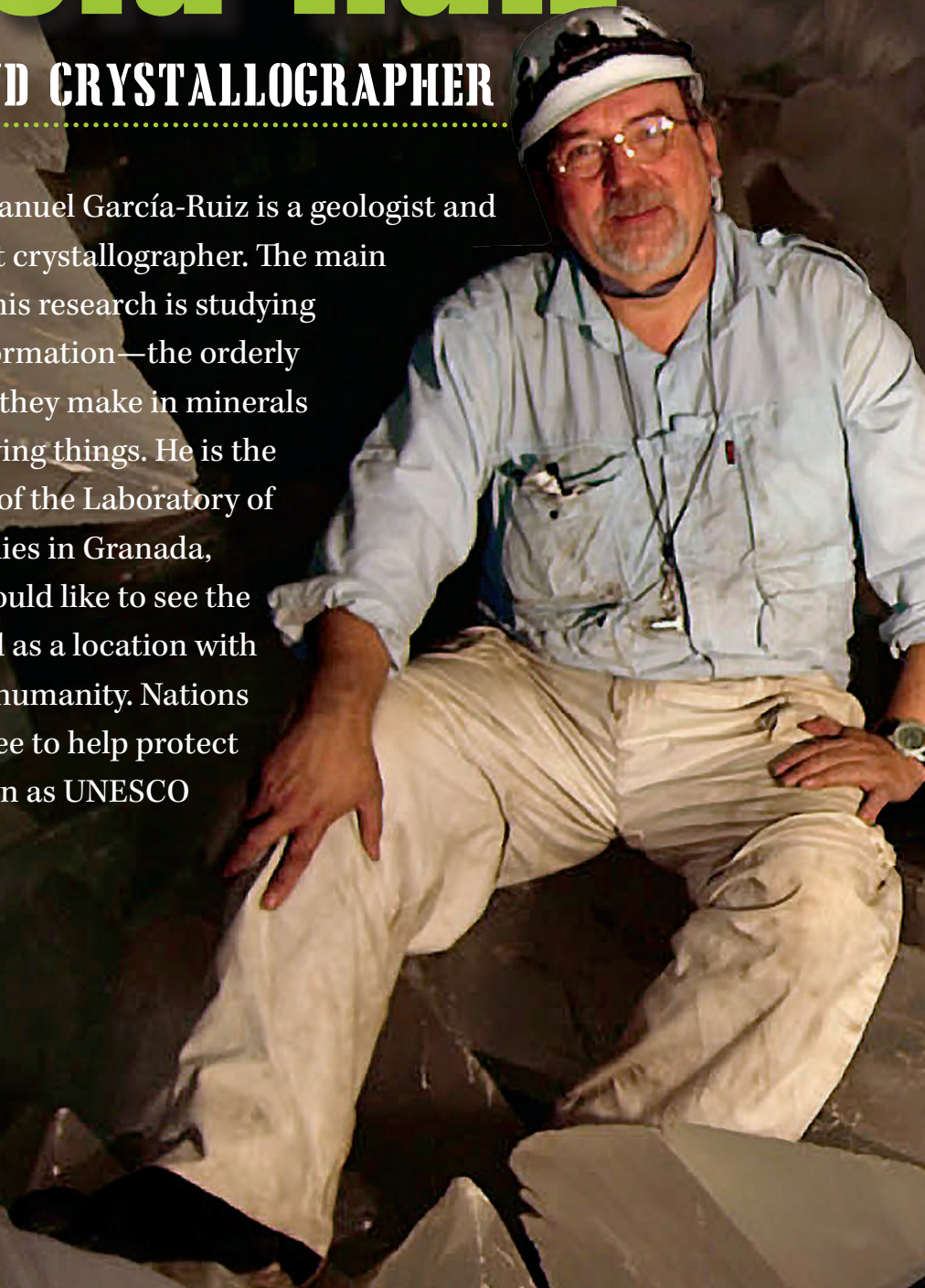
In his lab, García-Ruiz has created curved crystals from barium, a metal, and silica, a chemical in sand, glass, and quartz. The crystals look like ropes, flowers, and worms. Many resemble the Warrawoona fossils. García-Ruiz’s work developing curving crystals from metals is raising questions about how we define the oldest life on Earth.

—Linda Zajac

Juan Manuel García-Ruiz

GEOLOGIST AND CRYSTALLOGRAPHER

Dr. Juan Manuel García-Ruiz is a geologist and an expert crystallographer. The main focus of his research is studying crystal formation—the orderly patterns they make in minerals and in living things. He is the founder and director of the Laboratory of Crystallographic Studies in Granada, Spain. García-Ruiz would like to see the Cave of Crystals listed as a location with outstanding value to humanity. Nations around the world agree to help protect these locations, known as UNESCO World Heritage sites.



MUSE NEWS FALSE STORY:

Undiscovered Island
Is Pretty Boring

mineralogy, the work of crystallographers is essential. Of course we need crystallographers and crystal growers to produce the increasing number of crystals for silicon chips in high-tech devices.

Q What tools do you use?

I use very powerful optical and electron microscopes and also X-ray diffractometers [tools to study the structure of crystals]. I also have equipment to grow crystals in the laboratory.

Q Any unsolved mysteries?

There are many. We don't know when, exactly, life appeared on Earth and how the simplest, most primitive organisms emerged from pure minerals. We also need to search and explore other planets and moons for their mineral and rock formations and their geological histories.

Science writer **Linda Zajac** has a crystal ball on her coffee table. She's pretty sure it's glass, which doesn't have a crystal structure. Too bad she can't look into it and solve a geological mystery or two.

Silicon crystals help capture and conduct solar energy.

Q What fascinates you about your job?

I fell in love with geology because I was very interested in crystals and minerals. I wanted to know how they formed and how I could make them in the lab.

Q What is crystallography?

Crystallographers study crystals: their growth and their applications.

Q Why study them?

Crystals are important in the production of new materials and in our understanding of how life works at the molecular level. Crystals are intimately connected to life: living organisms form shells, bones, and teeth made of crystals. Crystals may even have been involved in the origins of life.

Q What opportunities are in this field?

There are many opportunities. The work of crystallographers is diverse. It's important for art preservation because most materials used in art, like pigments and paint, are made of crystals. It's necessary for structural biology and medicine too. In chemistry and

HOW OLD IS THAT ROCK?

There are two ways to tell. One is the relative age based on fossils found in the area. For example, *Tyrannosaurus rex* lived from 66 to 68 million years ago, so any rock discovered above the fossil layer is less than 66 million years old.

The second method is to use radiometric techniques such as carbon dating that measure radioactive decay. All rocks contain trace amounts of radioactive elements that are unstable. They break down over time into more stable forms. By precisely measuring the stable and unstable elements, geologists can determine the age of the rock.





by Carrie Clickard

Going Off *the (Really)* DEEP END

6.77 MILES DOWN IN THE MARIANA TRENCH

Help Wanted:

Expedition seeks explorers brave enough to face bizarre, glow-in-the-dark creatures. Must be able to navigate safely past vents spewing liquid carbon dioxide, erupting mud volcanoes, and a treacherous lake of molten sulfur.

What strange corner of the universe is this expedition headed for? It's a cozy little planet called Earth and a spot miles under the surface of the Pacific Ocean called the Mariana Trench.



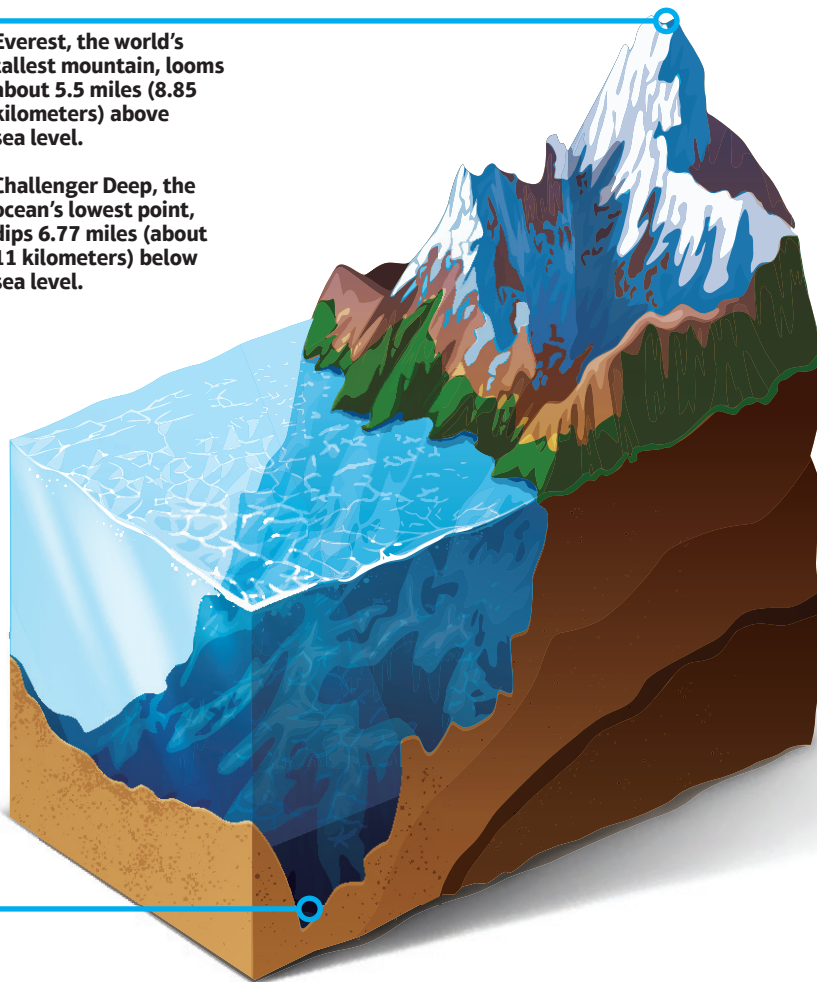
The sub *DeepSea Challenger* descends 5 miles (8,000 meters) in a test dive.



Jason, a remote-operated vehicle (ROV), takes samples at an underwater volcano near the Mariana Trench.

Everest, the world's tallest mountain, looms about 5.5 miles (8.85 kilometers) above sea level.

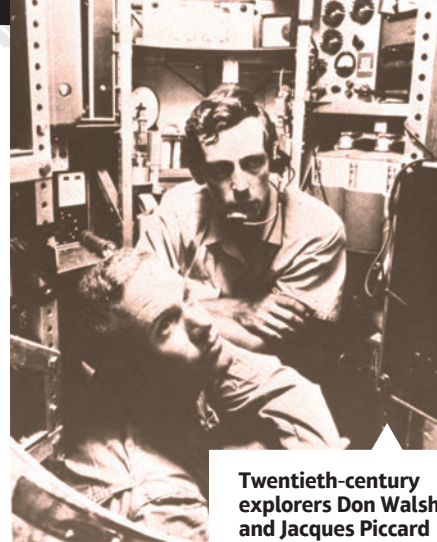
Challenger Deep, the ocean's lowest point, dips 6.77 miles (about 11 kilometers) below sea level.



A HOLE IN THE OCEAN FLOOR

In 1872, the HMS *Challenger* expedition set out to map the ocean floor. The explorers spent four years crisscrossing the globe, sailing 70,000 miles (112,654 kilometers)—one-third of the distance to the moon. It was backbreaking, boring work. Sail about 200 miles (322 kilometers), drop a weighted rope into the water.

Measure how much rope it took to hit bottom. Sail another 200 miles and do it again. And again. This expedition was a total snooze fest, until a day in 1875 about 200 miles off the coast of Guam. That morning, when the rope was dropped, the ocean swallowed up *miles* of it—five miles to be exact. The *Challenger's* crew had discovered a “hole” in the ocean floor.



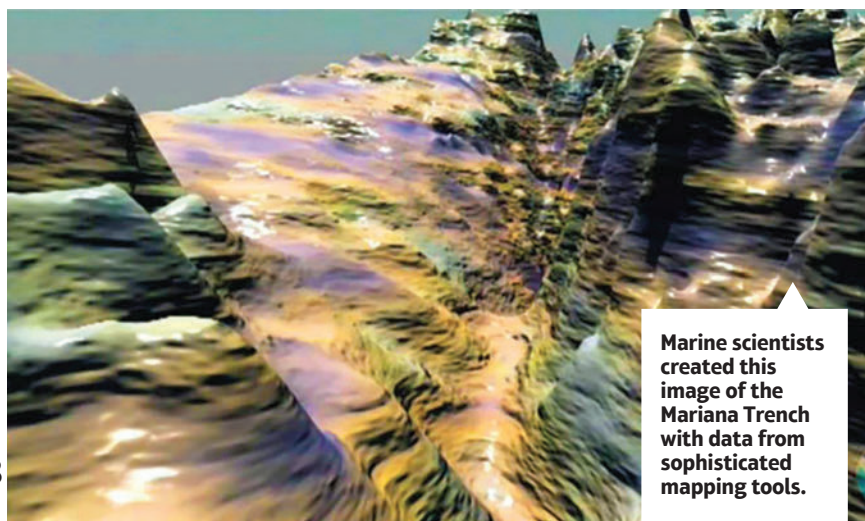
Twentieth-century explorers Don Walsh and Jacques Piccard

BRAVING THE DEPTHS

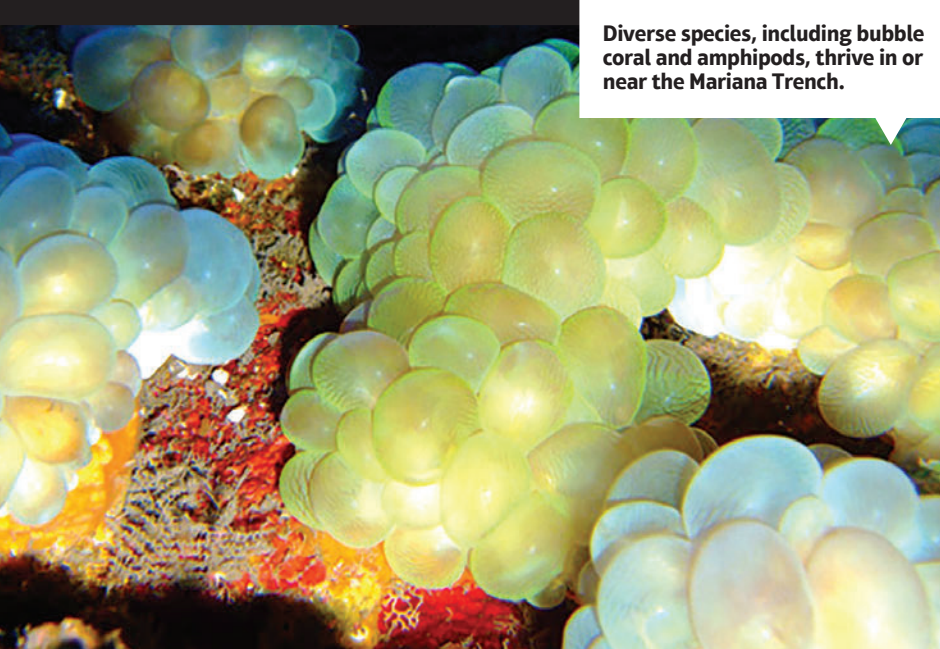
It wasn't until the 1950s that we knew just how big *Challenger's* discovery was. Using sonar (an instrument that sends out sound waves and measures how long it takes them to come back), scientists discovered that the hole is actually a trench. It is twice as long as the state of California and 43 miles (69 kilometers) wide. Parts of the trench are only five miles deep, but at its southern end, the trench drops to almost seven miles. That means if you planted Mount Everest on the bottom and stacked three Empire State buildings on top, you still wouldn't reach the surface of the ocean.

In 1960, two brave explorers, Jacques Piccard and Lt. Don Walsh, became the first human beings to see the trench with their own eyes. It took years to design and test a submersible ship strong enough to survive the immense water pressure in the trench. Called the *Trieste*, their ship weighed 150 tons, including fuel, and was almost 60 feet (18 meters) long. But for all its size, the two hydronauts would spend their journey in a round capsule only six feet in diameter. That's about the same amount of room per person that you'd find inside a refrigerator.

Crammed into that small space, at temperatures not much warmer than those in a fridge, it took the two explorers four hours and forty-eight minutes to descend the 6.77 miles (11 kilometers) into Challenger Deep—the deepest spot in the Mariana Trench. Unfortunately, during the 20 minutes



Marine scientists created this image of the Mariana Trench with data from sophisticated mapping tools.



Diverse species, including bubble coral and amphipods, thrive in or near the Mariana Trench.

they spent at the ocean bottom, the two hydronauts couldn't see much. The engines on the *Trieste* stirred up silt from the ocean floor and turned the water into what they described as swirling milk. But even though the *Trieste* didn't have the ability to take pictures outside the cabin, Piccard and Walsh got a chance to take the first deep-sea selfie.

THERE AND BACK AGAIN

In 2012, film director and explorer James Cameron led the second human expedition (and the first solo dive) into the Challenger Deep. It took him half the time to reach the bottom, two-and-a-half hours, and he did it in a ship that weighed less than one-tenth what the *Trieste* did. Surrounded by water pressure 1,000 times greater than at the ocean surface, he spent three hours filming and taking scientific samples.

With six high-definition cameras, Cameron and his team filmed some of the deepest-dwelling creatures in existence, including a giant amoeba-like xenophyophore four inches (10 centimeters) wide and a unique sea cucumber.

And since the *Trieste* explorers had already taken the first undersea selfie, Cameron's Twitter feed captured the moment he touched the ocean floor: "Hitting bottom never felt so good."



READY TO SIGN UP?

It will take a while before the next manned expedition heads to the trench. There are only a few vehicles in the world that can dive to those depths and even fewer that can protect humans at the same time. Woods Hole Oceanographic Institute lost its unmanned submersible vehicle, the *Nereus*, in May of 2014. The *Falkor*, a new UROV (underwater remote-operated vehicle) run by the Schmidt Ocean Institute, visited the trench in November and December 2014. But, as of late 2015, no one has plans to send another hydronaut into the trench.

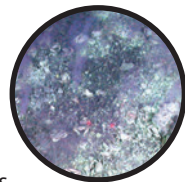
Will you be the next one to dare?

Carrie Clickard is a museum addict, scuba diver, and amateur explorer who plans to see the Mariana Trench for herself just as soon as pizza delivery goes that far underwater. When she's not feeding her curiosity in some strange corner of the world, she writes books and poetry.

4 FREAKY SIGHTS IN THE MARIANA TRENCH

1. Lake of molten sulfur

Just a quarter of a mile down into the trench, you'll find one of the rarest sights on Earth: a bubbling lake of molten sulfur. Located on the slopes of the Daikoku underwater volcano, this pit of bubbling black goo, nicknamed The Cauldron, burns at a sweltering 369°F/187°C. If you miss this molten sulfur lake, you'll have to travel to Io, one of Jupiter's moons, to find another.



2. Giant amoebas

No need to pack a microscope to see these bad boys. In the Mariana Trench, one-celled creatures called xenophyophores can grow up to four inches (10 centimeters) wide—about as wide as an adult human hand. Imagine seeing a swarm of those outside your window. One person's cool adventure is another person's nightmare.



3. See-through ghost fish

When you reach five miles (eight kilometers) below sea level, keep your eyes peeled for the bizarre "ghost fish." It's a newly discovered species with wide, wing-like fins, an eel-like tail, and "a head resembling a cartoon dog," says Alan Jamieson of the University of Aberdeen. And if that's not strange enough, the ghost fish has skin so translucent you can see its internal organs.



4. Blistering hot "black smokers"

If jumping from a snowbank into a hot tub is your idea of bliss, this is the spot for you. Water temperatures in the trench hover around 34°F/1°C—just two degrees shy of becoming ice. Right in the middle of this frosty fluid sit the chimney-like "black smokers." That's the nickname for hydrothermal vents that spew swirling black water as hot as 700°F/450°C. But don't think those temperatures mean you'll be alone. If you decide to visit this sizzling spa, you'll have to share the water with vent crabs, tube worms, and foot-long amphipods.



Antarctic Hidden Wetland

From
Ice to
E.T.

A huge lake hides miles below the ice sheet that covers most of Antarctica. That's big news for anyone interested in Earth. But scientists who look beyond our planet are excited too. Astronomers see signs of thick sheets of ice covering large bodies of liquid water in other places in our solar system.

This unseen world on our own planet could help scientists search for life beyond Earth. This possibility makes Antarctica one of the most valuable environments on Earth. At least, that's how scientists view it now.

Antarctica's

by Mary Reina

Unlikely in the Extreme

For a long time, most scientists didn't think liquid water could exist under Antarctica's ice cover. Water freezes at 32°F/0°C. A research station called Vostok is located on top of a thick Antarctic ice sheet. Scientists there once recorded the surface temperature as -128.6°F/-89°C.

In the 1950s, Andrei Kapitsa, a Russian scientist working at Vostok, noticed something strange. A formation of very flat ice stretched over the research area. He believed it was a clue suggesting a body of liquid water existed below the ice.

Then, in the 1970s, planes equipped with more advanced equipment offered new information. As part of a mapping project, pilots used ground-penetrating radar over the Vostok station. The data suggested the planes were flying over water. Even then, scientists did not fully realize that an amazing liquid world was hidden beneath the ice. Finally, in 1996, satellite technology revealed the shape of a huge subglacial lake.

Lake Vostok is about 140 miles (225 kilometers) long. It is about 30 miles (50 kilometers) wide and the water in the lake reaches as much as 2,625 feet (800 meters) deep. Such an immense size makes this lake one of the largest in the world. What had seemed impossible turned out to be true.

Signs of Life?

In addition to Lake Vostok, scientists found a huge system of rivers and almost 400 lakes hidden below the Antarctic ice. This could be the largest wetland in the world, as much as one and a half times the size of the United States.

While some scientists mapped out these hidden lakes on Earth, others were discovering ice-covered environments elsewhere in the solar system. During the 1990s, the *Galileo* spacecraft flew by the planet Jupiter and its moons. It sent back photographs suggesting that an ocean exists below the surface of the ice-covered moon called Europa.

As time went on, more research provided new possibilities. Other moons of Jupiter and Saturn seemed to be worlds where thick, icy shells surround large bodies of liquid water.

Could life exist in such an extreme environment? It certainly seems unlikely. As with the discovery of Lake Vostok, the clues for scientists seeking life pointed in "unlikely" directions. Most life on Earth depends on sunlight. How could sunlight penetrate an ice cover thousands of feet deep? Living things also depend on nutrients to grow. Where would these come from? Scientists wondered how nutrients could enter a system that has been cut off from the world above for millions of years. What's more, they knew that any kind of life in this extreme environment would have to survive tons and tons of pressure from the ice above.

Yet, in the deep ocean, some life forms exist without



sunlight. Their nutrients come from the chemicals that rise through the ocean floor from deep inside the Earth. These creatures have developed qualities that allow them to thrive under the weight of tons of water.

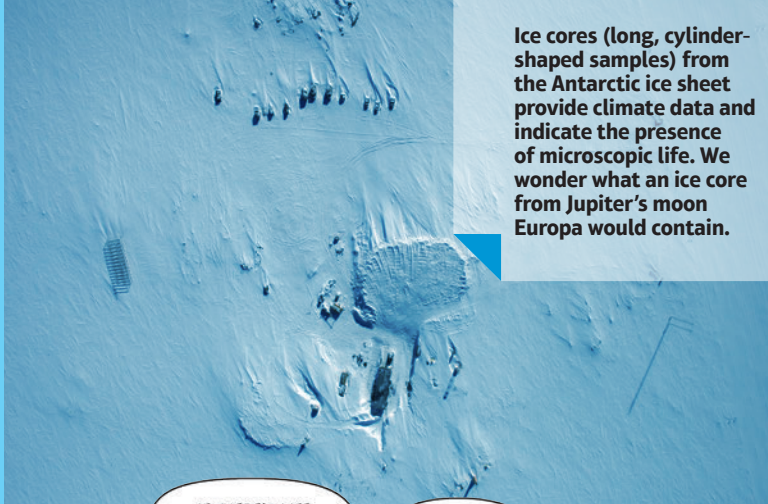
Could living things with similar abilities exist in Antarctica's subglacial wetland? If they do, life might also be possible in the icy moons of the outer solar system.

Looking for Proof

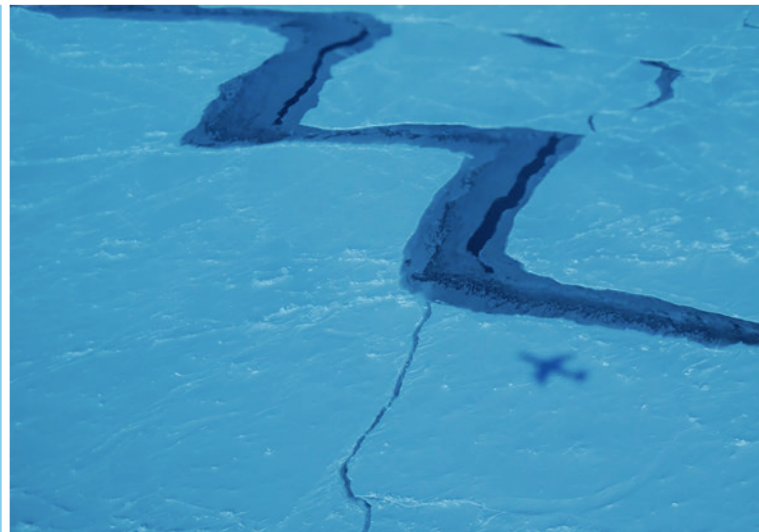
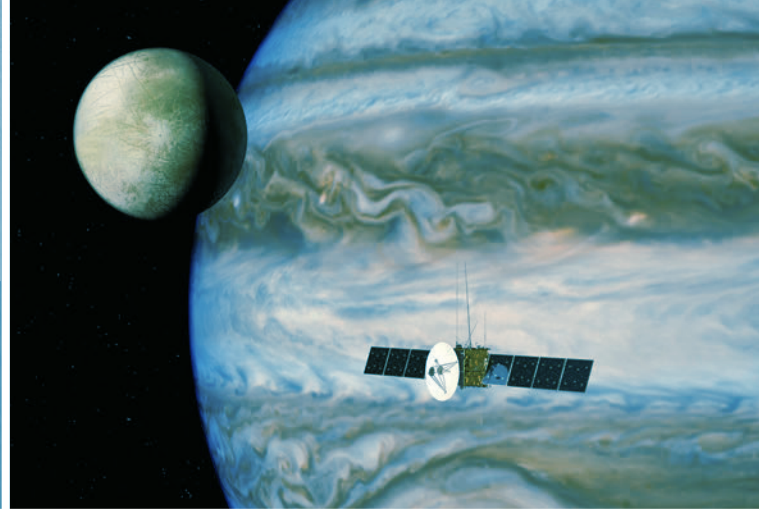
First, scientists needed to obtain and test water samples from Antarctica's hidden world. It was easier said than done. Antarctica's extreme cold and short summer season permits only a few months of research each year. Even then, drilling into the ice posed another big problem.

Life Forms in Lake Whillans

» **Lake Whillans, in western Antarctica,** is located more than 2,000 feet (800 meters) below the ice sheet. It is about 6.5 feet (2 meters) deep and 23 square miles (60 square kilometers) in size. A robotic micro-submarine recovered water samples from Lake Whillans. The sub was about the size and shape of a baseball bat. Researchers identified thousands of microbes in the water.



Ice cores (long, cylinder-shaped samples) from the Antarctic ice sheet provide climate data and indicate the presence of microscopic life. We wonder what an ice core from Jupiter's moon Europa would contain.



Drilling technology uses chemicals like kerosene and Freon to help melt the ice, make a borehole, and keep it open. If the drill penetrated the lake, the chemicals could contaminate the water. This process could also introduce microbes from the surface into water that had been isolated from the rest of the world for millions of years.

Scientists had been drilling into the ice above Lake Vostok long before its discovery. The ice cores they obtained helped them study a record of Antarctica's climate going back hundreds of thousands of years. Ice just above the lake showed signs of microscopic life. It was a clue but it was not proof.

A research team penetrated Lake Vostok in 2012. They used chemicals to melt the ice and to keep the borehole open. However, they believed they did not contaminate the lake because water rushed into the borehole and froze. The team removed the ice core to study it. However, many other scientists questioned this method.

In 2013, Lake Whillans, located in a different area of Antarctica, became the first subglacial lake where clean technology helped scientists obtain a water sample. Hot water and ultraviolet light helped sterilize the drills and equipment. Scientists wore sterile clothing so that they did not contaminate any water samples.

They found almost 4,000 types of microbes not only

surviving but also thriving in Lake Whillans. Some seem to feed on the chemicals found in solid matter, called sediment, at the bottom of the lake. Others use the dead bodies of other microbes as food.

So far, scientists have found only single-celled microbes living in the few places where they have tested the subglacial water. More research and testing may help them discover if larger life forms survive in this extreme environment.

Beyond Earth

Many scientists believe it is only a matter of time before they find life beyond Earth. In the not-too-distant future, space probes might carry drilling equipment to the icy moons of Jupiter and Saturn. They might carry water samples filled with alien microbes back to Earth. They might even photograph strange and wonderful creatures swimming in alien oceans.

If this seems outlandish, just think about the dark, mysterious wetland hidden below the Antarctic ice. Its discovery shows that, in scientific exploration, what at first seems impossible can turn out to be true.

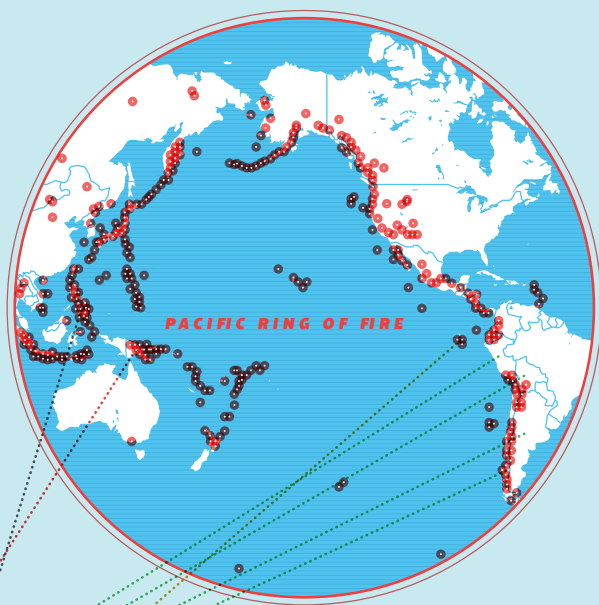
Mary Reina's books include *A Tour of Your Respiratory System* and *The Science of a Hurricane*. Her work has not yet been published on Jupiter, Saturn, or their respective moons.



THE RING OF FIRE

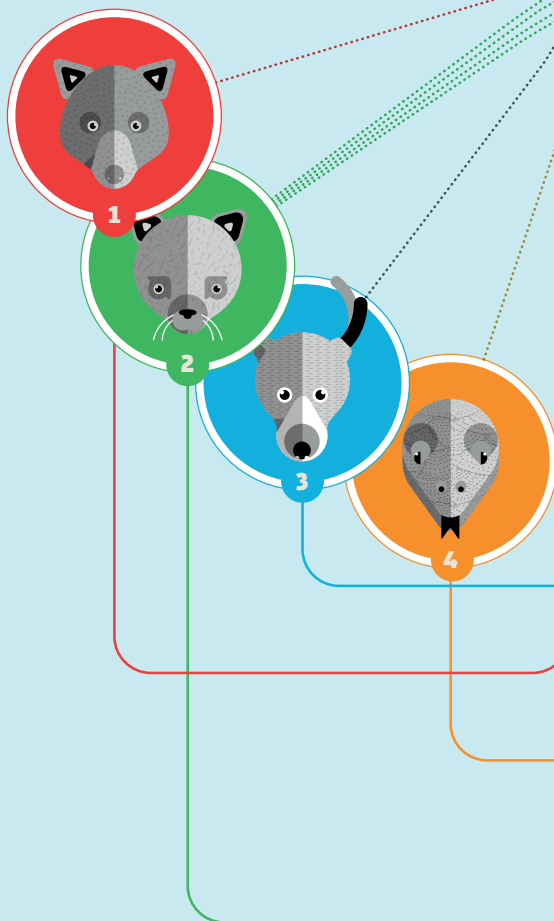
Around the edge of the Pacific Ocean, the Earth rumbles and shakes and belches fire. More than 75 percent of the world's volcanoes can be found here, roughly in the shape of a ring. Why does the ring of fire exist? The answer lies deep below the surface of the Earth with the plates that make up the Earth's crust.

Each plate is like a jigsaw puzzle piece that slides around, carrying the oceans and continents on its back. But these puzzle pieces don't fit together perfectly. Their edges jam into each other. Sometimes, the edges slowly crumple to form mountains or islands. Other times, one edge sinks below the other in a process called subduction. As part of this process, the plates may slip suddenly, causing an earthquake. And rock from the sinking plate melts into magma, which builds up inside of volcanoes. Eventually they erupt! The ring of fire is a dangerous but amazing place to live.



RARE ANIMALS

Volcanic activity helps create remote islands and isolated mountain peaks. These places are often home to small populations of creatures found nowhere else in the world.



1 GOLDEN-MANTLED TREE KANGAROO

New Guinea, South Pacific

Explorers discovered this tree-dwelling rarity in 1990.

Critically endangered ♦ ♦

2 ANDEAN MOUNTAIN CAT

Argentina, Bolivia, Chile, and Peru, South America

These wild cats hunt viscachas and chinchillas (rabbit-like rodents) in the Andes Mountains.

Endangered ♦

3 CALAMIAN DEER

Philippines, South Pacific

Local people hunt these deer. They eat the meat and use the hides and antlers to make drums and decorations.

Endangered ♦

4 PINK IGUANA

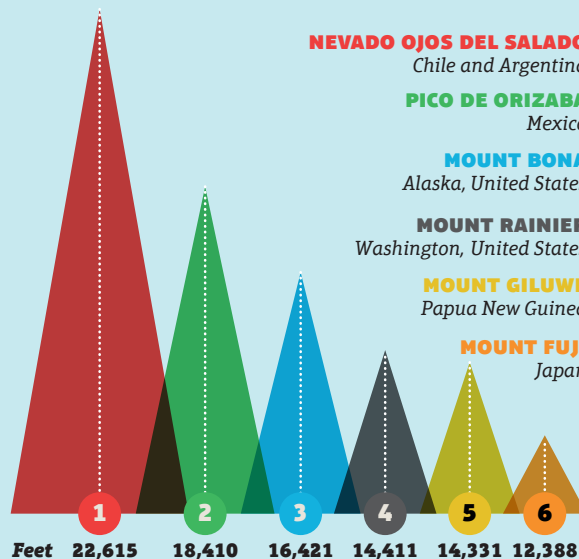
Galapagos, Pacific Ocean

Only one population of these rose-colored lizards exists. They live in an area that is smaller than Manhattan in New York City.

Critically endangered ♦ ♦

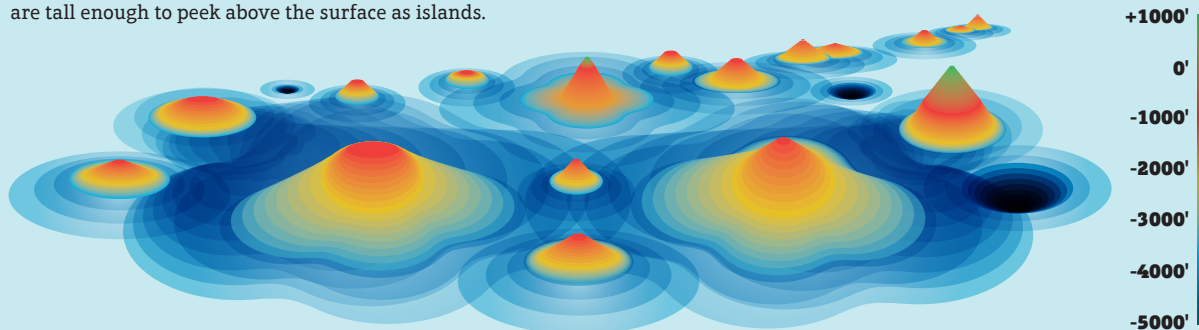
GREAT HEIGHTS

The ring of fire includes some lofty volcanoes, including the world's tallest.



HIDDEN VOLCANOES

The most mysterious mountains in the ring of fire lurk beneath the ocean. The Mariana Arc contains 69 active volcanoes. Only nine are tall enough to peek above the surface as islands.



QUAKING AND SHAKING

Deadly earthquakes regularly shake up land and oceans around the ring of fire. Earthquakes can trigger giant tidal waves called tsunamis, which make these disasters even more devastating.



HELEN SCALES

MARINE BIOLOGIST

Meet Dr. Helen Scales—
deep-sea diver, author,
and seashell whisperer.
She visits ocean animals
in their native habitats
and tells their stories.

Here she shares secrets about the
hidden lives of seashells.



Q What's the seashell's biggest secret?

A I think seashells' biggest secret is probably the truth about how life on Earth has changed over thousands of years. Quite a big secret! Seashells might be able to tell us why the dinosaurs went extinct.

The animals that make and live inside seashells are called molluscs. Molluscs include clams, mussels, and snails, as well as animals like octopuses and squid that have lost their shells. Molluscs first evolved in the oceans at least half a billion years ago—which, trust me, is a very long time ago! Molluscs with shells were some of the first complex animals to show up. Giant molluscs—with enormous 33-foot (10-meter) long shells—were the biggest and scariest hunters in the ocean, long before sharks evolved. Seashells have seen a lot of coming and going on the planet.

Q What was an exciting dive you took while researching seashells?

A I went to Sant'Antioco, a tiny island in the Mediterranean Sea, to search for the last people in the world who weave a mythical and mysterious fabric known as sea-silk. Traditionally, they spun golden threads from the fuzzy beards of giant seashells called nobel pen shells (*Pinna nobilis*). A local fisherman took me out to snorkel in the shallow seas around the island. Seagrass meadows are such wonderful places to visit, filled with many different species bustling about: fish, starfish, sea slugs, snails. Pen shells can grow up to 3 feet (1 meter) tall, although part of their shell is usually buried in the seabed, so you don't see the entire animal. I found a cluster of fairly small, young pen shells—about as wide as my outstretched hand. I saw a fish living inside an old pen shell, and apparently octopuses like living inside them too.



Japan's Mikasa City Museum displays large ammonite shells. (Ammonites were prehistoric, squid-like sea creatures.) Visitors can look *and* touch!





Q Should I take home seashells I find when visiting the beach?

A Certainly. I can never resist hunting around for a few pretty shells to take home. And there's absolutely nothing wrong with collecting a few empty shells, although you wouldn't want to take them all. If you did, then there'd be none left for the hermit crabs! The situation is less clear-cut if you take shells from living molluscs. If you buy shells, they almost certainly weren't found dead and empty on a beach but were taken from live animals. It's up to you whether you think it's okay to kill animals for their shells.

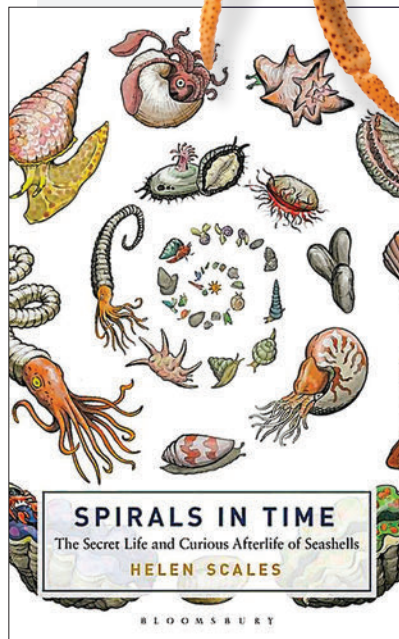
Q What can a dry seashell on a beach tell me about the ocean's food web?

A It's a mollusc-eat-mollusc world out there. You can tell from a shell's shape whether the shell-maker was a hunter: if a spiraling shell has an elongated notch in it, that's where a tube called the siphon poked out. The siphon acts as the snail's nose and can also be a weapon. The scariest hunting snails, called cone snails, shoot out poison darts through their siphons, which instantly stun their prey. Some snails will drill holes in other molluscs and then suck out their insides, leaving behind an empty shell with a telltale hole. If you find a shell on a beach with a tiny, neat, circular hole punched in it, this was an animal that met with a sticky end.

Mary Alexandra Agner has written about touring Titan, Saturn's largest moon, and the botany of "Plants vs. Zombies." She has not yet explored the curves of a seashell, but she would like to go inside and greet its inhabitant.



In *Spirals in Time* (Bloomsbury, 2015), Helen Scales dives into the hidden wonders of seashells and molluscs.



Q

If you can do things like light a light bulb or make a radio work with a lemon, then why haven't people harnessed that kind of energy to make things like cars run on renewable resources?

—Kate S., age 10, Virginia

A

Alex Golberg wondered the same thing. He's a bioengineer, and when he was studying for his PhD at Hebrew

University in Israel, he started investigating a promising renewable energy technology: the potato. Like lemons, spuds make excellent natural batteries and are "a very well-known example from school experiments," Golberg says. You may have even made a potato battery yourself in science class. "But when we started to look at the [scientific] literature, there was nothing [written about them]," Golberg says. If he wanted to make a better potato battery, one that might catch on outside of

classrooms, he would have to do his own experiments.

Golberg's potato battery started out simple, with a slice of spud sandwiched between thin sheets of zinc and copper. When he connected the two metals with a wire, electrons started to flow from one to the other, using the potato as a pathway. But potato cells have tough walls, and the electrons lost a lot of energy trying to travel through them, reducing the battery's power. Thinking through this problem, Golberg hit upon the innovation that makes his potato battery unique: cooking, which breaks down the spud's cell walls. By boiling his potatoes for eight minutes, Golberg managed to get 10 times more electricity out of his batteries.

So why aren't we all driving potato-powered cars? For one thing, even Golberg's new-and-improved potato battery generates only about half the

energy of a AA battery you can buy at the store. That's a long way from powering a car, but it's plenty of energy to power an LED light or charge a cell phone for about a month and a half, Golberg says. One day, he hopes to see potato batteries powering reading lamps for kids without electricity in the developing world.

But Golberg—now a professor at Tel Aviv University—is still working out how to make that idea a reality. So far, "there is not a clear business model for how people can make money off the potato battery," he says. For now, if you want a spud-powered lamp or radio, you'll have to make it yourself.

—Lizzie



Have any questions?

Send them to Muse Q&A,
70 E. Lake St., Suite 800,
Chicago, IL 60601,
or email them to
muse@cricketmedia.com



Diamond **Buried**

A STRANGE-LOOKING PLANT TELLS
PROSPECTORS WHERE TO DIG.

by Avery Elizabeth Hurt, illustration by Hendrik Gheerardyn

nds here



The center of the Earth doesn't easily give up its secrets, but sometimes it does spew up diamonds. To find the good ones, though, you have to know where to look. Stephen Haggerty, a geologist at Florida International University, has discovered a strange plant in the West African jungle that could make finding diamonds a whole lot easier.



Plant on Steroids

Diamonds are forever, or so the song says. They are certainly old—from one to three billion years old. Diamonds are the hardest natural substance on Earth, and the purest ones are colorless. When you look at one in soft lighting, even if you aren't a romantic, you'll have to admit, diamonds are beautiful. They are also rare.

Diamonds are found in kimberlite, a type of rock that forms when magma or molten lava cools. Kimberlite forms columns, called pipes, that reach deep into the Earth. But it isn't easy to find kimberlite pipes. The dense jungle in West Africa makes searching for them even more difficult. "If you've seen Tarzan movies, then you know what this place looks like," says Haggerty. After several years of working in the Liberian jungle, he started to realize that an unusual plant might be able to help people find diamonds. "At 10 to 15 meters [33 to 49 feet] in height, it looks more like a tree than a plant. These are like plants on steroids," he says. It has a weird above-ground

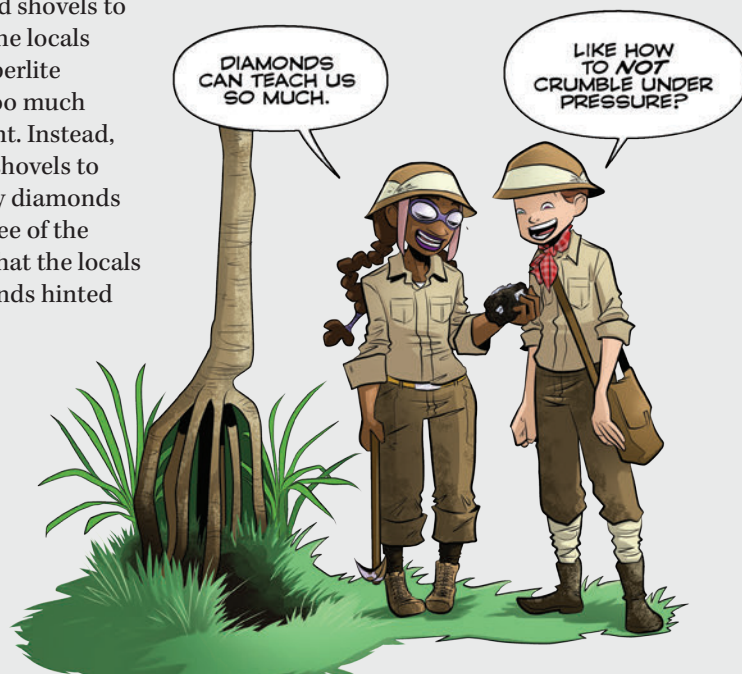
root system, spiny fronds, and is truly exotic-looking. The plant is called pamaya by the locals, who often use its leaves to roof their cottages. But when Haggerty sent pictures to tropical plant specialists, he found out that its botanical name is *Pandanus candelabrum*. Not much is known about the group of plants it belongs to. But here's the thing. Haggerty saw the plants *only* in areas where locals were using picks and shovels to dig for diamonds. The locals don't mine the kimberlite pipes—that takes too much expensive equipment. Instead, they use picks and shovels to dig for lower-quality diamonds that have washed free of the pipes. But the fact that the locals were finding diamonds hinted that there might be kimberlite pipes nearby.

Haggerty designed a special plunger to poke down under the

Pandanus candelabrum plant and, he reports, "Sure enough, in between the root systems, I found the kimberlite. I realized that these very unusual plants were growing right over the kimberlite." And, so far at least, they haven't been found growing anywhere else.

Not That Simple

This was a great find. As Haggerty puts it, "No kimberlite, no diamonds." But



finding kimberlite doesn't necessarily mean finding diamonds. There aren't many kimberlite pipes on Earth, and of those only a few have enough diamonds in them to be worth the trouble of mining. Diamonds are valuable, but it takes a lot of investment to get to them—even after you find a good pipe, explains Steven Shirey, a geologist at the Carnegie Institution for Science in Washington, DC. For example, you need big trucks to haul in the equipment used for mining, and just one tire of one of these huge trucks can cost \$10,000, he says. But if you find kimberlite with lots of high-quality stones, diamond mining can be very profitable. Many of the countries where diamonds are mined have been through conflict, Ebola epidemics, and droughts and desperately need the revenue that diamond mining can bring, says Shirey.

In the late 60s and 70s, De Beers, the world's largest diamond company, found three excellent mines in Botswana, a country in southern Africa. Botswana has a stable government, so it was able to partner with De Beers and share the profits from the diamond mine, explains Shirey. "This really changed life in the country. Botswana was especially hard hit by the AIDS epidemic, and the diamonds paid for AIDS drugs," he says. Some people have criticized diamond companies for the way they treat local communities. When it comes to environmental issues, diamond mining gets far less criticism. "Diamond mining has two big virtues," says Shirey. "The process is mechanical, not chemical, so there is no toxic waste, and diamonds are small, so you don't have to build lots of roads to get them out."

If the exotic-looking *Pandanus candelabrum* turns out to be as good an indicator as Haggerty hopes, it could make searching for diamonds less intrusive as well—just look under the pamaya plants.

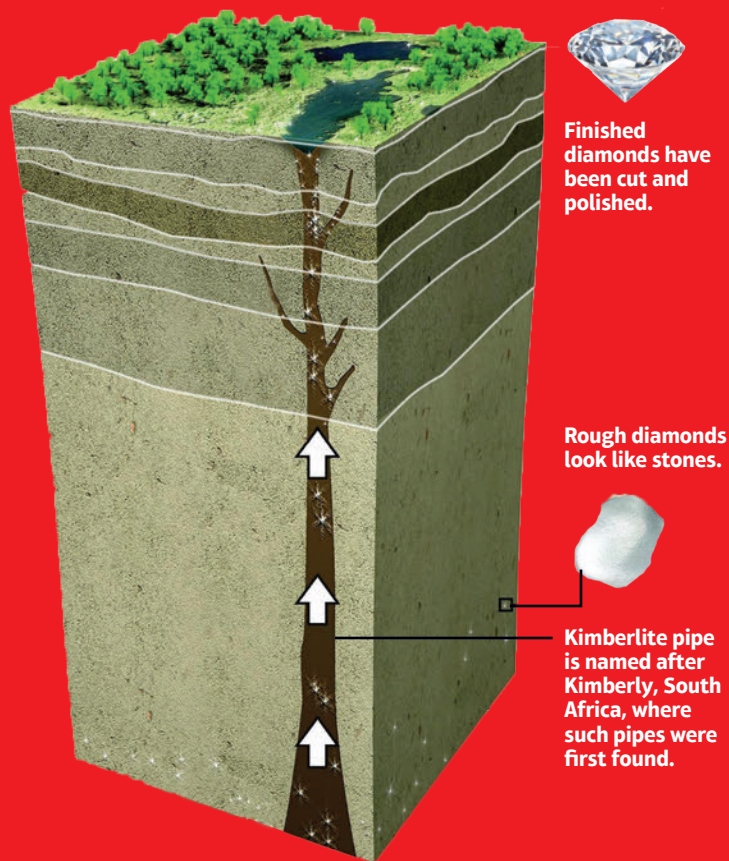
Not Just Money

But the profits from diamonds are not limited to money. They can also give us valuable insight into our planet's development. Shirey studies diamonds, which were formed by great heat and pressure way below the surface of the Earth, to try to understand the deep geological forces

that shaped the continents. "We can't drill that deep," he says, "so we have to learn from diamonds."

Diamonds convey messages about our planet's history. And now, it seems, *Pandanus candelabrum* whispers messages about diamonds.

Avery Elizabeth Hurt likes a sparkly diamond as much as the next person, but she's even more intrigued by those goofy-looking pamaya plants. Hurt lives in Birmingham, Alabama, and writes (mostly) about science for a variety of publications including *National Geographic Kids*, *Double Helix*, and, of course, *Muse*.



THE BIRTH OF DIAMONDS

A hundred miles deep in the Earth's mantle, the temperature is thousands of degrees, and there's tremendous pressure from the rocks above. Under such high heat and pressure, carbon atoms bond together and form crystals—diamonds. The diamonds mined today formed billions of years ago in the Earth's mantle.

We can't dig or drill that deep, but fortunately, diamonds came to us. Billions of years ago, volcanic eruptions in the Earth's mantle forced diamond-containing rock to the surface of the planet. The rock cooled and hardened. This rock is called kimberlite, and it is where most natural diamonds are found.

CAPTURING SPACE PARTICLES

AT THE SOUTH POLE

WHEN LAURA GLADSTONE WAS A young girl, she didn't know she would grow up to study science in Antarctica. As a child, she loved exploring the natural world and participating in science fairs. She felt science was like magic, only better, since doing experiments helped her discover how things work.

Now Gladstone is a scientist who has been to the South Pole to study invisible space particles called neutrinos. As a member of a large team of scientists from different countries around the world, Gladstone helped build the IceCube Neutrino Observatory, a unique telescope that can detect neutrinos as they travel through a large block of ice at the South Pole.

SPOTTING SUNDOGS

While outside, Gladstone spotted sundogs. Sundogs are bright spots in the sky that appear when light from the sun passes through ice crystals in the atmosphere. "As the light came off the sun, it reflected off ice clouds in the sky, and it looked like there was a rainbow around the sun with weird shapes, circles, slashes, and arcs," she says.





A UNIQUE TELESCOPE

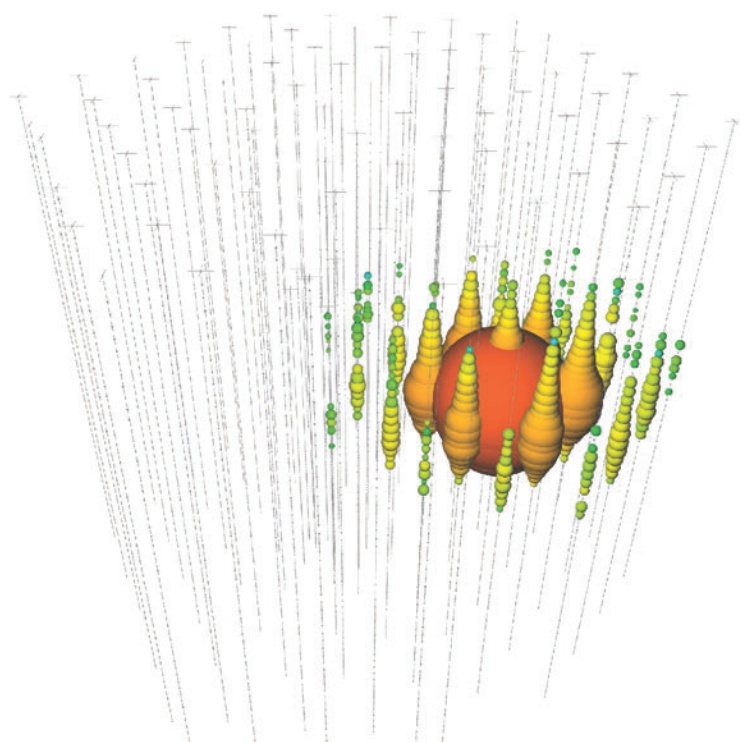
The neutrino telescope is different from a telescope you look through to spot stars on a clear night. It contains 1.3 billion cubic yards (1 cubic kilometer) of ice. If this ice melted, there would be enough water to fill one million swimming pools.

Buried deep inside the ice are more than 5,000 digital optical modules. Digital optical modules help detect the presence of neutrino particles. Here's how it works: as the neutrinos travel swiftly through the ice, they slam into other tiny particles. These collisions produce a shower of charged particles. These charged particles also move very fast, and they create shockwaves made up of light. The digital optical modules detect the light from the shockwaves.

GHOSTLY SPACE PARTICLES

Neutrinos are like ghosts: they are lightweight particles that zip around the universe at nearly the speed of light and are almost impossible to capture. They are born in outer space and come from a variety of sources, including the sun, cosmic rays, exploding stars, and black holes.

Other than particles of light, neutrinos are the most common particle in the universe. About 100 trillion neutrinos pass through your body each second. The image below represents the highest-energy neutrino ever observed by the IceCube telescope. The scientists named it Ernie.



WORKING AT THE SOUTH POLE

Laura Gladstone's job involved using computers to test digital optical modules to make sure the machines worked correctly before burying them in the ice.

Gladstone wore special clothing to stay warm when she went outside, including long underwear, snowpants, and a heavy red parka. She also put on gloves, a winter hat, neck scarf, goggles that had a plastic shield over her nose and mouth, and boots with four-inch platform heels to keep her feet above the icy ground.

PLAYING AT THE SOUTH POLE

Gladstone arrived in late November, which is summer at the South Pole. During the summer months from September to March, the sun never sets, but it is still bitterly cold.

When not working, Gladstone played card games and Scrabble with other scientists from around the world.

The scientists also had fun making ice cream in the snow, cross-country skiing, and even setting up a golf course and driving range.



ENDLESS EXPLORATION

Gladstone says helping build the neutrino telescope was a once-in-a-lifetime opportunity. She compares the world to a big puzzle that is never solved. "In science, every time we think we've described absolutely everything, we discover something completely new. It is an endless exploration," she says.



Laura Lane is a freelance writer in Madison, Wisconsin. Although the winters in Madison aren't quite as cold as the South Pole, Laura wears a knee-length winter coat, snowpants, hat, gloves, neck scarf, and moon boots when she plays with her giant Bernese mountain dog in the snow.



SHAPES UNKNOWN

Try tiling with pentagons.

The tiles that you see on walls and floors in many places, probably including your bathroom, are often squares arranged in neat rows and columns.

But using squares is not the only way to completely cover a flat surface with

identical copies of a shape. Tiles in the shape of any given rectangle—or, in fact, any four-sided figure—would do the job. So would regular hexagons, which have six sides of equal length and interior angles of 120 degrees.

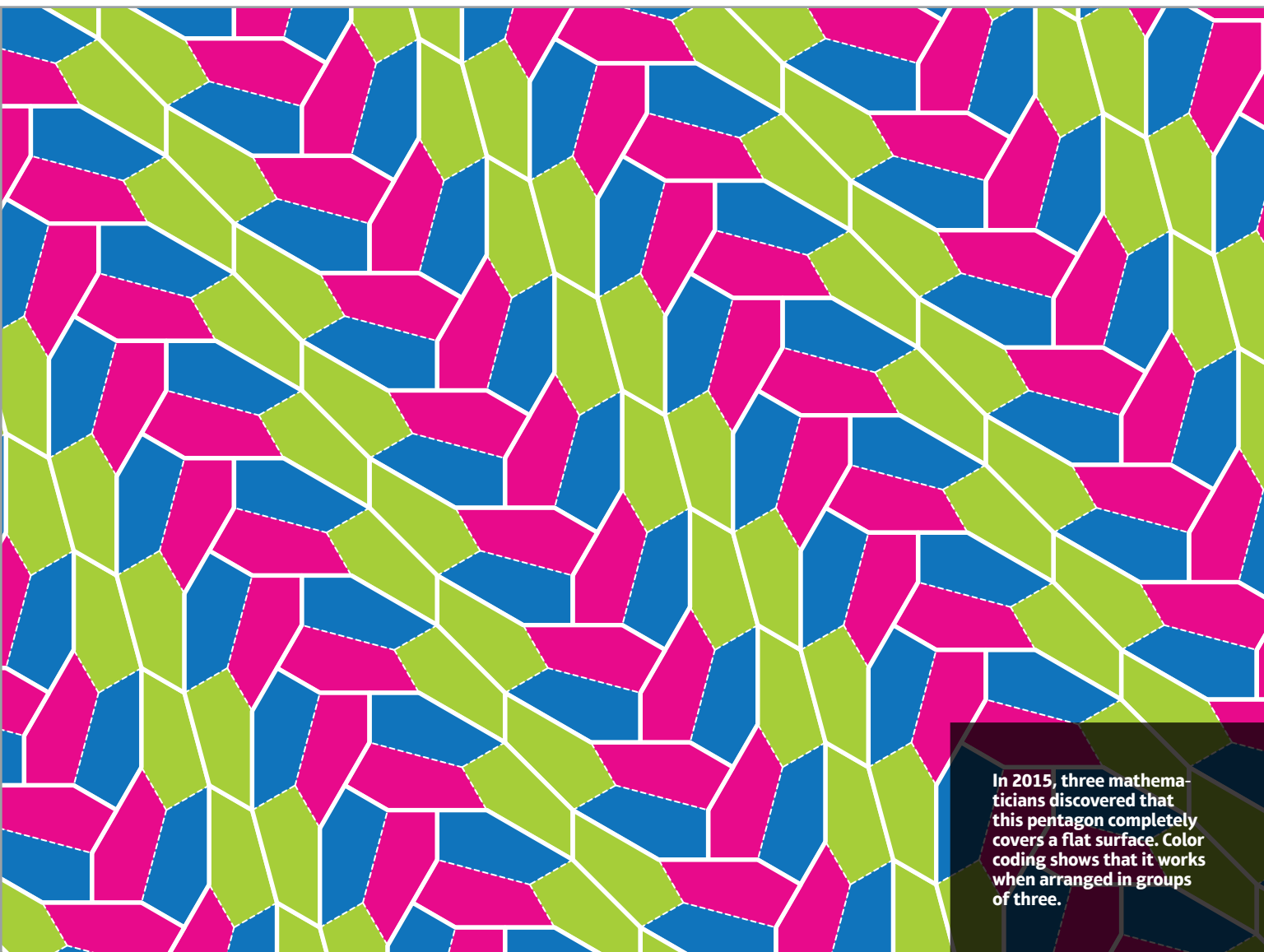
One option to make your bathroom décor more exciting is to use tiles in the shape of pentagons. Regular pentagons, with five sides of



equal length and interior angles of 108 degrees, however, won't work. Something challenging happens if you lay out such pentagonal tiles to cover a wall or floor. Trace and cut out some pentagons to see for yourself.

Did you try it? You likely ended up with gaps or overlaps. But pentagons don't have to have equal sides and equal angles; they just need five sides, so different combinations of interior angles and side lengths could work.

One possibility is to split a hexagon in half to create two identical pentagons. Trace and



In 2015, three mathematicians discovered that this pentagon completely covers a flat surface. Color coding shows that it works when arranged in groups of three.

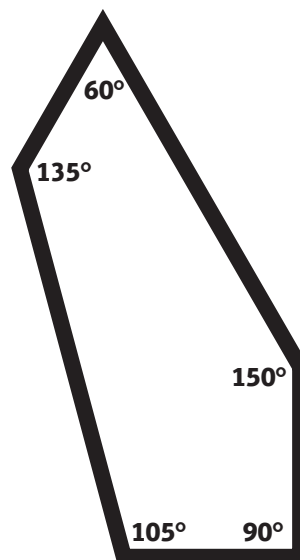
cut out a few hexagons to put this idea into action. You can arrange such pentagons into a pattern that covers a surface in the same way that hexagons do. In fact, any pentagon that has parallel sides will work.

So far, 15 types of pentagons are known to work as tiles. The fifteenth was discovered in August 2015 by mathematicians Casey Mann, Jennifer McLoud-Mann, and David Von Derau of the University of Washington–Bothell. (Von Derau, an undergraduate, wrote the computer program that made

the discovery possible.) Their new tile has interior angles of 60, 135, 105, 90, and 150 degrees.

Do more types of pentagonal tiles exist? No one knows yet. Even after you have identified a tile that works, there may also be more than one way in which copies of the tile can fit together to cover a surface. And what patterns could you get if you were to use a mixture of two different types of tiles? Give it a try!

The questions go on and on. There's a lot left to explore.



BY JOYCE FROHN

HENDRIK GHEERARDYN

TRACKS

A prose poem

I WAS in high school, visiting a great-aunt near Baraboo, Wisconsin, when I found the best tracks of my life. I've since seen the tracks of wolf and bear and dune mouse, but those were the tracks that taught me to look down. I had followed a snake's S-trail through the tall grass into a patch of mud where it erupted into a volcano of chaos. I had to kneel and crawl, trying to dissect why the snake had made such violent loops and deep grooves. My fingers followed grooves that ended in polka-dots of blood. I found the tiny handprints of a raccoon. Back paws dug in deep, front paws resting between the snake's last withering tracks. Then there was only the track of a raccoon dragging a snake. I spent minutes watching a completed battle. I'd love to mount the plaster footprints of wolf or bear on my walls. I will always treasure the memory of the tiny tracks of a dune mouse, one of the smallest of endangered mammals. But the time I wished most fervently that I could carry casting plaster in my pockets every day was looking over the hours-old scene of a tiny battle of predators.

Joyce Frohn has wanted to be a writer since she received the first *Cricket* magazine. In college she majored in biology, and she still misses the slime mold.

The tracks of 16 species found in a variety of Wisconsin habitats appear on these pages. How many can you identify? Answers on the inside back cover.

- 1 American Beaver
- 2 American Black Bear
- 3 Bobcat
- 4 Coyote
- 5 Eastern Cottontail
- 6 Frog
- 7 Northern Short-tailed Shrew
- 8 Plains Pocket Gopher
- 9 Raccoon
- 10 Red Fox
- 11 Red Squirrel
- 12 Snake
- 13 Snapping Turtle
- 14 Spotted Salamander
- 15 Toad
- 16 White-tailed Deer





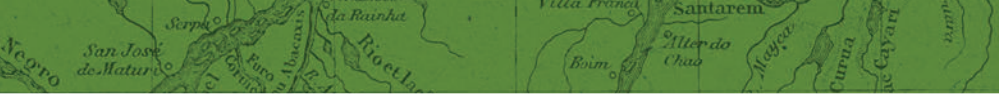
by Aimee Ogden

The Accidental Explorer

RARE LANGUAGES SPEAK VOLUMES ABOUT THE WAY WE INTERACT WITH THE WORLD.



When you think of researchers making new discoveries in the Amazon, what pops into your head? Rare birds, plants that have never been seen before, different insect species? All these can be found in the Amazon, but there's something else waiting there to be discovered too: some of the most unusual languages in the world.



The Pirahã live along the Maici River in northwest Brazil.



Daniel Everett, a professor at Bentley University in Massachusetts, knows a lot about those languages, but he didn't set out to learn about them. The Moody Bible Institute sent him into the Amazon as a missionary researcher to join the isolated Pirahã (pee-da-HA), a riverbank-dwelling native people. He planned to use his background in the study of languages to learn enough of the Pirahã language and culture to write a translation of the Bible that they could understand.

New Experiences

Life in the Amazon was very different for Everett and his family from what they had known at home in the United States. One day, Everett was swimming in the river with a Pirahã friend, when a Pirahã woman threw part of a cooked monkey carcass into the water nearby. When the water began frothing, Everett realized he was sharing the river with piranhas (sharp-toothed, predatory fish)! And the river wasn't

just full of piranhas. There were caimans too. These relatives of crocodiles attack unwary river travelers.

Of course, as Everett dealt with these predators, he was also trying to learn the language, a difficult task because none of the Pirahã spoke English. Everett plunged into the language by learning the basics first: he pointed at objects until someone else named them for him. Then he repeated the sounds the speaker made until he got them right. Finally, he confirmed each new word he learned with other Pirahã speakers, by pointing and naming the object—and then he could consider that word part of his vocabulary. Even as he picked up words, though, he realized that the Pirahã didn't consider him a true speaker of the language. To them, he was more like a very clever talking parrot who happened to be very good at sounding like a “real” person!

Everett wasn't the only one learning the language. His three children, Shannon, Kris, and Caleb, were 6, 3, and 1 year

Daniel Everett has spent years living with the Pirahã and learning their language.



old when they went to live among the Pirahã. They grew up trilingual: speaking English, Portuguese, and Pirahã. It was certainly a different life than what they had been used to. They encountered venomous snakes, jaguars, and other frightening animals of the jungle, but they also had friends here. The girls, Shannon and Kris, fished, picked fruits, and sang songs with the Pirahã girls. Caleb asked the men of the village to make him his own bow and arrow. “When we first went to the Pirahã,” Everett says, “my children thought the Pirahãs were ugly and strange. But when they left, they thought the Pirahãs were the most beautiful people anywhere.”

A Language Unlike English

The Pirahã language is unusual in many ways. For one thing, it contains only about 11 different sounds. (In English, we use around 40.) There is no writing system among the Pirahã. The language also has very few words for abstract ideas: they have no color words and no counting words or ways to number things, except for ideas like “a few” or “most.” Everett tried to teach the Pirahã to learn to count, but without much success; there was simply nothing in their language that related to numbering objects.

Another strange thing about the Pirahã language is that it doesn’t include something called “recursion,” a feature that all other known human languages have. Recursion is when sentences have ideas nested inside one another. For example, if you say, “The canoe that I like is on the river,” you are nesting together two separate thoughts about that canoe: you like it, and it’s on the river. That simple sentence is impossible to create in Pirahã! Instead, you would have to say something like, “I like the canoe. The canoe is on the river.”

And the Pirahã have even more fascinating ways of speaking. For sound to carry far through thick jungle, the Pirahã may use two separate ways to communicate: whistle-speech and shouting-speech. They also use musical-speech while dancing or providing important information and humming-speech for private conversations or for speaking to children.

Despite the dangers of his environment and the challenges of communication, Everett learned a lot about the Pirahã, and



became the first outsider to speak their language fluently. And what he learned also told him quite a lot about the way they thought, learned, and interacted with the world around them.

For example, the Pirahã consider the source of information carefully. Anything a Pirahã claims to have seen directly is considered trustworthy. But something a stranger tells you he saw isn't given the same regard. If you or someone you know didn't see it with your own eyes, it might as well not have happened. The Pirahã language and culture focus on the here-and-now. Overall, they appear to outsiders to be content, generally good-natured with one another, and disinterested in any culture, language, or technology other than their own.

Changing Direction

You can imagine how difficult it was for Everett to offer a Bible translation that the Pirahã would be interested in. Everett had not witnessed the events of the Bible himself. Christians believe that those events took place thousands of years in the past, and they also happened to outsiders half a world away. All of these factors make the information untrustworthy to the Pirahã, who don't share creation myths or stories within their own culture. Everett eventually gave up on his plan to share Christianity in favor of pursuing the exciting linguistic questions his life among the Pirahã had raised, such as how does this fascinating language reflect the culture of the Pirahã people? How has the way they speak shaped the way they think? And on the reverse, how does English reflect our own culture and the way we look at the world around us?

Aimee Ogden loves science, comic books, and Ultimate Frisbee. She speaks one language well and three others rather dimly.



THE SCIENCE OF SPEECH

How does the language you speak reflect the way you think? And how does the way you think reflect your language? The scientists trying to answer questions like these are called linguists, and the research they do is called linguistics.

Where you'll find linguists working depends a lot on exactly what kinds of questions about language they want to answer. Some work in museums or at archaeological sites, studying dead languages from ancient history and maybe trying to decipher their meanings. Some work in libraries and universities, dissecting grammar and the roots of words, or even slang, to see how languages grow and change over time. Some work in preschools and elementary schools, giving surveys and tests to study how young children learn language for the first time. And some work in hospitals and research labs, analyzing how the brain processes language—and how the languages you speak may change your brain!

Modern tools such as MRI machines have opened up many new lines of attack for linguistic research. The field of neurolinguistics combines research in neurology (the study of the brain) with linguistics (the study of language) to help scientists tackle these challenging questions: how and where does the brain store a word that you've learned? How do brain injuries damage language skills? And can those skills ever be restored?

But some questions are more difficult to answer in a lab. Can languages exist without words for numbers, or colors? What's the minimum number of sounds a language needs for its speakers to be able to form a variety of words? These questions need field linguists to seek out unique dialects from around the world, languages whose differences can tell us amazing things about our own.

—Aimee Ogden

>> NEW CONTEST

Not All Who Ponder Are Lost

You've lost your way in unknown *Muse* territory! Possibly in a labyrinth of underground caves, or in a paper bag. Draw us a map and send it with your trusty carrier pigeon, Rusty, so we can pinpoint your exact coordinates. We'll ready a rescue squad complete with hot-pink bunnies. (Points for drawing Rusty!)

CONTEST RULES

1. Your contest entry must be your very own original work. Ideas and words should not be copied.
2. Be sure to include your name, age, and full address on your entry.
3. Only one entry per person, please.
4. If you want your work returned, enclose a self-addressed, stamped envelope.
5. All entries must be signed by a parent or legal guardian, saying that this is your own work and no help was given and granting permission to publish. For detailed information about our compliance with the Children's Online Privacy Protection Act, visit the policy page at cricketmedia.com/privacy.
6. Your entry must be received by January 31, 2016. We will publish winning entries in the May/June 2016 issue of *Muse*.
7. Send entries to *Muse* Contest, 70 E. Lake St., Suite 800, Chicago, IL 60601 or via email to muse@cricketmedia.com. If entering a digital photo or scan, please send at 300 dpi.

BACK T. RIA

Perhaps you don't realize what microbes do. We help you manage stress. We help you digest foods. We keep you healthy. WE EVEN MAKE SOCKS SMELL BAD!!!! (So you 'll know when to change them!) The least you can do is respect that.

—CAMPBELL R. / age 11 / Washington

>> ANNOUNCING

CONTEST WINNERS!

In July/August 2015, we asked you to send a teeny-tiny tale written from the point of view of a virus or bacterium. Of course, it was quite a process to run each entry through the demicroscopitron, but we think it was worthwhile.

**EBOLA VIRUS**

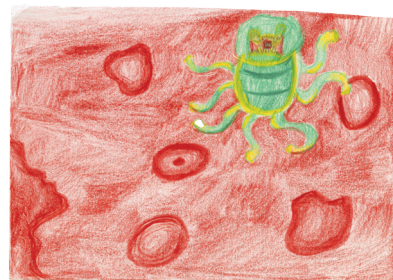
Have you ever been squashed with a microscope slide? P-A-I-N-F-U-L! Also, it's hard to breathe when you're flat as a pancake!! After that, you see a HORRIBLE thing that looks ... like ... this!!!

—CHARLOTTE B. / age 11
New Jersey

VERY MICROSCOPIC STORY

I'm splitting! What do I do? I find a home. Yay! Brilliant idea. What about here? Uh oh. There is a gigantic hole down there. I think I am in a nose. I am blown out, and I land on mountains of skin!

—MILENA F. / age 11 / Ohio

**INTERVIEWING A VIRUS**

Jack: This is Jack from national TV, and today we are interviewing the flu.

Flu: My name is influenza or just flu.

Jack: Why do you attack?

Flu: It just happens. I don't mean to.

—ETHAN T. / age 10 / Texas

>> RUNNERS-UP

Honorable Mention

This month's runners-up are Lara C., Massachusetts; Sophia R., 11, Virginia; Raven H., 10, Florida; Isaac C., 9, Ohio



ARE ROBOTS BETTER EXPLORERS THAN HUMANS?

VAST STRETCHES of land beneath the ocean remain shrouded in mystery. Movie director and explorer James Cameron spent \$10 million of his own money and made history in 2012 when he became the first person to travel alone to the deepest place on Earth: the Challenger Deep, located in the Mariana Trench in the Pacific Ocean.

But does it really make sense for people to visit the sea floor? In late 2015, only eight vehicles exist that can carry people down past 6,500 feet (2,000 meters). By comparison, approximately 10,000 robots are out there exploring the deep sea. (Mining and drilling companies operate most of them.)

Human explorers need to breathe, eat, drink, sleep, and go to the bathroom. Also they have to dive and return to the surface very slowly and carefully to adjust to changes in pressure. A human without a special vehicle would get squashed like a bug under the weight of all that water.

Robotic submarines can explore extreme locations safely, without putting human lives in danger. They can also dive faster and stay under the water longer than a person. All they need is a boat to launch from and a source of power. Engineers on the surface watch the video feed from the robot's cameras, help control where it goes, and even instruct it to pick up rocks, sea creatures, or pieces of shipwrecks.

Humans are still better than robots at looking around and deciding when to snap a photo, what to collect, or where to go next while exploring. But as computer technology improves, the robots are getting smart enough to make some of these decisions on their own.

No matter how smart robots get, though, people such as James Cameron will want to experience the thrill of venturing into the unknown. Can a person still feel that rush while controlling a robot from afar? Is the rush of discovery worth risking human lives in an unsafe environment?

What do you think? Should people continue to explore the deep ocean? Or should we only send robots?

Did You Know?

We know more about the surface of the moon than we do about the bottom of the sea.

THINGS THAT WANT TO BE LOST

... BUT JUST AREN'T

BURR STUCK TO A SOCK



SESAME SEED IN THE SPACE BETWEEN TOP TEETH



GUM ON PANTS



NOTE FROM TEACHER IN BACKPACK



GRAPE JUICE STAIN ON WHITE CARPET



EYELASH IN EYE



KITE STUCK IN TREE



TOILET PAPER ON BOTTOM OF SHOE



DRIED MUCUS INSIDE NOSTRIL





2016
5th Annual
Global

Invent It Challenge



Think about a real
world **health**
problem and come
up with a solution.

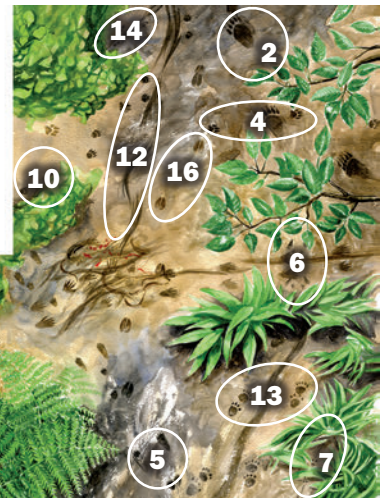
**Submit your
invention by
March 18, 2016.**

No purchase necessary to win.

Learn more by visiting:

Challenges.Epals.com/InventIt2016

**Answers to "Tracks,"
pages 40 and 41.**



SPONSORS:



Smithsonian



Try a black jelly bean
Stop visiting young Abe
Lincoln, it can't possibly
go anywhere.
Figure out where the
hot pink rabbits came
from.
Finish my screenplay
Stop pranking Edison
Go gluten free

Pfft!

BE
REALISTIC,
CATE!

