A ‘Radar’ for Dark Matter | COVID-Sniffing Dogs Are Up to Snuff

ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE ■ JULY 16, 2022 & JULY 30, 2022

TARDIGRADE TOUGH

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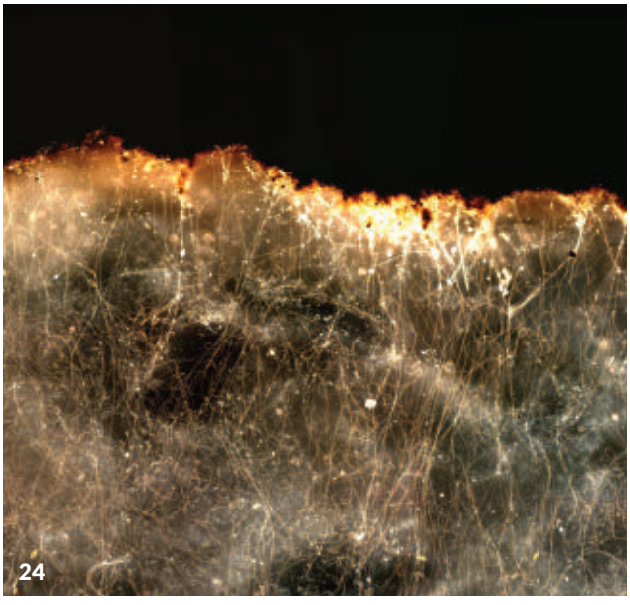
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COVER Tardigrades are found in moist, green places, hence the fitting nicknames water bear and moss piglet. *Eye of Science/Science Source*

FROM TOP: STEFFEN LARSEN, LARS RIIS DAMGAARD; S. TAKEUCHI; THOMAS W. JOHANSEN/NASA OCEANS MELTING GREENLAND

We won't shy away from covering politicized science

In this issue, we report on the science of pregnancy biology and how it has been misunderstood or misapplied in policies and laws regulating abortion (Page 6). We posted the article on our website on June 24, the day the U.S. Supreme Court ruled that the right to an abortion is not protected by the Constitution.

Covering one of the most consequential and controversial rulings in the court's history may seem off topic for a science magazine. But *Science News* has covered politically and ethically contentious issues since our founding in 1921. Our founders, zoologist William E. Ritter and newspaper magnate E.W. Scripps, thought it essential that Americans have accurate information about science so that they can understand the world around them and be informed citizens.

We have stayed true to that mission over the decades, reporting on science to inform public debate on a wide range of issues including abortion, racism, nuclear weapons and nuclear power, HIV/AIDS, poverty, pollution, gun violence and climate change. We have also explained where science has been manipulated or misapplied in the service of political agendas. And we have covered the rise of antiscience misinformation and disinformation on subjects including climate change, vaccines and the pandemic (SN: 5/8/21 & 5/22/21, p. 22).

Looking specifically at abortion, *Science News* has covered the subject consistently, including a 1937 study in JAMA that found abortion to be common among married women in New York City who use birth control, with 1 in 8 such women saying they had had at least one induced abortion (SN: 5/29/37, p. 349). We have also covered advances in understanding the basic biology of human reproduction, and research on public health and the social impacts of access to abortion and birth control. We will continue to cover these issues as the United States enters a new era of restrictions or bans on abortion and perhaps contraception.

With science increasingly under threat, we believe even more strongly in the importance of our founding mission and will continue to provide accurate coverage of science and its role in society. —*Nancy Shute, Editor in Chief*

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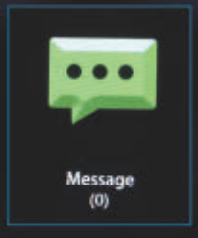

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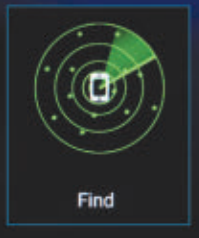

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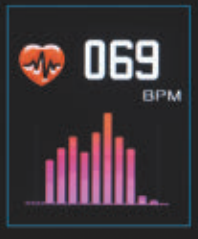

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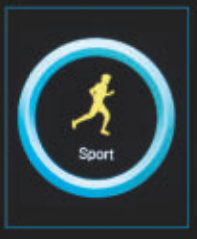

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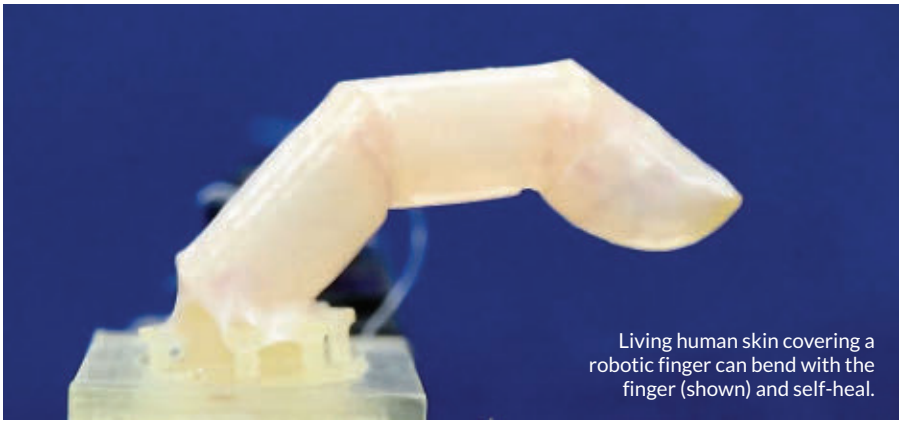
Excerpt from the July 22, 1972 issue of *Science News*

50 YEARS AGO

What did in the dinosaurs?

Dinosaurs might have been endothermic, or warm-blooded.... The combination of large size, endothermy and naked skin may explain the extinction of dinosaurs. About 65 million years ago there was a sharp drop in temperature.... Dinosaurs, lacking skin insulation and too large to burrow underground ... could not survive. Meanwhile, evidence has come that ... the shells [of their eggs] became progressively thinner ... too fragile to support the growing embryo.

UPDATE: Some dinosaurs may have been warm-blooded and some could have laid soft-shelled eggs (*SN: 7/12/14, p. 6*). But neither trait led to the reptiles' demise. In the late 1970s, geologists proposed that an asteroid strike triggered a mass extinction (*1/25/92, p. 56*), killing more than 75 percent of life on Earth. That theory is now widely accepted. Scientists have even found the killer's calling card: a crater about 180 kilometers wide on the coast of the Yucatán Peninsula in Mexico. The asteroid probably crash landed there in the springtime 66 million years ago, fossils hint (*SN: 3/26/22, p. 8*).



Living human skin covering a robotic finger can bend with the finger (shown) and self-heal.

HOW BIZARRE

A robotic finger's living skin heals like the real thing

The Terminator may be one step closer to reality.

Researchers at the University of Tokyo have built a robotic finger that, much like Arnold Schwarzenegger's titular cyborg assassin, is covered in living human skin. The goal is to someday build robots that look like real people — albeit for more altruistic purposes.

Super realistic–looking robots could more seamlessly interact with humans in medical care and service industries, say biohybrid engineer Shoji Takeuchi and his colleagues June 9 in *Matter*. (Whether cyborgs masked in living tissue would be congenial or creepy is probably in the eye of the beholder.)

To cover the finger in skin, Takeuchi and colleagues submerged the robotic digit in a blend of collagen and human skin cells called dermal fibroblasts. The mixture settled into a base layer of skin, or dermis, covering the finger. The team then poured a liquid containing human keratinocyte cells onto the finger, which formed an outer skin layer, or epidermis. After two weeks, skin covering the finger measured a few millimeters thick — comparable to the thickness of human skin.

This robotic finger spent much of its time in a nutrient bath to keep its skin suit healthy.

The lab-made skin was strong and stretchy enough to withstand the robotic finger bending. It could also heal itself: When researchers made a small cut on the robotic finger and covered it with a collagen bandage, the skin's fibroblast cells merged the bandage with the rest of the skin within a week.

"This is very interesting work and an important step forward in the field," says Ritu Raman, an MIT engineer who also builds machines with living components. "Biological materials are appealing because they can dynamically sense and adapt to their environments." For instance, she'd like to see a future version of the living robot skin embedded with nerve cells to make robots more aware of their surroundings.

But a robot can't wear this lab-grown skin suit around town just yet, Raman notes. The skin-covered robotic finger spent most of its time soaking in sugar, amino acids and other ingredients that skin cells need to survive. A cyborg wearing this skin would have to bathe often in a broth of nutrients or use some other complex skin care routine.

— *Maria Temming*

BOTH: S. TAKEUCHI

MYSTERY SOLVED

Why pumpkin toadlets are clumsy jumpers

Brachycephalus frogs from Brazil can leap into the air but have trouble landing.

Some frogs just can't stick the landing.

After launching into a leap, pumpkin toadlets careen through the air as if flung from a toddler's fist. They roll, cartwheel or backflip and then plummet to the ground, often belly flopping or crash-landing on their backs.

"I've looked at a lot of frogs, and these are the weirdest things I've ever seen," says Richard Essner Jr., a vertebrate zoologist at Southern Illinois University Edwardsville.

Essner and colleagues propose an explanation for why the tiny frogs are such clumsy jumpers: The animals lack the proper gyroscopic equipment to sense small changes in rotation, the team suggests June 15 in *Science Advances*.

When Essner saw videos of *Brachycephalus* frogs' awkward aerial maneuvers, he was so shocked that he hopped on a plane to study the animals with his colleagues in Brazil. Small enough to fit on a person's thumbnail, the frogs are tricky to find in the wild. Scientists listen for the amphibians' high-pitched, buzzy calls and then scoop leaf litter into a bag, hoping to find a few toadlets.

In the lab, the team used high-speed video to record more than 100 tiny frog jumps. The klutzy tumbles suggested that the toadlets have trouble orienting themselves in space.

Typically, fluid sloshing through bony tubes in the inner ear helps vertebrates sense their body's position. CT scans revealed that the frogs' tubes are the smallest ever recorded for adult vertebrates. Studies of other tiny animals suggest that the tubes don't work so well in miniature. It's difficult for the fluid to flow freely, Essner says. That means the frogs probably can't sense how they're twirling through the air, making it tough to prep for landing.

It's possible that bony back plates offer some crash protection, but the animals may stay mostly grounded for safety (SN: 4/27/19, p. 16). As Essner observed, the frogs are "almost always crawling really slowly." —*Meghan Rosen*

Friction determines how fast a row of dominoes falls, new research shows.

THE EVERYDAY EXPLAINED

Friction is key for falling dominoes

Domino research may seem like fun and games, but understanding how the tiles topple isn't child's play. "It's a problem that is so natural; everybody plays with dominoes," says David Cantor, a researcher at Polytechnique Montréal. So Cantor and physicist Kajetan Wojtacki of the Polish Academy of Sciences in Warsaw set out to simulate a row of dominoes collapsing in a chain reaction. Friction is crucial for determining the speed at which the collapse cascades, the pair reports in the June *Physical Review Applied*. Toppling cascaded quickest for closely spaced dominoes that had little friction between them and that stood on a high-friction surface. Less friction between the tiles means less energy is lost. And more friction between the dominoes and the surface means that the tiles don't slide too far backward as they fall, which would otherwise slow the cascade. In some simulations, tiles spaced far apart on a slippery surface backslid so much that the cascade stopped short. Turns out, there's serious science behind the spectacle. —*Emily Conover*

INTRODUCING

Lasers help physicists see 'smoke rings' in a new light

Doughnut-shaped structures called vortex rings are sometimes seen swirling through fluids. Smokers can form them with their mouths, volcanoes can spit them out during eruptions and dolphins can blow them as bubble rings. Now, scientists can create the rings with light.

A standard vortex is an eddy in a liquid or gas. Imagine taking that swirling tunnel, stretching it out and bending it into a circle and attaching it end to end. That's a vortex ring. These rings travel through the liquid or gas as they swirl. For example, smoke rings float through the air away from a smoker's head. In the new vortex rings, described June 2 in *Nature Photonics*, light behaves similarly: The flow of energy swirls as the ring moves.

Optics researcher Qiwen Zhan and colleagues started from a vortex tube, a hurricane-like structure they already knew how to create using laser light. The team used optics techniques to bend the tube into a ring.

The light rings aren't that different from smoke or bubble rings, says Zhan, of the University of Shanghai for Science and Technology. Further study might help scientists better understand how the geometry of rings and similar shapes affects light and its interaction with matter. —*Emily Conover*

Watch pumpkin toadlets jump at **bit.ly/SN_FrogFail**

BODY & BRAIN

Misconceptions cloud abortion debate

Key aspects of pregnancy biology are often misunderstood

BY LAURA SANDERS

When the U.S. Supreme Court overturned Roe v. Wade on June 24, the highest court in the country shifted decisions about a person's right to reproductive medical care to individual state and local governments.

Without the federal protections provided by the 1973 landmark Roe v. Wade decision, many states are expected to follow the actions of Texas and others that have already curtailed abortion access.

Many of those legislative efforts invoke medical and scientific language in an effort to define when life begins. Heart development, fetal pain and viability have all been brought into justification for abortion restrictions. But many of these rationales don't line up with the biology of early development. Texas' 2021 "heartbeat law," for instance, bans abortion after about six weeks when heart cells purportedly begin thumping. At that early stage of pregnancy, there isn't yet a fully formed heart to beat.

Like most aspects of biology, early human development involves many complex processes. Despite the rhetoric around these issues, clear lines—between having a heart and not having a heart, or being able to survive outside of the uterus or not—are scarce or nonexistent.

"There aren't these set black-and-white points for much of this," says obstetrician-gynecologist Nisha Verma, a fellow with the American College of Obstetricians and Gynecologists in Washington, D.C.

Here's what's known about five key aspects of pregnancy biology that often come up in abortion debates.

The early timeline of a pregnancy is easy to misunderstand

How dates of a pregnancy are determined is supremely confusing. The standard pregnancy clock actually starts ticking *before* a sperm cell encounters an egg, two weeks before, on average. An ovary releases an egg around day 14 of an average 28-day menstrual cycle (SN: 6/19/21, p. 16). Day one is the first day of menstruation; day one is also when a pregnancy officially begins in the month an egg is fertilized.

That means that when a sperm fertilizes an egg, a person is already officially two weeks pregnant. As nonsensical as that sounds, using the first day of an individual's last menstrual period is the simplest way for medical professionals to date a pregnancy.

That timeline means that an abortion ban that takes effect at around six weeks, like the one enacted in Texas, occurs earlier in pregnancy than many people think, Verma says. In 2020, she surveyed people in Georgia, where she was practicing medicine, about their understanding of the timing. "Some people will say the six weeks is after your first missed period," she says. "Some people think it's from the date of conception." Neither is correct.

The ban would start four weeks after fertilization. Counting back, that's two weeks after a missed period, which is often a person's first indication that they might be pregnant. Such bans leave very little time—two weeks after a missed period—to access an abortion.

What's more, these dates are based on averages. Many women have irregular menstrual cycles. Birth control isn't 100 percent effective, and certain types can eliminate menstruation altogether, throwing even more uncertainty into the early timeline of pregnancy.

Pregnancy requires more than a sperm meeting an egg

Fertilization—the process in which the sperm and egg fuse and mingle their genetic contents, creating what's known as a zygote—usually takes place in one of the two fallopian tubes near the ovaries. That fertilization does not automatically lead to a pregnancy, says obstetrician and gynecologist Jonas Swartz of Duke University School of Medicine. "Equating them doesn't make sense from a medical standpoint." Up to 50 percent of fertilized eggs do not implant in the uterus, researchers have estimated.

The genetic material needs to combine in the right way. The growing ball of cells needs to travel to the uterus and implant itself in the right spot. And the right balance of hormones needs to be churned out to support the pregnancy. "There

On June 14, security fencing surrounded the U.S. Supreme Court in anticipation of crowds gathering in response to the decision on the case challenging Roe v. Wade.

STEFANI REYNOLDS/AFP VIA GETTY IMAGES

are so many things other than the sperm meeting the egg that actually matter for this to become a pregnancy that has a chance to develop further," says Selina Sandoval, an obstetrician and gynecologist who specializes in complex family planning at the University of California, San Diego.

Lawmakers in some states are considering abortion rules that apply to a fertilized egg. That includes fertilized eggs that lodge in the wrong spot, the fallopian tube, for example. Called an ectopic pregnancy, it can lead to life-threatening medical emergencies when the growing tissue ruptures the tube and internal bleeding ensues. "These are pregnancies that under no circumstance can become a healthy pregnancy," Sandoval says. "In fact, if they aren't treated and continue to grow, they will kill the patient." Laws that apply to a fertilized egg could "limit our ability to treat patients for ectopic pregnancies," she says.

"Heartbeat laws" are misnamed

Texas law bans abortions "after detection of an unborn child's heartbeat" at around six weeks of pregnancy. But the rhythmic sounds heard on an ultrasound that early in pregnancy aren't caused by the opening and closing of heart valves as they move blood through the heart's chambers, the motion that produces a typical lubb-dupp sound. Those chambers haven't even developed yet. On early ultrasounds, the heartbeat-like sounds are created by the ultrasound machine itself.

"What we're seeing is actually the primitive heart tube and the cells in that heart tube having electrical activity that causes fluttering," Verma says. "The ultrasound is actually manufacturing that sound based on the electrical activity and fluttering motion."

Using the term "heartbeat" to describe the fluttering makes sense in some situations, like in conversations with excited parents-to-be, Verma says. "I've taken care of countless people who have seen that first 'heartbeat' on ultrasound for a desired pregnancy, and it's this huge, exciting moment," she says. "I don't want to be dismissive of that." She says two things can be true at the same time: "It can be exciting for a patient. It also isn't a scientific thing."

Fetal pain is difficult to define

A bit of biology that's often used to restrict abortions is the claim that fetuses, which form at week 11 of pregnancy, feel pain.

"Pain is very complex," Swartz says. "It requires not just a physical response, but the ability to suffer as a result."

Knowing what a fetus experiences is impossible, but brain development studies provide some clues. The experience of pain starts with the senses detecting something noxious. Those signals then have to travel to the cortex, the outer layer of the brain that helps interpret that sensation. In human fetuses, those brain connections don't exist until about week 24 or 25 of pregnancy. In guidelines written by members of the Society for Maternal-Fetal Medicine, researchers note that these connections are necessary for the experience of pain, but are not sufficient on their own to conclude that pain is possible.

In human fetuses, these connections aren't operational until about week 28 or 29 of pregnancy, other studies suggest. "We can say with really, really good confidence that no sooner than 28 weeks is [pain] even possible," Sandoval says.

The vast majority of abortions — over 90 percent — happen in the first trimester, before week 13 of pregnancy. The number of abortions after 24 or 25 weeks is "vanishingly small," Swartz says.

When a fetus could survive on its own is a complex calculation

"Viability" is often used as a sharp cut-off point to mark the age at which a fetus could survive outside of the uterus. The problem is that one clear cut-off does not exist.

"That has been a moving line as science has advanced and our ability to support very small babies has advanced," Swartz says. "But it's also not a fixed line for babies born now."

On average, babies born around 22 to 24 weeks gestation either don't survive or they survive with major health problems. Whether a fetus will survive if delivered depends on a suite of other factors, Swartz says. They include fetal sex, weight, developmental issues and mother's health, not to mention individual health care facilities' capabilities and training.

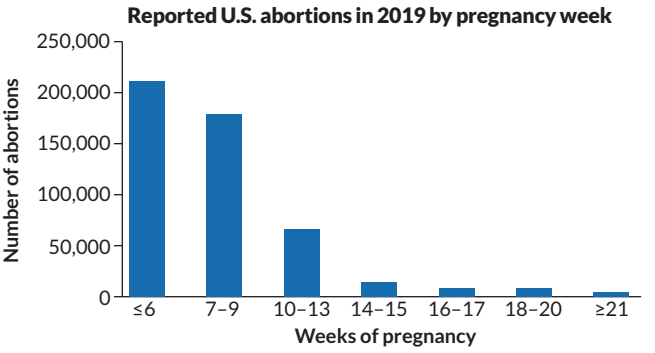
The American College of Obstetricians and Gynecologists recently removed mentions of "viability" in guidance on abortion care. "It's such a complicated concept that we can't make blanket statements about it," Verma says. "It's something that needs to be left to the clinician looking at the patient."

Inaccurate descriptions of biology can influence restrictions around reproductive health, and as a result, the health care people are able to receive, Swartz says. A colleague, for instance, wasn't able to get appropriate medical care when she experienced signs of a pregnancy loss. Because of state abortion restrictions, her physician decided to delay treatment, an emotionally distressing experience that she wrote about in the September 2021 issue of *Obstetrics & Gynecology*. Abortion regulation based on flawed medical and scientific premises, Swartz says, "places priority on a potential life over the actual life of the person sitting in front of me." ■

By the numbers

In 2019, roughly 490,000 abortions were reported to the U.S. Centers for Disease Control and Prevention with data on gestational age. Most of those abortions happened very early in pregnancy.

SOURCE: K. KORTSMIT *ET AL*/ *MMWR* 2021



E. OTWELL

BODY & BRAIN

The latest on COVID-19 reinfections

A second round is rare, but repeat cases appear to be on the rise

BY MEGHAN ROSEN

Not long before the end of the school year, my husband and I received an e-mail from our fifth-grader's principal. The subject line included the words: "MULTIPLE COVID CASES."

Several students in my daughter's class had tested positive for COVID-19. Her school acted fast. It reinstated a mask mandate for 10 days and required students who were not up-to-date on their COVID-19 vaccinations to quarantine.

These precautions may have helped; my daughter didn't bring the virus home. But for kids who do, COVID-19 can hopscotch through households, knocking down relatives one by one. And it's not clear how long one infection protects against a second round with the virus. Just a few months ago, scientists thought reinfections were relatively rare, occurring most often in unvaccinated people. But there are signs the number may be ticking up.

Omicron, the variant of the virus that sparked last winter's surge, is still spawning sneaky subvariants. Some can evade antibodies produced after infection with the original omicron strain, scientists report June 17 in *Nature*. So a previous COVID-19 infection might not be as helpful against future infections as it once was. Reinfection could even add to a person's risk of hospitalization or other adverse outcomes, a preliminary study suggests.

Scientists are still working to pin down the rate of reinfection. Like most questions involving COVID-19 case numbers, the answer is more than a little murky. "You really need to have a cohort of people who are well followed and tested every time they have symptoms," says Caroline Quach-Thanh, an infectious diseases specialist at CHU Sainte-Justine, a maternal and pediatric hospital at the University of Montreal.

A look at hundreds of thousands of cases in Quebec found that about 4 percent were reinfections, scientists report in a preliminary study posted May 3 at medRxiv.org. Quach-Thanh has seen a smaller rate in her own study of health care workers first infected between March and September of 2020. Most of the people in her study, which is unpublished, were vaccinated. "A natural infection [and] three doses of vaccines protects better than just a natural infection," she says.

As many people gear up for summer plans, I wanted to know more about COVID-19 risks. I talked with Quach-Thanh and Anna Durbin, an infectious diseases physician at Johns Hopkins Bloomberg School of Public Health. Our conversations have been edited for length and clarity.

What's the latest on reinfections?

Durbin: The strain circulating now is very different from the earlier strains. Whether you've been infected with COVID-19 or vaccinated, your body makes an immune response to fight future infections. It recognizes [the strain] your body originally saw. But as the virus changes, as it did with omicron, it becomes a fuzzier picture for the immune system. It doesn't recognize the virus as well. That's why we're seeing reinfections. With respiratory viruses, reinfections are very common.

How can scientists distinguish a true reinfection from a relapse of an original infection?

Quach-Thanh: There are multiple ways. The first is looking at the time elapsed between the first infection and a new positive PCR test. If it has been more than three months, it is unlikely to be just a remnant of a previous infection. We can also look at viral load. A really high viral load usually means it's a new infection. But the best way to tell is to sequence the virus [to determine its genetic makeup] to see if it is actually a new strain.

What do we know about the health risks of reinfection?

Quach-Thanh: The good thing is that most of the people who got reinfected [in the Quebec study] got a mild disease. When you get reinfected, you might [have symptoms] like a cold, or even sometimes a cough, and a little bit of a fever. But you usually don't progress to complications as much as you would with your first infection — if you're vaccinated.

Does reinfection increase the chance of developing long COVID?

Durbin: That's unknown, but it's being studied. As we look back at the omicron wave in the U.S. that happened in January and February, now is about the time we would start to see symptoms of long COVID. So far, we seem to be seeing a lower incidence of long COVID [after reinfection with omicron] than we did with primary infection. But those data are going to continue to be collected over the next few months.

How cautious do we need to be?

Quach-Thanh: It depends on your baseline risk of complications. If you're healthy, if you're doing most activities outdoors, if you're vaccinated, life can proceed. But if you're immune suppressed or elderly, the situation might be different.

If you have symptoms, it would be advisable to not mingle in indoor settings without a mask. There are immunocompromised people who might be at risk of serious infection. We need to keep them in mind. I think we have to be responsible, and if we're sick, we should get tested.

Durbin: This is what I tell my friends, family and patients: This virus is here to stay. Any time you're in a crowded place with poor ventilation and lots of people, there's a chance there's going to be transmission. The risk is never going to be zero. It's a message people don't want to hear. But as long as there are people to infect, this virus is not going away.

We have to move to acceptance, and we have to be better members of society. If we can, we should stay home when we're sick. If we can't stay home, we should wear a mask. We should wash our hands regularly. These are things that reduce transmission. They reduce your risk of getting not just COVID-19, but also a cold or the flu. ■

Trained dogs can sniff out COVID-19

Canines may be especially good at finding asymptomatic cases

BY TINA HESMAN SAEY

Dogs are as reliable as laboratory tests for detecting COVID-19 cases, and may be even better than PCR tests for identifying people with the virus who don't show symptoms. A bonus: The canines are cuter and less invasive than a swab up the nose.

In a study involving sweat samples from 335 people, trained dogs sniffed out 97 percent of the coronavirus cases that had been identified by PCR tests, researchers report June 1 in *PLOS ONE*. And the dogs found all 31 COVID-19 cases among 192 people who didn't have symptoms.

These findings provide evidence that dogs could be effective for mass screening efforts at places such as airports or concerts. Trained canines also may provide friendly alternatives for testing people who balk at nasal swabs, says veterinarian Dominique Grandjean of the National School of Veterinary Medicine of Alfort in Maisons-Alfort, France.

"The dog doesn't lie," but there are many ways PCR tests can go wrong, Grandjean says. The canines' noses identified more COVID-19 cases than did antigen tests that are similar to many at-home tests. And anecdotal evidence suggests the dogs can pick up asymptomatic cases as much as 48 hours before people test positive by PCR, he says. But the dogs sometimes mistook another respiratory virus for the coronavirus, Grandjean and colleagues found.

In the study, dogs from French fire stations and from the Ministry of the Interior of the United Arab Emirates were trained in coronavirus detection using rewards — usually tennis balls. "It's playtime for them," Grandjean says. Training a dog to pick out COVID-19 from sweat samples takes about three to six weeks, depending on the dog's experience with odor detection.

97 percent
Proportion of COVID-19 cases identified by PCR that trained dogs also sniffed out

The dogs then sniffed cones housing sweat samples collected from the underarms of human volunteers. Swabbing the sweat off the back of people's necks or giving the woofers a whiff of used face masks worked just as well, Grandjean says.

Those findings indicate that odors from multiple body sites can be used for canine screening, says Kenneth Furton, a forensic chemist at Florida International University in Miami who was not involved in the research.

What's more, the results are similar to previous, smaller studies that found dogs detect SARS-CoV-2, the virus that causes COVID-19, as well as or even better than PCR tests, Furton says. He and colleagues have used dogs at schools, a music festival and in a small trial screening airline employees for coronavirus infections.

One of the biggest advantages dogs have over other tests is their speed, Furton says. "Even with what we call a rapid test, you're still going to have to wait tens of minutes or even hours, where the dog in a matter of seconds or even fractions of seconds can make a response."

It's not clear exactly what dogs are smelling when they detect COVID-19 or other diseases, says Cynthia Otto, director of the University of Pennsylvania School of Veterinary Medicine's Working Dog Center. Perhaps rather than a single chemical, dogs are picking up a pattern of increasing and decreasing levels of certain aromas. "It's not like you could create an odor perfume bottle that would be the scent of COVID," says Otto, who was not involved in the study.

Even with repeated studies demonstrating dogs' COVID-detection prowess, some doctors, scientists and government officials are skeptical of the claims, Grandjean says. He finds the reluctance puzzling. Dogs are used to sniff out drugs and explosives, and are being tested for detecting other diseases such as cancer, he says. "Every time you take a plane, it's because dogs have been sniffing your luggage [and found] no explosives. So you trust them when you take a plane, but you don't want to trust them for COVID?"

One challenge with dogs, says Furton, is that people don't think of them as high-tech the way electronic sensors are. "But dogs are one of the highest-tech devices we have. They're just biological sensors, instead of electronic sensors," he says.

Another drawback for dogs is that they take time to train and there currently aren't even enough dogs trained to detect explosives, let alone diseases, Otto says. And "dogs that work well in that lab setting may not work well in a people setting," she says. Handlers can also influence the dog's response and must be able to read the dog well, she says. "We need more good dogs." ■

Dogs (including this one in the United Arab Emirates) that have been trained to detect COVID-19 can pick up on infections before people show symptoms, a study suggests.

NOSAÏS TEAM (CC BY 4.0)

In galaxy A1689-zD1 (illustrated), cool gas (red) extends farther into space than stars and hot gas (yellow). Astronomers think some energetic activity is pushing hot gas to the galaxy's outskirts where it cools.

ATOM & COSMOS

This early galaxy passes a lot of gas

The cosmic body makes just enough stars to expel the gas

BY LIZ KRUESI

PASADENA, CALIF. — A lucky celestial alignment has given astronomers a rare look at a galaxy in the early universe that is seeding its surroundings with the elements needed to forge later generations of stars and galaxies.

Seen as it was just 700 million years after the Big Bang, the distant galaxy has gas flowing over its edges. That makes it the earliest-known run-of-the-mill galaxy to show such complex behavior, astronomer Hollis Akins said June 14 during a news conference at the American Astronomical Society meeting.

"This outflow activity seems to be able to shape galaxy evolution, even in this very early part of the universe," said Akins, an incoming graduate student at the University of Texas at Austin. He and colleagues also submitted the findings June 14 to arXiv.org.

The galaxy, called A1689-zD1, shows up in light magnified by Abell 1689, a large galaxy cluster that can bend and intensify light from the universe's earliest galaxies (SN: 2/16/08, *p.* 100). Compared with other observed galaxies in the early universe, A1689-zD1 doesn't make many stars — converting less than 40 solar masses of gas into stars each year — which means the galaxy isn't very bright to our telescopes. But the intervening cluster magnified A1689-zD1's light by nearly 10 times.

Akins and colleagues studied the light with the Atacama Large Millimeter/submillimeter Array, or ALMA, a large network of radio telescopes in Chile. The team mapped the intensities of a specific form of oxygen, a tracer for hot ionized gas, and a specific form of carbon, a tracer for cold neutral gas. Hot gas shows up where the bright stars are, as expected, but the cold gas extends three times as far as the hot gas, which the team did not expect.

There has to be some mechanism driving the cold gas into the space outside of the galaxy, an area known as the circumgalactic medium, Akins said.

Only a few scenarios could explain the outflow. Perhaps small galaxies are merging with A1689-zD1 and flinging gas out of the galaxy where it cools, Akins said. Or maybe heat from star formation is pushing the gas out, though that would be a surprise considering the relatively low rate of star formation. While astronomers have seen outflowing gas in other early-universe galaxies, those galaxies bustle with activity, converting thousands of solar masses of gas into stars per year.

The team used the ALMA data to measure the motions of the cold and hot gases toward and away from Earth. The hot gas seems to be moving faster than the cold gas, which implies hot gas is being pushed from A1689-zD1's center to the galaxy's outer regions, Akins said.

The observations suggest an orderly bulk flow of gas, which implies outflows. Despite the galaxy's relatively low rate of star formation, Akins and colleagues think it is enough to heat up and push out the gas from the center of the galaxy. But the researchers are analyzing the movement of the gas in more detail and cannot yet rule out alternate scenarios.

When the hot gas flows out, it expands and eventually cools, Akins said, which is why the team sees the cold gas flowing over the galaxy's edge. That heavy element–rich gas enriches the circumgalactic medium and will eventually get incorporated into later generations of stars as gravity pulls the gas toward A1689-zD1's center (SN: 7/25/15, *p.* 8).

These observations of A1689-zD1 show that in the early universe, this flow of gas happens not only in the superbright, extreme galaxies, but also in normal ones. "Knowing how this cycle is working helps us to understand how these galaxies are forming stars, and how they grow," says Andreas Faisst, an astrophysicist at Caltech who was not involved in the study.

Astronomers aren't done learning about A1689-zD1. "It's a great target for follow-up observations," Faisst says. Some of Akins' colleagues plan to do just that with the James Webb Space Telescope (SN: 10/9/21 & 10/23/21, *p.* 26). ■

ALMA/ESO, NAOJ AND NRAO, B. SAXTON/NRAO/AUI AND NSF

ATOM & COSMOS

A celestial loner's identity stirs debate

The object could be a rogue black hole or a hefty neutron star

BY KATHERINE KORNEI

A solitary object more massive than the sun — yet far smaller — is wandering the galaxy a few thousand light-years from Earth. It might be the first isolated stellar-mass black hole to be detected in the Milky Way. Or it might be one of the heaviest neutron stars known.

The interstellar wanderer revealed itself in 2011, when its gravity briefly magnified the light from a more distant star. But the object's true nature eluded researchers. Now, two teams of astronomers have analyzed Hubble Space Telescope images to unmask the traveler's identity — and have reached different conclusions.

The mysterious rogue is a black hole roughly seven times as massive as the sun, astronomer Kailash Sahu of the Space Telescope Science Institute in Baltimore and colleagues report in a study to appear in the *Astrophysical Journal*.

Astronomer Casey Lam of the University of California, Berkeley and colleagues estimate that the object is a bit lighter, with a mass just two to four times that of the sun. That would mean the object is either an unusually lightweight black hole or a curiously hefty neutron star, the team reports in a study to appear in the *Astrophysical Journal Letters*.

Neutron stars and stellar-mass black holes — which are heavier than the sun but lighter than the behemoth black holes at the centers of galaxies — form when dying massive stars collapse under their own gravity. An estimated billion neutron stars and roughly 100 million stellar-mass black holes lurk in our galaxy (SN: 9/16/17, *p.* 7).

But these objects aren't easy to spot. Neutron stars are so tiny — about the size of a city — that they don't produce much light. And black holes emit no light at all. "The only way that we can find them is if they influence something else," Sahu says.

To date, scientists have detected nearly two dozen stellar-mass black holes (most of which reside in our galaxy) by watching how the objects interact with nearby celestial neighbors. A black hole locked in a gravitational dance with a star will rip away the star's matter and emit X-rays that space telescopes can detect.

But studying black holes in such binary systems paints only part of the picture of the black hole kingdom. These objects continuously accrete matter from stars, so it's challenging to determine the mass at which the black hole formed. And since birthweight is a key characteristic of a black hole, that's a significant drawback to looking at binary systems, Sahu says. "If we want to understand the properties of black holes, it's best to find isolated ones."

For more than a decade, researchers have been scanning the heavens for solitary black holes. The searches have hinged on Einstein's general theory of relativity, which states that any massive object, even an unseen one, bends spacetime in its vicinity (SN: 2/13/21, *p.* 16). That bending can magnify light from background stars, a phenomenon known as gravitational lensing. By measuring changes in the brightness and apparent position of stars, scientists can calculate the mass of the intervening object that acts as a lens.

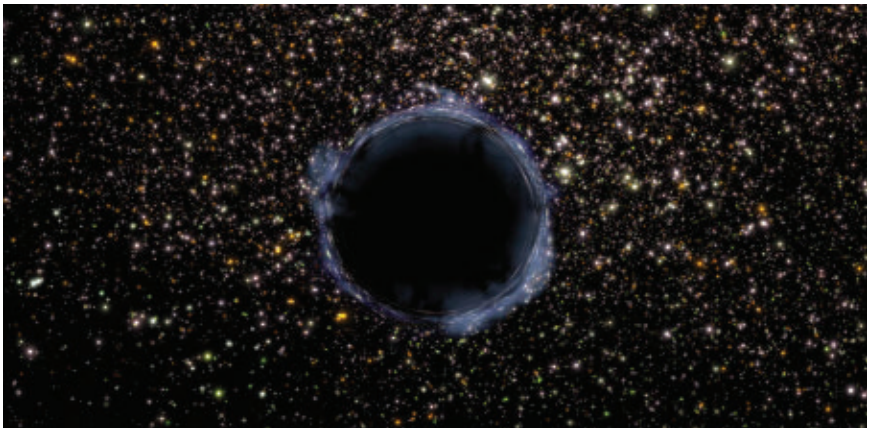
In 2011, ground-based telescopes in Chile and New Zealand spotted a star whose brightness suddenly and drastically increased. But those initial observations were unable to reveal whether the star's apparent position also changed.

If the lensing object is a heavyweight, its gravity would distort spacetime so much that the star would appear to move. But even a "big" shift in the star's position would have been extremely small and hard to detect. And unfortunately, fine details tend to be blurred out by our planet's turbulent atmosphere and so aren't captured by ground-based telescopes (SN: 8/29/20, *p.* 13). So Sahu's and Lam's teams turned to the Hubble Space Telescope, which orbits above most of Earth's atmosphere.

Both teams found that the star's location shifted over several years. Sahu and colleagues attribute the shift to an object roughly seven times as hefty as the sun. A star of that mass would have been blazingly bright in the Hubble images, but the researchers saw nothing. Something that heavy and dark must be a black hole, the researchers report.

Calculations by Lam and colleagues produced different findings. The object is about two to four times heavier than the sun, which would mean the object is either one of the most massive neutron stars or one of the least massive black holes discovered yet, the team says. "It falls within this strange region we call the mass gap," says UC Berkeley astronomer Jessica Lu.

Despite the disagreement, the findings are thrilling, says Will Farr, an astrophysicist at Stony Brook University in New York who was not involved in either study. "To be working at the instrumental limit at the real forefront of what's measurable is very exciting." ■



NASA, G. BACON/STSCI

A hefty but compact celestial object might be the first known isolated stellar-mass black hole (one illustrated) in the Milky Way, or it might be a heavy neutron star.

MATTER & ENERGY

Machine learning gets a quantum boost

For certain tasks, quantum techniques outperform classical

BY EMILY CONOVER

On certain types of machine learning tasks, quantum computers have an exponential advantage over standard computation, scientists report in the June 10 *Science*. The researchers proved that, according to quantum math, the advantage applies when using machine learning to understand quantum systems. And that advantage holds up in real-world tests.

"People are very excited about the potential of using quantum technology to improve [machine] learning," says theoretical physicist and computer scientist Hsin-Yuan Huang of Caltech. But it wasn't entirely clear if machine learning could benefit from quantum physics in practice.

In certain machine learning tasks, scientists attempt to glean information about a quantum system—say a group of particles—by performing repeated experiments and analyzing data from those experiments to allow the computer to learn about the system. Huang and colleagues studied several such tasks. In one, scientists aim to discern properties of the quantum system, such as the position and momentum of its particles. Quantum data from multiple experiments could be input into a quantum computer's memory, and the computer would process the data jointly to learn the system's characteristics.

Google's Sycamore quantum computer, cooled in a cryostat (shown), confirmed that machine learning can get a leg up from quantum physics.

The researchers proved theoretically that doing the same characterization with standard, or classical, techniques would require exponentially more experiments to learn the same information. Unlike a classical computer, a quantum computer can exploit entanglement—ethereal quantum linkages—to better analyze the results of multiple experiments.

But the new work goes beyond just the theoretical. "It's crucial to understand if this is realistic, if this is something we could see in the lab," says Dorit Aharonov of the Hebrew University of Jerusalem, who was not involved with the research.

So the team tested machine learning tasks with Google's quantum computer, Sycamore. Instead of measuring a real quantum system, the team used simulated quantum data and analyzed it using either quantum or classical techniques. Quantum machine learning won out, even though Google's quantum computer is "noisy," meaning errors can slip into calculations. Eventually, scientists plan to build quantum computers that can correct their own errors (SN: 6/20/20, *p.* 18). But for now, even without that error correction, quantum machine learning prevailed. ■

ATOM & COSMOS

Gravitational wave 'radar' could map the universe

'GRADAR' might someday help find hidden objects

BY ASA STAHL

It sounds like the setup for a joke: If radio waves give you radar and sound gives you sonar, what do gravitational waves give you? The answer might be "GRADAR," short for gravitational wave "radar," a potential technology that could use reflections of gravitational waves to map the unseen universe, researchers report in the June 24 *Physical Review Letters*.

Astronomers use gravitational waves—traveling ripples in the fabric of space and time itself, first detected in 2015—to watch cataclysmic events that are hard to study with light alone, such as the merging of two black holes.

But physicists have also known about a seemingly useless property of gravitational waves: They can scatter. Einstein's theory of gravity says that spacetime gets warped by matter, and any wave, including a gravitational wave, passing through these distortions will change course. The upshot is that when something emits gravitational waves, part of the signal comes straight at Earth, but some of it might arrive later, like an echo, after taking longer paths that bend around a star or anything else heavy.

These later signals, called "gravitational glints," were thought to be too weak to detect. But working off Einstein's theory, physicists Craig Copi and Glenn Starkman of Case Western Reserve University in Cleveland calculated how strong the signal would be when waves scatter through the gravitational field inside a star itself.

"The shocking thing is that you seem to get a much larger result than you would have expected," Copi says. "It's something we're still trying to understand, where that comes from, whether it's believable even, because it just seems too good to be true."

If gravitational glints can be strong, astronomers could possibly use them to trace the insides of stars, or even look for massive bodies that would otherwise be impossible to detect, like globs of dark matter or lone neutron stars on the other side of the observable universe.

"That would be a very exciting probe," says Maya Fishbach, an astrophysicist at Northwestern University in Evanston, Ill. But even if this phenomenon stands up to more scrutiny, Fishbach says, scientists would have to understand it better before they could use it. "The whole story of gravitational wave detection has been like that," Fishbach says. It was a struggle to do all the math needed to understand the measurements, she says, but now the field is taking off. "This is the time to really be creative with gravitational waves." ■

ERIC LUCERO/GOOGLE, INC.

LIFE & EVOLUTION

Sea ice isn't always a bear necessity

An isolated polar bear group survives on glacial mélange

BY NIKK OGASA

Pihoqahiak means "ever-wandering one," and is an Inuit name for the polar bear, a creature known to roam vast expanses of sea ice, sometimes plodding thousands of kilometers a year in search of seals to eat.

But along the fjord-cut coastline of southeastern Greenland, where the sea freezes over for just a few months of the year, some isolated polar bears are surviving as homebodies.

Unlike most polar bears, these bears don't follow the sea ice during its annual recession or move onto land to hunt. Instead, these crafty ursids stalk seals on nearby glacial mélange — a floating mishmash of icebergs, sea ice fragments and snow that persists year-round near the front of glaciers in the fjords, researchers report in the June 17 *Science*.

"They're residents in fjords that are sea ice–free for more than eight months of the year," says Kristin Laidre, a biologist at the University of Washington in Seattle. "Normally, a polar bear wouldn't be able to survive without sea ice for that long."

For polar bears (*Ursus maritimus*), sea ice isn't just frozen seawater. It's the platform they use to hunt their preferred prey, seals. As human-caused climate change raises Earth's global temperature, that ice is disappearing. Some polar bear subpopulations are already in decline, and researchers estimate that most subpopulations will collapse by 2100 unless greenhouse gas emissions are curbed. The International Union for Conservation of Nature classifies the species as "vulnerable."

The fjords in southeastern Greenland and probably those in Svalbard, Norway, could become last, temporary refuges for a small number of bears. But glacial mélange isn't widespread in the Arctic, and what exists could disappear if temperatures rise too much. So the only way to save the ice-dependent species is by curbing climate change, Laidre and colleagues say.

The researchers estimate that several hundred bears may dwell in the fjords of southeastern Greenland, though further work is needed for a more precise count.

The southeastern Greenland group came to the researchers' attention while they were studying polar bears along Greenland's eastern coast to provide advice to the Indigenous peoples who hunt the bears for subsistence. An analysis of 83 receiver-tagged polar bears from 1993 to 2021 revealed that, for the most part, bears living south of about 64° N latitude don't interact with bears to the north, and vice versa.

Southeastern Greenland bears may be mostly isolated by Greenland's ice sheet to the west and a rapid ocean current to the east, which could sweep seafaring bears south and stifle northward movement, the researchers say.

In northeastern Greenland, the median distance traveled by tagged bears was 40 kilometers every four days. But in the southeastern region, the median distance traveled was just 10 kilometers every four days, with bears sometimes moving between neighboring fjords and sometimes remaining in the same fjord for years.

"For a polar bear, that's nothing," says Steven Amstrup, a zoologist and chief scientist for the conservation organization Polar Bears International in Bozeman, Mont. "Apparently they're finding enough resources there that they don't have to make these huge, big movements."

Southeastern Greenland bears hunted on sea ice when it was present during a few months in winter and spring, the researchers found. For the rest of the year, the ursids used the glacial mélange as hunting grounds. "They use it just like sea ice," Laidre says. "They're able to walk [and hunt] on the mélange … and they can swim around between the pieces of ice and ambush seals."

It's not entirely surprising that polar bears have settled at the fronts, or toes, of glaciers in the fjords, Amstrup says. "Oftentimes, the toes of these glaciers are very productive areas," he says, because glacial meltwater can flush nutrients from deeper in the ocean up toward the water's surface. "You might expect that they would have seal populations [that] could support bears."

The researchers also analyzed rare genetic variations in the southeastern Greenland bears. Sampled animals shared a common ancestor about 200 years ago and have kept to themselves since. "They're the most genetically isolated polar bears in the world," Laidre says. Conserving the distinctive bears will be important for protecting polar bears' overall genetic diversity, which is already low, she says.

But for all their peculiarity, even southeastern Greenland polar bears will perish without human climate action (SN: 1/15/11, p. 5). "Loss of Arctic sea ice is still the primary threat to all polar bears," Laidre says. "This study does not change that." ■

THOMAS W. JOHANSEN/NASA OCEANS MELTING GREENLAND

Glacial mélange (shown), a mixture of snow, icebergs and sea ice fragments, could be a polar bear refuge as Earth warms. But climate action is still needed to preserve the species, researchers say.

EARTH & ENVIRONMENT

Fossils record earliest known wildfires

Charcoal helps pin down oxygen levels 430 million years ago

BY SID PERKINS

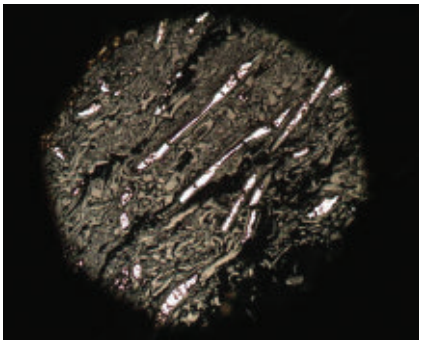
Bits of charcoal entombed in ancient rocks unearthed in Wales and Poland push back the earliest evidence for wildfires to about 430 million years ago.

Besides breaking the previous record by about 10 million years, the finds help pin down how much of Earth's atmosphere was oxygen at the time: at least 16 percent, researchers report June 13 in *Geology*. That conclusion is based on lab tests that show how much oxygen it takes for a wildfire to take hold and spread.

While oxygen makes up 21 percent of our air today, over the last 600 million years or so, atmospheric oxygen levels have fluctuated between 13 percent and 30 percent. Models simulating past oxygen concentrations are based on processes such as the burial of coal swamps, mountain building, erosion, and the chemical changes associated with them. But those models, some of which predict oxygen levels as low as 10 percent for the Silurian Period, which ran from about 444 million to 420 million years ago, provide broad-brush trends and may not capture brief spikes and dips, say Ian Glasspool and Robert Gastaldo, both paleobotanists at Colby College in Waterville, Maine.

Charcoal, a remnant of wildfire, is physical evidence that provides, at the least, a minimum threshold for oxygen concentrations. Oxygen is one of three ingredients needed to create a wildfire. During the Silurian, the second ingredient, ignition, came from lightning, Glasspool says. The third, fuel, came from burgeoning plants and fungi. Back then, low-growing plants just a few centimeters tall were the predominant greenery. Scattered among this ground cover were occasional knee-high to waist-high plants and *Prototaxites* fungi that towered up to nine meters tall. Before this time, most plants were single-celled and lived in the seas.

Once plants left the ocean and began to thrive, wildfire followed. "Almost as soon as we have evidence of plants on land, we have evidence of wildfire," Glasspool says.



In this microscope image of a fungus fossil, the gray veneers of charcoal surrounding bright white pyrite minerals are evidence of a wildfire about 430 million years ago.

That evidence, documented by Glasspool and Gastaldo, includes tiny chunks of partially charred plants, including charcoal as identified by its microstructure, as well as conglomerations of charcoal and associated minerals embedded within fossilized *Prototaxites* fungi. Those samples came from rocks of known ages that formed from sediments dumped just offshore of ancient landmasses. Streams or rivers carried this wildfire debris before it settled, accumulated and was preserved, the researchers suggest.

The discovery adds to previous evidence, including analyses of pockets of fluid trapped in halite minerals formed during the Silurian, that oxygen during that time approached or perhaps exceeded the 21 percent concentration seen today, Glasspool and Gastaldo note.

"The team has good evidence for charring," says Lee Kump, a biogeochemist at Penn State. Although that evidence points to higher oxygen levels than some models suggest for that time, it's possible that oxygen was a substantial component of the atmosphere even earlier than the Silurian, Kump says.

"We can't rule out that oxygen levels weren't higher even further back," he says. "It could be that plants from that era weren't amenable to leaving a charcoal record." ■

ATOM & COSMOS

Physicists claim to spot tetraneutrons

Neutron clusters would help scientists study nuclear forces

BY EMILY CONOVER

Physicists have found the strongest sign yet of a fabled four of a kind.

For six decades, researchers have hunted for clusters of four neutrons called tetraneutrons. But evidence for their existence has been shaky. Now, scientists say they have observed what appear to be tetraneutrons. The result strengthens the case that the fab four is more than a figment of physicists' imaginations. But some scientists doubt that the claimed tetraneutrons are really what they seem.

Unlike an atomic nucleus, in which protons and neutrons are solidly bound together, the purported tetraneutrons seem to be quasibound, or resonant, states. That means the clumps last only for fleeting instants — in this case, less than a billionth of a trillionth of a second, the researchers report in the June 23 *Nature*.

If confirmed, tetraneutrons would help scientists isolate and probe mysterious neutron-neutron forces and the inner workings of atomic nuclei. All atomic nuclei contain one or more protons, so scientists don't have a complete understanding of the forces at play within groups composed of only neutrons.

To create neutron quartets, nuclear physicist Meytal Duer of the Technical University of Darmstadt in Germany and colleagues started with a beam of a radioactive, neutron-rich type of helium called helium-8, created at the RIKEN research center in Wako, Japan. The team slammed that beam into a target containing protons. When a helium-8 nucleus and a proton collided, the proton knocked out a group of two protons and two neutrons, also called an alpha particle. Because each initial helium-8 nucleus had two protons and six neutrons, that left four neutrons alone.

By measuring the momenta of the alpha particle and the ricocheting proton, the researchers determined the energy

I. GLASSPOOL/COLBY COLLEGE

of the four neutrons. Such measurements, taken across multiple collisions, revealed a bump on a plot of the neutrons' energy—the signature of a resonance.

In the past, "there were indications, but it was never very clear" whether tetraneutrons existed, says nuclear physicist Marlène Assié of IJCLab in Orsay, France. In 2016, Assié and colleagues reported hints of a few tetraneutrons (*SN: 3/5/16, p. 10*). In the new study, Duer and colleagues report observing about 30 clusters. The bump on the new plot is much clearer, Assié says. "I have no doubts on this measurement."

But theoretical calculations of what happens when four neutrons collide have raised skepticism as to whether a tetraneutron resonance can exist. If the forces between neutrons were strong enough to create a tetraneutron resonance, certain types of atomic nuclei should exist that are known not to, says theoretical nuclear physicist Natalia Timofeyuk of the University of Surrey in Guildford, England.

Because of that contradiction, she thinks that the researchers have not observed a true resonance, but another effect that is not yet understood. For example, she says, the bump could result from a "memory" that the neutrons retain of how they were arranged in the helium-8 nucleus.

Other theoretical calculations are a closer match with the results. "Indeed, theoretical results are very controversial, as they either predict a tetraneutron resonance in good agreement with the results presented in this paper, or they don't predict any resonance at all," says theoretical nuclear physicist Stefano Gandolfi of Los Alamos National Laboratory in New Mexico. Further calculations will be needed to understand the new results.

New experiments could help too. Because detecting neutrons, which have no electric charge, is more difficult than detecting charged particles, Duer and colleagues didn't directly observe the four neutrons. In the future, the researchers hope to spot the neutrons and better pin down the tetraneutrons' properties. ■

LIFE & EVOLUTION

Butterflies may lose tails like lizards

Wing tails might facilitate escape from attacking predators

BY JAKE BUEHLER

On some butterfly wings, tails may be more than just elegant adornments. They might be survival tools too.

Tails seem to attract the attention of attacking birds, keeping them away from a butterfly's more vital body parts, researchers report in the May 25 *Proceedings of the Royal Society B*. The finding could help explain why the tails have independently evolved in different butterfly groups.

Some butterfly species with false head or eyespot patterns on their wings receive more attacks from predators at those patterns. Evolutionary biologist Ariane Chotard of the National Museum of Natural History in Paris and colleagues wondered if tails were also a target.

In summer 2020, the team collected 138 sail swallowtail butterflies (*Iphiclides podalirius*) in France. Sail swallowtails sport a conspicuous black tail on each hind wing with some blue and orange spotting, contrasting with the rest of the body's yellow striped coloration.

Among the collected swallowtails, 65, or 47 percent, had damaged wings. Of all of those mangled wings, more than 82 percent had damaged tails, suggesting that predators might target the spindly parts.

To test that idea, the team kept wild-caught songbirds in cages and showed the birds dummy butterflies made from gluing real swallowtail wings to a fake body made of black cardboard. Video recordings of bird attacks on the faux insects showed that 43 out of 59 beak strikes, or nearly 73 percent, were on the hind wings. Thirty-nine percent of strikes touched both a tail and colored areas on the upper part of a hind wing simultaneously, more than any other body area on the dummies.

Chotard and colleagues also estimated how much force was needed to tear various sections of the swallowtail wing. The vein of the hind wing tail was the most fragile part and probably most apt to break off in a hungry bird's beak.

The findings, the researchers argue, suggest that swallowtail tails deflect attacks away from a butterfly's vulnerable body to brittle extensions that easily tear off, allowing the insect to escape. This may be similar to how some lizards sacrifice their detachable tails to predators.

Some moth tails can deflect the attacks of echolocating bats (*SN: 3/21/15, p. 17*). "Now we have evidence that butterfly tails provide a similar benefit against visual predators," says evolutionary biologist Juliette Rubin of the University of Florida in Gainesville.

Determining the survival benefits of tails is the next step, Rubin says. "It would be informative to see how live swallowtail butterflies—both with and without tails—fare against bird predators." ■

The sail swallowtail butterfly has tail-like projections on its hind wings that may divert attacking birds away from the butterfly's vital parts.

CAROLINE GAUVIN/MOMENT/GETTY IMAGES

HUMANS & SOCIETY

DNA traces roots of the Black Death

This bubonic plague may have started in Central Asia

BY BRUCE BOWER

People in Tournai, Belgium, are depicted burying victims of the Black Death. A precursor of the bacterial strains that caused this medieval plague may have emerged in Central Asia.

Although best known as a plague that killed millions of Europeans from 1346 to 1353, the Black Death originated about a decade earlier in Central Asia, a new study suggests.

A strain of the plague-causing *Yersinia pestis* bacterium that killed people in what's now Kyrgyzstan in 1338 and 1339 was a common ancestor of four *Y. pestis* strains previously linked to the deadly European outbreak, say archaeogeneticist Maria Spyrou of the University of Tübingen in Germany and colleagues.

Spyrou's group identified *Y. pestis* DNA in the teeth of three individuals from an ancient Central Asian cemetery where tombstone inscriptions say that they, as well as many others buried there, died in 1338 and 1339 from an unspecified "pestilence." Comparisons of that genetic material with modern and historical samples of *Y. pestis* DNA indicate that the Central Asian folks perished from a version of the bacterium that gave rise to the strains that would wreak havoc on Europe, the Middle East and northern Africa until the early 1800s, the scientists report in the June 23 *Nature*.

"The source location and time when this plague emerged was most likely in Central Asia in the first half of the 14th century," Spyrou said in a June 14 news briefing.

Origins of the Black Death, or bubonic plague, have long been debated. What's certain is that *Y. pestis* gets transmitted to humans by fleas that live on rodents. One current proposal holds that the plague bacterium originated in East Asia and was carried across the continent starting in the 1200s as the Mongol Empire expanded. That scenario was based on historical records, ancient and modern plague genetic evidence, and reports of a plague outbreak connected to the Mongol conquest of Baghdad in 1258.

But solid archaeological and genetic clues to the Black Death's place and time of birth come from Central Asia, Spyrou says. Excavations at two cemeteries in northern Kyrgyzstan almost 140 years ago revealed tombstones indicating that many people buried there in 1338 and 1339 had died of an unknown epidemic. The cemeteries were used from the mid-1200s to the mid-1300s, but tombstone inscriptions indicated that deaths spiked in 1338 and 1339. Of 467 dated tombstones, 118 mark deaths in those two years.

Spyrou's group reconstructed the entire *Y. pestis* genome for two of three Central Asian individuals who died in 1338 or 1339 and whose teeth contained remnants of the bacterium's DNA. Comparisons with the genetic instructions of 20 modern *Y. pestis* samples and 47 *Y. pestis* samples dating from the 14th to 18th centuries pegged the Central Asian genomes as a single strain that was a direct ancestor of Black Death strains.

The researchers also found that marmots and other rodents now living in the same region of Central Asia carry forms of *Y. pestis* closely related to the ancient variant. The *Y. pestis* variant that killed Central Asians in 1338 and 1339 may thus have emerged locally, the investigators suggest.

Reasons for the rise of a particularly deadly form of *Y. pestis* in Central Asia during the early 1300s remain unclear. The earliest known *Y. pestis* strain, which dates to around 7,100 years ago in Eastern Europe, lacked a plague-inducing gene that enables rapid transmission from fleas to humans.

Spyrou's group convincingly traces the origin of *Y. pestis* strains involved in Europe's Black Death to Central Asia, says evolutionary biologist Nils Stenseth of the University of Oslo. He regards the new findings as consistent with a scenario in which periods of warm weather in Central Asia triggered repeated plague outbreaks in Europe starting in the 1300s. Troops, travelers and merchants moving along trade routes from Asia kept bringing the plague into Europe, Stenseth suspects.

While the newly identified *Y. pestis* strain appears to be an ancestor of later European strains, clear-cut origins of the Black Death — and other pandemics, including COVID-19 — are notoriously hard to pin down, says evolutionary geneticist Hendrik Poinar of McMaster University in Hamilton, Canada.

For instance, it will be challenging to determine whether the ancient *Y. pestis* strain from Central Asia existed even earlier across a broad swath of the continent, he says. If so, then a precursor strain of the Black Death may have arisen before 1338 in an as-yet-undetermined part of Asia. Temptations to translate ancient DNA findings into a story of the Black Death's precise place and time of origin "need to be tempered," he says. ■

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LIFE & EVOLUTION

Newfound bacteria make a big splash

The single-celled giants challenge ideas about complexity

Averaging 1 centimeter long, *Thiomargarita magnifica* bacteria (several shown with a dime) are big enough to see with the naked eye.

BY ERIN GARCIA DE JESÚS

There's a new record holder for biggest bacteria — and you don't need a microscope to see one.

A newfound species, *Thiomargarita magnifica*, averages a centimeter long and is surprisingly complex, researchers report in the June 24 *Science*.

These single-celled behemoths are roughly the size and shape of a human eyelash, marine biologist Jean-Marie Volland of the Laboratory for Research in Complex Systems in Menlo Park, Calif., said June 21 at a news conference. *T. magnifica*, which can max out at approximately 2 centimeters long, is about 50 times the size of other giant bacteria and about 5,000 times the size of average-size bacteria.

What's more, while the genetic material of most bacteria floats freely inside the cell, *T. magnifica* packs its DNA inside a sac surrounded by a membrane (*SN: 8/5/17, p. 12*). Such a compartment is a hallmark of the larger, more complex cells of eukaryotes — a group of organisms that includes plants and animals.

Marine biologist Olivier Gros of the Université des Antilles Pointe-á-Pitre in Guadeloupe, France, discovered *T. magnifica* while collecting water samples in mangrove forests in the Caribbean's Lesser Antilles. At first, he mistook the long, white filaments for some sort of eukaryote, Gros said at the news conference. Eventual genetic analyses showed that the organisms were actually bacteria. A closer look under the microscope revealed the cells' DNA-containing sacs.

Previous studies had predicted that bacterial cells' relative simplicity meant there was a limit to how large bacteria could grow. But the new discovery is "breaking our way of thinking about bacteria," says Ferran Garcia-Pichel, a microbiologist at Arizona State University in Tempe who was not involved with the study. When it comes to bacteria, people typically think small and simple. But that mind-set may make researchers miss lots of other bacterial species, Garcia-Pichel says. It's a bit like thinking the largest animal that exists is a small frog but then discovering elephants.

It's still unclear what role *T. magnifica* plays in the mangrove ecosystem. Also unknown is what drove the species to be so large. One possibility, Volland said, is that being at least a centimeter long helps bacteria access both the oxygen and sulfide that they need to survive. ■

FROM TOP: TOMAS TYML: GLDBURGER/ISTOCK/GETTY IMAGES PLUS

LIFE & EVOLUTION

Cats up plants' bug-repelling powers

For many cats, a mere whiff of catnip can send them into a licking, rolling, plant-shredding frenzy (shown, left). That destruction amplifies catnip's natural defenses against insects and the plant's appeal to felines, a new chemical analysis finds.

Compared with intact leaves, crushed leaves emit more insect-repelling volatile compounds called iridoids, an international team of scientists reports June 14 in *iScience*. The higher emissions also seem to encourage cats to roll on plant remains and coat themselves in this natural bug spray (*SN: 3/27/21, p. 9*).

The team analyzed the chemistry of catnip (*Nepeta cataria*) and silver vine (*Actinidia polygama*), a plant that also has a euphoric effect on cats. Both plants produce iridoids, which discourage insects from snacking on leaves. As cats toyed with the plants, damaged silver vine released about 10 times as many iridoids as intact leaves did while crushed catnip released over 20 times as many. Cats presented with dishes of intact and damaged silver vine unfailingly went for the dishes with damaged leaves. What's more, lab tests of iridoids suggest that damaged silver vine and catnip both repel mosquitoes, though silver vine does so faster than catnip at low concentrations. — *Anil Oza*

Moving Past Paralysis

New technologies aim to give people with paralysis more mobility and independence **By Laura Sanders**

As part of a small clinical trial, Michel Roccati uses an implanted electrical stimulator to activate his spine, allowing him to move around without a wheelchair after his spinal cord injury.

JIMMY RAVIER/EPFL

By his count, Michel Roccati is on his third life, at least. In the first, he was a fit young man riding his motorcycle around Italy. A 2017 crash in the hills near Turin turned him into the second man, one with a severe spinal cord injury that left him paralyzed from the waist down. Today, the third Michel Roccati works out in his home gym in Turin, gets around with a walker and climbs stairs to visit a friend in a second-story apartment. Today, he says, his life is "completely different than it was before."

Roccati, age 31, is one of three men who received experimental spinal cord stimulators as part of a clinical trial. All three had completely paralyzed lower bodies. The results have been a stunning success, just as Roccati had hoped. "I fixed in my mind how I was at the end of the project," he says. "I saw myself in a standing position and walking. At the end, it was exactly what I expected."

The technology that Roccati and others use, described in the February *Nature Medicine*, is an implanted array of electrodes that sits next to the spinal cord below the spot severed by the injury. Electrical signals from the device replace the missing signals from the brain, prompting muscles to move in ways that allow stepping, climbing stairs and even throwing down squats in the gym.

Today, Roccati spends time working at the consulting company he owns with his brother and sharing his ongoing physical accomplishments with researchers. "Every week we get a WhatsApp from Michel doing something new," says study coauthor Robin Demesmaeker, a neural engineer at NeuroRestore, a research and treatment center in Lausanne, Switzerland.

These results and others prove that, with the right technology, people with severe spinal cord injury may be able to stand up and walk again. It's a remarkable development.

But the really big news in this area goes far beyond walking. Many people with spinal cord injuries deal with problems that aren't as obvious as paralysis. Low blood pressure, sexual dysfunction and trouble breathing or controlling hands, arms, bladder and bowels can all be huge challenges for people with paralysis as they navigate their daily lives. "These are the things that actually matter to people with spinal cord injuries," says John Chernesky, who has a spinal cord injury. He works at the nonprofit Praxis Spinal Cord Institute in Vancouver, where he makes sure the priorities and voices of people living with spinal cord injuries are heard and addressed in research.

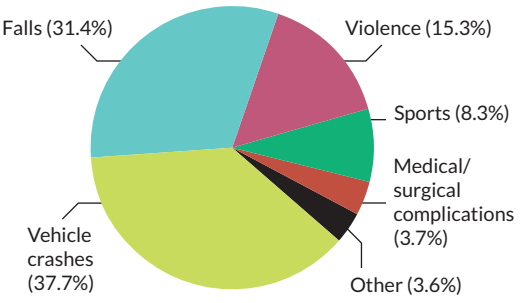
By figuring out the language of the spinal cord, researchers hope to learn how to precisely fill in the missing commands, bridging the gap left by the injury. The work may pave the way to treat many of these problems flagged by patients as important.

"The research field is changing … embracing all these other aspects," says neuroscientist Kim Anderson Erisman of MetroHealth Medical Center and Case Western Reserve University in Cleveland. Already, early clinical trials are tackling the less obvious troubles that come with spinal cord injuries. Some of the same scientists that helped Roccati recently showed that similar spinal cord stimulation eased a man's chronic low blood pressure. Other researchers are improving bladder and bowel function with stimulation. Still more work is focused on hand movements. The technology, and the understanding of how to use it to influence the nerves in the spinal cord, is moving quickly.

Not coincidentally, the way the research is being conducted is shifting, too, says Anderson Erisman, who has a spinal cord injury. "Scientists know the textbook things about spinal cord injuries," she says. "But that's not the same thing as living one day in the life with a spinal cord injury." Involving people with such injuries in studies — as true partners and collaborators, not just subjects — is pushing research further and faster. Such collaboration, she says, "will only make your program stronger."

These efforts are in the early stages. The stimulators are not available to the vast majority of people who might benefit from them. Only a handful of people have participated in these intense clinical trials so far. It's unclear how well the results will hold up in larger trials with a greater diversity of volunteers. Also unclear is how attainable the technology will be for people who need it. For now, the research often requires large teams of experts, typically in big cities, with patients needing surgery and months of training the body to respond.

Causes of spinal cord injuries in the United States



Lost signals
In the United States, an estimated 18,000 people suffer a spinal cord injury each year. Vehicle crashes and falls are the most common causes, data collected from 2015 to 2021 show. Violence, particularly gunshot wounds, and sports accidents are also common reasons.
SOURCE: NATIONAL SPINAL CORD INJURY STATISTICAL CENTER

C. CHANG

Still, the promise of spinal cord stimulation extends beyond spinal cord injuries. Stimulating nerves on the spinal cord could help people with symptoms from strokes, Parkinson's disease, multiple sclerosis, cerebral palsy and other disorders in which signals between the brain and body get garbled. Initially, "hardly anyone wanted to believe these [improvements] were happening," says V. Reggie Edgerton, an integrative biologist at the University of Southern California's Neurorestoration Center and the Rancho Los Amigos Rehabilitation Center in Downey, Calif. "But now, they're happening so regularly that it's undeniable."

A turnaround

Not so long ago, a serious spinal cord injury was a death sentence. "Prior to World War II, the life expectancy of a person with a spinal cord injury was measured in days or weeks," Chernesky says. If the injury didn't kill a person directly, they'd often succumb to respiratory distress or blood poisoning from a bladder infection. "If you lived six months, that was impressive," he says.

The spinal cord ferries signals between brain and body. Signals from the brain tell leg muscles to contract for a step, blood vessels to expand and the bladder to hold steady until a bathroom is within reach. Signals from the body to the brain carry sensations of moving, pain and touch. When the spinal cord is injured, as it is for an estimated 18,000 or so people each year in the United States alone, these signals are blocked.

At his home gym, Michel Roccati works out on modified equipment. He exercises both with and without spinal stimulation that he can control with a tablet.

M. ROCCATI

Researchers have long dreamed of repairing the damage by bridging the gap, perhaps with stem cells or growth factors that can beckon nerve cells to grow across the scar. The idea of using electricity to stimulate nerves below the site of the injury came, in part, from an accidental observation. In the mid-1970s, scientists were testing spinal cord stimulation as a treatment for severe and chronic pain. One participant happened to be a woman who was paralyzed from multiple sclerosis, a disease in which the body attacks its own nerves. With the device implanted on her spinal cord to ease pain, she was able to move again. That surprising discovery helped spark interest in spinal cord stimulation as a way to restore movement.

In 2011, researchers at the University of Louisville in Kentucky restored the ability to stand to a 23-year-old man with paraplegia. In 2018, that group and two others reported even greater strides in spinal stimulation: People with severe spinal cord injuries could step and walk with assistance (SN: 12/22/18 & 1/5/19, p. 30).

Earlier this year, Demesmaeker and his colleagues, including Grégoire Courtine of the Swiss Federal Institute of Technology in Lausanne, published the achievements of Roccati and two other men. All three men had been unable to move their lower limbs or feel any sensations there.

Most previous studies had relied on an electrode array designed and approved by the U.S. Food and Drug Administration to treat chronic pain. That device has electrodes that are implanted along the spinal cord, where their electrical jolts can ease long-term pain in the back and legs. But Roccati and the two other men received a specially designed device that was slightly longer and wider than that earlier device, able to cover more of the spinal cord's nerve roots and provide more stimulation options.

Several weeks after surgery, the men visited the laboratory in Lausanne to start searching for the optimal stimulation settings. The timing, pattern and strength of the electrode signals were adjusted to allow Roccati to move. "We found a good sequence with the engineers that allowed me to stand up and see my body standing in the mirror in front of me," Roccati says. "It was a very emotional moment. A standing ovation appeared from everyone in there."

That first day, he took steps with the stimulation while being supported by a harness. That quick improvement is important, says biomedical engineer Ismael Seáñez of Washington University in St. Louis. "From day one, you can start training." After months

of intense practice (four to five sessions a week for one to three hours at a time), Roccati could walk without the harness, using only a walker.

The men in the trial have all been getting stronger, even when the stimulation is off. That suggests that there's some sort of repair happening in the body, perhaps due to stronger neural pathways in the spinal cord. Just how the stimulation repairs the spinal cord is one of the big remaining mysteries.

"It's exciting to see," Seáñez says. "But it's a first step in all of the different challenges faced by people with spinal cord injuries."

Signaling blood vessels

One important problem with paralysis is low blood pressure. When the spinal cord is damaged, the signals that keep blood vessels constricted and blood pressure normal can get lost. Low blood pressure can leave people mentally foggy, exhausted and prone to fainting, not ideal conditions for physical rehab work. Blood pressure can also rise or fall quickly, upping the risk for stroke and heart attack. That's a huge problem, says Aaron Phillips, who studies the physiology of the nervous system at the University of Calgary in Canada. "Blood pressure is one of the vital signs of life," he says.

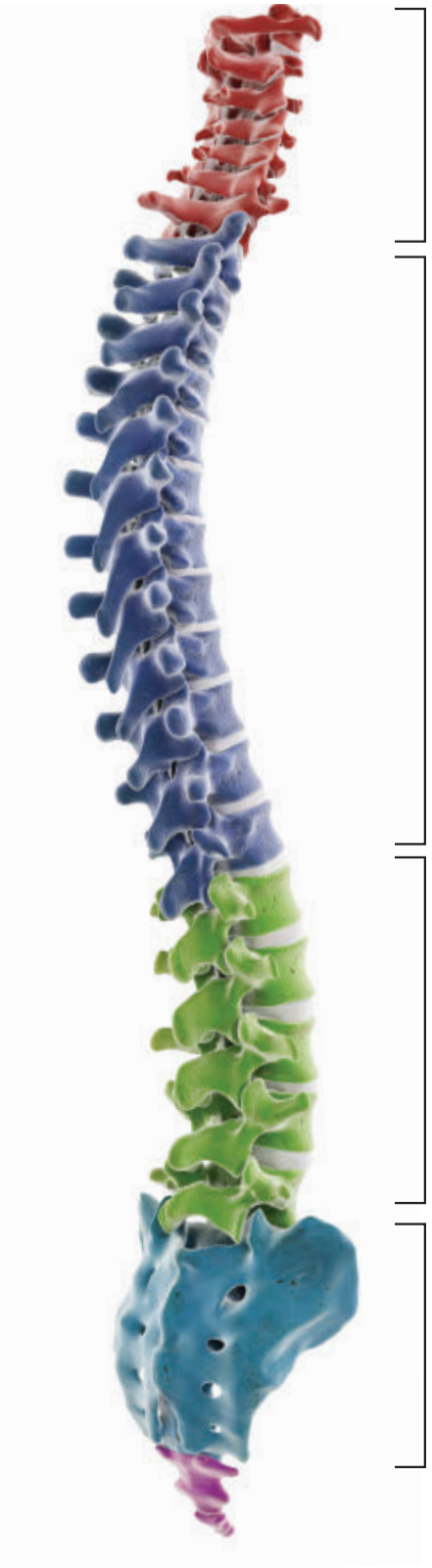
So Phillips, Courtine and colleagues decided to implant a spinal cord stimulator to see if it would help a man who had low blood pressure due to a spinal cord injury. When the machine was on, his blood pressure rose toward normal levels, the researchers reported last year in *Nature*. When the stimulation was turned off, the man's blood pressure dropped.

The scientists homed in on an area in the midback, just around thoracic segment 11 in the human spine. That spot had the biggest effect on the man's blood pressure. "We now know that there's a key area in the spinal cord that, when stimulated, controls neural circuits and the connected blood vessels to elevate and decrease blood pressure," Phillips says.

The system the researchers developed operated like a thermostat with a set point. In experiments with the man on a tilting table, monitors sensed low blood pressure when the table mimicked standing up. That triggered the stimulators, which in turn told the blood vessels to bring the pressure back up to an acceptable level.

The results represent "a huge pinnacle of my career," Phillips says. But many challenges remain. The system used in the study in *Nature* needs tweaking, and the long-term effects of such stimulation aren't known. Phillips and his colleagues hope to answer these questions. With funding from DARPA, a

Spinal cord control over parts of the body



Spinal control Nerves in each spinal cord region carry signals to and from different body parts. That means the outcome of an injury depends on its location, with lower injuries affecting less of the body. SOURCE: CHRISTOPHER AND DANA REEVE FOUNDATION

SEBASTIAN KAULITZKI/SCIENCE PHOTO LIBRARY/GETTY IMAGES PLUS

John Chernesky (left) advocates for patient perspectives to be included in spinal cord research. He also participated in a recent clinical trial that tested electrical stimulation of the spine through the skin (electrodes on his neck shown, right).

U.S. Department of Defense agency that invests in breakthrough technologies, the team is working on a wireless blood pressure monitor, and an upcoming clinical trial aims to enroll about 20 people with spinal cord injuries that affect their blood pressure.

Patient priorities

In 2004, Anderson Erisman and her colleagues asked people with spinal cord injuries to share their priorities for regaining function. For people with quadriplegia, who have impairments from the neck down, hand and arm function were most important. For people with paraplegia, who have use of their arms and upper body, sexual function was the highest priority. Both groups emphasized the desire for restored bladder and bowel function, Anderson Erisman and colleagues reported in the *Journal of Neurotrauma*. Walking was not at the top of either group's wish list.

That's no surprise to Chernesky, who uses a wheelchair. "The general population looks at people with spinal cord injuries rolling around in wheelchairs, and they say, 'Oh, poor bugger. I bet he wishes he could walk,'" he says. "They have no idea that quite rapidly after an injury, walking becomes a lower priority."

Chernesky himself recently participated in a clinical trial designed to externally stimulate the cervical spine, in his neck, to improve arm and hand movements. The device he tested sent signals to the spinal cord through the skin—a less invasive approach than surgery, but one that may sacrifice some specificity compared with implanted versions. Throughout that process, Chernesky noticed improvements in energy, sleep, strength, core stability and movement of both upper and lower limbs.

Other scientists are working on similar ways to externally stimulate the spinal cord to improve people's autonomic nervous system. That system keeps your blood pressure steady, makes you sweat when it's hot and tells you when you need to head to a bathroom.

In studies at the University of Southern California and elsewhere, Edgerton and colleagues have recently shown that external stimulation improved bowel function. He and others have also seen stimulators improve bladder function in people with spinal cord injuries and strokes. "We know some subjects can now feel when their bladder is full," says Edgerton, who started a company called SpineX in 2019 to develop the technology further. That newfound sensation gives people enough time to get to the bathroom. "This doesn't happen overnight, and it doesn't happen in every individual," he cautions. "But it happens a lot."

Getting past the hype

The next phase of research will be boring—in the best possible way. Large, standardized studies will need to address some mundane but crucial questions, such as who might benefit from stimulation, how much improvement can be made for certain symptoms and whether the therapy causes any extra trouble for some people. "This type of technology will go from a very exciting proof of concept to standard clinical care," Seáñez predicts.

Over his nearly 30 years of living with a spinal cord injury, Chernesky has witnessed enough so-called scientific breakthroughs to be skeptical. He's immune to hype. But he admits that he's excited by this moment. "Because now we can reverse paralysis," he says. That doesn't mean people are going to suddenly be tap dancing like Fred Astaire or playing a Chopin concerto anytime soon, he's quick to add. "But every little bit matters."

Roccati, for one, no longer has to recruit friends to carry him in his wheelchair up stairs to socialize. He feels more energetic. He is working on his summer six-pack abs. He has transformed, again, into someone new. "Now, after the implant, I am another type of person," he says, a more optimistic version of himself.

This technology is still a long way from helping everyone who might benefit. Still, these stimulators hold great promise. "I am quite hopeful, almost certain, that these devices are going to become available, and there will be a lot of people buying them," Chernesky says. "When you have nothing, and you can get a little bit back—how good is that?" ■

Explore more

- Vanesa Bochkezanian and Kim D. Anderson. "Comprehensive and person-centred approach in research: What is missing?" *Spinal Cord*. January 3, 2022.

FROM LEFT: PRAXIS; J. CHERNESKY

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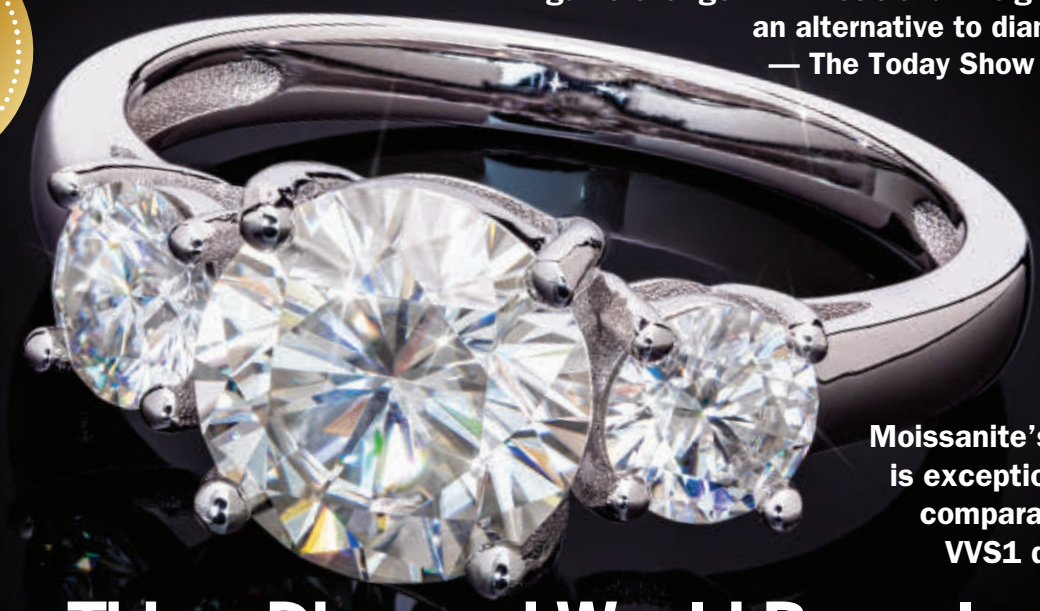

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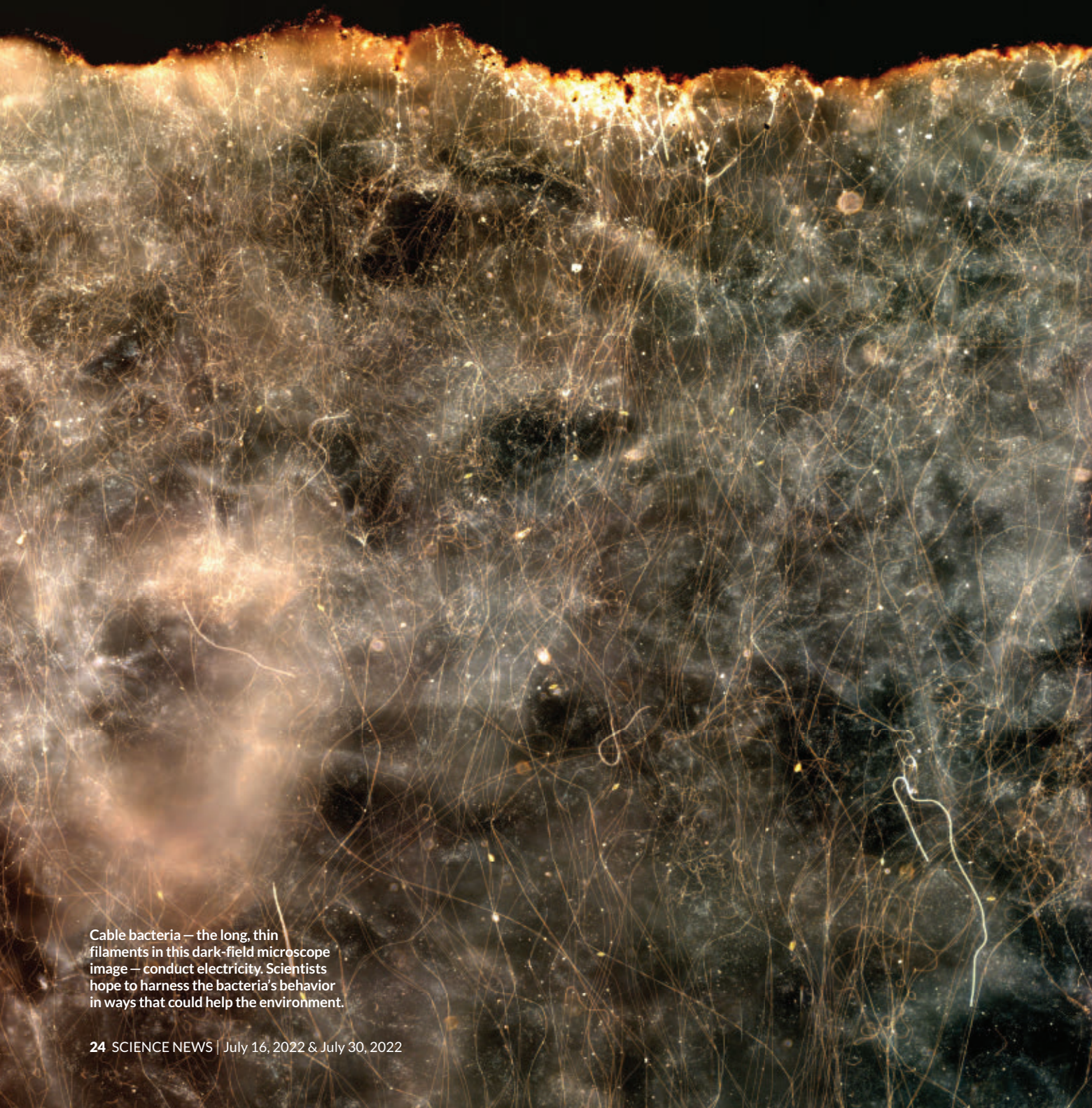


Cable bacteria — the long, thin filaments in this dark-field microscope image — conduct electricity. Scientists hope to harness the bacteria's behavior in ways that could help the environment.

Cable bacteria, which channel electricity, may help clean up coastal ecosystems

By Nikk Ogasa

The small motorboat anchors in the middle of the Chesapeake Bay. Shrieks of wintering birds assault the vessel's five crew members, all clad in bright orange flotation suits. One of the crew slowly pulls a rope out of the water to retrieve a plastic tube, about the length of a person's arm and filled with mud from the bottom of the bay. As the tube is hauled on board, the stench of rotten eggs fills the air.

"Chesapeake Bay mud is stinky," says Sairah Malkin, a biogeochemist at the University of Maryland Center for Environmental Science in Cambridge who is aboard the boat. The smell comes from sulfuric chemicals called sulfides within the mud. They're quite toxic, Malkin explains.

Malkin and her team venture out onto the bay every couple of months to sample the foul muck and track the abundance of squiggling mud dwellers called cable bacteria. The microbes are living wires: Their threadlike bodies — thinner than a human hair — can channel electricity.

Cable bacteria use that power to chemically rewire their surroundings. While some microbes in the area produce sulfides, the cable bacteria remove those chemicals and help prevent them from moving up into the water column. By managing sulfides, cable bacteria may protect fish, crustaceans and other aquatic organisms from a "toxic nightmare," says Filip Meysman, a biogeochemist at the University of Antwerp in Belgium. "They're kind of like guardian angels in these coastal ecosystems."

Now, scientists are studying how these living electrical filaments might do good in other ways. Laboratory experiments show that cable bacteria can support other microbes that consume crude oil, so researchers are investigating how to encourage the bacteria's growth to help clean up oil spills. What's more, researchers have shown that cable bacteria could help slash emissions of a potent greenhouse gas — methane — into the atmosphere.

There's plenty of evidence that cable bacteria exert a strong influence over their microbial neighbors, Meysman says. The next step, he says, is to figure out how to channel that influence for the greater good.

Sairah Malkin, of the University of Maryland Center for Environmental Science, cuts holes in a large sediment coring tube to sample mud collected from the bottom of the Chesapeake Bay.

Sediments near the bottom of this core sample, taken from the Chesapeake Bay, are probably dark due to the presence of sulfides, while sediments near the top are lighter because cable bacteria have removed the sulfides.

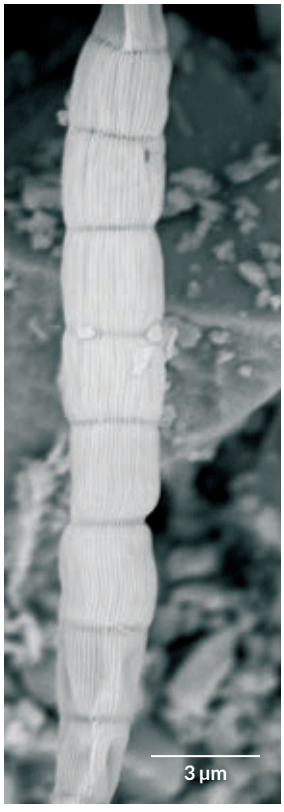
Electric life

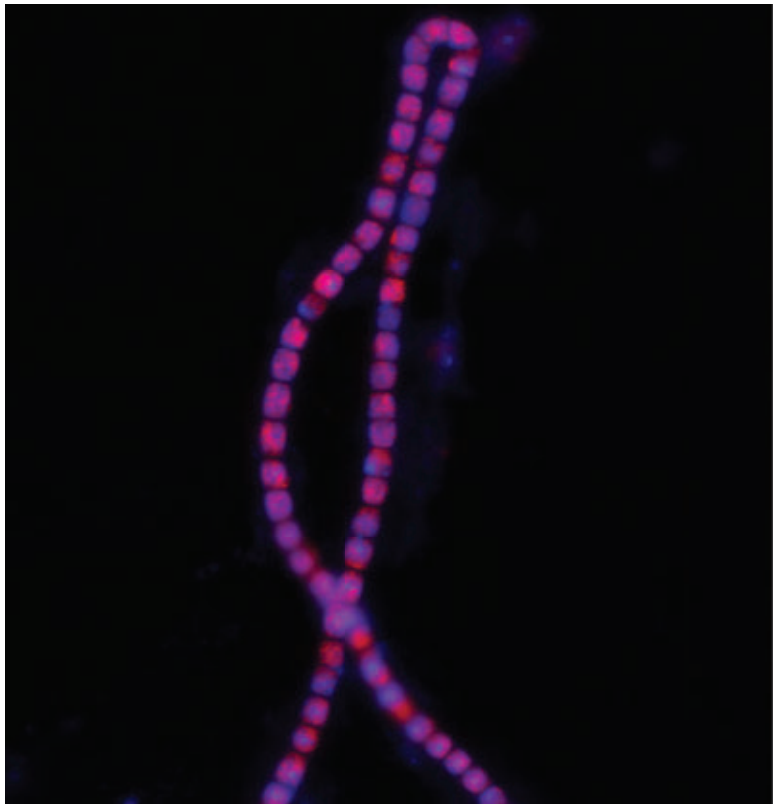
Under the microscope, cable bacteria resemble long sausage links. Their multicellular bodies can grow up to 5 centimeters long. Embedded in the envelope of each cell are parallel "wires" of conductive proteins, which the bacteria use to channel electrons. According to Meysman, the wires are more conductive than the semiconductors found in electronics.

About a decade ago, a team of scientists first discovered cable bacteria, in sediment collected from the bottom of Denmark's Aarhus Bay. Since then, cable bacteria have been found on at least four continents, in streams, lakes, estuaries and coastal environments. "Name me a country, and I'll show you where the cable bacteria are," Meysman says.

Most often, cable bacteria nestle shallow in the sediment, with one end positioned near the surface where there is oxygen and the other end plugged into deeper, sulfide-rich zones. Using their filamentous bodies as electrical conduits, cable bacteria snatch electrons from sulfides on one end and off-load them to oxygen — an eager electron

OPPOSITE PAGE: STEFFEN LARSEN, LARS RIIS DAMGAARD; THIS PAGE, FROM TOP: CLARA FUCHSMAN; S. MALKIN





A cable bacterium (far right) has a multicellular, segmented body that can grow up to 5 centimeters. Electrically conductive, parallel fibers (visible in the close-up at near right) encase the body.

FROM LEFT: N. GEERLINGS/UTRECHT UNIV.; SILVIA HIDALGO MARTINEZ/UNIV. OF ANTWERP

acceptor—at the other, says Nicole Geerlings, a biogeochemist at Utrecht University in the Netherlands. Similar to how batteries charge and release energy by transferring electrons between an anode and cathode, cable bacteria power themselves by channeling electrons, she says. "The electron transport gives [cable bacteria] energy."

This unique lifestyle allows cable bacteria to survive in an environment that many organisms could not endure.

Toxic fire wall

In 2015, Malkin, Meysman and colleagues reported that cable bacteria may help to counteract the onset of euxinia—a fatal buildup of sulfides in oxygen-starved bodies of water. Euxinia can trigger mass die-offs of fish, crustaceans and other aquatic life.

The lethal phenomenon can occur after fertilizers or sewage are washed into the sea or lakes. That flow of nutrients can trigger algal blooms. When those nutrients are depleted, the blooms die, and large quantities of organic matter sink and accumulate on the sediment. Microbes then decompose the dead material, devouring much of the oxygen in the surrounding water in the process. When oxygen levels become critically low, sulfides may begin to leak from the sediment into the water, giving rise to euxinia.

While studying cable bacteria in a brackish body of water in the Netherlands, Malkin and colleagues discovered a thin layer of rust coating the lake's bottom. As the cable bacteria pulled electrons from sulfides, converting the noxious chemicals into less-harmful sulfates, the water within the sediment became more acidic, which dissolved some minerals containing iron. The now-mobile iron percolated upward in the sediment, until it interacted with oxygen to form rust.

This layer of rust could capture sulfides that would otherwise flow into the water, acting as a "fire wall" that could delay euxinia for over a month, or even prevent it altogether, the researchers reported. Even when the cable bacteria's population dropped, the rust layer persisted, protecting other aquatic creatures from sulfide exposure. The rust may explain why even though instances of nutrient pollution, algal blooms and oxygen depletion are relatively common, reports of euxinia are rare.

Oil cleanup

Some researchers are trying to harness the bacteria's electrical abilities to tackle another devastating threat to coastal ecosystems—oil spills.

When an oil spill happens in a body of water, booms, skimmers or sorbents are often deployed

to limit the spread of hydrocarbons on the surface. But oil may also wash onto beaches, mix with sediments in shallow waters and aggregate onto sinking particles of organic debris, hitching a ride to the seafloor.

Cleaning up oil at the bottom of the sea is a difficult job, says Ugo Marzocchi, a biogeochemist at Aarhus University in Denmark. "I am not aware of a very effective way to remove hydrocarbons from the seafloor," he says. "In inland freshwater systems, what is generally done is to dig out the sediments," he says, an expensive strategy that would be even more costly at sea.

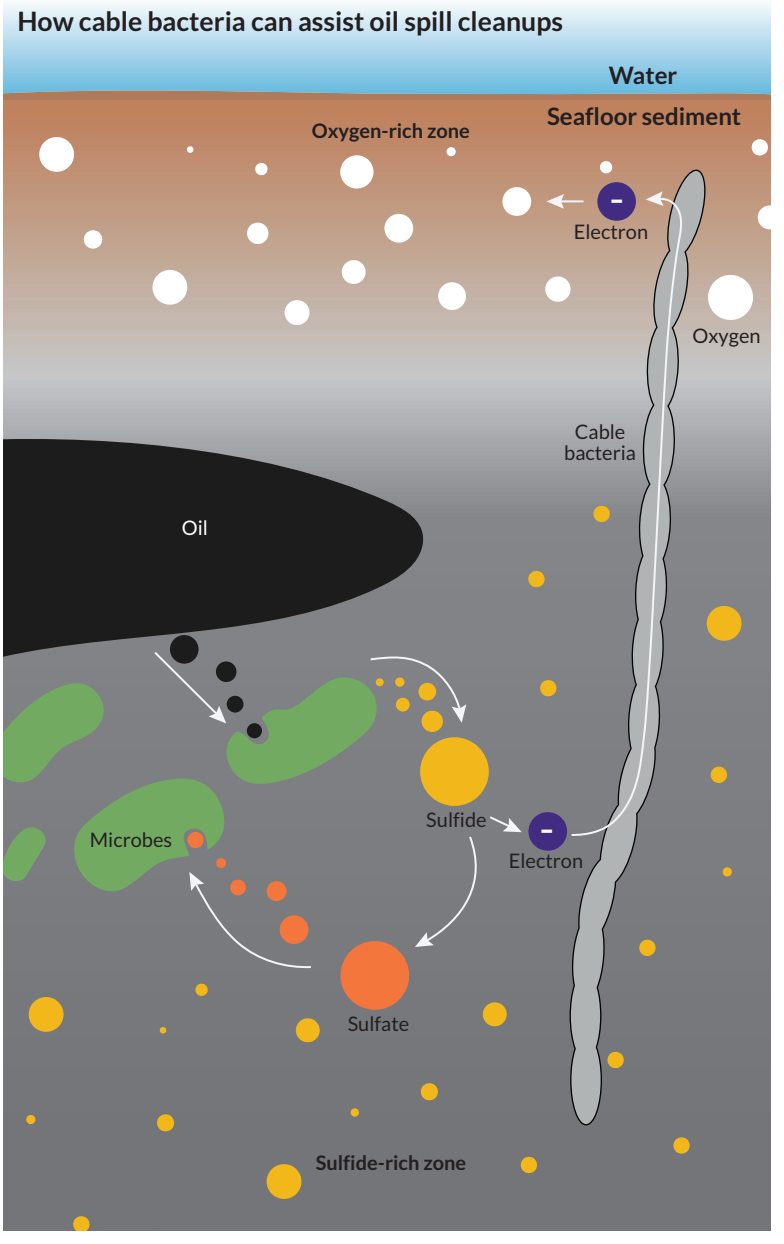
Some soil-dwelling microorganisms can use hydrocarbons to fuel their metabolism, and researchers have been studying how some of these oil burners might assist in the cleanup of contaminated sediments. But as they break down hydrocarbons, the microbes generate those concerning sulfides, which are detrimental to the microbes' own survival, Marzocchi says. In other words, the microbes can help clean up the oil for only so long before they're overwhelmed by their own toxic waste.

Cable bacteria might be just the solution, Marzocchi thought. In 2016, researchers reported finding evidence of the electrical microbes in a tar oil–contaminated groundwater aquifer in Germany. Knowing that cable bacteria could occupy sediments contaminated with hydrocarbons, Marzocchi and colleagues reasoned that these bacteria might be able to assist oil-burning microbes and accelerate oil cleanup.

The researchers filled several containers with oil-contaminated sediment from Aarhus Bay — which contained naturally occurring oil-eating bacteria. The group then injected a few containers with cable bacteria and monitored the degree of hydrocarbon degradation in all of the containers over seven weeks. By the end of the test, the concentration of alkanes — a type of hydrocarbon — in the sediment with cable bacteria had dropped from 0.125 milligrams per gram of sediment to 0.086 milligrams per gram — a 31 percent drop. That's 23 percentage points more than the 9 percent decrease in the control samples. Cable bacteria helped accelerate the metabolic activity of their oil-eating neighbors by converting the toxic sulfides into sulfates. The sulfates didn't harm the oil-eating microbes — in fact, they used the chemicals as fuel.

The researchers are now trying to develop methods to promote cable bacteria growth in the field and see if it's possible to enhance their effect on oil degradation. One catch is that in oil-contaminated sediment, oxygen is quickly used up by the microbes that break down hydrocarbons. That's a problem since cable bacteria need access to oxygen. Salts that slowly release oxygen or nitrate — which cable bacteria can use in place of oxygen — might help spur the electrical organisms' growth at oil spills. But more work is needed to identify the right chemical components and dosage, Marzocchi says.

Meanwhile, scientists are investigating how cable



To the rescue Oil-eating microbes can clean up seafloor sediments contaminated by an oil spill. But the microbes generate toxic sulfides as waste, which hampers the microbes' activity. Cable bacteria can help by harvesting electrons from the sulfides, converting them into sulfates, which the oil-eating microbes use as fuel. Meanwhile, the cable bacteria channel the electrons up their bodies and pass them off to oxygen in the sediment. This transport powers the cable bacteria's metabolism in the process.

T. TIBBITTS

In an experiment, pots of rice plants grown in soils with cable bacteria (far right) developed orange layers of rust and emitted less methane than pots without cable bacteria (near right).

V.V. SCHOLZ/AARHUS UNIV.

bacteria might help reduce emission of another hydrocarbon — one that accumulates in the sky.

Methane at the root

Colorless, odorless methane is the simplest hydrocarbon (SN: 8/15/20, p. 8). It consists of a single carbon atom attached to a quartet of hydrogen atoms. And it's a potent greenhouse gas — more than 25 times as effective at trapping heat in the atmosphere as carbon dioxide.

One major source of methane is rice paddies (SN: 9/25/21, p. 16). During the growing season, rice farmers typically flood their fields to help stave off weeds and pests. Methane-producing microbes — aptly named methanogens — thrive in these waterlogged soils. Paddy-dwelling methanogens are so prolific that rice fields are estimated to generate about 11 percent of all human-induced methane emissions.

But cable bacteria like paddies too. In 2019, Vincent Scholz, a microbiologist at Aarhus University, and colleagues reported that cable bacteria could flourish among the roots of rice plants and several other aquatic plant species.

That discovery inspired the researchers to investigate how the bacteria interact with methanogens in soils that grow rice. The team grew its own rice plants — some potted in soils with cable bacteria, and some without — and monitored methane emissions.

To the researchers' surprise, adding cable bacteria reduced rice soil methane emissions by 93 percent. In the process of removing electrons from sulfides, the bacteria generate sulfates, which other microbes can use as fuel. These sulfate-consuming microbes outcompeted methanogens for nutrients such as hydrogen and acetate in the rice soils, the researchers found. The results were "quite amazing," Scholz says, though the effectiveness of the electrical microbes in real rice fields has yet to be tested.

There are signs that cable bacteria are already plugged into real rice paddy soils. After analyzing genetic data collected from rice paddies in the United States, India, Vietnam and China, Scholz and colleagues reported in 2021 the presence of cable bacteria at sites in all four countries. Scholz is in Northern California this summer studying how cable bacteria live in rice fields and whether they're already impacting methane emissions. He is also exploring ways to introduce cable bacteria to rice fields where they don't yet exist or enhance the microbes' numbers in fields where they do.

There is still much to discover about how the wispy electrical conductors influence our world, Malkin says. Back in the Chesapeake Bay, she and colleagues have found that cable bacteria tend to flourish in the spring, a surge that has also been observed in the Netherlands. The findings add to a growing body of work that suggests cable bacteria are opportunistic organisms that interact with their environments in similar ways all around the world.

If cable bacteria are already hard at work across the planet, then a bit of coaxing from researchers may be all it takes to turn the mud-dwelling creatures into the most helpful neighbors that a living thing could ask for. ■

Explore more

- Vincent V. Scholz *et al.* "Cable bacteria reduce methane emissions from rice-vegetated soils." *Nature Communications*. April 2020.

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Microscopic animals called tardigrades (one shown) can withstand the freezing cold, desiccation and extreme levels of radiation thanks to unique molecular adaptations.

VIDEOLOGIA/ISTOCK/GETTY IMAGES PLUS

What Makes Tardigrades So Tough?

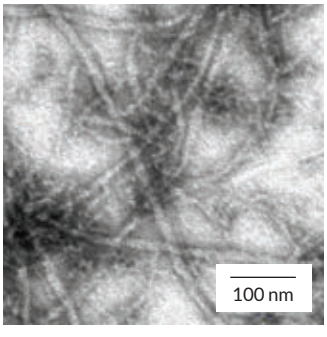
The tiny animals can teach us how to survive outer space and a whole lot more **By Douglas Fox**

No beast on Earth is tougher than the tiny tardigrade. It can survive being frozen at -272° Celsius, being exposed to the vacuum of outer space and even being blasted with 500 times the dose of X-rays that would kill a human.

In other words, the creature can endure conditions that don't even exist on Earth. This otherworldly resilience, combined with their endearing looks, has made tardigrades a favorite of animal lovers. But beyond that, researchers are looking to the microscopic animals, about the size of a dust mite, to learn how to prepare humans and crops to handle the rigors of space travel.

The tardigrade's indestructibility stems from its adaptations to its environment—which may seem surprising, since it lives in seemingly cushy places, like the cool, wet clumps of moss that dot a garden wall. In homage to such habitats, along with a pudgy appearance, some people call tardigrades water bears or, adorably, moss piglets.

But it turns out that a tardigrade's damp, mossy home can dry out many times each year. Drying is pretty catastrophic for most living things. It damages cells in some of the same ways that freezing, vacuum and radiation do.



As a tardigrade dries out, its cells create long, crisscrossing proteins (shown) that cushion and protect the cells' membranes.

For one thing, drying leads to high levels of peroxides and other reactive oxygen species. These toxic molecules chisel a cell's DNA into short fragments—just as radiation does. Drying also causes cell membranes to wrinkle and crack. And it can lead delicate proteins to unfold, rendering them as useless as crumpled paper airplanes. Tardigrades have evolved special strategies for dealing with these kinds of damage.

As a tardigrade dries out, its cells gush out several strange proteins that are unlike anything found in other animals. In water, the proteins are floppy and shapeless. But as water disappears, the proteins self-assemble into long, crisscrossing fibers that fill the cell's interior. Like Styrofoam packing peanuts, the fibers support the cell's membranes and proteins, preventing them from breaking or unfolding.

At least two species of tardigrade also produce another protein found in no other animal on Earth. This protein, dubbed Dsup, short for "damage suppressor," binds to DNA and may physically shield it from reactive forms of oxygen.

Emulating tardigrades could one day help humans colonize outer space. Food crops, yeast and insects could be engineered to produce tardigrade proteins, allowing these organisms to grow more efficiently on spacecraft where levels of radiation are elevated compared with on Earth.

Scientists have already inserted the gene for the Dsup protein into human cells in the lab. Many of those modified cells survived levels of X-rays or peroxide chemicals that kill ordinary cells (*SN: 11/9/19, p. 13*). And when inserted into tobacco plants—an experimental model for food crops—the gene for Dsup seemed to protect the plants from exposure to a DNA-damaging chemical called ethyl methanesulfonate. Plants with the extra gene grew more quickly than those without it. Plants with Dsup also incurred less DNA damage when exposed to ultraviolet radiation.

Tardigrades' "packing peanut" proteins show early signs of being protective for humans. When modified to produce those proteins, human cells became resistant to camptothecin, a cell-killing chemotherapy agent, researchers reported in the March 18 *ACS Synthetic Biology*. The tardigrade proteins did this by inhibiting apoptosis, a cellular self-destruct program that is often triggered by exposure to harmful chemicals or radiation.

So if humans ever succeed in reaching the stars, they may accomplish this feat, in part, by standing on the shoulders of the tiny eight-legged endurance specialists in your backyard. ■

Explore more

- Maho Yagi-Utsumi *et al*. "Desiccation-induced fibrous condensation of CAHS protein from an anhydrobiotic tardigrade." *Scientific Reports*. November 4, 2021.

Douglas Fox is a freelance journalist based in Northern California.

M. YAGI-UTSUMI *ET AL*/*SCIENTIFIC REPORTS* 2021

On May 12, seven members of Full Circle Everest, an all-Black mountaineering team, reached the summit of Mount Everest.

THE NORTH FACE, FULL CIRCLE EVEREST

It's the Climb

Demond Mullins tackles big mountains to help Black people and veterans see the benefits of time in nature

By Melba Newsome

Demond "Dom" Mullins' days as a student at Lehman College in New York were interrupted in 2004 when his National Guard unit was deployed to Baghdad. A year later, he returned home but struggled with depression and rage. Immersing himself in his studies helped him make sense of the world and his experiences. After completing degrees in Africana studies and political science, Mullins earned a Ph.D. in sociology, focusing his research on a subject he knew firsthand: how returning veterans reintegrate into society.

In 2015, the avid climber and adventure sportsman joined six other veterans and a journalist on a monthlong excursion to climb Alaska's Denali, the highest peak in North America. To understand the health benefits of high-risk outdoor adventuring outside the clinical therapy framework, Mullins interviewed each participant and collected data about group cohesion and the impact of such high-risk activities on social bonds for his study "Veterans Expeditions: Tapping the great outdoors."

Formerly an adjunct assistant professor at the Cooper Union for the Advancement of Science and Art in New York City, Mullins has climbed Kilimanjaro and Mount Kenya. In May, he tackled his biggest climbing challenge yet: summiting Mount Everest, the world's tallest mountain. He and seven other members of Full Circle Everest, an all-Black mountaineering team, set out to make history. Seven of them reached the summit, coming very close to doubling the number of Black people who have achieved that feat.

Science News asked Mullins, while he was preparing for the climb, about his research and why he wants more Black people in outdoor spaces. This interview was edited for clarity and length.

When you returned home from Iraq, you cut yourself off from others and contemplated ending your life. What helped you get through the worst times?

Education. I was grappling with the discontents of coming home and struggling with what I had experienced in the Iraq War. Education allowed me to explore aspects of my experience intellectually through things that really engaged me—history and social theory.

Did the war change what you envisioned for yourself academically?

It influenced my trajectory. Graduate school was not even on my radar before. When I came home, I had this great urgency to improve my future, learn more about global politics and understand how history could produce such a moment. I also wanted to know how all of that might influence veterans' reintegration.

How did the Denali research expedition follow on your work on veteran reintegration?

I became an avid mountaineer, rock and ice climber and began training with Veterans Expeditions [a nonprofit that works to enhance the life of U.S. veterans]. By the time the Denali expedition came about in May 2015, the cofounder [Nick Watson] asked me to be a part of it. I wanted to tell the story of veterans summiting Denali in a way that makes sense, was scientifically rigorous and could contribute to the research. I wanted to answer certain questions about how interventions like hiking and climbing might come into play. Ethnography [the study of people in their environment] was the best way to do that.

In 2004, Demond Mullins deployed to Iraq with the National Guard (left). As a sociologist, Mullins has studied how veterans reintegrate into civilian life, including through outdoor activities like mountain climbing (right).

BOTH: COURTESY OF D. MULLINS

The Full Circle Everest mountaineers, including, from left, Demond Mullins, Eddie Taylor, Fred Campbell, Manoah Ainuu, Rosemary Saal, Thomas Moore, James "KG" Kagambi and Abby Dione, hope that their expedition inspires the next generation of Black outdoor enthusiasts.

What did you learn about veterans and outdoor adventuring?

Much more than in the past, my generation of veterans is more willing to talk about their experiences with each other to find affinity and solidarity. After leaving the service, some lose their identity, partly because there is no space reserved for them to perform the identities they have cultivated through military training, socialization and performance. I learned that they engage in these kinds of high-risk sporting events to support their identities. The outdoors is sort of a theater to perform the heroic identities they've developed in a way that can be conducive to greater physical and communal health. One veteran said to me, "The rock and the ice don't lie to me." He was reasserting that he is a warrior.

How did you become a part of Full Circle Everest?

Through Veterans Expeditions, I developed a relationship with [world-famous mountaineer] Conrad Anker. Conrad had this idea about putting together an all-Black expedition to Everest. He introduced me to [Full Circle expedition leader and organizer] Philip Henderson, who had been considering this for a long time. I met Phil and knew right away that I wanted to be a part of that expedition and help find other athletes.

What, if anything, about your experience on Denali do you believe will benefit your attempt to summit Mount Everest?

Everest is 9,000 feet taller than Denali. It's a longer pursuit and a longer expedition, but the conditions will be similar. We got snowed in on Denali for 17 days, which I believe has prepared me for my expedition with Full Circle.

This pursuit is about developing relationships with people who have common experiences. It's having someone who gets your drift, who understands what you mean without you needing to explain everything. It's about building community and feeling like you belong. People want to feel like the group is better as a result of their participation. It's all about social cohesion.

Will you be conducting research on this expedition?

This time, I'll be studying myself—doing an autoethnography. I took time off from work to do this climb, so I don't have any pressing job to get back to. I plan to take some time to reflect and write about this once it's over, to help people understand the value of it for me.

The Full Circle team spent a few weeks together in January at the Khumbu Climbing Center in Nepal. Your teammates went home, then came back in April to start the climb, but you stayed in Nepal. Why?

It gives me an edge in so many different ways: having time for my body to properly acclimate to the elevation, understanding how to keep myself safe and comfortable in the elements. Also developing relationships with the locals, the Sherpas and the other Nepalese persons who are supporting the expedition.

What do you want people to take away from your Full Circle Everest expedition?

Diversity in the outdoors matters. The military completely introduced me to outdoor sports. When I was a kid, I never went camping or even hiking. I thought [Brooklyn's] Prospect Park was the wilderness. These activities have benefits for all people. Hopefully, Full Circle will help African Americans of all ages get outside to hike, camp and explore. ■

Explore more

- Full Circle Everest Expedition: fullcircleeverest.com
- Demond Mullins. "Veterans Expeditions: Tapping the great outdoors." In *The Civilian Lives of U.S. Veterans*. Louis Hicks, Eugenia L. Weiss and Jose E. Coll (eds.), Praeger, 2016.

Melba Newsome is a freelance writer based in Charlotte, N.C.

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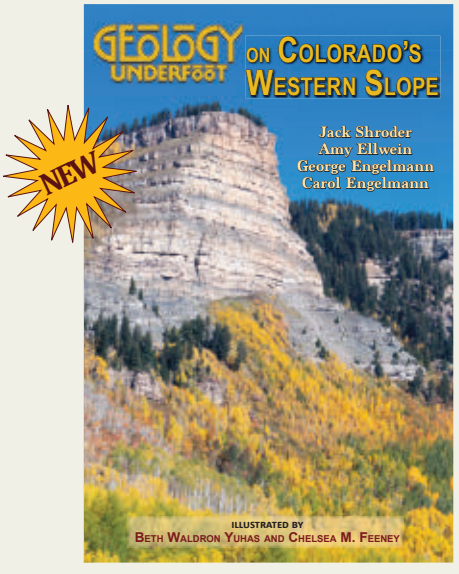

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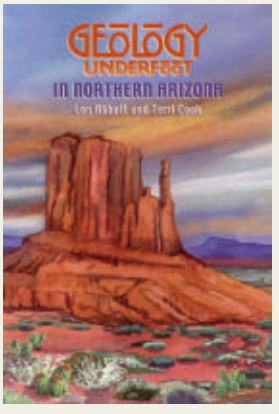

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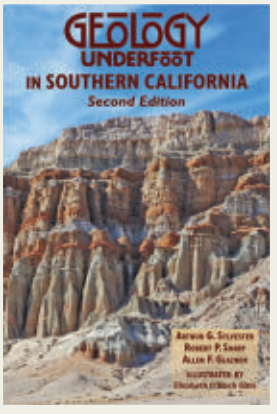

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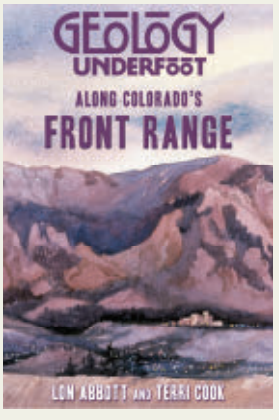

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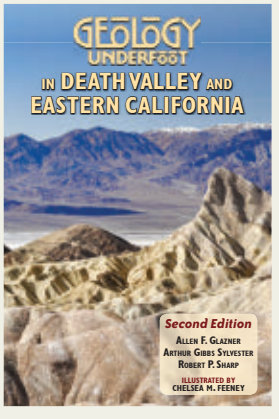

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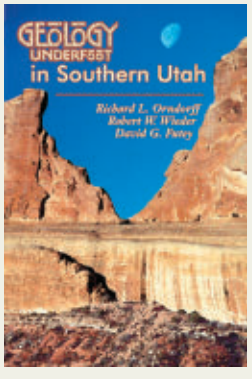

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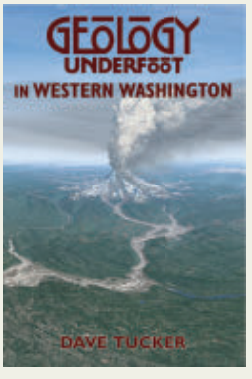

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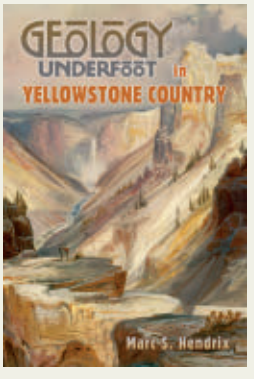

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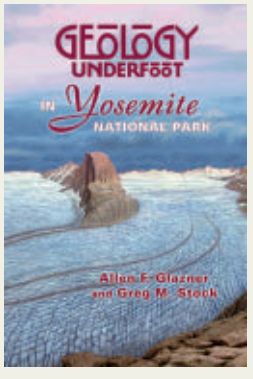

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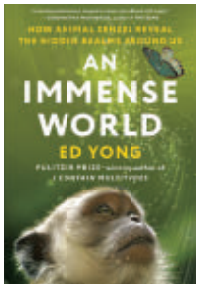
BOOKSHELF

Explore the hidden world of animal senses

This scallop has blue eyes that help it to see, but its vision is very different from how humans see the world.



An Immense World
Ed Yong
RANDOM HOUSE, $30

Emerald jewel wasps know what cockroach brains feel like.

This comes in handy when a female wasp needs to turn a cockroach into an obedient zombie that will host her larvae and serve as dinner. First, the wasp plunges its stinger into the cockroach's midsection to briefly paralyze the legs. Next comes a more delicate operation: stinging the head to deliver a dose of venom to specific nerve cells in the brain, which gives the wasp control over where its victim goes. But how does a wasp know when it's reached the brain? The stinger's tip is a sensory probe. In experiments using brainless cockroaches, a wasp will sting the head over and over again, searching fruitlessly for its desired target.

A brain-feeling stinger is just one example of the myriad ways animals sense the world around them. We humans tend to think the world is as we perceive it. But for everything that we can see, smell, taste, hear or touch, there's so much more that we're oblivious to.

In *An Immense World*, science journalist Ed Yong introduces that hidden world and the concept of *Umwelt*, a German word that refers to the parts of the environment an animal senses and experiences. Every creature has its own *Umwelt*. In a room filled with different types of organisms, or even multiple people, each individual would experience that shared atmosphere in wholly different ways.

Yong eases readers into the truly immense world of senses by starting with ones that we are intimately familiar with. In some cases, he tests the limits of his own abilities. Dog noses, for instance, are better than human noses at sniffing out a scent long after the source is gone, as Yong demonstrates. While crawling around on his hands and knees with his eyes closed, he was able to track a chocolate-scented string that a researcher had put on the ground. But he lost the scent when the string was removed. That wouldn't happen to a dog. It would pick up the trace, string or no string.

In exploring the vast sensory world, it helps to have a good imagination, as even familiar senses can seem quite strange. Scallops, for instance, have eyes and somehow "see" despite having a crude brain that can't process the images. Crickets have hairs that are so responsive to an approaching spider that trying to make the hairs more sensitive might break the rules of physics. A blind Ecuadorian catfish senses raging water with durable teeth that cover its skin. The animal uses the dentures to find calmer waters.

Going through these imagination warm-up exercises makes it somewhat easier to ponder what it might be like to be an echolocating bat, a bird that detects magnetic fields or a fish that communicates using electricity. Yong's vivid descriptions also help readers fathom these senses: "A river full of electric fish must be like a cocktail party where no one *ever* shuts up, even when their mouths are full." In a forest, foliage may seem largely silent, but some insects "talk" through plant stems using vibration. With headphones hooked up to plants so that scientists can listen in, "chirping cicadas sound like cows and katydids sound like revving chainsaws."

For all the book's wonder, the last chapter brings readers crashing back to today's reality. Humans are polluting animals' *Umwelten*; we're forcing animals to exist in environments contaminated with human-made stimuli. And the consequences can be deadly, Yong warns. Adding artificial light in the darkness of night is killing birds and insects (*SN Online*: 8/31/21). Making environments louder is masking the sounds of predators and forcing prey to spend more time keeping an eye out than eating (*SN*: 6/10/17, *p.* 14). "We are closer than ever to understanding what it is like to be another animal," Yong writes, "but we have made it harder than ever for other animals to be."

Since each of us has our own *Umwelt*, fully understanding the foreign worlds of animals is close to impossible, Yong writes. How do we know, for instance, which animals feel pain? Researchers can dissect the signals or stimuli an animal might receive. But what that creature experiences often remains a mystery. —*Erin Garcia de Jesús*

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BOOKSHELF

A microbiologist ponders our relationship with viruses

Virology
Joseph Osmundson
W.W. NORTON & CO., $16.95

As a journalist covering COVID-19, I've had a front-row seat to the pandemic. I've been overwhelmed with despair over the death and suffering. I've been numb, trying to keep up with the deluge of COVID-19 studies. One balm has been the understanding of colleagues who also report on COVID-19.

I found solace too in *Virology*, microbiologist Joseph Osmundson's book of 11 wide-ranging essays, in which he writes of the pandemic and calls for "a new rhetoric of care." Osmundson includes journal entries from the pandemic, and some of his experiences are similar to mine. He dreams he's at a gathering where no one is masked. He too felt the "density" of the pandemic: "Emotionally dense, with loss and struggle and even sometimes joy," he writes. "Scientifically dense, with papers and pre-prints out every day that need reading and some analysis."

Osmundson doesn't just focus on the coronavirus. He jumps from other viruses and the immune system to illness and metaphors for illness, to sex and HIV, to archiving history and whose stories get told. Parts of the book feel like an anthology, with quotes from many writers who have weighed in on these topics. Parts are a call to care for everyone, regardless of race, ethnicity, wealth or who one loves.

Overall, Osmundson questions how society thinks about viruses. "Viruses…are not evil, they don't invade. They just are," he writes. "The meaning we give a virus affects how we live with it." When we describe viruses as enemies and illness as a war, it "assumes the necessity of casualties." He argues instead to focus resources on caring for one another.

Born in the early 1980s, Osmundson, a gay man, is acutely aware of the messages that come with viruses. "Our generation of gay men came after the plague," he writes. "HIV didn't just kill bodies. It killed a type of sex as well, a type of pleasure." But new therapies have saved lives and altered perceptions. Pre-exposure prophylaxis can prevent infection, while treatment can render HIV untransmissible. These advances changed our relationship with the virus, Osmundson writes. "I used to think that HIV would make it harder to find love and sex. Now we know that HIV-positive and undetectable is safe. It's sexy."

But the biomedicine that can change our relationship with viruses has not been wielded equitably, Osmundson observes. He returns throughout the book to our common humanity. "That fact of all our bodies, vulnerable together, necessitates mutual care." —*Aimee Cunningham*

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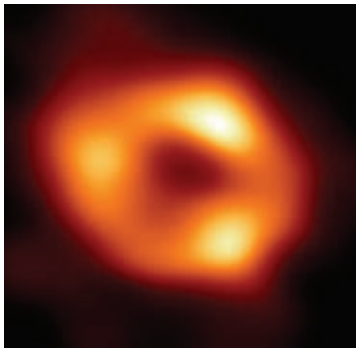
JUNE 4, 2022

Behold the beast

The world finally has an image of the supermassive black hole at the heart of the Milky Way (shown below). One reader wondered about the orientation of the image (see "Black hole views," right).



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Tweaking targets?

Now that a CRISPR-based gene drive to eliminate malaria-carrying mosquitoes has passed a big test, researchers are getting input from people in Africa, where the disease hits hard, about whether to release the technology, ***Tina Hesman Saey*** *reported in "A weapon against mosquitoes"* (SN: 6/4/22, p. 20).

Reader **Roger Floyd** asked whether gene drives could be used to target malaria parasites directly, instead of the mosquitoes carrying them.

Theoretically, scientists could design a gene drive targeting the parasite, **Saey** says. "But the organisms have enormously complicated life cycles, and it's not clear how the gene drive would work or how it would be introduced into the parasite population. It is far easier to design the gene drive against the mosquitoes that spread those parasites."

Black hole views

A global network of radio telescopes has assembled the first image of Sagittarius A, or Sgr A*, the supermassive black hole at the center of our galaxy,* ***Liz Kruesi*** *and* ***Emily Conover*** *reported in "Milky Way's beast comes into view"* (SN: 6/4/22, p. 6).

Reader **John Dohrmann** wondered why the image (shown, left) presents Sgr A* from a seemingly top-down angle.

The Sgr A* image is oriented almost straight on from Earth's viewpoint in the Milky Way's plane, says **Jason Dexter**, an astrophysicist at the University of Colorado Boulder. We get this top-down view because the swirling disk of gas and dust (we see the innermost edge of the disk as the orange ring in the image) around the black hole is not in the same orientation as the galactic plane. Such random orientations are unsurprising for black holes at the heart of galaxies, where complicated motions can influence orientation, **Dexter** says.

What's more, material that is moving toward Earth will appear brighter in the image than the material that is moving away, he says. Due to a combination of physics effects at a supermassive black hole's extreme boundary, "we expect [to] get this kind of crescent shape, or asymmetric ring-type shape," he says. "The amount of asymmetry you expect is related to how you're looking at it."

Listen to your mother

Teen brains pay attention to a stranger's voice more than mom's, a sign of shifting focus from family to wider networks during adolescence, ***Laura Sanders*** *reported in "Mom's voice loses its grip for teens"* (SN: 6/4/22, p. 14).

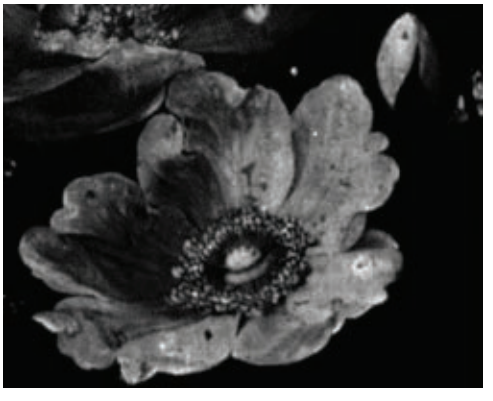
Reader **Renée Lux** wondered if adult children's brains refocus attention on aging parents' voices. "Now in my 50s, with parents in their late 70s and 80s, I'm aware of our dwindling time together," **Lux** wrote. "There seems to be a renewed need to know that I am meeting their needs (physically and emotionally) and to know that I have made them proud. Would this trigger the same part of my brain involved in … attention and rewards?"

This is a very interesting question, says neuroscientist **Eric Nelson** of the Center for Biobehavioral Health at Nationwide Children's Hospital in Columbus, Ohio. A number of studies have found that teens' emotional responding and attention shift away from parents toward peers during adolescence. Similar findings reported in other animals around the time of puberty suggest that this may be a biologically regulated process, he says. There is some evidence that the push toward peers relaxes in later teenage years and early adulthood, **Nelson** says. "I would expect [that] some level of reorienting toward parents would occur as teenagers become adults." But there doesn't seem to be specific research on this, he says.

A more interesting concept suggested by **Lux's** question, **Nelson** says, "is whether there is a specific shift in motivational systems back toward parents as adult children become caretakers of their dependent parents."

Correction

"The story of mammals is a tale of innovation" (SN: 6/18/22, p. 28) mistakenly stated that the hammer and anvil are bones in the inner ear. Both are in the middle ear.



Seeing the change in a painting's chemistry

The fading of a once-vibrant yellow rose reveals how the ravages of time and the accompanying chemical alteration can dampen the visual power of a painting.

Most of the flowers in Abraham Mignon's 17th century *Still Life with Flowers and a Watch* (left) seem to leap off the canvas. But one rose (close-up at bottom left), painted yellow with arsenic sulfide–based orpiment pigment, is a flat, jarring element. That wasn't Mignon's intention: The rose lost its luster because some of its original bright pigment chemically transformed into colorless lead arsenates, researchers report June 8 in *Science Advances*.

Paintings conservator Nouchka De Keyser of the Rijksmuseum in Amsterdam and colleagues analyzed the rose using noninvasive techniques including X-ray fluorescence imaging (SN: 11/6/21, p. 5). One X-ray image (bottom right) shows where arsenic remains (whiter regions have more of the element). This image along with those of other chemical elements reveal how Mignon carefully layered paint to create a seemingly 3-D rose out of light and shadow.

Analyses of the rose also uncovered layers of two crystals that formed from chemical reactions long after the painting was completed: mimetite and schultenite. First, orpiment reacted with light and created mobile forms of arsenic, including arsenolite. Those forms then found their way to an underlying layer of lead white paint and chemically reacted with it to produce the mimetite and schultenite. The newer crystals lack the bright color of the orpiment. Instead, they are colorless and flatten the flower's appearance.

Science can't turn back the clock on the transformation to restore the rose's erstwhile glory—that's a one-way street. But digital reconstructions made with similar techniques to those in the new study could offer several benefits, and not just to scientists and art historians, De Keyser says. Not only can such reconstructions reveal now-faded elements in other paintings, the re-creations could also be shown in museums, allowing visitors a ghostly glimpse of a painting's true past. —*Carolyn Gramling*

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