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ScienceNews

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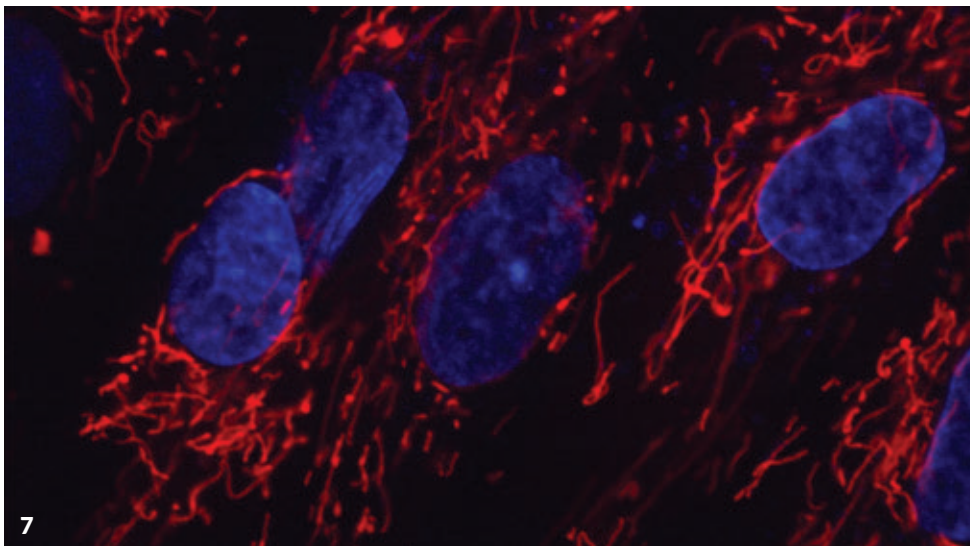
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COVER The setting and proximity to other people make a difference when it comes to a person's risk of getting COVID-19. *Neil Webb*



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FROM TOP: RIFKA HAYATI/GETTY IMAGES PLUS; DAGELDOG/GETTY IMAGES PLUS; TSILILAST/MOOTHALAB



Data visualizations turn numbers into a story

The tsunami of coronavirus news coverage can paradoxically make it hard to find the information you want. When I log on first thing in the morning, I search for the latest COVID-19 case numbers. The best way to absorb that data is a quick glance at a chart or graph.

The fact that information is often better conveyed with images rather than words is not news to associate digital editor Helen Thompson. She's the creative mind behind many of our website's beguiling video explainers, including a recent one on how an element earns a place on the periodic table.

Having previously covered Ebola outbreaks, Thompson knew that contact tracing is key to slowing disease transmission. She wanted to show how looking at clusters of infections has helped researchers figure out how the coronavirus spreads in common settings (Page 15). It's clear from just a glance at her data visualization that infections can spread widely in crowded indoor settings like ships and prisons, and that transmission within households is more common. "That's the power of data viz," she told me. "You can convey something in an instant that would take a paragraph."

To make the visualization, Thompson dove into a massive dataset of COVID-19 clusters worldwide, compiled by researchers at the London School of Tropical Medicine & Hygiene. She siphoned some of the data from the team's Google Sheets into Tableau, data visualization software often used by journalists. "It's an easier way to see trends, what countries were the most common, what settings were the most common," Thompson says. "I threw in the indoor-outdoor variable as a color; the difference was so stark."

Thompson worked with the researchers to make sure she interpreted the data correctly. She even added clusters to the database, including a wedding in Jordan where 76 of the roughly 360 attendees became infected. "People are thinking about whether they're going to go to family gatherings," Thompson notes. "My college roommate is going to a wedding in August, so I'm really nervous."

Data visualizations are complicated, labor-intensive beasts. Thompson mocked up multiple versions and tested how people interpreted them with help from the *Science News* staff plus some college roommates. She collaborated with design director Erin Otwell, features editor Cori Vanchieri and digital director Kate Travis to create different products for print and online. The online version is especially impressive; you can hover over the circles representing clusters and get details on each one.

And while you're on our site, take a gander at some of Thompson's other work. I'm particularly fond of the video of tiny legless larvae leaping into the air, accompanied by Strauss' "Also sprach Zarathustra." The Texas native with a wry sense of humor says she's partial to mixing science and music. She set a video on the physics of peacock twerking to the overture from "The Barber of Seville." "I grew up being forced to listen to a lot of opera," she says. (You can find our visualizations and videos at www.sciencenews.org/multimedia.)

So thanks to Helen's parents for all that opera, and to Thompson herself for bringing science into sharp focus. — *Nancy Shute, Editor in Chief*

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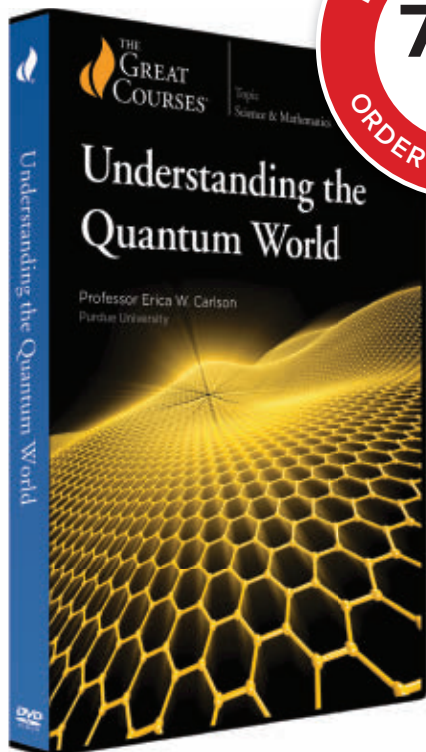
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Meet Schrödinger's Cat and Other Quantum Ideas

The word "quantum" evokes mystery and unreality such as the baffling paradox of Schrödinger's cat—a hypothetical pet that is simultaneously both dead and alive in a quantum experiment. Yet quantum mechanics is one of the most successful theories of reality ever developed, describing exactly how matter and radiation work, and leading to such inventions as lasers, atomic clocks, flash drives, and much more.

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Excerpt from the August 22 & 29, 1970 issue of *Science News*

50 YEARS AGO

Soviet research in Antarctica

There is a hypothesis that the Great Antarctic [Ice] Shield is gradually sliding into the sea at a rate of about 330 feet a year.... To learn how much ice is accumulated and how much of it slides off the continent, scientists set up special survey stakes.... During their latest trek they checked these survey stakes and determined the speed with which the ice masses creep.

UPDATE: Satellite monitoring that began in the early 1990s has let scientists precisely measure how fast ice moves across Antarctica. Ice near the heart of the continent today creeps coastward at less than 10 meters per year, while ice close to the coast picks up the pace, traveling up to a few kilometers per year. Due to global warming, Antarctica is losing ice faster than it can be replaced. From 2012 to 2017, the continent shed an average of about 219 billion metric tons of ice annually, compared with 76 billion tons per year during the previous two decades. Overall, Antarctic ice melt from 1992 to 2017 boosted global sea level by 7.6 millimeters on average (*SN*: 7/7/18, p. 6).

THE SCIENCE LIFE

Why you can find Yellowstone wolves on Ancestry.com

Wildlife ecologist Jim Halfpenny stood by the stone arch at the north entrance to Yellowstone National Park on January 12, 1995, as horse trailers eased through carrying the first wild gray wolves (*Canis lupus*) to enter the park in about 60 years. This first delivery of eight wolves from Canada was the beginning of a historic attempt to complete and restore the park's ecosystem by reintroducing a species wiped out decades before.

He remembers the gathered schoolchildren's disappointment when they couldn't get a glimpse of fur. However, Halfpenny and the other elated adults "were up there howling our heads off," he says. At the time, Halfpenny was working with the University of Colorado Boulder's Institute of Arctic and Alpine Research and starting his own education company, A Naturalist's World. Over the years, he recorded the introduced wolves' pairings, puppies and the rise and fall of packs, and he wished wolf fans everywhere also could follow the story lines. That's why he and some other enthusiasts gave the genealogy website Ancestry.com its first nonhuman entries. A Kickstarter campaign funded four intense months of data wrangling in 2017.

Anyone can find a Yellowstone wolf's history at wolfgenes.info and can request an invitation to get a free account to view wolf family trees at Ancestry.com. A media gallery on the Ancestry site includes images of many of the wolves along with life stories and family trees.

A Canadian-born female known as 5Fb

The alpha female of the Wapiti Lake pack is popular among visitors to Yellowstone National Park. She is descended from a group of 41 wolves released into the park in the 1990s.

was the first wolf carried from the trailers into Yellowstone. The next year she lost her mate and their four pups in an attack by a rival pack. She was hurt, too, but another survivor helped feed her, and she recovered to found a new pack with that male wolf. Another Canadian female, 9Fb, lost her first mate to an illegal shooting but was accepted, with her eight pups, by a young Canadian male. He often played with the pups, letting them sneak up and leaping to his feet at the last moment.



Jim Halfpenny holds a cast of a grizzly bear skull. The wildlife ecologist and his colleagues created online family trees for gray wolves in Yellowstone National Park.

One of these step-pups, 21Mb, is among Halfpenny's favorite wolves and stars in three National Geographic specials. "The biggest day for me," Halfpenny says, came when 21Mb as a young adult approached a pack that had just lost its alpha male. Near the end of an edgy, hourslong standoff, one female checked 21Mb out and put one paw on his back, Halfpenny says. 21Mb was on his way to

acceptance, and he became the alpha wolf. His biography describes him as a wolf that humans can admire: "As far as we know, he never lost a fight, and he never killed a vanquished wolf from an enemy pack."

For new Yellowstone visitors who want a glimpse of wolf life, Halfpenny has some advice: Watch for people. Passionate wolf-watchers gather just as night ends where they think wolves are likely to be. If the spotting scopes are trained in one direction, "that's a good sign." —*Susan Milius*

THE NAME GAME

Newly named asteroid is about to get schooled in hard knocks

Dimorphos is a small space rock with a big target on its back. On June 23, the International Astronomical Union officially named the rock because it has been marked for the first asteroid deflection mission. A NASA spacecraft will ram into Dimorphos to alter the asteroid's path through space. Just 160 meters across, Dimorphos will be about 11 million kilometers from Earth at the time of impact, making the rock a prime testing ground for a technique to ward off dangerous asteroids in the future.

"Dimorphos" is Greek for "having two forms," in honor of the rock's trajectories before and after the Double Asteroid Redirection Test spacecraft knocks it askew. DART is slated to launch in July 2021 and crash into the space rock in September 2022. The impact should shorten Dimorphos' 12-hour orbit around the larger asteroid Didymos by about 10 to 20 minutes, says planetary scientist Kleomenis Tsiganis of the Aristotle University of Thessaloniki in Greece. Telescopes on Earth will track the immediate aftermath of the crash, and in 2024 a probe will intercept Dimorphos to ensure it's on the new path. — *Maria Temming*

The asteroid dubbed Dimorphos (left in this illustration) is the target of the first asteroid deflection mission. A NASA spacecraft (right) will knock the rock off course.



CLOCKWISE FROM TOP LEFT: NASA; STEVE GRIBBEN/JHUAPL; J.M. SMOLIGA/BIOLOGY LETTERS 2020; DAGELDOGGE+/GETTY IMAGES PLUS

RETHINK

Calculating a dog's age takes a bit more math

To estimate your dog's age in human years, multiply the canine's age by seven, right? Wrong.

A more accurate conversion isn't so easy to do in your head: Multiply the natural logarithm of the dog's age by 16, then add 31. Researchers report this new canine age formula online July 2 in *Cell Systems*.

As animals get older, tiny chemical tags called

methyl groups get added and removed from DNA. These changes track with different stages of growth and can be used to determine biological age. Scientists can even compare changes across species. In this case, the researchers compared the methylation states of 320 humans, ages 1 to 103 years, with those of 104 Labrador retrievers, ages about 5 weeks to 16 years.

The relationship between human and dog years changes over time, the scientists found.

Early in life, puppies develop much

faster than humans, but as dogs get older, their aging curve begins to flatten. An 8-week-old puppy is roughly the same age as a 9-month-old human. A 1-year-old dog corresponds to around 31 human years, and a 4-year-old dog is closer to a 53-year-old human. The new equation also lines up the expected life span of a Lab — 12 years — with the average 70-year human life span.

The study focused only on Labrador retrievers (one shown at left). Since the life spans of other breeds vary, further studies are needed to find out the real age of every very good dog, the scientists say. — *Bethany Brookshire*



SCIENCE STATS

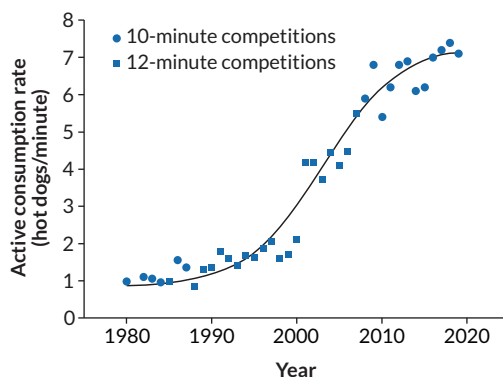
Science hits the brakes on hot dog-eating records

In the race to scarf down the most hot dogs in 10 minutes, competitive eaters may have a limit.

Physiologist James Smoliga extrapolated a maximum intake of 83 franks based on data from 152 competitors over 39 years of Nathan's Famous Hot Dog Eating Contest on New York City's Coney Island. That translates to a consumption rate of about 8.3 hot dogs per minute, Smoliga reports in the July *Biology Letters*.

The graph below shows winners' consumption rates rising and plateauing near this max rate. Quickly eating a lot of food may have been useful in our evolutionary past, says Smoliga, of High Point University in North Carolina. Nowadays, inhaling hot dogs mostly leads to digestive issues, and for the lucky, the coveted Mustard Belt of champions. — *Jonathan Lambert*

Consumption rate of winners of Nathan's Famous Hot Dog Eating Contest, 1980–2019



Earlier arrival in the Americas claimed

Artifacts hint humans lived in Mexico over 30,000 years ago



BY MARIA TEMMING

Humans may have reached North America way earlier than thought.

Purported stone tools unearthed in Mexico hint that humans lived in the area as early as about 33,000 years ago, researchers report online July 22 in *Nature*. That's more than 15,000 years before humans are generally thought to have settled North America. This controversial discovery enters a new piece of evidence into the fierce debate about when the Americas were first populated.

"A paper like this one is really stirring up the pot," says coauthor and evolutionary biologist Eske Willerslev of the University of Cambridge. It "will no doubt get a lot of arguments going."

For decades, archaeologists thought the Americas' first residents were the Clovis people—big game hunters known for their well-crafted spearpoints who crossed a land bridge from Asia to Alaska about 13,000 years ago. Recent, well-accepted archaeological work suggests that North America's first settlers actually arrived a few thousand years before the rise of the Clovis culture, by about 16,000 years ago, says Vance Holliday, an archaeologist at the University of Arizona in Tucson not involved in the new work.

If the new finds really are human tools, Holliday says, this would be the oldest evidence for a human-inhabited site anywhere in the Americas.

At Chiquihuite Cave in north-central Mexico, archaeologists found what appear to be over 1,900 stone tools. Using radiocarbon dating, the team determined that over 200 of the tools were embedded in a layer of earth up to 33,150 to 31,400 years old.

The tools, excavated from 2016 to 2017, do not resemble Clovis technology or any other stone tools found in the Americas, the researchers say. This haul "has a lot of small blades and small flakes that were used for cutting," says archaeologist Ciprian Ardelean of the Autonomous University of Zacatecas in Mexico. His team also dug up squarish stone fragments that he suspects were used to make composite tools of some sort, assembled from pieces of rock stuck into wooden or bone shafts.

"People are going to disagree about whether this qualifies as evidence" of human activity, says Loren Davis, an archaeologist at Oregon State University in Corvallis not involved in the work. "These are rocks that were broken, but... people don't have a monopoly on the physics involved with breaking rocks." Davis says that a closer examination of the artifacts in person or via 3-D models could convince him that the rocks are indeed relics of human craftsmanship.

Ben Potter, an archaeologist in Fairbanks, Alaska, affiliated with the Arctic Studies Center at Liaocheng

The discovery of what appear to be stone tools (one shown) in a Mexican cave suggests humans came to North America more than 15,000 years before typically thought.

University in China, is similarly "intrigued but unconvinced" that the cave was an ancient human abode. He points to the crude shape of many of the artifacts, as well as the absence of other evidence—such as butchered animal remains or human DNA—that would peg the site as a human residence.

Neither the tools' shape nor the apparent lack of other human-made remains disqualifies the cave as an ancient dwelling, Ardelean says. He argues that archaeologists' expectations of what North American stone tools should look like are overly influenced by the perfection of Clovis points, which were neatly chipped from brittle stone such as jasper. The limestone used by the Chiquihuite Cave dwellers was more difficult to work with, he says, so it makes sense that these implements would be more rugged.

As for corroborating evidence, Ardelean expects human DNA to turn up only in specific areas of the cave, like where people ate. His team may not have excavated those spots yet, he says. The area investigated in this dig was far from the cave's mouth, where people would more likely have cooked, eaten and performed other daily activities, he says.

Ruth Gruhn, an anthropologist at the University of Alberta in Edmonton, Canada, "wasn't a bit surprised" at the claim of 30,000-year-old human handiwork in Mexico. The cave joins a handful of sites in Brazil that have shown evidence of human occupation over 20,000 years ago—though those reports also are controversial (*SN: 4/20/13, p. 9*), says Gruhn, whose commentary on the new study appears in *Nature*. To convince many archaeologists that humans really were in the Americas so early, "what you need is an accumulation of sites of that antiquity." ■

New gene editor targets mitochondria

In a first, scientists make precise changes in the organelle's DNA

BY JACK J. LEE

Bacterial weaponry has a new and unexpected potential use in human cells.

A protein secreted by bacteria to kill other microbes has been re-engineered to tweak DNA found in a cell's mitochondria, scientists report in the July 23 *Nature*. The advance paves the way for one day fixing diseases caused by mutations in mitochondria. Those energy-producing organelles, generally inherited from only the mother, have their own DNA distinct from the genetic information, from both parents, stored in the cell nucleus.

"I've been a mitochondrial biologist for 25 years, and I view this as an extremely important advance for the field," says study coauthor Vamsi Mootha, a Howard Hughes Medical Institute investigator at Massachusetts General Hospital in Boston and the Broad Institute of MIT and Harvard.

Mutations in mitochondrial DNA cause more than 150 syndromes and affect 1,000 to 4,000 children born in the United States each year. Currently, there are no cures, and the only way to prevent a child from inheriting a mother's dysfunctional mitochondria is a controversial "three-parent baby" method, an in vitro fertilization technique that requires mitochondria from a donor egg (*SN*: 12/24/16 & 1/7/17, p. 22).

Gene editing is one approach for trying to cure genetic diseases. Researchers have used molecules called TALENs to cut up mitochondrial DNA in mice and eliminate, but not correct, defective organelles. A newer technology, called base editors, bolts proteins that can change DNA bases — represented by the letters A, C, G and T — to modified versions of proteins such as Cas9, a component of CRISPR/Cas9, the well-known molecular scissors that cut DNA (*SN*: 11/25/17, p. 7). Base editors chemically transform one DNA base into another to fix harmful typos, but this technology works only in nuclear DNA, not mitochondrial DNA.

The toxin secreted by the bacteria *Burkholderia cenocepacia* unexpectedly proved to be the solution needed to create a mitochondria-friendly base editor. Marcos de Moraes, a microbiologist at the University of Washington in Seattle, deduced that the toxin killed microbes by causing disruptive DNA mutations. But for months, he couldn't untangle how the process worked at a molecular level. He was on the verge of moving on from the project when a late-night experiment made everything fall into place.

He had suspected that the toxin protein attaches to DNA and modifies one

DNA letter, cytosine, so it resembles a different one, thymine. These forced DNA typos may be what bring down the toxin's victims. In his late-night experiment testing the protein on a particular DNA target, de Moraes learned that, unlike all other cytosine-converting proteins, the toxin alters double-stranded DNA rather than single-stranded DNA.

This seemingly minor difference has major implications. Thus far, base editors have used proteins like Cas9 to pry apart target DNA into single strands before making a change. But to function, these proteins require added pieces of RNA, which can't get into mitochondria. A base editor based on the *B. cenocepacia* toxin, with its ability to change double-stranded DNA, would not need to depend on Cas9.

But the toxin was lethal to mammalian cells, as it was to microbial prey. The first step in "taming the beast" was modifying the toxin so it didn't indiscriminately mess up double-stranded DNA, says study coauthor David Liu, a chemical biologist and HHMI investigator at Harvard and the Broad Institute. The researchers split the protein into nontoxic halves that changed cytosine to thymine only when brought to the same spot of DNA.

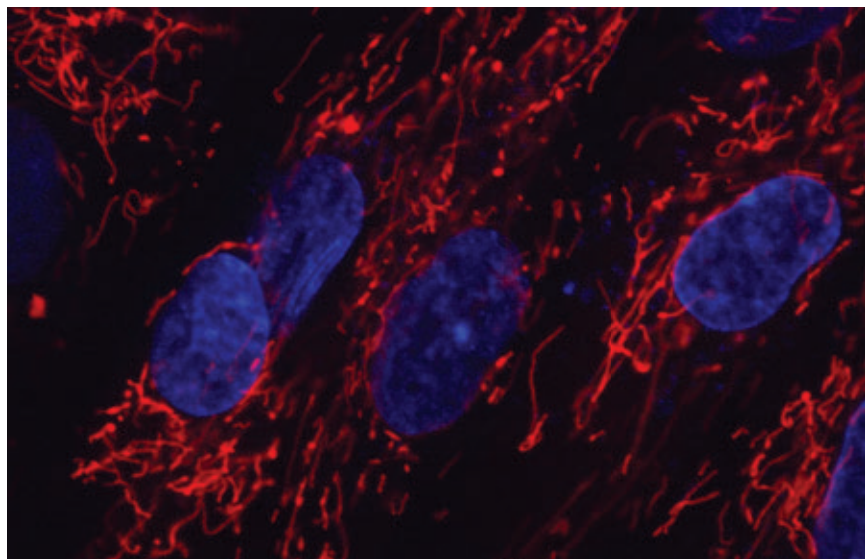
"That was quite brilliant," says Carlos Moraes, a mitochondrial biologist at the University of Miami in Florida who was not involved in the work.

To direct the activity of the protein halves, the researchers attached TALE proteins, short pieces of protein that could be chosen to target specific stretches of DNA. In cultures of human cells, the editor converted cytosine to thymine at intended mitochondrial DNA locations with a success rate ranging from about 5 to 49 percent.

Future work will aim to improve the efficiency, develop new types of mitochondrial editors that can produce other DNA base changes, and see if mitochondrial gene editing works in lab animals.

"This is just the first step," says mitochondrial biologist Shoukhrat Mitalipov, of the Oregon Health & Science University in Portland, who was not involved in the work. "But in the right direction." ■

Scientists are developing a new gene-editing tool that can target DNA in mitochondria (red). Other editors that alter individual bases of DNA are effective only in cell nuclei (blue).



ATOM & COSMOS

'Campfires' flicker on the sun's surface

Solar Orbiter captures small flares in closest images of the sun

BY LISA GROSSMAN

Get out the marshmallows and toasting sticks. The closest images yet taken of the sun show never-before-seen tiny flares dubbed “campfires.”

The images are the first from Solar Orbiter, a new sun-watching spacecraft that's a joint project between NASA and the European Space Agency.

“By looking from close by, we get so much sharper images,” astronomer David Berghmans of the Royal Observatory of Belgium in Brussels said July 16 during a news conference to announce the discovery. The pictures were better than the science team expected. “When the first images came in, the first thought was, ‘This is not possible! It cannot be that good.’”

The campfire flares are thought to be relatives of larger solar flares, powerful magnetic outbursts that shoot bright blasts of radiation into space (*SN: 9/30/17, p. 6*). Typical solar flares are a million to a billion times as big as campfire flares. The smallest campfire flares seen by the Solar Orbiter are a few hundred kilometers across, “about the size of a European country,” Berghmans said. It's not yet clear whether the flickers are just scaled-down solar flares or the two phenomena have different driving mechanisms, he said.

But solar physicists think campfires could help explain one of the biggest solar mysteries: why the solar corona,

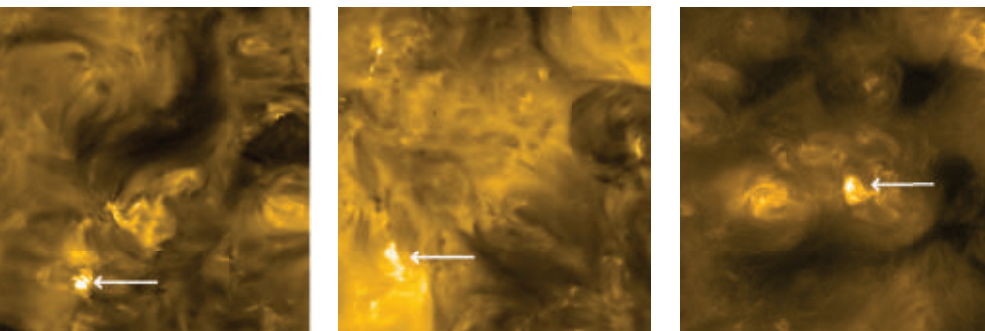
the sun's diffuse outer atmosphere, is millions of degrees hotter than the solar surface. The small but ubiquitous flares could be a source of energy to the corona that researchers haven't accounted for.

“These campfires are totally insignificant each by themselves, but summing up their effect all over the sun, they might be the dominant contribution to the heating of the solar corona,” Frédéric Auchère of the Institut d'Astrophysique Spatiale in Orsay, France, said in a news release.

Solar Orbiter launched February 9 with a suite of scientific instruments to observe the sun and its surroundings. The new images were taken May 30 with the Extreme Ultraviolet Imager camera when the spacecraft was 77 million kilometers from the sun, about half the distance that Earth is from the sun. Berghmans and Auchère are the principal investigators for the orbiter's ultraviolet camera.

Other spacecraft have swooped closer to the sun. The Parker Solar Probe has gotten as close as 24 million kilometers, collecting data but no direct photos because the spacecraft gets too close for equipment to work at such high temperatures. The Parker probe will eventually reach 6 million kilometers from the sun's surface (*SN: 7/21/18, p. 12*).

Ultimately, Solar Orbiter will come within about 42 million kilometers and fly over the sun's poles, providing scientists with the first photographs of these regions of the sun. ■



Solar Orbiter imaged “campfire” flares (indicated with arrows) on the sun in ultraviolet light. These flares, some only a few hundred kilometers across, may help heat the sun's outer atmosphere.

EARTH & ENVIRONMENT

Methane pollution soars to new highs

Agriculture and fossil fuels are behind the rising emissions

BY MARIA TEMMING

Methane levels in the atmosphere are at an all-time high. But curbing emissions of that potent greenhouse gas requires knowing where methane is released and why. Now, a global inventory of methane reveals the major culprits behind rising methane pollution in the 21st century.

Agriculture, landfill waste and fossil fuel use were the main reasons that the atmosphere absorbed about 40 million metric tons more methane from human activities in 2017 than it did per year in the early 2000s, researchers report in the July *Environmental Research Letters*.

Methane “is one of the most important greenhouse gases — arguably the second most important after CO₂,” says Alexander Turner, an atmospheric scientist who will join the University of Washington in Seattle in 2021.

Although there is far less methane than carbon dioxide in the atmosphere, methane can trap about 30 times as much heat over a century as the same amount of CO₂. Tallying methane sources can help prioritize strategies to quell pollution, like consuming less meat to cut down on emissions from cattle ranches and using aircraft or satellites to scout out leaky gas pipelines to fix.

Rob Jackson, an environmental scientist at Stanford University, and colleagues cataloged methane pollution in 2017, the most recent year with complete data, using measurements from towers and aircraft. The version, or isotope, of carbon in a methane sample contains clues about the methane's source — such as whether the gas was emitted by the oil and gas industry, or by microbes living in rice paddies, landfills or the guts of cattle (*SN: 11/28/15, p. 22*).

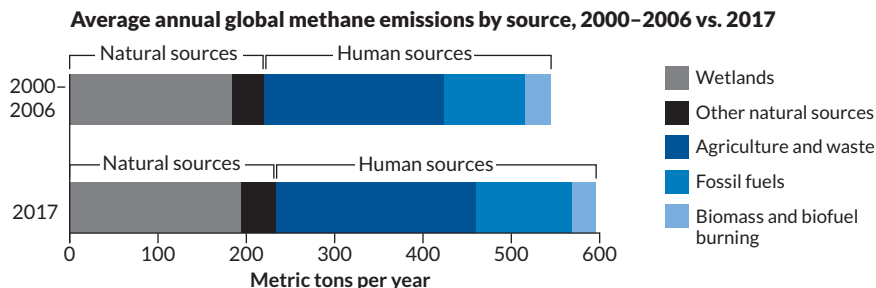
In 2017, human activities pumped out about 364 million tons of methane, compared with 324 million tons per

year, on average, in 2000 to 2006. About half of that 12 percent increase was the result of expanding agriculture and landfills; the other half arose from fossil fuels. Emissions from natural sources like wetlands, on the other hand, held relatively steady.

Emissions rose most sharply in Africa and the Middle East, as well as in South Asia and Oceania. Both regions ramped up emissions by 10 million to 15 million tons, mostly due to agricultural sources. In China and the United States, emissions swelled by 5 million to 10 million tons, driven by fossil fuel pollution.

One region that didn't show an uptick was the Arctic. That's curious, because the Arctic is warming faster than anywhere else and is covered in permafrost, which is expected to release lots of

Gassing up In 2017, human activities pumped about 40 million metric tons more methane into the atmosphere than in the early 2000s. Agriculture, along with landfill waste, and fossil fuel use were the major drivers behind the increase. Meanwhile, emissions from natural sources of methane, such as wetlands, increased by only about 12 million tons.



SOURCE: R.B. JACKSON ET AL/ENVIRONMENTAL RESEARCH LETTERS 2020

methane as it thaws, says biogeochemist Tonya DelSontro of the University of Waterloo in Canada who wasn't involved in the work.

The new findings could mean that the

Arctic has not bled much methane into the atmosphere yet — or that scientists have not collected enough data from this remote area to accurately gauge its methane emissions trends, DelSontro says. ■

ATOM & COSMOS

A cosmic clock would tick fast

Particles interacting with an oscillating field may beget time

BY EMILY CONOVER

Like a metronome that sets the tempo for a musician, a fundamental cosmic clock may keep time throughout the universe. If such a clock exists, it ticks faster than a billion trillion trillion times per second, according to a theoretical study in the June 19 *Physical Review Letters*.

Physicists typically think of time as a fourth dimension. But some researchers have speculated that time may be the result of a physical process, like the ticking of a built-in clock.

In particle physics, tiny fundamental particles can attain properties by interacting with other particles or fields. Particles acquire mass, for example, by interacting with the Higgs field, a sort of molasses that pervades all of space. Perhaps particles could experience time by interacting with a similar type of field, says study coauthor and physicist Martin Bojowald of Penn State. That field could oscillate, with each cycle serving as a

regular tick. “It’s really just like what we do with our clocks,” he says.

Time is a puzzling concept in physics: Two key theories clash on how to define it. In quantum mechanics, which describes atoms and particles, “time is just there. It’s fixed. It’s a background,” says physicist Flaminia Giacomini of the Perimeter Institute in Waterloo, Canada. But in the general theory of relativity, which describes gravity, time shifts in bizarre ways. A clock near a massive object ticks slower than one farther away, so a clock on Earth’s surface lags behind one aboard an orbiting satellite, for example.

In attempts to combine these theories into one theory of quantum gravity, “the problem of time is actually quite important,” Giacomini says. Studying different mechanisms for time, including fundamental clocks, could help physicists formulate that new theory.

Bojowald and colleagues considered the effect that a fundamental clock would have on atomic clocks, the most precise timekeepers ever made. If the fundamental clock ticked too slowly, these atomic clocks would be unreliable because they would get out of sync with the fundamental clock. As a result, the atomic clocks would tick at irregular intervals, like a metronome that can’t keep a steady

beat. But so far, atomic clocks have been highly reliable, allowing Bojowald and colleagues to constrain how fast that fundamental clock must tick, if it exists.

Physicists suspect that there’s an ultimate limit to how finely seconds can be divided. Quantum physics prohibits any slice of time smaller than about 10^{-43} seconds, a period called the Planck time. If a fundamental clock exists, the Planck time might be a reasonable pace for it to tick.

To test that idea, scientists would need to increase their current limit on the clock’s ticking rate — that billion trillion trillion times per second number — by a factor of about 20 billion. That seems like a huge gap. But “this is already surprisingly near to the Planck regime,” says Perimeter physicist Bianca Dittrich. “Usually the Planck regime is really far away from what we do.”

However, Dittrich thinks there’s probably not one fundamental clock, but rather a variety of processes that could be used to measure time.

Still, the new result edges closer to the Planck regime than experiments at the world’s largest particle accelerator, the Large Hadron Collider, Bojowald says. In the future, even more precise atomic clocks might provide further information about what makes the universe tick. ■



NEWS

HUMANS & SOCIETY

Little evidence backs police reforms

Research is needed to see which efforts really stem violence

BY SUJATA GUPTA

When Robin Engel suddenly found herself leading the effort to reform a police department under fire after a white police officer killed an unarmed Black man in July 2015, she looked for some kind of road map to follow. Instead, the criminologist found herself in poorly charted territory.

Engel, a professor at the University of Cincinnati, had been called on frequently to help police departments around the country manage their response to acts of police violence. This time, the call came from close to home. Campus officer Ray Tensing, 25, had shot and killed 43-year-old musician Samuel DuBose during an off-campus traffic stop.

Engel recommended that the university hire a high-ranking official to oversee the police department and its immediate response to the crisis, and initiate longer-term, comprehensive reforms to prevent future incidents.

Within days, Engel had become that official, reporting directly to the university president and outranking the police chief, despite lacking police experience herself.

She sought input from various community stakeholders, many of whom had been rankled by her appointment to lead the police division. She also turned to her most familiar tool—research. She began probing for studies to guide her on the sorts of reforms she could institute, ones with proven track records of

changing police behavior in the field. Her search was unfruitful.

“I thought most certainly we would have an evidence base that I could follow,” Engel says. “I was incredibly disappointed at the lack of evidence that was available. I was really disappointed in my own field.”

Evidence gap

Among her efforts, Engel scoured the literature for de-escalation programs with a history of success at defusing violence. Her review of that body of work, appearing online January 31 in *Criminology & Public Policy*, found 64 such programs in the United States and elsewhere—but mostly used to train nurses and psychologists. She found no programs that had been tested among police officers. Just three studies analyzed cause and effect and included a comparable control group, and the results of those programs were mixed.

In a review in the January *Annals of the American Academy of Political and Social Science*, Engel and colleagues discuss de-escalation trainings and four other reforms that tend to capture the public’s attention following fatal police-civilian encounters: body-worn cameras, implicit bias training (meant to reduce decisions and actions that arise from unconscious stereotypes), early intervention systems that identify problematic officers before a crisis and

Following the death of George Floyd, activists, including these protestors in New York City, have called on civic leaders to defund the police.

civilian oversight of the police.

Engel was unable to identify a single police reform with convincing evidence of behavior change among officers. Even the numerous studies on body cameras had mixed results. Engel cites a February 2019 review in *Criminology & Public Policy* by Cynthia Lum of George Mason University in Fairfax, Va., and colleagues. They looked at 70 studies to gauge the link between camera use and a reduction in force. Just 16 of those studies looked directly at whether cameras reduced officers’ reported use of force; of that subset, some showed that the cameras work as a deterrent to use of force whereas others found no effect.

Why no data?

The dearth of evidence stems from several factors, Engel says, but chief among them is the pressure for police departments to act fast when an instance of police violence captures national attention. Consider that less than two weeks after the May 25 death of George Floyd, when white police officer Derek Chauvin knelt on Floyd’s neck for several minutes, the majority of city councilors pledged to dismantle the Minneapolis Police Department in response to activists’ calls to “defund the police.”

Other places are also looking at ways to defund some police services, or reallocate to other agencies functions such as responding to mental health calls or monitoring safety in schools. Previous police brutality incidents have prompted calls for other sorts of reforms. A 2019 CBS News survey of 155 police agencies found that almost 70 percent had implicit bias training with over half of those programs implemented after a white policeman shot and killed Black teenager Michael Brown in Ferguson, Mo., in August 2014. Some 60 percent of agencies that responded to follow-up questions said they did not have a way to measure the success or failure of such programs.

“This year it’s defund; what is it going

to be next year, five years from now?” asks Renée Mitchell, a recently retired police sergeant with a Ph.D. in criminology. She’s also cofounder and president of the American Society of Evidence-Based Policing. Police departments are “flinging out interventions and having no clue about the effects, positive or negative.”

Police research is complicated by the fact that police officials and researchers often have different priorities, notes Erin Kerrison, an empirical legal scholar at the University of California, Berkeley. Why, she asks, would a police chief work with an academic who will publish papers about the department’s problems that may also receive press attention?

What’s more, like some other areas of research related to violence (*SN: 5/14/16, p. 16*), money for policing research is relatively limited. The National Institutes of Health, for instance, invested about \$39 billion in medical research in 2019, while the National Institute of Justice awarded far less than 1 percent of that amount — just under \$214 million — for research that same year.

Yet researchers and police officials largely agree that rapid response is necessary to meet the demands of the moment. What research does emerge following George Floyd’s death won’t start coming out for two years, Kerrison says. “There will have been a thousand more George Floyds at that point.”

Needing to act

Which is why, back at the University of Cincinnati Police Division, Engel needed to act, evidence or no evidence. She selected a de-escalation program run by Police Executive Research Forum, a Washington, D.C.-based nonprofit police research and policy organization. She was familiar with the organization and the content — which emphasizes training officers to recognize and effectively communicate with civilians behaving erratically who are either unarmed or armed with something other than a firearm — looked promising. Engel used the program to build her own evidence to help fill gaps in the field.

She treated reforms at her university

police department of 74 sworn officers as pilot projects that she could then test at larger departments. In February 2019, she and colleagues conducted a larger study of the de-escalation program when the Louisville Metro Police Department in Kentucky used it to train 1,250 officers.

Engel randomized the order in which officers in the nine Louisville precincts were trained. That way, officers in each untrained precinct served as a control until they underwent training. One benefit of this setup, called a stepped wedge trial, is that it doesn’t relegate one block of individuals into a control group that goes without training for the duration of the study. Stepped wedge trials have been used in other settings, such as health care and education. Officers were evaluated before and right after the training, and again four to six months later. Initial results will be released soon, Engel says. The team will continue to look for changes in police behavior and in frequency and severity around use of force for six more months.

Engel is conducting an analogous study of an implicit bias training program. Also piloted at the University of Cincinnati, the program was rolled out at the New York City Police Department.

Working together

Engel stepped down from overseeing the University of Cincinnati Police Division in January 2019, but the experience changed her thinking about criminology



A Minneapolis police officer wears a body camera as part of his gear while responding to a call in 2019. Research is mixed on whether the devices reduce violent encounters.

research. Academics tend to be interested in the philosophical, such as why officers use force, she says. But arguably more important are the nitty-gritty questions about how use of force can be mitigated in real life and in real time.

One challenge to understanding which reforms work is convincing police departments to collaborate with researchers, Kerrison says. In an August 2019 paper in *Police Practice and Research*, she and colleagues outlined how academics can enter into ethical relationships with police departments. Crucial to such partnerships are clearly stated goals or airtight memoranda of understanding. That way, all parties agree in advance on the sorts of findings that will be communicated to the public and in what fashion, and everybody commits to helping police operations throughout the study process.

For instance, police departments can mandate that researchers anonymize the community’s identity in publications. Kerrison can’t talk about relationships with police departments she’s working with due to such agreements. “Everybody has got to have skin in the game,” she says.

Given the challenges with funding and creating academic-police partnerships, sometimes the clearest path forward may be to train the police in how to do science, Mitchell says. At the American Society of Evidence-Based Policing, she and colleagues are launching a four-week training course in 2021 for police officers. “Nowhere have our police leaders been taught how to interpret data and how to interpret statistics and how to interpret a research article,” she says. With training, police departments will be better positioned to collect and evaluate data on their own.

Mitchell likens the model to medicine, where it would be a breach of ethics for doctors to advise patients without knowing about evidence-based treatments. Policing “should be held to the same standard,” she says.

However such research comes about, without it, police responses to crises will default to the quickest solutions, Engel says. “That is a very dangerous position to be in.” ■

LIFE & EVOLUTION

Dinosaur shed feathers bit by bit

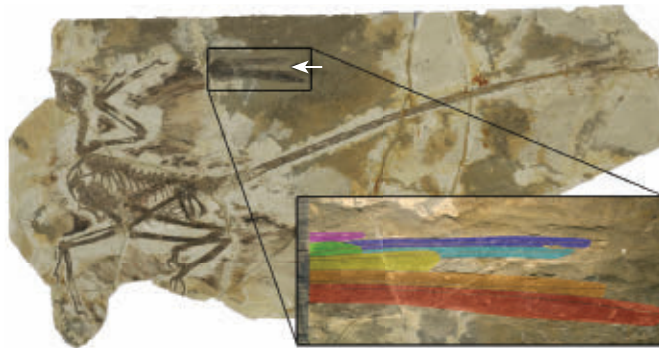
Sequential molting supports the idea that *Microraptor* flew

BY CAROLYN GRAMLING

A patch of three oddly short feathers spotted among the fossilized plumage of a *Microraptor* may be the first evidence of a nonbird dinosaur molting. Like modern songbirds, *Microraptor*, which lived 120 million years ago, may have shed only a few feathers at a time, researchers report online July 16 in *Current Biology*. Such “sequential molting” suggests that *Microraptor* was an adept, frequent flier.

Modern adult birds molt at least once a year to replace old, damaged feathers, or to exchange bright summer colors for drab winter camouflage.

Unlike many aquatic birds, songbirds lose only a few feathers at a time, enabling the birds to stay aloft year-round for for-



A gap (arrow) in the plumage on the right forelimb of this *Microraptor* fossil may be the result of molting, with three new feathers (colored green, yellow and orange in the inset) appearing to come in. The different lengths suggest the feathers were in different stages of growth, an indicator of sequential molting.

aging or to escape predators. The shorter feathers on the *Microraptor* fossil appear in just a small patch on one wing—a clue that the dinosaur molted sequentially, bird ecologist Yosef Kiat of the University of Haifa in Israel and colleagues report.

Genetic reconstructions of bird lineages have indicated that sequential molting goes back at least 70 million years and was a trait of modern birds’ most recent common ancestor. The new find could push back the origins of sequential molting by 50 million years or so.

Microraptor may have been one of the

earliest fliers, depending on how flying is defined. Previous work suggested the animal didn’t just glide from tree to tree but launched itself from the ground using its wings and back legs (*SN: 11/26/16, p. 9*).

The new discovery supports this scenario, suggesting “that not only could *Microraptor* fly, but it could fly well, and [that] flying was an indispensable part of its lifestyle,” says Steve Brusatte, a vertebrate paleontologist at the University of Edinburgh. That makes *Microraptor* one of the most convincing cases of a nonbird dinosaur that could fly, Brusatte adds. ■

ATOM & COSMOS

‘Braiding’ bolsters the case for anyons

Observed looping behavior suggests the quasiparticles do exist

BY EMILY CONOVER

Physicists have captured the first clear glimpse of the tangled web woven by particles called anyons.

The observed effect, called braiding, is the most striking evidence yet for the existence of anyons—a class of particle that can occur only in two dimensions. When anyons are braided, one anyon loops around another, altering the anyons’ quantum states. That braiding effect was spotted within a complex layer cake of materials, researchers report online June 25 at arXiv.org.

“It’s absolutely convincing,” says theoretical physicist Frank Wilczek of MIT, who coined the term “anyon” in the 1980s. Theoretical physicists have long thought that anyons exist, but “to see it in reality takes it to another level.”

Fundamental particles found in nature

fall into one of two classes: fermions, such as electrons, or bosons, such as photons (particles of light). Anyons don’t belong to either class. Technically “quasiparticles,” anyons result from the collective movements of many electrons, which behave like one particle.

A key way anyons differ from fermions and bosons is in how they braid. If you were to drag a boson or a fermion around another of its own kind, there would be no record of that looping. But for anyons, such braiding alters the particles’ wave function, the mathematical expression that describes a particle’s quantum state. The process inserts an extra factor, called a phase, into the wave function.

Physicist Michael Manfra of Purdue University in West Lafayette, Ind., and colleagues created a device in which anyons traveled within a 2-D layer along a

path that split into two. One path looped around other anyons at the device’s center—like a child playing duck, duck, goose with friends—while the other took a direct route. When the two paths reunited, the researchers measured the resulting electric current.

The extra phase acquired in the trek around the device would alter how the anyons interfere when the paths reunite and thereby affect the current. So the team tweaked the device’s voltage and magnetic field, changing the number of anyons in the center of the loop—like duck, duck, goose with a larger or smaller group. As anyons were removed or added, that altered how much extra phase was added to the looping anyons, producing distinct jumps in the current.

A study of colliding quasiparticles also recently reported hints of anyons (*SN: 5/9/20 & 5/23/20, p. 10*). ■

Editor’s Note: Frank Wilczek is a member of the Honorary Board of Society for Science & the Public, which publishes Science News.

BODY & BRAIN

Blood test identifies when steroids would help COVID-19 patients

A simple blood test for inflammation may help determine which COVID-19 patients will benefit from steroids.

That's the conclusion of an observational study of about 1,800 people hospitalized with COVID-19 in New York in March and April. In patients with high blood levels of an inflammation indicator called C-reactive protein, steroid use reduced by 77 percent the chance of going on a ventilator or dying compared with similar patients who didn't get steroids. But for patients with low levels of the protein, steroid treatment more than doubled the risk of needing a ventilator or dying, researchers report online July 22 in the *Journal of Hospital Medicine*.

Steroids "need to be given at the just right time," says infectious diseases doctor Luis Ostrosky of the University of Texas Health Science Center at Houston, who wasn't involved with the study. Giving steroids too early may rein in the immune system too much so that it's ineffective against the coronavirus. "If you give steroids too late, the damage is already done."

The researchers plan to use data collected in this study to determine whether tracking C-reactive protein can also predict whether patients are recovering. — *Tina Hesman Saey*

EARTH & ENVIRONMENT

Recent Siberian heat wave blamed on climate change

The heat wave that gripped Siberia during the first half of 2020 would have been essentially impossible without human-caused climate change. Researchers with the World Weather Attribution Network report that climate change made the heat wave at least 600 times and possibly as much as 99,000 times more likely.

The study, released July 15, examined two aspects of the heat wave: the persistence and intensity of average temperatures across Siberia from January to June, and daily maximum June temperatures in the Russian town of Verkhoyansk.

On June 20, Verkhoyansk logged a record high temperature of 38° Celsius

(about 100° Fahrenheit).

Using weather data, the researchers first assessed the rarity of the observed temperatures and determined temperature trends and then compared these observations with climate simulations using different greenhouse gas warming scenarios. Had such a six-month hot spell occurred in 1900 instead of 2020, the average temperatures would have been at least 2 degrees cooler on average, the researchers found.

Such heat waves are likely to become more common: By 2050, Siberian temperatures could increase by up to 7 degrees compared with 1900. — *Carolyn Gramling*

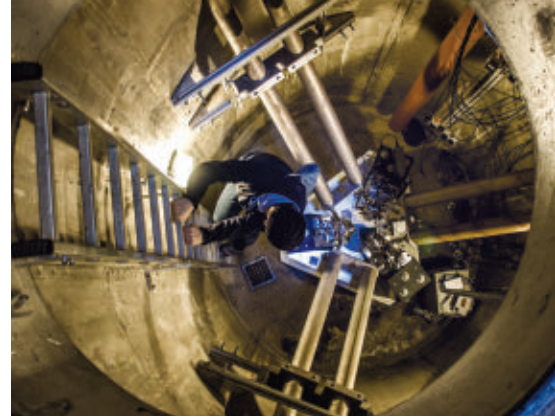
EARTH & ENVIRONMENT

Giant gyroscope array keeps tabs on Earth's minute motions

A giant underground motion sensor in Germany has taken its first measurements of Earth's spin and tilt. Someday the sensor could help keep GPS navigation working reliably.

Phenomena like earthquakes and ocean tides continually knock Earth's rotation off-kilter, requiring constant correction of GPS satellite signals. Typically, corrections use telescope observations, which offer celestial coordinates to determine Earth's orientation in space. But telescope data can take days to process. The Rotational Motions in Seismology, or ROMY, gyroscope array can monitor Earth's wobbles continuously, researchers report in the July 17 *Physical Review Letters*.

ROMY is an upside-down triangular pyramid of pipes, about the length of a telephone pole on each side. Its four triangular faces measure motion in different directions. On each face, one laser beam runs clockwise through the triangular piping, while another runs counterclockwise. As the triangles move with Earth's rotation, the laser beams whose movements align with Earth's have to travel farther to loop around the triangle. That stretches out the beams' wavelength. Meanwhile, the beams going the opposite way have their wavelength compressed by their shorter path. The mismatch between wavelengths reveals the speed and tilt of Earth's rotation.



The Rotational Motions in Seismology, or ROMY, array is a giant motion sensor built into an underground bunker in Germany.

In a nearly seven-week test run, ROMY was sensitive to changes in Earth's tilt of less than 0.00014 degrees. ROMY also detected a change in Earth's spin rate so small that it would add up to only a four-second difference in the length of a day.

Still, to compete with telescopes, ROMY must be at least 100 times as accurate as in the test. That will require fortifying the machine against temperature shifts that cause the piping to expand and contract. — *Maria Temming*

LIFE & EVOLUTION

Fossil hints crocodiles swam from Africa to the Americas

A resemblance between American crocodiles and an extinct African croc goes beyond the bump on their snouts.

Analyses of a roughly 7-million-year-old *Crocodylus checchiai* skull from Libya suggest that crocs traveled from Africa to the Americas millions of years ago, scientists say July 23 in *Scientific Reports*. With CT scanning, the team mapped the skull's structure, revealing traits tying the animal to American crocodiles.

This fossil predates the earliest known American crocodile by about 2 million years. The skull's structural features place *C. checchiai* at the base of the American crocs' branch of the croc family tree.

The continents would have been in roughly the same place as now when *C. checchiai* or a close relative was on the move. Study coauthor Massimo Delfino, a paleoherpetologist at the University of Turin in Italy, suggests that an African croc made a transatlantic trip. He notes that crocodilians today can survive saltwater and travel hundreds of kilometers when helped by ocean currents. — *Carolyn Wilke*

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

Unopened for 138 Years!

Coin experts amazed by "Incredible Opportunity"

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



Actual size is 38.1 mm

- ✓ 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 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.

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People are venturing out again, like these shoppers on July 20 at a mall in southwestern France. An analysis of COVID-19 clusters may help people weigh their risks.

Lessons from COVID-19 case clusters

Outbreaks in restaurants, offices and households offer guidance amid the chaos

By Helen Thompson

More than eight months into the COVID-19 pandemic, countries are struggling to figure out how to safely reopen and restart their economies, and people are weighing the risk of getting sick against a need to work or at least escape cabin fever. But tough lessons have surfaced from regions that reopened prematurely, as well as countries that were hit early in the pandemic.

Consider South Korea: In April, after new cases declined to single digits, the country began easing social distancing restrictions. But that respite was short-lived. On May 6, a 29-year-old man tested positive for SARS-CoV-2, the virus that causes COVID-19. A few nights before, he had visited five dance clubs in Seoul's Itaewon district. South Korea responded quickly, urging bars and clubs to shut down again for a month on June 8 and postponing plans to reopen schools. As of June 8, the Korea Centers for Disease Control and Prevention had linked the sick man to 96 other clubgoers who got COVID-19, plus 178 people with whom those clubgoers came into contact.

Soon the country saw more clusters pop up in an online retail center, a day care, a table tennis club and a handful of churches. "Reopening is not a one-way street, and we may need to make

a U-turn," says Andrew Noymer, an epidemiologist at the University of California, Irvine. As stay-at-home rules are relaxed, starts and stops should be expected. In the United States, after Texas reopened bars and other businesses in May, COVID-19 cases began to surge in June. Clusters emerged at construction sites and family birthday parties. The state government ultimately had to shut down bars again and pause other reopening efforts, as cases overwhelmed hospitals in some parts of the state.

Studying these kinds of transmission clusters as well as common environments where COVID-19 moves easily person-to-person provides crucial insights on how to avoid the U-turns. To that end, epidemiologist Gwenan Knight and her colleagues at the London School of Hygiene & Tropical Medicine compiled a massive database of worldwide COVID-19 case clusters based on media accounts, published scientific studies and health department reports.

As of July 10, the database included 265 cluster events, or groups of cases tied to the same place in the same time period. The data are limited to known clusters and to what the patients involved could recall and what they told investigators.

Some noteworthy trends have emerged. Indoor settings dominate, partly because the coronavirus hit during winter, when people were spending most of their time indoors, and partly because in outdoor settings an abundant flow of fresh air helps dissipate virus particles exhaled by an infected person. Ultraviolet rays from the sun might also help kill virus particles.

Households were the most common place for transmission,

accounting for roughly 14 percent, or 38 of 265, cluster events. And mealtime was prime time. “It’s not the eating. It’s the sitting around and talking,” Noymer suspects. SARS-CoV-2 primarily spreads via respiratory droplets and direct contact. While sharing food or utensils could theoretically pose a risk for infection, no clusters have been linked to eating itself. A study published online June 3 in *Emerging Infectious Diseases* found traces of SARS-CoV-2 genetic material on chopsticks used by patients in Hong Kong. But whether virus particles could survive on a chopstick and actually infect someone remains unknown.

The largest known clusters occurred in settings that are by now well publicized: ships (the *Diamond Princess* cruise ship and the U.S.S. *Theodore Roosevelt* aircraft carrier), food-processing plants and prisons. Dormitories in Singapore, where migrant workers live in cramped conditions, also saw large numbers of infections. In all of these places, people live or work in close quarters over long periods of time.

The dataset also points to settings where one activity may be riskier than another, says Quentin Leclerc, an epidemiologist on Knight’s team who manages the database. “For example, why have we found clusters associated with one type of indoor sport, but not another?” In 112 cases stemming from Zumba classes in Cheonan, South Korea, a Pilates and yoga instructor from the same gym was among those infected. But that instructor did not subsequently pass the virus to any students in her classes. High-intensity sports that involve a lot of heavy breathing in confined spaces could be prime activities for transmission, while lower-intensity activities, like yoga, might not be as risky.

Only one transportation cluster — three cases on a bus — appears in the database, but that doesn’t mean the virus doesn’t spread on buses or trains. “Transport outbreaks are very difficult to identify,” says Yuguo Li, an engineer

at the University of Hong Kong who studies infectious disease transmission.

Of course there could be other possible transmission settings that researchers don’t know about or haven’t been able to study. But the case clusters that follow offer key insights that can inform policy making and individual choices.

A windowless restaurant

A cautionary tale of poor ventilation comes from Guangzhou, China, on the eve of the Lunar New Year in January. A 63-year-old woman and her family walked into a crowded restaurant for lunch, after arriving from Wuhan, where the pandemic originated, the day before. That same day she developed a fever and cough; she later tested positive for the coronavirus.

Of the 89 other customers who visited the restaurant that day, 10 fell ill with COVID-19, including four of the woman’s family members. Patients are most contagious around the time their symptoms emerge, so this woman was most likely the index case — the first person in the cluster to become infected.

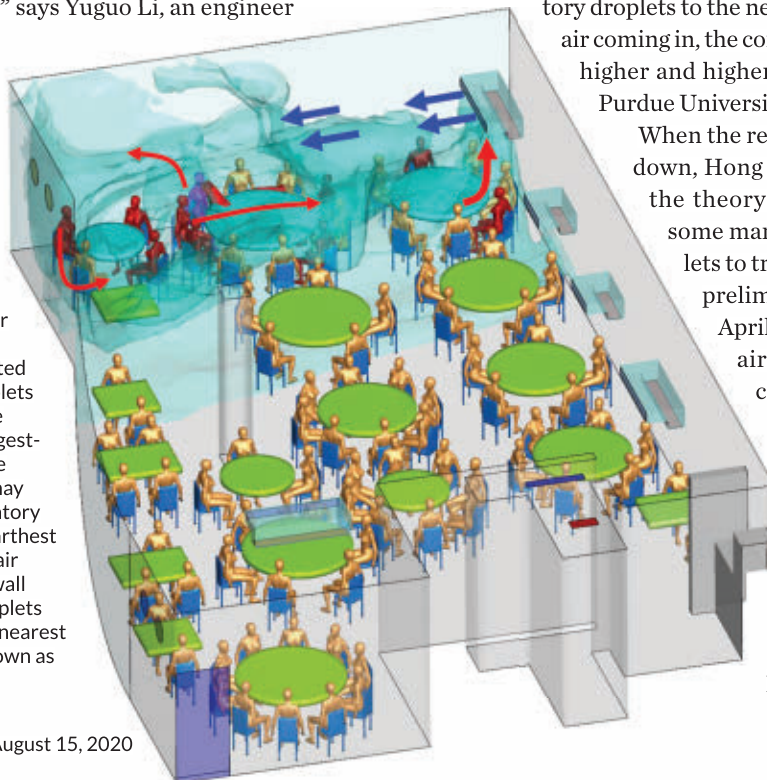
The five other infections occurred in families seated at the tables on either side of hers, less than a meter away. Security footage shows that none of the families interacted or touched the same objects. The droplets the woman produced as she chatted with her family were unlikely to reach the other tables on their own. So the virus probably got some help from the air-conditioning unit blowing directly over the row of three tables, researchers from the Guangzhou Center for Disease Control and Prevention report in the July *Emerging Infectious Diseases*.

The restaurant had no windows. The only source of outside air was an exhaust fan in a bathroom. The air-conditioning unit only recirculated indoor air, blowing the woman’s respiratory droplets to the nearby tables. With very little fresh air coming in, the concentration of droplets would get higher and higher, says Yan Chen, an engineer at Purdue University in West Lafayette, Ind.

When the restaurant was empty during lockdown, Hong Kong’s Li and colleagues tested the theory with a few human volunteers, some mannequins and nontoxic gas droplets to trace and simulate the spread. The preliminary simulations, posted online April 22 at medRxiv.org, show that the air-conditioning flow in the room could have created a bubble of small droplets around the three tables, and that there was an exceptionally low amount of fresh air in the room. That’s where the blame for infection lies, Li’s team argues. With more fresh air in the mix, droplet concentration would probably have been lower.

In the zone

One sick patron in a restaurant in Guangzhou, China, infected nine others. The infected woman (purple, at top of image) was seated with her family between two other tables. In this computer simulation based on trace gas tests conducted at the restaurant, droplets (turquoise) congregate around the tables, suggesting air flowing from the air-conditioning unit may have blown her respiratory droplets to the table farthest from the AC unit. The air then bounced off the wall and brought those droplets back toward the table nearest the AC. The people shown as red became infected.



Long, close work shifts

A case cluster in a South Korean call center shows how COVID-19 can emerge in a busy open-office setting — and how to intervene and stop transmission.

The call center in downtown Seoul occupies four floors in a 19-story building that has commercial offices and residences. All but two of the building's workers, residents and visitors were tested. And 94 of the 97 who were positive for SARS-CoV-2 worked in call center offices on the 11th floor, researchers report in the August *Emerging Infectious Diseases*.

Employees sat side by side, talking on the phone for long shifts. Because a striking majority of cases were concentrated in a single open work area on one side of the building, researchers suspect that prolonged proximity, rather than, say, touching the same elevator button, drove the spread.

At the call center, the Korean CDC and local health departments were extremely thorough in their attempts to find cases and stop the spread, testing 99.8 percent of the 1,145 people who had any contact with the building and quickly isolating all positive cases. Beyond the building, investigators tracked 225 household contacts of those positive cases, and 34 tested positive. Through this intensive screening, the agencies cut transmission chains and prevented new cases. "It shows how intervention can work," says Werner Bischoff, an epidemiologist at Wake Forest University in Winston-Salem, N.C.

Sharing more than memories

A sobering warning about the importance of social distancing comes from a family wedding in Irbid, Jordan, about 90 kilometers north of Amman. Of the roughly 360 people who attended the March event, 76 tested positive for the coronavirus in the four weeks that followed, researchers report in the September *Emerging Infectious Diseases*.

Two days before the ceremony the bride's 58-year-old father, who had traveled from Spain, felt feverish and developed a runny nose and cough. He tested positive for the coronavirus two days after the wedding.

Though he did not recall having contact with anyone who had COVID-19 in Spain, scientists believe he sparked the cluster. In Jordan, it's common for the bride's family to greet all of the guests at the reception entrance, usually with a hug or a kiss. "These factors, in addition to crowded dancing and close face-to-face communication, likely contributed to the large number of infections from this wedding," the researchers wrote.

Lockdown exit strategies

Some unknowns — like the degree to which infected people without symptoms spread the coronavirus — could influence the risk equation in any of these and other settings.

As restrictions lift, people will have to make tough choices about in-person interactions. Social distancing is still important. You might limit your contacts, but other people you encounter might not. Some public health officials suggest creating COVID-19 "bubbles," or expanding social circles to

Crowded call center Most of the 97 COVID-19 cases in a mixed residential and commercial building in downtown Seoul, South Korea, were concentrated on the 11th floor. There, 94 call center employees tested positive for COVID-19 (workstations of people who got infected shown in blue), most of them working on one side of the building.



people who agree to observe the same precautionary measures.

Masks have become controversial in some communities in the United States, even though studies have shown that wearing masks could curb the spread of COVID-19 (*SN Online*: 6/26/20). Resistance to wearing masks could impact how the virus spreads in certain settings.

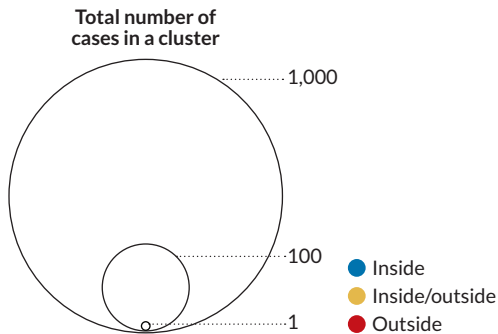
Restaurants and workplaces can take steps to try to limit transmission, as some have already done. Installing plexiglass barriers between tables and improving ventilation by opening windows, serving customers outside, turning on exhaust fans and using HEPA filters could help lower transmission risk. Keeping tables or desks at least two meters apart is also a good idea. The U.S. Centers for Disease Control and Prevention has released reopening guidelines for everything from restaurants to water parks.

As temperatures climbed at the start of this summer, cases continued to rise in the United States, with troubling clusters emerging. At a summer camp in Missouri, 82 people tested positive for the virus, as of July 6; and several college football teams have reported multiple cases among the athletes who've returned to campus to train together. With incomplete data on how the virus behaves in summer, it's too early to say if new cluster trends are emerging in outdoor settings.

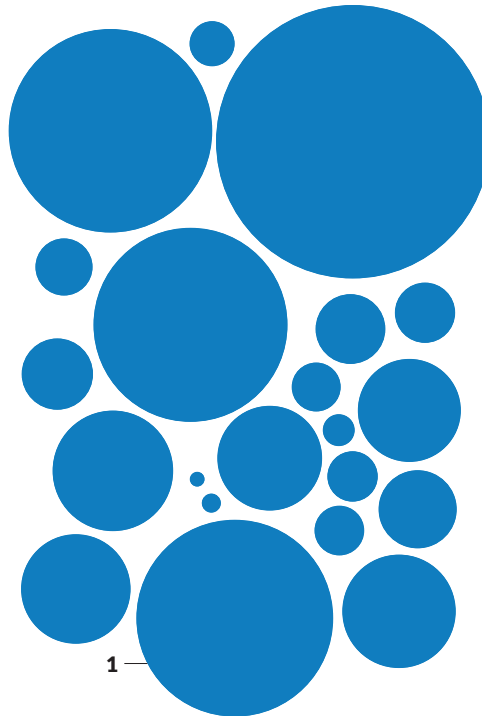
If thwarted first attempts at loosening restrictions in places like South Korea and Texas have taught us anything, it's that reopening and relaxing social distancing practices comes with one certainty: New COVID-19 infections will happen. Hugs and high fives are still a long way off. "This isn't a marathon," Noymer at UC Irvine says. "It's a 26.2-mile sprint."

Where the virus spreads

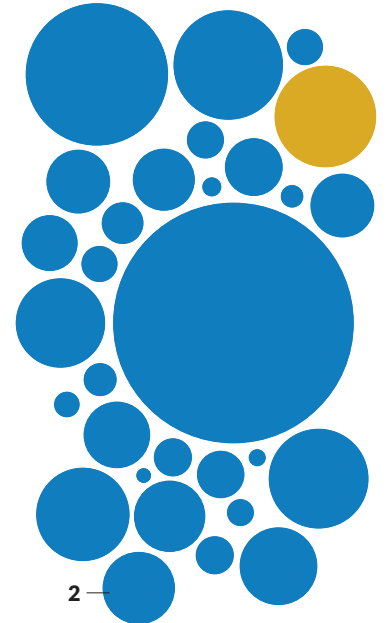
This compilation of known COVID-19 case clusters, as of July 10, is from a database produced by a team at the London School of Hygiene & Tropical Medicine. Some of the team's entries represent more than one cluster. In this chart, they have been separated so each bubble represents a single cluster, bringing the total cluster count to 364. Indoor transmission is more common than outdoor; the most common setting is households; and the largest clusters have occurred aboard ships, at food-processing plants and in large, shared living quarters.



Food-processing plant



Large, shared accommodation



1. Fish-processing plant, 533 cases

Tema, Ghana

In the port city of Tema, 533 fish factory workers tested positive for COVID-19 in April, CNN reported May 11. Public health officials have linked all cases to one worker.

2. Refugee accommodation center, 72 cases

Frankfurt, Germany

Out of some 380 residents in a refugee housing center run by the German Red Cross, 72 tested positive for COVID-19, the *Frankfurter Allgemeine* reported May 22.

3. Jail, 353 cases

Cook County, Illinois, United States

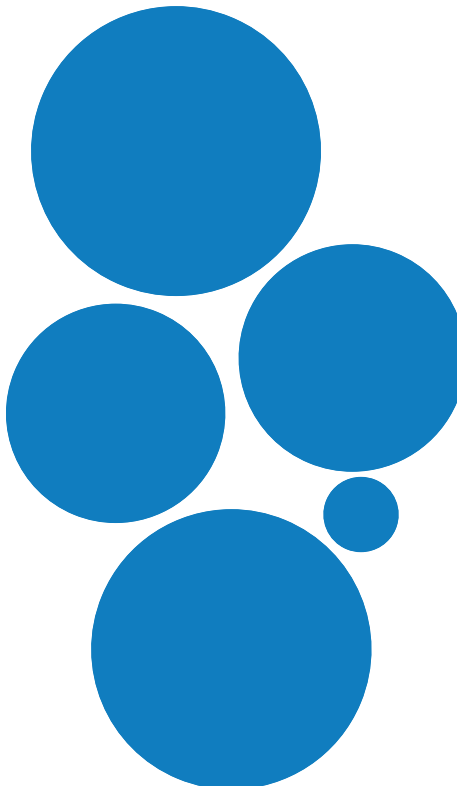
On March 23, two inmates tested positive for the coronavirus. Though they were placed in isolation cells, COVID-19 spread to 236 more inmates and 115 staff members, the *New York Times* reported April 8.

4. Nursing home, 167 cases

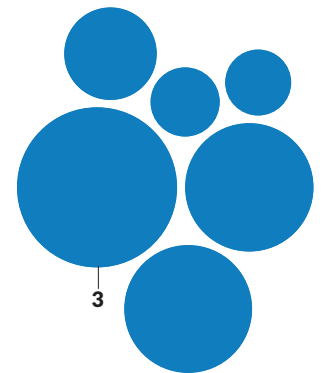
King County, Washington, United States

After a 73-year-old woman developed COVID-19 symptoms at a King County nursing home in Washington state, 167 cases were discovered: 101 in residents, 50 in health care professionals and 16 among visitors, as of March 18. Eight other nursing home facilities in the area experienced outbreaks; three had clear links to the original nursing home, researchers reported May 21 in the *New England Journal of Medicine*.

Ship



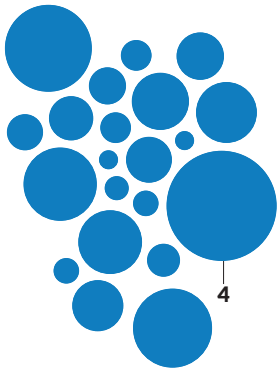
Prison



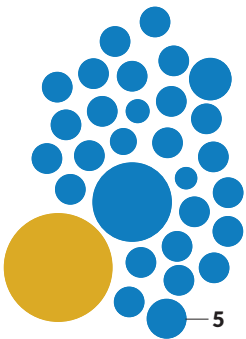
Religious



Elderly care



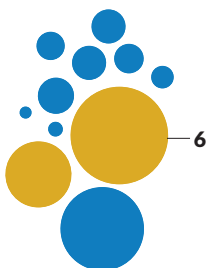
Shopping



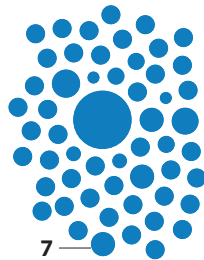
Party



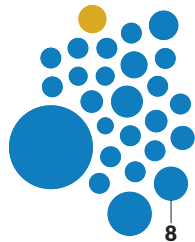
School



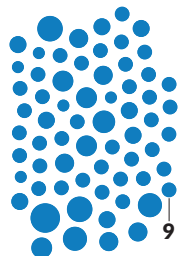
Meal



Work



Household



Wedding



Hospital



Sport



Conference



Public



Construction site



Funeral



Hotel



Shipyards



Transport



5. Department store, 22 cases Tianjin, China

At a department store in Baodi, a suburb of Tianjin, 19 customers may have picked up COVID-19 in January from staff members, researchers reported June 12 in the *American Journal of Infection Control*. All of the customers had visited one of four areas of the store — shoes, small home appliances, jewelry and clothing — where salespeople who were later diagnosed with COVID-19 worked.

6. High school, 133 cases Oise, France

Health officials identified two students at a high school in northern France who had symptoms of COVID-19 in February. Scientists reported online at medRxiv.org on April 23 that 133 students and staff had antibodies to the coronavirus, evidence of recent infection.

7. Family birthday meal, 8 cases Chicago, Illinois, United States

A man with mild respiratory symptoms attended a family birthday celebration a few days after returning from an out-of-state trip in February. Attendees shared food, hugged and visited for around three hours. Seven of nine other family members who attended fell ill with COVID-19; two of them died, researchers reported April 8 in *Morbidity and Mortality Weekly Report*. The man has also been linked to a cluster around a funeral.

8. Business meeting, 12 cases Munich, Germany

On February 20 and 21, six company scientists and eight dermatologists attended an advisory board meeting in Munich. One man had COVID-19 symptoms the second night after he returned home to Italy; he later tested positive. He likely picked up the virus from a patient seen in the days before the meeting. Of the 13 other meeting attendees, 11 were diagnosed with COVID-19, researchers reported in the August *Emerging Infectious Diseases*. The meeting involved hours of discussions; attendees shared handshakes, snacks, taxis and meals.

9. Household, 3 cases Suwon, South Korea

On January 20, a man returned to South Korea from Wuhan, where he had been running a store. On January 29, he started to self-quarantine in his bedroom but broke his isolation to share meals with his wife, daughter, sister, brother-in-law and 10-year-old niece. He, his sister and niece all developed signs of COVID-19. This was the first known case of COVID-19 in a child in South Korea, researchers reported March 23 in the *Journal of Korean Medical Science*.

10. Running partners, 2 cases Codogno, Italy

A 38-year-old man in Codogno, Italy, tested positive for the coronavirus on February 20. He transmitted the virus to a friend during a run, the *Guardian* reported February 26. The man has also been linked to clusters in a pub, his home and a hospital. ■

FEATURE



Fractured rituals

Why do we miss the traditions put on hold by the pandemic? **By Sujata Gupta**

For over a thousand years, the various prayers of the Catholic Holy Mass remained largely unaltered. Starting in the 1960s, though, the Catholic Church began implementing changes to make the Mass more modern. One such change occurred on November 27, 2011, when the church attempted to unify the world's English-speaking Catholics by having them all use the same wording. The changes were slight; for instance, instead of responding to the priest's "The Lord be with you" with "And also with you," the response became: "And with your spirit."

The seemingly small modification sparked an uproar so fierce that some leaders warned of a "ritual whiplash."

The new wording has stayed intact, but that outsize reaction did not surprise ritual scholars. "The ritual reflects the sacred values of the group," says Juliana Schroeder, a social psychologist at the University of California, Berkeley. "Those [ritual actions] are nonnegotiable."

But in the midst of the global coronavirus pandemic, people are being forced to renegotiate rituals large and small. Cruelly, a pandemic that has taken more than half a million lives worldwide has disrupted cherished funeral and grieving rituals.

Even when rituals can be tweaked to fit the moment, such as virtual religious services or car parades in place of graduation ceremonies, the experiences don't carry the same emotional heft as the real thing. That's because the immutability of rituals — their fixed and often repetitive nature — is core to their definition, Schroeder and others say. So too is the symbolic meaning people attach to behaviors; doing the ritual "right" can matter more than the outcome.

Why do such behaviors even exist? Anthropologists, psychologists and neuroscientists have all weighed in, so much so that the theories used to explain the purpose of rituals feel as myriad as the forms rituals have taken the world over.

That growing body of research can help explain the unrest people are now experiencing as beloved rituals go virtual or get punted to some unsettled future. Multiple lines of evidence suggest, for instance, that rituals help with emotional regulation, particularly during periods of uncertainty, when control over events is not within reach. Rituals also foster social cohesion. Engaging in rituals, in other words, could really help people and societies navigate this new and fraught global landscape.

"This is exactly the time... when we want to be able to congregate with other people, get social support and engage in the kinds of collective rituals that promote cooperation [and] reduce anxiety," says developmental psychologist Cristine Legare of the University of Texas at Austin. And yet, with COVID-19, congregating in any sort of group can be downright dangerous. What does that mean for how we persevere?

An illusion of control

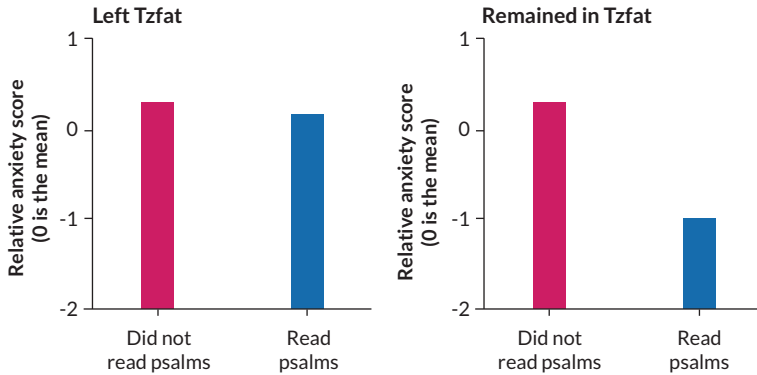
Polish-born British anthropologist Bronislaw Malinowski documented rituals and speculated on their reason for being in the early 1900s. Living among fishermen on the Trobriand Islands off New Guinea from 1915 to 1918, Malinowski noticed that when the fishermen stuck to the safe and reliable lagoon, they described their successes and failures in terms of skill and knowledge.

But when venturing into deeper waters, the fishermen practiced rituals during all stages of the

CLOCKWISE FROM TOP LEFT: RIKA HAYATI/GETTY IMAGES PLUS; PARKER JARNIGAN/UNSPASH; KALI/GETTY IMAGES PLUS; HARSH BHUSHAN SAHU/UNSPASH; PHYNART STUDIO/ISTOCK/GETTY IMAGES PLUS; MARCOS MARTINEZ SANCHEZ/GETTY IMAGES PLUS



Psalm reading helps when circumstances seem out of control



When psalms help

Looking at psalm reading and anxiety levels among Orthodox Jewish women who stayed or fled war-torn Tzfat, Israel, in 2006, researchers found that anxiety scores were similar among women who read sacred texts and nonreaders who left, and nonreaders who stayed. But the anxiety levels of women in the war zone who read psalms were much lower than the other groups'. SOURCE: R. SOSIS AND W.P. HANDWERKER/AM. ANTHROPOLOGIST 2011

journey, acts Malinowski collectively referred to as “magic.” Before setting out, the men consumed special herbs and sacrificed pigs. While on the water, the fishermen beat the canoe with banana leaves, applied body paint, blew on conch shells and chanted in synchrony. Malinowski later used that Trobriand data to comment more broadly on human behavior.

“We find magic wherever the elements of chance and accident, and the emotional play between hope and fear, have a wide and extensive range. We do not find magic whenever the pursuit is certain, reliable and well under control of rational methods,” Malinowski wrote in an essay published posthumously in 1948.

Working in the late 1960s and early 1970s, American anthropologist Roy Rappaport built on that idea by developing a social framework for ritual, theorizing that such behaviors help individuals and groups maintain a balanced psychological state — much like a thermostat system that controls when the heat kicks on. In recent decades, anthropologists and psychologists have tested the idea that rituals regulate emotions.

In 2002, during a period of intense fighting between Palestine and Israel, anthropologist Richard Sosis took a taxi from Jerusalem to Tzfat, in northern Israel. Sosis, of the University of Connecticut in Storrs, noticed that the driver was carrying the Hebrew Bible’s Book of Psalms despite professing little religious inclination and admitting he didn’t read it. The driver said the book was there for his protection. Sosis suspected that the mere presence of the book helped the cabdriver manage the stress of possibly violent encounters. But how?

A few years later, Sosis and his team recruited 115 Orthodox Jewish women from Tzfat to take part in a study about psalm reading. By the time interviews began in August 2006, war between

Israel and Lebanon’s Hezbollah had broken out; 71 percent of the women in the study had fled Tzfat for central Israel.

The researchers asked the women to list their three top stressors during the war. The women listed many of the same issues, with a few important differences. Almost 76 percent of those who stayed in Tzfat reported concerns about property damage compared with just 11 percent of women who left. Women who left were more likely than women who stayed to worry about stressors associated with displacement, such as inadequate child care (32 percent versus 9 percent) and a lack of schedule (32 percent compared with 6 percent).

The researchers also had the women fill out a questionnaire about anxiety. Psalm reading provided anxiety relief, but the psalms’ true power depended on the women’s location. That is, the anxiety scores of women who left Tzfat and recited psalms were only slightly lower than the scores of women who left but did not recite psalms. The anxiety scores of women who stayed in Tzfat and recited psalms, on the other hand, were more than 50 percent lower than women who stayed and did not recite psalms. Overall, those who remained in Tzfat and recited psalms had lower anxiety scores than those who left.

“Reciting the psalms was effective under conditions in which the stressor was uncontrollable. But once you could devise instrumental solutions to a problem, such as taking care of your kids or finding work, reciting psalms isn’t going to fix anything,” says Sosis, whose findings appeared in *American Anthropologist* in 2011. Several more recent studies conducted on individuals living in war and earthquake zones mirror Sosis’ finding that rituals give participants a sense — or a comforting illusion — of control over the uncontrollable.

Testing the illusion

In recent years, researchers have begun testing the psychological benefits of rituals using controlled experiments and physiological monitors. In one study, Dimitris Xygalatas, an anthropologist and psychologist also at the University of Connecticut, and colleagues recruited 74 Hindu women in southwest Mauritius. Thirty-two women were sent to a lab and the rest to the local temple. All participants completed a survey evaluating their overall anxiety and were fitted with heart rate monitors.

Researchers elicited anxiety among the women by giving them three minutes to put together a speech on their flood preparedness — natural disasters are a common threat to the island — to

ostensibly be evaluated later by government experts.

Afterward, women at the temple performed their usual routine — praying to Hindu deities and offering fruits and flowers. These actions tended to follow the same pattern across participants, such as holding an oil lamp or incense stick and moving it slowly clockwise before the statue of a deity. Women at the lab, meanwhile, sat quietly for 11 minutes, about the same time it took for the other women to pray. All participants then took a second anxiety survey.

On the first survey, both groups reported similar levels of anxiety. But the women who then performed their rituals at the temple reported half as much anxiety as the women in the lab.

That divergence also showed up on the heart monitors, specifically on a marker for resilience known as heart rate variability. During periods of stress, heart rate becomes less variable and the time between beats gets shorter.

Spacing between heartbeats for women who sat quietly increased only about 3 percent from the baseline rate, measured when the women first arrived at the lab. But for women who performed the ritual and experienced stress reduction, the space between beats lengthened 22 percent from the baseline rate, Xygalatas and colleagues reported in the Aug. 17 *Philosophical Transactions of the Royal Society B*. That is, heart rate variability was 30 percent higher among women performing

the ritual than women who sat quietly.

Xygalatas' and Sosis' studies suggest that engaging in the individual, repetitive rituals often seen in religious practices, such as reading psalms or reciting prayers, could serve as a balm during the pandemic. But, typically, even individual rituals carry a social component. For instance, it was common for women in Sosis' study to divvy up the 150 passages so that they could read the entire Book of Psalms in a single day. "Women recognize that other women are also engaging in these psalm-recitation activities," Sosis says.

Researchers largely concur that the power of rituals rests within a larger social fabric. Rituals "are created by groups, and individuals inherit them," Legare says. The problem is, during the pandemic, even if people are engaging in rituals on their own, those larger groups are now fractured.

Merging with the in-group

The idea that rituals serve to bond individuals is not new. Fourteenth century scholar Ibn Khaldūn used the term *asabiyah*, Arabic for solidarity, to describe the social cohesion that emerges from engaging in collective rituals. Khaldūn believed that solidarity had its foundations in kinship but extended to tribes and even nations. Centuries later, in the early 1900s, French sociologist Émile Durkheim theorized that group rituals fostered unity among practitioners.

In contemporary times, researchers have

In Mauritius, many women regularly pay tribute to the gods in the Hindu pantheon, such as this woman (left) making an offering to Lakshmi, the goddess of wealth, and these worshippers (right) holding trays bearing fruits and flowers as gifts to the gods.

BOTH: D. XYGALATAS



sought to understand the ways in which rituals bind people together. Work by University of Oxford anthropologist Harvey Whitehouse suggests that rituals exist on either side of a dichotomy. On one side are “imagistic” rituals that fuse people together, often more tightly than kin, through intense moments and painful rites of passage, such as piercing or tattooing one’s body and walking on fire.

Today, imagistic rituals are much less common than the “doctrinal” rituals that characterize modern-day life — prayers, religious services and various regimented rites of passage, such as baby showers and birthday parties. Such rituals appear to have become established as societies grew increasingly complex with the emergence of agriculture. While not binding people as tightly as imagistic rituals, doctrinal rituals enable group members to both identify those in their larger group and spot and police social deviants, Whitehouse says.

Several studies of contemporary communities support the idea that doctrinal rituals help unite social groups. In the early 2000s, Sosis compared cooperation among members of secular versus religious collective farming settlements, called kibbutzim, in Israel. The two types of kibbutzim operated in similar ways, except that men in the religious settlements were required to pray in groups of 10 or more people at least three times a day. Women also prayed, but did not have to do so collectively. Sosis reported in *Current Anthropology* in 2003 that members of religious kibbutzim were more cooperative, as evidenced

by taking less money out of a communal pot, than members of secular kibbutzim. That difference was driven entirely by those ritual-practicing men in the religious kibbutzim.

In her research, Legare — who invents rituals to see how children understand such practices — has shown that children use rituals to identify and reinforce connections with members of their own group while shunning those outside the group. Recently, Legare, working with Nicole Wen, now at Brunel University London, divided 60 children, ages 4 to 11, into two groups. The children were given wristbands denoting their group’s color. One group was then walked through a highly scripted, ritualized process to make a bead necklace with

prompts like: “First, hold up a green string. Then, touch a green star to your head. Then, string on a green star” and so on. The other group made necklaces with the same materials, but no script.

The activities continued for two weeks, during which the researchers measured how long children spent comparing their handiwork to that of members of their own group and how long they spent watching members of the other group, such as by looking over their shoulders. Reporting in the Aug. 17 *Philosophical Transactions of the Royal Society B*, the team found that during the experiment, children in the ritual group spent on average twice as much time as children in the nonritual group showing off their necklaces to members of their own group and monitoring the behavior of those not in the group.

“Rituals take the effects of a group experience and turn them way up.”

CRISTINE LEGARE

Working in a group helps people bond even without a script to follow, Legare says. But “rituals take the effects of a group experience and turn them way up.”

Legare’s project and others also illustrate how rituals engender in-groups and out-groups. Whitehouse’s work suggests that shared traumatic experiences, which may include imagistic rituals, contribute to the cohesion of terrorist cell networks, where fighters would sooner die for fellow fighters than even family (*SN*: 7/9/16, p. 18).

The pandemic itself is the latest example of how a shared traumatic experience and the resulting rituals — Zoom parties, alliances around wearing or eschewing masks and reactions to civil rights rallies — can break or bind communities.

“Human social groups ... [are] always going to be vulnerable to in-group preferences and out-group biases,” Legare says. Whether we use ritual for good — or evil — is up to us.

Pandemic asynchrony

Certain rituals, such as singing and dancing together, are particularly good at amplifying group cohesion and a spirit of generosity. But these group rituals, tragically, also can spread the coronavirus.

On March 10 in Skagit County, Wash., 61 members of a church choir met for practice. One singer, who had been feeling unwell for a few days, later tested positive for COVID-19. Within weeks, almost 90 percent of those in attendance had developed similar symptoms, with 33 confirmed cases; two members died from the disease. Similar stories linking choir practice to superspreading



2X

Extra time that children who beaded necklaces using rituals, compared with children who beaded necklaces without ritual, spent showing off their handiwork and checking out the work of the other group

events have emerged (see Page 15). And the collective singing that characterizes so many religious services has emerged as a particularly risky activity in this pandemic.

In a series of experiments reported in 2013, researchers tested to see if dancing or chanting together made people feel more generous toward members of their group. One of the tests divided 27 volunteers into groups of three and handed them a list of one-syllable words divided into three columns. The researchers told some of the groups to go down the list and chant the words together for six minutes, keeping in beat with a metronome — effectively a ritual performed in synchrony. Other groups recited the words sequentially, with each member reading the words in only one column.

The participants then played a cooperative game within their groups. Anonymously, each member could choose either option X, a guaranteed prize of \$7, or option Y, a prize of \$10 that came through only if every group member chose Y. If a single member chose X, no one would get money. Reporting in *PLOS ONE*, the researchers found that 62 percent of participants who chanted together chose Y compared with just 21 percent who chanted in sequence.

Other synchronized activities, such as marching, dancing, rowing and even collective social distancing while out in public, can bond participants, Whitehouse says. The alliance forged by synchrony is arguably playing out across the United States even now as both Black and non-Black people march and chant in unison to protest police brutality (see Page 10) and systemic racism. In any context, Legare says, synchrony “is a powerful social catalyst.”

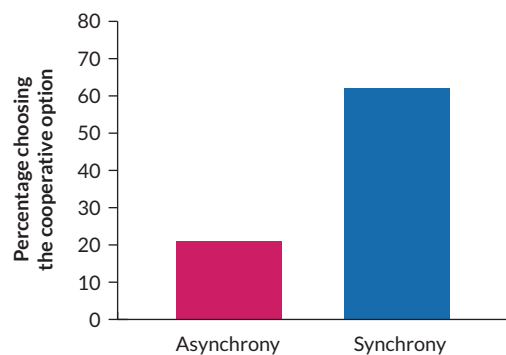
New rituals

Ironically, as the pandemic makes practicing rituals, particularly social rituals, profoundly challenging, decades of research have made clear that people turn to such regimented behaviors during periods of unrest. “Anthropologists have long observed that during times of anxiety, you see spikes in ritual activity,” Xygalatas says.

So even as rituals are being disrupted and diluted, people are seeking new sources of solace. Many people, for instance, are turning to their immediate family members to fill that ritual void.

“It’s possible that lockdowns are actually leading to the invention of new family rituals that foster this kind of resilience, ranging from the arrangement of rainbows and teddy bears in windows to the revival of more traditional

Synchronous chanting increases cooperation



family rituals like eating, singing [and] telling stories together,” Whitehouse says.

People are also finding new ways to experience old traditions. Rachel Fraumann, a Methodist minister in Barre, Vt., says online attendance at her recorded sermons has more than doubled since mid-March. In her view, now is a great time for the ritually and spiritually adrift to shop around for their ritual fit.

Such “shopping” doesn’t need to occur within a religious context. Secular rituals, such as those centered around crafts, music or sports, have shown similar promises, and pitfalls, as religious activities, says Oxford cognitive anthropologist Martha Newson. Which means now could be a great time to try new hobbies with a solo component as a way to practice in the here and now, with a group component to look forward to after the pandemic ends, such as knitting with the goal of joining a knitting circle or buying a rowing machine to get fit enough to join the local crew team, where bodies move in sync.

Creating rituals outside of religion, though, can be hard to get right. “It’s not the hobby, it’s the people who do the hobby who make the tribe. Precisely what the magic ingredients are for that, we [don’t] know,” Newson says.

Those challenges won’t stop people from trying once the pandemic ends, Legare says. “I would predict that there will be an increase in attending religious services but [also] an increase in attending all kinds of social group activities. People are so starved for social interaction, I would predict increased enrollment in absolutely everything.” ■

Explore more

- Rachel E. Watson-Jones and Cristine H. Legare. “The social functions of group rituals.” *Current Directions in Psychological Science*. February 10, 2016.

One for all

Participants who chanted as a group at the same time were more cooperative when playing a game after the chanting than those who chanted words sequentially. SOURCE: P. REDDISH ET AL./PLOS ONE 2013



A new movie about Nikola Tesla (played by Ethan Hawke) follows the inventor's efforts to pioneer a new electricity supply system, which put him in fierce competition with Thomas Edison.

FILM

Tesla's life lights up offbeat film

It is a David and Goliath story for the Industrial Age. Young, idealistic Nikola Tesla came to the United States in 1884 hoping that electricity mogul Thomas Edison would work with him on a new system for generating and distributing electricity. Tesla's alternating current system promised to transmit electricity much greater distances than the reigning direct current setup that Edison had pioneered. But Edison dismissed Tesla's ideas as impractical, forcing Tesla to strike out on his own.

The new biopic *Tesla*, directed by Michael Almereyda, follows what came to be known as the War of the Currents between Tesla and Edison. The film premieres August 21, available on demand through a variety of cable and digital platforms.

Tesla (portrayed by Ethan Hawke) is the underdog hero. He lacks Edison's business acumen and penchant for self-promotion, but is armed with a visionary idea and relentless ambition. To make his electrical system a reality, Tesla struggles against duplicitous business partners and a smear campaign by Edison (Kyle MacLachlan) to cast alternating current as unsafe. In one macabre scene, one of Edison's employees goes so far as to publicly electrocute a dog with alternating current.

Ultimately, Tesla's system wins out as the preeminent means of electrical production and distribution worldwide. (Although the film doesn't explain in detail, AC has an edge over DC electricity because it is easily switched between high and low voltages. That allows high-voltage electricity to travel efficiently across long power lines before getting converted to low voltages for safe in-home use.)

Almereyda's *Tesla* is a modest man, more concerned with using his inventions for good than earning money or recognition. But *Tesla* also explores the less flattering aspects of the inventor's character. His reclusiveness and overactive mind made it difficult to maintain relationships. One of Tesla's most loyal associates was Anne Morgan (Eve Hewson), daughter of J.P. Morgan, the Wall Street titan who was a patron of Tesla's work. Anne Morgan was drawn to Tesla's intellect and altruism, and seemed to want to marry him. But Tesla was married to his work, and ultimately moved to Colorado without Morgan to pursue mysterious, lightning-powered experiments. Thus began the second act of Tesla's career, during which he chased increasingly outlandish ideas that scared off investors and left him destitute.

Morgan occasionally breaks the fourth wall to narrate Tesla's story, as though she were reflecting on it from a modern perspective, armed with a laptop and projector to display visuals. The film also invokes other unusual storytelling elements, such as playing out alternative scenes to explore what might have been. Some of these what-if scenarios are intriguing, like one where Edison admits he misjudged Tesla and suggests they become an electrical engineering dynamic duo. Some of these scenes are just whacky, such as when Tesla smashes an ice cream cone into Edison's face during an argument. ("This is pretty surely not how it happened," Morgan narrates.)

Such quirks are off-putting at times, but overall, *Tesla* is a lot like its namesake: introspective, intriguing and oddly charming. — *Maria Temming*

Tesla
PREMIERES AUGUST 21
IFC FILMS

BOOKSHELF

Galileo's struggles are still relevant today

In basketball, legends are often known by first name alone: LeBron, Kobe, Michael. Same with entertainers: Madonna, Cher, Beyoncé.

But lists of scientific legends almost always include surnames, never just Isaac or Albert or Charles. Among the titans of modern scientific lore, only one is generally referred to exclusively by a first name: Galileo.

The man had a last name: Galilei. But fewer people know his surname than know he was one of the primary founders of modern science. Galileo merged mathematics with natural philosophy and quantitative experimental methodology to provide a foundation for understanding nature on nature's terms, rather than Aristotle's.

Galileo's life has been well-documented. Dozens of biographies have been written about him since the first by Vincenzo Viviani, published in 1717 (but composed before Thomas Salusbury's English language Galileo biography of 1664). As recently as 2010, two major scholarly biographies (by David Wootton and John Heilbron) analyzed Galileo's life and science in great depth.

But with the lives of legends, there is always a license to produce yet another interpretation. In *Galileo and the Science Deniers*, astrophysicist Mario Livio has invoked that license to tell Galileo's story once more, this time with a particular concern for Galileo's relevance to science today (and the impediments to its acceptance). "In a world of governmental antisience attitudes with science deniers at key positions," Livio writes, "Galileo's tale serves ... as a potent reminder of the importance of freedom of thought."

Livio also set out to produce a biography more accessible to a general reader than the typical scholarly tomes. And he succeeded. His commentaries comparing Galileo's time to today's are weaved into an engagingly composed

and pleasantly readable account.

In Livio's view, today's deniers of climate change science or the validity of evolutionary theory are comparable to the religious opponents of Galileo's scientific views, particularly his insistence on the motion of the Earth around the sun. Serving that end, the book is not an in-depth biography as much as a summary of Galileo's life and science, plus a thorough recounting of the events leading up to his famous trial. Livio plays the role of a highly capable legal commentator in analyzing the issues raised during the trial, including discussion of the questionable tactics by the prosecution and Galileo's not always effective defense.

Galileo's trial centered on his book *Dialogue Concerning the Two Chief World Systems*, in which three characters discuss the pros and cons of the Aristotelian cosmos, with Earth at the

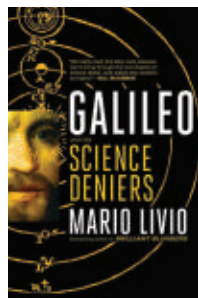
center, and the sun-centered solar system advocated by Copernicus. Galileo thought his book had been approved by the proper censors. But his enemies orchestrated heresy charges. Galileo's book, the prosecution alleged, defied a Catholic Church order in 1616 forbidding him from advocating Copernicanism. Galileo's argument that his book merely described the opposing views without affirming either side was rejected; he was convicted and sentenced to house arrest for the rest of his life.

Livio's account of this well-known story is enhanced by insights drawn from more recent scholarship, including the discovery in 1998 of a letter written during the trial suggesting that a plea bargain might have been considered. Of particular interest is Livio's account of a Galileo biography written by Pio Paschini, commissioned in the

1940s by the Pontifical Academy of Sciences, supposedly to explain how the Catholic Church had not really persecuted Galileo, but helped him. Instead, Paschini's manuscript told the truth, so the church refused to publish it. In the 1960s, after Paschini's death, the church relented, authorizing publication — but only after revisions that bowdlerized the original version to portray the church in a more favorable light.

Today, of course, science and religion still encounter tensions. But most recently, opposition to science has emerged as a more general public attitude, driven most prominently by climate science deniers and anti-vaccine propagandists. At times, Livio's comparisons of such movements to opposition to Galileo seem a bit of a stretch. But in its essence, his point is on target. In particular, he assails a common misinterpretation of the Galileo lesson: that the minority view should be considered correct. Some climate change deniers, Livio notes, argue that the majority opposed Galileo, even though he turned out to be right; therefore minority views on climate change, though mocked by the majority, will also turn out to be right. But such reasoning is deeply flawed. "Galileo was right not because he had been mocked and criticized but because the *scientific evidence* was on his side," Livio rightly declares.

As Paschini had written in his censored manuscript, Galileo presented a fair account of the scientific evidence for the Aristotelian and Copernican views of the universe. Paschini argued, as Livio notes, that "it wasn't Galileo's fault ... that Copernicanism appeared much stronger." Then as now, some scientific cases are stronger than others. Sadly, now as then, the stronger scientific case does not always sway the policy of the authorities — as the U.S. government's response to the current pandemic illustrates. In the end, Galileo's case was strong enough to survive. So his story is worth retelling. — Tom Siegfried



Galileo and the Science Deniers
Mario Livio
SIMON & SCHUSTER, \$28

After publishing a book describing Copernicus' idea that the sun is at the center of the solar system, Galileo stood trial on suspicions of heresy, as depicted in this 19th century painting. Galileo's experiences hold lessons in today's age of science denialism, a new book argues.



JOSEPH NICOLAS ROBERT-FLEURY/ALAMY STOCK PHOTO

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Silk-based microneedles may help treat diseased plants

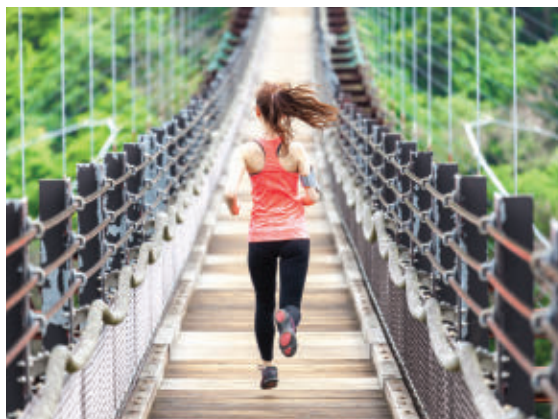
Plants get sick, just as people do. To treat crop diseases, farmers usually spray chemicals. Some kill disease-causing germs. Others target pests that carry germs. But “less than 5 percent [of those medicines] go inside the plant,” notes engineer Yunteng Cao of MIT. His team’s new drug-delivery system (red in photo) sticks a patch of silk microneedles onto a plant. They deliver medicine directly and fully into the “patient” as they dissolve. In tests of what farmers might want to do, Cao’s team used a drone to dart plants from the air with a batch of the needles. — *Kathryn Hulick*

Read more: www.sciencenewsforstudents.org/microneedles

Working up a sweat may one day power up a device

One route to greener electronics may involve working up a good sweat. Engineers at the University of Glasgow in Scotland are designing supercapacitors recharged by perspiration. Electrodes in the fabric-based device are made from a polymer that conducts electricity. The device works for thousands of charge-and-discharge cycles, even when twisted and bent. Some of its developers strapped one on as they ran (and sweated). It produced enough electricity to light a few LEDs and run a sensor that measured how salty the sweat was. — *Carolyn Wilke*

Read more: www.sciencenewsforstudents.org/powering-device



Waiting for a ‘smart’ toilet? It’s nearly here

Body wastes can say a lot about our health. Yet describing them to doctors can be uncomfortable (if we even remember the details). Enter smart toilets. They analyze poop and pee so you don’t have to. Groups at Stanford and Duke universities have models under development. One can record the “structure” of feces, how often you go and how long each poop takes. It can even measure white blood cells and types of protein in urine. But how does a toilet know whose wastes it’s analyzing? Some engineers want a camera to ID your butt. Counter would-be users: No pictures, please! — *Stephanie Parker*

Read more: www.sciencenewsforstudents.org/smart-toilet



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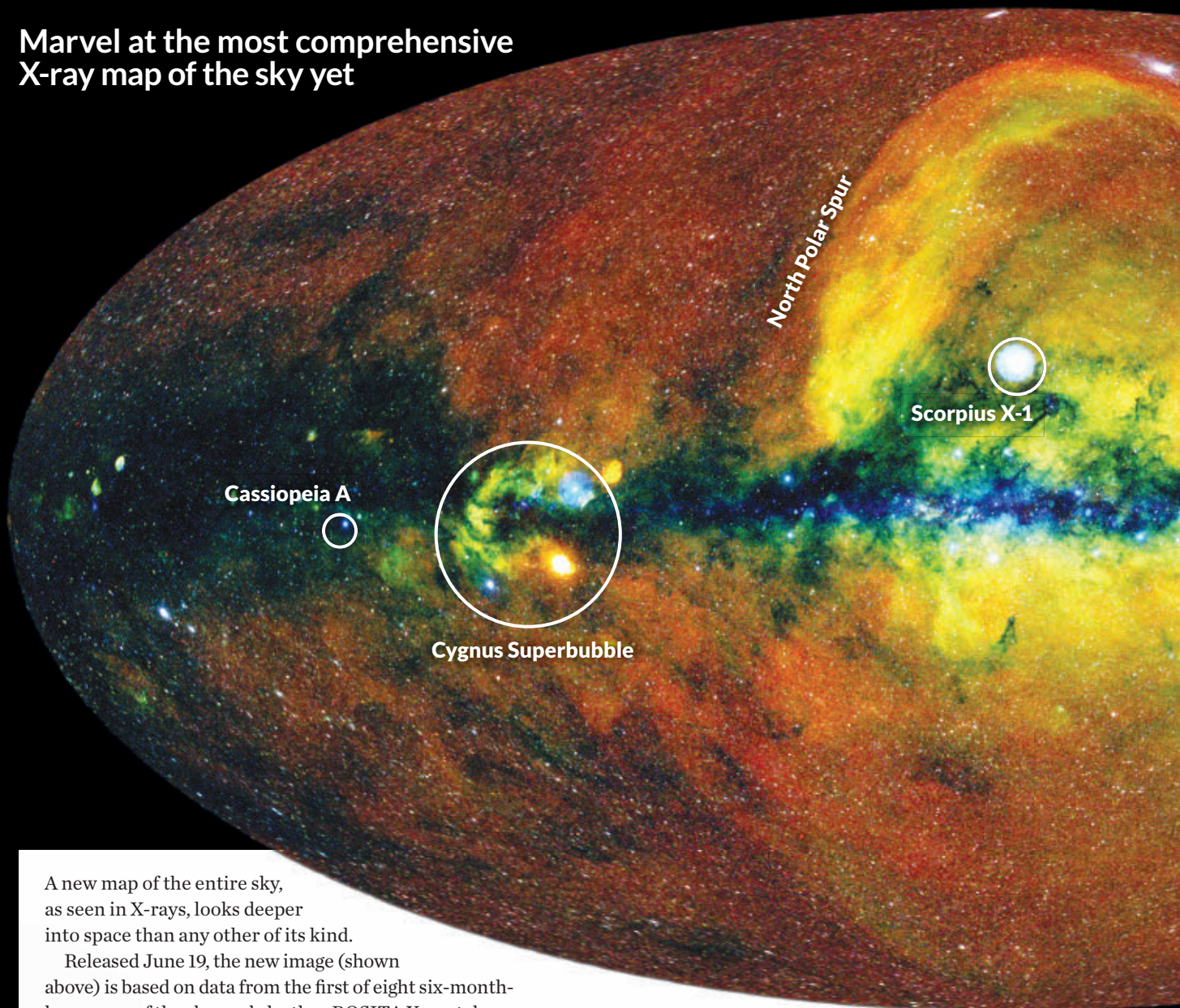
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Marvel at the most comprehensive X-ray map of the sky yet



A new map of the entire sky, as seen in X-rays, looks deeper into space than any other of its kind.

Released June 19, the new image (shown above) is based on data from the first of eight six-month-long scans of the sky made by the eROSITA X-ray telescope on the Russian-German SRG spacecraft. This scan cataloged some 1.1 million X-ray sources — just about doubling the number of known X-ray emitters in the universe.

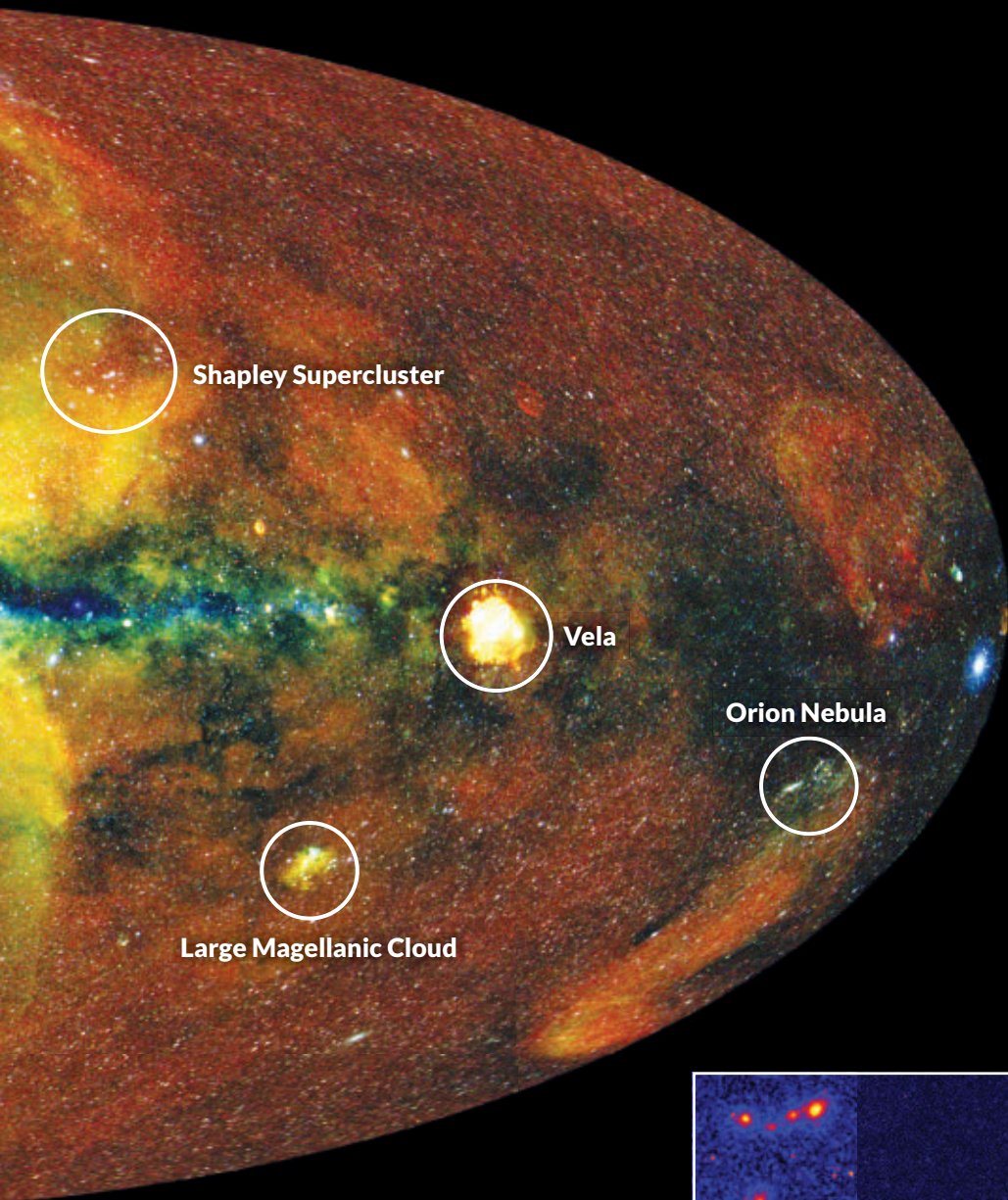
In the map, X-rays from celestial objects are color-coded by energy: Blue signifies the highest energies, followed by green, yellow, orange and red. The red foreground glow comes from hot gas near the solar system; the Milky Way plane appears blue because gas and dust in the disk absorb all but the most energetic X-rays.

Many of the Milky Way's supernova remnants, including Cassiopeia A and Vela, are included in the map as well as a star system called Scorpius X-1, the first source of X-rays discovered outside the solar system. Also showcased from our galaxy are star-forming regions, such as

the Orion Nebula and the Cygnus Superbubble. The map also shows the North Polar Spur, a giant, enigmatic arc of X-rays above the Milky Way plane, in new detail, which might help scientists figure out the spur's origins.

Beyond the Milky Way are nearby galaxies, such as the Large Magellanic Cloud, and distant galaxy clusters, such as those in the Shapley Supercluster. eROSITA has snapped close-ups of some of these objects (a few are shown on the opposite page).

Eventually, eROSITA's eight maps all together will reveal objects one-fifth as bright as those that can be seen on a single map of the universe. That new view will allow scientists to see more X-ray sources in more detail and track how they change over time. — *Maria Temming*

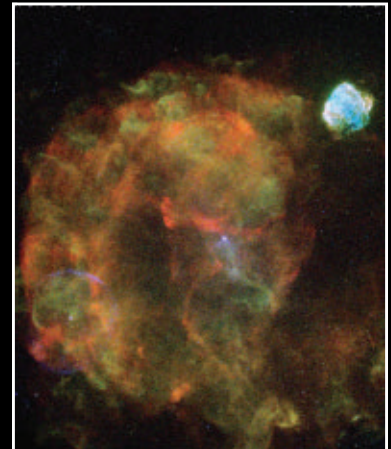


Shapley Supercluster

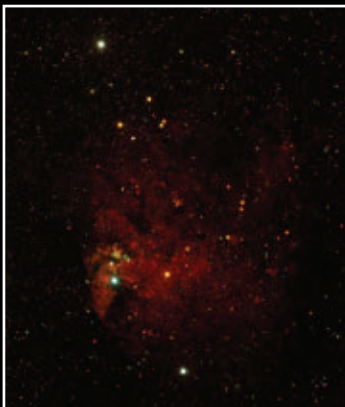
Vela

Orion Nebula

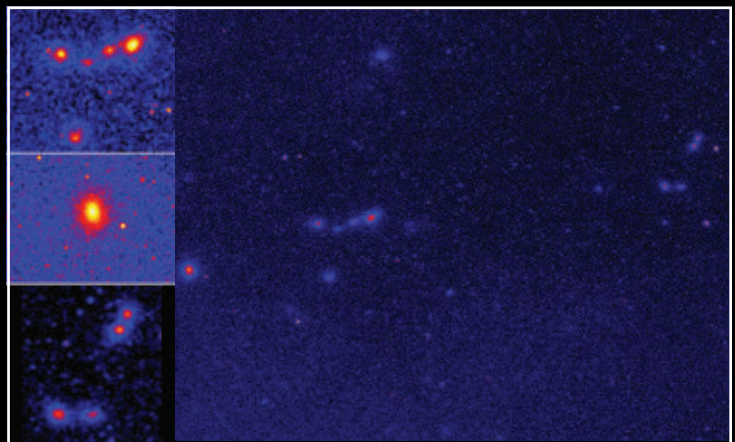
Large Magellanic Cloud



Vela This supernova remnant is one of the most prominent sources of X-rays in the sky. Past X-ray surveys have found fewer supernova remnants than expected, based on how many massive stars astronomers think have blown up over the Milky Way's history. But eROSITA observations so far have revealed plumes of debris that could be overlooked stellar graves.



Large Magellanic Cloud This small galaxy that orbits the Milky Way is one of our galaxy's closest neighbors. It emits a diffuse X-ray glow (shown in red and orange) from its interstellar material and brighter dots of X-rays from binary star systems and supernova remnants.



Shapley Supercluster About 650 million light-years away, this supercluster (right) is composed of smaller clumps of hundreds to thousands of galaxies (several seen in the zoomed-in images, left column). Roughly 8,000 galaxy clusters are known in the universe. eROSITA, expected to find 50,000 to 100,000 clusters, already picked out about 20,000 in its first scan. That census could give a better sense of the sizes and distributions of these clusters over cosmic history, giving insight into dark matter and how fast the universe is expanding.

CLOCKWISE FROM TOP: PETER PREDELL AND WERNER BECKER/NASA/ESA/INTEGRAL; ESA/BUBBUL AND J. SANDERS/MPPE; FRANK HABERL AND CHANDREYEE MAITRA/MPPE



JUNE 20, 2020

Viral heritage

Lab experiments are needed to see if mutations in the new coronavirus change how the virus infects cells, **Erin Garcia de Jesus** reported in “The new coronavirus is mutating” (SN: 6/20/20, p. 7).

Reader **Roger W. Yoerges** asked if a person could be infected with multiple forms, or variants, of a virus at once. He wondered if that would allow very infectious variants to spread more.

That’s a fantastic question, **Garcia de Jesus** says. “Given how RNA viruses replicate, their progeny typically are different from the parent viruses,” she says. During an infection, progeny can form groups of viral particles that have a mix of mutations. Some rare variants within a group may have mutations that change how those viruses work, including how they infect cells, **Garcia de Jesus** says. Those mutations, whether good or bad for the virus, don’t guarantee that variants with the mutations will spread to the next host. Only a few variants will spread, perhaps due to random chance.

Editor’s note

On July 22, *Nature* retracted the study described in “Gamers rise to physics challenge” (SN: 5/14/16, p. 7) at the researchers’ request. Because of an error in the computer code, the researchers say, their findings — that humans outperformed a computer game that simulated quantum mechanics — are not valid.

Nature also retracted the study described in “This ancient dinosaur was no bigger than a hummingbird” (SN: 4/11/20, p. 4) at the researchers’ request. “Although the description of *Oculudentavis khaungrae* remains accurate, a new unpublished specimen casts doubts upon our hypothesis regarding the [species’s] phylogenetic position,” paleontologist Jingmai O’Connor and colleagues write in the retraction. A recent study posted online at bioRxiv.org examined the creature’s skull and suggested that it is not a dinosaur, but a lizard. In an e-mail to *Science News*, O’Connor

concedes *Oculudentavis* probably was a lizard, but she maintains the animal is an important discovery.

Correction

“Mars dust storm danger” (SN: 7/4/20 & 7/18/20, p. 24) incorrectly identified Opportunity mission team member Keri Bean’s role in 2018. She had just joined the rover-driving team after having been part of the rover-operations team since 2007.

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**What Stauer Clients
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