The Largest Known Genome | The Quirks That Make Ice Slick

Science News

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Does Social Status Shape Height?

Growing tall may depend on more than just genetics and nutrition

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Science News

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COVER In addition to genetics and nutrition, social factors may play a role in human height. *Phil Wrigglesworth*

FROM TOP: SO-PHOTOGRAPHY/ALAMY STOCK PHOTO; A. MINETTI LAB; ZAC MILLS PHOTOGRAPHY

AI is coming to medicine, but it's got a lot to learn

When you're a journalist, potential sources are everywhere, even at a medical appointment. When I had my annual mammogram in May, radiologist Pouneh Razavi said all looked well. Then she said: "And we used AI!"

We here at *Science News* had been talking about medical uses of AI, so I had to find out what was up. It turns out that Sibley Memorial Hospital in Washington, D.C., which is part of Johns Hopkins Medicine, had started using artificial intelligence to help read mammograms just two months before. Razavi, who is director of breast imaging in the National Capital Region, Johns Hopkins, told me that my scan and others would be used to train algorithms, with the goal of giving more information to physicians and making diagnoses more accurate. I had done my bit for science while wearing a cotton robe.

My experience will almost certainly become increasingly common. Artificial intelligence is already in use in medical care, and many of those efforts focus on medical imaging (SN: 12/17/22 & 12/31/22, p. 32). Razavi isn't the only medical professional excited about the possibilities; when *Science News* senior writer Meghan Rosen attended a conference on AI and medicine in New York last month, she found that at least half of the presentations were about medical imaging.

"There was an attitude of excitement and hopefulness," Rosen told me. "It really interested me that one field is leaping ahead, and I wanted to know why."

Rosen learned that radiologists have to perform detailed analyses of large numbers of scans, day after day after day. Although radiologists' daily error rates are fairly low — Rosen says it averages 3 to 5 percent — errors can creep in when the doctors are overworked. AI could help by learning to recognize signs of disease, alerting the physician and helping them prioritize the most serious cases.

After the conference, Rosen talked with Razavi, the radiologist who told me about my AI-assisted mammogram (Page 14). I had told Rosen about my experience because I thought it was pretty darn cool, and because I thought the doctor might be willing to talk with Rosen about her work experimenting with a new technology in the clinic.

There's more than enough hype about the potential for AI to change the world, and more than enough reason for skepticism. Rosen says the same physicians and researchers who are excited about the possibilities of AI to improve medical imaging are also cautious; these are early days. "It was hopeful to see that this was not being hyped," she says. "Scientists were talking about how difficult it is to get it working well in the real world."

AI will not become a tool that reveals every detail about a person's health in a scan; that's going to remain in the realm of science fiction for the foreseeable future. But I too am optimistic that the technology can make complex tasks like reading mammograms more accurate, and free up more of doctors' precious time. It's not a magic wand, but a tool that may help physicians better serve their patients. — *Nancy Shute, Editor in Chief*

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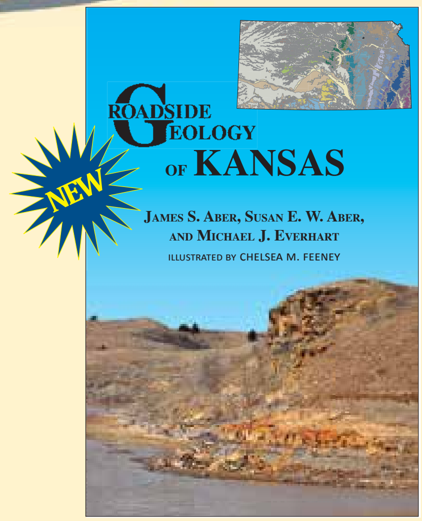

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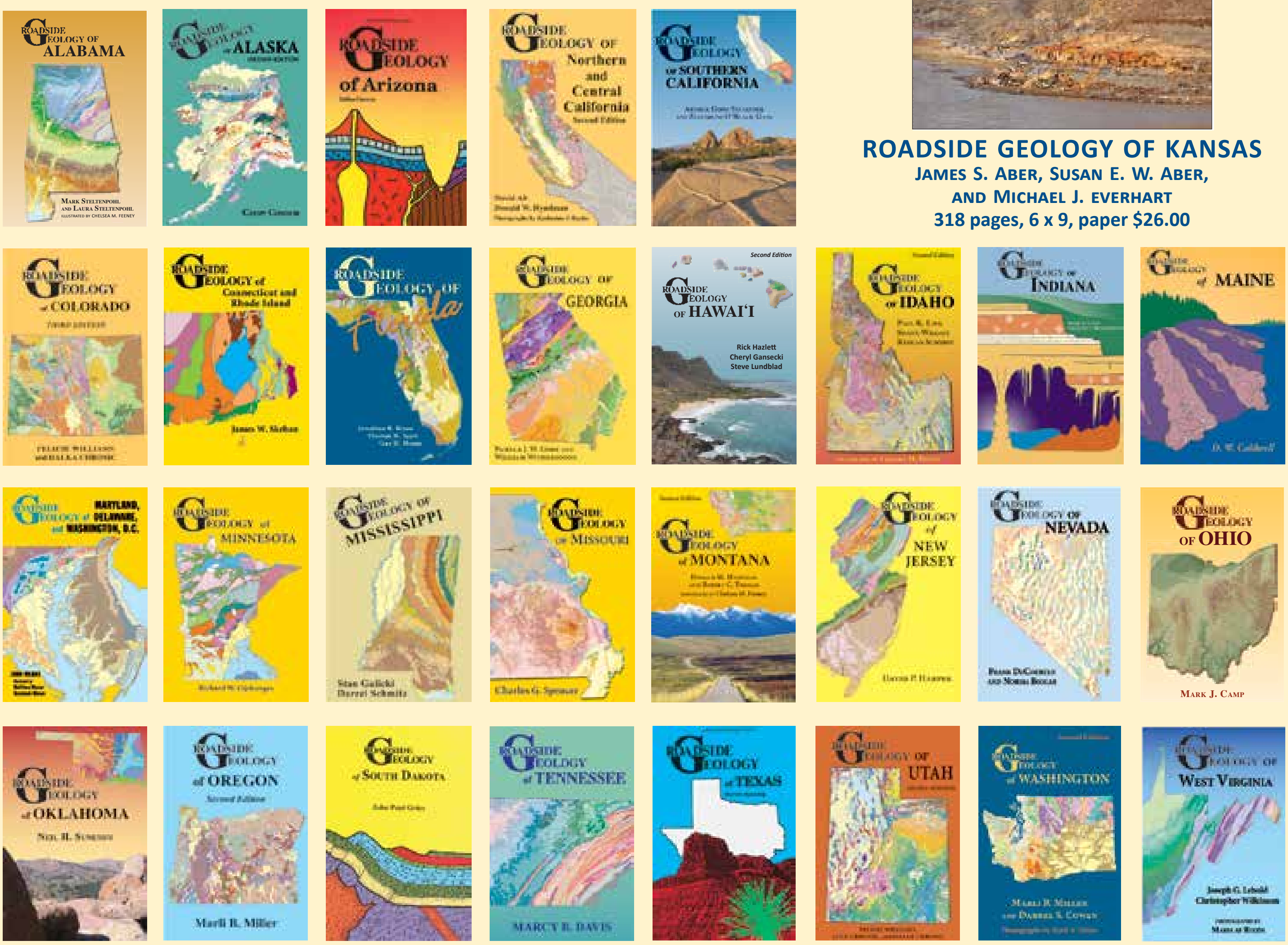

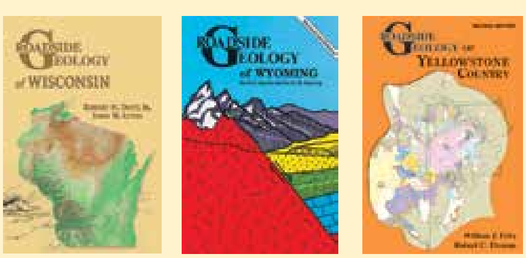

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Excerpt from the June 29, 1974 issue of *Science News*

50 YEARS AGO

Sweet discovery for wine industry

Pierce's disease remains a problem for California grape growers.... [Pathologists] have identified the cause of the disease. They were able to isolate a small, non-motile, rod-shaped bacterium which is probably a new species and therefore as yet unnamed.

UPDATE: Pierce's disease still vexes California vineyards and is estimated to cost the state more than $100 million per year. But researchers now know more about the culprit: *Xylella fastidiosa*.

The bacterium spreads among grapevines via insects, specifically sharpshooter leafhoppers and spittlebugs. When the insects suck sap from an infected plant, they pick up the microbe, which harmlessly multiplies in their mouths. Leafhoppers and spittlebugs then transmit the pathogen to vines when they latch onto a healthy plant. The subsequent infection prevents water and nutrients from flowing into the plant, eventually killing it.

There's still no treatment for Pierce's disease. Perhaps one day it will be possible to genetically engineer domesticated grapevines to be resistant to the bacteria.

Physiologist Gaspare Pavei generates enough centrifugal force to run on a vertical wooden wall. The technique could help future moon dwellers maintain bone and muscle mass.

THE SCIENCE LIFE

How to run on the moon

It was a dreary, drizzly June day near Parma, Italy, when two scientists first took on the Wall of Death.

An amusement park attraction, the wall looks something like a giant wooden barrel with the top sawed off. Daredevils on motorcycles zip around the inside, driving along the circular wall in a feat that seems to defy gravity.

But exercise physiologists Gaspare Pavei and Valentina Natalucci weren't doing motorcycle stunts—they were testing out a technique to run on the moon.

If their calculations are correct, future moon dwellers running fast enough inside a cylinder would be able to stay on the wall, rather than float to the ground, says physiologist Alberto Minetti of the University of Milan. That suggests the technique could offer future lunar inhabitants a new means of Earthlike exercise, some 384,000 kilometers from our home planet.

THE –EST

The largest known genome belongs to a tiny fern

Big things can sometimes come in small packages. A 15-centimeter-long fork fern has broken the record for the largest known genome, researchers report May 31 in *iScience*. The plant's genetic instruction manual is made up of about 160 billion pairs of DNA building blocks, or bases. That's 10 billion more base pairs than the genome of the previous record holder, the flower *Paris japonica*, and 50 times as large as the human genome.

Evolutionary biologist Jaume Pellicer of the Botanical Institute of Barcelona and colleagues examined six *Tmesipteris* fern species from New Caledonia in the South Pacific. The scientists isolated fern cells and stained nuclear DNA with a fluorescent dye. Comparing how much the DNA glowed let the team calculate each species's genome size. *T. oblanceolata* stood out from the other ferns and all other organisms with known genome sizes. Maintaining all that genetic material can get complicated. The fern has to replicate over 100 meters of DNA every time a cell divides, Pellicer says. Studying the genome in detail could reveal how it grew so large. *—Jake Buehler*

The fork fern *Tmesipteris oblanceolata* has 160 billion pairs of DNA building blocks in its genome, making the genetic instruction manual the largest known.

FROM TOP: A. MINETTI LAB; ORIANE HIDALGO

Watch a scientist run on the Wall of Death at **bit.ly/SN_MoonRun**

Because the moon has only about a sixth of Earth's gravity, there's a world of difference between exercising there and here. Lower gravity means the human body doesn't experience the same physical stresses it does on Earth. Pounding the pavement during a run or doing pushups at Earth gravity, or 1 g, builds muscle and strengthens bone. But on the moon or in space, muscles atrophy and bones become brittle (*SN: 8/13/22, p. 4*). Scientists are looking for ways to counteract these detrimental effects.

Running horizontally along a cylinder's curved wall generates centrifugal force, the same thing that holds water at the bottom of a bucket when whirled overhead. Enough force would keep moon runners — and scientists emulating lunar gravity in Italy — on the wall and let them experience artificial gravity that's close to Earth's.

So on that gray day last June, Minetti's lab members Pavei and Natalucci donned harnesses and took a giant leap for science. Each harness was attached to a bungee cord suspended from a crane. That effectively reduced Pavei's and Natalucci's weight, mimicking moon gravity. Then, they had to figure out how to shift from standing vertically on the ground to running horizontally along the cylinder's walls.

> "I knew that physics and mathematics predicted this, but it's different … when you see it in reality."
>
> **ALBERTO MINETTI**

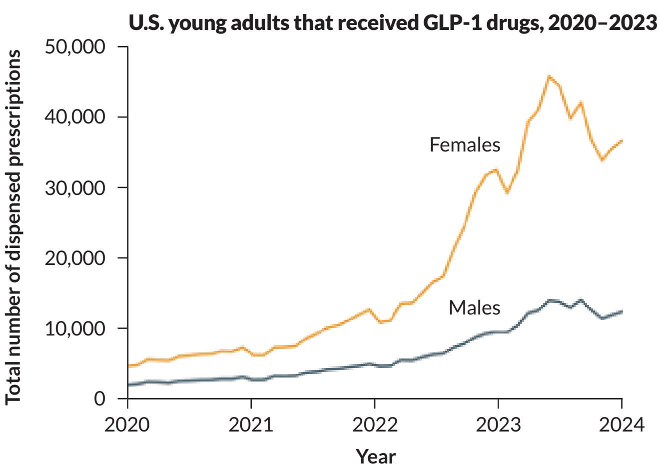
Pavei was up first. He sprinted straight at the wall like a kid trying parkour and skidded to the ground. After a few failed attempts, Pavei took a cue from Wall of Death motorcyclists. He approached the wall at an angle, running counterclockwise up a ramp at the cylinder's base. Suddenly, he was cruising, shoes slapping the walls, body almost parallel to the ground.

"Wow!" Minetti remembers screaming in excitement. "I knew that physics and mathematics predicted this," he says, "but it's different … when you see it in reality."

Analyzing distance traveled, how long runners' feet were in contact with the wall and how long they were airborne revealed that Pavei and Natalucci generated about three-quarters of a g during sprints, the team reports in the May *Royal Society Open Science*. The finding suggests that running eight to nine laps daily on the moon would be enough to prevent bone loss, even with breaks every few laps.

Minetti points out a minor issue for would-be moon runners: They need to race fast, about 5 to 6 meters per second. But astronauts could achieve this speed in short bursts, Pavei says. It's about half as fast as the world record for the 100-meter dash, set by Olympian Usain Bolt.

Running faster would generate more artificial gravity and have a greater impact on the body. If Bolt were to sprint around the wall at top speed, he'd likely surpass 1 g, Pavei says. "I would be very happy to test him." — *Meghan Rosen*



J.M. LEE *ET AL*/*JAMA* 2024, B. PRICE

SCIENCE STATS

More and more young people are being prescribed weight loss drugs

From 2020 through 2023, the number of young people in the United States who got Ozempic and other GLP-1 drugs rose nearly 600 percent, from 8,700 people to over 60,000, scientists report May 22 in *JAMA*. Among those ages 18 to 25, almost three times as many females got the drugs as males (see graph). That may reflect societal bias around weight, says pediatrician Joyce Lee of the University of Michigan in Ann Arbor. — *Meghan Rosen*

SAY WHAT?

Tauonium \tao-oh-nee-um\ n.

A theoretical atom composed of a tau lepton and its antiparticle

Scientists are proposing a hunt for a new variety of atom that lacks a nucleus and electrons. Tauonium would consist of a negatively charged tau lepton and its positively charged antimatter counterpart, an antitau.

A relative of the electron, the tau lepton has about 3,500 times an electron's mass, making it heavier than a proton. In the 1950s, scientists discovered an atom called positronium, consisting of an electron and its positively charged antiparticle, a positron. Tauonium, if discovered, would be a burlier atom.

Physicist Jing-Hang Fu of Beihang University in Beijing and colleagues propose searching for tauonium by smashing electrons and positrons together at a future particle collider designed to produce tau leptons, which has been proposed in China and Russia. Such a facility could find tauonium within a year of starting up, the researchers report in the May 30 *Science Bulletin*. With the complexity of the atomic nucleus out of the picture, studies of tauonium could scrutinize the physics theory that describes electrically charged particles (*SN: 2/24/24, p. 8*). — *Emily Conover*

News

EARTH

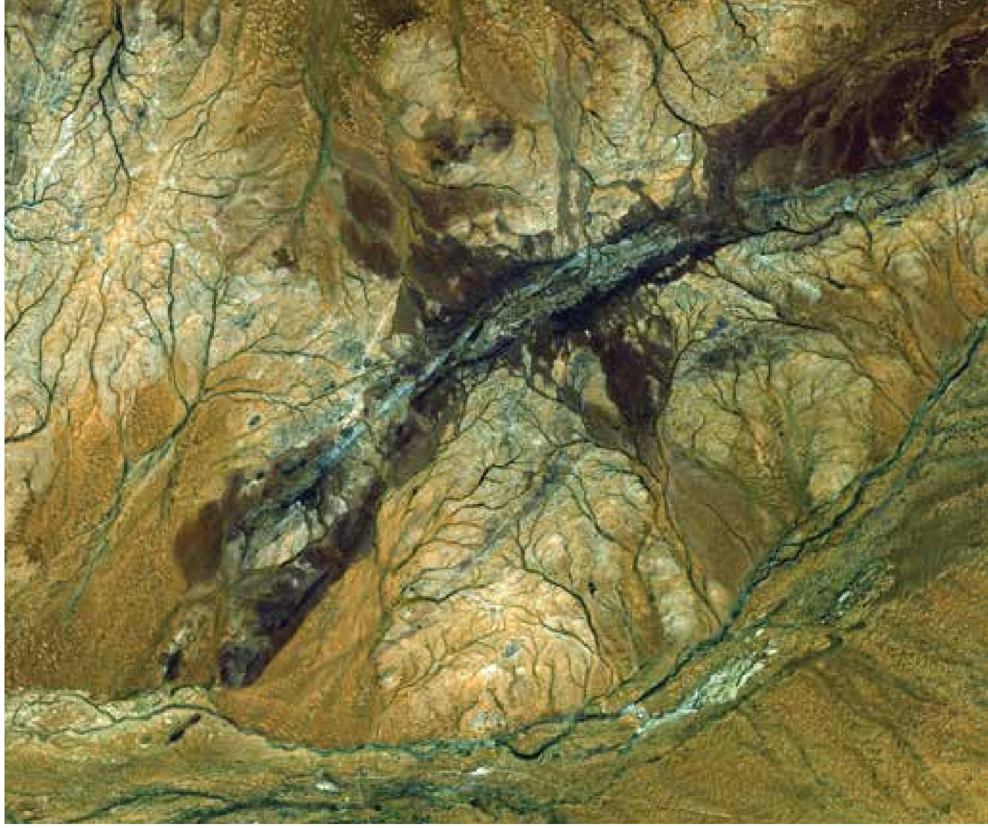
When did Earth's water cycle arise?

Freshwater may have appeared on the planet 4 billion years ago

BY CAROLYN GRAMLING

Earth may have had fresh, not just salty, water less than 600 million years after the planet formed — a mere blink of an eye in geologic time.

Researchers analyzed oxygen molecules within 4-billion-year-old zircon crystals from Western Australia's Jack Hills, one of the oldest rock formations on Earth. The relative proportions of oxygen's heaviest and lightest forms, or isotopes, in the zircons are possible only if there had been a significant amount of freshwater present, geochemist Hamed Gamaleldien of Khalifa University in Abu Dhabi, United Arab Emirates, and colleagues report June 3 in *Nature Geoscience*.



An analysis of zircon crystals from the Jack Hills formation (aerial image, shown) in Australia suggests freshwater cycled on Earth hundreds of millions of years earlier than previously thought.

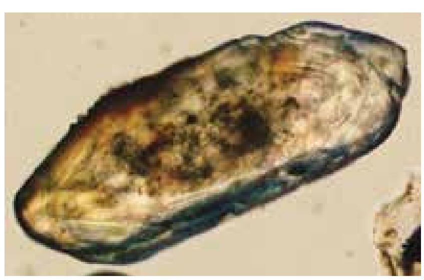
The finding suggests that freshwater may have been actively cycling on Earth hundreds of millions of years earlier than previously thought. Past studies have found evidence that a robust water cycle, one that involved rain and evaporation from the land back to the atmosphere and then rain again, existed by at least 3.2 billion years ago.

The presence of freshwater has implications for Earth's habitability 4 billion years ago. It doesn't necessarily mean life was present, Gamaleldien says, "but at least we have the main ingredient to form life." Currently, the oldest agreed-upon evidence for life on Earth comes from fossilized microbial mats in Australia's Strelley Pool Chert that date to 3.4 billion years ago.

Cycles of evaporation and rain alter the chemical makeup of water molecules. When water evaporates from the ocean's surface, leaving the salt behind, the lighter form of oxygen, oxygen-16, tends to evaporate faster than the heavier oxygen-18. That lighter water may then rain out over land, and perhaps evaporate again. Over time, the freshwater becomes more concentrated in oxygen-16 compared with the original seawater.

When that rainwater percolates through the ground, it can chemically react with bedrock or with magma pockets in the rock, imparting lighter isotopic oxygen values — clues that freshwater was present.

The team analyzed oxygen isotopic ratios of over 1,300 zircon crystals ranging in age from 4.2 billion to 3.3 billion years ago. Most of the zircons had relatively heavy oxygen isotopic values, as would be expected from seawater. At around 3.4 billion years ago and 4 billion years ago, the ratios indicated a greater proportion of lighter oxygen.



Zircon crystals like this one hold chemical clues that can shed light on early Earth.

In the 3.4-billion-year-old zircons, the team measured ratios of oxygen-18 to oxygen-16 that were as low as 0.1 per mil — a measurement of the ratio of those isotopes when compared with a standard oxygen isotopic ratio from ocean water. That value is very low compared with the average for rocks at that time, about 5 per mil. The 4-billion-year-old zircons had oxygen isotopic values that were about 2 per mil.

The team ran thousands of computer simulations to determine the likelihood of different explanations for the observed ratios. "We concluded that the main water on Earth was oceanic," Gamaleldien says. "But only when we used freshwater [did] it create the results we see."

Gamaleldien's team presents a convincing case that there was freshwater cycling on Earth 3.4 billion years ago, but the jury is still out on whether that was the case 4 billion years ago, says geochemist Jesse Reimink of Penn State. "The early Earth is really difficult [to study] because there are so few data points," Reimink says. Ancient crystals like these remain the only clues scientists have to Earth's earliest time, he adds. "We need to keep pushing the limits of these zircon grains." ■

CLIMATE

Stealthy seawater threatens Thwaites

Under-ice incursions could amplify retreat of the Antarctic glacier

BY DOUGLAS FOX

In Antarctica, the warm ocean is attacking a major glacier through a previously unknown route, undermining the glacier's foundation on a daily basis.

As each rising tide lifts the coastal terminus of the southern continent's Thwaites Glacier a tiny bit off the seafloor, warm seawater squeezes in underneath, satellite measurements reveal. This inrush of salty water forces its way many kilometers inland as it melts the ice from beneath. The meltwater and seawater are then flushed back out as the tide falls, researchers report in the May 28 *Proceedings of the National Academy of Sciences*.

That will greatly accelerate the retreat of the ice in some places, says Ted Scambos, a glaciologist at the University of Colorado Boulder who was not involved in the study.

The West Antarctic Ice Sheet, where Thwaites Glacier resides, is a fortress besieged by enemies. This dome of ice larger than Alaska sits in a bowl-shaped ocean basin. The ice sheet's grounding line, where its outer edges rest on the seafloor, is constantly assaulted by warm, dense, salty ocean currents that pour across the seafloor like invading armies.

The thermal assault is especially ferocious along the section of coastline where Thwaites, a rapidly moving corridor of ice 120 kilometers across, empties into the ocean (SN: 3/11/23, *p.* 8). Thwaites is currently hemorrhaging 75 billion metric tons of ice per year — accounting for more than half the ice lost from all of Antarctica annually.

Much of this loss stems from the melting and retreat of the glacier's grounding line. As Thwaites' grounding line recedes, it reduces friction at the glacier's bed. This allows the glacier to slide and dump its ice into the ocean more quickly, contributing to sea level rise, says Eric Rignot, a glaciologist at University of California, Irvine.

For two decades, Rignot had used sporadic satellite radar measurements to monitor Thwaites' grounding line, which is currently retreating roughly half a kilometer per year. But in 2023, he and colleagues used a new set of satellites, called ICEYE, to capture these radar measurements three times a day.

Those more frequent measurements revealed "some big surprises," Rignot says. "We see a dynamic that we've never seen before."

At each high tide, a layer of seawater 10 to 70 centimeters thick pushed under the edge of the ice sheet and migrated six to 12 kilometers inland. The researchers could detect this because the satellite radar showed the top surface of the ice rising and falling as the water moved beneath it. Across the entire mouth of the glacier, that amounts to 200 million cubic meters of seawater rushing in and out each day — about 400 times the volume of the world's largest type of oil tanker.

That seawater is just 3.7 degrees Celsius above the ice's melting point — but it packs a surprising punch. "The glacier ice hates the salt" because it accelerates melting, Rignot says.

His team estimates that during the intrusions, this water injects 150 million kilowatts of thermal power into the ice, similar to the heat output of 10 million kitchen ovens. The researchers estimate that this could be melting 20 meters off the bottom of the ice each year — roughly the height of a five-story building.

Rignot noticed that the seawater intruded in blobby, irregular patterns, rushing far inland in some places but not others. To explain this, he turned to Christine Dow, a glaciologist at the University of Waterloo in Canada who has mapped several subglacial freshwater rivers that flow out from beneath Thwaites Glacier and pour into the ocean.

Dow found that the seawater preferentially migrates under the ice in the broad areas between the rivers, where it can flow across level or downward sloping terrain, and the ice is most easily lifted due to variations in pressure.

This kind of saltwater invasion could potentially double the overall rate of ice loss in some glaciers, recent simulations suggest. The new results might explain why the grounding lines of two nearby glaciers, Pope and Smith, retreated two to four kilometers in a single year.

This tidal intrusion "is a phenomenon we just haven't known to look for," Dow says. "I suspect it's very widespread."

Scambos notes that it will be important to include this new phenomenon in computer simulations that predict future ice loss and sea level rise. "I'm really interested to see how this will affect the retreat rates," he says. ■

JIM YUNGEL/NASA

Daily influxes of warm seawater under Antarctica's Thwaites Glacier, shown here in 2012, could be shaving 20 meters of ice off the bottom each year, scientists estimate.

EARTH

Kilauea erupted like a stomp rocket toy

Mechanism explains the Hawaiian volcano's odd 2018 outburst

BY CAROLYN GRAMLING

A series of explosions from the Hawaiian volcano Kilauea in 2018 may have been triggered by a never-before-seen style of eruption — one that's reminiscent of a stomp rocket.

In May of that year, plumes of hot gas and rock shot up to eight kilometers into the sky as the volcano erupted explosively 12 times in succession. The cause of those unusual blasts was the progressive collapse of Kilauea's summit crater, or caldera, researchers report May 27 in *Nature Geoscience*.

Each time large chunks of crater rock plunged into the magma chamber beneath, the sudden compression of air in the chamber sent volcanic debris shooting skyward, much like the way stepping hard on the air bladder of a stomp rocket sends its foam projectile flying, the team says.

Explosive volcanic eruptions are usually triggered by some combination of two well-known mechanisms, says geophysicist Joshua Crozier of Stanford University. Depressurization of hot magma as it ascends releases bubbles of gas that can expand to burst molten rock out of the caldera. Alternatively, a rising magma plume can flash-heat groundwater in rocks, sending bursts of steam and rock skyward.

But neither of the mechanisms could explain Kilauea's strange sequence of explosive eruptions, geophysical data indicated. The erupted material didn't contain bubbly bits of magma, and the rocks were already far too hot to contain much liquid water that could be superheated, Crozier says. He and others suspected that a series of collapses of the volcano's caldera, which began in mid-May, might have had something to do with it.

Crozier's team analyzed frequency data on infrasound waves that traveled through the ground during the eruption. A pattern emerged: The chamber seemed to enlarge, and then there was an explosion of some sort. The corresponding seismic data showed a series of distinct earthquakes, each less than magnitude 5.

The team suspects that the magma chamber drained enough to make the caldera roof over it unstable, causing that rock to drop downward under its own weight. That decreased the reservoir's volume. Plumes emerged from the summit about 20 to 30 seconds later, the result of air pressurization from the collapsing roof shooting the hot gas and rock debris in the chamber upward.

"This is the first time to my knowledge that such a mechanism has been suggested to drive eruptions," says volcanologist Larry Mastin of the U.S. Geological Survey's Cascades Volcano Observatory in Vancouver, Wash. "It's a rather unusual mechanism, but the circumstances of this eruption are unusual."

Stomp rocket–style eruptions probably aren't unique to Kilauea, Crozier says. But the volcano's extensive monitoring system made it possible to detect. The findings, he says, could help researchers reduce hazards from less well-monitored volcanoes. ■

A strange series of explosive eruptions at Kilauea in 2018, shown here on May 27, were caused by a newly described stomp rocket–style mechanism.

HAWAIIAN VOLCANO OBSERVATORY/USGS

PLANETARY SCIENCE

Venus spacecraft saw hints of lava

Decades-old data reveal signs of relatively fresh flows

BY ADAM MANN

Present-day volcanism on Venus might be far more pervasive than previously believed.

A new analysis of decades-old data from NASA's Magellan spacecraft finds signs of fresh lava flows occurring on the Venusian surface between 1990 and 1992, scientists report May 27 in *Nature Astronomy*.

"This definitely is another step in the path to understanding Venus as a living, breathing world," says planetary scientist Paul Byrne of Washington University in St. Louis, who was not involved in the work.

Despite being nearly the same size as Earth, Venus was for a long time considered geologically dead. Still, many scientists suspected that Earth's near twin should have comparable levels of internal heat, the main driver of things like volcanoes and quakes.

Last year, researchers announced that they had spotted a volcanic vent changing shape and potentially spilling out lava in Magellan data, the first definitive evidence of recent volcanic activity on Earth's hellish neighbor (*SN: 4/8/23, p. 10*).

The new work follows a similar path, hunting across Venus' surface — three times the area of Earth's dry land — for signs of recent volcanism. On the western slopes of Sif Mons, a large shield volcano, and Niobe Planitia, a flat region studded with volcanic vents, Magellan's radar images showed long sinuous features appearing between two of the spacecraft's passes over the planet.

Planetary scientist Davide Sulcanese of d'Annunzio University in Chieti-Pescara, Italy, and colleagues considered the possibility that the features were artifacts in the radar data or the result of other geologic events like landslides. The features followed the local topography, which suggests they really were spilling across Venus' surface. And they occurred in fairly

Sif Mons, a large shield volcano on Venus, shows signs of relatively recent lava flows (arrow) in archival data from NASA's Magellan spacecraft.

flat areas where landslides wouldn't be expected, the researchers argue.

"They were able to show, I think convincingly, that in these two instances the changes in how the surface looks in radar is best explained by there being lava flows," Byrne says.

The relatively low resolution of Magellan's data and Venus' enormous land area means that it took painstaking effort to uncover these few signs of active volcanism. Byrne suspects there could be more. "If you had an army of people day in and day out looking through the entire surface, there's likely much more to be found," he says.

Both Byrne and the study authors agree that present-day Venus could have as much volcanic activity as Earth. NASA's DAVINCI and VERITAS probes, which are expected to launch in the next decade, will map the Venusian surface in far more detail, potentially making it easier to spot signs of active volcanism. ■

PHYSICS

Physicists get a grip on slippery ice

Molecular arrangements reveal how a slick surface layer forms

BY EMILY CONOVER

The surface of ice is a slippery subject.

For more than 160 years, scientists have been debating the quirks of ice's exterior. Frozen water is coated in a layer of molecules that behave like a liquid. A new experiment visualizes the surface of ice and hints at the origins of its quasi-liquid layer.

Ice's melty coating appears even at temperatures well below freezing, a phenomenon known as premelting. That layer acts as a lubricant, explaining why ice is slippery even under frigid conditions. But ever since the idea of a liquidlike coating was first presented by British scientist Michael Faraday in the 1850s, ice's unusual surface has remained poorly understood.

Now, scientists have used atomic force microscopy to measure the locations of atoms on the surface of ice. At temperatures around –150° Celsius, the surface is made of not just one kind of ice, but two, physicist Ying Jiang of Peking University in Beijing and colleagues report May 22 in *Nature*. What's more, the team found defects in the surface's structure that seem to kick off premelting.

Ice comes in many forms, depending on the arrangement of its molecules. Under normal conditions, water molecules form layers of hexagons stacked on top of one another. This hexagonal ice, called ice Ih, is the variety Jiang's team studied. But the atomic force microscope images revealed that the surface consisted of some regions of ice Ih and other regions of ice Ic, in which the hexagons in each layer are shifted to create a structure similar to the arrangement of carbon atoms in diamond.

"It's very hard to identify where the molecules are, but I think they very successfully get it," says chemist Yuki Nagata of the Max Planck Institute for Polymer Research in Mainz, Germany.

At the borders of ice Ih and ice Ic, the researchers found defects in the material's structure, resulting from the misalignment of the two patterns. When the team cranked up the temperature by a few degrees, those disordered regions expanded. In liquids, atoms and molecules are similarly jumbled, and the same goes for ice's quasi-liquid layer. The expansion of the disorder marks the initial stages of premelting, the team argues.

As the temperature was raised further, structures in those borders amplified the disorder even more. Normally, ice is made up of crinkled layers: Some water molecules in each layer are lower, and some higher. But the team found places where water molecules lined up in a plane, a structure that served as a "seed" of yet more disorder.

At even higher temperatures, the disorder would expand to cover the entire surface of the ice, giving ice its full liquidlike patina, computer simulations suggest.

The experiment was performed at temperatures much lower than ice in everyday experience. But because it must be done in a vacuum, raising the temperature too much would cause water molecules to escape. The team hopes to use short laser pulses to briefly heat the ice to get measurements under balmier conditions. ■

D. SULCANESE/D'ANNUNZIO UNIV.

HEALTH & MEDICINE

How to keep cats safe from bird flu

Pet owners can take steps to avoid the H5N1 virus

BY TINA HESMAN SAEY

A growing number of cats are getting and dying of bird flu, sparking worries about the risk that the ongoing outbreak poses for feline furballs and their humans.

The current U.S. outbreak of highly pathogenic H5N1 virus has been sickening and killing wild birds and poultry since 2021. H5N1 has also jumped into mammals, including farm animals such as goats, dairy cattle and alpacas. When this happens, if the virus gets a random mutation that helps it replicate better in mammalian cells, the bird flu could adapt to spread easily in people.

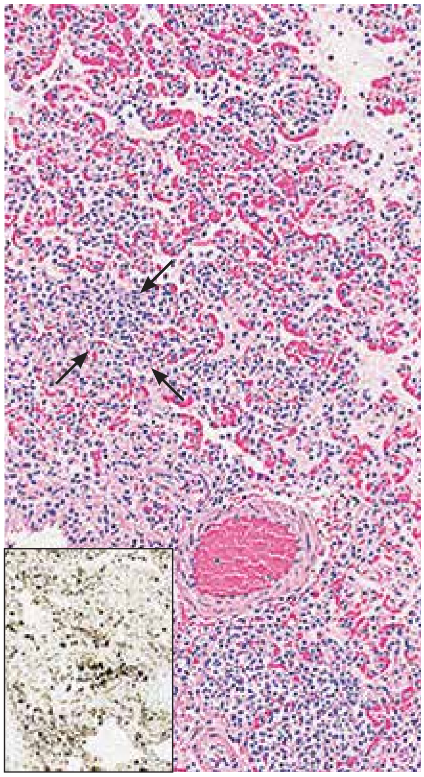
There's no sign yet that the virus has acquired the changes needed for person-to-person transmission, the U.S. Centers for Disease Control and Prevention reported May 24. Out of the handful of people who have been infected in the United States so far, most were in close contact with poultry or cattle. But bird flu showing up in domestic cats might give the virus an easier route to infecting people. After all, most people are more likely to encounter (and cuddle) kitties than chickens or cows.

How cats get bird flu

Outdoor cats may contract the virus after catching an infected bird, whether or not the cats eat the bird, says Meghan Davis, a veterinarian and environmental epidemiologist at the Johns Hopkins Bloomberg School of Public Health.

The food that people feed their cats could also put the animals at risk, Davis says. "Raw meat diets, and specifically raw poultry diets, have been associated with some [outbreaks]."

The U.S. Department of Agriculture has found viral particles in muscle and other tissue from a culled dairy cow, the agency said May 24. None of the meat entered the food supply, but the incident highlights



Bird flu can ravage a cat's vital organs, including the lungs (tissue magnified 200x, arrows point to infection; H5N1, inset, looks dark brown).

that raw beef might contain the virus.

Raw, unpasteurized cow milk has also become an avenue for infection. Raw milk, some of which is labeled for pet use only, could be a way that indoor cats that don't have direct contact with birds could get infected, Davis says. Water or surfaces contaminated with bird droppings also might be potential sources of infection.

Some evidence suggests that cats might pass the virus to each other, Davis says.

Bird flu can be deadly for cats

In 2022 and 2023, at least 13 cats in the United States got bird flu and about half died. Some were farm cats that had contact with infected chickens, but some were domestic cats that somehow got sick. So far in 2024, more than 20 cats have contracted H5N1, most of them on dairy farms, the World Organization for Animal Health reports. At least five have died.

The numbers of infections and deaths are likely higher. For instance, about half of two dozen cats that were fed raw milk from infected cattle on one Texas farm earlier this year died, researchers report in the July *Emerging Infectious Diseases*. Those cases don't appear to be counted by the World Organization for Animal Health.

Symptoms before the Texan cats' deaths included stiff body movements, wobbliness, circling, runny noses and blindness. Researchers examined two of the dead cats and found evidence that the virus had infected their whole bodies. The infection may have killed the cats after reaching the brain. "Unfortunately, it's not great news if we get to that point," Davis says.

The risk to people seems to be low

It's rare but possible for people to catch bird flu from animals, the CDC says, though the exact odds haven't yet been established. Even less clear is whether particularly susceptible people, such as those with weakened immune systems, who live with cats might have a higher risk of getting infected, Davis says.

Public health agencies stress that the risk of getting bird flu is low for people who aren't exposed to infected birds and their droppings or to other infected animals.

Protecting cats (and yourself)

There are no bird flu vaccines available for cats right now. So keeping felines inside is the best form of protection. For cats that go outside, limit their exposure to bird feces, Davis says. "Keep the bird feeders out of the catio."

Pet owners can further limit exposure by cleaning their shoes after walking in places where there are bird droppings, disinfecting surfaces where shoes are stored and keeping shoes away from cats.

If your cat brings home a dead bird, don't touch the bird if you can help it, Davis says. Otherwise, put on a mask, gloves and goggles before disposing of the bird. If you don't have protective gear, a stick and a box will do. Wash your hands after handling the bird. Monitor the cat and notify your vet if it becomes ill. Symptoms tend to appear two to three days after infection.

Finally, don't give cats food that might contain H5N1, especially raw meat or raw milk, Davis says. "Not feeding [these] products to pets is as important as not consuming them yourselves." ■

E.R. BURROUGH *ET AL*/*EMERGING INFECTIOUS DISEASES* 2024

A young Sumatran orangutan reclines in a treetop nest in Indonesia. These apes start learning how to build nests as early as 6 months old, a new study shows.

ANIMALS

Baby orangutans try building nests

The precocious apes start honing their techniques in infancy

ZAC MILLS PHOTOGRAPHY

BY ELIZABETH ANNE BROWN

At six months old, human infants are still working on sitting up by themselves. But baby orangutans at that age are already developing their engineering skills.

Orangutans build complex sleeping platforms as high as 20 meters in the tree canopy — equivalent to about five stories above the ground — every single evening. The intricate nests can include woven elements, pillows, blankets, padding and roofs to protect from rain.

But nest building isn't instinctive to orangutans; it has to be learned through years of (sometimes hilarious) trial and error that starts in infancy, researchers report in the May *Animal Behaviour*. The finding could be important for conserving populations of the critically endangered apes.

Treetops are "a dangerous place to live when you're so big and heavy," says primatologist Andrea Permana of the University of Warwick in England. A poorly made nest can spell disaster.

To see how orangutans become expert canopy architects, Permana and colleagues tracked the development of 27 young Sumatran orangutans (*Pongo abelii*) at the Suaq Balimbing monitoring station in Sumatra, Indonesia, over 13 years. Those observations allowed the researchers to create a detailed timeline of how nest building emerges.

By 6 months old, baby orangutans take an active interest in nest building, even adding leaves and twigs to their mother's nest.

Young orangutans begin by building "day nests" — temporary platforms, often in fruit trees, for lounging while foraging. "Sometime before their first birthday, they've already started to try and bend branches around in a circle to try and make a nest foundation," Permana says.

At this age, they're not always strong enough to get the job done. "They'll hang on [a branch] with their body weight to try and break it, really pulling, trying to bend it," Permana says. "They think they've made a circle and they let go and it just pings open. You can see they're kind of surprised, like 'Oh! It's not as easy as it looks.'"

Ages 3 to 4 are a frenzy of nest-building practice as the young orangutans perfect their day nests and try their hand at night nests. Permana recalls one young male named Fredy who, at about age 3, built and destroyed 21 nests in a single day. (They varied wildly in effort, quality and longevity.)

By about age 5, young orangutans can build a respectable place to spend the night, usually constructing a nest a few meters above their mother's in the same tree. But even if they go to sleep solo, young orangutans always seem to wake up back in mom's nest until they're fully weaned at about 7 or 8 years old, Permana found.

After they've got the nest-building basics down, the comfort features — like roofs and blankets — appear to take still more years of practice to master. The cozy accoutrements show up more frequently in nests made by adults.

This study is "the first real, detailed investigation of the development of nest-building in apes," says primatologist Elizabeth Lonsdorf of Emory University in Atlanta. It also underscores the important work done by forest schools, rehabilitation facilities designed to prepare orphaned orangutans for a life in the wild by teaching them key skills — like nest building.

Forest schools may need to add something a little extra to the curriculum; there's an element of culture to the bedtime routine, Permana says. Each night, orangutans in Suaq that include a pillow in their nest make a special vocalization. But it's not the soulful lullaby you might expect from these gentle giants, she says. "It's like a human blowing a raspberry." ■

Watch a baby orangutan build a nest at **bit.ly/SN_Nesting**

SCIENCE & SOCIETY

Health apps risk women's safety

Despite scrutiny, dodgy data collection and sharing persist

BY PAYAL DHAR

With millions of users globally, the women's health app market is projected to cross $18 billion by 2031. Yet these apps are among the least trustworthy. They collect data about users' menstrual cycles, sex lives and pregnancy status, as well as phone numbers and email addresses. In recent years, some apps have come under scrutiny for privacy violations.

A number of concerning practices persist, researchers reported in Honolulu in May at the Conference on Human Factors in Computing Systems.

Computer scientist Lisa Mekioussa Malki of University College London and colleagues evaluated 20 of the most popular female health apps in the U.S. and U.K. Google Play Stores. The team found instances of apps covertly gathering sensitive user data, inconsistent privacy policies and features, and flawed data-deletion mechanisms. What's more, apps often linked user data to their web searches or browsing, putting the user's anonymity at risk. To use a data-deletion feature, some apps manipulated users into disclosing private information, such as requiring them to indicate whether they have had a miscarriage or abortion.

Malki talked to *Science News* about how these findings may impact app users. The conversation has been edited for length and clarity.

What implications do the findings have for users' privacy?

These apps collect a lot of different data points, and only a small part of it is directly provided by users. There are some limitations [by law, based on your location] on sharing and commercializing that data. Though, in a few apps, the privacy policy explicitly states that things like pregnancy trimester could be shared with advertisers.

There's also a lot of data that apps will collect from the user's device: IP address and information about how they use the app, like what articles they click on. That data is, according to the privacy policy, to be shared with analytics companies.

But there's not much transparency around exactly what types of behavioral data are being shared. It could just be, "Oh, the user logged in." Or it could be, "They opened an article about contraception or pregnancy." And that could be used to create inferences about users and predictions that are actually quite sensitive. It's absolutely not reasonable to expect that the user would have a perfect understanding [of what's being shared] based off reading a privacy policy.

What about users' physical safety?

There's the key issue of criminalization [of abortion in the post-Roe United States], but there's also a lot of other issues that could result from reproductive health data being leaked. For example, if someone's pregnancy status is leaked, that could lead to discrimination in the workplace. There has been previous work that's explored stalking and intimate partner violence. In communities where issues around reproductive health are stigmatized, the sharing of this information could lead to real concrete harms.

What advice do you have for people who use these apps?

A lot of people, when they see a scary news article [about data breaches], they delete the apps. That won't necessarily protect user data. Look for a data or account-deletion feature in the app, or contact the developers. If you live in Europe, you can cite your right to be forgotten. ■

SPACE

China retrieves samples from lunar farside

China has become the first country to collect samples from the farside of the moon. On June 1, a grab-and-go mission named Chang'e 6 touched down in Apollo crater (shown above), which sits inside the much larger South Pole–Aitken basin, one of the biggest meteorite impact sites in the solar system. During the spacecraft's two-day stay, Chang'e 6 used a scoop and drill to snag two kilograms of lunar material, which was transferred to a return vehicle. As of June 10, the vehicle was on its way back to Earth.

"We all dream as lunar scientists to get samples from the farside," says planetary geologist Kerri Donaldson Hanna of the University of Central Florida in Orlando. Such samples could provide scientists with new insights into the history and formation of the moon. Both Chinese and international researchers will be able to study the material. "It's a great time to be a lunar scientist," Donaldson Hanna says. *—Adam Mann*

CLEP/CNSA

ARTIFICIAL INTELLIGENCE

AI could level up medical imaging

The tech can help spot disease but isn't taking over medicine

BY MEGHAN ROSEN

When radiologist Pouneh Razavi reads a patient's mammogram, she hunts for blips in the X-ray image that could indicate breast cancer. Then, a second reader looks at the image, and the two compare results.

But that second reader is no doctor — it's artificial intelligence. Since early March, Razavi and colleagues at Johns Hopkins School of Medicine have been using AI software as a second set of eyes.

It's early days, so her team is still learning from the software, and it can learn from them, too. Images from Razavi's practice could help train the AI on blips that it missed, so it improves over time. The jury's still out on its performance — Razavi's colleagues are still collecting data — but "we're excited about it," she says. Her patients are, too. That includes *Science News* Editor in Chief Nancy Shute, who got her first AI-analyzed mammogram from Razavi in May at Sibley Memorial Hospital in Washington, D.C.

In addition to mammograms, doctors are using AI to scan X-rays of people's lungs, ultrasound videos of infants' hearts and more. The technology's use in medicine is growing at a rapid clip, and "imaging is leading the way," Stanford University radiologist Curtis Langlotz said at The New Wave of AI in Healthcare symposium in New York City in May.

Since 1995, the U.S Food and Drug Administration has approved nearly 900 AI-related medical devices — about 75 percent focus on radiology. But not many clinics around the country are plugged into the technology, Cornell University technologist Mert Sabuncu said at the meeting. "We're just starting to deploy them."

Doctors and researchers point to a variety of reasons why AI in medical imaging is taking off, and what the promise and potential pitfalls might be.

How AI can help radiologists

It's not unusual for Langlotz to arrive at the hospital on a Saturday morning to find 150 patient images awaiting his review. He'll pore over chest X-rays, looking for nodules, fractured ribs or fluid in the lungs.

The job takes training, focus and attention to detail, but even experts can make mistakes. A radiologist's daily error rate may be around 3 to 5 percent. Such errors tend to stem from being overworked, scientists reported in 2023 in the *European Journal of Radiology*. "We need help," Langlotz said.

The problem isn't likely to disappear. More people are getting scans more frequently, which means doctors are acquiring more images than they used to, and the number of pixels in each image is also growing. For radiologists searching for a suspicious spot on an X-ray, Sabuncu said, it's like "looking for a needle in a haystack under immense time pressure when the patient's health is on the line, when you have legal liability, and you really don't want to miss anything."

What can be challenging for humans may be a ripe opportunity for AI. Scientists can use the massive quantities of high-quality digital images to train AI computer models to seek out specific features in scans, like a smudge in a breast image or signs of lung disease on an X-ray.

Such models may help improve radiologists' accuracy and efficiency, and even flag images that look most alarming so doctors can triage cases based on which ones may need immediate attention. When Langlotz sees his cases piling up in the morning, "I'd love to know which of those is more likely to have a problem," he said.

Spotting signs of disease

When a person gets a chest X-ray, a radiologist may be checking for lung cancer or signs of an infection. But within that image, other health details are hiding in plain sight. AI models have the potential to squeeze more information out of each scan. There's a richness to image data that isn't being mined by radiologists, Sabuncu said. "We're leaving a lot of information on the table."

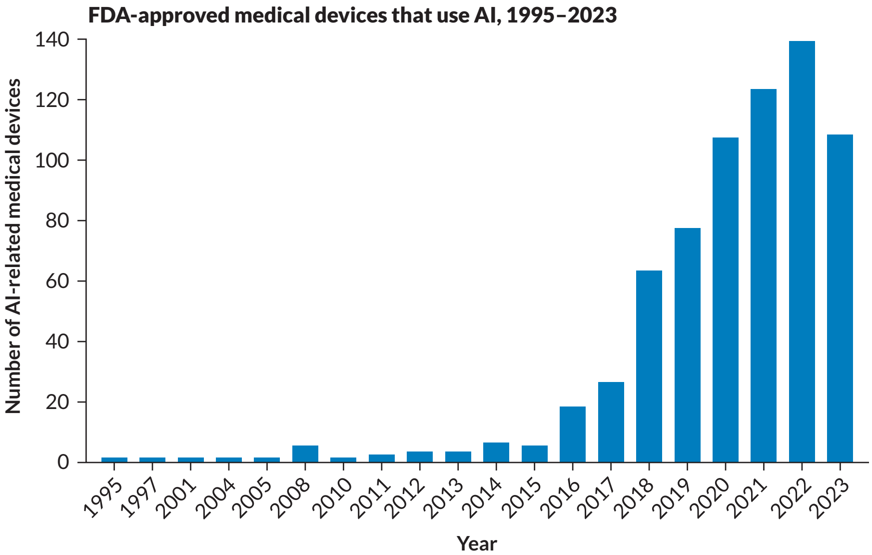
Take cardiovascular disease. Doctors usually calculate a person's risk by factoring in information like cholesterol levels and blood pressure. But those calculations can't be done if data are missing. That's where AI could step in: by gleaning cardiovascular information from routine X-rays.

Using a set of previously collected images and follow-up data, an AI model scanned chest X-rays from nearly 8,900 people ages 50 to 75 and identified who might later experience a heart attack or stroke, researchers reported in the April *Annals of Internal Medicine*. It's an example of opportunistic imaging, where AI trawls images for medical clues

YUMIYUM/ISTOCK/GETTY IMAGES PLUS

AI computer models can scan chest X-rays (example shown) to glean details about a person's cardiovascular health and predict which patients might later experience a heart attack or stroke.

Going up The number of AI-related medical devices approved annually by the U.S. Food and Drug Administration has grown dramatically, especially in recent years. As of October 2023, the FDA had approved 691 such devices (and nearly 200 since). The first device approved in 1995 was aimed at screening pap smears, a routine test for cervical cancer. SOURCE: G. JOSHI *ET AL/ELECTRONICS* 2024



beyond the original purpose of the X-ray. The roughly 4,200 people flagged by the AI were 1.5 times as likely to have a serious cardiovascular problem over the next 10 years as other people evaluated.

A similar study in 2023 used a different X-ray scanning AI to successfully detect type 2 diabetes. Researchers trained the AI on hundreds of thousands of chest X-rays and told it which ones came from patients with the disease. Those people tended to have fat distributed in similar ways, including around the heart and liver, which the AI could pick out.

It's not something doctors typically look for in a routine X-ray. But that's a theme of AI in imaging, Langlotz said. "We'll be extracting information from images that we don't normally extract as radiologists."

Such an AI tool could help people who lack access to regular health care, the study authors say. During an emergency room visit, a person might get a routine chest X-ray that could flag issues other than the one that brought them to the hospital.

Sabuncu sees yet another use for AI, as something that can help us peer into our future by taking a closer look at our past. Most AI image analyses suggest a diagnosis based on a single image. Sabuncu is interested in AI tools that could examine how people's medical images change over time.

He and colleagues recently built a model that scours a person's mammograms over the years. This historical data helped the model pinpoint suspicious lesions. The AI was more than 80 percent effective at distinguishing between people who would develop cancer within the next five years and those who wouldn't, the team reported in a paper submitted April 29 to arXiv.org. The researchers checked the AI's performance using patient outcome data that the AI hadn't seen.

AI can also help scientists comb through even more complex visual data, like ultrasound videos of newborn babies' hearts, says computer scientist Julia Vogt of ETH Zurich. Trained pediatricians can look at those videos and spot infants who might have heart problems, but it's difficult and time consuming. Doctors at a clinic in Germany asked her team if it could help.

Vogt's team created an AI model that analyzes babies' ultrasounds along with other data. In a test using videos of 192 newborns who had previously been evaluated by cardiologists, the model accurately ID'd which infants had a heart issue called pulmonary hypertension about 80 percent of the time, her team reported February 6 in the *International Journal of Computer Vision*. By spotting the problem early, Vogt says, "we can actually make a huge impact on newborns." Such issues can often be treated with supplemental oxygen or medications.

AI is unlikely to replace doctors

Before AI models are ready for use, they need to be tested in settings that go beyond their training. They need people with the technical know-how to use them. They need regulatory approval. And ideally, they'd be deployed in the real world and evaluated on performance, Sabuncu said.

Like most AI systems reported today, the model Vogt's team developed isn't ready for widespread rollout. The researchers first need to train it on more data. At this point, there are too many variables that might confuse it, like how different hospitals capture video and what types of ultrasound machines are used. More training plus clinical trials to confirm the model works could take three to five years, Vogt estimates.

Sabuncu thinks the public's expectations around technology timelines is where AI hype can creep in. "There is no doubt that AI has a lot of potential," he said. He envisions the technology could someday have a huge impact in medicine, but "I don't think we'll see that impact very rapidly."

Still, using AI tools thoughtfully and carefully could make health care more efficient. "AI is not magic," Vogt says, but it does have the potential to solve some problems. AI could ease workloads, giving doctors more time with patients.

Neither Vogt nor the other experts *Science News* spoke with envision AI replacing doctors any time soon, though it's a concern they've all heard. Some patients think they'll get a scan and then interact only with an AI, Razavi says. But that's not accurate. All images at Johns Hopkins imaging centers are read by a radiologist.

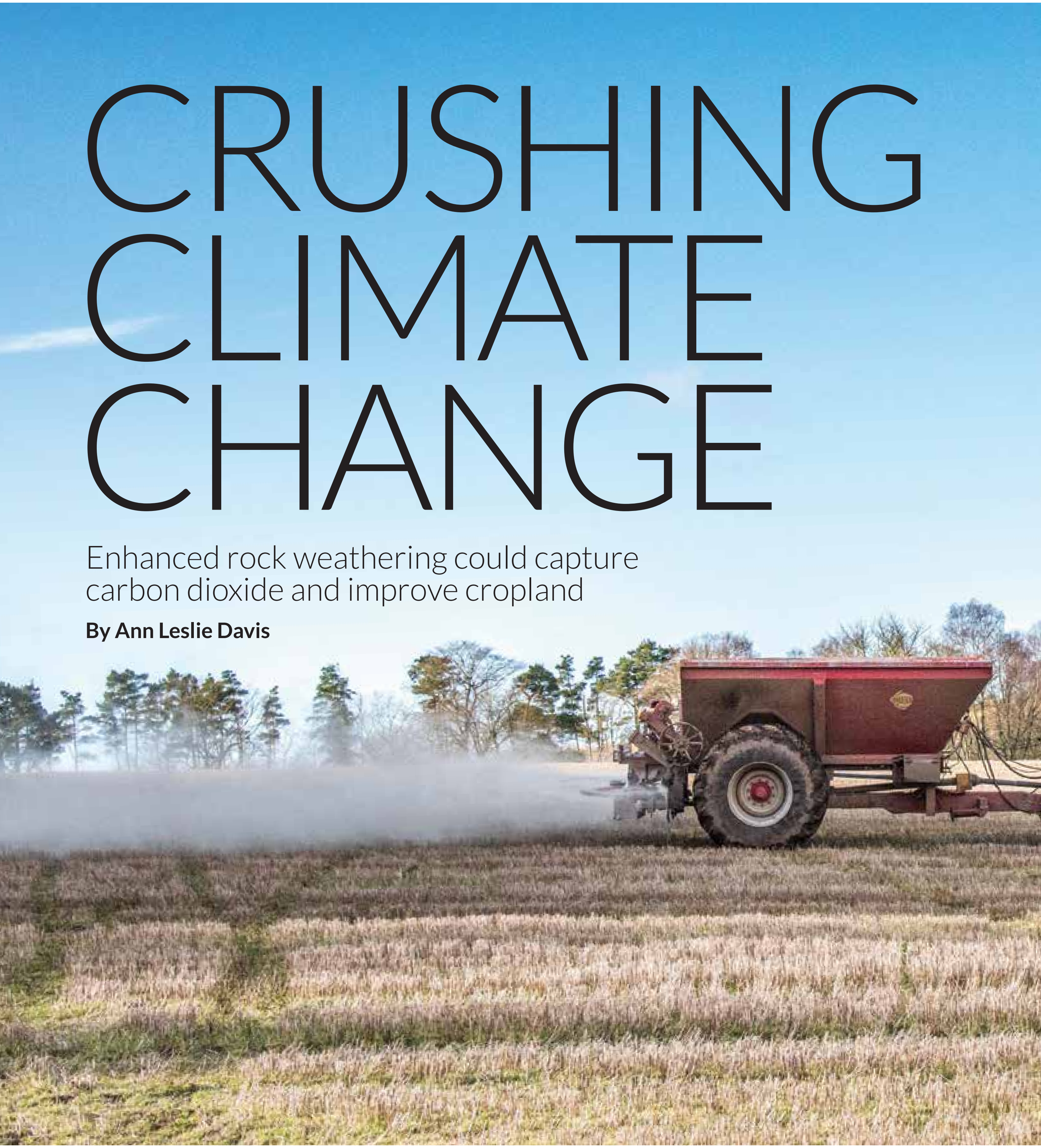
Her team hopes AI can help doctors spot cancer earlier, reduce false positives and triage work. How widespread those potential benefits are will depend on how good AI can get, how clinics use the technology, and who can access it. Some places charge patients $40 or more to have AI analyze their scans. Johns Hopkins does it for free, Razavi says. "If there is a technology that can help find a small cancer, we don't want to deny that to someone." ■

C. CHANG

CRUSHING CLIMATE CHANGE

Enhanced rock weathering could capture carbon dioxide and improve cropland

By Ann Leslie Davis



A farmer in Scotland spreads rock dust on a field before cultivation. The pulverized rock could help pull excess carbon dioxide from the atmosphere and sequester it for thousands of years.

On a banana plantation in rural Australia, a second-generation farming family spreads crushed volcanic rock between rows of ripening fruit. Eight thousand kilometers away, two young men in Central India dust the same type of rock powder onto their dry-season rice paddy, while across the ocean, a farmer in Kenya sprinkles the powder by hand onto his potato plants. Far to the north in foggy Scotland, a plot of potatoes gets the same treatment, as do cattle pastures on sunny slopes in southern Brazil.

And from Michigan to Mississippi, farmers are scattering volcanic rock dust on their wheat, soy and corn fields with ag spreaders typically reserved for dispersing crushed limestone to adjust soil acidity.

Across six continents, these farmers are experimenting with a technique called enhanced rock weathering, designed to improve degraded soils and help save the planet from climate doom.

Enhanced rock weathering takes advantage of Earth's natural carbon cycle, which keeps carbon dioxide in perpetual rotation between air, water and soil. Volcanic rock naturally traps atmospheric CO_2 in a process that transforms the gas into a solid form. Like a thermostat, rock weathering can slowly moderate Earth's temperatures over geologic time by keeping atmospheric levels of CO_2, a greenhouse gas, in check.

Over the last two decades, scientists the world over have studied how to accelerate weathering as a potential climate solution. Grinding volcanic rock into powder increases the surface area available for trapping CO_2. While this rock dust can theoretically be spread anywhere, proponents typically target cropland, which offers easy access and multiple crop benefits.

Enhanced rock weathering is one of many carbon dioxide removal technologies that aim to strip the atmosphere of excess carbon dioxide. Approaches that lock up carbon dioxide could be key to meeting climate goals, according to the Intergovernmental Panel on Climate Change. Limiting global warming to 1.5 degrees Celsius above preindustrial levels — a target of the 2015 Paris Agreement — would require the removal of 100 billion to 1,000 billion metric tons of carbon dioxide by the end of the century, the IPCC says.

Enhanced rock weathering could put a substantial dent in that quantity, a team of researchers in the United States reported last year in *Earth's Future*. If applied to all arable lands on the planet, the method could remove up to 215 billion tons over the next 75 years, according to the team's computer simulations. That's a fifth of the IPCC's

THE CLIMATE FIX

This article is part of a series of stories on climate change solutions and how people around the world are tackling the biggest challenge of our time.

Farmer Erich Schott inspects concrete powder that was spread across his soybean field south of Chicago in 2023. Like volcanic rock powder, concrete powder can enhance the natural weathering process that traps carbon.

maximum estimate for needed removals.

"Crushing rocks — it's almost too dumb an idea. But it actually works," says Adam Wolf, cofounder and chief innovation officer of Eion, an enhanced rock weathering start-up that appeared in *Time* magazine's list of best inventions last year.

Enhanced rock weathering may sound like a no-brainer. But it faces significant obstacles, including fears of potential environmental contamination and the challenge of how to measure and verify the carbon removal. There's also concern that this relative newcomer to climate change mitigation might shunt money from longer-standing priorities, like preserving forests and their carbon-absorbing trees (SN: 7/3/21 & 7/17/21, *p.* 24).

Because some approaches to carbon dioxide removal have been embraced by the fossil fuel industry, critics also worry that supporting them will allow oil and gas producers to keep emitting rather than shifting to clean energy.

But the reality is that the world is far from achieving its emission-reduction goals and short on time. As the IPCC warns, both emission reductions and atmospheric carbon dioxide removal are needed now. The only sensible course is to stop engaging in turf wars and immediately embrace all climate solutions — even newcomers, says Gabrielle Walker, an author and scientist by training who has founded multiple carbon dioxide removal initiatives.

"If we don't build climate removals to gigaton scale by 2030," Walker says, "we cannot achieve our climate goals."

A primer on rock weathering

Enhanced rock weathering relies on a process that's even older than the dinosaurs: the breakdown and buildup of rock. Water droplets in the atmosphere combine with carbon dioxide to form carbonic acid. When the weak acid rains down on volcanic rock, silicate minerals in the rock dissolve. This weathering releases calcium, magnesium and other nutrients needed by plants and forms stable bicarbonate ions (molecules with a net electric charge). The bicarbonate, HCO_3^-, traps the carbon from the atmosphere.

Bicarbonate flows from groundwater into streams and eventually the ocean, where corals, clams and other critters use it to make their shells and skeletons. Upon dying, the animals sink to the ocean floor and are eventually recycled into Earth's interior at subduction zones, where one tectonic plate dives beneath another. The carbon remains inside the planet for tens of thousands of years or longer before volcanoes shoot out clouds of CO_2 and spew silicate-containing lava, starting the cycle anew.

Natural rock weathering captures about 1.1 billion tons of CO_2 each year. In 1990, German-born physicist Walter Seifritz pointed out that weathering could help counter climate change. But little happened until 2006, when Dutch geochemist Olaf Schuiling suggested spreading highly reactive olivine, a mineral often found in volcanic rock, on land to pull excess CO_2 from the air.

Since then, research has boomed. Much of it has been spearheaded by the Leverhulme Centre for Climate Change Mitigation at the University of Sheffield in England, which has conducted studies in the lab and the field on multiple continents.

Spurred by promising results, dozens of enhanced rock weathering companies have formed in the last few years. Some already spread volcanic rock like basalt, some are in the trial phase and some are little more than a catchy web page. Most of these companies focus on cropland. They haul basalt from mines or quarries, grind it, transport it to farms and spread some 25 tons per hectare. Instead of basalt, the Irish company Silicate spreads leftover concrete, which is high in silicate. Companies provide the soil amendment to farmers for free, with the goal of generating revenue by selling carbon credits to large corporations such as Microsoft that want to offset their carbon footprints.

The Netherlands-based company greenSand takes a different approach, using olivine gravel for pathways and edging, driveways, decorative stones and bedding material to keep artificial turf springy.

Other companies are exploring the possibility of

PREVIOUS PAGE: SO-PHOTOGRAPHY/ALAMY STOCK PHOTO; THIS PAGE: BRIAN CASSELLA/CHICAGO TRIBUNE spreading rock dust on beaches and ocean waters, which could not only draw down carbon but potentially counter ocean acidification (SN: 4/6/24, p. 22).

The perks of rock powder

Enhanced rock weathering has multiple advantages over other forms of carbon dioxide removal, proponents say. The technique is built on a natural process, which may help lend credibility to the concept. It also builds on existing industrial processes — mining and agriculture — which can allow for rapid scale-up and reasonable expense.

All carbon dioxide removal methods require energy, land and water, and in these areas, enhanced rock weathering has a competitive edge over higher-tech methods like direct air capture and bioenergy with carbon capture and storage, an approach favored in Europe. That method involves growing crops such as sugar cane to absorb CO_2 and then burning the plants, capturing the released carbon for storage underground and harnessing the heat for energy.

Energy needs for rock weathering, mostly related to the grinding and transport of rock, vary widely depending on parameters like distance to a farm and the fineness of the powder (using rock dust left over from mines can help save energy). In general, though, enhanced rock weathering typically requires only half as much energy as direct air capture, David Beerling, director of the Leverhulme Centre, and colleagues reported in 2022 in *Communications Earth & Environment*. The team studied carbon dioxide removal techniques in different countries.

A direct air capture plant uses massive fans and filters to suck CO_2 out of the air. By one estimate, removing 1 billion tons of CO_2 in this way would require about 1,200 terawatt-hours of electricity. That's roughly three times as much electricity as the entire U.S. renewable sector generated in 2019.

In addition to energy savings, enhanced rock weathering can complement existing land uses. That's unlike some other carbon dioxide removal methods, such as bioenergy with carbon capture and storage. To achieve significant carbon removal, some researchers say this grow-and-burn strategy would need a total area of land larger than India. A study published in February in *Science* concluded that scaling up bioenergy with carbon capture and storage may "threaten food security and human rights … with potentially irreversible consequences."

Another benefit of enhanced rock weathering is that it requires only a tenth or a hundredth as much water as direct air capture, bioenergy with carbon capture and storage, and some other carbon dioxide removal strategies, Beerling and colleagues found.

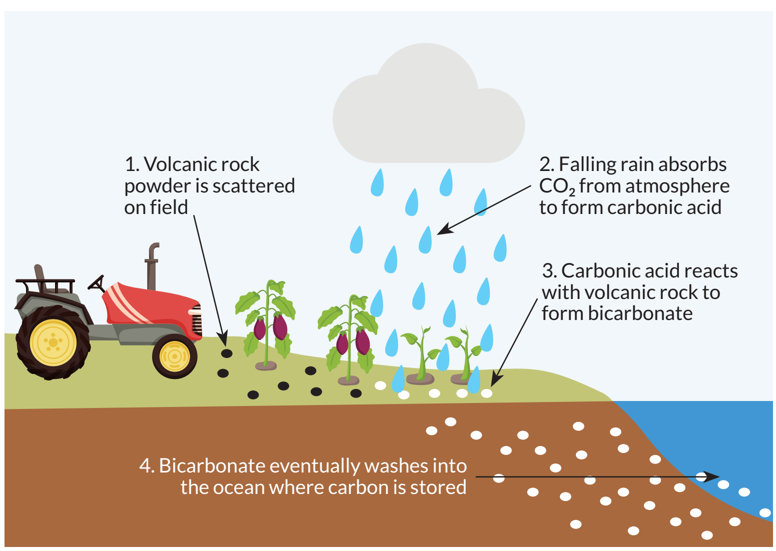
Beyond climate benefits, enhanced rock weathering could help farmers. Modern agricultural practices — tilling soil, removing dead plant matter, monocropping, and applying pesticides, herbicides and synthetic fertilizers — have damaged soil structure, eroded fields and acidified soil. When soil becomes too acidic, essential nutrients can wash away, and microbes that help plants grow can be damaged. Overuse of nitrogen fertilizers can lead to the formation of nitrous oxide, a highly potent greenhouse gas (SN: 3/3/18, p. 9).

Farmers already add crushed limestone to fields to raise soil pH. Volcanic rock powder has the same effect, and due to differences in chemical makeup, can remove more carbon from the atmosphere than limestone can. Volcanic rock powder can also release essential plant nutrients, add silicon (which may make plants more resistant to pathogens) and increase crop productivity. It even appears to reduce nitrous oxide emissions. Many of these benefits also come with regenerative agriculture techniques, such as no-till farming and the use of cover crops, that aim to improve soil health. Enhanced rock weathering is compatible with these techniques.

What could go wrong?

Although the mechanics of enhanced rock weathering are well understood, the potential long-term risks are not. The most serious concern is the potential for heavy metal accumulation in soils. This concern was raised at last year's United Nations Climate Change Conference, COP28. Geochemist Gideon Henderson, chief scientific adviser at the U.K. Department for Environment, Food and Rural Affairs, warned against rushing to embrace

How it works
With enhanced rock weathering, companies spread volcanic rock powder on cropland. Carbon dioxide in the atmosphere combines with water droplets to form carbonic acid. When that acid rains down on the rock powder, chemical reactions trap the acid's carbon in bicarbonate, which eventually flows into the ocean.



C. CHANG

enhanced rock weathering approaches that involve pure olivine. "Olivine has high trace-metal content, including some toxins, and in the long term may cause significant negative environmental consequences," Henderson said.

Heavy metals in olivine such as nickel can endanger health if absorbed at high enough levels by plants and ingested by humans (small amounts of nickel are essential for plant growth). Concerns about heavy metals arise from the fact that enhanced rock weathering works best with repeat applications, which can increase levels of the metals.

The study showing a 215-billion-ton reduction in atmospheric CO_2 over a 75-year period assumes annual application of 10 tons of basalt per hectare. But one study, which assumed a commonly used application rate of 40 tons of basalt per hectare, suggests that safety limits for that level of application may be exceeded after only 10 years of repeat application.

Up to 1,000

billion metric tons

Amount of atmospheric CO_2 that must be removed by 2100 to keep global warming below 1.5 degrees Celsius

215

billion metric tons

Amount of atmospheric CO_2 that enhanced rock weathering could remove in 75 years if deployed on all arable land

Eion, with projects located in the southeastern United States, uses olivine. Wolf, the company's cofounder and chief innovation officer, points out that soil nickel levels in that region are so low that nickel fertilizer is actually recommended. In addition, plants absorb nickel more readily in acidic soil, something that olivine corrects. "No paper I know of has ever shown an actual toxicity impact of olivine," Wolf says, including one by Henderson.

"If we don't build climate removals to gigaton scale by 2030, we cannot achieve our climate goals."

GABRIELLE WALKER

Still, at least one start-up isn't taking any chances. Metalplant, an offshoot of the climate think tank Climitigation, grows a nickel-absorbing crop on fields treated with volcanic rock powder. Then the company extracts the nickel from the plants with the aim to sell the metal.

There's also the question of how adding volcanic rock powder or crushed concrete will affect soil microbes. Geochemist Frank McDermott of University College Dublin is the scientific lead at Silicate, the start-up that uses concrete powder. While the microbial community generally responds well to an increase in soil pH when agricultural lime is added, basalt and concrete bring different mineral and chemical makeups. Despite extensive work, he says, scientists still don't know how the addition of these powders, perhaps in higher quantity than lime, will impact the ability of soil microbes to break down organic matter, which is essential to soil health. "Soils have a big store of organic carbon, and the goal is to protect and increase it over time. But if you add material that's external to the system, and the microbes there have never seen basalt or concrete before, how will they react?" McDermott asks.

Another unknown is the possible effect of these rock powders on the flora and fauna of adjacent lands, lakes or ponds, or on marine life if rock powder is sprinkled into the ocean.

Measure and verify

In the acronym-heavy world of carbon dioxide removal, one jumble of letters stands out above all others: MRV, for measurement, reporting and verification. Accurate MRV is essential to assessing a technique's effectiveness and enabling companies to sell carbon credits.

But how do you measure something you can't see? A direct air capture machine filters CO_2 from the air and concentrates it in purified form, allowing for easier measurement. With enhanced rock weathering, there's no way to directly measure how much CO_2 is drawn down.

Companies currently use multiple methods of measurement. For instance, soil releases a certain amount of CO_2 into the atmosphere through normal soil respiration. The application of rock powder lowers the percentage of CO_2 released. Respiration can be measured to infer carbon removal. Bicarbonate levels in groundwater samples are another measurement, along with quantifying how much rock powder dissolves. Eion developed its own process by using a trace element within olivine that leaves a "fingerprint" after the rock breaks down.

Each approach comes with uncertainties, but using multiple methods together might help verify that carbon removal has happened and provides a close approximation of the amount.

Yet conducting these field measurements can be a burden for small start-ups trying to stay afloat. For that reason, many companies are turning to simulations to predict CO_2 removal rates.

Skeptics of this method say that simulations can't yet replicate the complexity of nature. Ecologist Benjamin Houlton of Cornell University was among the first researchers to conduct field studies on enhanced rock weathering with basalt. Carbon drawdown can be accurately measured in small, tightly controlled test plots, he argues. But "scaling those measurements to something as big as an acre or multiple acres or thousands of acres is still not possible. It's just not there yet," Houlton says.

"I think what we're seeing is a collision between the start-up culture wanting things to work, wanting to believe things will work — and that's so important — versus the scientific process, which is conservative, careful and calculated," Houlton adds. "The truth is somewhere in the middle."

Some researchers, however, point to simulations' fundamental role in studying climate. "If you accept that models can be used to model arguably more complicated systems [like climate change], I think it's not a giant leap to expect that we can get models that are good enough to determine rock weathering and carbon dioxide removal rate," says geoengineer Mike Kelland of the Leverhulme Centre.

Perhaps one way to increase confidence in carbon removal estimates is to work with an independent rating institution. In 2022, Puro.earth, a carbon credit platform based in Finland, developed the first set of certification standards for enhanced rock weathering. Puro.earth hopes this will encourage companies to adopt uniform measurement methods and soothe nervous carbon credit buyers.

To sell enhanced rock weathering carbon credits, Puro.earth requires that a company provide field data that show two different signals of rock weathering, such as measurements of respiration and bicarbonate levels. Start-ups must also prove that carbonic acid, and not some other soil acid, weathered the rock. Companies also have to take quantifiable measurements of CO_2 capture. And Puro.earth requires proof that fields don't exceed guidelines for heavy metal contamination.

"Puro.earth is adamant in that only robustly quantified and verified carbon removals can be credited," says Marianne Tikkanen, cofounder and head of standard at Puro.earth. "Any enhanced weathering project must [verify] their soil conditions and explicitly and conservatively quantify the effect of all the various uncertainty factors and risks of reversal."

Start-ups in North America, South America, the United Kingdom and India are using Puro.earth's methodology. And in April 2023, Microsoft bought the first carbon credits based on enhanced rock weathering under Puro.earth's crediting system from the Scottish company UNDO.

The future

Research on enhanced rock weathering is far from done. In a 2020 study published in *Nature*, Beerling and colleagues pinpointed the United States, China, India and Brazil as the major agricultural countries that are most suitable for immediate deployment of enhanced rock weathering. The strategy could help the United States and China offset up to 10 percent of their emission-reduction goals. For India, it's 40 percent and for Brazil, it's more than 100 percent.

Combining enhanced rock weathering with other strategies could lead to an even greater effect. Rock powder used alongside bioenergy with carbon capture and storage may improve the health of feedstock crops. And adding it to other nature-based methods can make agricultural land a more effective carbon sink.

To date, though, most government funding for carbon removal in the United States and Europe has gone to high-tech solutions like direct air capture. But that balance may be ever so slightly shifting. In May, the U.S. Department of Energy awarded five enhanced rock weathering projects, including Eion, $50,000 each to scale up the technology. And the European Union recently allowed enhanced weathering advocates to apply for consideration as an eventual removal strategy in Europe.

In this all-hands-on-deck moment, collaboration and open-mindedness may be key to avoiding the worst effects of climate change, Walker says. All carbon removal solutions need support. "This is not a zero-sum game," she says. "This is an attempt to get to net-zero at the speed that we need." ■

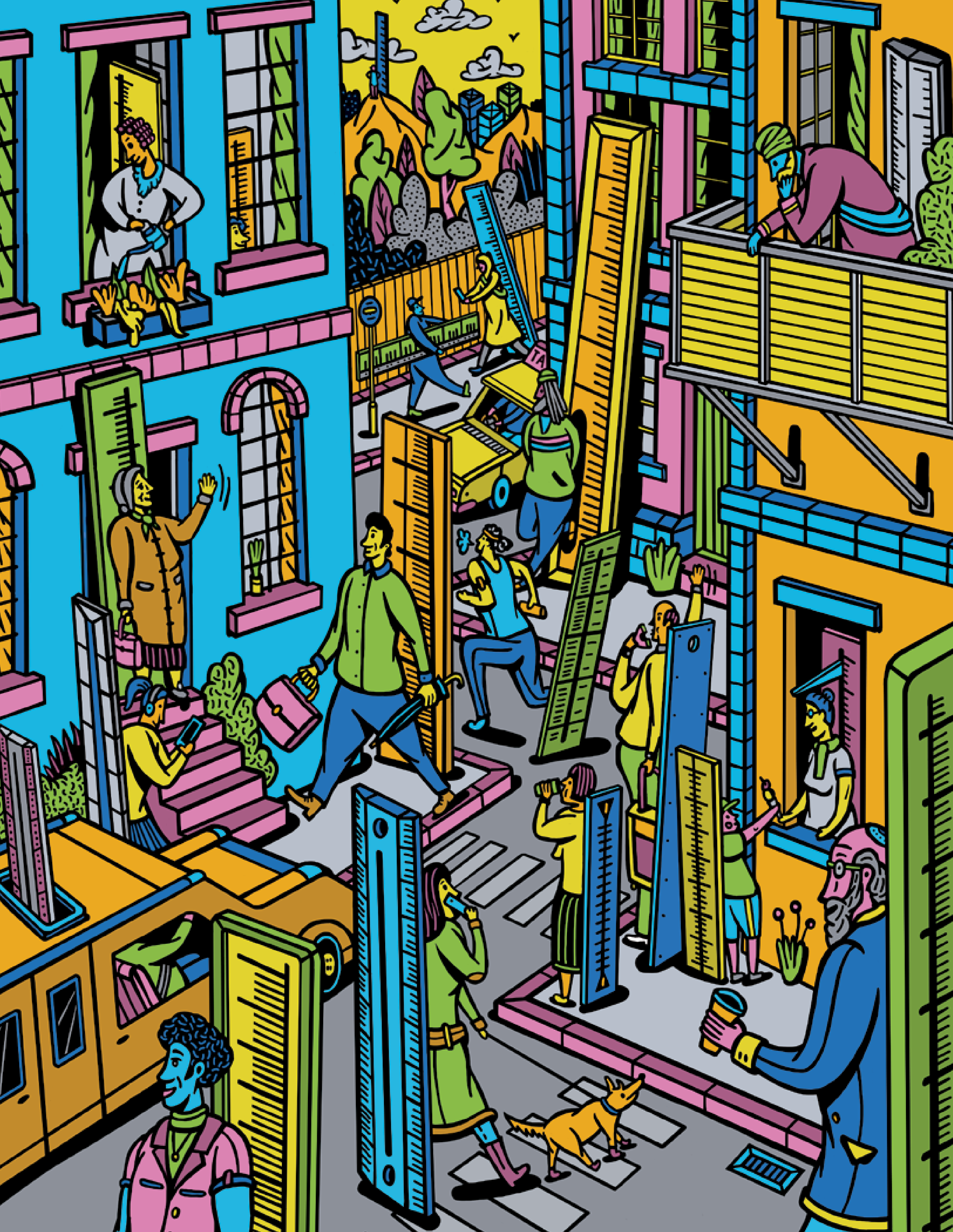
CARBON DRAWDOWN INITIATIVE

Researchers in Germany install devices for measuring the weathering process in a field trial of enhanced rock weathering. One sticking point with enhanced rock weathering is how best to measure and verify carbon capture.

Explore more

- Seung H. Baek *et al*. "Impact of climate on the global capacity for enhanced rock weathering on croplands." *Earth's Future*. August 14, 2023.

Ann Leslie Davis is a freelance science writer based in the San Francisco Bay Area.



The Social Side of Height

A contentious idea suggests there's more to stature than genetics and nutrition

By Sujata Gupta

The Maya people of Guatemala are among the shortest people in the world. Men on average hover a few inches above 5 feet and women a few inches below. But if they move to the United States as children, the Maya grow taller. That extra growth carries to the next generation: Maya children born to Guatemalan immigrants in the United States are roughly four inches taller than their peers in Guatemala, research by biological anthropologist Barry Bogin shows. Some of that gap disappears as children reach adulthood, but even then, Maya people in the United States are still taller than people in their native country.

Economists have long observed increases in height across immigrant communities worldwide. Improved nutrition and sanitation are the conventional explanations for such growth.

But Bogin, of Loughborough University in England, and other researchers think there's more to it than just better health. Even wealthy children in Guatemala tend to be shorter than children who grow up in the United States. Moving a child from one society to another — even if their lifestyle doesn't change significantly — shifts their growth trajectory to match that of children in their new community, Bogin says.

His proposal that height has a social component rests on evidence that genetics and nutrition can't explain all variation in human height. It's also based on research in behavioral ecology showing that the growth of many social animals adapts in response to members of their community, a phenomenon referred to as "strategic growth." In species with rigid hierarchies, dominant members often grow larger while subordinate members stay smaller.

Strategic growth also drives growth in humans, Bogin proposed in 2021 in *Human Biology and Public Health*. His research suggests that height not only reflects a person's perceived social status within their community, but also their society's underlying political and economic conditions. For instance, height disparities are wider in highly unequal societies and shrink in more egalitarian ones. When people in highly stratified countries move to more egalitarian communities, they tend to grow taller, studies of Western countries suggest. Based on animal research, Bogin suspects hormones, including those released when the body is under stress, may modulate the social aspects of height.

Many researchers agree that the stress of living in a harsh environment can suppress growth. But they balk at the idea that one's peers can influence height. "It all sounds like … manifesting," says sociologist

Illustration by ***Phil Wrigglesworth***

Gert Stulp of the University of Groningen in the Netherlands. "You see other tall people and then also want to be taller and then you become taller."

But Bogin is a renowned height researcher. His book *Patterns of Human Growth*, now in its third edition, is among the most widely read textbooks in the field. That reputation has left colleagues inclined to consider what might otherwise sound outlandish.

It's plausible that social status influences human growth, says behavioral ecologist Peter Buston of Boston University, who studies strategic growth in clown fish. But he urges caution. Bogin and his collaborators "haven't yet done the studies that I would like to see done to make the strong case," Buston says.

Framing height as at least partially socially driven could have profound implications for public health. Extreme shortness among children, or stunting, seen in some 149 million children under age 5 worldwide, might be a sign of social disadvantage rather than malnutrition, Bogin and others argue. What's needed in such cases may not be nutrition supplementation, the common approach, but programs that alleviate societal inequities.

Status, size and clown fish

The clown fish Buston studies live in colonies of two to six fish. The largest member is the breeding female followed by the breeding male. The remaining fish, none of whom breed, get progressively smaller, so that each is about 80 percent the size of the fish ahead of it in rank, Buston has found. This rigid hierarchy helps prevent conflict, Buston theorized more than two decades ago. A graduate student in his lab recently found that if a larger fish is introduced into a colony to replace a smaller fish, the large fish gets shunned. A smaller replacement fish doesn't.

In the wild, eviction, and the resulting exposure to predators, would be a likely death sentence. In clown fish at least, Buston says, "there's been really strong natural selection for individuals who can regulate their growth and turn their growth on and off."

Strategic growth also shows up in social mammals. Consider meerkats, which live in groups of three to 50 members with a dominant breeding pair that accounts for 90 percent of the group's reproduction. Those two meerkats are also typically the largest. Smaller, often younger subordinates help feed and care for the pups, with the largest nondominant animals replacing the dominant breeding pair if they die.

In one experiment reported in 2016, researchers gave a nutritional supplement of hard-boiled eggs to some small, nonbreeding meerkats in a wild group, which helped the animals grow bigger. Meerkats that subsequently became dominant continued growing heavier in the two to four months after reaching the top rank, even when egg supplementation ended.

Hormonal changes associated with a rise in the social hierarchy may explain that continued growth, the researchers suspect. Dominant females have higher levels of the sex hormones estradiol and progesterone than subordinate females. And both dominant males and females have higher levels of cortisol, a primary stress hormone. Sex hormones and cortisol regulate growth in mammals (though

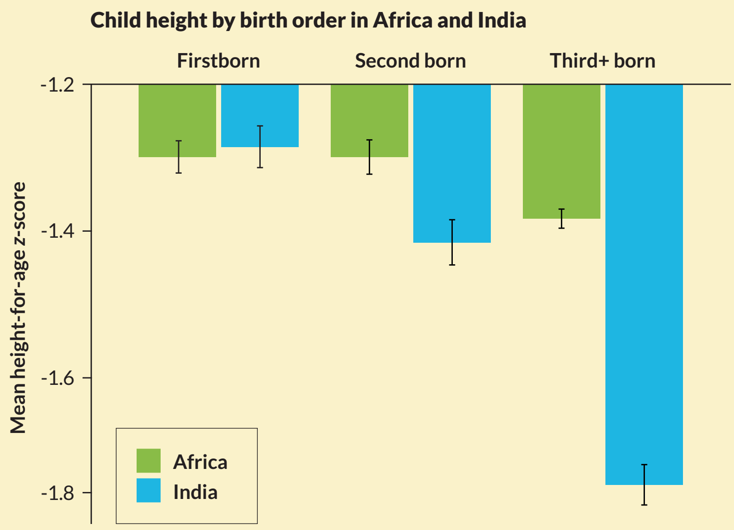
Clown fish and meerkats exhibit strategic growth, when an individual's growth adapts in response to social surroundings. Some research hints that humans might do the same.

FROM LEFT: ANDAMANSE/GETTY IMAGES; UTOPIA_88/GETTY IMAGES high cortisol probably suppresses growth in humans).

Growing larger may come with trade-offs, the meerkat researchers think. Allocating extra resources to growth may well decrease disease-fighting ability or shorten life span.

Strategic growth may also occur in species with very different mating structures from clown fish and meerkats. For instance, among African riverine antelopes known as the puku, males fight for territory to attract females. A male with his own territory secretes more scent-marking hormones than males without one. The rise in hormones coincides with increases in the territorial male's size.

Sibling rivalry In a study of children in India and sub-Saharan Africa, birth order had more of an effect on height in India than in Africa. In India, the eldest son was taller than younger siblings, raising the average z-score of firstborns. For each cohort, the z-score represents the number of standard deviations from the average height of a reference population. The more negative the score, the shorter the cohort. SOURCE: S. JAYACHANDRAN AND R. PANDE/*AMERICAN ECONOMIC REVIEW* 2017



B. PRICE

Height is a puzzle

But what factors influence human height and by how much remains an open question. Genetics is no doubt involved, though it doesn't seem to account for all patterns. Same for nutrition and sanitation. Evidence from the present and past hint that other factors must also be at play.

An analysis of 168,000 children in India and sub-Saharan Africa, for example, found that eldest sons in India were taller, on average, than eldest sons in Africa. But other Indian siblings were shorter than children of the same age and birth rank in Africa. The findings, reported in 2017, suggest that Indian children have the genetic potential to grow as tall as sub-Saharan African children, but for some reason only eldest sons attain that potential. The wealthiest families in India showed the widest height disparities between older and younger siblings, unexpected if nutrition or sanitation were the primary issues.

Archaeologist Samantha Cox of the University of Pennsylvania has found a similar height disparity among adult females in early Neolithic communities in Europe. Analyzing ancient DNA samples from skeletal remains that date back some 7,000 years, Cox discovered that females in North Central Europe (modern-day northern Germany) measured a couple inches shorter than females in South Central Europe (southern Germany, Austria and Slovakia), despite similarities in genetics and resource access. Males across both regions, meanwhile, were the same height, Cox's team reported in the February *Nature Human Behaviour*.

Northerners, however, had considerably more physical signs of stress than southerners. Cox thinks that may be due to the challenges northern Neolithic communities faced in growing food. Some social factor may explain why northern males were able to recover from that stress while northern females were not. Females in the north may have suffered discrimination. "It seems pretty clear that there is male preference here," she says.

These and other status-related differences in height have been observed in modern societies too. "High-social-status people are taller than low-status people … this is definitely true," Stulp says. For instance, tall people tend to earn more money than short people, creating a so-called height premium. That premium, though, varies by geography, researchers reported in 2023 in *Economics & Human Biology*. In wealthy, typically Western countries, such as the United States and Australia, the height premium is lower, on average, than in countries in Asia and Latin America. The researchers attribute this discrepancy to the role of environmental conditions, which become more variable as poverty rises. So compared with people in high-income countries, people in lower-income countries may more likely associate tallness with better health and fitness, resulting in a greater height premium.

Economists have known for decades that height variations, especially those related to class or gender, can provide clues about a society's social order. "We know that height is very sensitive to inequality," says Joan Costa-Font, a health economist at the London School of Economics and Political Science.

Inequality has been linked to shorter populations overall. Such disparities show up early in life and tend to persist into adulthood. In one analysis, researchers evaluated the heights of more than 37,000 children ages 4 to 6 from five affluent countries. Inequality, measured on a standardized scale, varied; the United States was the most unequal, followed by the United Kingdom, Australia, the Netherlands and Sweden. Children in the Netherlands and Sweden were taller at every income bracket than children from the other three countries, researchers reported in 2019 in *BMJ Paediatrics Open*. And the disparity from country to country was widest for children in the lowest income bracket.

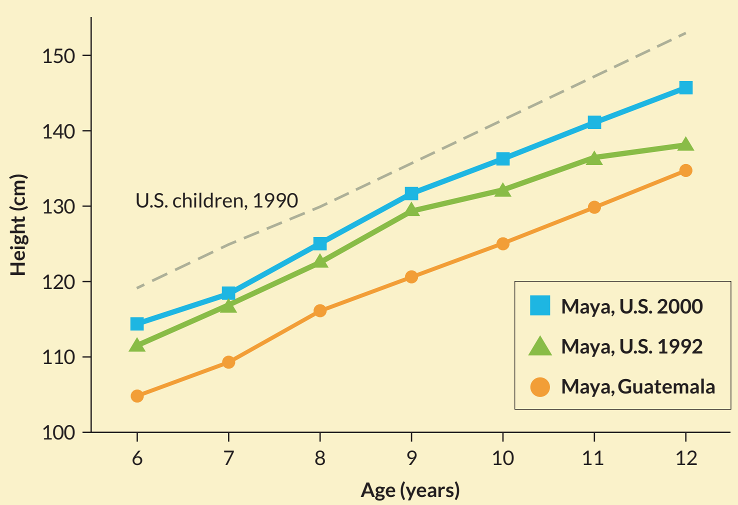
Even in well-off countries, where starvation is not a concern, inequality may aggravate stressors known to worsen health, and potentially height, such as low social belonging and caregivers' longer working hours, the researchers say. More egalitarian countries typically offer generous social programs that reduce such burdens.

Increasing social parity could explain why people in Western Europe have been growing taller for the last 140 years, says Björn Quanjer, a historical demographer at Radboud University in Nijmegen, Netherlands. But it can't fully explain why some populations are taller than others. Men born in 1980 average about 6 feet in the Netherlands compared with 5 feet, 9 inches to 5 feet, 11 inches elsewhere in Europe.

"All Western European countries grew taller, but the Netherlands outgrew them," Quanjer says. High education levels, low disease burden, good nutrition and genetics are all cited as possible explanations for that extra height. But, Quanjer says, "the simple answer is we don't know."

Growing taller Maya children living in the United States are taller than their counterparts in their native Guatemala. About 50 percent of the cohort of Maya children measured in 1992 were born in the United States; 93 percent of the 2000 cohort were U.S.-born. Different social environments may help explain the differences in height. SOURCE: P.K. SMITH *ET AL/ECONOMICS & HUMAN BIOLOGY* 2003

Height of Maya children in Guatemala vs. the United States



Strategic growth in humans?

Bogin and others, including pediatric endocrinologist Michael Hermanussen, theorize that strategic growth, as seen in clown fish and meerkats, might underpin at least some of what is going on.

Hermanussen has been identifying patterns in human height variations using European military records for decades. His research on conscript data on East and West Germans shows that before reunification began in 1989, East German conscripts were roughly one inch shorter than West German conscripts. That height disparity made little sense to Hermanussen, who runs a private practice in Altenhof, Germany. East and West German boys were genetically similar. What's more, both sets of boys were about the same height until age 12 or so, suggesting that nutrition wasn't likely the major contributing factor either.

After reunification, the height of East German conscripts steadily increased. Within five years they were as tall as West German conscripts. Hermanussen suspected that the massive social and political changes that occurred after the fall of East Germany's notoriously manipulative regime explained that collective growth spurt.

Others were skeptical, Hermanussen says. "People thought... it must be genes, it must be health, it must be nutrition."

Hermanussen went on to work on another population with human biologist Christiane Scheffler of the University of Potsdam in Germany and statistician Christian Aßmann of the University of Bamberg in Germany. They found what Hermanussen and Scheffler now think is a sign of strategic growth in Swiss conscript data spanning three time frames: 1884–1891, 1908–1910 and 2004–2009. Looking at Switzerland as a single network with 169 cities linked via 345 roads, the team found that conscripts' height tended to cluster in more connected communities. If one community was relatively short, then the neighboring community was likewise short.

"The community effect was quite clear," Hermanussen says. "When you look at people who live in groups, they are almost all the same in height."

What's more, he found that increases in height in Switzerland over time varied from one district to another, but variation in height within a given community stayed the same. That is, everybody grew taller by roughly the same amount.

"It must be something in the air," Hermanussen recalls thinking, until he came across the meerkat experiment. What if, Hermanussen wondered, Europe's democratization, starting in places like Switzerland and the Netherlands in the mid-1800s,

B. PRICE

was akin to the equalizing in size of rival meerkats? As with the meerkats, such equalization could perhaps lead to a height race. Without a rigid hierarchy, people may continuously jockey for social position, Hermanussen supposes. "This makes people tall."

In human societies, social scientists refer to this freedom to rise in rank as social mobility. Bogin suspects a lack of mobility in Guatemala keeps people short. Inequality is high, with some surveys suggesting that just a couple hundred people control roughly half the country's wealth. Most Maya families live in poverty, with little opportunity for advancement. Even Maya and non-Maya families of means must contend with the constant threat of kidnappings for ransom and other violence.

People in Guatemala lack hope for a better future, Bogin argues. "Stress hormones block growth hormones."

In the United States, a cleaner environment and better food certainly help immigrants grow, Bogin says. But so, too, may social factors, including living in a safer world and optimism about the future.

Stunting and status

If height does have a social component, then conventional public health wisdom tying stunting primarily to starvation may need a rethink. Starvation unquestionably inhibits growth, Scheffler says. But just because a person is short does not mean they are starving.

For instance, in a study reported in 2020 in the *European Journal of Clinical Nutrition*, Scheffler and colleagues recruited more than 1,700 children, ranging in age from 6 to 13, from three areas of Indonesia: West Timor, among the poorest regions in the country; North Sumatra, a more affluent, low-industry province; and Bali, a wealthy tourist enclave.

The researchers measured both the children's height and skinfold thickness, or subcutaneous fat, at various spots on the body. Based on the skinfold thickness, none of the children who would've qualified as "stunted" showed signs of malnutrition. Zooming in on more than 700 children in West Timor, where stunting rates ranged from roughly 9 percent among youngsters from the wealthiest families to 47 percent among the poorest, the team again found no link between stunting and malnutrition.

Rather than a proxy for malnutrition, stunting is a proxy for social disadvantage, Scheffler argues. "It could be that malnourished people are stunted, but stunted people are not always malnourished."

That could help explain a growing body of research showing that nutrition interventions do little to improve child growth, says anthropologist Emily Yates-Doerr of Oregon State University in Corvallis. "Global health professionals are finding it difficult to feed people taller."

Precise numbers for how much money goes toward reducing stunting worldwide are hard to come by. One 2016 estimate suggests that globally, countries spend almost $4 billion per year to address stunting and other hunger-related issues, such as anemia. And many researchers and policy makers believe that substantially more money is needed. "Height is a signal and this needs to be discussed and to be understood. Because if we misinterpret the signal, we draw false conclusions," Hermanussen says.

But not everyone is convinced that social status plays any role in human height, let alone a big role. Research suggests that humans can show dominance in ways besides height, such as by walking together in a group — displaying power in numbers — or using weapons, says Christopher von Rueden, an evolutionary anthropologist at the University of Richmond in Virginia. Gauging social status via height and not, say, collective fighting ability or muscle mass, he says is "odd."

And human societies are complex. In particular, social networks are fluid, with people moving in and out. Any signal from strategic growth may be swamped by other factors.

Central to the debate is one's view of human nature. Would a pecking order persist in human societies if other inequalities could be erased? Or would the need for a ranking system also go away? In the absence of the elaborate political and cultural systems thought to drive inequality among humans, social animals still establish hierarchies, Bogin says. Why should an equalized human society be any different?

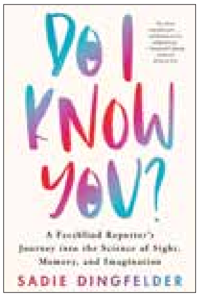
"If everything were totally equal for everybody … we would still have a lot of variation in height," Bogin says.

But many researchers studying height disagree. If resources were equally divided, height variations that Bogin and others attribute to social status would disappear too, says Cox, adding: "Height seems like such a basic trait. I think a lot of people would be really surprised to know how little we actually understand about it." ■

"It could be that malnourished people are stunted, but stunted people are not always malnourished."
CHRISTIANE SCHEFFLER

Explore more

- Barry Bogin. "Social-Economic-Political-Emotional (SEPE) factors regulate human growth." *Human Biology and Public Health*. June 22, 2021.



Do I Know You?
Sadie Dingfelder
LITTLE, BROWN SPARK, $32

BOOKSHELF

A memoir highlights the astonishing diversity of our inner lives

A friend and I recently stumbled into a conversation about inner monologues. He referred to nearly constant chatter, in his own voice, as if it were normal. My inner monologue? Largely nonexistent. I don't usually hear internal words, and I certainly don't hear my own voice. At least not as he described. I found myself struggling to explain exactly what's going on in my mind when I think something or read something. We both came away puzzled and entertained by the other's experience.

I didn't know it at the time, but this conversation primed me for science journalist Sadie Dingfelder's hilarious and philosophical memoir, *Do I Know You?* "The variety of ways people experience being awake and alive," Dingfelder writes, "is, frankly, mind-boggling."

Over the course of 300 pages, Dingfelder proves this point again and again, using her own highly unusual mind as a key piece of evidence. She is unable to recognize people's faces. She also can't see depth, lacks the ability to create mental images and has trouble with memory. Her way of perceiving the world is probably not like yours.

Throughout the book, Dingfelder covers the history of psychology and neuroscience, compelling case studies of other interesting minds and the latest brain science. With this sweeping context and well-chosen anecdotes from her own life, some absurd and some powerful, Dingfelder does her best to show us what it's like inside her mind. It's fascinating in there.

Dingfelder didn't realize how different her perception of the world might be until she was middle-aged, when she applied her reporter instincts to some of her more bizarre experiences. The resulting revelation sparked her "nerdy midlife crisis," a journey of identifying and understanding these differences.

Dingfelder aggressively pursues a scientific description of her brain. She volunteers for research studies, undergoes brain scans, takes vision tests, plays virtual reality games and scores a beeper that she wears for a few hours each week, intermittently prompting her to record every bit of her conscious experience.

We're there when she learns she is a certified prosopagnosiac, a person unable to recognize faces. This insight explains some of the more puzzling encounters she has had throughout her life: why she ignored an old friend in a grocery store, why she accosted a stranger over peanut butter (he was wearing a coat similar to her husband's) and why she mistook her aunt for her mother (only briefly; her aunt had changed her hair).

After a lot of conflicting emotions, Dingfelder eventually takes this diagnosis in stride and even lays out some upsides: She credits her sense of humor to the condition, because "you can't take yourself too seriously when you're constantly making silly mistakes." She's impressively adaptable because her condition often lands her in unfamiliar spots. And she's learned to pay close attention and ask lots of questions. "This is basically the job description for being a reporter," she writes.

The plethora of scientific studies Dingfelder participates in reveal quirks that go beyond face blindness. Further testing confirms that she can't see depth, a difference made clear through her vivid and harrowing descriptions of learning to drive a busted-up 1988 Ford F-150. She also can't create images in her mind's eye. "Things that I thought were just figures of speech — daydreaming, imaginary friends, undressing someone with your eyes, counting sheep — are much more real than I realized," she writes. "Why didn't anyone tell me?"

Dingfelder's writing is funny, poignant, philosophical and almost euphoric. The memoir is a beautiful reminder that our inner lives are not uniform. None of us can possibly know what it feels like to be someone else, but as Dingfelder shows, it's fun to try. — *Laura Sanders*

An exhibit on the science of James Bond includes 13 vehicles from the film franchise.

MUSEUM OF SCIENCE AND INDUSTRY

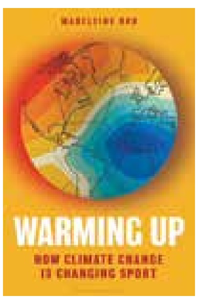
TO DO

Apollo: When We Went to the Moon
THROUGH SEPTEMBER 2
The story of NASA's Apollo program is told through photos, interactive media and rarely seen artifacts.
INTREPID MUSEUM, NEW YORK CITY

007 Science: Inventing the World of James Bond
THROUGH OCTOBER 27
Filled with movie props, this exhibit details how science informed the cinematic world of the fictitious British spy.
GRIFFIN MUSEUM OF SCIENCE AND INDUSTRY, CHICAGO

Survival of the Slowest
THROUGH JANUARY 2025
Sloths, snakes, hedgehogs and other sluggish animals demonstrate the evolutionary advantages of being a slowpoke.
MUSEUM OF SCIENCE, BOSTON

On an unusually warm day in January 2023, skiers in Austria glide down an artificial snow slope.



Warming Up
Madeleine Orr
BLOOMSBURY SIGMA, $28

BOOKSHELF

Climate change endangers sports

It's easy to think of sports as an escape from reality, removed from the glaring problems of our world. Researcher Madeleine Orr shatters that illusion in *Warming Up: How Climate Change Is Changing Sport*. In her debut book, Orr shepherds readers through an at-times overwhelming deluge of all the ways climate change is disrupting sports around the world, providing a compelling case for action from athletes, sports leagues and fans alike.

Orr, a sport ecologist at the University of Toronto, draws on her academic expertise to outline how climate change is upending sports, be it wildfires almost destroying a high school football program or rising seas subsuming coastal golf courses. While Orr bolsters her argument with data and interviews with experts, it's the personal stories that are most powerful. There's the heartbreaking story of University of Maryland college football player Jordan McNair, who died of heat stroke suffered at practice. Orr, an avid skier, shares her beef with global warming literally melting away winter sports around the world — and the local economies they sustain.

In the introduction, Orr says that the order of the chapters is irrelevant. But the chapters do follow a loose organization, and grouping them into sections would have made the overall trajectory of the book easier to follow. The first 11 of the book's 17 chapters mainly focus on how warming temperatures, rising seas, increasing wildfires and other consequences of climate change are already impacting the industry and will worsen in the future. For instance, outdoor pond hockey, a crucial part of Canada's culture and the launchpad of many of ice hockey's greats, is at risk of disappearing altogether as winters become warmer and ice becomes rarer.

It's refreshing to see Orr explicitly talk about how climate change is disproportionately impacting nations that are least responsible for global greenhouse gas emissions, a point that can get lost in Western reporting on the topic. High temperatures are threatening Kenyan runners. Rising seas are eroding a famous rugby beach in Fiji. A 2022 flood devastated Pakistan's sports leagues — along with much of the country.

But against the backdrop of climate change's harrowing reality, Orr keeps hope alive in the last six chapters. The sports world can adapt to climate change to reduce its own culpability and to ensure that imperiled sports survive. She spotlights the past and present activism of athletes who are fighting for sustainability. One heartening example is Innes FitzGerald, a teenage cross-country runner who refused to fly from Britain to Australia for the 2023 World Athletics Championships out of concern for air travel's carbon emissions. Before FitzGerald, "no athlete had actually passed up championship opportunities because of a moral quandary with flying," Orr notes. Like climate activism in so many other sectors of society, it seems changes in sports will be spearheaded by the youth.

Orr's writing is authoritative and conversational, and while she sometimes slips into academic jargon, her language is largely accessible even to readers with no scientific background. The book is jam-packed with information and has something for sports fanatics and casual fans alike. In the fight against climate change, *Warming Up* shows us that it's time for the sports world to play ball. — *Darren Incorvaia*

CHRISTOF STACHE/AFP VIA GETTY IMAGES

INVERTEBRATES ARE PRETTY CLEVER

We tend to think dogs, horses, whales and other animals experience the world somewhat like we do. But what about the 97 percent of animals that are invertebrates? Think insects, scorpions, shrimp and worms. Are they self-aware, able to understand they are individuals? Can they feel pain, which scientists often use as a stand-in for consciousness? New studies are exploring this and other behaviors that may point to invertebrate consciousness.

Invertebrates "are not just little people," notes Marlene Zuk, an evolutionary biologist at the University of Minnesota in St. Paul. They experience the world very differently. So we may never know for sure if invertebrates are conscious, scientists say. But if they are, consciousness may manifest in them quite differently than in humans.

Read more about this story online and in the May issue of Science News Explores, our award-winning magazine for young people. While paging through that issue, you can learn about a hack to trick AI-voice recognition spyware and an evaluation of the ladder-like strength of Rapunzel's hair.

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Secrets of space

New data hint that dark energy's density, commonly thought to remain constant, might vary over time, ***Emily Conover*** *reported in "3-D map hints at dark energy's secrets"* (SN: 5/4/24 & 5/18/24, p. 6)*.*

In the standard picture of the cosmos, the amount of dark energy is increasing as the universe expands. Reader **Mark Granville** wondered where new dark energy comes from.

Dark energy's source is an enduring mystery. Quantum fluctuations in empty space, in which particles pop into existence for extremely brief moments, could be one explanation, **Conover** says. But these fluctuations yield even more questions. Some calculations predict that much more dark energy exists than researchers are observing in the universe, by 120 orders of magnitude, **Conover** says. Scientists still don't know how to explain that discrepancy.

Feel the pain

Tattooing experiments suggest that the tattoos of Ötzi the Iceman, who lived 5,200 years ago, were hand poked, not sliced, into his skin, ***Bruce Bower*** *reported in "How Ötzi the Iceman really got his tattoos"* (SN: 5/4/24 & 5/18/24, p. 4)*.*

Reader **Amy Perry** wondered whether the tattooing process was painful for Ötzi and whether pain relief measures were available.

Tattoos generally can be painful. The pain a person experiences depends on their pain tolerance, the tool and technique used, and tattoo size and placement on the body, says archaeologist **Aaron Deter-Wolf** of the Tennessee Division of Archaeology in Nashville.

Scientists can't know for sure the level of pain Ötzi felt during the tattooing process. But the relatively small markings and his rugged lifestyle may mean that the tattoos did not cause him too much pain, **Deter-Wolf** speculates.

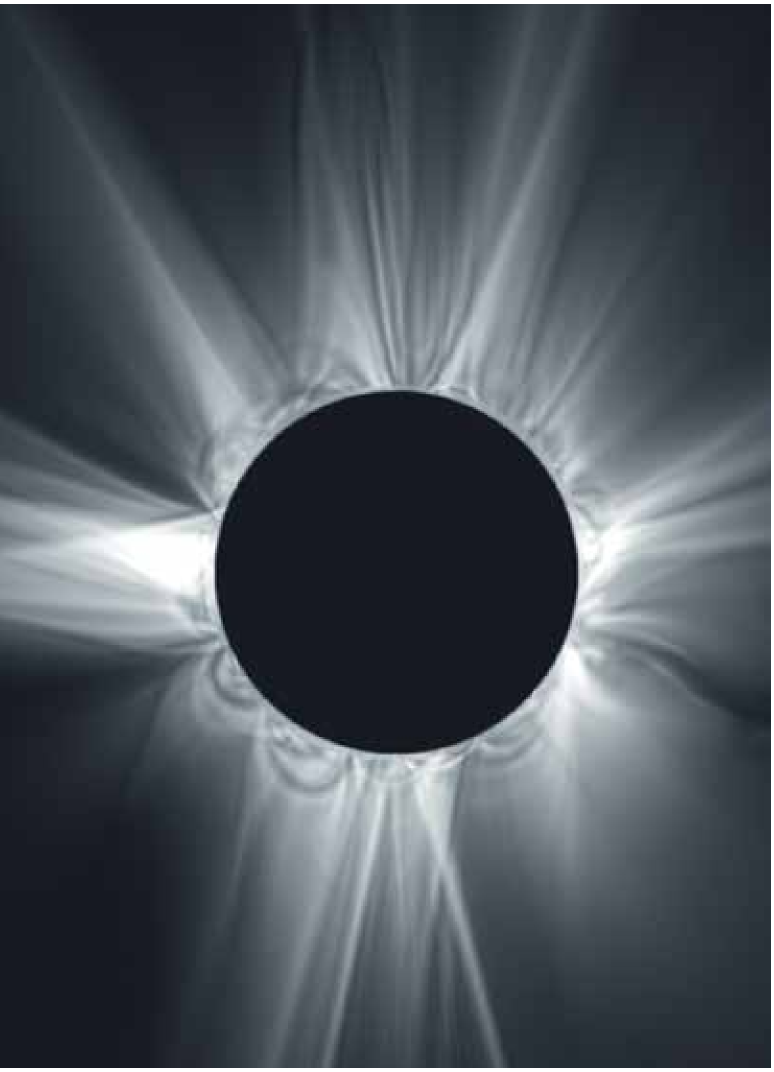
Whether Ötzi used pain relief for the tattoos is unknown. His mummified body was found with natural substances that have disinfecting and pain-relieving properties. Scientists think that the Iceman may have used these substances, which include bog mosses and a type of fungus called birch polypore, to dress wounds during his final days. It's hard to say whether he applied the substances to his tattoos, which had long since healed, says **Katharina Hersel**, a spokesperson at South Tyrol Museum of Archaeology in Bolzano, Italy, where Ötzi is kept.

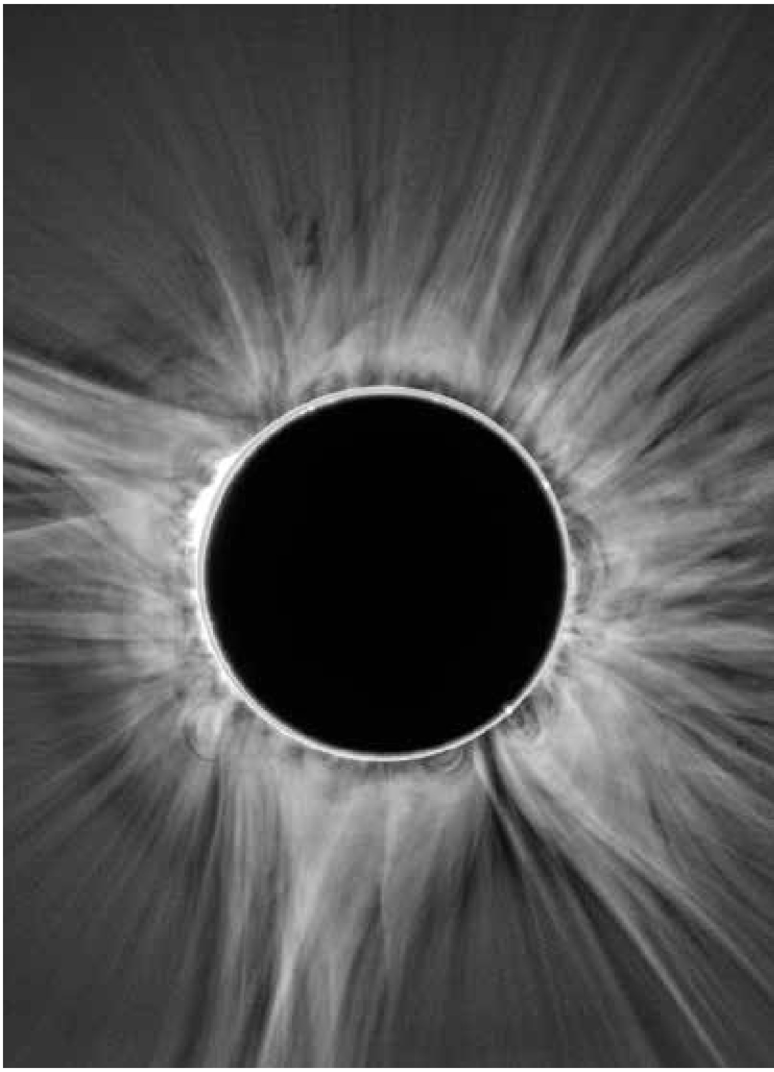
Sleeper species

Some invasive plants lurk for hundreds of years in a new location before choking out native species there, ***Susan Milius*** *reported in "Plant invasions can take centuries"* (SN: 5/4/24 & 5/18/24, p. 15)*.*

Reader **Christina Gullion** asked if the lags are driven by genetic mutations that, over time, allow initially well-behaved invaders to thrive in a new environment.

This is one potential explanation, says invasion ecologist **Shaun Coutts** of the University of Lincoln in England. Previous studies have suggested that adaptations may arise and spread within an invasive population after it has arrived in its new home, **Coutts** says.





Here's how a prediction of the sun's corona during the 2024 eclipse fared

For most folks, the spectacular sight of the sun's fiery corona can be seen only during a total solar eclipse. But even before the widely watched event on April 8, researchers at Predictive Science Inc. in San Diego had a clue as to what people might see when they looked up (SN: 3/9/24, *p. 24*).

Since 1994, the company's founders have been creating sophisticated computer simulations of the sun's dynamic and magnetized atmosphere. These simulations use constantly updated information about the corona to forecast its appearance.

Such predictions are extremely important for "our colleagues who are studying the corona," says Cooper Downs, an astrophysicist at the company. "It can help with planning [for an eclipse] to say, 'OK, this streamer is in the prediction, maybe we should point our instruments there.'" The predictions also help validate computer models of how the corona works.

The company published its final prediction for this year's eclipse (above left) just a few minutes before totality. That prediction got the corona's appearance (right) close but not perfect, forecasting several long streams that ended up in different places. Researchers still got good data on these features, Downs says, since they relied on other sources such as satellite imagery for planning and focused on large, stable streamers.

For the previous U.S. total eclipse, in 2017, forecasting was helped by the sun being near solar minimum, a low point in its 11-year activity cycle. Sudden changes on the sun were rare. The company could put out its corona prediction — which closely matched reality — seven days ahead of the eclipse.

This year, the sun is near solar maximum, which drove much of the mismatch between prediction and reality. During solar maximum, the sun is a roiling tempest, with frequent flares bursting forth with no warning. Information about eruptions on its backside couldn't be included in the simulations until the sun rotated and brought that activity into view.

Still, Downs says, he wasn't disappointed by the model's imperfections. It just points, he says, to the need for more holistic observations of the sun. — *Adam Mann*

FROM LEFT: PREDICTIVE SCIENCE INC.; ECLIPSE TEAM OF NANJING UNIV.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