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ScienceNews

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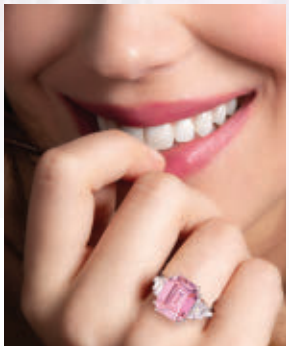

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Fighting the Virus

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Departments

COVER Researchers are learning all they can about the SARS-CoV-2 virus, illustrated. *Vitalli 3D/Alamy Stock Photo*

FROM TOP: VITALLI 3D/ALAMY STOCK PHOTO; ANDREY ATUCHIN; A. BRENNER/HARVARD UNIV.

We have learned much, and need to learn much more

One year ago, the cover of *Science News* focused on the threat posed by a global disease outbreak: measles. Vaccine use had faltered, leading to 1,282 confirmed cases in the United States last year, and more than 400,000 worldwide. Little did we know that we would soon be under attack by a ferocious new viral foe. When this magazine went to press in mid-May, the United States had over 1.5 million confirmed cases of COVID-19 and more than 92,000 deaths, out of 4.9 million confirmed cases and about 324,000 deaths worldwide.

The speed and scope of what has happened to us all is still hard to grasp. I never imagined a world in which going to the grocery store could pose mortal peril, but here we are. Some days it feels as if everything that was once certain in life has been erased by uncertainty and dread.

In this issue, we step back from the daily flood of news to consider where we are in the fight against the virus, less than six months in. It's not where anyone would hope to be: no approved treatments, no vaccines and with many countries still lacking systems for testing or contact tracing.

But we have also learned so much, so fast. Since December 31, when China reported a cluster of pneumonia cases of unknown cause, researchers worldwide have been racing to learn the workings of the new virus, identify its vulnerabilities and develop treatments and vaccines. The pace is dizzying; two prominent online repositories of "preprint" studies, bioRxiv and medRxiv, have posted more than 3,000 coronavirus-related studies since January.

Some of this work, which is not yet peer-reviewed, will turn out to be wrong, such as a study claiming that the virus had recently mutated to be more contagious. But many other efforts will either prove useful in their own right, or help advance the work of others.

We're watching science happen in real time right before our eyes: messy, flawed, riveting. For many of us, never has the effort been greater; never has so much been at stake. —*Nancy Shute, Editor in Chief*

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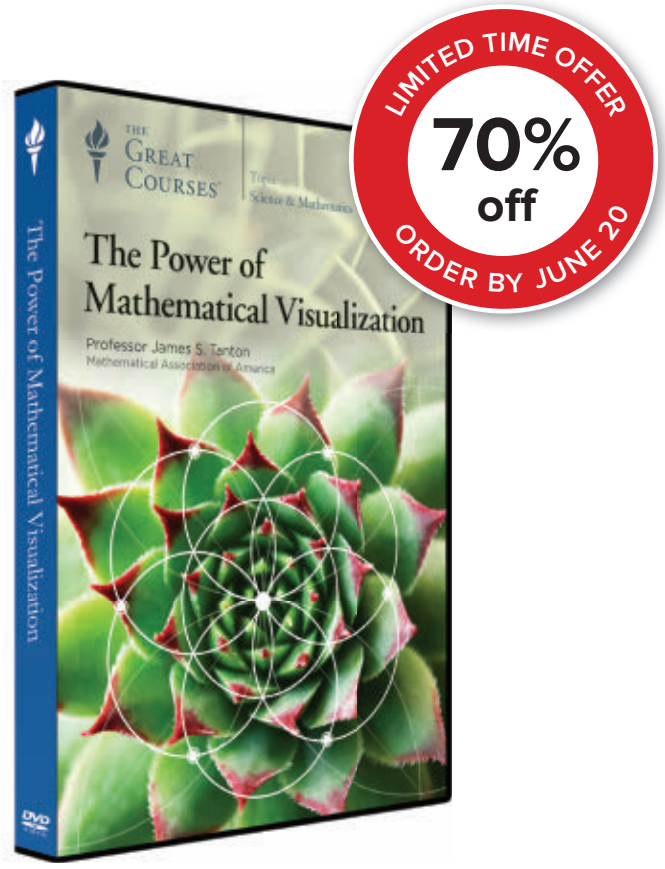

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Excerpt from the June 27, 1970 issue of *Science News*

50 YEARS AGO

Into the eye of a storm

Meteorologists, it has been said, too often are forced to combine inadequate observations with unsupportable assumptions.... To draw more information from the atmosphere and the hearts of storms, meteorologists are turning to a host of electronic aids. Laser beams, microwaves and sound, radio and infrared waves are all being used.

UPDATE: Improvements to radar and satellite technologies have enhanced researchers' abilities to forecast severe storms. Data collected from airplanes flying through hurricanes and thunderstorms have helped clarify how the storms form and provided insights into the strength and speed of storm winds (*SN: 6/2/12, p. 26*). In the early 2010s, the U.S. radar network, which tracks nationwide storm activity, added dual-polarized radar technology to strengthen estimates for rain or snowfall in locations across the United States. In terms of satellites, GOES-16, launched by the United States in 2016, provides images at four times better resolution than previous GOES satellites (*SN Online: 9/21/17*).

Two people stand under sauropod footprints bulging from a cave ceiling in France.

THE SCIENCE LIFE

This paleontologist goes spelunking for dino prints

Crawling through tight underground passages in southern France, paleontologist Jean-David Moreau and his colleagues have to descend 500 meters to reach the only known footprints of long-necked dinosaurs called sauropods ever found in a natural cave.

The team discovered the prints, left by behemoths related to *Brachiosaurus*, in Castelbouc Cave in December 2015. But getting to the site might make even the most hardened field scientists balk. Wriggling through such dark, damp and cramped spaces is challenging for elbows and knees, and even trickier when carrying delicate equipment such as cameras, lights and laser scanners.

It's physically exhausting and "not comfortable for someone claustrophobic," says Moreau, of the Université Bourgogne Franche-Comté in Dijon. It can be dangerous too, as some parts of the cave are periodically flooded.

Paleontologist Jean-David Moreau examines a three-toed dinosaur footprint in Malaval Cave.

Moreau's team is one of only two to have discovered dinosaur footprints in natural caverns. The first prints his team found were at a site called Malaval Cave, 20 kilometers from Castelbouc. Carnivorous dinosaurs left those three-toed prints, each up to 30 centimeters long, about 200 million years ago.

The five-toed herbivore tracks in Castelbouc Cave are each up to 1.25 meters long and were left by three enormous sauropods that walked the shoreline of a sea about 168 million years ago. What's more, the prints are on the cave's ceiling, about 10 meters above the floor, the team reports online March 25 in the *Journal of Vertebrate Paleontology*.

The tracks on the roof are "counterprints," Moreau says. Footprints in clay were filled in by sediment. The clay eroded to form the cave, leaving casts of the prints in the ceiling.

The prints, which hail from the mid-Jurassic Period when sauropods were diversifying and spreading across the world, confirm that the herbivores inhabited coastal or wetland environments in what is now southern France.
— John Pickrell

FROM TOP: RÉMI FLAMENT; VINCENT TRINCAL

MYSTERY SOLVED

A 'crazy beast' finally gets some relatives

A mysterious house cat–sized mammal (illustrated) has been identified as a new species of gondwanatherian, a member of an enigmatic group that lived during the age of dinosaurs.

The ancient mammal *Adalatherium hui* is so weird that it eluded classification for nearly two decades.

A skeleton of the species, roughly 70 million years old and uncovered in Madagascar in 1999, was clearly a mammal. But the skeleton boasted several distinctly unmammalian features, such as a large hole on top of its snout. Also, although the animal's forelimbs were aligned with the spine, like a typical mammal, the back legs were splayed out to the sides like a reptile.

"It is so strange compared to any other mammal, living or extinct," says paleontologist David Krause of the Denver Museum of Nature & Science. "It was just crazy." Hence the name *Adalatherium hui*, from a Malagasy word meaning "crazy" and the Greek word for "beast."

Now, the crazy beast has been identified as a gondwanatherian — a member of an obscure group of mammals that roamed the Southern Hemisphere during the age of dinosaurs, Krause and colleagues report online April 29 in *Nature*. The key to ID'ing the animal was comparing its fossil with an intact skull from a known gondwanatherian, discovered in 2014 also in Madagascar. The arrangement of bones in the skull's snout matched that of *A. hui*, pegging the animals as relatives.

Placing *A. hui* among the gondwanatherians gives new insight into how this group fit into the mammal family tree. Until 2014, the only other known traces of gondwanatherians were a handful of teeth and jaws. Given the historically sparse fossil record for gondwanatherians, "we knew very little about their anatomy," and therefore how they were related to other ancient animals, Krause says.

But the features of *A. hui*'s nearly complete skeleton reveal that it was closely related to a mammal group called multituberculates, living mostly in the Northern Hemisphere around the same time (*SN: 12/14/96, p. 378*). "It's almost like we have a southern counterpart to the multituberculates" in the gondwanatherians, Krause says.

Try saying that 10 times fast.

— Maria Temming

HOW BIZARRE

Physicists foil an oobleck party trick

Running on oobleck is a classic science party trick. When hit forcefully, the liquid mixture of cornstarch and water solidifies. But a new technique could sink would-be runners.

In lab tests, a cylinder dropped onto oobleck's surface sank more quickly when the mixture's container was rapidly rotated clockwise and counterclockwise, physicist Meera Ramaswamy of Cornell University and colleagues report May 8 in *Science Advances*. Normally, the impact would cause particles of cornstarch to come into contact, jamming up into a solid. But by oscillating the container, "you basically move the particles so they are no longer in contact," Ramaswamy says. The same effect would sink a foot hitting the surface of oobleck in a rotating tub. *— Emily Conover*

SCIENCE STATS

Deep-sea mining may scar ecosystems for decades

Microbe communities living in the seafloor off Peru haven't bounced back 26 years after a deep-sea mining experiment. Mined regions could take more than 50 years to fully recover, researchers report April 29 in *Science Advances*.

From 1989 to 1996, the DISCOL experiment plowed grooves into the South Pacific seafloor to mimic deep-sea mining for valuable metal-bearing rocks. Though the effects of such mining have concerned researchers, there is little data on how the ecosystem, particularly the microbes that cycle nitrogen between the seafloor and bottom waters, fares.

50+
years
Time for microbe communities to recover from deep-sea mining

In 2015, scientists compared the grooves with five-week-old tracks. Cell counts of microbes in the young tracks were reduced by about 50 percent compared with undisturbed areas; in DISCOL tracks, cell numbers were reduced by about 30 percent. *— Carolyn Gramling*

FROM TOP: ANDREY ATUCHIN; BRETT MORRISON/BEAKERHEAD/FLICKR (CC BY-NC-ND 2.0)

EARTH & ENVIRONMENT

Deadly heat and humidity are here

Temperatures predicted for later this century already occur

BY JONATHAN LAMBERT

Climate change is already testing the limits of one of our superpowers — sweating.

When temperatures rise, sweat cools the skin to prevent overheating. But when it gets too hot and humid, the laws of physics inhibit this self-cooling. That threshold is reached when a bulb thermometer wrapped in a wet cloth, a "wet-bulb" temperature, hits 35° Celsius (95° Fahrenheit). Even the fittest person with an unlimited water supply probably wouldn't survive for more than a few hours in such conditions.

That extreme wet-bulb temperature was thought to rarely, if ever, occur, though climate simulations suggest that this temperature will become more common toward the latter half of the century in certain regions, endangering hundreds of millions of people (*SN: 9/2/17, p. 10*).

It turns out we won't have to wait that long for such lethal heat and humidity.

An analysis of global weather data shows that this survivability limit has been briefly surpassed at least a dozen times in the last four decades along the Persian Gulf in the Middle East and in the Indus River Valley in Pakistan and India, researchers report May 8 in *Science Advances*. Lower but still dangerous wet-bulb temperatures are increasingly common in summer across larger swaths of the Middle East, South Asia and the U.S. Gulf Coast.

"We expect these extreme wet-bulb values to be rare, but to become more common as the world warms," says climate scientist Matthew Huber of Purdue University in West Lafayette, Ind., who wasn't involved in the study. "It's disturbing to see it happening in real time."

Researchers have only recently begun using statistical simulations to estimate where and when this extreme moist-heat threshold will be approached or crossed. The models simplify and aggregate weather data across a region; fine details often get sacrificed in service of broader trends, potentially obscuring local spots where the threshold is briefly reached.

Those fine details matter to Colin Raymond, a climate scientist at NASA's Jet Propulsion Laboratory in Pasadena, Calif. Whether temperatures already have reached this physiological limit somewhere on Earth "seems almost to be an essential piece of knowledge for us as a species," he says.

His team scoured data from 4,576 weather stations, looking for instances of extreme wet-bulb temperatures and tracking trends from 1979 to 2017. Extreme wet-bulb temperatures have occurred mostly along subtropical coasts, where warm, moist air from the ocean collides with hot air on land. In South Asia, monsoon winds fuel such extremes.

Wet-bulb temperatures at or beyond the physiological limit, 35° C, were rare, mostly confined to an hour or two at spots along the Persian Gulf.

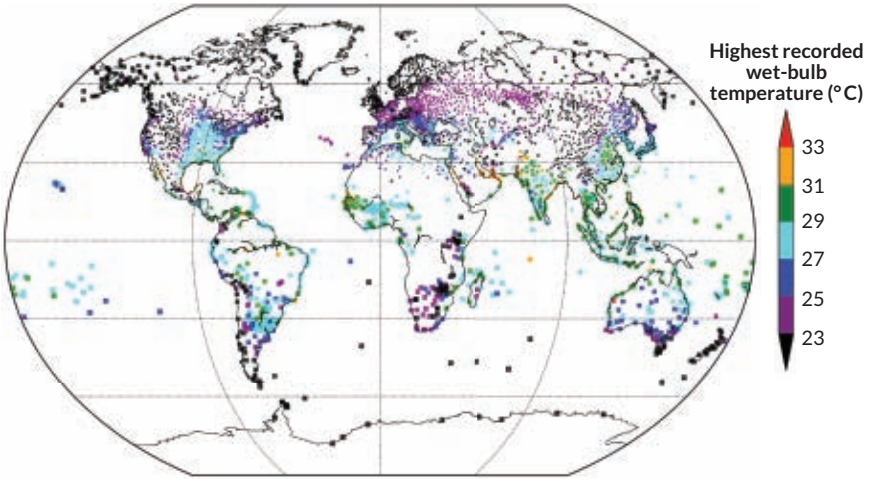
The team also documented wet-bulb temperatures of 33° C, roughly translating to a heat index of 60° C (139° F). That temperature is just shy of the physiological limit but still "much hotter and more humid than many of us have experienced," Raymond says. Forty years ago, these events happened once or twice a year. But now, such events happen 25 to 30 times a year. "There is a doubling or more of these extreme events over four decades," says Raymond, who did the study while at Columbia University.

Joy Merwin Monteiro, a climate scientist at the Indian Institute of Science Education and Research in Pune, notes that simulations predicting that these temperatures wouldn't arrive until later this century weren't necessarily wrong. "Models are too coarse to give a clear picture of what's happening at these finer spatial and temporal scales." Complementing existing models with more detailed, on-the-ground data was long overdue, Monteiro says.

If carbon emissions aren't drastically curbed, conditions in some places will become unbearable without technology like air conditioning, and outdoor labor will become nearly impossible, Raymond says.

"We may have to rethink how to live in a place that's experiencing conditions outside of what we've evolved to experience," he says. "Living in the Persian Gulf in the summer may come to resemble living at the South Pole in the winter." ■

Maximum humid heat, or wet-bulb, measurements, 1979–2017



Too-hot spots Data from 4,000 weather stations show which regions have experienced the highest "wet-bulb" temperatures, a measure of heat and humidity. Red represents a mix of heat and humidity that's close to or at the threshold at which humans can't survive for long.

C. RAYMOND, T. MATTHEWS AND R.M. HORTON/*SCIENCE ADVANCES* 2020

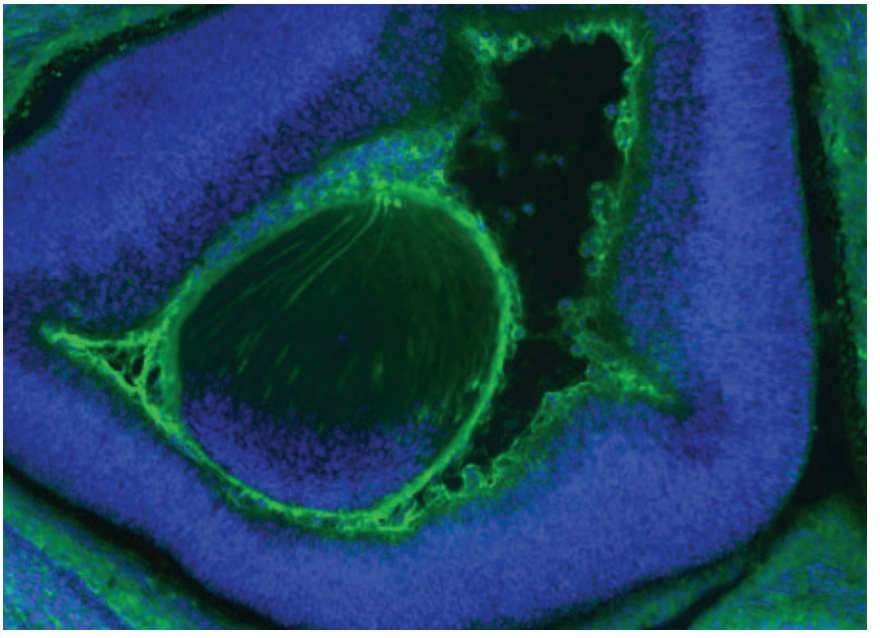
Explore an interactive version of the map at **bit.ly/wet-bulb_map**

GENES & CELLS

Mouse embryos host human cells

Chimeras are a step toward growing human organs

BY LAURA SANDERS



Human cells (green) pack into a developing eye (blue) in this mouse embryo.

J. FENG

Scientists have made embryos that are a lot mouse and a little bit human.

With a bit of help, human stem cells can knit themselves into growing mouse embryos, populating the developing liver, heart, retina and blood, researchers report May 13 in *Science Advances*.

Finicky human cells don't tend to grow well in other animals. But for one of the new mouse embryos, 4 percent of its cells were human — the most thorough mixing between human and mouse yet.

That level of integration is "quite striking," says Juan Carlos Izpisua Belmonte, a stem cell and developmental biologist at the Salk Institute for Biological Studies in La Jolla, Calif. If other scientists can replicate the findings, "it potentially represents a major advance," says Izpisua Belmonte, who was not involved in the study.

Such chimeras could help reveal how a single cell can give rise to an entire organism. Humanized animals could also prove valuable in studying diseases such as malaria that affect people more than other animals. And with more advances, chimeras could ultimately turn out to be a source of human organs.

Many scientists have hit roadblocks in growing human stem cells in mice or other animals, including pigs and cows. "We have analyzed thousands of embryos but never saw robust chimeric contribution" of human stem cells to mouse embryos beyond day 12, says stem cell and developmental biologist Jun Wu of the University of Texas Southwestern Medical Center in Dallas, who wasn't involved in the study.

The new method's success comes down to timing, says neuroscientist and stem cell biologist Jian Feng. To grow and thrive in a mouse embryo, human stem cells' developmental clocks must be turned back to an earlier phase called the naïve stage. "You need to basically push the human cells back" to that phase, says Feng, of the University at Buffalo in New York.

> Human cells knitted themselves into tissues destined to become the liver, heart, bone marrow and blood.

Feng and his colleagues reset the stem cells' clocks by silencing a protein called mTOR for three hours. This brief treatment shocked the cells back to their naïve stage, presumably restoring their ability to turn into any cell in the body.

Researchers injected batches of 10 to 12 of these more youthful human stem cells into mouse embryos containing about 60 to 80 mouse cells and allowed the embryos to develop for 17 days.

To outward appearances, these embryos grew normally despite harboring human cells. By tallying DNA that was specific to either mouse or human, the researchers found that human cells accounted for between 0.1 and 4 percent of the total cells in the embryos.

Human cells knitted themselves into tissues destined to become the liver, heart, bone marrow and blood. Human red blood cells were particularly abundant in these mouse embryos, the researchers found. A small number of human cells showed up in tissue that will form the brain; one embryo had a swarm of human photoreceptors, eye cells that help detect light.

As far as the researchers could tell, no human cells were among the cells that go on to form sperm and egg. The capacity of chimeras to reproduce is one of the worrisome ethical questions that scientists are still trying to figure out.

Once inside a mouse embryo, the normally sluggish developmental pace of the human cells sped up to match their hosts. Human stem cells typically are slow to turn into certain types of mature photoreceptors, liver cells or red blood cells, Feng says. But "you put the same human cells in a mouse embryo, [and] they go fast," he says. "In 17 days, you get all these mature cells that would otherwise take months to get in a normal human embryo."

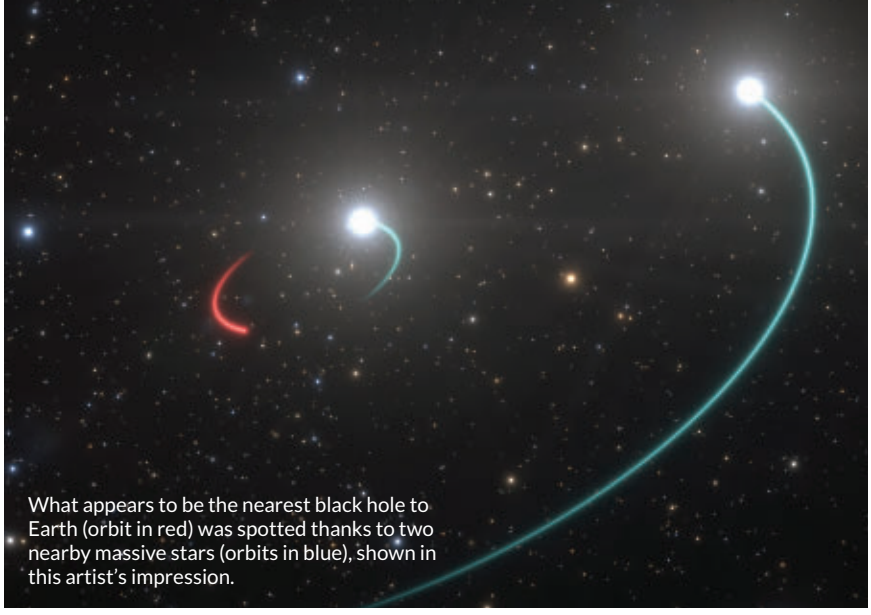
Other scientists emphasize that different laboratories need to repeat the experiments. But "if it works — a big if here — this has big implications," Wu says. ■

ATOM & COSMOS

Is this Earth's closest black hole?

Object with two companions is just 1,000 light-years away

BY LISA GROSSMAN



What appears to be the nearest black hole to Earth (orbit in red) was spotted thanks to two nearby massive stars (orbits in blue), shown in this artist's impression.

L. CALÇADA/ESO

What may be the closest black hole to the solar system ever spotted is just 1,000 light-years away. This neighbor is at least 4.2 times as massive as the sun and lives with two ordinary stars whose funny orbits gave the proposed black hole's presence away, researchers report in the May *Astronomy & Astrophysics*.

Astronomers expect the Milky Way to harbor between 100 million and a billion black holes with masses between a few and 100 times the sun's. But most of those black holes are invisible. "If it's lonely out there without a companion, you'll never find it," says astrophysicist Thomas Rivinius of the European Southern Observatory in Santiago, Chile.

The few dozen small black holes that have been spotted so far gobble up gas from a companion star and heat the gas until it emits X-rays. The previous nearest known black hole emits X-rays from about 3,200 light-years from Earth.

The neighbor black hole, in a system called HR 6819, is not actively eating and so is invisible, Rivinius and colleagues say. But it appears to have two companions: a star that the black hole orbits every 40 days that is heavier and hotter than the sun, and a more distant, massive star orbiting the star–black hole pair that is rotating so fast that it's almost breaking apart. The two stars' motions hinted that something weighing at least four solar masses was orbiting with them, unseen.

"We would have seen it if it was a normal star," Rivinius says. "If it's not a normal star, the only thing it can be otherwise is a black hole."

There could be many other unseen black holes of similar mass in the Milky Way, says study coauthor Marianne Heida, an ESO astronomer based in Garching, Germany. "It would be a little bit too convenient, if there's only one in the Milky Way, that it's right next door."

A team led by Stanislav Štefl, then of ESO in Santiago, first suspected the

MATTER & ENERGY

Supercurrent flows on a material's rim

Strange superconductor could improve quantum computers

BY EMILY CONOVER

Superconductors are getting edgy.

For the first time, scientists have spotted a superconducting current traveling along the edge of a material, like a trail of ants crawling along the rim of a dinner plate without venturing into its middle.

Normally, superconducting currents, in which electricity flows without any loss of energy, permeate an entire material. But in a thin sheet of molybdenum ditelluride chilled to near absolute zero, the interior and edge make up two distinct superconductors, physicist Nai Phuan Ong and colleagues report in the May 1 *Science*. The two superconductors are "basically ignoring each other," says Ong, of Princeton University.

This distinction between exterior and interior makes molybdenum ditelluride an example of what are called topological materials. Their behavior is closely tied to the mathematical field of topology, in which shapes are considered distinct only if one can't be molded into another without cutting or melding. In topological insulators, electric currents can flow on the surface of a material but not the interior, like a potato covered in tinfoil.

Topological superconductors are superconducting in their interiors and behave differently on their surfaces. Although some researchers suspected topological superconductors might also host superconducting current on their edges, no such supercurrents had been found. But the new observation is "extremely convincing," says physical chemist Claudia Felser of the Max Planck Institute for Chemical Physics of Solids in Dresden, Germany.

Molybdenum ditelluride is a metal-like compound called a Weyl semimetal (*SN: 8/22/15, p. 11*). Its unusual properties might mean it could harbor Majorana fermions, disturbances within a material that scientists hope to use to create better quantum computers. Such topological quantum computers are expected to resist the jitters that impair quantum calculations (*SN: 8/9/17, p. 8*).

In their experiment, Ong and colleagues gradually ramped up the magnetic field on the material. They measured how much they could increase the electric current before the superconducting edge state was lost, a value known as the critical current. As the magnetic field increased, the critical current oscillated,

black hole's presence more than 10 years ago while studying fast-spinning pairs of stars. The team thought there might be a third, invisible object locked in an orbital dance with the two visible stars.

But in 2014, before the team could publish the observations, Štefl died in a car accident. "I consider this part of his legacy, this work," Rivinius says.

The team picked up the work again after a black hole in a system called LB-1 was reported in 2019. That black hole appears to orbit a more ordinary star and seems weirdly heavy, about 68 times the sun's mass. Rivinius' team thinks that, like HR 6819, LB-1 may actually have a smaller black hole with two companions.

HR 6819 and LB-1 could be more ordinary than they appear, says astrophysicist J.J. Eldridge of the University of Auckland in New Zealand. Instead of a black hole, the systems could involve a third massive star with a disk around it, she says. Because of the way that the observations were made and the complexity of the orbits, "it would be really, really difficult to disentangle," she says. "The interpretation of a black hole is more interesting, but also may not be correct." ■

getting larger, smaller and larger again in a repeating pattern — a hallmark of an edge superconductor.

The oscillation results from the weird physics of superconductors, in which electrons form partnerships called Cooper pairs. The pairs act as a unified whole, all taking on the same quantum state, or wave function, which determines the probability of a particle being found at a particular location.

A property of the wave function called the phase is analogous to twists in a party streamer hung around the edges of a room, Ong says. If connected at the ends, the party streamer can twist once or twice, but never 1.2 times, for example, because the ends wouldn't align. Similarly, the phase must make a full number of twists around the material. The interplay between the increasing magnetic field and the twisting constraint causes the critical current to oscillate. ■

ATOM & COSMOS

A mystery: Why is the sun so quiet?

Our star is less magnetically active than similar stars

BY LISA GROSSMAN

The sun might be a slacker. A star census shows that the sun is less magnetically active than others of its kind, astrophysicists report in the May 1 *Science*. The result could support the idea that the sun is in a "midlife crisis," transitioning into a quieter phase of life. Or it could mean that the sun has capacity for much more magnetic oomph than it's shown in the past.

"Our sun could potentially become [as] active" as other stars, says Timo Reinhold of the Max Planck Institute for Solar System Research in Göttingen, Germany.

A star's magnetism can drive dramatic outbursts such as coronal mass ejections. Understanding the sun's magnetic field is thought to be the key to predicting those outbursts, which can damage satellites and shut down power grids on Earth.

Magnetic fields also create a star's dark sunspots and bright spots called faculae. These spots change with magnetic activity, altering a star's brightness.

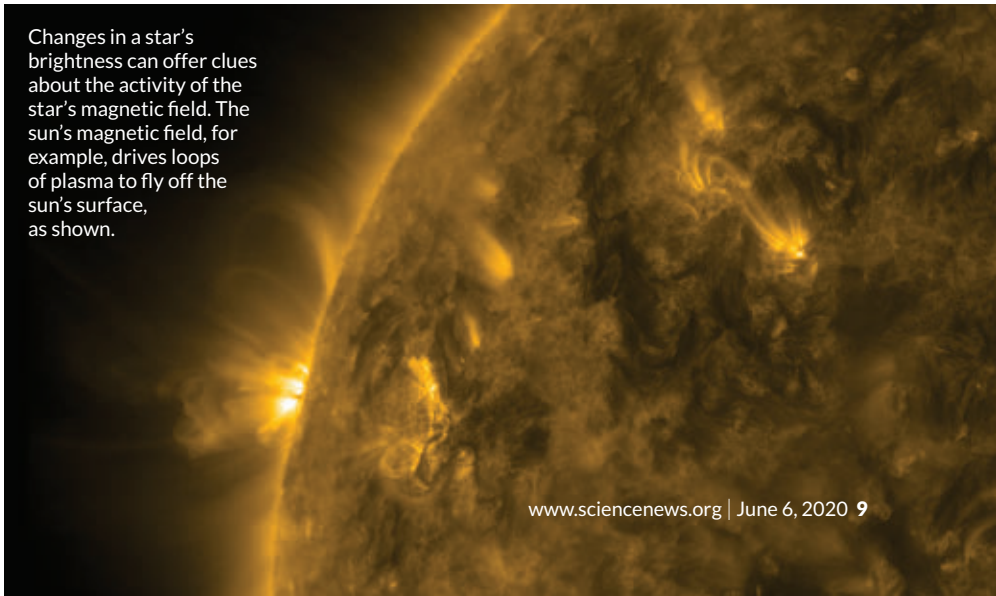
Astronomers have tracked those surface features since the 17th century. While the sun's magnetic activity waxes and wanes in an 11-year cycle, the sun has been fairly calm while humans have been watching. Inferences from radioactive elements found in tree rings and ice cores suggest that the overall cycle of magnetic activity has held steady for the last 9,000 years.

Because other stars are so far away, tiny changes in brightness that reveal magnetic changes were hard to detect until the Kepler space telescope launched in 2009. Kepler found exoplanets by recording dips in starlight as planets orbited in front of stars. Kepler also noted other changes in the brightness of stars.

With Kepler data from 2009 to 2013, Reinhold's team studied 365 stars whose age, surface gravity, chemical makeup, temperature and rotation period are similar to the sun's. The stars were up to five times as magnetically active as the sun.

Either something is different about those stars, Reinhold says, or the sun may go through periods of greater magnetic activity than has been recorded.

Astronomer Travis Metcalfe of the Space Science Institute in Boulder, Colo., offers another explanation. Stars are expected to continually lose momentum and slow their spins as they get old. But in 2016, he and colleagues reported that Kepler saw stars rotating too fast for their old age. The team suggested that stars stop their slowdowns in middle age due to a change in their magnetic field (*SN: 8/31/19, p. 11*). The new result "could be the best evidence yet that the sun is in the midst of a magnetic midlife crisis," says Metcalfe. The study's hyperactive stars appear to be slightly younger than the sun and so may not have transitioned yet. ■



Changes in a star's brightness can offer clues about the activity of the star's magnetic field. The sun's magnetic field, for example, drives loops of plasma to fly off the sun's surface, as shown.

SOLAR DYNAMICS OBSERVATORY/GSFC/NASA

EARTH & ENVIRONMENT

Early start for plate tectonics proposed

Crust may have traveled in modern ways by 3.2 billion years ago

BY CAROLYN GRAMLING

Modern plate tectonics may have gotten under way as early as 3.2 billion years ago, about 400 million years earlier than many scientists thought. That timing suggests that the movement of large pieces of Earth's crust could have played a role in making the planet more hospitable to life.

Alec Brenner, a Harvard geologist, and colleagues measured the magnetic orientations of iron-bearing minerals in the Honeyeater Basalt, a rock layer that formed between 3.19 billion and 3.18 billion years ago. The basalt is part of Australia's East Pilbara Craton, which includes rocks as old as 3.5 billion years.

This craton, an ancient bit of continent, was on the move between 3.35 billion and 3.18 billion years ago, drifting at a rate of at least 2.5 centimeters per year, the team reports April 22 in *Science Advances*. That's a speed comparable to modern plate motions.

The basalt, which burbled up as lava and hardened during the journey, contains iron-bearing minerals that point the way toward Earth's magnetic poles. While the lava was still molten, the minerals rotated, orienting themselves to align with the north magnetic pole. By tracking the changes in orientation within the lava as more basalt formed during the journey, the researchers were able to determine the craton's speed.

Scientists have long used such magnetic signposts to retrace the steps of continents. But the constant grinding and shifting of tectonic plates over the last few billion years has reworked Earth's surface many times over, leaving few outcrops older than 3 billion years. The Honeyeater Basalt is a rare site, both ancient and relatively unworked by heat and pressure that could have altered the minerals and reset their orientation.

The team examined 235 samples of the basalt to create a high-resolution map of magnetic orientations within the rock.

Based on the map, the team estimates that about 3.2 billion years ago, the East Pilbara Craton was at a latitude of about 45°, Brenner said April 21 in a news conference. But scientists don't know if the craton was north or south of the equator because they don't know the orientation of the magnetic poles back then. Either way, this crust moved steadily for a long way — a hallmark of modern plate tectonics, the researchers say. Today, the craton is at about 21° S, just north of the Tropic of Capricorn.

Plate tectonics is generally thought to have become well-established no earlier than about 2.8 billion years ago. Before that, Earth's interior was thought to be too hot for cold, rigid plates to form or for subduction to occur, in which one plate dives beneath another.

An earlier start for plate tectonics would have implications for the evolution of life, Brenner said. Whether the process was in operation when single-celled organisms emerged, thought to be at least 3.45 billion years ago, isn't clear, he said.

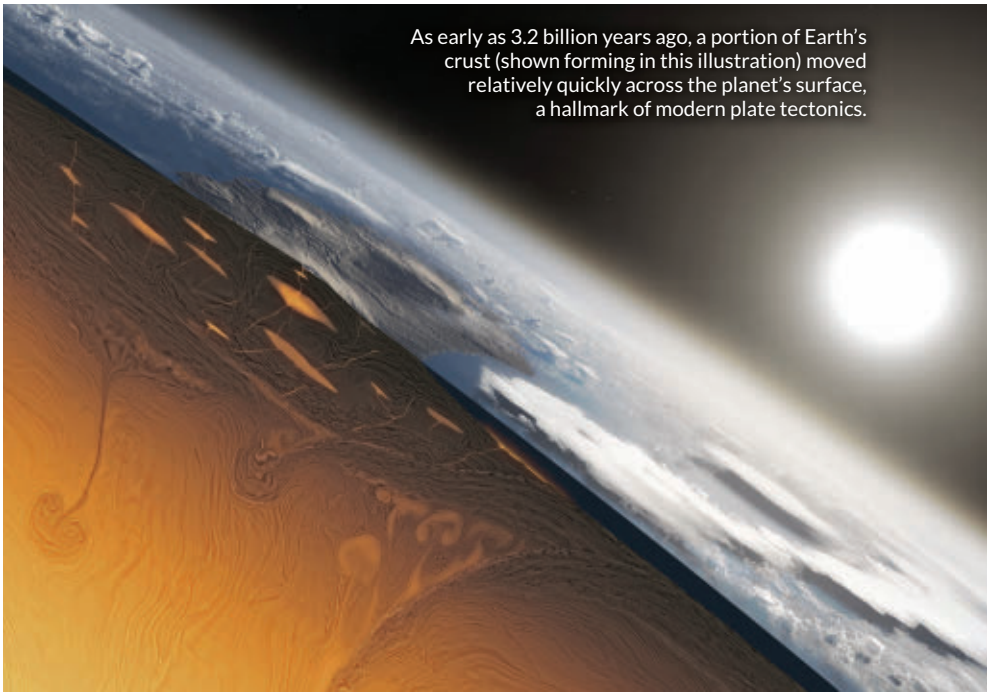
But plate tectonics is linked to the biosphere today: Plate tectonics modulates climate over millions to billions of years by promoting chemical reactions between once-buried rocks and the atmosphere. "So if [plate tectonics] happened on the early Earth, these processes were likely playing a part in the evolution of life," Brenner said.

Active, modern-style plate tectonics is the most likely explanation for the data, the researchers say. But they acknowledge that they can't yet rule out other explanations. For example, some researchers think there was a proto–plate tectonics process in which bits of crust moved in fits and starts as the planet began to cool after its formation (*SN: 6/2/12, p. 11*).

The new data could support episodic rather than gradual plate motion, says Michael Brown, a geologist at the University of Maryland in College Park. After its burst of speed, the craton slowed considerably, from 2.5 cm/yr to 0.37 cm/yr, he notes.

Early plate tectonics may have been regional, kick-started by large meteorite impacts or by plumes rising from the mantle, says Stephan Sobolev, a geophysicist at the University of Potsdam in Germany. Those forces could have broken apart Earth's surface, generating regional cells in which blocks of crust sank into the mantle.

Such a regional cell may have formed the East Pilbara Craton, Sobolev says. But for that bit of crust to have traveled so far so quickly, he says, "large-scale subduction must have been involved" — a surprising possibility for early Earth. ■



As early as 3.2 billion years ago, a portion of Earth's crust (shown forming in this illustration) moved relatively quickly across the planet's surface, a hallmark of modern plate tectonics.

A. BRENNER/HARVARD UNIV.

ATOM & COSMOS

Hydrogen worlds could harbor life

Earthlike atmosphere is not a necessity, lab study suggests

BY LISA GROSSMAN

Microbes can grow in a wide variety of atmospheres, including those made of pure hydrogen, tests show. The finding could widen the range of environments where astronomers seek signs of life.

"We're trying to expand people's view of what should be considered a habitable planet," says exoplanet astronomer Sara Seager of MIT.

Seager and colleagues put *E. coli* and yeast in bottles with some nutrient broth. The team displaced the air in six bottles and replaced it with pure hydrogen, pure helium or a mixture of 80 percent nitrogen and 20 percent carbon dioxide. A final set of bottles was left with Earth air (about 78 percent nitrogen, 21 percent oxygen and 1 percent other gases).

Every few hours, the researchers assessed how many microbes were alive. Microbes replicated in every atmosphere tested, the team reports May 4 in *Nature Astronomy*, thriving most in Earth air.

The results suggest that checking planets with hydrogen atmospheres may be a good strategy for finding signs of life. Because hydrogen is so light, an atmosphere of all or mostly hydrogen would be puffier than an atmosphere of mostly helium or nitrogen. A hydrogen atmosphere, for example, would extend up to 14 times farther from the surface than Earth's nitrogen-dominated atmosphere. That means more starlight would filter through the atmosphere before reaching Earthly telescopes, making it easier to probe for signatures of life.

But just seeking a hydrogen-rich atmosphere isn't enough, says astrobiologist John Baross of the University of Washington in Seattle. For life to arise, a planet would also need to have the equivalent of the nutrient broth, perhaps a liquid water ocean that exchanges chemicals with a rocky surface.

It's not clear if rocky planets with pure hydrogen atmospheres exist. Based on what's known about how planets form, such atmospheres should be rare, says MIT planetary scientist Daniel Koll, who was not involved in the work.

Seager notes that the study might not be surprising to biologists. After all, Earth microbes can live in hydrogen-rich environments. And both *E. coli* and yeast can survive without oxygen, but since neither microbe is adapted to a purely hydrogen environment, Seager thought it was worth testing.

Koll agrees. "This is a very in-your-face demonstration that if Earth life can exist under hydrogen atmosphere conditions, then certainly alien life should be able to," Koll says. "We shouldn't limit, or be too Earth-centric, in what we consider interesting when we study other planets." ■

LIFE & EVOLUTION

Drunk elephants may not be a myth

Metabolizing alcohol could be difficult for certain mammals

BY SUSAN MILIUS

An elephant, a narwhal and a guinea pig walk into a bar. From there, things could get ugly.

All three might get drunk easily, as they're among the creatures on 10 branches of the mammalian family tree where the *ADH7* gene has broken. Inheriting a dysfunctional form of that gene might make it harder for these animals' bodies to break down ethanol, says molecular anthropologist Mareike Janiak of the University of Calgary in Canada.

She and colleagues didn't look at all the genes needed to metabolize ethanol, but the failure of this important one might allow ethanol to build up more easily in the bloodstream, Janiak and colleagues report in the April *Biology Letters*.

Most of the animals identified as potentially easy drunks probably don't binge on sugary fruit and nectar that brews ethanol. Elephants, however, will feast on fruit, so the study reopens a debate over whether elephants get tipsy.

Descriptions of elephants behaving oddly after binging on overripe fruit go back at least to 1875, Janiak says. Later, observers reported that after elephants were offered water spiked with ethanol, they swayed more when moving and seemed more aggressive.

In 2006, physiologist Steve Morris of the University of Bristol in England and colleagues attacked that notion as "a myth." They calculated that even if elephants really do feast on fallen, fermenting fruit, the animals could not eat the huge amount necessary to get a buzz. However, that calculation extrapolated from human physiology. The new insight that elephants' *ADH7* gene doesn't work might mean they have a lower tolerance.

It wasn't elephants, though, but tree shrews and their prodigious tolerance for alcohol that inspired the new work, says Amanda Melin, a biological anthropologist also at Calgary. She, Janiak and colleagues surveyed all of the available genetic data on 79 mammal species to indirectly assess responses to alcohol.

Elephants, horses, foxes and some other mammals might have a low alcohol tolerance.

The team found that *ADH7* has lost its function in 10 spots on mammals' family tree. The ethanol-susceptible twigs sprout quite different animals: elephants, armadillos, rhinos, degus, beavers and cattle among them.

In contrast, humans and nonhuman African apes have the reverse situation, a mutation that renders *ADH7* some 40 times as efficient at dismantling ethanol as a typical mammalian version. What gives tree shrews their drinking superpower remains a mystery: They don't have the same superefficient gene.

Finding the gene dysfunction in elephants raises questions about the arguments against inebriation. A slower capacity for clearing ethanol could mean that the smallish amount that an elephant can eat might be enough to change its behavior, Melin says.

Phyllis Lee, director of science for Amboseli Trust for Elephants, has been watching elephants in Kenya since 1982. "In my youth, we tried to brew a form of maize beer (we were desperate), and the elephants loved to drink it." She doesn't take sides in the debate, though she muses that the "huge liver" of elephants would have some detoxifying power.

Lee says she never saw a tipsy elephant, but the home brew "didn't do much for us puny humans either." ■

BODY & BRAIN

Pill could buy time after a snakebite

Drug for treating heavy metal poisoning extended mice's lives

BY CHRISTIE WILCOX

Doctors have long sought a "snakebite pill" that can deliver life-prolonging medicine when and where it's most needed. Tests with a drug that treats heavy metal poisoning are stoking that dream.

Given orally, the drug saved or extended the lives of mice injected with lethal doses of viper venom, researchers report in the May 6 *Science Translational Medicine*.

Snakebites kill tens of thousands of people every year and leave many more with damaged limbs, in part due to difficulty getting quick, effective treatment. Bites often happen in remote areas, so snakebite victims may have to travel hours or even days before reaching a medical facility equipped to provide life-saving antivenom intravenously.

Nicholas Casewell, a biomedical scientist at the Liverpool School of Tropical Medicine in England, and colleagues set out to find something portable and easy to administer that could counteract some of the most widespread, dangerous venom toxins: snake venom metalloproteases. Often a major component in blood-poisoning venoms, like those of many vipers, these toxins cause massive internal hemorrhaging, tissue damage around the bite site and other problems.

The toxins, however, have an Achilles' heel, Casewell says. "They rely on zinc ions to function."

Drugs used to treat heavy metal poisoning bind up loose metal ions, so the scientists wondered if those drugs could also starve venom toxins of zinc. One drug in particular — unithiol — did just that.

Administration of the drug 15 minutes after venom injection delayed the death of mice compared with mice that didn't get the drug, and some even survived the experiment. For example, of

ANDREW LINSCOTT/E+/GETTY IMAGES PLUS

the five mice injected with West African carpet viper venom and given the drug, three lasted from 12 to 21 hours, and two survived the 24-hour experiment. Mice that didn't get the drug died within four hours.

Quickly administered unithiol worked as well as a delayed antivenom treatment — and even better when paired with it, the researchers found. Unithiol also prevented local tissue damage at the site of venom injection.

Researchers have wondered since the 1980s whether drugs that bind to metal ions could treat viper bites, says Leslie Boyer, a doctor who studies envenomation treatment at the University of Arizona in Tucson. "This is an old drug, and it's an old concept that's finally being put to the test," she says. But she stresses that tests in mice aren't the same as tests in humans.

If it does work in people, the treatment has potential "to buy those patients many hours before the onset of really serious symptoms," Casewell says.

The team plans to run a safety trial in sub-Saharan Africa — where viper bites exact a heavy toll — before giving the pill to snakebite victims. Previous trials of the drug before its use as a heavy metal poisoning treatment were conducted exclusively in white European men, so the safety trial is needed to reveal unforeseen side effects in an untested population, Casewell says.

Even if all goes well, Casewell says, "this isn't a single cure-all." The treatment may do little, if anything, for bites from snakes such as cobras whose toxins predominantly target nerves instead of blood. Ultimately, he envisions pairing the pill with other drugs that inhibit more of the major toxins in snake venom, creating a universal snakebite pill.

That kind of accessible, first aid measure is "reasonable to expect ... within the next few years," Boyer says. After that, the next challenge will be to get the drug into the hands of those who need it most, who are often rural and poor, she says. "It won't help at all to have a pill that minimizes the damage from snakebite if you don't have the pill nearby." ■

LIFE & EVOLUTION

Spinosaurus had a tail for swimming

Discovery bolsters claim that the dinosaur was semiaquatic

BY CAROLYN GRAMLING

Spinosaurus didn't just stand in the shallows to snag fish for dinner; the dinosaur may have been an excellent swimmer.

A fossilized tail with a paddle shape found in 95-million-year-old rocks suggests that *Spinosaurus* was semiaquatic, researchers report in the May 7 *Nature*. That's contrary to prevailing wisdom that dinosaurs were solely land dwellers.

"When I first saw the illustrations of the tail, I literally giggled with surprise and delight — and I'm not someone who usually giggles," says vertebrate paleontologist Matthew Lamanna of the Carnegie Museum of Natural History in Pittsburgh, who peer-reviewed the paper for *Nature*. "The tail was just so awesomely weird-looking for a predatory dinosaur."

Spinosaurus was known to have lived near the water and eaten seafood: The animal's cone-shaped teeth would have been adept at grabbing slippery fish. "But for most people, the model they were more comfortable with was a wading dinosaur that waited for the fish to swim by," the way a grizzly bear may splash into the water to catch a fish, says study leader Nizar Ibrahim, a vertebrate paleontologist at the University of Detroit Mercy.

Ibrahim previously proposed that *Spinosaurus* was more than an occasional wader. In 2014, he and colleagues reported that the creature had denser bones than other nonavian theropods, the branch of predatory dinosaurs that includes *Tyrannosaurus rex* (*SN: 10/18/14, p. 10*). Denser bones could be an adaptation to a more aquatic life, allowing for greater buoyancy control.

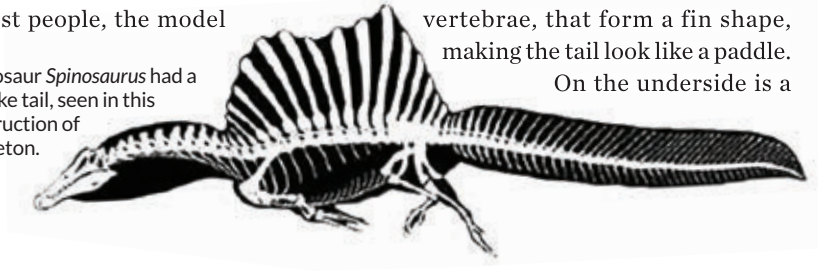
After previously finding *Spinosaurus* specimens in Morocco's Kem Kem beds, Ibrahim's team returned after the 2014 paper was published and unearthed a tail that was about 80 percent complete. The tail has very long neural spines, bony projections on the vertebrae, that form a fin shape, making the tail look like a paddle. On the underside is a row of V-shaped bones called chevrons. Most dinosaur chevrons "are fairly long at the base of the tail, and then get shorter and shorter" toward the tip, Ibrahim says. *Spinosaurus* chevrons are long until near the tail's end.

Ibrahim and colleagues tested the possible power of *Spinosaurus*' tail shape against those of other animals, including two theropods and two modern, semiaquatic animals, a crocodile and a newt.

Plastic tails were swung back and forth by robotic controllers in a water tank, while sensors measured the tails' propulsive efficiency and thrust. *Spinosaurus*' tail performed nearly as well as the semiaquatic animals' tails and far better than the other dinosaurs' tails, Ibrahim says.

That finding suggests *Spinosaurus* could actively pursue prey in the water. "I think it's the nail in the coffin of the idea that dinosaurs never invaded the aquatic world," Ibrahim says.

It's also possible that the extended tail vertebrae were meant for display, not swimming, says Thomas Holtz, a vertebrate paleontologist at the University of Maryland in College Park. "But to be fair, those aren't mutually exclusive things." When the tail shape is considered along with other unusual attributes, he says, "there is a consistent pattern which is certainly suggestive of it being an aquatic animal." ■



The dinosaur *Spinosaurus* had a paddlelike tail, seen in this reconstruction of the skeleton.

N. IBRAHIM *ET AL*/*NATURE* 2020

HUMANS & SOCIETY

An earlier arrival for humans in Europe

Homo sapiens may have influenced Neandertal behavior

BY BRUCE BOWER

A tooth and six bone fragments found in a Bulgarian cave are the oldest directly dated remains of *Homo sapiens* in Europe, scientists say.

Until now, most of the earliest fossils of humans on the continent ranged in age from about 45,000 to 41,500 years old. But those ages are based on dates for sediment and artifacts associated with the fossils, not the fossils themselves. The newfound remains date to between roughly 46,000 and 44,000 years ago, scientists report May 11 in a paper in *Nature* and in a paper in *Nature Ecology & Evolution*.

Researchers previously reported that the earliest human fossil in Europe was a skull fragment found in Greece (*SN: 8/3/19, p. 6*). That fossil may date to at least 210,000 years ago, which would make it the oldest by far, but the dating and species identification are controversial.

The new discoveries at Bulgaria's Bacho Kiro Cave add more evidence for a scenario in which African *H. sapiens* reached the Middle East about 50,000 years ago (*SN: 2/21/15, p. 15*) and then rapidly dispersed into Europe and Central Asia, the scientists conclude.

Except for the tooth, the *H. sapiens* fossils were too fragmentary to identify by their appearance. But researchers could extract proteins from the fossils. An analysis of how the proteins' building blocks were arranged, which can distinguish between species, pegged the fossils as human, say paleoanthropologist Jean-Jacques Hublin of the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, and colleagues. Mitochondrial DNA from six of the seven fossils also identified them as human.

Radiocarbon dates of the fossils and age calculations for recovered mitochondrial DNA, based on comparisons with ancient and living people's mitochondrial DNA, consistently put the finds at between around 46,000 and 44,000 years old.

More than 11,000 animal bone fragments also unearthed at Bacho Kiro come from 23 species, including bison, red deer, cave bears and goats. Some bones displayed stone-tool marks made during butchery and skinning of animals, as well as intentional breaks where marrow was removed, the researchers say.

Stone artifacts and personal ornaments found with the fossils are the earliest examples of a shift in tool and ornament making from what's known as the Initial Upper Paleolithic culture, Hublin and colleagues say. Along with several earlier European excavations, the new finds indicate that Initial Upper Paleolithic tools were made for only a few thousand years before being replaced by related implements from the Aurignacian culture, which dates to between 43,000 and 33,000 years ago (*SN: 4/4/15, p. 16*).

The newfound stone tools and pendants made from cave bear teeth appear to have inspired similar objects made a few thousand years later by Neandertals, Hublin says, suggesting that ancient humans in Bulgaria mingled with native Neandertals. "The Bacho Kiro cave provides evidence that pioneer groups of *Homo sapiens* brought new behaviors into Europe and interacted with local Neandertals," Hublin says.

Although that's possible, Neandertals made jewelry out of eagle talons around 130,000 years ago (*SN: 4/18/15, p. 7*). That's long before *H. sapiens* are generally thought to have first reached Europe, and thus Neandertals may not have been influenced by the newcomers' ornaments, says paleoanthropologist Chris Stringer of the Natural History Museum in London.

Human groups that brought Initial Upper Paleolithic toolmaking to Europe may have been too small to stay or survive for long when confronted with larger numbers of Neandertals and frequent climate fluctuations at the time, Stringer says. For as yet unclear reasons, it was the Aurignacian toolmakers who first took root in Europe and witnessed "a physical but not genetic end" to Neandertals, some of whose DNA survived in humans as a result of interbreeding, he says.

The Bacho Kiro discoveries fill in the picture of where *H. sapiens* were in southeastern Europe during a period already known to have included interbreeding between humans and Neandertals, says Paul Pettitt, an archaeologist at Durham University in England. Like Stringer, Pettitt suspects humans' stay at Bacho Kiro "was brief and ultimately a failure." ■

Humans who reached southeastern Europe by about 46,000 years ago made bone tools (top row) as well as bear-tooth pendants and other personal ornaments (bottom row).

J.-J. HUBLIN *ET AL*/*NATURE* 2020

BODY & BRAIN

Vaping may be bad for the heart

Switching from smoking to vaping may not help with cardiovascular health.

In a study of more than 400 healthy adults ages 21 to 45, people who use cigarettes, e-cigarettes or both had stiffer arteries than those who don't smoke or vape, researchers report in the May 5 *Journal of the American Heart Association*. All of the e-cigarette users in the study were former smokers.

That stiffness can damage small blood vessels and strain the heart, both of which can contribute to the development of cardiovascular disease.

Cardiovascular disease is a major cause of death for smokers, and some experts have suggested that switching to e-cigarettes might prove less harmful.

Participants who vaped had been doing so for at least three months. Previous research has shown that healthy smokers who quit can see a reduction in artery stiffness in as little as four weeks. "Our work suggests that the abnormalities in vascular stiffness persist in e-cigarette users," says vascular biologist Jessica Fetterman of Boston University School of Medicine. — *Aimee Cunningham*

ATOM & COSMOS

Collision of mismatched black holes detected for the first time

As far as odd couples go, this is one for the record books.

The ripples in spacetime stirred up by two distant, merging black holes indicate that one of the pair was much bigger than the other. It's the first definitively mismatched black hole pair spotted by the LIGO and Virgo collaborations, which search for gravitational waves. The collision, detected April 12, occurred about 2.5 billion light-years from Earth.

The bigger black hole had a mass about 30 times that of the sun, while the smaller was about eight solar masses, researchers reported April 18 at a meeting of the American Physical Society, which was held virtually due to COVID-19.

Before this result, scientists did not know if such lopsided partnerships existed. Understanding what types of black holes partner up could help answer how the duos form. Black holes might pair up within a dense star cluster, or when two stars are born together as twins and both collapse into black holes. Both possibilities could occasionally create unequal mass partnerships. — *Emily Conover*

LIFE & EVOLUTION

When the going gets tough, comb jellies eat their young

Some comb jellies go ballistic when their prey disappears — cannibalistic that is.

Warty comb jellies (*Mnemiopsis leidyi*), native to the western Atlantic, invaded Eurasian waters in the 1980s. The jellies have since flourished, cycling through population booms in summer when prey is abundant and busts in fall and winter when food is scarce. That's when adults eat their young, a new study suggests.

Understanding how the invasive jellies conquer new territory could reveal ways to control them, says marine ecologist Jamileh Javidpour of the University of Southern Denmark in Odense.

Javidpour and colleagues studied comb jellies in the Baltic Sea in August and September 2008, before and after the population collapsed. As adult jellies' preferred food, copepod crustaceans, declined at the end of August, so did young jellies. By the end of the collapse, adults made up the bulk of the population.

Feasting on their own larvae may help adult warty comb jellies (one shown) survive winter, when food is scarce.

BRUNO C. VELLUTINI/WIKIMEDIA COMMONS (CC BY-SA 3.0)

In the lab, the researchers chemically labeled larvae with a rare type of nitrogen and placed the young jellies with starved adults. After 36 hours, those adults had higher levels of the nitrogen than adults fed a normal diet, a sign that the animals ate the larvae, the team reports May 7 in *Communications Biology*.

Larvae can't survive cold winters. The researchers suggest the comb jellies ramp up reproduction in late summer — when it might otherwise be counterproductive — to feast on the young and bulk up before winter. — *Erin Garcia de Jesus*

HUMANS & SOCIETY

Transatlantic slave trade brought new diseases to the Americas

Slavery proved contagious when Spain colonized Mexico in the 16th century. Africans abducted into the slave trade and taken to Mexico may have introduced forms of two infectious diseases, hepatitis B and yaws, to the Americas.

DNA of three men whose skeletons were excavated near Mexico City indicates the men were from western or southern Africa. Their upper front teeth had been filed down, a trait that characterized African slaves, scientists report online April 30 in *Current Biology*.

The chemistry of the men's teeth also suggests childhood origins outside Mexico.

One man's tooth carried DNA from a strain of the hepatitis B virus typically found in modern-day West Africans. While it's unclear when hepatitis B first occurred in the Americas, the researchers contend that slaves brought a novel genetic form of hepatitis B to Mexico.

Another man's tooth yielded bacterial DNA from a yaws strain also observed in living West Africans. Yaws is a painful infection of the bones, joints and skin.

The three men lived sometime between 1436 and 1626, based on radiocarbon dating of their teeth. The men are the oldest genetically identified first-generation Africans in the Americas. As slaves, they likely reached Mexico in a bondage system Spain started in the early 1500s, the scientists suspect. — *Bruce Bower*

A researcher at Protein Sciences in Meriden, Conn., works on a vaccine for COVID-19, one of dozens under development.

JESSICA HILL/ASSOCIATED PRESS

Special Report: Fighting the Virus

Less than six months ago, news broke that a mysterious pneumonia was sweeping through a city in China. For many of us in the United States, the danger seemed too distant for concern. People continued to fly, gather for family events and conferences — and set off on cruise ships. Within a month, though, the new coronavirus, eventually named SARS-CoV-2, had crossed borders to at least 19 countries, including the United States. By March 17, the virus was in all 50 states. Nine days later, the United States had more active infections than hard-hit Italy and China.

In many countries, schools closed and moved classes online, businesses were shuttered and people were ordered to stay home. Overwhelmed hospitals, caught short on supplies, went searching for ventilators and personal protective gear. People died; others feared for their lives and their livelihoods. As the virus spread, scientists raced to figure out how the pathogen attacks and how it might be tamed. The work continues, but the public is understandably impatient.

This special report investigates what it will take to regain some sense of normalcy. It's going to take safe and effective treatments and a vaccine, along with testing and contact-tracing systems. The stress of the pandemic and all the uncertainty can mess with our brains, but we might need to get used to it. As George F. Gao, director general of the Chinese Center for Disease Control and Prevention in Beijing, says: "We've got to dance with the virus." — *Cori Vanchieri*

The agonizing wait for treatments and a vaccine

It's early days in the battle against COVID-19

By Tina Hesman Saey

Aggressive public health measures to stem the tidal wave of coronavirus infections have left people isolated, unemployed and wondering when it will all end. Life probably won't get close to normal until a vaccine against the virus is available, experts warn.

Researchers are working hard on that front. At least six vaccines are currently being tested in people worldwide, says Esther Krofah, executive director of the FasterCures center at the Milken Institute in Washington, D.C. "We expect about two dozen more to enter clinical trials by this summer and early fall. That is a huge number," Krofah said at an April 17 briefing. Dozens more are in earlier stages of testing.

In unpublished, preliminary results of a test of one vaccine, inoculated people made as many antibodies against the coronavirus as people who have recovered from COVID-19 (*SN Online: 5/18/20*). The mRNA-based vaccine induces human cells to make one of the virus's proteins, which the immune system then builds antibodies to attack. That study was small, only eight people, but a second phase of safety testing has begun.

But vaccines take time to test thoroughly (*SN: 3/14/20, p. 6*). Even with accelerated timelines and talk of emergency use of promising vaccines for health care workers and others at high risk of catching the virus, known as SARS-CoV-2, the general public will likely wait a year or even longer to be vaccinated.

In the meantime, new treatments may help save lives and lessen the severity of disease in people who become ill. Researchers around the world are experimenting with more than 130 drugs to find out if any can help COVID-19 patients, according to a tracker maintained by the Milken Institute.

Some of those drugs are aimed at stopping the virus, while others may help calm overactive immune responses that damage lungs and other organs. Although researchers are testing a battery of repurposed drugs and devising new ones, there is still a great deal of uncertainty over whether any of the drugs will help, or maybe even hurt.

The wait is frustrating, but there's still much doctors and scientists don't know about how this new coronavirus affects the body. Getting answers will take time, and finding measures to counter the virus that are both safe and effective will take even more. Early results suggest that the antiviral drug remdesivir can modestly speed recovery from COVID-19 (*SN Online: 5/13/20*). It is not a cure, but the drug may become the new standard of care as researchers continue to test other therapies.

Head-on attacks

Antiviral drugs interfere with a virus's ability to replicate itself, though such drugs are difficult to create. Remdesivir is being tested in half a dozen clinical trials worldwide. The drug mimics a building block of RNA, the genetic material of the coronavirus (*SN: 3/28/20, p. 20*). When the virus copies its RNA, remdesivir replaces some of the building blocks, preventing new virus copies from being produced, laboratory studies have shown.

Early results in COVID-19 patients given the drug outside of a clinical trial showed that 68 percent needed less oxygen support after treatment, as reported online April 10 in the *New England Journal of Medicine*. The drug went to very sick patients, including those who needed oxygen from a ventilator or through tubes in the nose. Other researchers have disputed those results, questioning the study methods and statistical analyses, which may have given an exaggerated impression of good outcomes. The study's authors say they have reanalyzed the data and still conclude that remdesivir has benefits.

Soon after, the U.S. National Institute of Allergy and Infectious Diseases announced that hospitalized patients with COVID-19 who got intravenous remdesivir recovered more quickly than patients on a placebo: in 11 days versus 15. Those findings had not been reviewed by other scientists at the time of the announcement. But the drug provides researchers with a baseline for comparing other treatments. "We think it's really opening the door to the fact that we now have the capability of treating," Anthony Fauci, NIAID director, said April 29 in a news briefing at the White House.

Antiviral medications used against HIV are also being tested against COVID-19. The combination of lopinavir and ritonavir stops an HIV enzyme called the M protease from cutting viral proteins so that the virus can't replicate itself. The SARS-CoV-2 virus produces a similar enzyme. But early results from a small study in China showed that the combination didn't stop viral replication or improve symptoms (*SN: 4/11/20, p. 13*), and

there were serious side effects. Those drugs may not work well against SARS-CoV-2, even though the virus and HIV have similar M proteases: The coronavirus's enzyme lacks a pocket where the drugs fit in the HIV version of the enzyme.

This illustrates why antiviral drugs are so difficult to develop. Designing a drug requires learning the 3-D structure of a virus's proteins, which can take months to years. But researchers are already getting some closeup views of the new coronavirus. A team in China examined the structure of the coronavirus's M protease and designed small molecules that could block a part that the protein needs to do its job. The team described two such molecules, dubbed 11a and 11b, online April 22 in *Science*.

In test tubes, both molecules stopped the virus from replicating in monkey cells. In mice, 11a stuck around longer in the blood than 11b, so the researchers tested 11a further and found it seems safe in rats and beagles. More animal tests will probably be needed to show whether it stops the virus, and then multiple stages of human tests will have to follow. The drug development and testing process often takes 10 years or more, and can fail at any point along the way.

Meanwhile, hundreds of thousands of people worldwide have recovered from COVID-19, and many are donating blood that might contain virus-fighting antibodies. Clinical trials are under way to test whether antibodies from recovered patients' blood plasma can help people fight off the virus (*SN: 4/25/20, p. 6*). More such trials are planned.

Helping the immune system

Stopping the virus is only half the problem. In some people seriously ill with COVID-19, their immune system becomes the enemy, unleashing storms of immune chemicals called cytokines. Those cytokines trigger immune cells to join the fight against the virus, but sometimes the cells go too far and cause damaging inflammation.

Some of the drugs used to calm cytokines in cancer patients may also help people with COVID-19 ride out the storm, says cancer researcher Lee Greenberger, chief scientific officer of the Leukemia and Lymphoma Society. Several of those drugs are being tested against the coronavirus now.

Hydroxychloroquine, a drug approved to treat autoimmune disorders such as lupus and rheumatoid arthritis, became a household word after President Donald Trump touted it as a possible COVID-19 treatment.

The drug is being tested in numerous large clinical trials around the world to see if it might help calm cytokine storms in COVID-19 patients as well. But so far, there is no solid evidence that it works either to prevent infection in people or to treat people who already have the disease.

And in some studies the drug has caused serious side effects, including irregular heartbeats, says Raymond Woosley, a pharmacologist at the University of Arizona College of Medicine in Phoenix. People with heart problems, low potassium or low oxygen levels in their blood are at higher risk of these side effects, he says. And those are exactly the kinds of patients who are most vulnerable to COVID-19 (*SN: 4/11/20, p. 7*). "So the very sickest COVID patients are those at most risk for these life-threatening arrhythmias and cardiac effects," Woosley says.

Results of some rigorous clinical trials of hydroxychloroquine are expected this summer. Meanwhile, the U.S. Food and Drug Administration allows "emergency use" when a patient can't join a clinical trial.

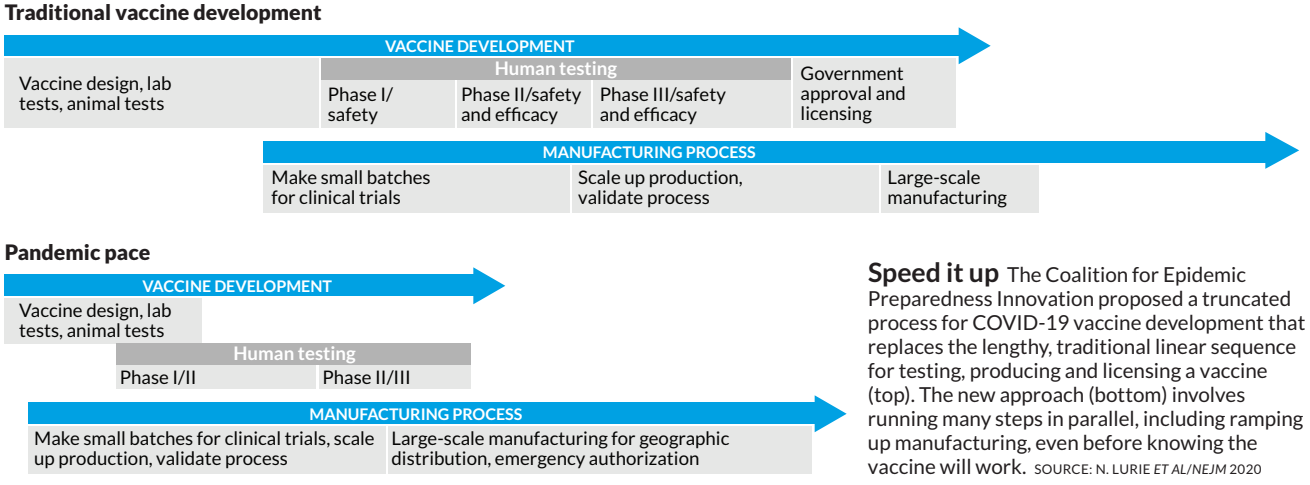
Today's enthusiasm for any drug that seems promising feels familiar, Woosley says. He remembers the excitement over AZT, the first drug used to fight HIV in the 1980s. It wasn't the best drug to combat the AIDS epidemic, and better ones came later. Likewise, the first treatments for COVID-19 might be better than nothing, but not the best we will ultimately get.

Meanwhile, we wait.

With hundreds of clinical trials going on around the world, some answers may come soon. But for now, reducing the coronavirus's toll will probably require aggressive testing, tracing and isolating contacts of people who have the virus, and continued social distancing. ■

Explore more

■ Milken Institute's COVID-19 tracker: bit.ly/Milken_tracker



Speed it up The Coalition for Epidemic Preparedness Innovation proposed a truncated process for COVID-19 vaccine development that replaces the lengthy, traditional linear sequence for testing, producing and licensing a vaccine (top). The new approach (bottom) involves running many steps in parallel, including ramping up manufacturing, even before knowing the vaccine will work. SOURCE: N. LURIE *ET AL*/*NEJM* 2020

A sprint to contact tracing

Catherine Waldron (right) talks with epidemiologist Elizabeth Goff in Savannah, Ga. Waldron, a medical student, is helping the Georgia health department with contact tracing to find contacts of confirmed COVID-19 cases and instruct them to self-isolate.

RUSS BYNUM/ASSOCIATED PRESS

There's an urgent need to set up systems to contain the virus

By Jonathan Lambert

Right now, many countries are fighting the spread of COVID-19 with the bluntest tool possible: widespread social distancing. To deny the virus the opportunity to hop between people, many of us are staying in, regardless of whether we've come into contact with the virus.

But social distancing, which has saved lives and eased the burden on hospitals, comes at a high cost. Lost jobs, closed businesses and a frozen economy have many people anxious for restrictions to be eased and for life to resume.

If countries hit the restart button too soon, epidemiologists say, the virus will come roaring back, because so many people are still susceptible. Until a vaccine arrives, two key public health tools will need to pick up the slack as social distancing is eased.

One is widespread, accessible testing (*SN Online: 4/17/20*). And when a person tests positive, a second system must quickly identify people who may have been infected by that person to prevent further spread. That's known as contact tracing.

Following the links

The bread and butter of infectious disease control for over a century, contact tracing is a targeted way of breaking a pathogen's chain of transmission. When a positive case pops up on the radar of public health officials, a contact tracer will spring to action, doing detective work to track down all the people that person has encountered.

Then, the contact tracer notifies those contacts that they may have been exposed to the virus and asks them to quarantine for the incubation period of the virus (about two weeks for cases of COVID-19). Starved of new hosts, the epidemic fizzles out, and contact tracers keep tabs on the people who are potentially infected to see if they develop symptoms.

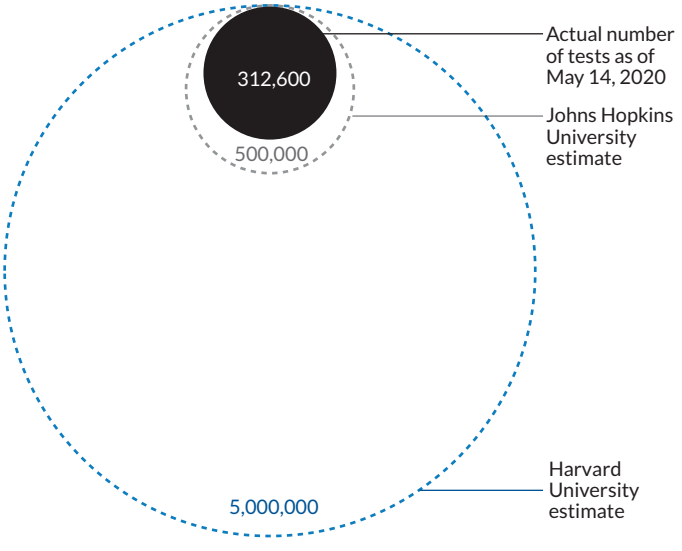
Contact tracing helped contain the 2003 outbreak of SARS, or severe acute respiratory syndrome. More recently, it helped control the 2014 Ebola outbreak in West Africa.

But people with SARS or Ebola spread the disease only when they're clearly sick, making it easier to identify and isolate cases. COVID-19 is a different story. Infected people who don't yet show symptoms, or never do, may account for nearly half of all transmissions (*SN Online: 4/15/20*), a factor that helped COVID-19 silently spread around the world at a vastly larger scale than those previous outbreaks.

Raising an army

To be effective, contact tracing requires readily available diagnostic testing, plus a public health workforce large enough to track down as many cases and contacts as possible. The United States and many other countries currently have neither. "We're not where we need to be right now," says Crystal Watson, a public health preparedness expert at Johns Hopkins Center for Health Security.

Number of COVID-19 tests needed per day to open U.S. economy



More testing needed To get an accurate picture of the spread of COVID-19 in the United States, experts say testing levels must skyrocket. As of May 14, about 312,600 tests were being administered daily. Researchers don't yet agree on how many daily tests will be needed to begin safely opening the economy.

As of May 14, the United States has conducted 9.9 million COVID-19 tests, reporting an average of 312,600 tests per day, according to the COVID Tracking Project, launched by the *Atlantic*. That may sound like a lot, but about 14 percent of those tests have come back positive. For a country to be confident that it's identifying most cases, and not just the people who are obviously sick, no more than 10 percent of tests should come back positive, according to the World Health Organization.

Experts differ on how much more testing we need. An April 20 report from Harvard University estimates the United States may need 5 million tests a day by early June to safely begin reopening its economy, eventually building to 20 million tests a day for a full reopening. Watson and colleagues at Johns Hopkins suggest 500,000 per day is a sufficient starting point. The Rockefeller Foundation released a testing action plan on April 21, calling for 4.3 million tests per day when testing is at full throttle.

The number of contact tracers will have to rise quickly to keep up with all those tests. In Wuhan, China, a city of 11 million where the outbreak began, 9,000 contact tracers have been deployed as lockdown measures have eased. As of early April, the United States had 2,200 contact tracers, according to the Association of State and Territorial Health Officials, or ASTHO.

States have been scrambling to boost those ranks. In an NPR survey of state public health departments, reported April 28, the District of Columbia and 41 states that replied reported having a total of about 7,600 contract tracers on staff. That's still nowhere near enough. An additional 100,000 contact tracers will need to be quickly trained and deployed to control the spread of COVID-19 in the United States, according to an April 10 analysis by Watson, her colleagues and ASTHO.

In Massachusetts, a large-scale effort is under way to hire 1,000 new contact tracers. As of May 11, 41,000 people had applied, says John Welch, director of partnerships and operations for the Massachusetts COVID-19 Community Tracing Collaborative at Partners in Health, a nonprofit health care organization involved in the state's response. "There are a lot of qualified people who are also out of work and already know the communities that they're serving," he says.

New hires get a three-day crash course. They learn how to ask those who test positive about relevant contacts (right now that means anyone the person has been within six feet of for more than 15 minutes), how to log that data into a statewide database, and how to inform those contacts that they've been exposed and need to self-isolate.

Talking someone through a 14-day quarantine process isn't always straightforward. Questions like "How do I self-isolate from my partner of 40 years?" "How do I get food?" or "Who's going to look after my elderly mother?" can often come up.

"You realize pretty quickly that this thing that feels like a very scientific activity is really just talking to people about this thing we're all going through together," Welch says.

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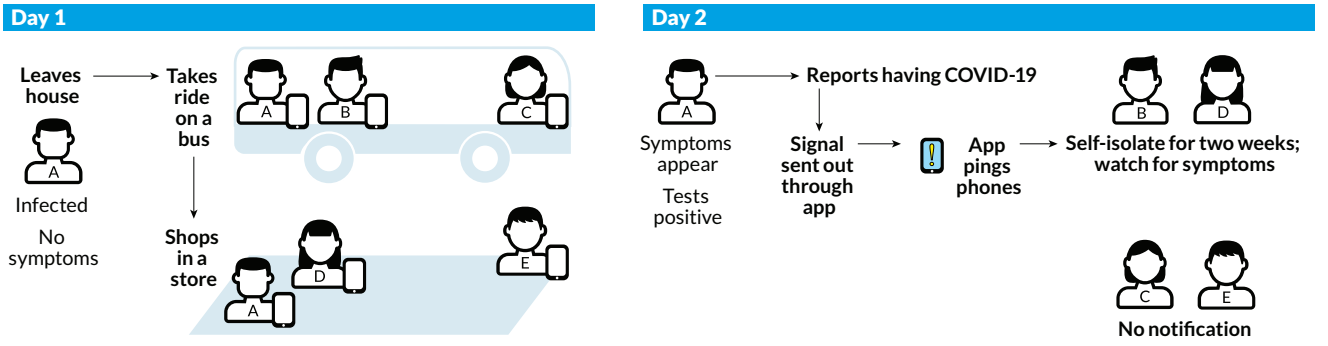
An app for that Some countries are using cell phone apps to speed contact tracing. Generally, the apps work by logging when a phone spends a certain period of time near another phone that has the app. If someone with the app later tests positive, public health officials can ping app-carrying phones that came within a certain distance to inform the users of their exposure and ask them to self-isolate for 14 days to prevent further spread of COVID-19. SOURCE: L. FERRETTI *ET AL*/*SCIENCE* 2020



Help from smartphones

Many experts worry that the pandemic has grown too large, and that the virus spreads too easily, for people-powered contact tracing alone to work. Cell phone data can help accelerate the tracing process in communities willing to use the more intrusive approach of cell phone monitoring.

In Singapore, citizens can download the TraceTogether app, which uses Bluetooth signals to register when phones with the app come into close contact. When someone with the app tests positive, public health officials can quickly identify contacts and notify them.

Google and Apple announced on April 10 a partnership to develop a similar system for both Apple and Android phones.

Enhancing contact tracing with digital tools could slow, or even stop, COVID-19 outbreaks in many places, according to a study in the May 8 *Science*. In principle, if everyone used an app, individuals could be instantly notified when someone they contacted tests positive. In such a scenario, contact tracing would need to be only 50 to 60 percent effective to end an outbreak, researchers concluded. Effectiveness in the study referred both to how many contacts actually self-isolate and how well people limit their contact with others.

Timing is key. "The earlier a contact is traced and self-isolates, the faster you can slow" the epidemic, says study coauthor Michelle Kendall, a statistician at the University of Oxford. If it takes a couple days to notify contacts of a positive case, she says, contact tracing becomes much less effective as people unwittingly spread the virus. That means rapid and widely available testing is a must, though Kendall says that an app-based system could work without widespread testing if symptoms alone were enough to instigate a contact trace.

But technology can't solve everything. "An app can ping you and recommend that you self-isolate, but unless people actually adhere to it, it won't do anything," Kendall says. "You've got to have public trust."

Widespread adoption and adherence to these kinds of intrusive measures have so far helped South Korea avoid massive lockdowns. And China is easing some restrictions because it can enforce quarantines by requiring that residents install location-tracking software. Such measures will be a tough sell in independence-minded Western cultures, says Annelies Wilder-Smith, an infectious disease expert at the London School of Hygiene and Tropical Medicine.

"We need a good communication strategy that starts now," she says, to build awareness and buy-in before systems are in place. Without widespread participation, even the most advanced technical tools won't help curb the pandemic.

Even if the public is enthusiastic initially, buy-in may wane as the pandemic stretches on. In areas with ongoing outbreaks, it's not inconceivable that someone could finish one two-week bout of self-isolation only to be pinged days later that they've come into contact with the virus again. And decisions will need to be made as to what counts as a meaningful contact. If merely walking past someone on the sidewalk who later gets confirmed with COVID-19 sparks a message to self-isolate, many may ignore requests. Massachusetts is trying for 15 minutes of exposure, but will transmission events be missed? Even if a system finds a sweet spot, people may be exposed multiple times in the coming months, and asked to self-isolate each time.

That may not seem sustainable, "but right now we're shooting blindly, and millions of people who don't need to be quarantined are stuck at home," Wilder-Smith says. "No solution is perfect, but of all the worst scenarios, strict contact tracing and isolation is the best scenario, and I think that's how you have to sell it." ■

Explore more

- Crystal Watson *et al.* "A national plan to enable comprehensive COVID-19 case finding and contact tracing in the U.S." Johns Hopkins Bloomberg School of Public Health and ASTHO. April 10, 2020. bit.ly/JHUcontacttracing
- Rockefeller Foundation. National COVID-19 Testing Action Plan. April 20, 2020. bit.ly/Rockefeller_COVID-19
- Harvard University. Roadmap to Pandemic Resilience, April 20, 2020. ethics.harvard.edu/Covid-Roadmap

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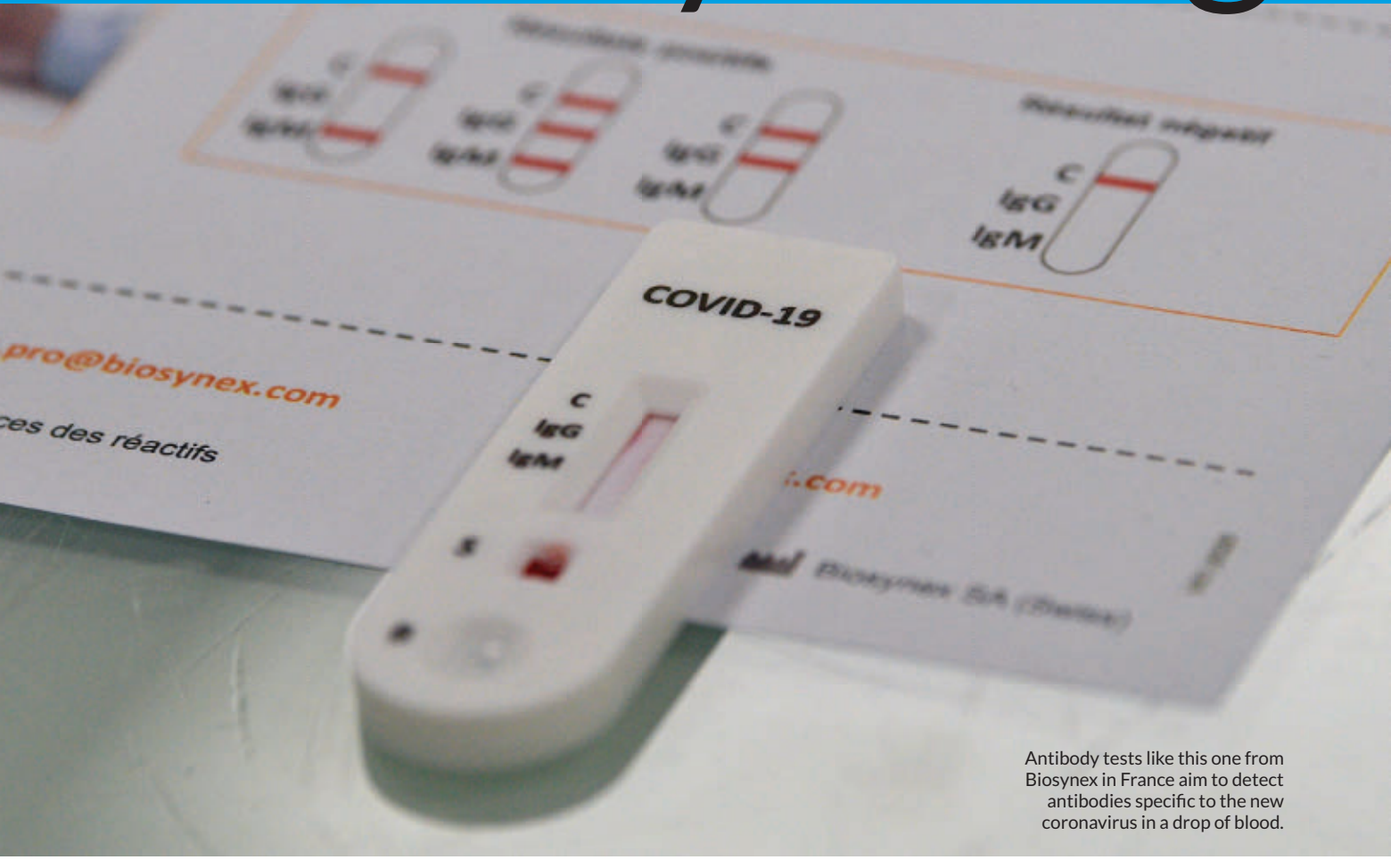
So many questions on antibody testing



Antibody tests like this one from Biosynex in France aim to detect antibodies specific to the new coronavirus in a drop of blood.

NICOLAS ROSES/ABACA/SIPA USA (SIPA VIA AP IMAGES)

Do virus-fighting antibodies confer immunity to COVID-19?

By Erin Garcia de Jesus

As some countries begin to reopen in the midst of the ongoing coronavirus pandemic, experts are racing to ramp up the development and use of blood tests that flag people who have been exposed to the virus that causes COVID-19 and are no longer infected.

The tests detect antibodies, proteins made by the immune system to fight infection (*SN Online: 3/27/20*). People who carry antibodies specific to the novel coronavirus, called SARS-CoV-2, have been infected previously, even if they didn't know it. For those people, discovering that they have these virus-fighting antibodies could raise hopes of immunity and a return to human interaction.

But what these blood tests might really tell us is still unknown. There isn't enough evidence to confirm that recovered people are protected from the disease and, if so, for how long, the World Health Organization said in a statement on April 24.

For researchers and public health officials, though, the tests

can reveal the true extent of the pandemic. The U.S. National Institutes of Health announced April 10 that researchers had begun recruiting people for a nationwide study that aims to test as many as 10,000 volunteers without an official COVID-19 diagnosis, which could help clarify how many people across the country have actually been infected. A number of similar, more local studies are also under way.

The goal is to fill in the gaps created by the bungled rollout of diagnostic tests, which detect the virus's genetic material and can catch an active infection. That effort has faced roadblocks such as flawed tests, supply shortages and highly restrictive definitions of who can get tested. As a result, some sick people were left wondering whether their symptoms were from COVID-19 or a different respiratory infection.

Diagnostic tests can't detect the virus once the infection has cleared. But antibodies typically stick around in the body after the virus has gone, giving scientists a glimpse into the past. So for people who weren't able to get a diagnostic test, the antibody test "will give us the ability to let them know, yes, you did have COVID-19," says Aneesh Mehta, an infectious disease physician at Emory University in Atlanta.

Knowing how many people have already been exposed to the virus is also a step toward understanding when the pandemic might end. Previously infected people can protect the population as a whole from outbreaks if they're immune from reinfection, creating what's called herd immunity. Researchers estimate that around one-third to two-thirds of a population would need to have been infected with SARS-CoV-2 to reach herd immunity.

> COVID-19 antibody tests "don't accurately detect every single antibody, and they may have both false positives and false negatives."
>
> ANGELA RASMUSSEN

Positive or negative

For an individual, an antibody test result isn't black and white: exposed or not exposed, immune or not immune.

This is in part because antibody tests, in general, are not 100 percent accurate, says Angela Rasmussen, a virologist at Columbia University. "They don't accurately detect every single antibody, and they may have both false positives and false negatives."

In the tests, a small sample of a patient's blood is taken and exposed to proteins that match parts of the virus. If any antibodies specific to the coronavirus are present, they should recognize and bind to the virus components. Such antibodies might attach to any of a variety of places on the virus — including spots that are similar among closely related viruses. Therefore, researchers have to carefully choose which part of the new coronavirus to use.

The tests usually detect two types of antibodies. One, called IgM, is typically produced about a week after infection and could identify patients who may still be infected. Levels of IgM begin to wane as the body makes another type of antibody called IgG, which can persist for longer periods of time.

The best antibody tests are both highly sensitive — detecting a wide range of IgM or IgG antibodies that recognize different parts of a viral protein — and highly specific, meaning the detected antibodies are for only that virus. Coronaviruses that cause colds, for example, also circulate around the globe. Antibody tests with low specificity and high sensitivity might detect antibodies against cold viruses and give a false positive. But a test with high specificity and low sensitivity could miss antibodies, resulting in a false negative. Timing for the test is also crucial, as patients whose infections are too new to have instigated antibodies would test negative.

Though coronavirus antibody tests have flooded the market, the U.S. Food and Drug Administration has authorized just 12 for emergency use, as of May 12. Based on data the test developers provided to the FDA, the sensitivity and specificity of the tests vary widely, from 88 to 100 percent for sensitivity and 90 to 100 percent for specificity.

Plus, "certain people just don't make as much antibody as other people do and don't respond the same to an infection," Mehta says. "There will be some people that had the infection, but we won't be able to detect them."

Immune or not

Even if the tests are accurate, immunity is not a given. The tests being rolled out now look only for the presence or absence of antibodies, not how effective those particular antibodies are at knocking out the virus. "We need to look at people who do have antibody — and that does seem to be the majority of patients — and see if that antibody is protective," Rasmussen says.

In one cluster of COVID-19 patients from China, most people produced neutralizing antibodies that prevent the virus from infecting new cells, according to a preliminary report posted online April 6 at medRxiv.org. Of 175 patients who recovered after mild symptoms, 94 percent developed antibodies around 10 days after symptoms began. Among those, elderly and middle-aged people had the highest levels.

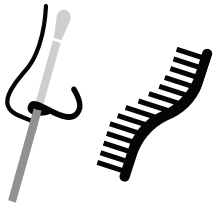
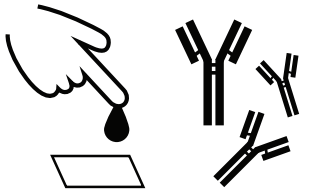
Younger patients tended to have lower levels overall, including 10 people who didn't have any detectable antibodies. But it's possible that those 10 people developed antibodies that recognized a different viral protein than the one used in the test, producing a false-negative result. Or maybe, a different arm of the immune system — one that targets infected cells and doesn't leave behind antibodies — did most of the work in the younger patients' recovery.

Long-term protection

It's unclear what antibody levels might provide the best defense.

With its exposure to the outside, "it's very hard to protect the nose from being reinfected," says Mark Slifka, a viral immunologist at Oregon Health & Science University in Portland. Having a strong antibody response might help, he says, "to still

Infected or recovered There are big differences between the diagnostic tests that tell if a person is infected with SARS-CoV-2 and the antibody tests that pick up evidence that a person was infected in the past. One relies on RNA from the virus; the other detects antibodies that a person's body has made to fight the infection. Because the virus is a newly discovered pathogen, work is still being done to improve the tests.

	Diagnostic test	Antibody test
Purpose:	Diagnose a current illness.	Detect a past infection.
What it does:	Tells if the virus is present in the body.	Tells if antibodies created by the immune system to fight the virus are present in the body.
How it works:	 Picks up viral RNA from a swab into the nose or throat. The existence of viral RNA indicates that there is virus in the body.	 Picks up antibodies from a person's blood.
Strengths:	• This test can potentially capture cases before symptoms occur.	• Some rapid tests require just a finger prick. • Widespread use of antibody testing tells researchers where the virus has spread.
Weaknesses:	• Prone to false negatives if the swab doesn't touch cells in the nose that are actively releasing the virus.	• Researchers don't yet know if having antibodies means a person is immune to reinfection. • It is unclear if a certain level of antibodies is needed to offer protection. • It's unknown how long protection might last. • Lots of versions are out there, and although authorized for emergency use, none have been independently validated by the FDA.

ramp up a rapid [immune] response" and prevent the virus from spreading deeper into the lungs.

Even people with protective antibodies aren't necessarily "bulletproof," Slifka says. Some people may be completely protected against infection, a state known as sterilizing immunity, which is hard to achieve. Others may get infected again, but have mild or no symptoms.

Anecdotal reports from patients in South Korea and China who tested positive after recovering have suggested that some people could be reinfected. But samples from 108 of these "reinfected" COVID-19 patients had no infectious viruses despite testing positive for the virus's genetic material, the Korea Centers for Disease Control and Prevention reported in a May 19 news release. The diagnostic test may be detecting lingering fragments of the coronavirus as it is cleared from the body rather than a reinfection.

When four rhesus macaques were infected, allowed to recover and then exposed to the virus again, they weren't reinfected, according to preliminary findings posted online March 14 at bioRxiv.org. That hints that at least in the short term, people may be protected. To know for sure, "we would have to follow recovered COVID-19 patients who are antibody-positive for a long period of time and see if any of them become infected again," Rasmussen says.

Researchers also don't know how long SARS-CoV-2 antibodies stick around. Some viruses, such as measles, can trigger protection that lasts a lifetime. Defenses against other viruses can wane over time. Studies suggest that protection against coronaviruses that cause the cold can last for about a year. Antibodies for the SARS virus that emerged in 2003 slowly vanished over a few years. Since SARS no longer infects people, it's unclear whether a lack of antibodies means lack of protection. And because the new coronavirus has been infecting people for only a few months, it's still unknown whether it will behave similarly.

Despite the unknowns surrounding antibodies and SARS-CoV-2, some countries including the United States are considering using antibody tests as a stepping stone to provide "immunity certificates" to people who have antibodies to allow them to re-enter society or return to work. Some experts, however, are skeptical.

"We don't know that having antibodies necessarily means you're immune, so it could give people a false sense of security about how safe they are," Rasmussen says.

And, according to the WHO, that could increase the risk that the virus will continue to spread. ■

Explore more

■ U.S. Centers for Disease Control and Prevention. Test for past infection. bit.ly/CDC_COVID-19testing

E. OTWELL

CLOCKWISE FROM TOP LEFT: ALISSA ECKERT AND DAN HIGGINS/CDC; TKHATSKO/ISTOCK/GETTY IMAGES PLUS; LORDHENRIVOTON/E+/GETTY IMAGES PLUS; JUANMONINO/E+/GETTY IMAGES PLUS; GWENGOAT/ISTOCK/GETTY IMAGES PLUS; NICOOLAY/E+/GETTY IMAGES PLUS; KAMELEON007/ISTOCK/GETTY IMAGES PLUS

The Stress Is Real

How this pandemic is scrambling our brains

By Laura Sanders

I'm on deadline, but instead of focusing, my mind buzzes with unrelated tidbits. My first-grader's tablet needs an update before her online school session tomorrow. Heartbreaking deaths from COVID-19 in New York City make me tear up again. Was that a kid's scream from upstairs? Do I need to run up there, or will my husband take care of it?

These hornets of thoughts drive out the clear thinking my job demands. Try as I might to conjure up a coherent story, the relevant wisps float away.

I'm scattered, worried and tired. And even though we're all socially isolated, I'm not alone. The pandemic — and its social and economic upheavals — has left people around the world feeling like they can't string two thoughts together. Stress has really done a number on us.

That's no surprise to scientists who study stress. Our brains are not built to do complex thinking, planning and remembering in times of massive upheaval. Feeling impaired is "a natural biological response," says Amy Arnsten, a neuroscientist at Yale School of Medicine. "This is how our brains are wired."

Decades of research have chronicled the ways stress can disrupt business as usual in our brains. Recent studies have made even more clear how stress saps our ability to plan ahead and have pointed to one way that stress changes how certain brain cells operate.

Scientists recognize the pandemic as an opportunity for a massive, real-time experiment on stress. COVID-19 foisted on us a heavy mix of health, economic and social stressors. And the end date is nowhere in sight. Scientists have begun collecting data to answer a range of questions. But one thing is clear: This pandemic has thrown all of us into uncharted territory.

53 percent of U.S. men say the pandemic is affecting their mental health

60 percent of U.S. women say the pandemic is affecting their mental health

SOURCE: KFF HEALTH TRACKING POLL, APRIL 2020

Short-circuited

The human brain's astonishing abilities rely on a web of nerve cell connections. One hub of activity is the prefrontal cortex, which is important for some of our fanciest forms of thinking. These "executive functions" include abstract thinking, planning, focusing, juggling multiple bits of information and even practicing patience. Stress can muffle that hub's signals, studies of lab animals and humans have shown.

"Even relatively mild stress can impair the prefrontal cortex," says Elizabeth Phelps, a psychologist and neuroscientist at Harvard University. "That's one of the most robust effects of stress on the brain."

That impairment has been described in lots of studies. One memorable example comes from 20 panicky medical students facing licensing exams. After a month of high-stress test prep, the students performed worse on an attention test than they did after exams were over. Functional MRI scans showed that under stress, the students' prefrontal connections to other brain areas were diminished, scientists reported in *Proceedings of the National Academy of Sciences* in 2009.

When the prefrontal cortex goes quiet, more reactionary brain networks take over. Some of these "primitive" circuits, as Arnsten calls them, center on the amygdalae, two almond-shaped structures buried deep inside the brain that help us sense and respond to threats. Those fast, instinctual reactions "are helpful if you're being faced with a snake," Arnsten says, "but not helpful if you're being faced with a complex medical decision."

A more recent experiment, published online April 2 in *Current Biology*, illustrates how stress can shift people away from thoughtful planning. When people were threatened with electric shocks, their abilities to plan ahead flew out the window. Anthony Wagner, a cognitive neuroscientist at Stanford University, and colleagues asked 38 people to learn a familiar route through virtual towns. With practice,

people learned these routes, as well as the locations of recognizable objects, such as a zebra, an apple, a stapler or Taylor Swift's face, along the way.

"Our question was, 'What are the effects of stress?'" Wagner says. To find out, the researchers used "moderately painful" electric zaps to induce stress in some participants, who returned to familiar virtual towns and were asked to find their way to the zebra, for instance. Subjects didn't know when they would be shocked, and they couldn't control any aspect of it.

After the training, the participants — some under stress from the expectation of further shocks and some not — were sent back into the virtual town and asked to find their way to a specific item.

But there was a trick: Participants could reach the stapler, for example, faster and more efficiently by taking a shortcut. The shortcut, however, required more planning, more initiative and a heavier reliance on previously learned relationships among streets.

Stressed people were less inclined to take the shortcut, the researchers found. People who were stressed by the possibility of a shock took the shortcut 31 percent of the time, compared with 47 percent for those who weren't stressed. The stressed people still reached the object they were after, but in a roundabout way.

Functional MRI brain scans hinted at what the added stress did to the volunteers' thinking. The objects planted around town evoked recognizable patterns of brain activity when a person was seeing one of the previously seen objects, or even just thinking about it. By spotting these neural signposts, researchers could tell when people were thinking of a particular path — or of no path at all.

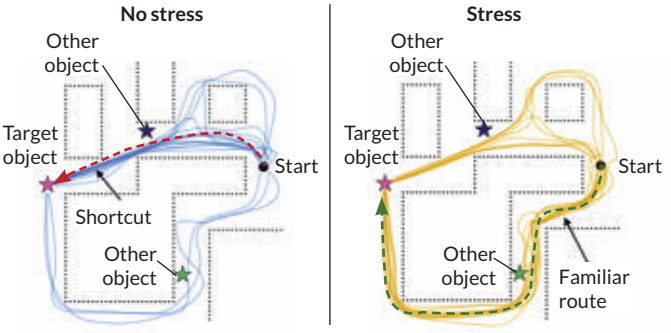
Participants were given eight seconds to plan their approach to reach the target object. Unstressed people generally had a plan; their brain activity contained patterns that signaled these volunteers were thinking about the objects along the shortcut route. Neural signals of a plan even showed up among those who chose to take the familiar route.

Those awaiting a shock appeared to use little foresight. "The stressed people didn't seem to be thinking about the familiar route when they took it," says study coauthor Thackery Brown, a cognitive neuroscientist at Georgia Tech in Atlanta. "They were on this fight-or-flight autopilot type behavior."

What's more, stress quieted the activity of brain areas needed to make a good plan, including a part of the prefrontal cortex and the hippocampus, a structure important for memory. Those findings suggest that under stress, we are less able to call up our previously learned knowledge and memories. We are working with a deficit.

"In some sense, we're privileged when we're not stressed, able to fully harness our cognitive machinery," Wagner says. "That allows us to behave in more strategic, more efficient, more goal-directed ways."

Brown sees parallels between these lab-based stressors and the complex and longer-lasting stresses of real life. The participants were attempting to do something complicated while worrying about something else. The stressor is "operating in the background while you're trying to plan your daily life," Brown says. "There's a connection there with the type of thing people are experiencing right now in the context of the pandemic."



Where to? In a virtual town, people devised a shortcut (left map, red dotted line) to reach a target object. But under the threat of a moderate electric shock, people were more likely to fall back on a familiar route (right map, green dotted line), even though it was longer.

Shrunken cells

Zooming in to individual cells provides a view of stress's physical destruction in the brain. Stress can shrink nerve cells and cull their connections, and the prefrontal cortex is particularly vulnerable, studies in both humans and other animals suggest. Other kinds of brain cells are affected too, new research on mice shows.

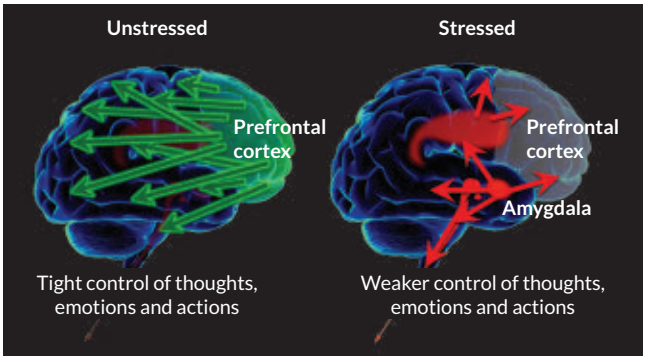
Big, arboreal cells called astrocytes have many jobs in the brain. Specialized astrocytes called Bergmann glia extend into synapses, the space between nerve cells where chemical messages flow, and slurp up extra chemical signals. This helps keep nerve cells communicating clearly with one another (*SN Online: 8/4/15*).

But in a test of mice stressed by the ominous smell of a predatory fox, these astrocytes retracted from synapses, neuroscientist Siqiong June Liu of Louisiana State University School of Medicine in New Orleans and colleagues found. That pulling away occurred with a single exposure to that stressful fox odor, and the cells were still retracted 24 hours later, the researchers reported in the April 22 *Journal of Neuroscience*.

Stress sends a "shrink" message to these astrocytes by reducing the levels of a protein called GluA1. It's not known whether a similar process, and the resulting changes in how brain cells communicate under stress, happens in the brains of people.

Some stress signals may travel certain neural highways. Physiologist Kazuhiro Nakamura of Nagoya University Graduate School of Medicine in Japan and colleagues studied rats that had just been through the stressful experience of losing a fight, a defeat that is meant to mimic human social stress. A somewhat mysterious region inside the rat's prefrontal cortex, called the DPC/DTT for dorsal peduncular cortex

T.I. BROWN, S.A. GAGNON AND A.D. WAGNER/*CURRENT BIOLOGY* 2020



Normally, an alert person's brain has moderate amounts of chemical messengers that lead the prefrontal cortex to take charge and perform high-level thinking (left). But with stress, those chemical signals can flood the brain, activating amygdala-linked brain networks involved in sensing and responding to threats (right).

and dorsal tenia tecta, is important for sending stressed-out signals, the researchers reported in the March 6 *Science*.

From there, the signals shoot to the hypothalamus, a brain structure that can spark some of stress's most obvious effects in the body, including a racing heart and sweating. It's possible that similar brain areas in humans might have roles in sparking stress signals.

These clues are giving scientists a more precise understanding of how stress moves through and affects the brain. But lab studies on stress, by design, have to be somewhat short-lived, with relatively mild stress. Applying lab findings to people's experiences in life comes with caveats. Huge questions remain about how the crushing and varied stresses of a pandemic might influence people.

Embracing the stress

Most advice about how to weather extreme stress covers basic care and feeding of the body: Eat right, exercise and get enough sleep. Those three good ideas hover near the top of many self-help lists, as does making time to connect (for now, remotely) with friends or doing something that brings joy.

But here's something else that might help: a mind-set adjustment. Stress — even severe stress — doesn't have to be a bad thing, says psychologist Alia Crum of Stanford University. She and colleagues have found that beliefs about stress have a lot to do with how someone experiences challenges. People who believe stress can be an enhancing part of life do a better job of handling challenges, evidence suggests.

Even for people in the brutal Navy SEALs training program, those with a stress-is-enhancing mind-set lasted longer in the program than people who considered stress debilitating, Crum and colleagues reported January 15 in *Frontiers in Psychology*. "Positive, even transformative, effects can occur under even the most extreme stressors," Crum says. "These effects are simply more likely to occur when people are in a mind-set that orients them that way."

To help people begin to shift their thinking, Crum has helped develop an approach with three main steps: Acknowledge the stress, recognize that we stress over things we value and finally, figure out a way to use that stress to our advantage. — *Laura Sanders*

A natural experiment

Psychologists and brain scientists are on it. As of mid-May, a database tracking COVID-19 social science projects had 294 research projects related to the current pandemic.

These kinds of natural experiments — studying people who had experienced uncontrollable, intense stress in their lives — have happened before. Phelps and colleagues studied how people remember the events of 9/11. People who were in downtown Manhattan at the time of the attacks seemed to rely more heavily on their amygdalae to call up memories of the shocking event than people who were farther away, the researchers reported in 2007 in *Proceedings of the National Academy of Sciences*. Other researchers have identified thinking problems in people who lived through Hurricane Katrina and other natural disasters.

Stress from the COVID-19 pandemic might influence decision making, Phelps suspects. How do you respond to positive and negative feedback when you're stressed? Does your desire to do hard work change? She and colleagues are hoping to get answers by surveying people across the United States. Participants will describe their stress reactions and complete online tasks that test decision making and memory.

Other long-term studies will examine how autobiographical memories of the pandemic change over time, how the pandemic affects stress during pregnancy and how mind-set might influence how people cope.

As this chaotic period rolls on, stressors will change and accumulate. Sustained crisis, scientists suspect, can change our brains and their capabilities in even more profound ways than temporary stress.

For now, each of us is left to manage our own personalized stress cocktails. Mine grows more potent with an expanding backlog of tasks, both domestic and job-related, the cumulative sorrow of seeing my kids isolated from their friends and a steady drip of small losses. And I worry for the many people who are worse off, facing illness and financial strain. It's a lot.

As we all grapple with this reality, scientists have a message for us, one that I find comforting: "Forgive yourself," Phelps says. "If you're finding it challenging right now to focus, forgive yourself." ■

Explore more

- Dibyadeep Datta and Amy Arnsten. "Loss of prefrontal cortical higher cognition with uncontrollable stress: molecular mechanisms, changes with age and relevance to treatment." *Brain Sciences*. May 17, 2019.

A. ARNSTEN

SOCIETY UPDATE

A SPECIAL THANK YOU

We are grateful for our members, alumni and everyone in the Society for Science & the Public family who are stepping up to help during the coronavirus pandemic, from comforting the sick to developing treatments and tests. In this time of global need, we'd like to highlight the contributions of Society alumni who are leading on the front lines, tackling the most urgent scientific and humanitarian crisis of our time.

△

Dr. Ben Abella (STS 1988), Vice Chair for Research in the Department of Emergency Medicine at the University of Pennsylvania, is deeply engrossed in both treating people suffering from COVID-19 and in conducting clinical trials to validate or rule out potential treatments.

△

Aakshi Agarwal (BCM 2013, ISEF 2016, STS 2017) cofounded Telehealth Access for Seniors, a nonprofit that helps connect seniors with their physicians and health care providers for telehealth appointments. The organization collects and sanitizes donated devices to give to the elderly.

△

Dr. Deborah Birx (ISEF 1973) is leading the United States' coronavirus response as the White House Coronavirus Response Coordinator. She has worked closely with three different presidents over the years—George W. Bush, Barack Obama and now Donald Trump.

George Yancopoulos (STS 1976), **Len Schleifer** (STS 1970) and their colleagues at Regeneron are studying an existing medicine and developing novel antibodies for prevention and treatment of COVID-19. Regeneron is also supporting communities and workers on the front lines in New York state with testing kit supplies and charitable contributions.

▽

◁

Dr. Daniel Durand (STS 1997) is Chief Innovation Officer, Chairman of Radiology and Vice President of Research for LifeBridge Health, a five-hospital health system in Maryland. Dan and his team assisted in creating and implementing an app that has helped thousands of patients with confirmed or suspected COVID-19 self-isolate and quarantine while remaining in contact with the health system. They also teamed up with Under Armour to make protective gear.

△

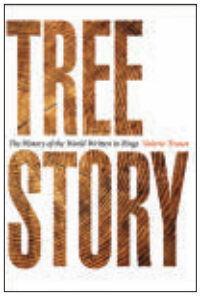
Feng Zhang (ISEF 1998–1999, STS 2000), along with a group of scientists at MIT, the McGovern Institute and the Broad Institute, developed STOPCovid, an effort to develop point-of-care and at-home tests for COVID-19.

△

Elyse Hope (DCYSC 2002, ISEF 2004–2006, STS 2006) is managing new projects related to COVID-19 at the nonprofit research institution Genome British Columbia, ranging from drug evaluation to statistical modeling to protective gear sterilization.

△

Shiv Gaglani (ISEF 2004–2006) and **Ryan Haynes** (ISEF 2002) are cofounders of Osmosis.org, a health education platform that reaches millions of health care workers, patients and their family members. During the pandemic, Osmosis has kicked into high gear and released frequent updates on COVID-19, including educational videos and a brand new podcast.



Tree Story
Valerie Trouet
JOHNS HOPKINS UNIV., $27

BOOKSHELF

Tree rings record secrets from the past

Once you look at trees through the eyes of a dendrochronologist, you never quite see the leafy wonders the same way again. Peel away the hard, rough bark and there is a living document, history recorded in rings of wood cells. Each tree ring pattern of growth is unique, as the width of a ring depends on how much water was available that year. By comparing and compiling databases of these "fingerprints" from many different trees in many different parts of the world, scientists can peer into past climates, past ecosystems and even past civilizations.

Humans' and trees' histories have long been intertwined. In her new book *Tree Story*, tree ring researcher Valerie Trouet examines this shared past as she describes the curious, convoluted history of dendrochronology. It's a field that was born a little over a century ago, almost as a hobby for an astronomer at the University of Arizona.

Andrew Douglass was interested in tree rings for what they might tell him about how past solar cycles influenced Earth's climate. He began amassing a tree ring collection dating back to the mid-15th century. Then Douglass began examining an even older source of data: ancient wooden beams from Puebloan ruins in the U.S. Southwest. By linking the patterns in the beams to his own tree ring samples, he created a long chronological history for the region — and so the science of dendrochronology was born. Through this new dating technique, Douglass also solved a long-standing mystery, calculating ages for the different Puebloan sites ranging from the 10th to the 14th century.

Trees rings have documented other pivotal moments in human history, Trouet explains. Unusually wet years from 1211 to 1225 may have given a boost to grasses in central Asia's steppe — fodder for Genghis Khan's mounted forces and key to the rapid expansion of the Mongol Empire. The 1986 Chernobyl nuclear power plant accident left its mark in the strangely aligned wood cells of surviving pine trees. Wood patterns in a violin crafted by Antonio Stradivari (and worth an estimated $20 million) authenticated not only the violin's age but its geographic origins.

Tree ring data spanning over 1,000 years was also instrumental in helping scientists reconstruct the planet's recent climate history and in highlighting the dramatic warming observed in the last century.

Trouet, a member of the University of Arizona's Laboratory of Tree-Ring Research in Tucson, is a dendroclimatologist; she uses tree rings to study Earth's past climate. She tells of "the thrill of the chase" to find the oldest, least disturbed trees on Earth, with circular rings and growth related only to changes in climate. These trees have helped her identify, for example, periods of medieval drought in northern Africa that are linked to a large-scale weather pattern known as the North Atlantic Oscillation — also the probable reason for a historically documented period of warmth in Europe known as the Medieval Climate Anomaly, she suggests.

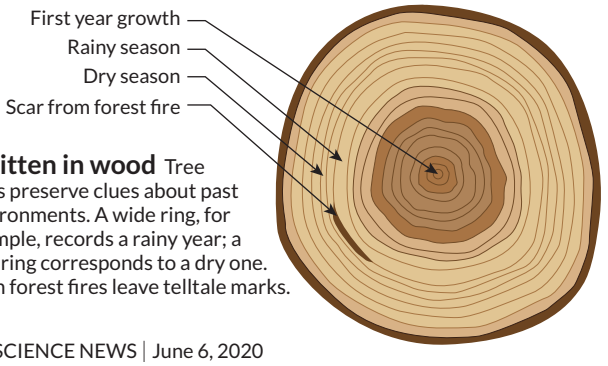
Now, she and colleagues are examining tree rings from Europe to trace how the high-speed jet stream winds that encircle the Northern Hemisphere have shifted over time. The waviness of the jet stream — how far south these winds might dip and curl — is linked to patterns of storms across the northern latitudes. Understanding those links in the past, Trouet argues, could provide clues to how storminess may change in the future, as the planet's climate changes.

> Tree ring scientists can peer into past climates, past ecosystems and even past civilizations.

Tree Story gives readers a lively, sometimes visceral feel for Trouet's work. She describes the beauty of tiny wood cells smaller in diameter than a human hair, and the elbow grease involved in manually twisting a borer into the heart of a tree to retrieve a sample. "This requires quite a bit of upper-body strength, especially if you're coring dozens of trees a day, and this often comes as a surprise to dendro newbies." Trouet's humor also comes through when she describes how fieldwork is sometimes driven by testosterone-fueled stubbornness, and how she has had to convince male colleagues hunting for trees in the mountains that it's OK to admit to being tired, hungry or cold. "As a woman scientist, I got 99 problems, but at least starving or freezing to death to protect my ego ain't one."

Peppered throughout the book are italicized terms and helpful definitions of scientific jargon such as "crossdating" (matching ring patterns among different trees, whether alive or dead, to create a consistent chronology). I particularly enjoyed getting a glimpse into odd tree ring lingo: To "hit the pith" is to core all the way to the oldest part of a tree; "cookies" are the round cross sections of a fallen trunk, cut with a chainsaw or an ax.

Trouet loves trees, but she says she is not a tree-hugger, nor does she believe trees are sentient. Instead, she is drawn to unlocking the secrets the trees contain. "Wood is gorgeous," she writes. "And finding matching tree ring patterns is like solving a puzzle — it is addictive." — *Carolyn Gramling*



Written in wood Tree rings preserve clues about past environments. A wide ring, for example, records a rainy year; a thin ring corresponds to a dry one. Even forest fires leave telltale marks.

C. CHANG

APRIL 11, 2020

A song of science

Adding space telescopes to the Event Horizon Telescope network could help capture additional rings of light (simulation shown) around galaxy M87's supermassive black hole, **Emily Conover** reported in "How to find a black hole's 'photon ring'" (*SN: 4/11/20, p. 12*). Reader **Kevin Ker** used the story as inspiration for a song he wrote called "Black Holes." Listen to the song at bit.ly/photon-ring

M.D. JOHNSON *ET AL/SCIENCE ADVANCES* 2020

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Not your bookshelf's dust

*Dust may explain why the star Betelgeuse suddenly dimmed in 2019, **Lisa Grossman** reported in "Betelgeuse is not about to explode" (*SN: 4/11/20, p. 6*).*

Reader **Steve Ostrom** was intrigued by how gas clouds around red giant stars like Betelgeuse condense into dust. "I have read many times about 'dust' in space, and have always wondered what that is," **Ostrom** wrote. "I doubt it's the same dust that accumulates on my bookshelves every month. Exactly what is this 'dust,' and how does it condense out of gas?"

The definition of dust in space depends on where you're looking and who you're talking to, **Grossman** says. "Planetary scientists have a different definition than astrophysicists. But in this case, the dust that red giant stars puff out is gas from the star that has cooled down enough to turn solid," she says. Below a certain temperature, atoms start to collide and stick together, but the details are far from understood, says cosmochemist **Larry Nittler** of the Carnegie Institution for Science in Washington, D.C. The composition of the dust depends on the composition of the star — carbon-rich stars make mostly carbon dust, while oxygen-rich stars make mostly silicates.

Playground perks

*Playground designs that encourage active imaginative play can make a difference in how much kids move, **Emily Anthes** reported in "Building playgrounds that get kids moving" (*SN: 4/11/20, p. 20*).*

Reader **Stephen Restaino** believes that such playgrounds may have other benefits, like decreasing bullying and boosting grades. A pediatrician, **Restaino** mentioned studies that suggest active recess decreases in-class behavior issues. "This isn't just about ... getting a child's heart rate up," he wrote. "It's time for these researchers to go back and talk [with] parents, teachers and [administrators] for a more substantive, broader evaluation of these new playgrounds and the other perks that accrue from money well spent."

COVID-19 Q&A

Science News *reporters **Tina Hesman Saey**, **Aimee Cunningham**, **Jonathan Lambert** and **Erin Garcia de Jesus** are following the latest research to keep you up to date on the coronavirus pandemic. The team is answering reader questions about COVID-19.*

Reader **Nick R.** asked if exercising outdoors while practicing social distancing is safe.

Exercising outdoors while keeping at least six feet from others is generally considered a low-risk activity when it comes to catching COVID-19. But virus-laden droplets can travel farther than six feet (*SN: 5/9/20 & 5/23/20, p. 6*). Whether six feet is safe enough outside likely depends on the weather, how long the virus remains infectious in those conditions and how little of the virus is needed to kick-start an infection. Scientists are still working to understand the interplay of those factors.

A brief encounter with an infected person outside probably isn't enough contact to catch the virus, some evidence suggests. But if parks or trails are crowded enough to make it difficult to stay away from others, it might be a good idea to exercise during off-hours or wear a cloth mask.

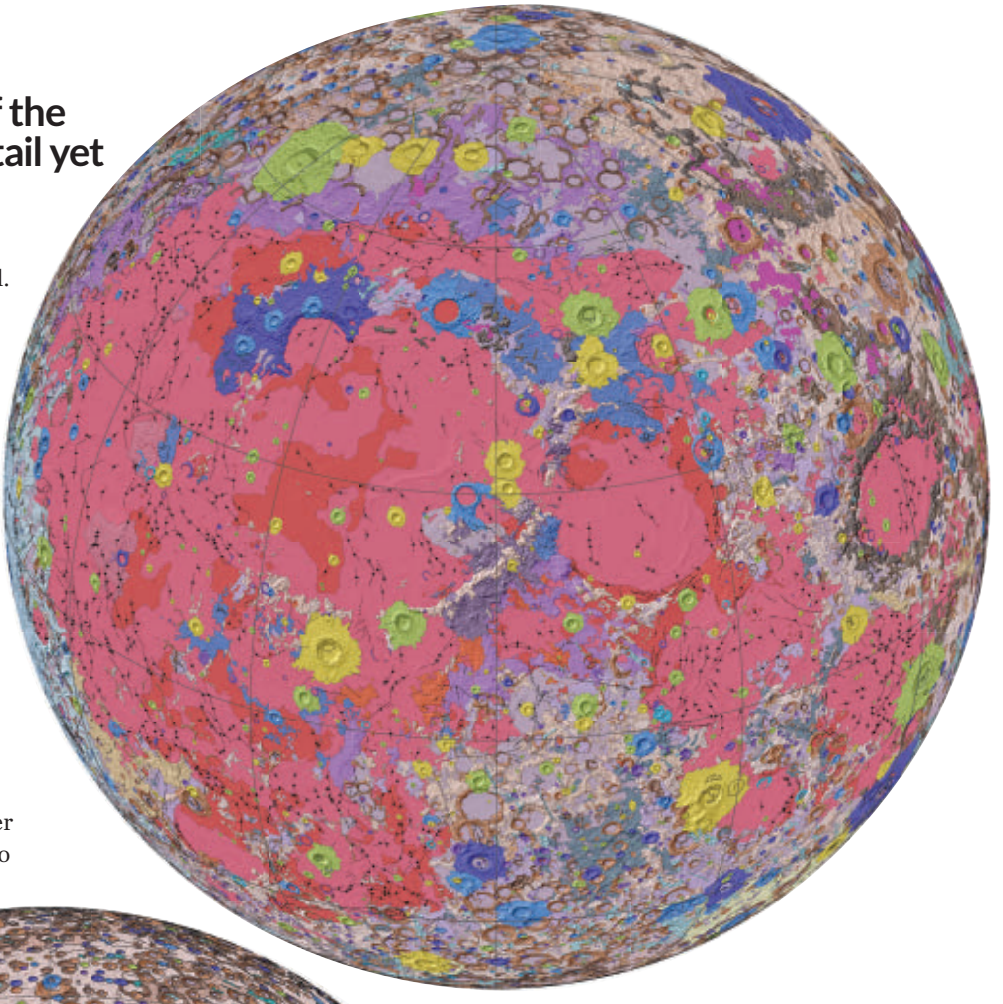
Correction

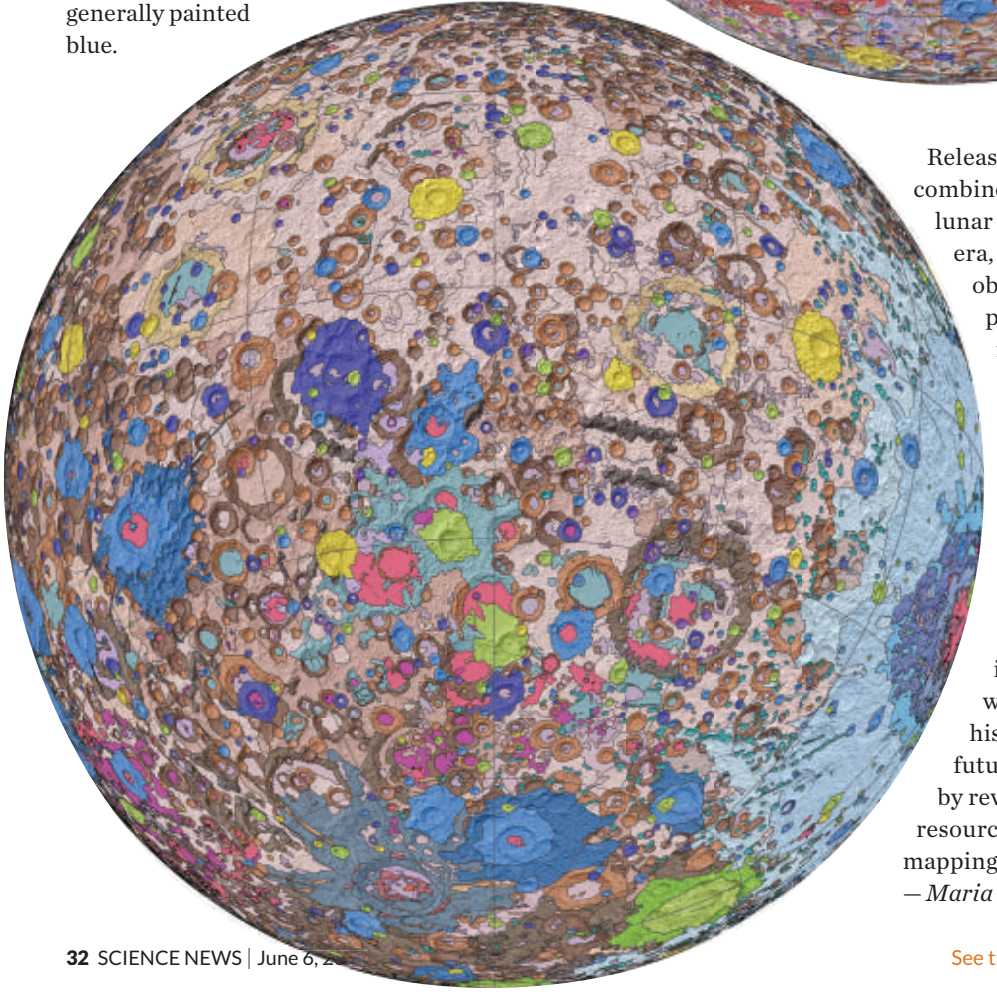
In "Relic's origins may refute tie to Jesus" (*SN: 4/25/20, p. 13*), Nazareth is incorrectly identified as the location of Jesus' tomb. Experts believe the tomb is in Jerusalem.

A new geologic map of the moon has the most detail yet

In the most comprehensive map of lunar geology ever made, the moon looks like it's been playing paintball.

Each color identifies a type of rock or land formation, including craters, basins and ancient lava fields, on the moon's nearside (top) and farside (bottom). For instance, "the darker, more earth tones are these highland-type terrains, and the reds and the purples tend to be more of these volcanic and lava flow materials," says geologist James Skinner of the U.S. Geological Survey in Flagstaff, Ariz. Craters associated with the Eratosthenian Period on the moon (about 3.2 billion to 1.1 billion years ago) are typically marked green. Craters from the older Imbrian Period (around 3.9 billion to 3.2 billion years ago) are generally painted blue.





Released April 20 by the USGS, the map combines information from six regional lunar maps created during the Apollo era, as well as more recent spacecraft observations. This lunar cartography project was trickier than just fitting Apollo-era maps together like puzzle pieces and using new data to tweak the details — in part because the edges of the regional maps didn't line up. Many surface features at the boundaries between neighboring maps were labeled with inconsistent names, descriptions and ages.

The map is useful for hammering out crater formation timelines, which give insight into the moon's history. And the map could inform future human missions to the moon by revealing regions that may be rich in resources or areas that need more detailed mapping to safely land a spacecraft there.

— Maria Temming

BOTH: GSFC/NASA, USGS

See this map in 3-D at **bit.ly/SN_Moon_Geology**

Discovered! Unopened Bag of 138-Year-Old Morgan Silver Dollars

Unopened for 138 Years!

Coin experts amazed by "Incredible Opportunity"

- ✓ Historic Morgan Silver Dollars
- ✓ Minted in New Orleans
- ✓ Struck and bagged in 1882
- ✓ Unopened for 138 years
- ✓ 26.73 grams of 90% fine silver
- ✓ Hefty 38.1 mm diameter
- ✓ Certified Brilliant Uncirculated by NGC
- ✓ Certified "Great Southern Treasury Hoard" pedigree
- ✓ Limit five coins per household

The Morgan Silver Dollar is the most popular and iconic vintage U.S. coin. They were the Silver Dollars of the Wild West, going on countless untold adventures in dusty saddlebags across the nation. Finding a secret hoard of Morgans doesn't happen often—and when it does, it's a *big deal*.

How big? Here's numismatist, author and consultant to the Smithsonian® Jeff Garrett:

"It's very rare to find large quantities of Morgan Silver Dollars, especially in bags that have been sealed... to find several thousand Morgan Silver Dollars that are from the U.S. Treasury Hoards, still unopened, is really an incredible opportunity."
-Jeff Garrett

But where did this unique hoard come from? Read on...

Morgans from the New Orleans Mint

In 1859, Nevada's Comstock Lode was discovered, and soon its rich silver ore made its way across the nation, including to the fabled New Orleans Mint, the only U.S. Mint branch to have served under the U.S. government, the State of Louisiana and the Confederacy. In 1882, some of that silver was struck into Morgan Silver Dollars, each featuring the iconic "O" mint mark of the New Orleans Mint. Employees then placed the freshly struck coins into canvas bags...

The U.S. Treasury Hoard

Fast-forward nearly 80 years. In the 1960s, the U.S. government opened its vaults and revealed a massive store of Morgan Silver Dollars—including *full, unopened bags* of "fresh" 1882-O Morgan Silver Dollars. A number of bags were secured by a child of the Great Depression—a southern gentleman whose upbringing showed him the value of hard assets like silver. He stashed the unopened bags of "fresh" Morgans away, and there they stayed...

The Great Southern Treasury Hoard

That is, until *another* 50 years later, when the man's family finally decided to sell the coins—still in their unopened bags—which we secured, bag and all! We submitted the coins to respected third-party grading service Numismatic Guaranty Corporation (NGC), and they agreed to honor the southern gentleman by giving the coins the pedigree of the "Great Southern Treasury Hoard."

These gorgeous 1882-O Morgans are as bright and new as the day they were struck and bagged 138 years ago. Coins are graded on a 70-point scale, with those graded at least Mint State-60 (MS60) often referred to as "Brilliant Uncirculated" or BU. Of all 1882-O Morgans struck, *LESS THAN 1% have earned a Mint State grade*. This makes these unopened bags of 1882-O Morgans extremely rare, certified as being in BU condition—nearly unheard of for coins 138 years old.

Don't Miss This Rare Opportunity—Order Now!

Regular 1882-O Morgans sell elsewhere for as much as $133, and that's without the original brilliant shine these "fresh" 138-year-old coins have, without their special NGC hoard designation, and without their ability to tell their full, complete story from the Comstock Lode all the way to your collection.

Given the limited quantity of coins available from this historic hoard, we must set a strict limit of five coins per household. Call quickly to secure yours today as supplies are sure to sell out quickly!

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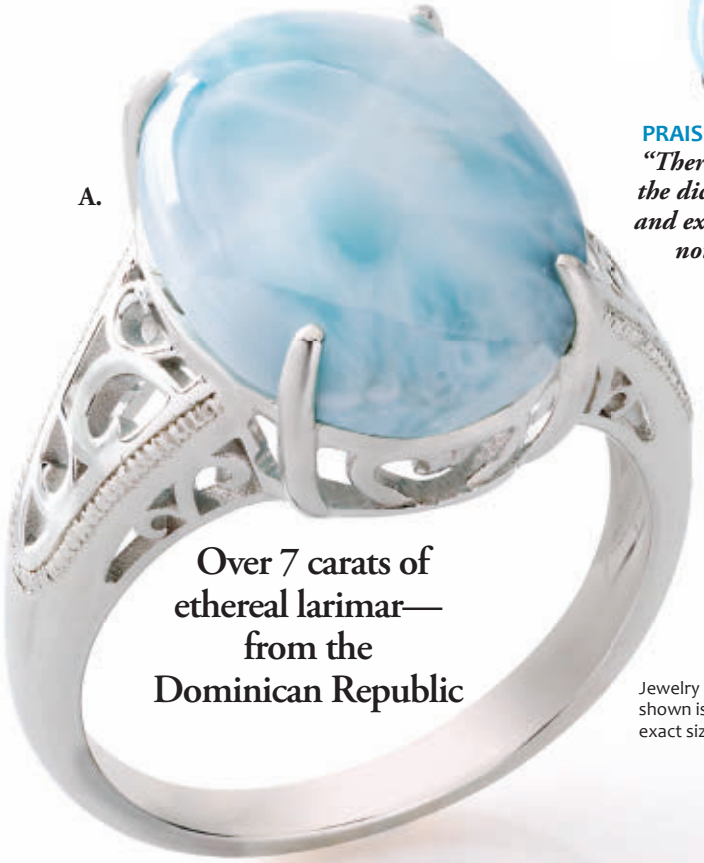
A.



Over 7 carats of ethereal larimar—from the Dominican Republic

B.

C.

PRAISE FOR STAUER LARIMAR RINGS

"There are not enough adjectives in the dictionary to describe the beauty and excellence of this ring. Buy it, do not wait." **— C., Longwood, FL**

D.

Jewelry shown is not exact size

"You can't take her to the Caribbean, so bring the Caribbean to her."

So **Rare**, You Can Only Find It One Place on Earth. Two, If You Count Stauer!

Few have ever seen a larimar stone, and far fewer still are fortunate as to actually own this rare gem with the gorgeous blue colors of the Caribbean. The gemstone comes only from a single remote mountainside, in the Dominican Republic, on a single kilometer, and is not found anywhere else in the world. This makes larimar 10,000 times rarer than diamonds. But luckily, the prices are not controlled by a syndicate so this rare stone is still affordable, as long as you know where to look. You've come to the right place, we *are* your ticket to paradise.

We've crafted rare larimar into remarkable jewelry that's also remarkably affordable. Each stone in our ***Sea of Love Larimar Collection*** is a picture of perfect swirling blue. Nature guarantees that no two larimar gemstones will be exactly alike, each has a wispy white swirl that looks like the highest clouds on a sun-filled day.

You could spend well over $500 for a larimar ring set in sterling silver. But why would you when you can bring her this gorgeous stone for an exclusive Stauer price.

Her Satisfaction is 100% Guaranteed. If she's not swept away, simply return your purchase for a refund of the item price.

Mother Nature has given us such a small quantity of this beautiful stone and there is no way to replenish the few carats that are available. Don't miss the boat on this one.

Sea of Love Larimar Collection

A. Ring (7 ½ carat)..... ~~$299~~ $99* ***Save $200***
B. Earrings (5 ctw) ..... ~~$299~~ $99* ***Save $200***
C. Pendant (7 ½ carat) ..... ~~$299~~ $129* ***Save $170***
18" Sterling Silver Cable Chain $59
D. 7 ½" Bracelet (7 ¾ ctw) ..... ~~$299~~ $129* ***Save $170***
Pendant, Chain, Earrings & Bracelet ~~$956~~ $279 ***Save $677***

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• Larimar from the Dominican Republic • .925 sterling silver settings • Ring: whole sizes 5-10 • Earrings: Post back

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