SCHOLASTIC

OCTOBER 31, 2016
VOL. 73 NO. 4
ISSN 1041-1410

ScienceWorld®
current science®

SCHOLASTIC.COM/SCIENCEWORLD

INSIDE

PHYSICS

GOING BATTY

How bats are inspiring the next generation of drones

SCHOLASTIC
ScienceWorld
current science
OCTOBER 31, 2016 VOL. 73, NO. 4

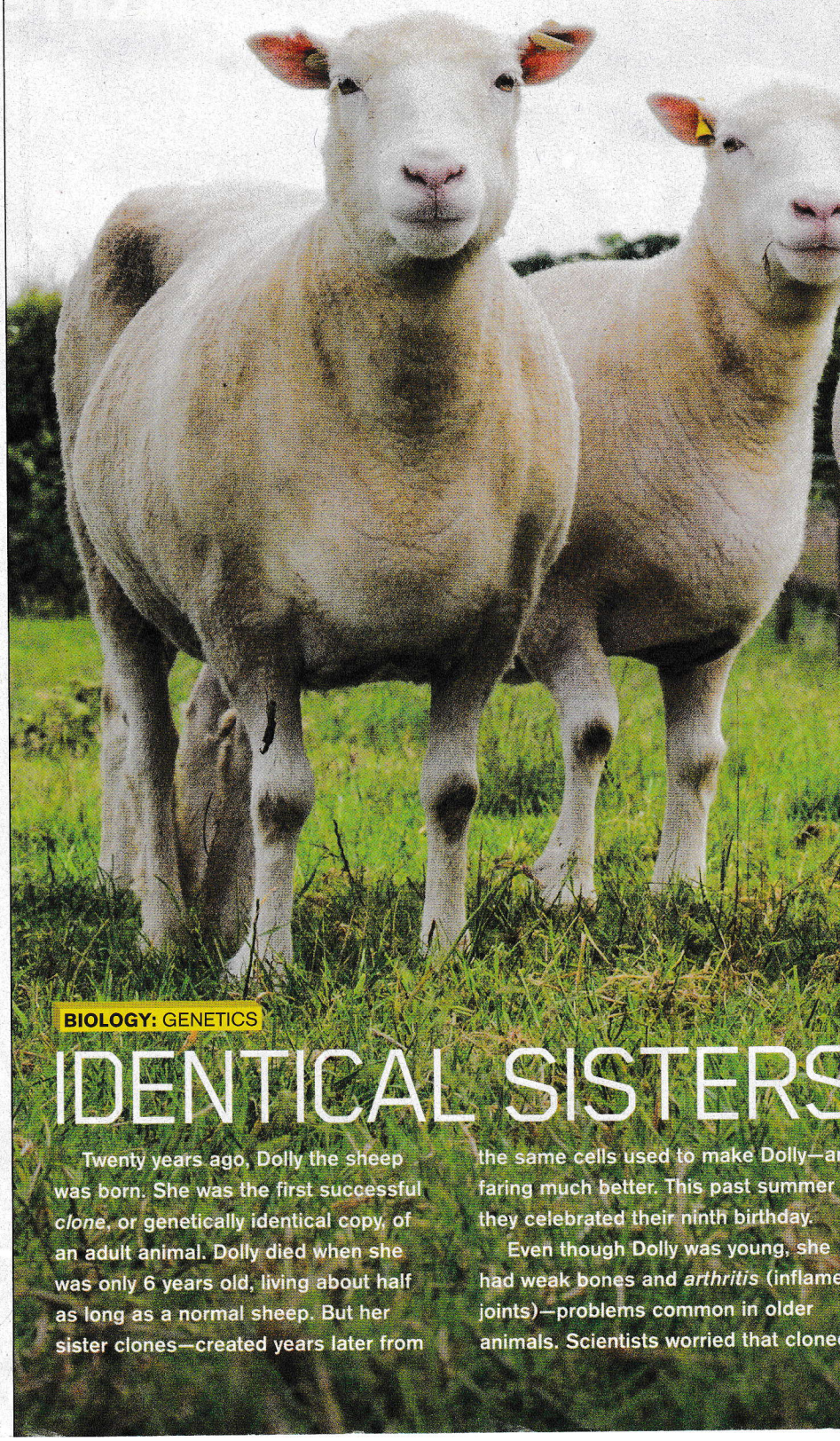
SCIENCE WORLD OCTOBER 31, 2016
VOL. 73, NO. 4 Editorial Director: Patricia Janes **Senior Editor:** Jennifer Barone **Associate Editor:** Jacob Batchelor **Contributing Editor:** Andrew Klein **Editorial Consultant:** Cody Crane **Interns:** Jeanette Ferrara and John Hering **Education Editor:** Matt Friedman **Online Editor:** Catherine Wilshusen **Senior Art Director:** Sarah Irick **Photo Editor:** Els Rijper **Production Editor:** Allan Molho **Senior Copy Editors:** Ingrid Accardi, Suzanne Bilyeu **Copy Editor:** Troy Reynolds **Digital Imager:** Vanessa Irena **Media Editor:** Marie Morreale **Executive VP, Scholastic:** Hugh Roome **Creative Director:** Judith Christ-Lafond **Design Director:** Felix Batcup **Executive Director of Production and Operations:** Barbara Schwartz **Executive Editorial Director, Copy Desk:** Craig Moskowitz **President, Chief Exec. Officer, and Chairman of the Board of Scholastic Inc.:** Richard Robinson. **POSTAL INFORMATION:** *SCIENCE WORLD* (ISSN 1041-1410; in Canada, 2-c no. 55948) is published 12 times annually; biweekly: September, October, March; monthly: November, December, January, February, April, May; by Scholastic Inc., 2931 East McCarty St., P.O. Box 3710, Jefferson City, MO 65102-3710. Periodical postage paid at Jefferson City, MO 65102 and at additional mailing offices. POSTMASTERS: Send notice of address changes to *SCIENCE WORLD*, 2931 East McCarty St., P.O. Box 3710, Jefferson City, MO 65102-3710.

TO ORDER *SCIENCE WORLD*, CALL 1-800-SCHOLASTIC.

COVER: INGO ARNDT/MINDEN PICTURES

SCIENCE NEWS

FAMILY RESEMBLANCE Daisy, Debbie, Denise, an Diana are all genetically identical to Dolly.



BIOLOGY: GENETICS

IDENTICAL SISTERS

Twenty years ago, Dolly the sheep was born. She was the first successful *clone*, or genetically identical copy, of an adult animal. Dolly died when she was only 6 years old, living about half as long as a normal sheep. But her sister clones—created years later from the same cells used to make Dolly—ar faring much better. This past summer they celebrated their ninth birthday.

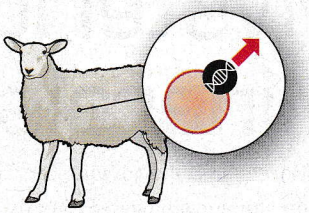
Even though Dolly was young, she had weak bones and *arthritis* (inflame joints)—problems common in older animals. Scientists worried that clone

animals aged *prematurely*, or earlier than usual. But a checkup has revealed that Dolly's sister clones' bones, hearts, and joints are in good condition. "They're perfectly healthy for their age," says Kevin Sinclair, a biologist at the University of Nottingham in England who raised the sheep.

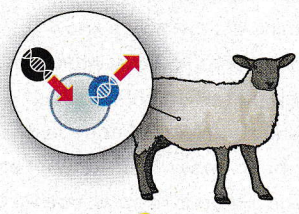
Some scientists hope the same techniques used to create Dolly and her sisters could be used to clone endangered species and help save them from extinction. *—Amy Barth*

HOW TO CLONE A SHEEP

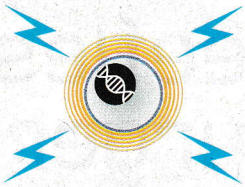
Here's how scientists create clones like Dolly and her sisters.



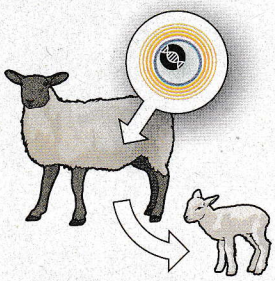
1. Extract the *nucleus* (the part of the cell that contains the genetic material) from a cell of the sheep to be cloned.



2. Take an egg cell from a female sheep and remove its nucleus. Replace it with the nucleus from the sheep being cloned.



3. Chemically or electrically stimulate the altered egg cell to make it begin dividing.



4. Implant the egg cell into the uterus of a female sheep. It grows into a sheep genetically identical to the original sheep.

EARTH SCIENCE: ROCKS & MINERALS

Mysterious Minerals

More than 50 years ago, two minerals called stepanovite (steh-PAN-oh-vite) and zhemchuzhnikovite (zhem-chooz-NIK-oh-vite) were discovered in a mine in Siberia, Russia. Scientists at McGill University in Canada recently found that the minerals are solids known as *metal organic frameworks*. Researchers had created such materials in labs, but none had ever been observed in nature before.

The minerals' *crystals* are made up of molecules arranged in a pattern that resembles a honeycomb. That structure allows them to store other molecules within the pattern's spaces, chemists say. Such materials could have many applications. For instance, they could be used to soak up harmful *greenhouse gases*, like carbon dioxide, that trap heat in Earth's atmosphere. —*Jeanette Ferrara*

STRANGE CRYSTAL: The mineral stepanovite exists naturally (*far left, on coal*) and in a synthetic form (*above*).

CHEMISTRY: MOLECULES

Beefless Burger

WANT A BITE? A restaurant in New York City has begun serving the Impossible Burger.

You can't tell by looking at it, but this juicy burger contains no meat or animal products. Yet its creators say it looks and tastes like real beef.

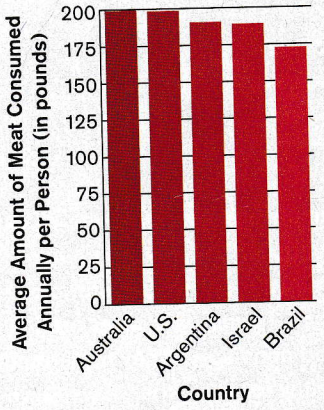
The California company Impossible Foods makes its burger using wheat, potato, and coconut oil. But the secret to its realistic appearance and flavor is *heme*. This iron-rich molecule is a component of proteins found in muscle and blood that give them their red color. Plants also contain small concentrations of heme.

Biochemists at Impossible Foods isolated the gene for heme in soybeans and inserted it into *yeast*. This single-celled organism then produced heme for use as an ingredient. The result: the meatless but bloody-looking Impossible Burger.

Its creators say their burger uses fewer resources than red meat. But how's the taste? "I grew up on a farm, so I'm used to eating a lot of meat," says Nick Halla of Impossible Foods, "and I think it really tastes like meat." —*Jeanette Ferrar*

WORLD'S TOP FIVE MEAT EATERS

About how much more meat does an average Australian consume each year than an average Brazilian?



SOURCE: OECD,

BIOLOGY: ANIMAL PHYSIOLOGY

WHAT SHARP TEETH YOU HAVE!

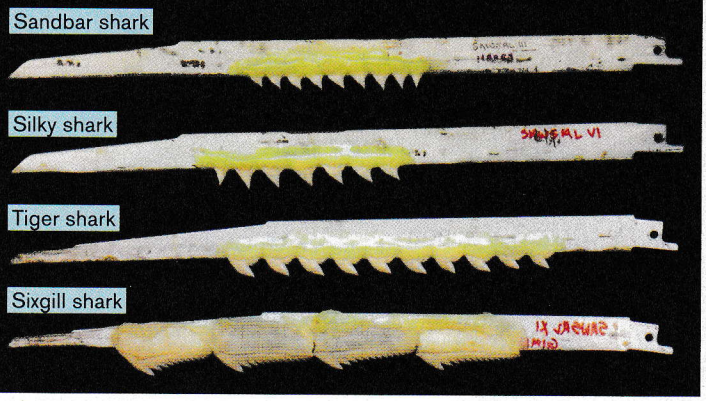
Just how sharp are sharks' teeth? To find out, biologists at the University of Washington glued teeth from four shark species onto power saw blades. The scientists used the blades to slice through chunks of raw salmon to see how well the different teeth cut.

Teeth from the tiger, sandbar, and silky sharks sliced through the fish "like butter" but dulled quickly, says evolutionary biologist Stacy Farina. The sixgill shark's teeth didn't cut as well but wore down more slowly.

There might be a trade-off between a tooth's cutting ability and its strength. "Sharks replace their teeth pretty often," says Farina. Those with blunter teeth—like the sixgill—may not have to regrow their teeth as frequently, she says. *—Kathryn Free*

TOOTHY CONTENDERS

Here are the saw blades made from the teeth of the four shark species the scientists investigated. The sixgill's teeth proved to be less sharp but more durable than those of the other species.



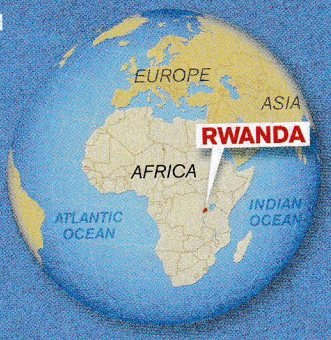
ENGINEERING: MECHANICAL ENGINEERING

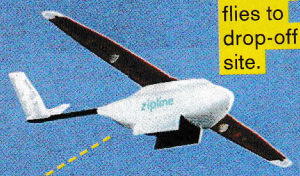
SPECIAL DELIVERY

Drones will soon begin delivering blood and other medical supplies to rural parts of the U.S. A company called Zipline, based in California, currently uses small robotic aircraft to transport these items to remote areas in Africa. Now the company is working with the U.S. government to do the same in Maryland, Nevada, and Washington.

In Rwanda, a mountainous country in Central Africa, poor roads make it difficult to transport blood, vaccines, and medicine. But with drones, medical workers can receive deliveries of these supplies within 30 minutes.

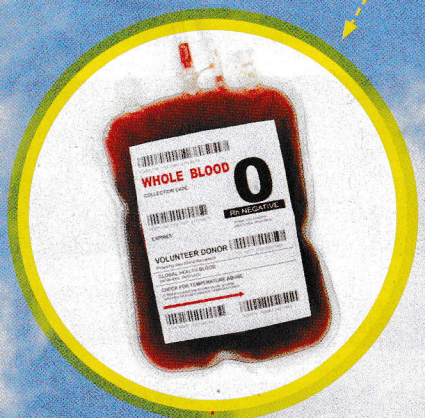
Zipline's drones can fly up to 70 kilometers (43 miles) each way from their takeoff site and release their cargo via a parachute. "Each delivery we make has the potential to save someone's life," says co-founder Ryan Oksenhorn. *—Kathryn Free*





DRONE flies to drop-off site.

CARGO PACKAGE contains medical supplies.



BLOOD and other supplies arrive at destination.

HOW DRONES WORK

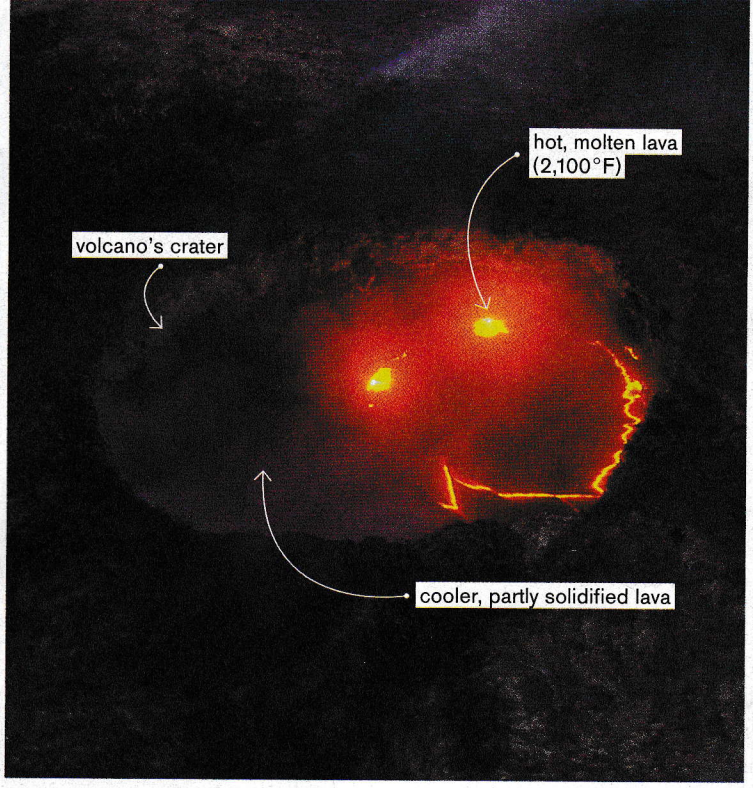
Drones are being used by the military, movie directors, scientists, and even some mail carriers.

FLIGHT CONTROL: Software determines if motors need more or less power to keep the drone steady.

REMOTE CONTROL: Some drones fly completely independently. Others can receive instructions from a controller via radio signal.

NAVIGATION: GPS and a *barometer*, which measures atmospheric pressure, tell the flight-control software where the drone is and how to get to its destination.

CAMERA: An onboard camera can record or send video as the drone flies.



EARTH SCIENCE: LANDFORMS

Smiling Volcano

This volcano in Hawaii was all smiles during an ongoing eruption this past summer. A filmmaker flying above Kilauea captured this cheerful image of the accidental jack-o'-lantern.

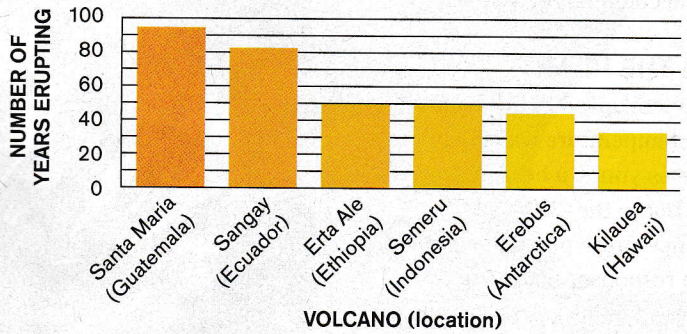
Parts of Kilauea have been erupting nonstop for 33 years. The smiley face formed on a *lava lake*—a pool of molten rock inside a volcanic crater. A dark layer of cooled lava covers the surface of the lake. As lava churns within the crater, that surface can pull apart, revealing glowing orange lava underneath. At Kilauea, the cracks formed what looked like a smile.

"The lava is always changing," says Janet Babb, a geologist at the U.S. Geological Survey Hawaiian Volcano Observatory. "It was total chance that the smiley face formed."

—*Amy Barth*

ONGOING ERUPTIONS

Many volcanoes like Kilauea erupt on and off for years. Approximately when did Guatemala's Santa María eruption begin?



SOURCE: GLOBAL VOLCANISM PROGRAM

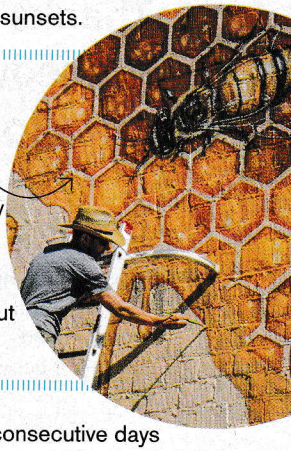
NUMBERS IN THE NEWS

1,880 trillion

Distance from Earth in miles of a newly discovered exoplanet. The planet, HD 131399Ab, is in a star system with three suns—making for triple sunsets.

50,000

Number of honeybees American artist Matthew Willey plans to paint on walls around the world to raise awareness about the pollinators' decline.



150 Number of consecutive days Costa Rica went without using fossil fuels to generate electricity, as of September. The country aims to get 100 percent of its power from renewable energy.

34

Weight in kilograms of a pearl discovered inside a giant clam by a fisherman in the Philippines. The pearl is worth about $100 million.

5 Number of Marvel comic book covers released this fall that have a special STEAM (Science, Technology, Engineering, Arts, and Math) theme.

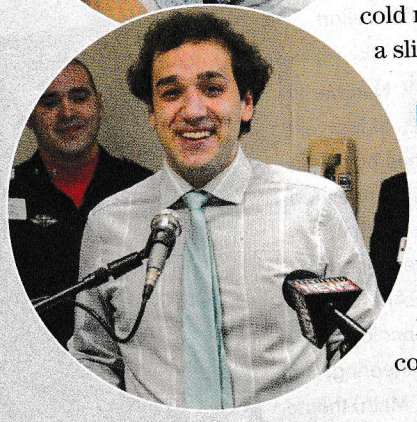
BACK FROM

Thanks to a life-saving medical procedure, a young man was brought back to life after a tragic accident

ESSENTIAL QUESTION: How might long-term exposure to extreme cold affect the body?

On February 21, 2015, Justin Smith died and came back to life. The night before, he had stumbled into a snowbank near his home in McAdoo, Pennsylvania, and lost consciousness. Early the next morning, his dad, Don Smith, found him frozen with his eyes wide open. The 25-year-old college student, who had been outside in subzero temperatures for nearly 10 hours, wasn't breathing and didn't have a pulse. Don called 911 and watched in horror as first responders covered his son with a white sheet.

One of the paramedics called nearby Lehigh Valley Hospital-Hazelton to report the incident. "All signs lead us to believe that he's been dead for a considerable amount of time," he told emergency medical doctor Gerald Coleman.



LIFE SAVED: Before and after Justin's amazing recovery

But after learning more about Justin—relatively young, in seemingly good health—Coleman decided that he wasn't comfortable pronouncing him dead. That's because Justin had suffered *hypothermia*—a condition that occurs when the body loses more heat than it can produce. And Coleman knew that the extreme cold might have protected Justin's body, creating a slim chance that he could be revived.

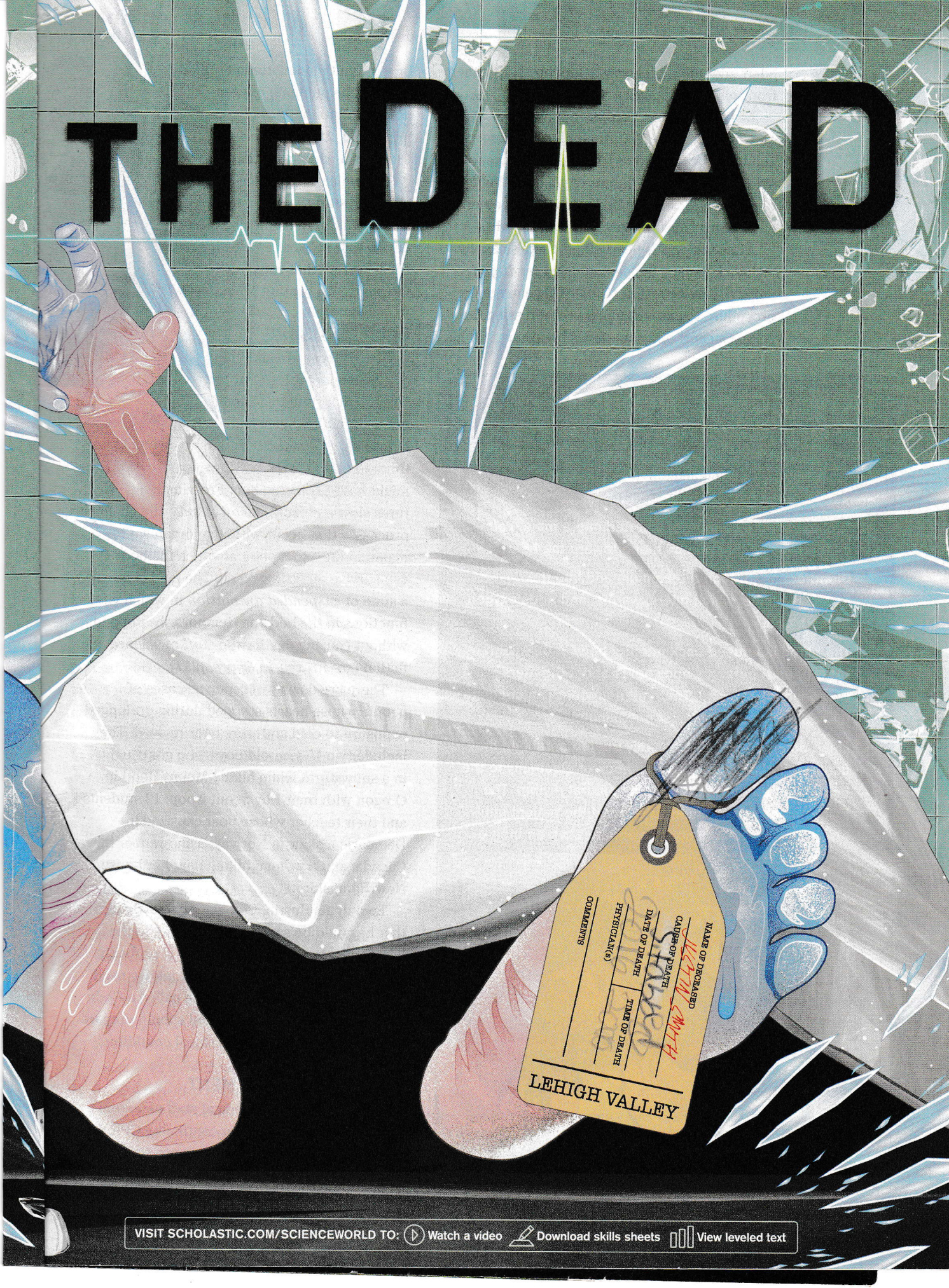
RESTARTING THE HEART

Before Justin collapsed in the snowbank, his body temperature was likely about the same as yours: a healthy 37°C (98.6°F). But in the -20°C (-4°F) weather, his temperature plummeted to 18°C (64.4°F). In response, Justin's body concentrated his blood in his core, where his

Continued on page 10 →

GUY STAUBER (ILLUSTRATION); ERIC CONOVER/HAZLETON STANDARD-SPEAKER/AP PHOTO (HOSPITAL, SPEAKING)

THE DEAD



heart and other vital organs are, protecting them from serious damage.

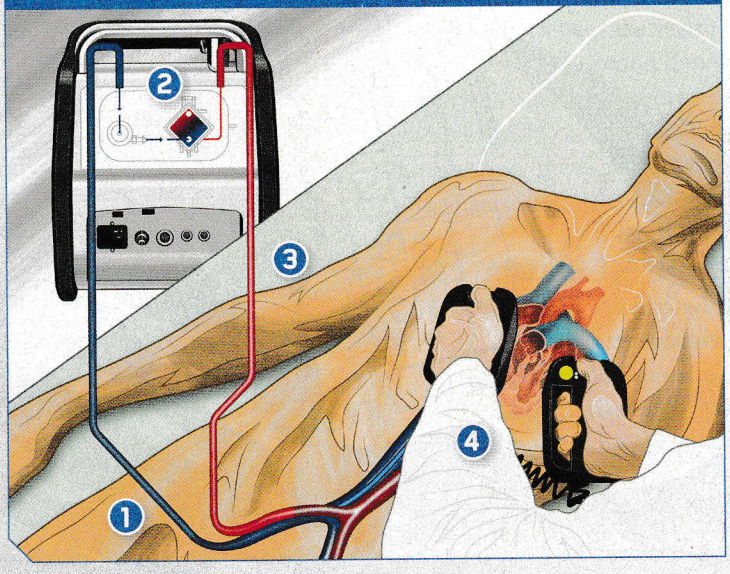
As the blood left his extremities, Justin's skin grew pale and his lips turned blue. His fingers and toes succumbed to *frostbite*—damage to skin and underlying tissues exposed to frigid temperatures. Justin's body grew even colder, causing his heart to slow until it stopped.

After someone's heart stops, there's usually a chance to save the person using *cardiopulmonary resuscitation* (CPR). This emergency procedure requires manually compressing the person's chest and sometimes breathing into his or her mouth in an attempt to continue pumping oxygenated blood to the heart, brain, and other organs. CPR provides a window of time during which medics may be able to restart the heart using a *defibrillator*, a medical device that delivers an electrical current that can shock the heart into beating again.

HOW ECMO WORKS

Doctors often use extracorporeal membrane oxygenation (ECMO) to treat heart patients and sometimes victims of severe hypothermia by connecting them to a machine that does the work of both the heart and the lungs.

1. Tubing called a *cannula* is inserted into a major *vein*—a blood vessel that pumps blood toward the heart.
2. Blood drains through the cannula and into the ECMO machine, which filters, warms, and adds oxygen to the blood.
3. The blood is infused back into the body. A 68 kilogram (150 pound) person's body holds about 5.5 liters (1.5 gallons) of blood. That entire amount can circulate through the machine in just one minute.
4. Once doctors have successfully treated a patient, they use a defibrillator to deliver a shock of electricity to the heart in an attempt to restore its natural rhythm. The ECMO machine continues to support the patient until his or her heart and lungs are able to work on their own.



COLD EXPOSURE

The chances are slim that a person undergoing CPR for more than 20 minutes can be revived. Justin's heart had likely stopped hours before his dad found him, and no one had been there to try to save him. However, the cold might have protected him. Freezing temperatures slow a person's *metabolism*—the chemical processes that occur within an organism to maintain life—to a point at which the body can survive on little oxygen. The cold creates a state of *suspended animation* in which vital functions in the body are temporarily stopped without causing death—the stuff of science fiction (*see Frozen in Space, p. 11*).

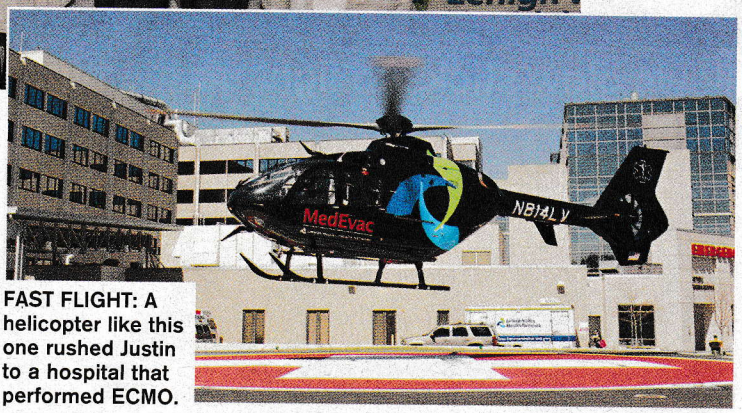
There are dozens of reported cases of people whose hearts stopped during prolonged exposure to cold and were later revived. They include two 15-year-old boys who got caught in a snowstorm while hiking Mount Hood in Oregon with their Boy Scout troop; 12 students and their teacher whose boat capsized in Denmark; a skier in Norway; a snowshoer in Canada; and a woman hiking near her house in New Hampshire.

Luckily for Justin, Coleman took a chance that he could be saved too. Speaking to the paramedic, the doctor said, "This is probably going to be a futile effort, but I think we need to do our best for him." Then he called a Code Blue, signaling that the hospital should prepare for an incoming patient in critical condition.

LIFE-SAVING TREATMENT

At the hospital, 15 medical staff members fought to save Justin's life, continuing CPR for more than two hours while trying to revive him. But Justin's heart wouldn't respond. Still, Coleman refused to give up. There was

LIFE-SAVING TEAM (*left to right*): Emergency medical doctor Gerald Coleman, neurologist John Castaldo, patient Justin Smith, and heart surgeon James Wu



FAST FLIGHT: A helicopter like this one rushed Justin to a hospital that performed ECMO.

one more procedure to try: *extracorporeal membrane oxygenation* (ECMO). This treatment drains the blood from a patient's body and into a machine that acts like an external heart and lungs (*see How ECMO Works, p. 10*).

Unfortunately, the hospital in Hazelton didn't have an ECMO machine. However, there was one in Allentown, about 18 minutes away by helicopter. Coleman called the hospital and talked to James Wu, a heart surgeon. Wu agreed that Justin might have a chance with ECMO. Justin was flown to the hospital and rushed into the operating room.

Once he was hooked up to the ECMO machine, Justin's temperature began to rise. Wu told Justin's family that he might have a 50/50 chance of surviving. When Justin's temperature reached about 29°C (84.2°F), Wu shocked his heart three times with a defibrillator . . . and amazingly got a pulse! Justin remained in a *coma*, but it was soon determined that his brain function was normal. Justin regained consciousness a few weeks later.

The traumatic experience left Justin with neither pinky fingers nor any of his toes, which had to be surgically removed because of frostbite. "The most surprising thing was that he didn't have any major *neurologic* [nervous-system-related] damage," says Wu.

Justin's story of survival is helping medical experts better understand the human body. Even the boundary between life and death, which we once considered absolute, might be less clear than previously imagined.

—Rene Ebersole

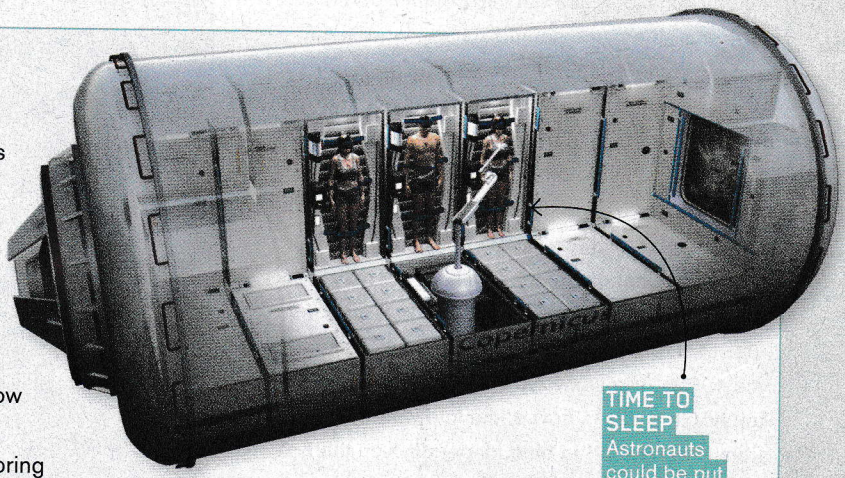
CORE QUESTION

Explain how ECMO works in your own words, using evidence from the text and diagram.

FROZEN IN SPACE

The ability to survive extreme cold could have applications for space travel. A journey to Mars from Earth, for example, would take from 150 to 300 days. It would require enough food, water, and supplies to support an entire crew during that time. If astronauts could be put into a state of suspended animation while traveling, it could vastly reduce the amount of cargo they would need to carry. That would allow for smaller, faster space capsules.

NASA-funded researchers are already exploring suspended animation. They're working on a device called RhinoChill, which uses tubes to shoot cold liquid through the nose into the base of the brain to mimic the effects of extreme hypothermia. Like hibernating bears, astronauts could ride through space without ever needing to eat or go to the bathroom. Such research could open a new era of space exploration and discovery.



TIME TO SLEEP Astronauts could be put into suspended animation for long space flights.

GLOW-STICK SCIENCE

Find out how chemistry allows glow sticks to light up the nigh

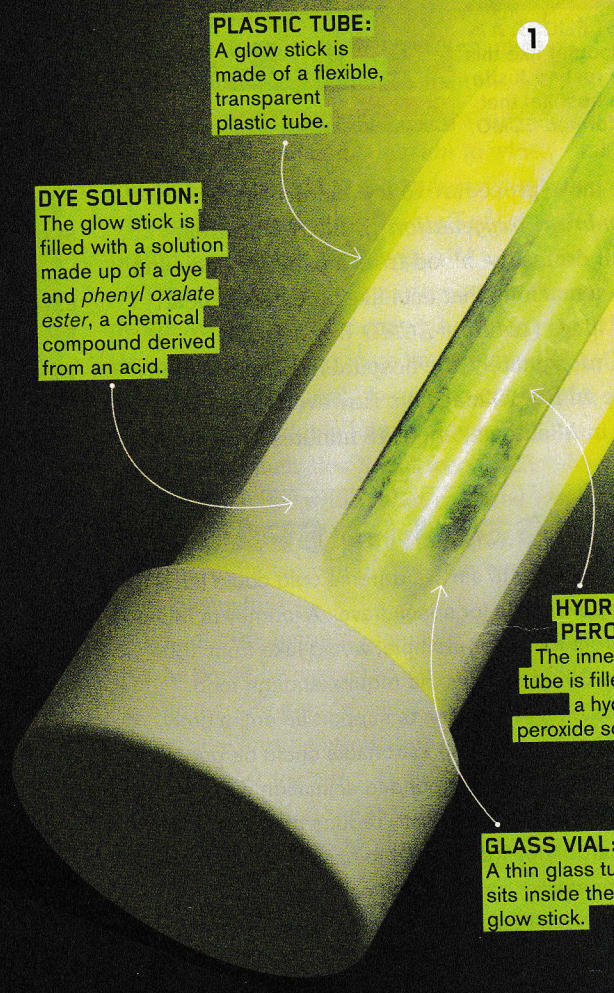
ESSENTIAL QUESTION: What is a chemical reaction? Can you give an example?

Trick-or-treaters often carry glow sticks to make themselves more visible in the dark as they travel door-to-door. But how exactly do these Halloween staples produce their eerie glow? They rely on *chemical reactions*, which occur when substances interact and change to create new substances. Some chemical reactions—like those happening inside glow sticks—give off light. This process is called *chemiluminescence* (ke-mee-loo-mih-NEH-sens).

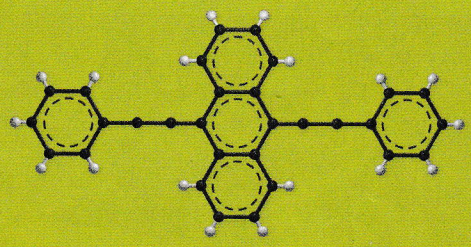
A glow stick is made of a flexible, transparent plastic tube filled with a dye *solution*, a liquid mixture made up of two or more substances. The tube also holds a smaller glass vial that contains *hydrogen peroxide*—the same chemical used to treat cuts and scrapes. To activate the glow stick, a person bends the tube, breaking the vial inside. This allows the different chemicals to mix. Once they come in contact with one another, they react and glow. Glow sticks keep making light until all the chemicals inside them react, anywhere from 4 to 12 hours.

Edwin Chandross, a chemist at the research company Bell Labs in New Jersey, first discovered the reactions needed to make glow sticks light up in the 1960s. The same type of reactions are still used today. Glow sticks now come in a variety of colors, from green to red to blue, depending on the type of dye they contain. And the sticks aren't used just for fun. Military personnel, emergency responders, and underwater divers rely on glow sticks to see in dark places and alert others to their presence.

—Jennifer Barone



COLOR CHEMISTRY
Different dye molecules inside glow sticks produce different colors. The molecule shown here creates an eerie green glow.

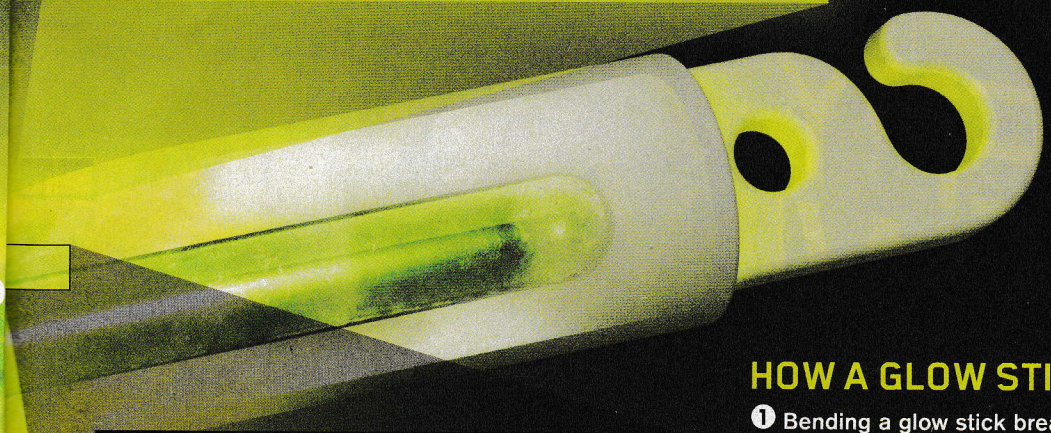


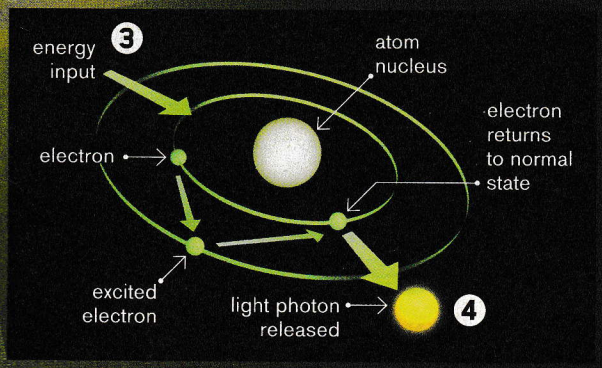
KEY
= hydrogen
= carbon

CHEMICAL NAME:
9,10-bis(phenylethynyl)anthracene

CHEMICAL FORMULA = $C_{30}H_{18}$

CORE QUESTION
Describe the process that results in a glow stick lighting up.





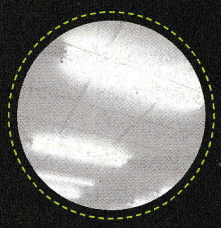
HOW A GLOW STICK WORKS

1. Bending a glow stick breaks the glass tube inside it, releasing hydrogen peroxide.
2. The hydrogen peroxide reacts with the phenyl oxalate ester to create an unstable compound that breaks down, releasing energy.
3. The energy excites negatively charged particles called *electrons* in the atoms of the dye molecules.
4. This causes the molecules to release the excess energy as light.

NAME THAT GLOW

Chemiluminescence is just one way to produce light. Here are some others.

INCANDESCENCE:
A substance like the metal tungsten (W), used to make the filaments in conventional light bulbs, gives off light when heated.



FLUORESCENCE:
A substance like the coating on the inside of a fluorescent light bulb absorbs one wavelength of light and quickly releases another.

PHOSPHORESCENCE:
A substance like zinc sulfide in glow-in-the-dark stickers absorbs light energy and releases it over an extended period of time.

RADIOLUMINESCENCE:
A substance like a phosphor releases light when hit with *ionizing radiation* (high-energy particles or waves).

BIOLUMINESCENCE:
Chemical reactions produce light inside a living organism.

VISIT SCHOLASTIC.COM/SCIENCEWORLD TO: Watch a video | Download skills sheets | View leveled text

IMAGES (RADIOLUMINESCENCE), DARWIN DALE/PHOTO RESEARCHERS, INC./SCIENCE SOURCE (BIOLUMINESCENCE)

CREEPY-CRAWLY CAVE

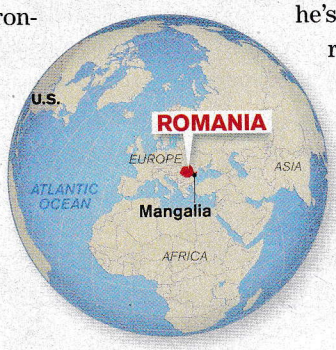
Meet the bizarre creatures that live in one of Earth's most extreme habitats

ESSENTIAL QUESTION: What features might help cave-dwelling organisms survive underground?

Deep inside a cave in Romania, there are creatures that have never seen the light of day. White, eyeless spiders, scorpions, worms, and centipedes scuttle and slither in the darkness. They feed on a thick, floating mat of bacteria that covers an underground lake. The cave and the species that call it home have been sealed off from the outside world for 5.5 million years. During that time, the cave has developed into an *ecosystem*—a community of organisms interacting with their physical environment—unlike anything else on planet Earth.

In 1986, workers preparing to construct a power plant in the city of Mangalia uncovered the Movile (*moh-VEE-luh*) Cave. Since its discovery, fewer than 100 people have been allowed inside. Not only is the descent into the cave treacherous, but the air inside is hot, humid, and toxic. The area around the cave is known for its *geothermal springs*. These naturally hot bodies of water release harmful gases like hydrogen sulfide that fill the cave.

A few brave scientists have ventured into the cave's depths to study its bizarre life-forms. "To many, Movile Cave is the stuff of horror movies," says Rich Boden, a microbiologist at Plymouth University in England. But he's intrigued by it. Boden and other researchers hope to learn how the cave's organisms have adapted to survive—and thrive—in the dark and deadly environment.



TRAPPED UNDERGROUND

Scientists think Movile formed under a hill millions of

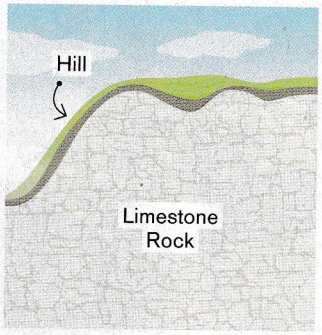
years ago (*see How Movile Cave Formed, right*). Back then, the cave likely had an opening in the side of the hill. Water and gas from a geothermal spring inside the cave slowly ate away at the cave's limestone walls, weakening them until the hill collapsed. The cave and everything inside it—including the organisms living there—were sealed off from the outside world.

Some animals trapped inside the cave couldn't survive. Movile Cave contains fossils of mice that became extinct long ago. But some creatures developed physical traits that enabled them to live on. "Over time, highly adapted organisms emerged," says Boden. Above ground, many bacteria use sunlight to turn carbon dioxide gas and water into food—a process called *photosynthesis*. The microorganisms inside Movile Cave instead rely on *chemosynthesis* to convert chemicals like sulfur into

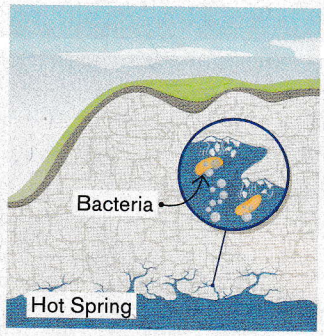
Continued on page 16 →

HOW MOVILE CAVE FORMED

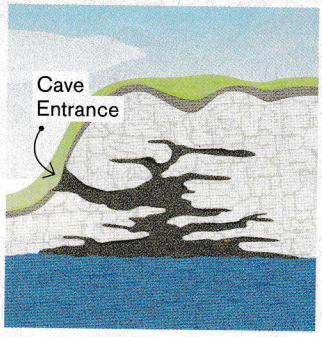
Movile Cave was created by an unusual feature—an underground hot spring, heated by geothermal activity deep within Earth.



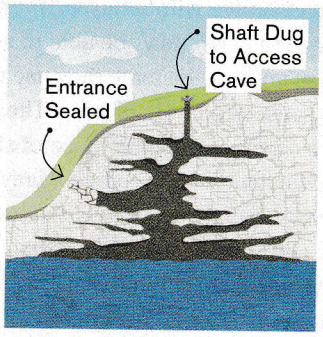
1 Movile Cave formed beneath a hill made of limestone rock.



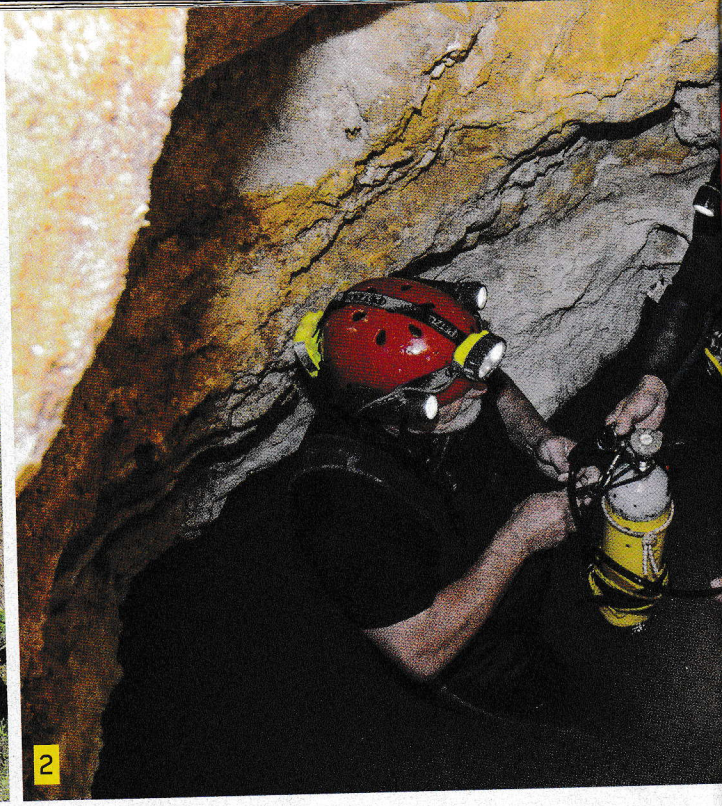
2 Water that contained hydrogen sulfide gas bubbled up from a hot spring beneath the hill. Bacteria converted the hydrogen sulfide into energy and excreted sulfuric acid, which dissolved the limestone and formed cracks in the rock.



3 The rock continued to wear away, enlarging the cave and creating an opening to the outside world.



4 After millions of years, so much limestone had dissolved that the weakened hillside collapsed. The cave was sealed off. In 1986, workers accidentally discovered the cave. A shaft was dug to explore its depths.



STUDYING MOVILE

1 Scientists don protective suits before entering the cave.

2 Diving gear is needed for exploring flooded areas.

3 Scientists collect samples of the cave's air, rocks, and life-forms.

energy. Tiny crustaceans and worms feed on the bacteria. They, in turn, become prey for predators like scorpions, spiders, and centipedes.

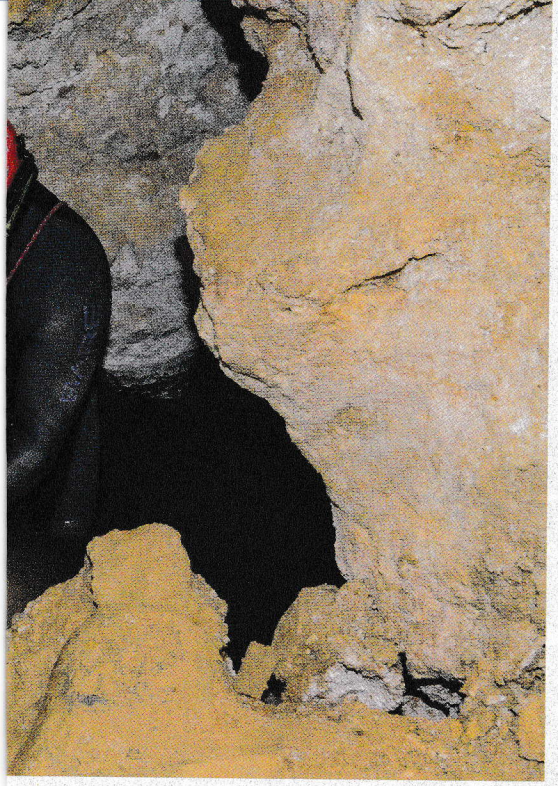
Many insects and spiders living inside the cave survive without eyes. They don't need them since they wouldn't be able to see in the darkness anyway. Instead, they use their antennae to sense predators or prey. These appendages are often longer than those of similar animals that live outside the cave. Many of the cave's creatures are also totally white. The *pigment*, or natural coloring, that normally helps protect animals from sunlight isn't needed in the cave's pitch-black environment.

On the walls of the cave, white spiders spin webs to catch tiny insects called springtails. The largest predator in the cave is a type of brown centipede commonly found in gardens, called *Cryptops anomalans*. The ones found in the cave, though, are colorless and about three times larger than those above ground. The centipedes have huge antennae and legs but no eyes. The water scorpion *Nepa anophthalma* also lives in the cave. It's also missing eyes and pigmentation—unlike its relatives at Earth's surface.

When Boden was first asked whether he wanted to go inside Movile Cave to collect samples, he said no. The trip seemed too dangerous. Then he thought, "I'm never going to get another chance. I have to do this!" Six years ago, Boden became the 29th person to venture inside the cave.

ENTER AT YOUR OWN RISK

Before he went in, Boden put on a helmet and a protective suit and donned special shoes—careful to keep them free of anything that could contaminate the pristine cave. Then he lowered himself down a narrow shaft dug into the ground and through a series of trapdoors that are designed to keep the cave sealed



off from the outside world. "Once you climb through the final door and shut it, you're totally cut off," Boden says. "It's surprisingly relaxing there, deep within Earth."

CAVE MYSTERIES

Boden descended into the lowest section of the cave, known as the Lake Room. The room contains a pool of water—the same spring that bubbled millions of years ago. Even though the space is only about the size of a small car, it's teeming with life. There, Boden collected samples of organisms, rocks, and clay. He even bottled up some of the cave's gas to study back at his lab.

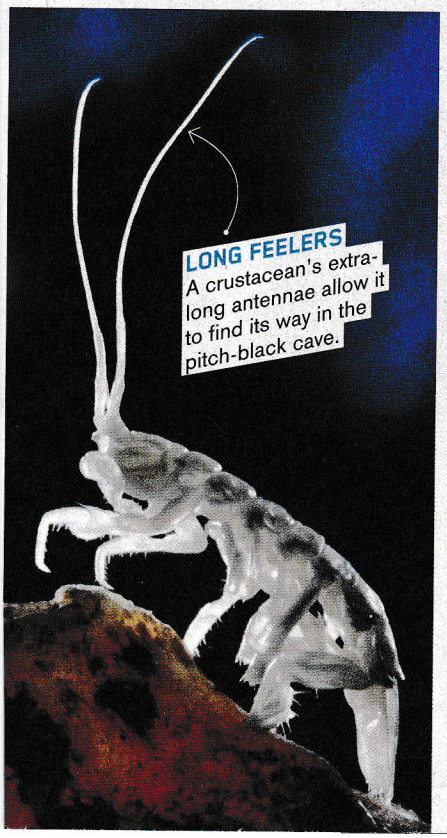
Not only does the atmosphere inside the cave contain toxic gases, the air also has just 10 percent oxygen—compared with 21 percent found at Earth's surface—and more than 80 times the carbon dioxide. After a half hour under these conditions, people start to feel tired and sweaty. Their skin turns red from a potentially deadly condition called *hypercapnia*, which occurs when there's too much carbon dioxide in the blood. "You start to feel sluggish," says Boden. "If someone asked me to pass a container, I had to think about it for a few seconds." Boden could work safely in this environment for only about four hours before he had to return to the surface.

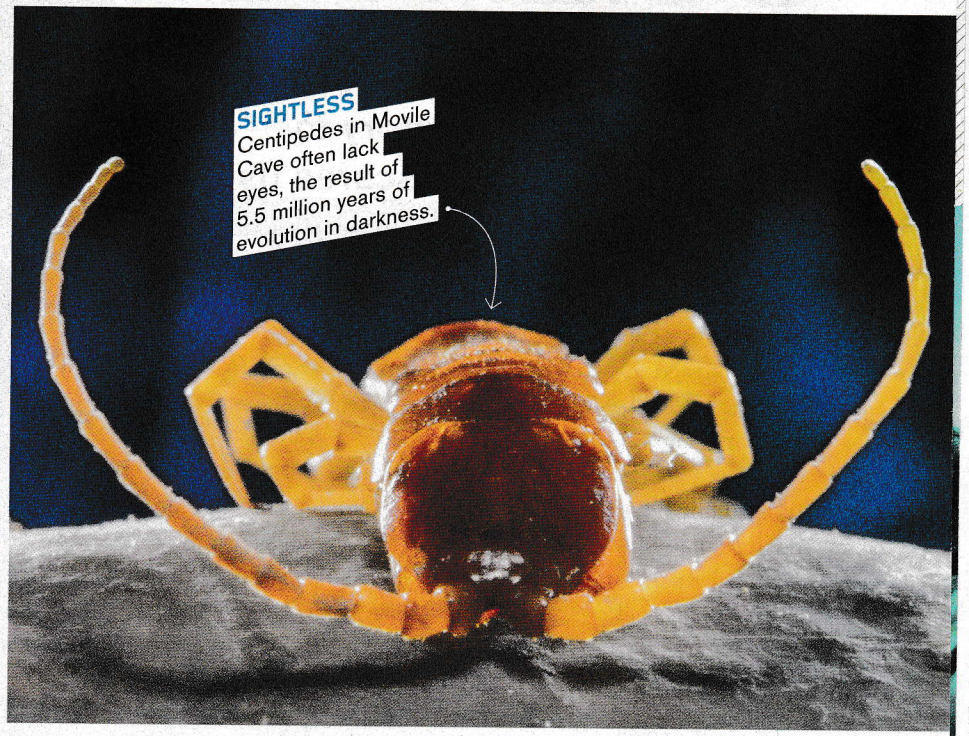
The samples Boden and other scientists collected are allowing them to learn about the cave's unique food web and environment. They might help answer larger questions too. "The cave helps us understand life and how it came about," says Boden. It could even shed light on whether life could exist in other extreme environments, like on Mars.

—Amy Barth

CORE QUESTION

Why do conditions inside Movile Cave make it dangerous for people to enter? Use evidence from the text to support your answer.





SCREAM SCIENTIST

Margee Kerr studies fear in her haunted house laboratory to figure out what really scares us

Halloween is the time of year when many people actually like being scared. They watch suspenseful movies, dress up in creepy costumes, and visit "haunted" houses. In fact, every year roughly 10 million people across the U.S. visit these spooky attractions. One of the most popular is ScareHouse in Pittsburgh, Pennsylvania. Part of Margee Kerr's job is to make this horrifying haunt as chilling as possible.

Kerr is a *sociologist* who teaches at the University of Pittsburgh. She studies human behavior, especially how people respond to fear. One way she does that is by designing truly terrifying scares—from hideous zombies to ghastly ghouls—for an area of ScareHouse known as "The Basement." Then she observes the reactions of volunteers who enter her chamber of horrors. Kerr hopes the information she gathers will help her better understand what scares people and why some of us seek out scary situations like haunted houses.

SCARED SILLY: A frightful moment at a haunted house in Mississippi

How did you end up studying what scares people?

It came about in an unexpected way. In 2008, I visited ScareHouse around Halloween. I realized that all fear isn't bad. Our response to things that scare us keeps us safe and is responsible for our survival.

How do you measure people's responses to fear at ScareHouse?

Volunteers walking through the attraction wear portable devices that measure heart rate and *electrodermal activity*—the levels of electricity conducted by the skin. An *electroencephalograph* (EEG) also measures participants' brain-wave activity before and after they enter. The devices relay data to computers in our lab (a room in The Basement), informing us about how people's bodies and brains are responding to being scared.

SCARY FACE: Makeup is applied to a haunted house cast member.

How do you come up with your ideas for The Basement?

I take a lot of ideas from what science says will startle people, like flashes of light or blasts of air. I also get inspiration from real-life stories and pop culture. For example, one year, zombies might be the trendy monster. The next year, it will be something else.

Do different people find different things scary?

Yes. Past research tells us that a lot of it has to do with personal history. It often only takes one exposure to something that could hurt us, like a snake, for us to fear it for the rest of our lives. This is called fear conditioning—when your brain associates something with being scary. It's an *adaptation* that helps humans survive. When people are scared, they also experience *fight-or-flight*—when we choose to tough it out (fight) or run away (flight) from frightening situations. The intensity of this response is different depending on the person. Some people startle easily while others don't even flinch.

Why do some people like being scared?

Being scared releases a handful of chemicals that control certain functions in the body. Some, like *endorphins*, which block pain, can actually make us feel good—even when scared. Facing something scary head-on in a safe place can also give people a confidence boost. They feel like they've achieved a personal goal or overcome a challenge.

What is your favorite part of the job?

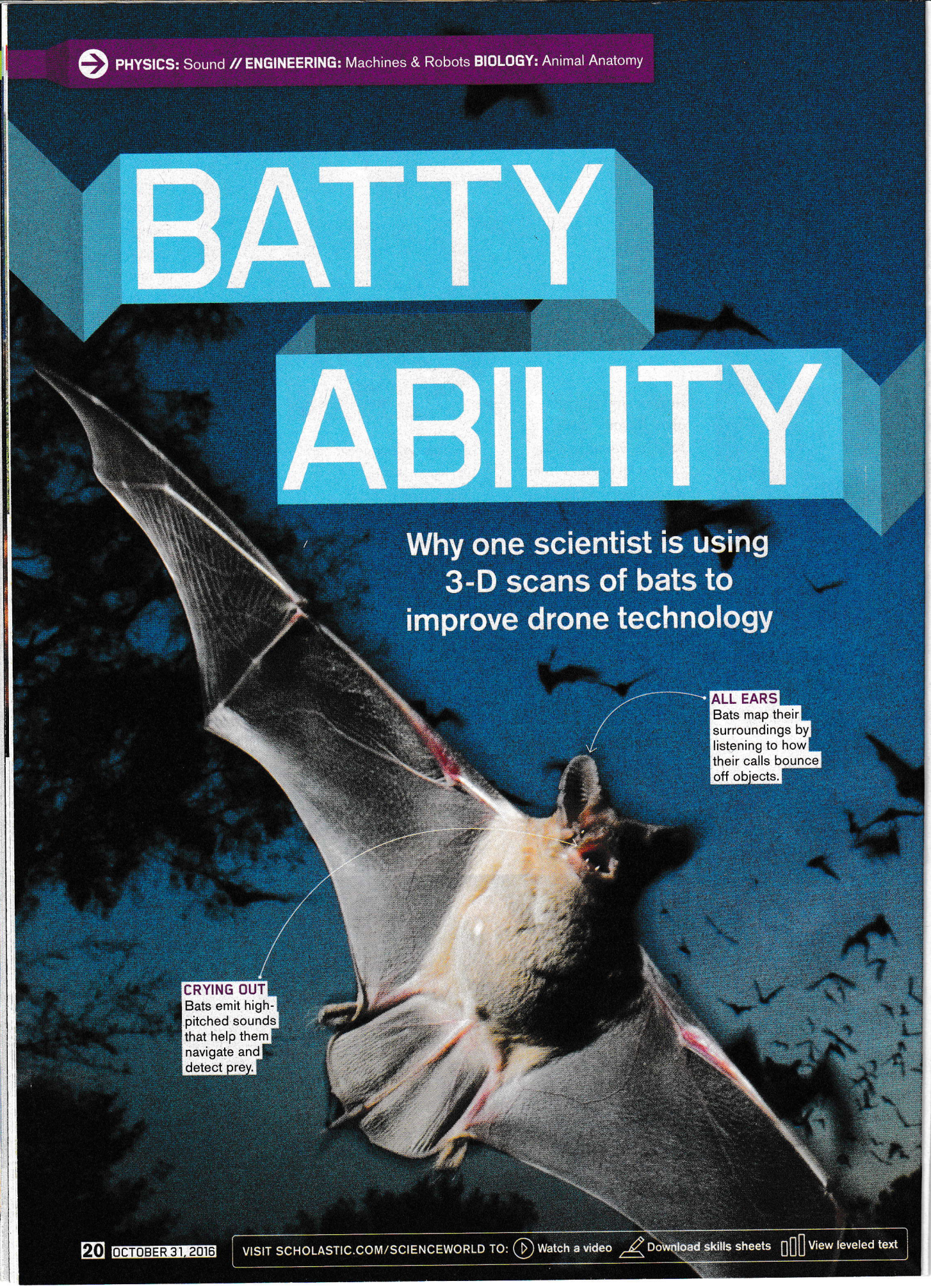
I love my work with haunted attractions. I enjoy seeing people have a really good time being frightened: smiling, laughing, high-fiving, and hugging each other after they leave.

—Jeanette Ferrara

PEEK-A-BOO! A monster surprise at a haunted house in Ohio

BATTY ABILITY

Why one scientist is using 3-D scans of bats to improve drone technology



ALL EARS
Bats map their surroundings by listening to how their calls bounce off objects.

CRYING OUT
Bats emit high-pitched sounds that help them navigate and detect prey.

ESSENTIAL QUESTION: How do bats use sound to navigate? Are there any devices used by people that work in the same way?

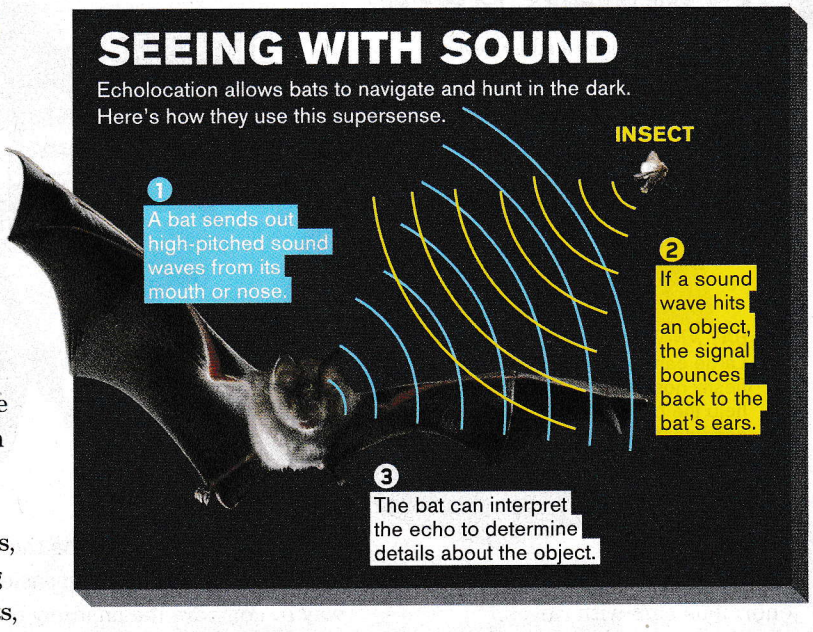
Dusk falls on a dense forest in China's Shandong province. As the sun dips below the horizon, hundreds of horseshoe bats swoop from the mouth of a cave. They dart across the dark sky, nabbing insect after insect. Before the sun rises the next morning, each bat will have eaten as many as 8,000 bugs—without bumping into a single tree or colliding with another bat. They accomplish this feat by using *echolocation*, a sixth sense that allows them to "see" using sound waves.

The bats navigate with high-pitched squeaks, many of which humans can't hear. By listening to how their calls *reflect*, or bounce, off objects, they can map their surroundings. It's an ability no human technology comes close to matching. But Rolf Mueller wants to change that.

Mueller is a mechanical engineering professor at Virginia Tech University in Blacksburg, Virginia. He's attempting to design high-tech navigation systems that mimic bats' amazing abilities. These systems could, for example, enable drones to maneuver in dark, cramped spaces like disaster zones more easily.

LISTENING IN

Bats emit chirps—some through their mouths and others through their noses—as many as 200 times per second. When the sound waves hit an object, like a tree or an insect, they reflect back to the bat's ears. The echo gives the bat information about the object's size and location, and whether it's moving and how fast (*see Seeing With Sound, above*).



A device called *sonar*, which is used in submarines, operates on the same principles as echolocation. But it requires large, cumbersome arrays of transmitters to produce sounds and microphones to detect their echoes. To Mueller, it seemed logical to turn to bats for inspiration to improve sonar technology. Nature, he says, has already designed echolocation—a more elegant and sophisticated version of sonar.

FREAKY FEATURES

Some bats have evolved unusual *adaptations* that improve their ability to echolocate. Species like horseshoe and leaf-nosed bats have nostrils

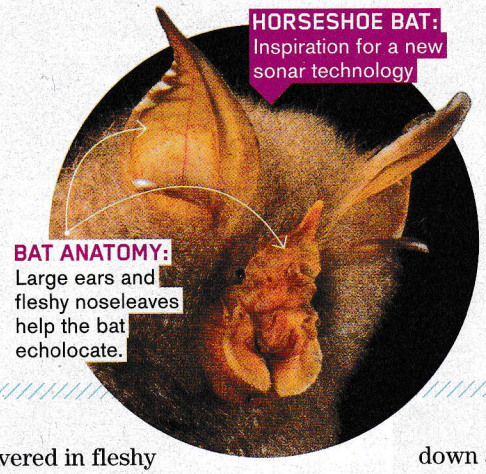
Continued on the next page →

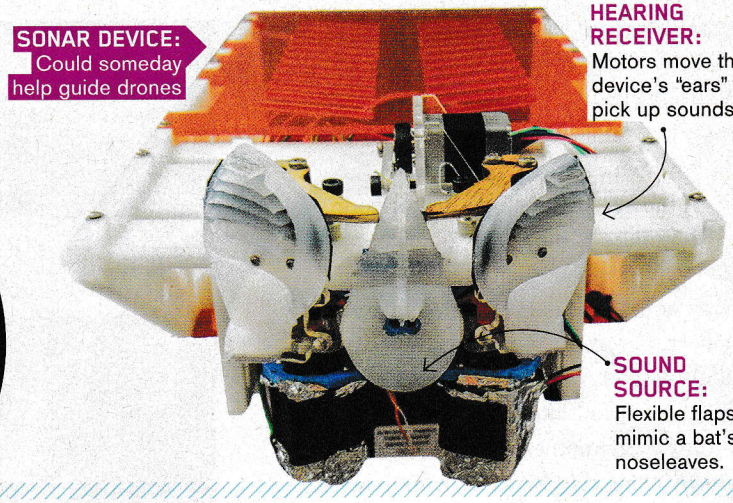
3-D SCAN

A scientist creates digital models of bat specimens. These three scans each show different aspects of a bat's anatomy.

COPYING BATS

A scientist designs a sonar device based on bats' facial features.





covered in fleshy folds, called *noseleaves*, as well as enormous ears with ridges.

By moving their noseleaves, these bats can modify the echolocation signals they send out. Some horseshoe bats adjust their nostrils to direct outgoing sound waves over cavities in their noses. This amplifies the sound at a specific frequency so they can focus on it. The bats' oversized, wrinkly ears act like large antennas to pick up reflected sounds. By bending and twisting their ears, the bats can filter out some sounds while tuning in to others. That helps them evaluate different features in their surroundings.

Being able to fine-tune the sound waves they send and receive gives bats a more detailed picture of their environments. This, says Mueller, probably explains why bats in the world's thickest jungles have evolved the most extreme nose and ear shapes.

BAT SCANS

To learn more about how bats' noses and ears aid in echolocation, Mueller needed to examine these features up close. He began tracking down and capturing bats in the wild. But then he discovered an easier way to compare the anatomy of bats from around the world: Go to the Smithsonian Institution's National Museum of Natural History.

The museum, located in Washington, D.C., houses more than 125,000 preserved bat specimens. Mueller made molds of some of the bats' noses and ears. Then he switched to studying them using a *3-D scanner*. This device creates a digital copy of an object's shape (*see 3-D Scan, p. 21*). So far, Mueller has catalogued the ears and noses of more than 100 bat species.

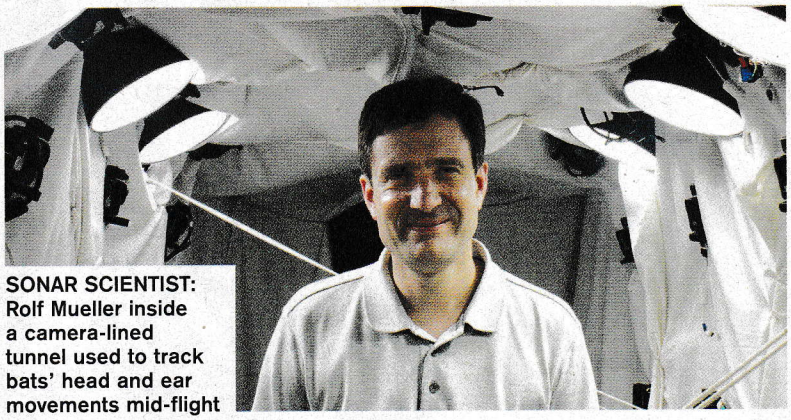
TRIAL RUN

Using that information, Mueller has created a bat-inspired sonar system (*see Copying Bats, above*). The device has a "nose" with rubber-like silicone flaps and a speaker that emits sound. The device also has "ears"—two microphones surrounded by silicone. Tiny motors move the flexible features to change their shape, just as bats do.

Mueller is testing the device in his lab in Blacksburg. He's also strapping it to a zip line and sending it zooming through the forest near Virginia Tech's laboratory in Shandong to see how well the system detects objects in its path. Once the device is perfected, Mueller plans to attach it to a small flying drone. It will whiz through the dark jungle alongside real bats. Someday, the sonar-guided drones could perform ground surveys, help farmers monitor their crops, and even deliver packages to homes.

"Having the drone is one thing—now what can you do with it?" says Mueller. "That is something that's going to keep us busy for years to come."

—Stephanie Warren Drimmer



SONAR SCIENTIST: Rolf Mueller inside a camera-lined tunnel used to track bats' head and ear movements mid-flight

CORE QUESTION

What characteristics did Mueller borrow from bats to create his bat-inspired sonar system? Why?

SLITHERY STUNT

During a performance at an amusement park in China's Zhejiang province, this man let two snakes crawl up his nose and out through his mouth. Onlookers were shocked.

How was this twisted trick possible? The nose's nasal passages connect to the mouth via a tubelike structure called the *pharynx*.

The pharynx allows air to pass from the nose and mouth into the lungs. It also allows food to travel down the *esophagus* (food pipe) to the stomach. These snakes traveled through the performer's nostrils, down the pharynx, and out of his mouth. "It's almost a 180-degree turn," says Dr. John Edwards, an *otolaryngologist* who treats disorders of the ear, nose, and throat, in San Antonio, Texas.

The pharynx is only about 11 millimeters (0.4 inches) wide. It's a tight fit, but the reptiles are probably unharmed during the stunt, says Terry Phillip, a snake handler from Reptile Gardens, a wild animal park in Rapid City, South Dakota. A snake's ribs connect to its backbone but not to a breastbone in the front like other *vertebrates*, such as humans. This *adaptation* allows a snake to expand the circumference of its ribs when eating a big meal or contract it to squeeze through narrow spaces, says Phillip.

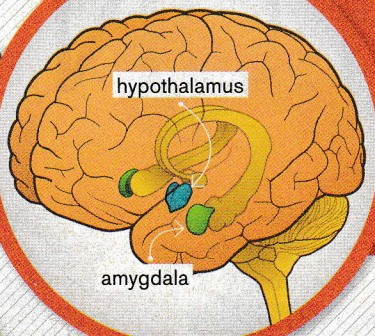
Why would snakes willingly slither up someone's nose in the first place? "Snakes get stressed out when they're used for shows," says Phillip. "So when they're offered an opportunity to hide in a dark hole—like a nostril—they take it."

—Kathryn Free

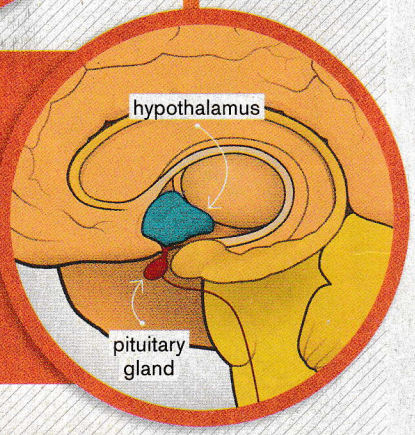
SCARE SCIENCE

Here's what happens in your body during a *fight-or-flight reaction*—when you choose to either tough it out (fight) or run away (flight) from frightening situations.

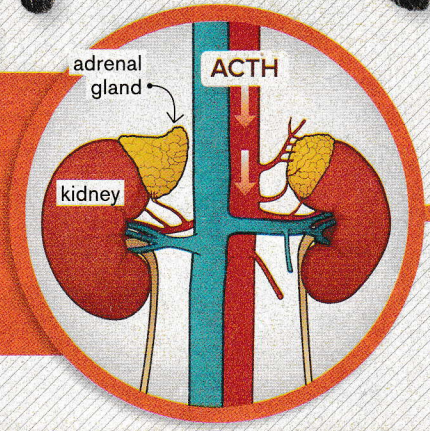
1 THREAT: Someone experiences something scary or dangerous.



2 BRAIN PROCESSING: An area of the brain called the *amygdala* determines whether something is a threat. If it is, the brain's *hypothalamus* starts the body's fight-or-flight reaction.

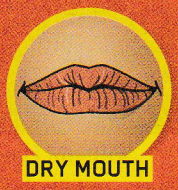


3 CHEMICAL SIGNAL: The hypothalamus activates the *pituitary gland*, located at the base of the brain, to release the chemical hormone *ACTH* (adrenocorticotropic hormone).

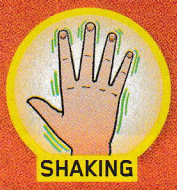


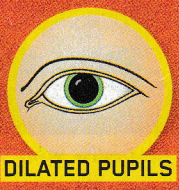
4 FEAR HORMONES: ACTH travels through the blood. It activates the adrenal glands, located on the kidneys, which release three stress hormones—adrenaline, norepinephrine, and cortisol.

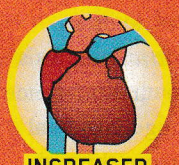
5 PHYSICAL REACTIONS: Depending on how scary a situation is, stress hormones can cause one or more of these reactions.

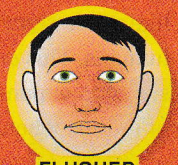

DRY MOUTH

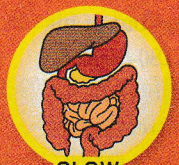

TUNNEL VISION


SHAKING


DILATED PUPILS


INCREASED HEART RATE


FLUSHED FACE

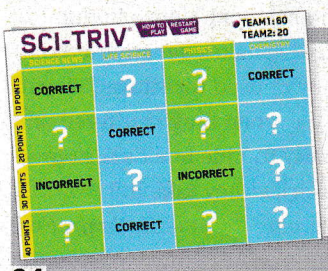

SLOW DIGESTION


BLADDER RELAXATION


HEARING LOSS

ANALYZE IT

Why do you think the body reacts the way it does when a person is scared or threatened?



TEST YOUR SCIENCE SMARTS

Play our science trivia game online! Just click this button in the digital edition and select whether you'd like questions from this issue only or from our archive.

Visit scholastic.com/scienceworld to play Sci-Triv.

CHECK US OUT ONLINE

ScholasticTeachers
@ScholasticTeach
ScienceWorld@scholastic.com