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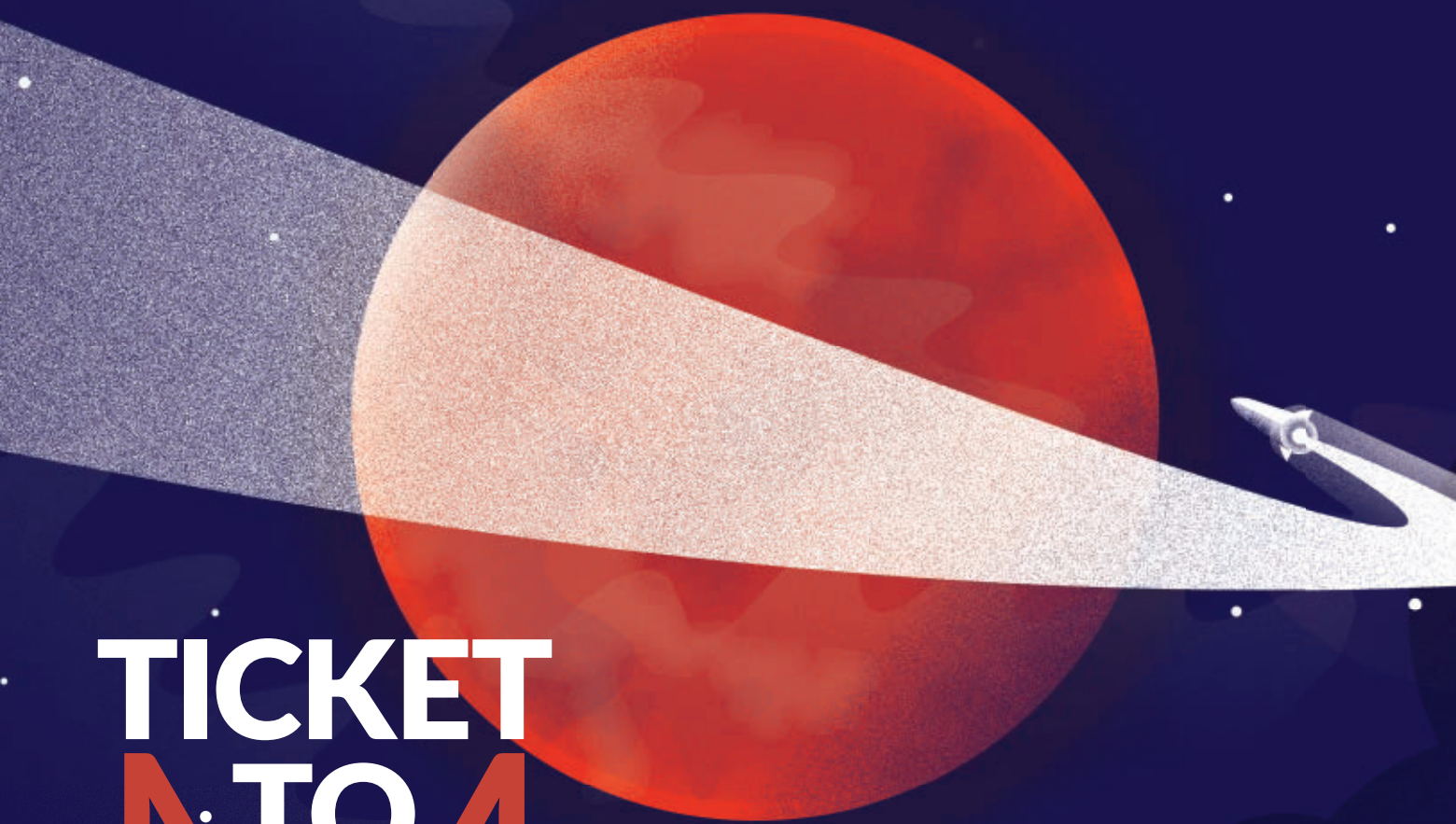
ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ JULY 4, 2020 & JULY 18, 2020



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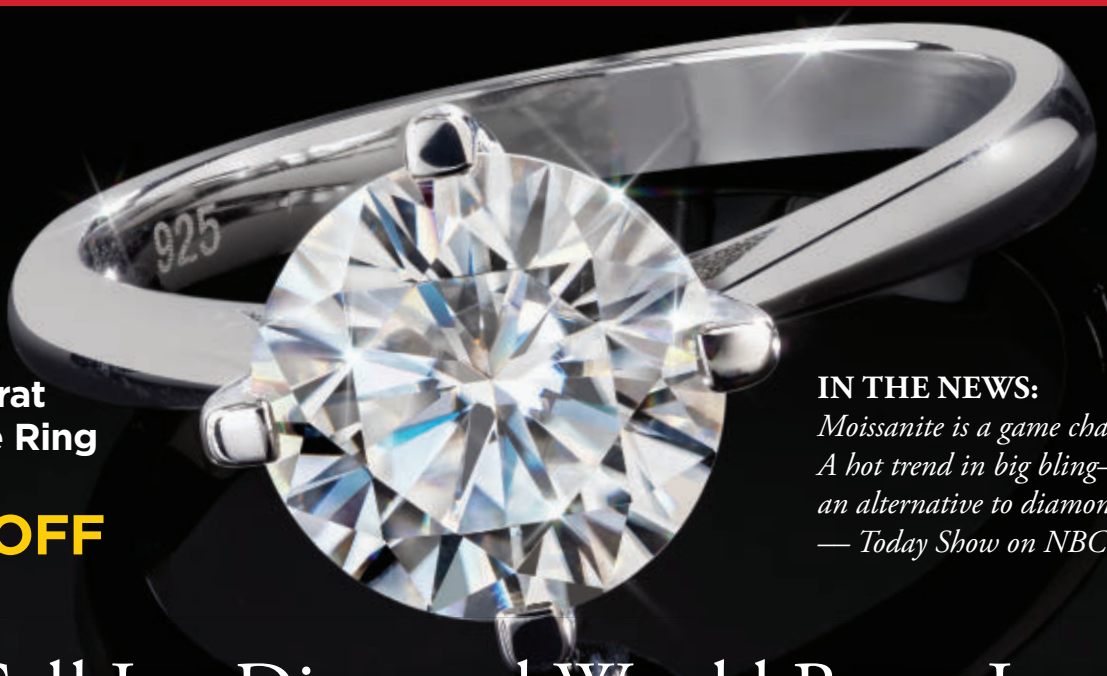

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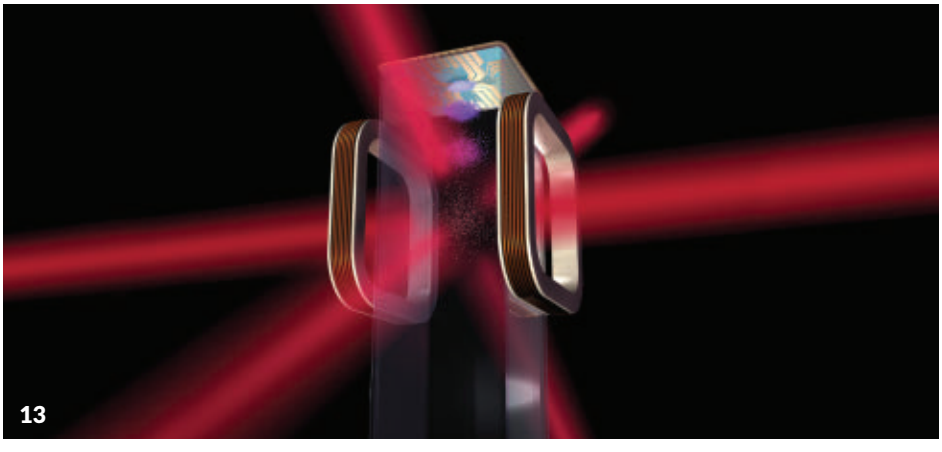
News



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Departments

COVER In science fiction, astronauts walk about in roomy spaceships, sheltered from the dangerous elements of deep space. Not so on a future real trip to Mars. *Neil Webb*

FROM TOP: ESA, DLR, FU BERLIN (CC BY-SA 3.0 IGO); DAVID LIITTSCHWAGER; JPL-CALTECH/NASA

Can science help create a more just society?

Since the days of Plato, thinkers have wrestled with what makes for a just society, and whether the responsibility for justice rests with the individual or with government. Over the centuries, those questions have evolved from the realm of the natural philosophers into new fields of science, including sociology (first called "social physics"), psychology and economics.

With our country facing a reckoning on its legacy of racial violence and inequity, sparked by police killings of black people and the subsequent worldwide protests, the sciences help us better understand how we came to this moment, and how those inequities can be overcome. As science journalists, we not only explain the workings of science and scientists, we also use science as a lens to examine human behavior, societies and the world around us.

A browse through the *Science News* archive reveals that the magazine has a long history covering race and policy, including the landmark 1965 report coauthored by Daniel Patrick Moynihan, then a U.S. Department of Labor assistant secretary. Moynihan used social science research to reveal the failures of civil rights laws to ameliorate economic and racial inequality. Often this magazine's approach was quite pointed, as when it criticized President Lyndon Johnson for failing to act on the 1968 Kerner Commission's finding that pervasive racism fueled civil disorder.

Other reports in our archives read like they could have been written today, including Bruce Bower's story from 1996 on how a keener scientific understanding of stereotypes could help ethnic groups or nations identify the cultural disparities that trigger distrust (*SN: 6/29/96, p. 408*).

This year, we've described the challenges scientists face in accurately defining race for the U.S. census (*SN: 3/14/20, p. 16*), explained how long-standing health disparities have made African-Americans more vulnerable to COVID-19 (*SN Online: 4/10/20*) and explored the world of birders and other naturalists during Black Birders Week (*SN Online: 6/4/20*). I knew that just a small percentage of U.S. scientists are African-American, but I was startled to learn reading staff writer Jonathan Lambert's article that less than 1 percent of Ph.D.s granted in 2018 in ecology, evolutionary biology or wildlife ecology went to students who identified as African-American or black.

And though journalists often feel as if we stand outside, observing history, we are not immune to it. This magazine has a shameful history of endorsing the racist pseudoscience of eugenics, and of perpetuating ethnic and gender stereotypes that are embarrassing to read today. We'll be taking a deeper look at that coverage as we approach the 100th anniversary of the magazine.

We like to think we're doing better now, but just like our nation, we've got much work to do.

If we're going to accurately report where science succeeds and when it falls short in encompassing the breadth and diversity of the human experience, we have to make sure that we're not blinded by our own biases and assumptions. You can help us in that task. Write us at feedback@sciencenews.org.

— Nancy Shute, Editor in Chief

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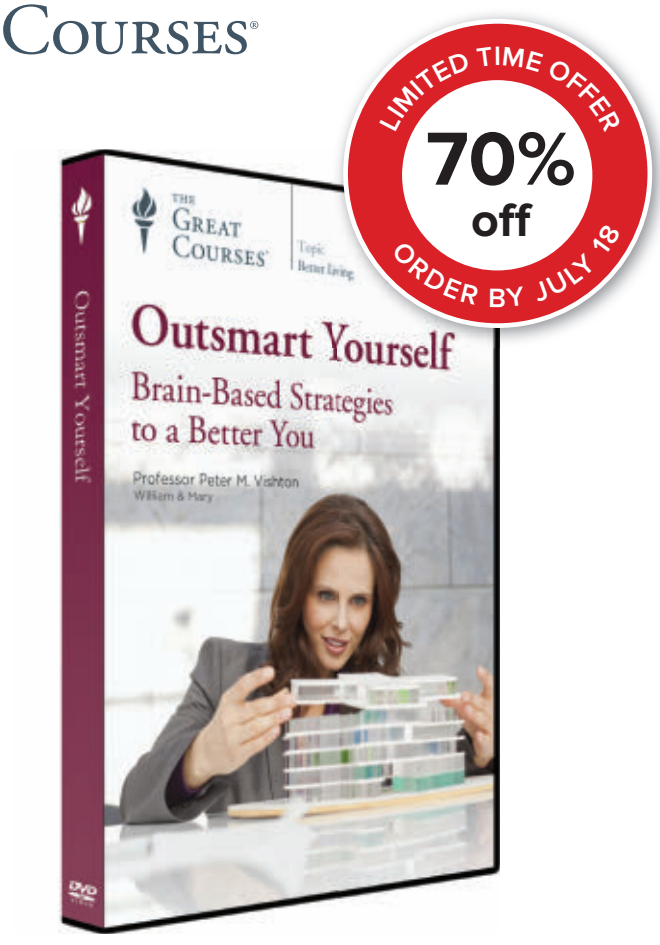

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Excerpt from the July 4, 1970 issue of *Science News*

50 YEARS AGO

Power for Skylab

The largest solar cell array system for electrical power ever devised for a spacecraft is now being completed.... The solar array will be used for the workshop and telescope components of the Skylab cluster to be launched as a space station forerunner.

UPDATE: One might think Skylab was cursed. Astronauts there made unprecedented observations of Earth and the sun, and set new records for time spent in space — but many misfortunes befell the early NASA space station. Skylab's May 1973 launch damaged its solar panels. Astronauts, who arrived on their first mission to the station about two weeks later, salvaged one panel, but not without a lot of frustration (*SN: 6/2/73, p. 352*). Equipment failures plagued a second and third mission, and NASA abandoned the station in early 1974. But the space agency's Skylab problems were far from over. Despite NASA's efforts to keep the station in orbit, Skylab broke up in Earth's atmosphere in 1979 and scattered debris across Western Australia. Luckily, no one got hurt.

Lowland tapirs, the largest mammal in South America, disperse seeds throughout the Amazon in giant dung piles.

THE SCIENCE LIFE

An ecologist taps tapirs for Amazon forest revival

Beneath the viridescent understory of the Brazilian Amazon, ecologist Lucas Paolucci has been honing his skills for hunting tapir dung. In this region's degraded rainforests, he sees the trunk-nosed, piglike mammal's enormous piles of poop as a treasure.

Chock full of seeds, the dung from lowland tapirs (*Tapirus terrestris*) may be key in regenerating forests that have been hit by intensive logging and slash-and-burn agriculture, says Paolucci, of the Amazon Environmental Research Institute in Brazil.

"Tapirs in Brazil are known as the gardeners of the forests," he says. Feasting on the fruit of about 300 plant species, the animals travel through the forest underbrush with bellies full of seeds. That includes seeds of large, carbon-storing trees. Such seeds can't pass through smaller animals, so the lowland tapir, South America's largest mammal, is one of the primary agents dispersing seeds throughout the Amazon.

In 2016, Paolucci began studying the role of these magnanimous defecators in restoring disturbed forests. His team conducted an experiment in the Brazilian state of Mato Grosso, where two forest plots had been control burned to varying degrees from 2004 to 2010.

The team compared the locations of 163 dung piles with camera-trap recordings of tapirs roaming through the area. Then the researchers sieved the feces to separate out seeds, counting 129,204 seeds from 24 plant species. The camera traps showed tapirs spent far more time in burned areas than in the pristine forest, Paolucci says. The animals also deposited more than three times as many seeds per hectare on average in burned areas as in the untouched forest.

Just months after the team published those findings, in March 2019 in *Biotropica*, the Amazon saw one of its most destructive fire seasons in years. That made Paolucci even more determined to understand tapirs' role in forest recovery. But he knows the tapirs aren't doing the job alone. Dung beetles are responsible for pushing tapir poop around and helping seeds germinate.

In early 2019, Paolucci returned to the forest plots to monitor clumps of tapir dung that he loaded with dummy seeds. Dummy seeds missing after 24 hours had presumably been rolled away by the beetles and indicated how many seeds would potentially grow into plants. Paolucci hopes to publish the results in 2021.

Ecologist Lucas Paolucci, shown near a pile of tapir dung, studies how tapirs and dung beetles may aid forest recovery.

Tapirs could help replant trees that have been cleared illegally, Paolucci says. But the population of lowland tapirs, the only tapir species widespread in the Amazon, is decreasing due to habitat loss and hunting. Fewer tapirs means seed dispersal will "rely even more on organisms such as dung beetles," he says. — *Gloria Dickie*

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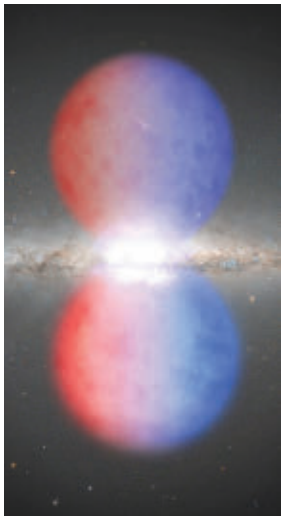
FIRST

New eyes on the Milky Way's giant gas bubbles



Mysterious cosmic bubbles are being seen in a new light. For the first time, scientists have observed visible light from Fermi bubbles, enormous blobs of gas that sandwich the plane of the Milky Way galaxy.

The newly spotted glow was emitted by electrically charged hydrogen gas within the bubbles. Astronomer Dhanesh Krishnarao of the University of Wisconsin–Madison described the finding June 3 at the American Astronomical Society virtual meeting.

The structures, each 25,000 light-years tall, spew high-energy gamma rays and may be relics of an ancient outburst of gas from the galaxy's center. But scientists don't know the source of the outflow. It could have been the result of the black hole at the center of the galaxy gobbling up matter, or emissions from bursts of stars forming.

Within the bubbles, the expansion of gas alters the wavelength of the gas's light as seen from Earth (illustrated above; red is gas moving away, blue is moving toward Earth). Krishnarao's team used the wavelength shift at one location to pinpoint the gas's velocity: about 220 kilometers per second. Krishnarao hopes to fully map that velocity to figure out how the bubbles' energy output has changed over time. "That'll really be able to nail down more about the origin," he said. — *Emily Conover*

TEASER

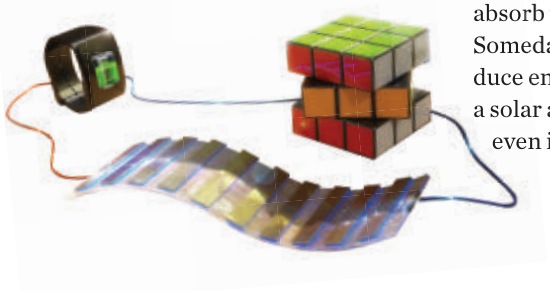
A new generator juices up with shadows

Someday, shadows and light could team up to provide power.

A new device exploits the contrast between bright spots and shade to create a current that can power small electronics. "We can harvest energy anywhere on Earth, not just open spaces," says Swee Ching Tan, a materials scientist at the National University of Singapore.

The device, called a shadow-effect energy generator, works thanks to a superthin coating of gold on silicon — a typical solar cell material. Light shining on silicon energizes its electrons. The excited electrons jump from the silicon to the gold. With part of the device shaded, the voltage of the illuminated metal increases relative to the dark area, and electrons in the generator flow from high to low voltage. Sending the electrons through an external circuit creates a current that can power a gadget, Tan and colleagues report online April 15 in *Energy & Environmental Science*. Tan's team used eight generators to run an electronic watch in low light. The devices can also serve as sensors. When a remote-controlled car passed by, its shadow fell on a generator, lighting up an LED.

In this illustration, a shadow-effect energy generator harnesses energy, with help from a shadow cast by a Rubik's Cube, to power an electronic watch.



The greater the contrast between light and dark, the more energy a generator provides. So the team is working to increase the light these generators absorb to better exploit shadows. Someday, the generators might produce energy in the shadowy spots in a solar array, between skyscrapers or even indoors. — *Carolyn Wilke*

MYSTERY SOLVED

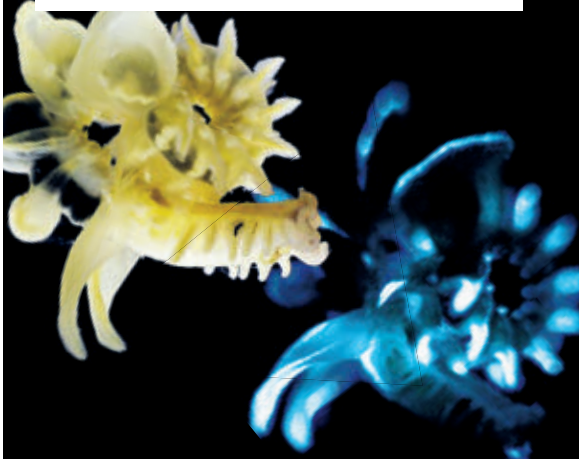
How a tube worm powers its glowing blue goo

Predators that tread on a colony of parchment tube worms may find themselves slimed. When threatened, these ocean creatures exude a sticky mucus that can glow blue for days. The slime's light may help it shine on, new results suggest.

This sort of light produced by animals, bacteria or algae typically is gone in a flash. But with the mucus oozed by *Chaetopterus* tube worms, "we have easily 16 hours and sometimes 72 hours of light," says Evelien De Meulenaere, a biochemist at the Scripps Institution of Oceanography in La Jolla, Calif.

Making and sustaining such bioluminescence requires energy. But the slime glows outside the body, where it can't draw energy from the worms (shown in natural light and darkness, below). To unlock its secrets, De Meulenaere's team dissected the goo's complex chemistry.

The mucus contains ferritin, a protein that releases electrically charged iron atoms, or ions. Those ions can trigger the mucus to emit bursts of blue light, the team found. Ferritin itself seems to respond to blue light by releasing ions more quickly. That suggests the slime's light triggers more light production to sustain the glow. The team had planned to present the results in early April at the canceled Experimental Biology 2020 meeting. — *Carolyn Wilke*



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HUMANS & SOCIETY

Oldest, largest Maya monument found

Lidar discovery supports alternative view of the culture's rise

BY BRUCE BOWER

Maya society got off to a monumentally fast start around 3,000 years ago.

Excavations and airborne mapping at a previously unknown site in Mexico called Aguada Fénix have uncovered the oldest and largest known structure built by Maya people, say archaeologist Takeshi Inomata of the University of Arizona in Tucson and his colleagues. This raised ceremonial area made of clay and earth was constructed from about 1000 B.C. to 800 B.C., the scientists report online June 3 in *Nature*.

The discovery adds to recent evidence that from its very beginnings, the Maya civilization, which spread through parts of southern Mexico and Central America, built monumental structures. A similar but smaller ritual area previously discovered by Inomata and colleagues at a Maya site in Guatemala called Ceibal dates to 950 B.C. (*SN: 6/1/13, p. 12*).

The finds run counter to the idea that Maya society developed gradually from small villages to urban centers with pyramids and other massive buildings. Large Maya cities and kingdoms didn't flourish until about A.D. 250 to 900.

Inomata's team turned to light detection and ranging, or lidar, to peer through forests in Tabasco, Mexico. The airborne remote-sensing technique uses laser pulses to gather data on the contours of vegetation-covered land. The team discovered the remains of 21 ceremonial centers, including Aguada Fénix. Each site contains, from west to east, a round or square mound near a long, rectangular platform. Areas where public rituals were held in many later Maya cities had a similar layout.

At Aguada Fénix, the team discovered an elevated, rectangular plateau measuring about 1,400 meters long and nearly 400 meters wide. Within that space is a roughly 400-meter-long platform — the length of more than four American football fields — positioned east of a 10-meter-tall earthen mound. Lidar revealed rectangular buildings, plazas and reservoirs around the plateau.

Discoveries at Aguada Fénix challenge the assumption that only large settlements directed by kings and a ruling class could organize and execute big building projects, Inomata says. Sculptures of high-ranking individuals or other remnants of a royal class that appear at later Maya sites have so far not been found at Aguada Fénix. People living in the area must have banded together to create a ritual site for big gatherings, Inomata says.

"Though there were probably some [Aguada Fénix] leaders who played central roles in planning and organizing such work, the main factor was people's voluntary participation, which does not necessarily require a centralized government," Inomata says.

Large crowds from surrounding areas probably gathered at the site on special occasions, possibly related to key dates and astronomical events, Inomata suspects. Nine causeways connected to the site's rectangular platform held processions of people participating in rituals, he suggests. A set of jade axes excavated in the center of the platform may have been deposited during a ritual event.

The ancient Maya site of Aguada Fénix, shown in this 3-D rendering, had a ceremonial plateau with a platform and mound in its center.

T. INOMATA

Inomata's conclusions make sense to Andrew Scherer, an anthropological archaeologist at Brown University in Providence, R.I. "The public spaces at Aguada Fénix are huge, and there is nothing to indicate that access was limited to a privileged few," he says.

A limestone animal sculpture at the site, perhaps of a white-lipped peccary or a coatimundi, contrasts with sculptures at later Olmec and Maya sites that celebrated supernatural beings and human leaders who governed ranked societies, Scherer says. While the meaning of the sculpture is unknown, there is no evidence that such depictions referred to high-ranking Maya individuals.

Francisco Estrada-Belli, an archaeologist at Tulane University in New Orleans, awaits further excavations before assuming Aguada Fénix's structures were built by a community without a social hierarchy. But the site's large platform and plaza resemble those at a slightly older Olmec site, suggesting the two civilizations developed in parallel, Estrada-Belli says.

Some researchers have argued that the Olmec society, which was west of Aguada Fénix near Mexico's Gulf Coast, served as a "mother culture" for the Maya. That mysterious culture arose about 3,500 years ago and lasted until roughly 2,400 years ago. But Inomata suspects a more complicated situation, in which Maya and Olmec people influenced each other's ritual practices between about 3,000 and 2,800 years ago.

The Maya expanded on an Olmec tradition of building long platforms and developed ritual areas featuring a western mound or pyramid and an eastern long platform, Inomata says. That Maya practice then appeared at an Olmec site called La Venta, which flourished between 800 B.C. and 400 B.C.

Inomata's scenario suggests that the two ancient societies were more like older and younger siblings than mother and child. ■

Mangrove forests protect coastal areas from erosion and damaging storm surges.

BALLLLAD/ISTOCK/GETTY IMAGES PLUS

EARTH & ENVIRONMENT

Sea level rise could drown mangroves

Rapid climate change will test the coastal forests' resilience

BY CAROLYN GRAMLING

Mangrove forests can only take so much. The resilient, salt-tolerant and twisty trees have so far managed to handle rising sea levels, providing a valuable buffer to coastal communities. But researchers have found the forests' limit. Mangrove forests cannot survive in seas rising faster than about 7 millimeters per year, the scientists report in the June 5 *Science*.

Sea levels are rising globally at an average rate of about 3.4 mm/yr, according to the Intergovernmental Panel on Climate Change. How quickly the seas rise over the next century will depend on the rate of global warming, which causes seawater to expand and ice sheets to melt — and that, in turn, depends on rates of greenhouse gas emissions. Current projections suggest sea level rise will accelerate to between about 5 and 10 mm/yr by 2100.

> "The future of the world's mangroves is in our hands."
> **NEIL SAINTILAN**

That could drown mangrove forests, which protect coastlines by reducing erosion from tides and dampening the energy of storm waves. Mangroves come with additional benefits, says biogeographer Neil Saintilan of Macquarie University in Sydney. The forests reduce atmospheric carbon dioxide levels by drawing the greenhouse gas out of the air and burying the carbon in soils.

In the face of changing sea levels, mangrove forests are typically resilient, holding their ground by building up sediment among their tangled roots. Scientists have observed this, Saintilan says, by recording sediment accumulation and land surface elevation.

But those data span only a few years to perhaps a decade or two, he says. As a result, there have been two big unknowns: how long mangrove forests might be able to keep up this balancing act and at what point the seas might simply rise too quickly for the trees.

To understand how mangroves may respond to faster-rising seas, Saintilan and colleagues turned to the past. The peak of the most recent ice age was between about 26,000 and 20,000 years ago. After that, the ice sheets retreated as the world warmed, and sea levels quickly rose, at rates faster than 12 mm/yr.

The team focused on a period between 10,000 and 6,000 years ago, as sea level rise began to slow and mangrove forests began to expand across coastlines and accumulate thick layers of soil. The researchers examined previously published data on 78 sediment cores collected from coastal sites around the planet and compared them with computer simulations of sea level rise rates for each site.

The forests did not flourish until sea level rise had slowed to an average global rate of 6.1 mm/yr. Today, under a scenario of high greenhouse gas emissions, sea level rise will accelerate to about 6 or 7 mm/yr within the next 30 years. Even under midrange scenarios that include cuts in greenhouse gases, the rate of rise will exceed that threshold by the end of the century. At that point, mangroves will be unable to keep up, the researchers say.

"The future of the world's mangroves is in our hands," Saintilan says.

Establishing a threshold for mangrove survival is key to future coastal management, ecologist Catherine Lovelock of the University of Queensland in Brisbane, Australia, wrote in a commentary in the same issue of *Science*. The threshold itself may vary by mangrove species or by the frequency and intensity of the storms that strike a particular coastal setting, she says.

The findings also underscore the need for the world to "quickly and aggressively" act to mitigate greenhouse gas emissions, says ecologist Holly Jones of Northern Illinois University in DeKalb.

In a study published May 29 in *PLOS ONE*, Jones and colleagues estimate that mangrove forests help protect about 5.3 million people globally from storm surges and other effects of sea level rise. "It is especially painful to think that through our actions, we could be causing mangroves that provide critical protection to people ... to drown," she says.

Future studies, Jones says, can incorporate the threshold to anticipate mangroves' response. From that, scientists may be able to determine which forests will survive and which may need help migrating inland, such as by reshaping landscapes to help the trees propagate.

"We need to get started yesterday to ensure these important ecosystems are around to protect us into the future," Jones says. ■

BODY & BRAIN

Hydroxychloroquine study disappoints

People taking the drug still got sick after exposure to COVID-19

BY TINA HESMAN SAEY

The U.S. Food and Drug Administration no longer endorses the malaria drug hydroxychloroquine as a treatment for COVID-19. And one of the latest studies to take the shine off the drug suggests that it is not an effective prophylactic either. In a clinical trial, hydroxychloroquine was no better than a sugar pill at stopping health care workers and others exposed to COVID-19 from getting sick.

In a study of 821 people exposed to someone with a confirmed case of COVID-19, 11.8 percent of people taking hydroxychloroquine and 14.3 percent of people taking a placebo developed symptoms. There is no statistically meaningful difference in the numbers, researchers report online June 3 in the *New England Journal of Medicine*.

"This study definitely tempers enthusiasm for postexposure prophylaxis among health care workers," says Rachel Hess, a primary care doctor and health services researcher at the University of Utah School of Medicine in Salt Lake City. She is testing hydroxychloroquine in a clinical trial of people newly diagnosed with COVID-19.

A far larger study of the drug's potential to prevent disease, involving thousands of health care workers, is still ongoing.

Interest in hydroxychloroquine stems from studies in lab dishes that have suggested that the drug could block coronavirus entry into cells and slow viral replication. But studies testing the drug against severe cases of COVID-19 largely haven't panned out.

A study published May 22 in the *Lancet* also suggested that hydroxychloroquine carries a higher risk of death for people with serious cases of COVID-19, leading the World Health Organization to stop one part of a clinical trial testing the drug. But on June 3, editors of the *Lancet* issued an expression of concern that the study might be based on faulty data provided by a company founded by coauthor Sapan Desai. Chicago-based Surgisphere Corp. refused to turn its proprietary database over to reviewers, so on June 5, the other study authors retracted the paper. The WHO announced June 3 that testing of the drug will resume after a safety review found no reason to halt the trial.

But given the weight of the scientific evidence finding no benefit, on June 15, the FDA revoked emergency permission to use the drug outside of clinical trials for treating hospitalized COVID-19 patients (*SN Online: 6/15/20*).

Despite disappointing results from studies of patients with severe disease, researchers were hopeful that giving the drug earlier might have benefits (*SN Online: 5/22/20*). "There is some thought that it could still be clinically important, but we're less optimistic than we were before we got our results," says infectious diseases doctor Sarah Lofgren of the University of Minnesota in Minneapolis.

Lofgren and colleagues recruited participants via the internet. Volunteers were mostly health care workers or family members of a person with a known case of COVID-19 who had been exposed for 10 minutes or longer while not wearing a mask or eye protection. That's considered high-risk exposure. Some people had moderate-risk exposure: wearing masks but not eye protection.

Researchers asked participants to take 19 tablets over five days, assigning people at random to get hydroxychloroquine or a placebo. People then reported symptoms and side effects for 14 days, with follow-up surveys several weeks later.

Because the study began in March when tests for COVID-19 were scarce, only 20 people in the study got tested with PCR, which detects the virus's genetic material, to confirm infection. To determine whether other participants had COVID-19, the team used symptoms. Studies have shown that nearly half of people who contract the virus have mild or no symptoms. "If they were asymptomatic, we missed them," Lofgren says.

About 40 percent of participants who took hydroxychloroquine had side effects, which mostly consisted of gastrointestinal problems such as nausea and diarrhea. Only about 17 percent of people taking the placebo reported side effects. None of the reported side effects were severe. But the lack of clear benefit led a review board to stop the trial early for "futility."

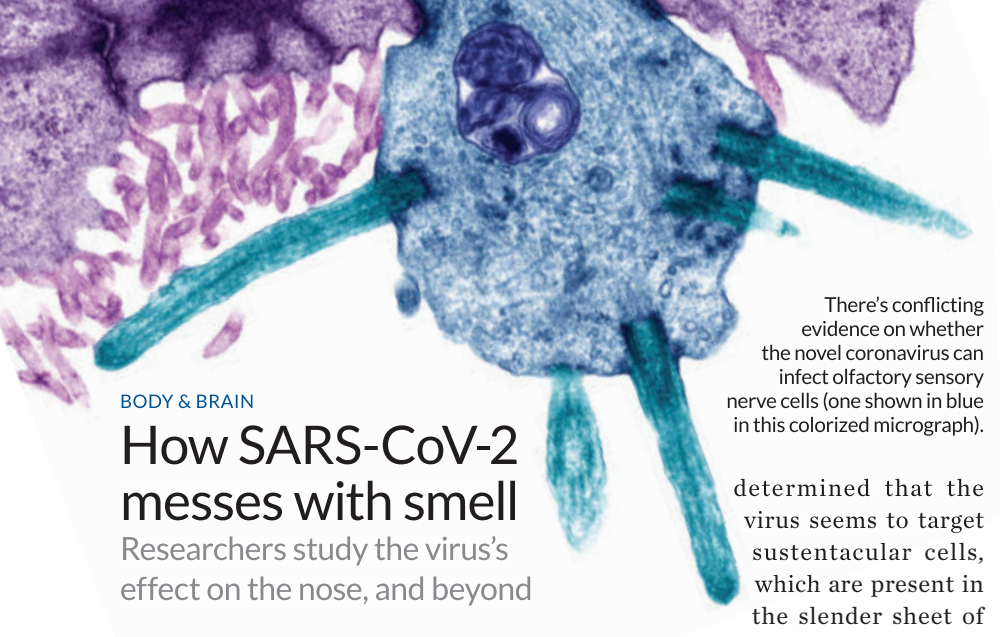
Lofgren and colleagues are finishing two other trials testing whether the drug can prevent infection when given before exposure and whether it can hold off serious disease for those already infected.

But Myron Cohen, director of the Institute for Global Health & Infectious Diseases at the University of North Carolina School of Medicine in Chapel Hill, suggests that the jury is still out on hydroxychloroquine's preventive power. The results "are more provocative than definitive, suggesting that the potential prevention benefits of hydroxychloroquine remain to be determined," he wrote in an editorial published June 3 in the journal. He notes that some participants quit taking the drug before finishing all 19 pills, usually due to side effects.

Hess says she awaits other studies to confirm or contradict this study. The new results indicate people should not take the drug as a preventive if not enrolled in a clinical trial, she adds. Instead, wearing masks, social distancing and thorough handwashing are the best protection. ■

In a study of health care workers and household contacts of people diagnosed with COVID-19, taking hydroxychloroquine didn't prevent infections.

MARC BRUXELLE/ALAMY STOCK PHOTO



There's conflicting evidence on whether the novel coronavirus can infect olfactory sensory nerve cells (one shown in blue in this colorized micrograph).

STEVE GSCHMEISSNER/SCIENCE SOURCE/ALAMY STOCK PHOTO

BODY & BRAIN

How SARS-CoV-2 messes with smell

Researchers study the virus's effect on the nose, and beyond

BY LAURA SANDERS

The virus responsible for COVID-19 can steal a person's sense of smell, leaving them noseblind to fresh-cut grass, a pungent meal or even their own stale clothes.

Scientists are unsure how the coronavirus called SARS-CoV-2 infiltrates and shuts down the body's smelling machinery, though new studies have begun to identify the nasal cells that seem vulnerable to the virus. Another hint comes from a health care worker who lost her sense of smell and had signs of viral infection in her brain.

Other studies, however, have not turned up signs of the virus in the brain. Contradictory evidence means that no one knows whether SARS-CoV-2 can infect nerve cells in the brain directly, and if so, whether the virus's route to the brain can start in the nose. Understanding how people's sense of smell is harmed, a symptom estimated to afflict up to 80 percent of people with COVID-19, could reveal more about how the virus operates.

One thing is certain: How the virus steals the sense of smell is not normal.

"There's something unusual about the relationship between COVID-19 and smell," says neuroscientist Sandeep Robert Datta of Harvard Medical School. Colds can prevent smelling by stuffing the nose up with mucus. But SARS-CoV-2 generally leaves the nose clear. "Lots of people are complaining about losing their sense of smell when they don't feel stuffed up at all," Datta says.

Datta's team is one of two that recently determined that the virus seems to target sustentacular cells, which are present in the slender sheet of tissue that lines part of the nasal cavity.

Datta and colleagues looked for signs of ACE2, the protein that SARS-CoV-2 latches onto to break into cells, in nose cells from both mice and people. On May 18 at bioRxiv.org, a repository of research that hasn't been peer-reviewed, the team reported detecting ACE2 in sustentacular cells, which are thought to help maintain precise concentrations of chemicals in the nose. These mixtures allow nerve cells called olfactory sensory neurons to fire off smell signals to the brain. Although sustentacular cells had ACE2, the protein was absent from olfactory sensory neurons, the team reports.

Another study, published in the June 3 *ACS Chemical Neuroscience*, found similar results in mice. Sustentacular cells had ACE2 protein, but neurons did not, Rafal Butowt of Nicolaus Copernicus University in Bydgoszcz, Poland, and colleagues report. The results imply that SARS-CoV-2 can't infect olfactory sensory neurons, or if it can, it happens rarely, Butowt says. Datta, for now, remains agnostic on whether neurons can become infected.

If SARS-CoV-2 doesn't target olfactory sensory neurons directly, that could be good news. That's because olfactory sensory neurons are unusual — they live outside of the brain but keep one foot inside it. This straddle renders the brain — through these cells — vulnerable to infections. Other pathogens, including a different coronavirus, can use these neurons, and their message-sending axons that reach the brain, as conduits to the brain. "The big open question is whether or not the SARS-CoV-2 virus can move along olfactory neuronal axons to the brain," Butowt says.

Other research hints that the virus can invade the brain. In one study, scientists put the virus in the noses of mice engineered to have the human form of ACE2. Later, the virus spread to the mice's lungs, trachea and brains, the scientists report online May 26 in *Cell Host & Microbe*.

"That's the right experiment to do," Datta says. But he notes that some key details, such as where the neurons are in the brain, and how many of them are infected, are not reported in depth in the paper. It's also not clear how the virus actually got to the brain.

Studies on human brains are mixed. In postmortem studies of 10 people who died of COVID-19, none had SARS-CoV-2 in cerebrospinal fluid, suggesting that the virus wasn't in the brain. The report, published online May 21 in *JAMA*, didn't note whether the people had lost the ability to smell.

But an MRI of a woman's brain turned up signs of SARS-CoV-2 infection in several areas involved in smell, including the olfactory bulb and a part of the brain called the right gyrus rectus, which helps process smell signals, scientists report online May 29 in *JAMA Neurology*. The woman, a radiographer in a ward treating COVID-19 patients, had lost her sense of smell but had only mild symptoms otherwise. Based on these findings, the authors of the report suspect that the virus moved into the brain from the nose.

Neurons aren't the only potential vehicle. Studies have shown that the coronavirus can infect pericytes, cells that wrap around blood vessels and help control flow. In the brain, pericytes help maintain the blood-brain barrier, which keeps pathogens out. A breach there could let the virus into the brain.

For now, gaps in basic knowledge and a dearth of documented cases leave open the question of whether the coronavirus reaches the brain. More studies are urgently needed, Datta says. "We need much more information than we have now." ■

Animal DNA extracted from fragments of the Dead Sea Scrolls, including this one, indicates which pieces likely come from the same manuscripts and where those documents originated.

HUMANS & SOCIETY

DNA unravels Dead Sea Scroll secrets

Sheep and cow genetics illuminate the documents' history

BY BRUCE BOWER

Genetic clues are revealing the diverse origins of the Dead Sea Scrolls.

The ancient scrolls are made of sheepskin and cowskin, which retain DNA from those animals, say molecular biologist Oded Rechavi of Tel Aviv University and colleagues. Analyzing that DNA is a new way to see which of the more than 25,000 Dead Sea Scroll fragments come from the same or related animals, and thus likely the same documents.

The origins of the fragments studied so far indicate the Dead Sea Scrolls reflect religious and biblical developments across southern Israel about 2,000 years ago, not just among people living near the caves where many scrolls were stored, as some scholars argue, the researchers report in the June 11 *Cell*.

The Dead Sea Scrolls were probably written between the third century B.C. and the first century A.D., during the Second Temple period, a crucial time in the development of Judaism and the emergence of Christianity. "Our results demonstrate the heterogeneity inherent in Second Temple Judaism, which formed the matrix for [early] Christianity," says study coauthor and biblical scholar Noam Mizrahi of Tel Aviv University.

About 1,000 manuscripts make up the Dead Sea Scrolls, including the earliest known versions of books of the Hebrew Bible. The largest set of scrolls comes from 11 caves near Qumran, a desert site on the Dead Sea's northwest shore.

Many researchers have surmised that the Qumran scrolls reflect the beliefs of a small Jewish sect that broke from mainstream Judaism. But the new DNA evidence suggests that the ideas in those documents extended beyond Qumran.

Rechavi's group isolated animal DNA from 26 scroll fragments, all of which were made of sheepskin except for two made of cowskin. Fragments from closely related sheep were assumed to be more likely to come from the same document than those from distantly related sheep or from cows.

Previous work suggests that many Qumran scrolls have spellings and other details of a tradition distinct to a small set of scribes. DNA supports that idea. Seven of eight fragments with writing classed as part of the "Qumran scribal practice" came from closely related sheep.

"For the first time, this theory [of a Qumran scribal practice] has been supported by independent ancient DNA research," says biblical scholar Emanuel Tov of Hebrew University of Jerusalem.

Four Qumran scraps from the Hebrew Bible's Book of Jeremiah likely came from two versions of that book. Two sheepskin scraps belonged to one version and two cowskin scraps belonged to another. Cows couldn't have been raised in the desert, so cowskin scrolls must have been written elsewhere, Mizrahi says.

DNA findings also indicate that the Songs of the Sabbath Sacrifice, a nonbiblical text about religious practices, was popular beyond Qumran. Fragments from three copies of this text found in two Qumran caves were made from closely related sheep. But a fragment from a copy found at Masada, about 55 kilometers south of Qumran, came from another line of sheep, a sign that people there made their own copy of the text. ■

EARTH & ENVIRONMENT

Impact left Earth's crust in hot water

Study of Chicxulub crater has implications for origins of life

BY CAROLYN GRAMLING

The asteroid that slammed into Earth 66 million years ago left behind more than a legacy of mass destruction. The impact also sent superheated groundwater swirling through the crust for more than a million years, chemically overhauling the rock. Similar hydrothermal systems left in the wake of powerful impacts earlier in Earth's history may have been a crucible for early life, researchers report May 29 in *Science Advances*.

The massive Chicxulub crater on Mexico's Yucatán Peninsula is the fingerprint of a killer, the asteroid probably responsible for the extinction of all nonbird dinosaurs. In 2016, scientists trekked to the partially submerged crater, drilling deep into the crater to study the crime scene from numerous angles.

Among the researchers was planetary scientist David Kring of the Lunar and Planetary Institute in Houston. A dozen years earlier, Kring had found evidence at Chicxulub that the layers of rock bearing the signs of the impact — features such as shocked quartz and melted spherules — were subsequently cut through by veins of newer minerals. Such veins, Kring thought, were clues that hydrothermal water had circulated beneath Chicxulub after the impact.

Hydrothermal systems can occur where Earth is tectonically active, such as where mantle plumes like the one beneath Yellowstone rise up into the crust. The molten rock superheats water already circulating within the crust.

But the Yucatán Peninsula has been tectonically quiet over the last 66 million years, Kring says. As part of the 2016 expedition to Chicxulub, he and colleagues drilled 1,335 meters below the crater's peak ring, a circular, mountainous region within the vast crater bowl, and retrieved cores of sediment and rock.

SHAI HALEVI, COURTESY OF THE ISRAEL ANTIQUITIES AUTHORITY

In analyzing the cores' minerals, "it was immediately obvious that they had been hydrothermally altered," Kring says. Heat from the circulating groundwater caused chemical reactions, transforming some minerals into others. By identifying the types of minerals, the team determined the water's initial temperature was over 300° Celsius, later cooling to about 90° C.

The entire length of the cores showed chemically altered rocks, and computer simulations suggest the region of hydrothermal alteration beneath the crater goes even deeper, down to perhaps about four or five kilometers. The hydrothermally altered zone covers a volume more than nine times that of the Yellowstone Caldera system, Kring says. Paleomagnetic data suggest that the hydrothermal system lasted for more than a million years and perhaps longer than 2 million.

Those conditions, the researchers say, may have been capable of fostering life akin to the extremophiles that thrive in Yellowstone's boiling pools. In addition to the metal-rich water providing an energy source, the rocks beneath Chicxulub have interconnected nooks and crannies that could have sheltered microbes.

Kring has previously suggested that the same destructive impacts that annihilate life may also create appealing habitats — not just on Earth, but perhaps on other planetary bodies such as Mars. Even more tantalizing is the possibility that hydrothermal systems beneath ancient impacts may have been where life on Earth began (*SN: 4/6/13, p. 9*).

Evidence from lunar craters suggests that Earth was heavily bombarded by asteroids about 3.9 billion years ago. Most of those more ancient craters have long since vanished or been altered by the constant recycling of Earth's surface. So the hydrothermal alterations beneath Chicxulub offer a window into what such systems might have looked like much deeper in the past, says geophysicist Norman Sleep of Stanford University. "It shows the reality of the process."

Whether a microbial cast of characters was actually present beneath Chicxulub is a question for future studies, Kring says. "This paper has no evidence of microbial life," he says. "We just have all the properties of hydrothermal systems that do support life elsewhere on Earth." ■

LIFE & EVOLUTION

Fossils may be earliest known parasite

Tube animals took food from their hosts' mouths, study suggests

BY JONATHAN LAMBERT

Tube-dwelling creatures that spent their lives cemented to the shells of clamlike brachiopods over 500 million years ago may be the earliest known parasites.

In Yunnan, China, scientists discovered hundreds of tube-encrusted brachiopods. The 512-million-year-old fossils offer compelling evidence of a parasite-host relationship, Zhifei Zhang, a paleontologist at Northwest University in Xi'an, China, and colleagues report June 2 in *Nature Communications*.

"Parasitism is an integral part of life on Earth, but it's been hard to determine when it emerged," says parasitologist Tommy Leung of the University of New England in Armidale, Australia. It likely arose early, he says, in part because today nearly "every living thing has some kind of parasitic thing living on or in them, even down to parasites themselves."

Parasites don't usually fossilize well because their bodies are often small and soft, Leung says. And even if two organisms happen to be entombed in the same fossil, it can be difficult to discern whether the relationship was parasitic, mutualistic or somewhere in between. Fossils of tongue worms from 425 million years ago represent a clear early example, but previously found older fossils only hint at possibly parasitic relationships.

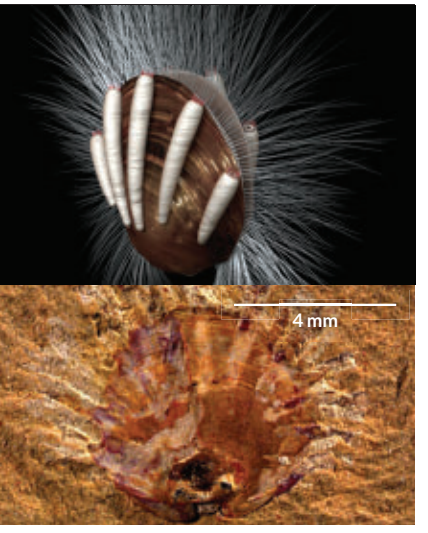
In the fossils from China, the tubelike, tapered structures affixed to the exterior of the brachiopod shells were arrayed like the spines of a fan with the mouthlike parts positioned along the open edge of the shell. The tubes appeared only on brachiopods, never alone or associated with other fossils, suggesting that the tubular organism couldn't survive on its own.

The brachiopods were likely filter feeders, catching whatever food drifted into their open shells. Zhang and colleagues hypothesize that the tubes snatched food from the edge of the shell before the brachiopod could have its dinner.

If true, tube-covered brachiopods got less food and should be lighter than their tube-free brethren. Tube-free brachiopods were indeed almost always heavier, though the number of tubes didn't have an effect on mass.

Leung says he isn't so sure that the relationship was antagonistic. If it was, brachiopods with more tubes should have been worse off. Rather than a lower mass reflecting a cost of parasitism, tube creatures might have just preferred to affix to less massive shells, Leung says.

Whether a relationship is parasitic can depend on context. Tube-laden brachiopods might have been stressed by tubes only if food was scarce. Or perhaps tubes caught food too small for their hosts anyway. "With these kinds of relationships, the answer isn't always that this is good or bad," Leung says. "Interactions are usually more complicated than that." ■



Over 500 million years ago, tube-dwelling animals may have parasitized clamlike brachiopods (illustrated, top; fossil, bottom).

BOTH: Z. ZHANG/NORTHWEST UNIV.

ATOM & COSMOS

The cosmic 'Cow' now has company

Scientists report more short-lived bursts of unknown origins

BY EMILY CONOVER

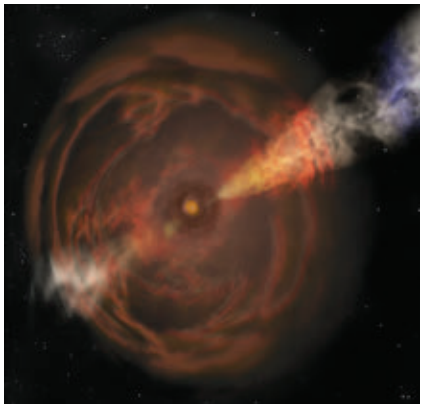
First, astronomers discovered the "Cow." Now they've rounded up a small herd.

A celestial flare-up with a bovine nickname has been joined by two similarly unusual outbursts. The events were brighter than typical supernovas, explosions of stars that are a common source of light shows in the sky. And the bursts came and went quickly; their visible light brightened and dimmed over days instead of the weeks typical of supernovas.

As particularly luminous examples of a poorly understood class known as fast blue optical transients, the three novel bursts have unknown origins. But they seem to be kin. "It's like people going out to find different creatures and find out how they're related to each other. We're in the early stages of the 'zoology' of this class," says Caltech astronomer Anna Ho.

Detected in June 2018, the Cow earned its moniker thanks to the automatically assigned letters within its official name, AT2018cow. It is joined by the "Koala," Ho and colleagues report in the May 20 *Astrophysical Journal*. Named for the ending letters in its handle, ZTF18abvkwla, the Koala appeared in September 2018. The third event, reported in the May 20 *Astrophysical Journal Letters*, resisted cute nicknames. Known as CSS161010, it was detected in 2016, but its significance wasn't understood until now.

A possible explanation is that these events result from an unusual type of supernova that explodes into a dense shell of material. For all three bursts, telescopes detected radio waves plus a short-lived flare of visible light. Radio waves could have been produced by accelerated electrons kicked up when a debris blast from the explosion slammed into the surrounding shell. If an aging star shed its outer layers before exploding, that could have created the sheath.



Stellar explosions (one illustrated) with jets of material powered by an "engine" such as a black hole may explain mysterious cosmic flares.

But the events are still enigmatic. "We don't actually know what they are yet," says astrophysicist Deanne Coppejans of Northwestern University in Evanston, Ill., an author of the paper on CSS161010. Scientists still can't rule out the possibility that the events are the result of a black hole ripping apart a star, rather than the aftermath of a supernova, she says.

Scientists had speculated that whatever created the Cow may have involved some kind of cosmic "engine," a dense object like a black hole or spinning neutron star that could add some oomph to the eruption by launching powerful jets of material. In light of the new results, "I'm driven to think that there really is some kind of central compact object driving these explosions," says astrophysicist Brian Metzger of Columbia University.

That's because the two new events

ATOM & COSMOS

Milky Way flash may solve mystery

Discovery points to possible source of fast radio bursts

BY MARIA TEMMING

Astronomers think they've spotted the first example of a superbright blast of radio waves, called a fast radio burst, originating within the Milky Way.

Dozens of these bursts have been seen in other galaxies — all too far away to identify the celestial engines that power them. But the outburst in our own galaxy, detected simultaneously by two radio arrays on April 28, was close enough to see that it was generated by a highly magnetic neutron star called a magnetar.

That observation is a smoking gun that magnetars are behind at least some of the extragalactic fast radio bursts, or FRBs, that have defied explanation for over a decade (*SN: 8/9/14, p. 22*). The magnetar's radio burst is described online May 20 and May 21 at arXiv.org.

"When I first heard about it, I thought, 'No way. Too good to be true,' " says Ben Margalit, an astrophysicist at the University of California, Berkeley, who wasn't involved in the observations. "Just, wow. It's really an incredible discovery."

Researchers using the CHIME, or Canadian Hydrogen Intensity Mapping Experiment, radio telescope in British Columbia first noted an intense radio outburst from a young, active magnetar about 30,000 light-years away, dubbed SGR 1935+2154. CHIME had detected about 3 octillion, or 3×10^{27}, joules of energy from the burst. That was far brighter than any flash of radio waves previously seen from any of the five magnetars in and around the Milky Way known to emit radio pulses.

That report inspired another group to check concurrent data from the Survey for Transient Astronomical Radio Emission 2, or STARE2, detectors in the American Southwest. STARE2 measured 22 octillion joules from the burst.

"This thing put out, in a millisecond, as much energy as the sun puts out in 100 seconds," says Caltech astronomer Vikram Ravi, who was on the team that analyzed the STARE2 data. That made this event 4,000 times as energetic as the brightest millisecond radio pulse ever seen in the Milky Way. If such an intense burst had happened in a nearby galaxy, it would have looked like an FRB.

BILL SAXTON, NRAO/AUI AND NSF

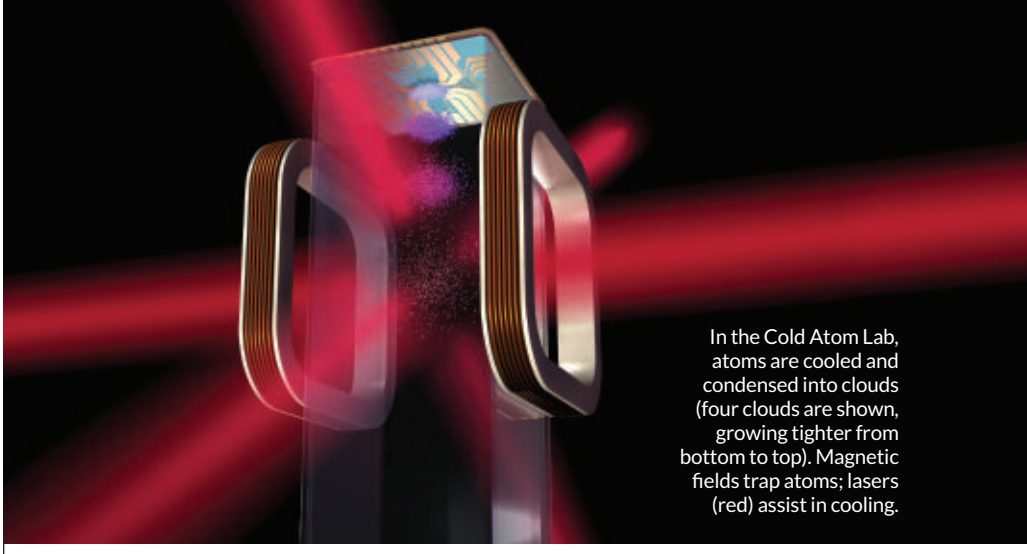
both spewed matter at blazing speeds. The Koala ejected its detritus at more than 38 percent of the speed of light; CSS161010's ejecta reached more than 55 percent light speed. In the case of CSS161010, the researchers also observed X-rays, which could likewise have been stirred up by such an engine.

Scientists have been regularly detecting fast blue optical transients for only the last several years. Blips of light in the sky are spotted by comparing images taken of the same locations at different times. In the past, telescopes surveyed the sky at intervals short enough to catch normal supernovas but missed briefer events. Faster-paced surveys have made it possible to spot changes that occur on timescales of days. Those surveys include the Zwicky Transient Facility, which detected the Koala, and the Catalina Real-time Transient Survey and the All-Sky Automated Survey for Supernovae, both of which detected CSS161010.

"There are more surveys coming online that are going to be capable of detecting these things," says astrophysicist Patricia Schady of the University of Bath in England. To fully pin down the source of the events, Schady says, "we really do need more of these things." ■

"I was basically in shock," says radio astronomer Christopher Bochenek of Caltech, who combed through the STARE2 data to find the burst. "It took me a while, and a call to a friend, to calm me down enough to go and make sure that this thing was actually real."

The weakest known FRB from another galaxy was still about 40 times as energetic as this flare. But that's "pretty close, on astronomical terms," says Keith Bannister, a radio astronomer at Australia's Commonwealth Scientific and Industrial Research Organization in Sydney, who was not involved in the work. Magnetars "could be responsible for some fraction, if not all, of the FRBs that we've seen so far," he says. "This motivates future studies to try and find similar sorts of objects in other, nearby galaxies." ■



In the Cold Atom Lab, atoms are cooled and condensed into clouds (four clouds are shown, growing tighter from bottom to top). Magnetic fields trap atoms; lasers (red) assist in cooling.

JPL-CALTECH/NASA

MATTER & ENERGY

Atoms chill out on the space station

Bose-Einstein condensates are made in orbit for the first time

BY EMILY CONOVER

On the International Space Station, astronauts are effectively weightless. Atoms are, too.

That weightlessness makes it easier to study a weird quantum state of matter known as a Bose-Einstein condensate. Now, the first Bose-Einstein condensates made on the space station are reported in the June 11 *Nature*.

The ability to study this state of matter in orbit will aid scientists' understanding of fundamental physics, as well as make possible new, more sensitive quantum measurements, says Lisa Wörner of the German Aerospace Center's Institute of Quantum Technologies in Bremen. "I cannot overstate the importance of this experiment to the community," she says.

A Bose-Einstein condensate occurs when certain types of atoms are cooled to such low temperatures that they take on one unified state. "It's as though they're joining arms and behaving as one harmonious object," says physicist David Aveline of NASA's Jet Propulsion Laboratory in Pasadena, Calif. To produce this state of matter in orbit, he and colleagues created the Cold Atom Lab, installed on the space station in 2018.

In orbit, the atoms are in free fall, continuously plummeting under the force of gravity, producing a weightlessness like that felt by riders when a roller coaster suddenly drops. Those conditions, known as microgravity, make the space station an ideal environment for studying Bose-Einstein condensates.

To make a Bose-Einstein condensate, atoms must be cooled while trapped with magnetic fields. On Earth, the trap must be strong enough to prop the atoms up against gravity. That's not a concern in microgravity, so the trap can be weakened, allowing the cloud of atoms to expand and cool as a result. This process allows the condensate to achieve lower temperatures than are possible on Earth. In the Cold Atom Lab, rubidium atoms reached tenths of billionths of a kelvin.

With further improvement to the cooling techniques, the Cold Atom Lab could go even colder, to temperatures below any known in the universe.

Another boon of microgravity is that measurements of the matter can be made for longer periods of time. Normally, atoms are released from the trap and then imaged quickly before gravity pulls them out of view. On Earth, observation times are about 40 milliseconds. But in microgravity, researchers observed released atoms for as long as 1.1 seconds.

Those longer observation times could allow for more sensitive measurements. The atoms could be used to detect forces, including how Earth's gravity varies over time and across different parts of the planet. And future experiments on dedicated satellites could make new, more sensitive measurements of phenomena such as sea level rise. ■

LIFE & EVOLUTION

More sightings of Asian giant hornets

What to know about the invasion of so-called murder hornets

BY SUSAN MILIUS

This year, Asian giant hornets are turning up again in the Pacific Northwest. So much for last year's efforts to kill off the invading menace to North America's honeybees.

Sensationalized as the "murder hornet" in newspaper headlines, lone foragers of *Vespa mandarinia* bite off a bee's head and take the remaining meat home as baby food. Raiding parties of several dozen Asian giant hornets can kill whole hives — thousands of bees — in a few hours.

Hopes that last year's invasion was over died when an alert person reported a giant hornet in Langley, British Columbia, on May 15. Then a big, orange-and-black hornet queen was spotted dead in a driveway near Custer, Wash. Next came a hornet "wiggling on the porch" of a house in Bellingham, Wash., officials announced June 11. The person reporting the intruder "stepped on it, killing it."

An invasion like this isn't a surprise, says Lynn Kimsey, director of the R.M. Bohart Museum of Entomology at the University of California, Davis. The Port of Oakland alone, for instance, takes in about 1 million shipping containers from overseas each year but can inspect maybe 10 percent for invasive pests under the best scenarios, she says. "What's more amazing is that we don't see more invasives."

Amid the recent uproar over the giant hornets, a few facts have been overlooked. For one, North America has previously had at least one close call — not publicized at the time — with the world's largest hornet. That episode had a happy ending, at least for the people and native insects of North America. Not so much for the hornets. What's more, these aren't the only big, bad hornets that have arrived at the borders of the continent.

In the text that follows, *Science News* answers questions about what we know so far about the invading hornets.

Is this invasion really new?

Not entirely. What's new for North America is that last year scientists confirmed Asian giant hornets in the wild.

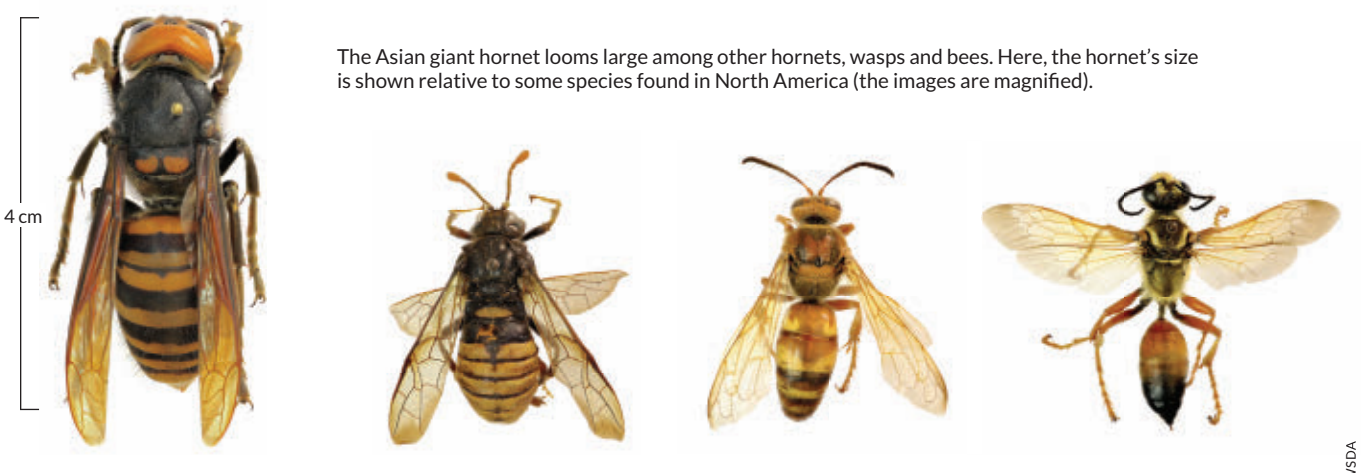
In September, beekeepers tracked down and destroyed a hornet nest near a public footpath in Nanaimo, a city outside of Vancouver. Lone flying hornets also showed up on both sides of the U.S.-Canada border, one at a hummingbird feeder near Blaine, Wash.

But those weren't the Asian giant hornet's first touchdowns on North American soil. California had a close call in 2016. It wasn't just some lone hornet hiding in a cargo container, says entomologist Allan Smith-Pardo, now at the U.S. Department of Agriculture's Animal and Plant Health Inspection Service in Sacramento, Calif. He was the scientist charged with identifying any suspicious wasps or bees found in cargo or mail nationwide. An inspector flagged an express package coming into the San Francisco airport without any mention of insects in its labeling. Yet it held some kind of papery honeycomb-like nest.

The inspector wondered if someone was smuggling in bees, which U.S. rules strictly ban to slow the influx of viruses, predatory mites and other menaces. Smith-Pardo identified the package as something even more dramatic: a nest of Asian giant hornets. "There were no adults in the package, but plenty of pupae and larvae," he says. A few were still alive.

The package was probably meant to be a gourmet treat or even a health aid. In their native home, "adults, pupae and larvae are soaked in liquor," says retired entomologist Jung-Tai Chao, who studied paper wasp social behavior at the University of Georgia, as well as hornet ecology at the Taiwan Forestry Research Institute. This "hornet liquor," he says, is believed to ease arthritis pain.

Because the 2016 package was opened in a secure room, that potential insect disaster became no more than a data point mentioned briefly on Page 23 of the May 2020 issue of *Insect Systematics and Diversity*. The report looked only at



The Asian giant hornet looms large among other hornets, wasps and bees. Here, the hornet's size is shown relative to some species found in North America (the images are magnified).

Asian giant hornet
Vespa mandarinia

Elm sawfly
Cimbex sp.

Cicada killer
Sphecius sp.

Great golden digger wasp
Sphex ichneumoneus

ALL: WSDA

hornets intercepted in the United States during one decade, so there could have been other run-ins with giants.

Is the Asian giant hornet the first hornet to invade North America?

Far from it. In the mid-19th century, the hornet *V. crabro* spread from Europe into New York. Now in some places east of the Rockies, the hornets nest in hollow trees and nooks within walls. Humans who blunder too close can get painful stings, says Bob Jacobson, a retired entomologist in Cincinnati. His cousin was stung.

Like the Asian giant hornet, the European invader attacks honeybees, and Jacobson has seen it go after bumblebees, as well as yellow jackets and some other wasps. Unlike the new invader, a *V. crabro* hornet hunts alone. It picks off a bee on a flower or at a hive but doesn't gang up in groups to slaughter whole colonies.

Other hornets have also turned up in North America without stirring public interest. The data search of interceptions in the United States between 2010 and 2018 showed that inspectors stopped four other species besides the giant. Whether those arrivals could make a permanent home remains to be seen.

What exactly are hornets?

True hornets are big, predatory, colony-forming wasps in the *Vespa* genus. Apart from *V. crabro*, which hails from both Europe and Asia, and another transcontinental species, hornets are native to Asia. They need meat to feed their young, unlike honeybees, which collect plant pollen for protein. Another difference: A honeybee dies after its single-use stinger rips out of its body. Hornets, however, can sting and sting again.

European hornet
Vespa crabro

Western honeybee
Apis mellifera

North America has several native wasps nicknamed hornets. These natives, however, belong on a nearby but different twig of the insect evolutionary tree.

Why do the hornets attack honeybees?

Asian giant hornets don't really specialize in honeybees, says James Carpenter, a hornet specialist at the American Museum of Natural History in New York City. In the early months of the one-year life cycle of a nest in temperate climates, workers forage alone, often for beetles.

Toward the fall, when the colony's time is running out, workers face heavy demands for protein to raise the next generation of queens that will take shelter during the winter and then start their own colonies in spring. Several dozen workers will band together to attack high-value targets, such as whole nests of honeybees or yellow jackets. Giant hornets "slaughter the adults, then carry back the brood as food for their larvae," Carpenter says. "Besides the impact on honeybees, then, they might have an impact on native yellow jackets."

How could beekeepers fight the hornets?

Beekeepers in Asia try to turn the giants' size against them, says entomologist Jeff Pettis, president of Apimondia, an international federation of beekeepers' associations. He has seen screening devices and traps set up at hive entrances that let a slim honeybee slip through but block big clunking hornets.

Not to be deterred, the hornets will lurk in front of a blocked hive to pick off emerging bees. Pettis has even seen apiary workers with a tennis or badminton racket chasing and "just whacking 'em."

That's not recommended, by the way. Giant hornets have giant stingers, so it's better to stay out of their way.

How bad is the sting?

There's no real relationship between how dangerous and how painful an insect's sting is, says entomologist Justin Schmidt of the University of Arizona in Tucson.

The Asian giant hornet delivers a big dose of fairly strong venom, he and colleagues determined in tests on lab mice. Based on what venom did to mice, just one full sting would have a 50 percent chance of killing a decent-sized rodent.

The venom of *Tetraponera* ants from Malaysia has "exquisite lethality," but the sting isn't very painful, Schmidt noted in *Toxins* in 2019. He has spent decades ranking his level of pain when he allowed himself to be stung. He has personal data on 96 species of stinging insects, though the Asian giant hornet isn't one of them. (So far.) From talking to colleagues who have been stung, he estimates that it's equivalent to three to 10 yellow jackets stinging simultaneously. That's painful, but "not the end of the world," he says. What ranks at roughly 10 times more painful in his view are bullet ants.

How dangerous is the hornet to people?

A much-quoted number from a 2007 paper puts Japan's death toll for people stung by *V. mandarinia* at around 30 to 50 people per year. The less-quoted parts of the paper point out that of the 15 people hospitalized for stings and discussed in the paper, those with fewer than 50 stings had a good chance of surviving.

Chao himself was stung while collecting an Asian giant hornet nest. He's allergic to stings. "Unfortunately, I did not have my antihistamines with me," he says. He was rushed to a hospital; after injections and a few hours' observation, he was released.

If the Asian giant gets established in North America, will people stay indoors?

Probably not, says Paul van Westendorp. As the principal beekeeping specialist for the province of British Columbia, he got the first Asian giant hornet specimens from beekeepers last year and knows how much damage the hornets can do.

The hornets perch at the apex of major insect predators. "Apex predators are maybe very fierce in what they can do, but there are only a few of them around," says van Westendorp. So for most people, the odds of ever coming across one are low. "On a beautiful, hot summer day, one will normally have no hesitation to go for a nice swim in the ocean — even if we recognize that there are orcas out there." ■

BODY & BRAIN

It's time to build a microbial Noah's ark

Project aims to preserve the human microbiome's diversity

BY CAROLYN BEANS

Our bodies host a vast ecosystem of bacteria, viruses and fungi. Just as scientists are beginning to understand how this microbiome supports human health, hallmarks of modern life such as antibiotics and processed foods may be pushing many of our microbial residents toward extinction.

An international team of scientists wants to safeguard humankind's long-term health by creating a Noah's ark for microbes. Taking inspiration from the Svalbard Global Seed Vault in Norway, which protects the world's crop diversity from natural or human-made disasters, the scientists propose to create the Microbiota Vault to preserve human microbiome collections that may one day be used to prevent disease.

The project is both possible and prudent, a team of independent experts at two Switzerland-based firms called advocacy and EvalueScience conclude in a report released June 11. "If we are just at the beginning of really understanding and elucidating what is the role of the microbiota, it is of course precautionary to at least safeguard part of this diversity before it just goes away," says Dominik Steiger, chief operating officer of EvalueScience, which is based in Zurich.

Studies, mostly in lab animals, suggest that a dearth of microbial diversity may contribute to a wide range of health conditions, from obesity and inflammatory bowel disorders (*SN: 11/25/17, p. 10*) to *C. difficile* infection and Lou Gehrig's disease (*SN: 8/17/19, p. 8*).

Researchers suspect that many modern practices contribute to the decline of our beneficial microbial partners, including birth by cesarean section (*SN: 10/12/19 & 10/26/19, p. 26*), a low-fiber diet and overuse of antibiotics.

"Rural peoples are urbanizing and traditional peoples living in savannas and in jungles are moving to cities," says Maria Gloria Dominguez-Bello, a microbiologist at Rutgers University in New Brunswick, N.J., and a leader of the Microbiota Vault initiative. "We are losing [microbiome] diversity, and in parallel there is a correlation with increase in chronic diseases."

The *Lactobacillus* bacteria in our intestines, shown in a computer illustration, are just some of humans' microbial residents that proponents of the Microbiota Vault want to protect.

Dominguez-Bello has worked with local researchers in Venezuela, Bolivia, Peru and Brazil to collect and study stool samples from indigenous populations in those countries. In 2017, she and colleagues published a study in *Science* showing that the more industrialized a society, the less diverse people's microbiomes. The gut diversity of people in the United States is almost half that of the most isolated Amerindians living in South America, she says.

Dominguez-Bello recognizes the importance of preserving these microbes. Her research collections have been in jeopardy many times, from political unrest when her lab was in Venezuela to Hurricane Sandy after she had moved her lab to New York University.

So the idea for the Microbiota Vault, first proposed by Dominguez-Bello and colleagues in a 2018 paper in *Science*, is that microbiome collections, many of which already exist in research or health facilities all over the world, would be maintained locally, but also stored in a backup vault in a politically stable location. The feasibility report recommends Switzerland or Norway, possibly even alongside or within the Svalbard Global Seed Vault.

The report also suggests that specimens could be preserved by cryopreservation, cooling them to very low temperatures. As a backup, researchers should also consider using a less-tested freeze-drying technique known as lyophilization.

The initiative, run as a global nonprofit, would encourage the development of more microbiome collections by creating courses to train researchers across the globe to collect samples from indigenous populations in their regions. In a pilot phase, Dominguez-Bello plans to host a course in Lima, Peru, with collaborators from local universities, but the timing is uncertain due to the coronavirus pandemic.

Start-up funding for such an initiative would likely come from research entities and philanthropic organizations, but could grow to include a larger portion of government funding once the project becomes more established, Steiger says.

"The Microbiota Vault really seems like it has huge potential to benefit human health," says Matthew Kelly, a pediatrician and global health specialist at Duke University who is not involved with the initiative. But Kelly cautions that the ethics of the project are complex, and researchers will need to clearly communicate with indigenous communities about the benefits, if any, to their participation in this research.

Ethics will be a major component of the courses, says Dominguez-Bello. In a 2016 opinion piece in *Nature Microbiology*, she and coauthors stated that any commercialization resulting from samples collected from indigenous peoples "should be done with the highest ethical standards, respect for native cultures, and involving a mediator of their choice, familiarized with financial systems and terms, who can defend their interests."

Many indigenous communities also recognize the potential health benefit of banking their microbes, as they too are moving toward industrialization, Dominguez-Bello says. ■

SCIENCE PHOTO LIBRARY/ALAMY STOCK PHOTO

The World's First Guardian Angel Coin

1,680-Year-Old Coin From The First Christian Empire

Actual size is approximately 18 mm

We've carried angel coins in our pockets for generations. In 1465, the British Gold Angel served as a good luck charm, with coins received from the hands of monarchs believed to protect against disease and poverty. During the French Revolution, it's said that the designer of the French "Lucky" Angel coin was saved from execution by divine intervention. Napoleon Bonaparte is said to have carried one of these coins, but lost his the day before the fateful Battle of Waterloo. Even sea captains and fighter pilots have carried "guardian" angel coins with them to ensure a safe return.

But the history of Angel coins dates back to ancient times—to the days of the first Christian Empire...

Constantine's Angel of Victory

Constantine was the world's first Christian emperor, having merged worship of the sun god Sol Invictus with the worship of Christ. During his reign, he moved the empire's capital to Byzantium, renaming it Constantinopolis. The city would be the world's first Christian capital, and remained the capital of the Roman/Byzantine Empire for the next 1,000 years.

To mark the occasion, Constantine minted special coins bearing the Angel of Victory, bearing her scepter and shield while watching from on high. The world's first Christian Emperor had given the world its very first Guardian Angel coin.

The Face of the Roman Empire's First Christian Capital

During Constantine's reign, coins would feature the patron gods and goddesses of the city in which they were struck. Thus, the obverse of the First Guardian Angel Coin displays a helmeted bust of the goddess Constantinopolis.

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- Struck By Hand—No Two Are Alike!
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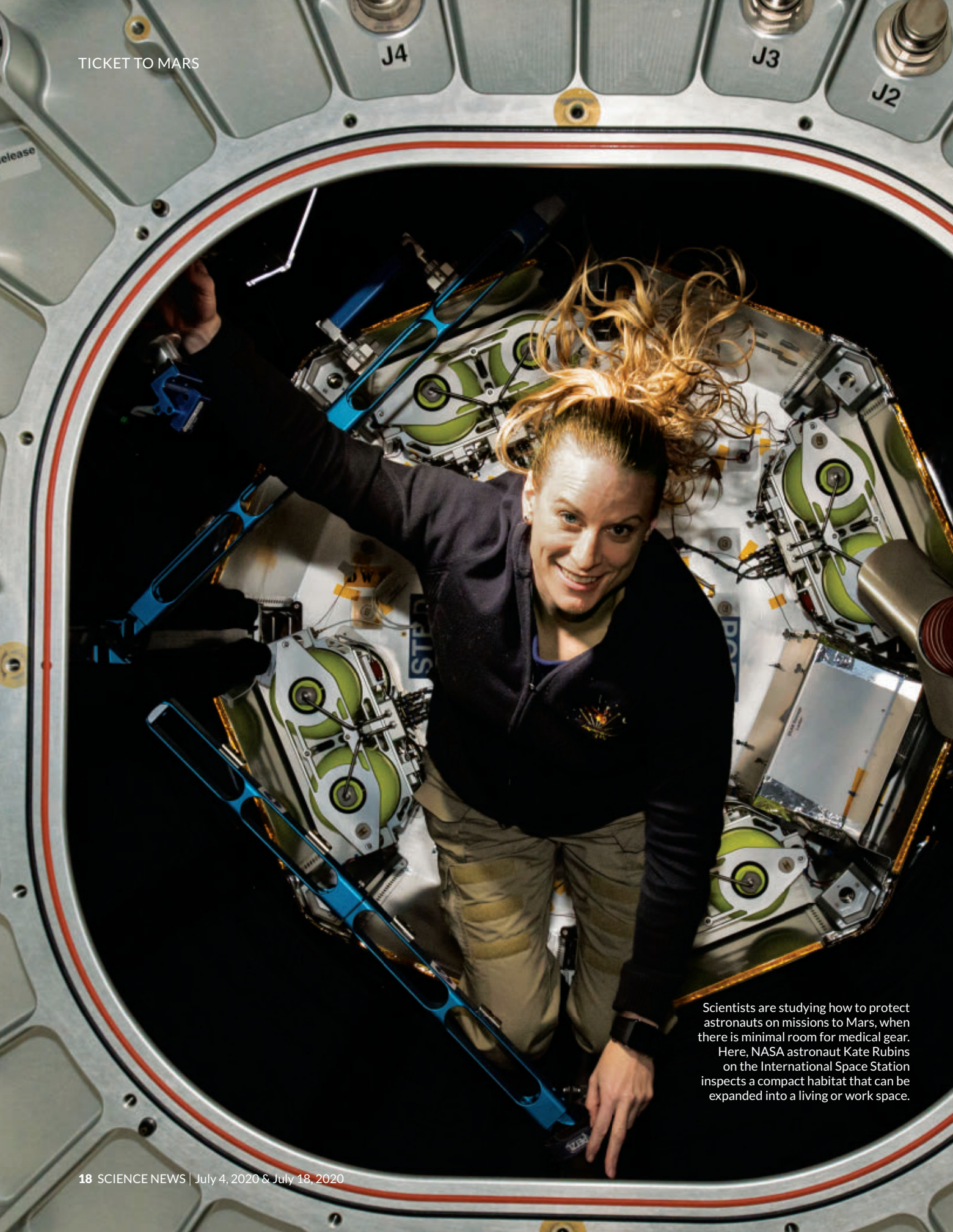


Scientists are studying how to protect astronauts on missions to Mars, when there is minimal room for medical gear. Here, NASA astronaut Kate Rubins on the International Space Station inspects a compact habitat that can be expanded into a living or work space.

NASA

Packing for MARS

What goes in the medical bag when space is tight?

By Maria Temming

On movie missions to Mars, getting there is the easy part. *The Martian*'s Mark Watney was fine until a dust storm left him fending for himself. Douglas Quaid's jaunt to the Red Planet in *Total Recall* was smooth sailing until he came under fire at Martian customs and immigration.

But in real life, just getting to Mars and back will be rife with dangers that have nothing to do with extreme weather or armed gunmen.

"The mission to Mars is likely going to be four to six individuals [living] together in a can the size of a Winnebago for three years," says Leticia Vega, associate chief scientist for the NASA Human Research Program in Houston. Time on the planet will be sandwiched between a six- to nine-month journey there plus the same long trip back.

> "The moon was like a camping trip when you think about going to Mars."
>
> ERIK ANTONSEN

Once outside of Earth's protective gravitational and magnetic fields, microgravity and radiation become big worries. Microgravity allows fluid buildup in the head, which can cause vision problems, and adventurers cruising through interplanetary space will be continually pelted with high-energy charged particles that zip right through the metal belly of a spacecraft. Researchers don't know just how harmful that radiation is, but lab experiments suggest it could raise astronauts' risk of cancer and other diseases.

The length of the mission brings its own dangers. "The moon was like a camping trip when you think about going to Mars," says Erik Antonsen, an emergency medicine physician and aerospace engineer at NASA's Johnson Space Center in Houston. Setting aside the social and psychological problems that could arise among people trapped together inside an interplanetary mobile home (*SN: 11/29/14, p. 22*), three years offers a lot more time and opportunity to get sick or injured than a dayslong Apollo mission. And Mars is about 600 times farther from Earth than the moon is. Even light-speed communications will take about 20 minutes to reach Earth from Mars. Phoning Houston for help in an emergency is not an option.

"The reality is, when we do the first missions to Mars, there's a high likelihood that somebody may die," Antonsen says. "If someone goes out and they get an abrasion on their eyeball and it's not responding to whatever [is] on the vehicle, they're coming back one-eyed Jack."

Despite those dangers, the United States, Russia, China and other nations have all voiced their intentions to send people to the Red Planet. NASA is gunning for a mission to Mars in the 2030s. With that deadline in mind, researchers are developing a suite of medical devices and medications to bring on a trip to Mars.

The items on this packing list are in the very early stages of development, and in some cases, still pretty impractical and unproven. Universal diagnostic wands are a distant dream. But researchers are devising artificial-gravity suits, anti-radiation medications and miniature medical tools that scientists hope will be ready in about a decade to keep the first travelers to Mars safe and healthy.

Faking gravity

For something that looks so relaxing, floating in microgravity is surprisingly bad for you. When the body doesn't have to pull its own weight, muscles and bones weaken. This was a big problem in the early days of spaceflight. When the Soviet Soyuz 9 crew returned from a record 18 days in space in

Lower body negative pressure, or LBNP, suits (in testing, top) mimic the effects of gravity by using vacuum pressure to pull a person's body toward the bottoms of the feet. Centrifuges (bottom) re-create this footward force by spinning people around.

June 1970, one cosmonaut was so weak that he couldn't carry his own helmet when he stepped out of the landing capsule (*SN: 6/27/70, p. 615*). Today, astronauts on the International Space Station keep up their strength by exercising for a couple of hours each day. But other problems with life in microgravity remain unsolved.

In space, bodily fluids that Earth's gravity normally keeps in the lower body drift toward the head, increasing intracranial pressure. "If you were to sit down in a chair and put your head between your knees ... that's a bit what it feels like," says NASA astronaut Thomas Marshburn, who completed a five-month stint on the space station in 2013.

Researchers suspect that constant elevated pressure behind the eyes is to blame for vision problems, such as farsightedness, that about half of astronauts develop in space. "I had a harder time reading the keys on the laptop," Marshburn recalls.

Weightlessness also confuses the gravity-sensing vestibular organs in the inner ear that play a role in balance and motor control. Upon returning to Earth, "I could walk in a straight line pretty easily by the end of that day, but it took me a few days before I could start to walk around a corner" without running into the wall, Marshburn says.

To make sure astronauts can walk straight and see what they're doing on Mars, a spaceship could be outfitted with artificial-gravity machines. One such machine is a lower body negative pressure, or LBNP, chamber. The device applies vacuum pressure to the lower half of the body while a person is sealed in from the waist down. The vacuum re-creates the downward pull of gravity, planting the person's feet firmly on the floor of the chamber and drawing bodily fluids toward the legs.

In one experiment, 10 volunteers who already had medical devices implanted to measure intracranial pressure sealed their lower bodies inside an LBNP chamber. Participants had to lie down for the experiment to bring their intracranial pressure closer to what it would be like in space. When someone on Earth goes from standing to lying down, their intracranial pressure rises from around 0 millimeters of mercury to about 15 mmHg — closer to what astronauts are thought to experience in space. As the researchers slowly increased the device's vacuum pressure, participants' average intracranial pressure dropped from 15 to 9.4 mmHg, the researchers reported in 2019 in the *Journal of Physiology*.

"We really don't know right now how much time [in LBNP] we need to protect the body" from the harmful effects of fluid shifts in space, says Alan Hargens, a space physiologist at the University of California, San Diego. But in case LBNP becomes a significant part of the day, Hargens' team built a prototype LBNP suit that can be worn during daily activity. The suit consists of a pair of overalls with built-in shoes and a seal around the waist. Vacuum pressure pulls the wearer down onto the shoe soles. "These lower body negative pressure devices are an early form of artificial gravity," Hargens says. Such devices may be easier to send into space than alternatives being tested, such as centrifuges.

A centrifuge simulates gravity through centrifugal force — the effect that keeps water in the bottom of a bucket when you swing it over your head. A centrifuge designed to help astronauts

FROM TOP: NASA; GERMAN SPACE AGENCY

in microgravity looks sort of like a carousel, but with beds instead of ponies. The rider lies on a bed, head pointing toward the center of the carousel, which spins to exert a horizontal centrifugal force out toward the feet that's as strong as the downward pull of gravity. A room-sized centrifuge would be a lot harder to launch in a spaceship than an LBNP suit. But some researchers think the whole-body-centrifuge experience may combat microgravity issues that LBNP doesn't, such as the inner ear problems.

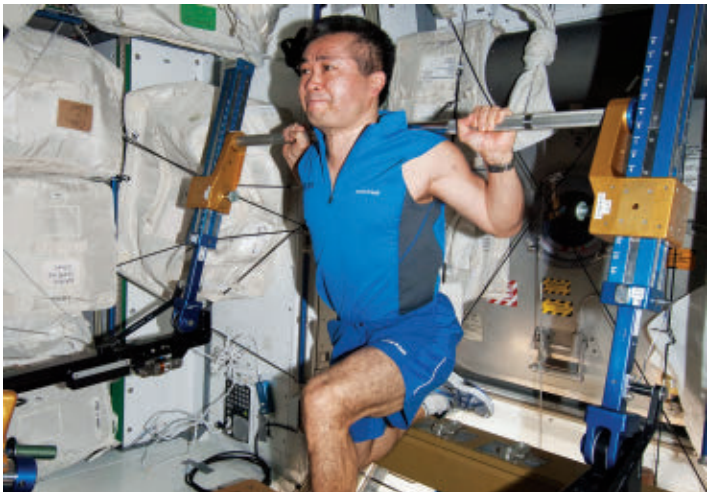
To investigate the effects of a centrifuge on sensorimotor control, Rachael Seidler, a motor control researcher at the University of Florida in Gainesville, and colleagues kept 24 volunteers in bed for 60 days to mimic life in microgravity. Sixteen of the participants spun in a centrifuge for a total of 30 minutes each day, while the other eight got no centrifugation. Before and after bed rest, participants were tested on their balance and were put through an obstacle course. "We've just had a very preliminary peek" at the data, Seidler says, but "it does look like the artificial gravity was helpful" for motor control.

Bracing for radiation

Life in microgravity may be a problem for a Mars crew, but at least it's a familiar challenge to astronauts. Chronic exposure to deep space radiation, on the other hand, is a hazard that no space traveler has faced before.

The solar system is awash in charged particles called galactic cosmic rays that travel at nearly the speed of light. These particles tear through metal like it's tissue paper and can kill cells or create mutations in the DNA within. Astronauts on the space station, like folks on Earth, are largely protected from these tiny wrecking balls by Earth's magnetic field. But a Mars-bound crew will be totally exposed. En route to the Red Planet, astronauts are expected to receive almost two millisieverts of radiation daily — roughly equal to getting a full- body CT scan every six days.

The only people ever fully immersed in deep space radiation were those who went to the moon, but they were exposed for less than two weeks. On a Mars mission, "we really don't know exactly what's going to happen to humans when they get these types of exposures," says Emmanuel Urquieta, a space medicine researcher at Baylor College of Medicine in Houston. But judging by lab animal and cell experiments, this radiation won't be giving astronauts any superpowers.



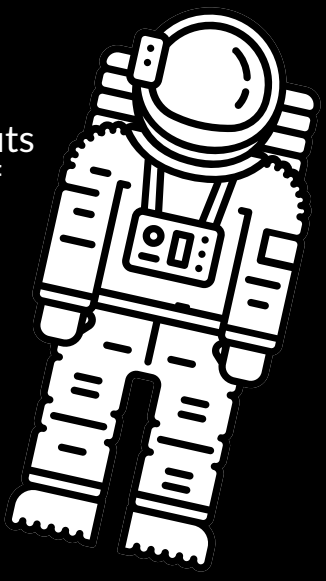
While in space, astronauts like Koichi Wakata of the Japanese Aerospace Exploration Agency exercise about two hours every day to keep their muscles and bones from severely weakening.

Radiation exposure on a trip to Mars would be like getting a full-body CT scan every six days.

In tests on animals and in human tissue, beams of particles designed to mimic space radiation degrade heart and blood vessel tissue, suggesting a Mars crew may be at higher risk for cardiovascular diseases, according to a 2018 report in *Nature Reviews Cardiology*. Similarly, observations of rodents exposed to radiation suggest that space radiation impairs cognitive function, researchers reported in a review article in the May 2019 *Life Sciences in Space Research*.

Medical problems astronauts are at relatively high risk of developing while in space:

- Rashes/skin irritation
- Motion sickness
- Insomnia
- Blood clots
- Back pain
- Nasal congestion
- Kidney stones
- Farsightedness



FROM TOP: NASA; T. TIBBITTS

"There's also a good amount of data on radiation's ability to induce cancer" in the lungs, liver and brain, says Peter Guida, a researcher at Brookhaven National Laboratory in Upton, N.Y., who studies the biological effects of radiation.

Scary radiation effects seen in lab animals or cell cultures should be taken with a grain of salt. A mouse is not a person, and brain cells in a dish do not make a brain. Also, animals and cells typically get the entire Mars mission–level dose of radiation in a single session or in a series of radiation exposures over weeks or months, which is not the same thing as getting constant, low-level exposure. But the warning signs from these experiments are worrying enough that researchers are testing various anti-radiation medications.

"The biggest and most promising field for countermeasure development is antioxidants," Guida says. High-energy charged particles can cause damage by splintering water molecules in the body into toxic compounds called reactive oxygen species. Priming the body with antioxidants could help neutralize some of those reactive oxygen species and curb their effects. Options include vitamins A and E, as well as selenomethionine, an ingredient found in some dietary supplements. "All these have shown at various levels to decrease the negative effects of radiation," he says.

Even harnessing the natural antioxidant powers of berries might help. In one experiment, rats fed food laced with freeze-dried blueberry powder for four weeks seemed to perform slightly better on a memory test after exposure to high-energy charged particles than rats fed normal chow before exposure. In the test, the rats were shown two objects: one they had seen before radiation exposure and one they had not. Blueberry-fed rats spent almost 70 percent of their time exploring the new object, as expected of animals that recognized the old object. But the other rats spent about half their time exploring each object, suggesting that they'd forgotten the object they'd seen before, researchers reported in 2017 in *Life Sciences in Space Research*.

Antioxidants, on their own, may not be enough protection, says Marjan Boerma, a radiation biologist at the University of Arkansas for Medical Sciences in Little Rock. Boerma and colleagues are testing whether aspirin and other anti-inflammatories, including a form of vitamin E called gamma-tocotrienol, can help reduce cell damage from high-energy particles. It may take a medley of pharmaceuticals — or perhaps a carefully blended smoothie. Scientists are still far from hammering out the exact ingredients of that anti-radiation regimen, she says.

Astronaut, heal thyself

Pulling shifts in artificial gravity and swallowing antioxidants may become part of an astronaut's daily routine. But Mars visitors will also have to deal with any unexpected illnesses and injuries without mission control to talk them through an emergency.

A Mars crew may include a physician. "But that person could also get sick," Urquieta says, "and that physician is not going to be board-certified in 10 different specialties." Ideally, the Mars spaceship would be equipped with artificial intelligence that could consider an astronaut's symptoms, recommend medical tests, make diagnoses and assign treatments. But a reliable "Dr. AI" is nowhere close to reality.

Right now, the most sophisticated symptom checkers are tools like VisualDx, diagnostic software used by health care workers in hospitals and clinics. The user answers questions about a patient, such as symptoms and demographic features, to winnow down possible diagnoses. For skin conditions, VisualDx can also analyze photos of a patient's skin; it's now being expanded to help users assess ultrasound scans.

Art Papier, a dermatologist and chief executive officer at VisualDx, and colleagues designed a version of the system for use in deep space that works on a laptop without internet. The software doesn't have to account for every possible diagnosis, like infectious diseases from the tropics. Instead, the focus is on medical conditions that astronauts have a fairly high chance of developing, like rashes or kidney stones.

To help walk astronauts through first aid and medical exams, spaceflight physiologist and space medicine scientist Douglas Ebert of KBR, Inc. in Houston and colleagues are developing a tool called the Autonomous Medical Officer Support, or AMOS, system. An early version of the software uses pictures and

A new portable ultrasound machine, the Butterfly iQ, uses a single probe (left) containing a silicon chip that buzzes to generate ultrasonic waves at a variety of frequencies to do whole-body scans. About the size of an electric razor, the probe displays images on a smartphone (right) and is smaller and easier to use than ultrasound machines on the International Space Station.

BUTTERFLY NETWORK

videos to teach novices how to perform an eye exam, for example, or insert a breathing tube.

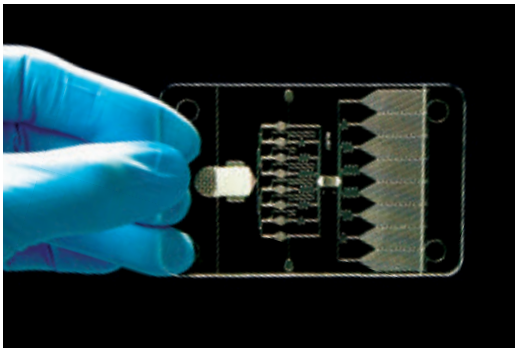
The researchers tested an AMOS prototype with about 30 nonphysicians, who learned how to perform several medical procedures. Those people came back three to nine months later to do the procedures again, using the software for guidance as necessary, to mimic how an astronaut would use AMOS for preflight training and in-the-moment support during an emergency.

Around 80 percent of participants accurately performed eye exams and ultrasounds and about 70 percent correctly inserted an IV. When it came to a tougher task — inserting a breathing tube — just about half pulled it off, Ebert and colleagues reported in January in Galveston, Texas, at the NASA Human Research Program Investigators' Workshop. In April, astronauts on board the space station successfully used the software to perform kidney and bladder ultrasound scans without help from ground control.

When performing medical exams, astronauts won't have the starship *Enterprise*'s sick bay at their disposal. They'll need miniature medical devices that fit on the spacecraft.

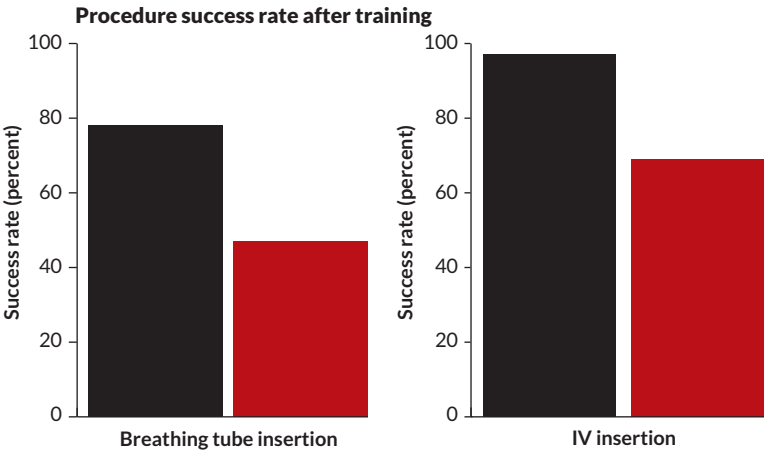
For medical imaging, space medicine researchers have their eyes on a new ultrasound device called the Butterfly iQ that replaces the variety of transducers usually needed to image different body parts with a single probe the size of an electric razor. Standard ultrasound machinery is around 15 times heavier than the Butterfly iQ, which displays images on a mobile app.

The company 1Drop Diagnostics, which is developing credit card–sized chips to detect chemical markers of different diseases in blood samples from a finger prick, is working on portable blood tests for astronauts.



1Drop Diagnostics is developing a credit card–sized chip to detect markers of disease in a blood drop. An array of detectors on the chip contains chemicals that emit fluorescent light when they latch onto a specific biomarker. The higher a biomarker's concentration in the blood, the brighter the glow, which is translated by a reader. 1Drop chips can detect biomarkers of heart failure and blood clots in the lungs, plus liver and kidney problems.

1DROP DIAGNOSTICS



Measuring up About 30 nonphysicians learned first aid from a software system designed to help astronauts. Months after training, the novices did pretty well, except for inserting a breathing tube and an IV. SOURCE: D. EBERT *ET AL*/NASA HUMAN RESEARCH PROGRAM INVESTIGATORS' WORKSHOP 2020

The medical kit that astronauts use to patch each other up will have to be lightweight and compact. To decide what goes in a spaceship first aid kit, researchers use NASA's Integrated Medical Model, which forecasts which health problems the astronauts on a particular mission are most likely to have.

Researchers plug in mission details, like where the crew is headed and astronauts' genders and preexisting conditions. The model then runs thousands of mission simulations to gauge the risks of that specific crew having anything from constipation to a heart attack so that planners can prioritize medical kit supplies.

Ebert and colleagues have already used this system to build a preliminary first aid packing list for a crewed lunar flyby mission that NASA has planned for 2022. For this three-week trip, the first aid kit is pretty simple: medication for back pain, motion sickness and the like.

Packing for Mars is going to be a whole new ball game, Ebert says. But researchers still have at least a decade to shrink their equipment down to size and figure out what mix of medical supplies will give Mars astronauts the best chance of surviving their epic voyage. ■

Explore more

- NASA Human Research Program. Five hazards of human spaceflight. bit.ly/spacehazards
- NASA's Plan for Sustained Lunar Exploration and Development. go.nasa.gov/372dbZm

Mars Dust

How the next Mars missions will help forecast the weather on the Red Planet

By Lisa Grossman

It started with a spring breeze. The Opportunity rover watched with its robotic eyes as the wind blowing through Perseverance Valley kicked puffs of rusty Mars dust into the air. In more than 14 Earth years of exploring the Red Planet, the rover had seen plenty of this kind of weather.

But the dust grew thicker. Small flecks swirled like wildfire smoke through the atmosphere, turning sun-filled midday into dusk, then night. Within a week, the dust storm spanned more than twice the area of the contiguous United States and eventually encircled the whole planet, allowing just 5 percent of the normal amount of light to reach Opportunity's solar panels. The rover went quiet.

"It got so bad so quickly, we didn't even have time to react," says Keri Bean of NASA's Jet Propulsion Laboratory in Pasadena, Calif. Bean had joined Opportunity's rover-operating team just before that May 2018 storm.

Dust storms like that one, which snuffed out Opportunity for good, are the most dramatic and least predictable events on the Red Planet (*SN: 3/16/19, p. 7*). Such storms can make the nail-biting process of landing on Mars even more

ESA, DLR, FU BERLIN (CC BY-SA 3.0 IGO)

Storm Danger

dangerous and could certainly make life difficult for future human explorers.

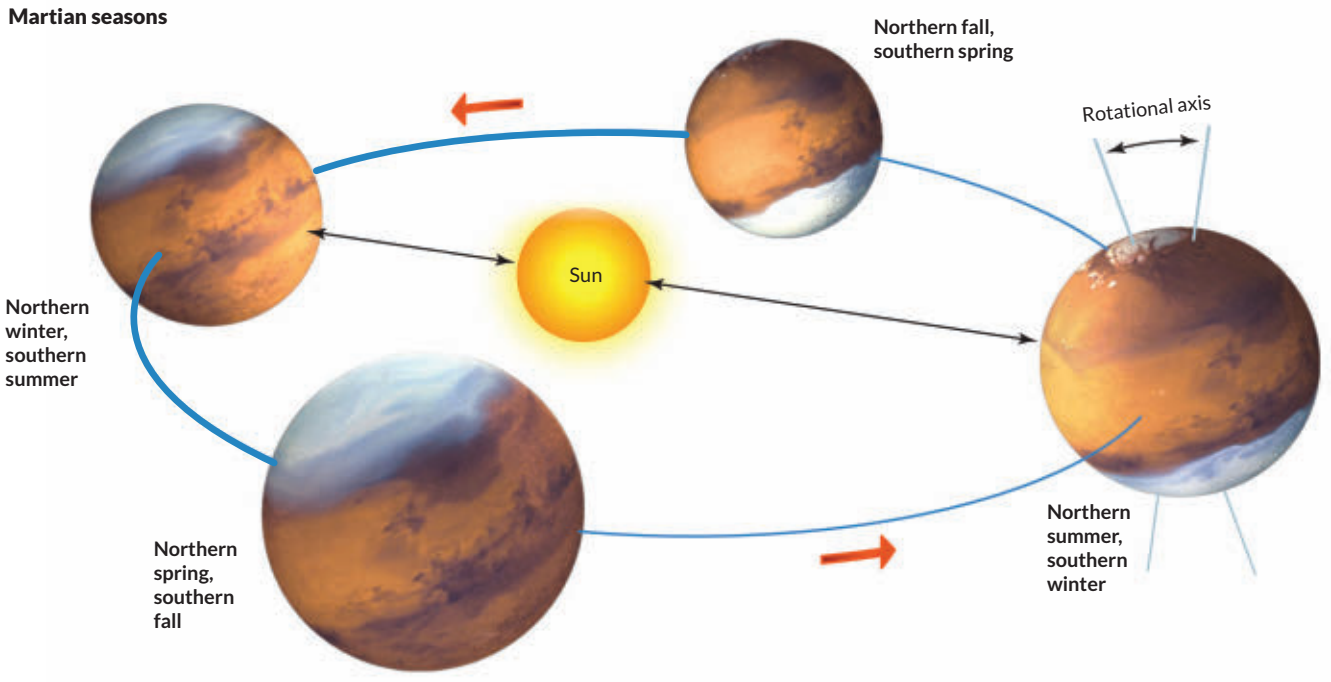
Despite almost 50 years of study, scientists are missing some key data that would help explain how dust gets kicked into the air to form planet-wide storms and what keeps it circulating for weeks or months at a time.

"We just do not understand how dust storms form on Mars," says planetary meteorologist Scott Guzewich of NASA's Goddard Space Flight Center in Greenbelt, Md. History has shown that certain regions and seasons are more prone to dust than others. "Other than that, we're ... blind."

Mars missions set to launch this summer, from the United States, China and the United Arab Emirates, will help solve that pressing mystery. NASA's new rover, Perseverance, will carry a suite of weather sensors called MEDA, for Mars Environmental Dynamics Analyzer (see Page 30). Those sensors will build on decades of Mars exploration and fill in missing puzzle pieces.

"Predicting dust is the ultimate goal" for MEDA, says planetary scientist Germán Martínez of the Lunar and Planetary Institute in Houston. The

A dust storm rolls across Mars in this April 2018 image from the European Space Agency's Mars Express spacecraft. That dusty season also launched a storm that engulfed the entire planet and snuffed out the solar-powered Opportunity Mars rover.



There is a season
Mars' dusty season lasts from the start of southern spring to the end of southern summer (thicker blue line), when the Red Planet orbits closest to the sun. The extra sunlight warms the atmosphere, setting off a feedback loop that can lift dust into the sky and send it circulating around the globe.

data MEDA will collect will be "the most substantial contribution to this topic so far."

Dust, dust everywhere

Dust is as important to weather on Mars as water is on Earth. With no oceans, scant water vapor and a thin atmosphere, Martian weather can be monotonously calm for about half the Martian year, which lasts close to 687 Earth days. But when the Red Planet's orbit brings it closer to the sun, dust storm season begins.

In the 10-month dusty season, which corresponds to spring and summer in the southern hemisphere, extra sunlight warms the atmosphere. That warmth generates strong winds as air moves from warm to cool regions. Those winds lift more dust, which absorbs sunlight and warms the atmosphere, generating still stronger winds, which lift even more dust.

The storms come in a range of sizes: Local storms can cover an area about the size of Alaska and last up to three Martian days (each of which lasts about 24.5 hours); global storms can engulf the planet for months. The storm that defeated Opportunity raged from the end of May through late July. Such global storms probably result when several smaller storms merge.

Global dust storms have affected Mars exploration since the arrival of the first long-term robotic visitor in 1971, when NASA's Mariner 9 orbiter found the planet's surface entirely obscured. Opportunity and its twin rover, Spirit, both survived a global dust storm in 2007, yet a large regional dust storm ended the Phoenix lander's mission in 2008.

There has never been a Mars mission that didn't worry about dust.

A farmer's almanac

Luckily, Mariner 9 was an orbiter, with no plans to land. It just had to wait for the skies to clear to start snapping pictures of the Martian surface. But the same 1971 storm is probably to blame for vanquishing two Soviet landers that arrived at almost the same time.

Spacecraft that must land to do their work can't just wait for better timing. Launch windows for missions between Earth and Mars open only every 26 months or so. Engineers who design landing systems need to know what conditions a spacecraft will face when it gets there, says Allen Chen of the Jet Propulsion Lab, who leads the entry, descent and landing for Perseverance.

The most important factor is the density of the atmosphere. Even though Mars' atmosphere exerts just 1 percent of the pressure of Earth's on the planet's surface, both the thin Martian air and the wind blowing through it slow down the spacecraft and affect where it lands, Chen says.

Perseverance will take pictures of the ground

UNIVERSAL IMAGES GROUP NORTH AMERICA LLC/ALAMY STOCK PHOTO

while parachuting through the atmosphere and match the images to an onboard map made with images from NASA's Mars Reconnaissance Orbiter. Based on those details, an in-flight navigation system will steer the rover to a safe landing spot, helping the rover touch down within an area 25 kilometers wide — the most precise Mars landing ever.

"But that's dependent on being able to see the ground," Chen says, without dust obscuring the view.

To land a rover, engineers like Chen rely on forecasts that use the past to tell the future — similar to weather forecasts on Earth, but with less data. Atmospheric scientist Bruce Cantor of Malin Space Science Systems in San Diego, a self-described Mars weatherman, put out a Mars weather report every week until September 2019. His forecasts are based on statistics and historical data, mostly taken from orbit. "It's almost like a farmer's almanac in my head," he says.

Cantor's forecasts for Mars landings since 1999 have been "pretty accurate," he says, and he boasts that he predicted the storm that ended the Phoenix mission to within three days. More accuracy wouldn't have saved Phoenix, he says. The lander's batteries were already low from low winter sunlight levels and the buildup of dust on the solar panels. "It was just a matter of what storm was going to be the mission-ending one," he says.

He foresees clear skies for Perseverance's touchdown in February 2021. Based on the season and weather patterns in the past, the probability of a dust storm hitting within 1,000 kilometers of the center of Perseverance's landing area is less than 2 percent, Cantor and colleagues reported in the journal *Icarus* in March 2019.

But just in case, Chen's team trained the navigation system to "deal with it being pretty darn dusty," Chen says.

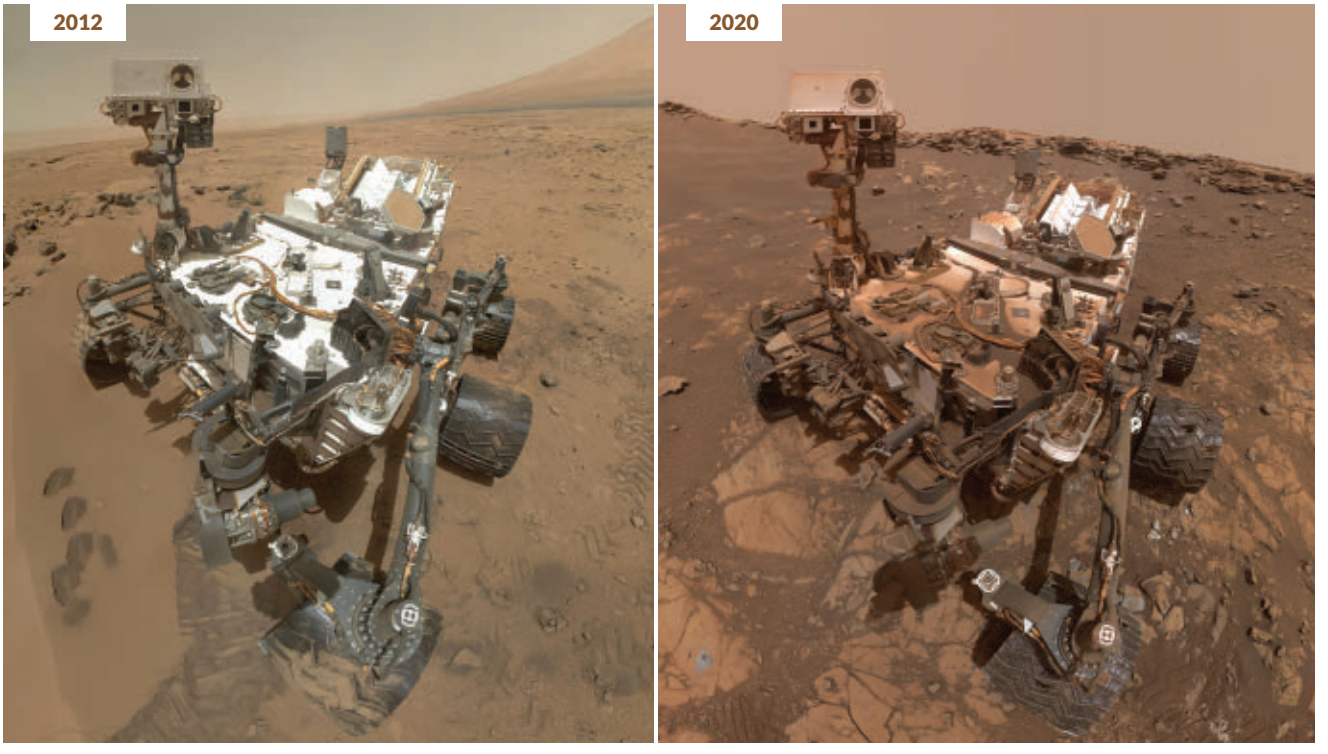
A constellation of weather stations

As Mars missions get more complex, and especially as NASA and other groups contemplate sending human explorers (see Page 18), being able to prepare for dust storms takes on extra urgency.

"Someday, somebody is going to go to Mars, and they're going to want to know when and where storms occur," Cantor says. "That's when this stuff becomes really important."

Cantor would know. Well over a decade ago, while testing a different rover system in Southern California, he jumped into a 2-meter-tall dust devil just to see what it would feel like. "Not one of my smartest moves," he says. He wasn't injured, but "it did not feel good. It felt like getting sandblasted."

Martian astronauts would be protected by more than shorts and a T-shirt, but dust could easily invade human habitats and clog air filters — or damage astronauts' lungs if they breathe it in. The



More than seven Earth years in the Red Planet's dusty atmosphere has taken its toll on the Curiosity rover, shown in "selfies" the rover took in October 2012 (the 84th Martian day of its mission, left) and in February 2020 (Martian day 2,687, right).

BOTH: JPL-CALTECH/NASA, MALIN SPACE SCIENCE SYSTEMS

dust may even carry poisonous and carcinogenic materials that could make astronauts ill over the course of a mission.

Astronauts will need to know when to stay inside. Part of the problem in predicting storms is a sheer lack of data. For Earth's weather, meteorologists use thousands of ground-based weather stations, plus data from satellites, balloons and airplanes. Mars has only six active satellites, run by NASA and the European and Indian space agencies. And just two sets of weather instruments report from Mars' surface: one on the Curiosity rover, which has been collecting data since 2012 (*SN: 5/2/15, p. 24*), and a nearly identical set that arrived with the InSight lander in 2018.

But those two spacecraft are practically neighbors, a big weakness for understanding the whole planet. "It'd be like having one of your weather stations in D.C. and the other in Buffalo," Guzewich says.

Perseverance will help fill in the gaps. So might China's first Mars rover, Tianwen-1, set to launch in July with an instrument to measure air temperature, pressure and wind. The Russian and European ExoMars mission, scheduled to launch in 2022, includes a lander called Kazachok equipped with meteorology and dust sensors (*SN Online: 3/12/20*).

From the air, the UAE's Emirates Mars Mission, known as Hope, will observe weather, including storms, and how the atmosphere interacts with the ground. Over one Martian year in orbit, Hope will help build a global picture of how the atmosphere changes day to day and between the seasons.

Just having a few more weather stations will be a big boost, says José A. Rodríguez Manfredi of the Center for Astrobiology in Madrid, principal investigator for MEDA, the weather sensors on Perseverance. "We will have a mini network working on Mars in a few years."

But four or five weather stations on the ground probably won't be enough. To reliably predict dust storms, what Mars scientists need is a global network collecting data all the time.

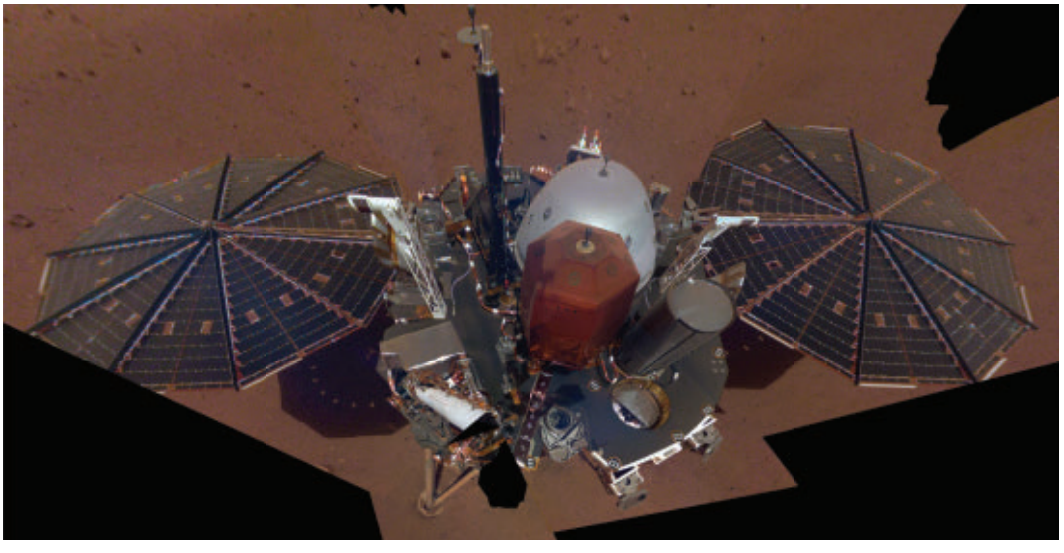
To cut down on the cost of such a network, Guzewich suggests figuring out which measurements "would give us the most bang for our buck." For Earth, NASA and other agencies use a type of study called an Observing System Simulation Experiment to figure out which variables are most important for predicting the weather. Satellites are then designed to focus on those most valuable observations. Such a study has never been done for Mars, but the only obstacle is funding, Guzewich says.

"Mars atmospheric scientists have been clamoring" for such experiments, he says. "We're not going to reproduce Earth's observing network before humans go to Mars. It's not going to happen.... But maybe we could do something that is financially and technologically reasonable that really does make a difference and gets us to the point where we can predict the future a couple days in advance."

Blowing in the wind

Mars forecasts also suffer from a lack of fundamental information, Martínez says. How hard does the wind have to blow to lift the dust? And what does the dust do once it's airborne?

This is where Perseverance will shine. The rover will make the best direct measurements yet



JPL-CALTECH/NASA

NASA's InSight lander, shown here in a mosaic of selfies the spacecraft took, carries a set of weather sensors called TWINS, or Temperature and Wind for InSight. The lander is one of just two weather stations on the Martian surface. Mars atmospheric scientists say they need more to predict dangerous dust storms.

of wind speed and direction on Mars, especially the vertical wind that lifts dust upward.

For a long time, scientists struggled to understand how dust was lifted into the air at all. "It seemed like it couldn't be possible," Guzewich says. "The atmosphere is so thin, a single particle of dust or sand is so heavy, it just shouldn't work." Observations and experiments over the last 20 years suggest that once sand grains start bouncing along the surface, they can knock into other grains and knock smaller particles upward. But it's still not possible to tell which of those bouncing grains will lead to a storm — or which of those storms will go global.

Mars climatologists have tried to make detailed wind measurements for decades, Martínez says, but have hit several stretches of bad luck. Only five surface missions — the Viking 1 and 2 landers in 1976, the Pathfinder lander in 1997 and the ongoing Curiosity and InSight missions — have provided useful data on wind speed and direction near the surface. And even those have had mixed results.

"Arguably, the best wind record on Mars is still the one from the Vikings, 40 years ago," Martínez says. Curiosity was supposed to take direct wind measurements in all directions with a pair of electrically heated booms that jutted away from the rover's neck. "We had great expectations," Martínez says.

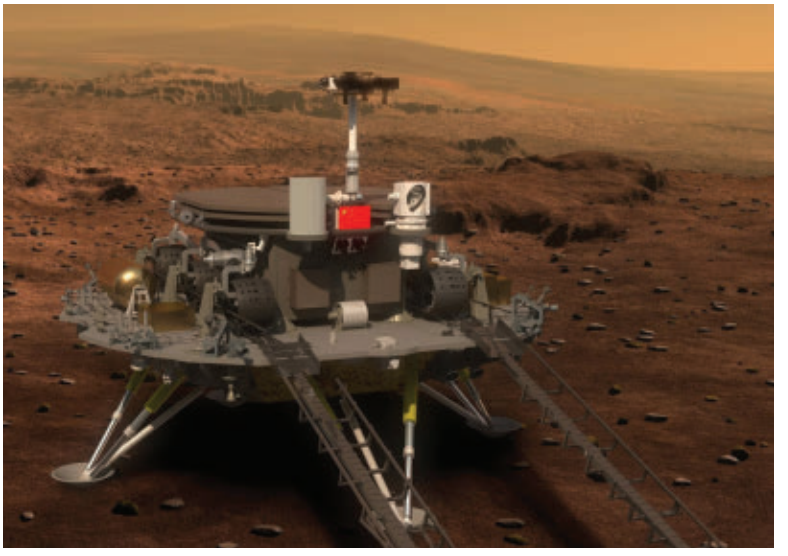
But photos the rover took of itself showed that one boom was damaged as the rover landed, and out of commission. For the first 1,490 Martian days of Curiosity's mission, the rover could take measurements only when the wind was blowing head on. Then, in October 2016, the second boom broke. In April, researchers suggested a way to hack Curiosity's temperature sensors to get wind data, but there's no plan to use that hack at the moment, Guzewich says.

That leaves InSight, but its wind readings are muddled by other parts of the lander getting in the way of airflow. The readings are still useful, but the MEDA team hopes to do better.

Taking lessons from InSight and Curiosity, Perseverance's MEDA will have more wind sensors that reach farther from the rover's body. The sensors will be protected by a shield until after the rover has landed safely.

"We are very excited," Martínez says. "The vertical wind has never been measured before on Mars. We're going to do that."

Measuring wind speeds will help scientists determine how hard the wind must blow to kick up dust, the first step in triggering a dust storm.



China's space agency plans to launch its first Mars mission, called Tianwen-1, in July. Its rover (illustrated atop the lander) will measure air temperature, pressure and wind, among other things.

XINHUA

That figure has personal resonance for Bean, the former Opportunity rover operator. Her first shift was exactly two weeks before the mission-ending global dust storm. She told the rover to use its arm to brush the surface of a rock.

"My coworkers blamed me for starting a whole butterfly effect," she says. "You brushed the surface," they joked, "the dust went up, you started the whole dust storm."

In its end-of-mission report, the Opportunity team admits it will never really know what ended Opportunity's nearly 15-year run. One possibility is that the dust grew too thick on the solar panels for gentle wind in the calm season to blow the dust off.

One potential fix would be to design future rovers to vibrate their solar panels fast enough to make dust skitter off, Bean says. Once humans are on the planet, they could just clear dust with their arms.

A week or so before Opportunity was officially declared lost, Bean decided to memorialize the rover. "I'd always liked tattoos, but nothing ever spoke to me," she says. In college, she had studied Mars' atmospheric opacity — the amount of light that can penetrate an atmosphere's dust, represented by the Greek letter τ. So Bean got a tattoo on her arm of the last measurement Opportunity sent to Earth: "τ=10.8." That stands for a night-dark sky in the middle of the day. ■

Explore more

- J.L. Callas, M.P. Golombek and A.A. Fraeman. "Mars Exploration Rover Opportunity end of mission report." October 1, 2019. go.nasa.gov/3fjQpiK

Perseverance is on a roll for rocks

The NASA rover will search high and low for signs of past Martian life

By Lisa Grossman

NASA's next rover is a connoisseur of Martian rocks. The main job of the Perseverance rover, set to launch between July 20 and August 11, is to pick out rocks that might preserve signs of past life and store the samples for a future mission back to Earth.

"We're giving a gift to the future," says planetary scientist Adrian Brown, who works at NASA Headquarters in Washington, D.C.

Most of the rover's seven sets of scientific instruments work in service of that goal, including zoomable cameras to pick out the best rocks from afar and lasers and spectrometers to identify a rock's makeup. After the rover lands in February 2021, it's capable of collecting and storing 20 samples within the first Martian year (about two Earth years). The NASA team plans to collect at least 30 samples over the whole mission, says planetary scientist Katie Stack Morgan of NASA's Jet Propulsion Laboratory in Pasadena, Calif.

Fortunately, Perseverance is headed to a spot that should be full of collection-worthy rocks. The landing site in Jezero crater, just north of the Martian equator, contains an ancient river delta that looks like it once carried water and silt into a long-lived lake.

"We can already predict which parts of that delta might give us the highest return for possible biosignatures," Stack Morgan says. The crater has a "bathtub ring" of carbonates, minerals that settle in shallow, warm waters that are especially good at preserving signs of life. "That makes Jezero special," she says.

But Perseverance is more than a rock collector. The rover will probe the ground beneath its wheels, fly a helicopter, track the weather and test tech for turning Martian air into rocket fuel. Every part of the rover has a job to do.

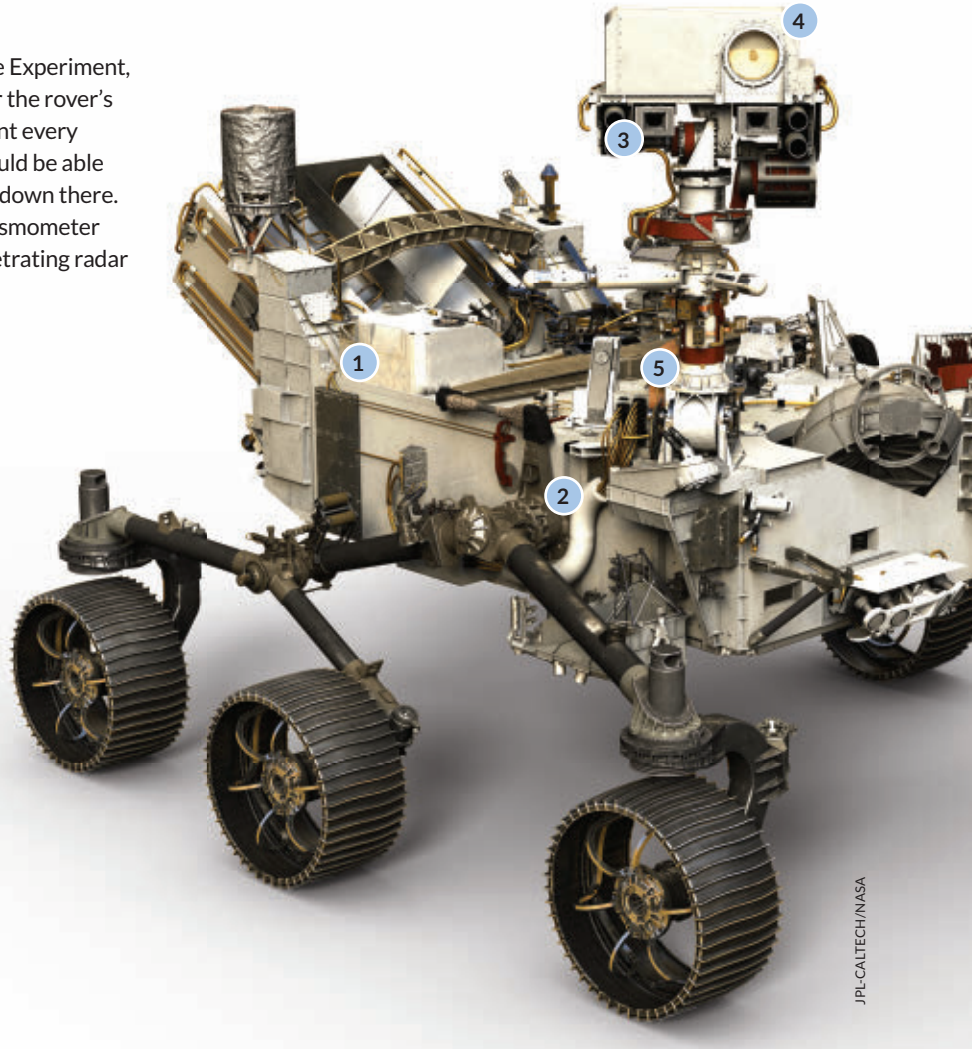
1 RIMFAX

RIMFAX, or Radar Imager for Mars' Subsurface Experiment, will use radio waves to probe the ground under the rover's wheels. The instrument will take a measurement every 10 centimeters along the rover's track and should be able to sense 10 meters deep, depending on what's down there. The InSight lander, currently on Mars, has a seismometer that listens for Marsquakes, but a ground-penetrating radar to understand the Martian interior is a first.

2 MOXIE

Human explorers will need oxygen on Mars, but not just for breathing, says former astronaut Jeffrey Hoffman. "It's for the rocket," says Hoffman, now an engineer at MIT. To take off from the Martian surface and return home, astronauts will need liquid oxygen rocket fuel. Bringing all that fuel from Earth is not an option.

To demonstrate how to make fuel from scratch, MOXIE, or Mars Oxygen In-Situ Resource Utilization Experiment, will pull carbon dioxide out of the Martian atmosphere and convert it to oxygen. MOXIE will produce about 10 grams of oxygen per hour, which is only about 0.5 percent of what's needed to make enough fuel for a human mission over the 26 months between launch windows. But the effort will teach engineers on Earth how to scale up the technology.



JPL-CALTECH/NASA

3 Mastcam-Z

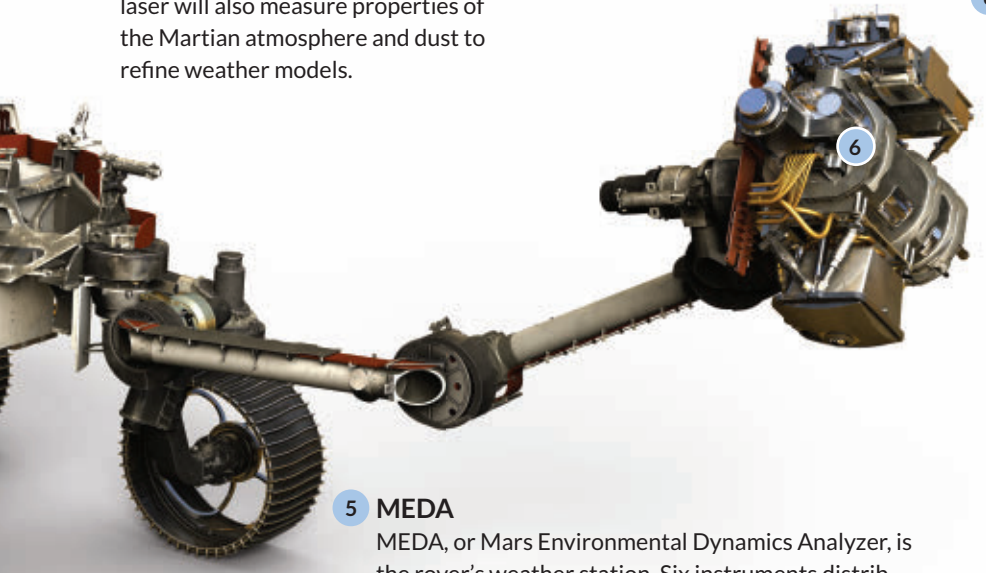
Set atop Perseverance's neck, Mastcam-Z, the rover's main set of eyes, can swivel 360 degrees laterally and 180 degrees up and down to view the surrounding landscape. Like its predecessor on the Curiosity rover, the camera will take color, 3-D and panoramic images to help scientists understand the terrain and the mineralogy of the surrounding rocks. Mastcam-Z can also zoom in on distant features — a first for a Mars rover.

4 SuperCam

How can Perseverance look for signs of ancient microbes in rocks too far away to touch? Enter SuperCam, a laser spectrometer mounted on the rover's head. SuperCam will shoot rocks with a laser from more than seven meters away, vaporizing a tiny bit of the minerals. Researchers will then analyze the vapor to help figure out what the rocks are made of, without having to drive the rover down steep slopes or up rugged crags. The laser will also measure properties of the Martian atmosphere and dust to refine weather models.

Ingenuity

Perseverance will also carry a stowaway folded up origami-style in a protective shield the size of a pizza box: a helicopter called Ingenuity. At a smooth, flat spot, Ingenuity will drop to the ground and unfold, then take about five flights in 30 Martian days. These flights are mainly to show that the copter can get enough lift in the thin Martian atmosphere. If Ingenuity is successful, future helicopters might help run reconnaissance for rovers. "There's always a question with the rover, what's over that cliff? What's over that rise?" says planetary scientist Briony Horgan of Purdue University in West Lafayette, Ind. "If you have a helicopter, you can see those things ahead of time."



6 PIXL, SHERLOC and WATSON

Geologists never go into the field without a hand lens. Likewise, Perseverance will be prepared with three arm-mounted magnifying instruments. PIXL, the Planetary Instrument for X-ray Lithochemistry, will have a camera that can resolve grains of Martian rock and dirt to scales smaller than a millimeter. It will also detect the chemical makeup of those rocks by zapping them with X-rays and measuring the wavelength of light the rocks emit in response. SHERLOC, or Scanning Habitable Environments with Raman and Luminescence for Organics and Chemicals, will take similar measurements using an ultraviolet laser. WATSON, the Wide Angle Topographic Sensor for Operations and Engineering, will take pictures with a resolution of 30 micrometers to put the chemistry in context. The instruments will seek signs of ancient microbes preserved in Martian rocks and soil, and help scientists decide which rocks to store for a future mission to return to Earth. ■

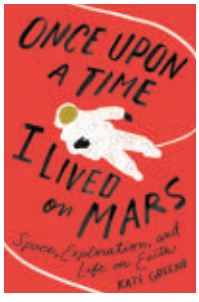
5 MEDA

MEDA, or Mars Environmental Dynamics Analyzer, is the rover's weather station. Six instruments distributed across the neck, body and interior will measure air temperature, air pressure, humidity, radiation and wind speed and direction. The tools will also analyze the physical characteristics of the all-important Mars dust. Scientists hope to use the information from these sensors to better predict Mars weather (see Page 24).

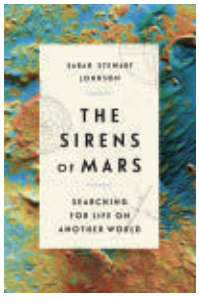
JPL-CALTECH/NASA

In a new book, Kate Greene describes her experience living in this dome on Hawaii's Mauna Loa volcano as part of a scientific dress rehearsal for missions to Mars.

ANGELO VERMEULEN



Once Upon a Time I Lived on Mars
Kate Greene
ST. MARTIN'S PRESS, $27.99



The Sirens of Mars
Sarah Stewart Johnson
CROWN, $28.99

BOOKSHELF

Mars books explore what it is to be human

Science writer Kate Greene couldn't have known that her memoir about her time on a make-believe Mars mission would be published as millions of people on Earth isolated themselves in their homes for months amid a pandemic.

But her book is one of two about Mars published this month that are oddly well-suited to the present moment. *Once Upon a Time I Lived on Mars* and Sarah Stewart Johnson's *The Sirens of Mars* are both about exploration. Yet they're also about many different types of isolation and the human yearning to not be alone.

Greene participated in a mock Mars mission, called HI-SEAS, for Hawaii Space Exploration Analog and Simulation, in 2013. She and five others lived in a dome on a rocky, barren patch atop Mauna Loa volcano for four months with no fresh food, no fresh air (all excursions were conducted in clunky "spacesuits") and no instantaneous contact with the outside world.

NASA and other space agencies run such missions to figure out best practices for keeping astronauts sane and productive in isolated and stressful environments. It's well-documented that boredom can lead to mistakes or inattention. Other simulated Mars missions suggest that astronauts isolated together could develop an us-versus-them mentality that would lead the crew to stop listening to mission control, which could be dangerous on a long mission.

With humor and sensitivity, Greene relates how her crew got along (or didn't), what she read, what she ate and the time-delayed e-mails she exchanged with loved ones back on "Earth." Through the book's series of essays, she uses the mission as a lens to examine everything from the ethics and economics of space travel to the nature of time, love and home.

Her descriptions of boredom and seclusion feel especially apt in a time of social distancing: "the way certain aspects of your environment, daily schedule and conversations smooth over, lose their texture." Greene relates her experience to astronaut Michael Collins' time orbiting in the Apollo 11 capsule alone while his crewmates walked on the moon. She connects both of those experiences to that of her brother, who spent the last year and a half of his life confined to a hospital room.

"On this oasis of a planet," she writes, "there are so many ways to feel isolated, each of us with the potential to sit with the terror of being alive and possibly alone in the cosmos."

The Sirens of Mars starts with a much broader view of Mars exploration. In lyrical, engaging writing, Stewart Johnson, a planetary scientist, chronicles how our perception of Mars has swung from a world teeming with life, to definitely dead and boring, and back again over and over since the invention of telescopes.

Stewart Johnson brings together a cast of characters to tell this history, from Galileo to the present-day team working on the Curiosity rover. Those characters include astronomer Carl Sagan, whose *Cosmos* TV series Stewart Johnson watched as a child. Sagan was almost ridiculed out of science for his obsession with "exobiology."

She also introduces less famous but equally important people, like Sagan's colleague Wolf Vishniac, whose "Wolf Trap" life-detection experiment was cut from NASA's life-hunting Viking landers in the 1970s. To get over his disappointment, Vishniac went searching for microbes in Antarctica and died in an accident there before the Viking missions launched.

In this sweeping history of human fascination with the Red Planet, Stewart Johnson also tells a personal story of finding her place in the world, from an inquisitive child to an unrooted adventurer to a wife and mother and member of a scientific team.

She makes a clear case that the search for life on Mars is an effort to not be alone. In one of the most poignant scenes in her book, she is hiking on Mauna Kea — the next volcano over from Greene's Mars habitat — and finds a fern growing amid the volcanic desolation.

"It was then, on that trip, that the idea of looking for life in the universe began to make sense to me," she writes. "I suddenly saw something I might haunt the stratosphere for, something for which I'd fall into the sea.... a chance to discover the smallest breath in the deepest night and, in so doing, vanquish the void that lurked between human existence and all else in the cosmos." — *Lisa Grossman*

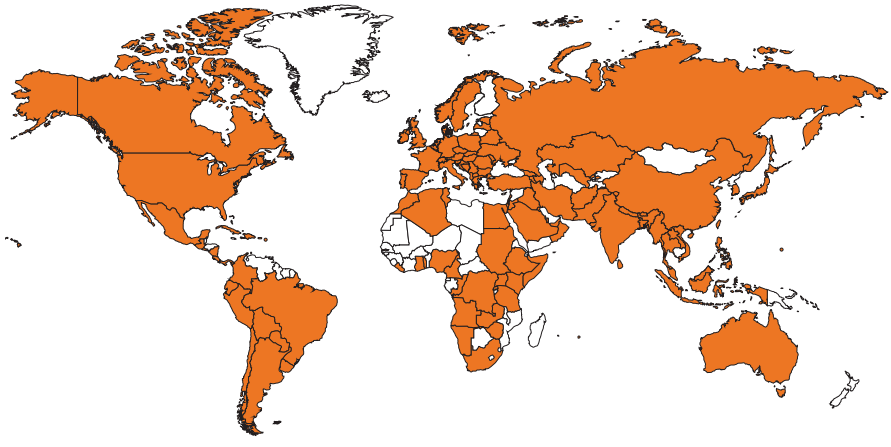
SOCIETY UPDATE

REGENERON ISEF GOES VIRTUAL IN 2020

REGENERON ISEF
A PROGRAM OF SOCIETY FOR SCIENCE & THE PUBLIC
VIRTUAL | 2020

The Society for Science & the Public hosted a Virtual Regeneron International Science and Engineering Fair (ISEF) in May, inviting the scientific community to come together in a celebration of science and engineering.

VIRTUAL REGENERON ISEF ATTENDANCE



18,523
registrants

131
countries, regions and territories

VIRTUAL REGENERON ISEF WEEK INCLUDED

88 distinguished speakers

70 colleges, universities, educational institutions and scientific organizations

4 Nobel laureates

REGENERON ISEF FINALISTS

1,369
finalists

1,064
projects

51%
male finalists

49%
female finalists

317 affiliated fairs

56 countries, regions and territories

136 danced in the opening ceremony video

MAY 9, 2020 & MAY 23, 2020

Warming up

Auroras inject extra energy into Saturn's atmosphere, which may make it hotter than expected, ***Lisa Grossman*** *reported in "Auroras could heat up Saturn"* (SN: 5/9/20 & 5/23/20, p. 12)*. The same process could take place on exoplanets, scientists say.*

Reader **Jeremy Schwartz** wondered if scientists consider heat sources other than stars when evaluating an exoplanet's habitability.

A planet can get heat from its star, from the radioactive decay of elements within rocks inside the planet, from gravitational interactions with a moon or maybe even from auroras, **Grossman** says. Scientists can measure only one of those things for exoplanets: The heat they get from their stars. "From Earth, there's no way to know how much gravitational or radioactive heating an exoplanet gets. It took a spacecraft flyby to figure these things out for Pluto," **Grossman** says. "Until we can send a probe to an exoplanet, we won't know how else it might get its heat."

Sharing responsibility

Individual actions, including eating a plant-based diet and using renewable energy, can create ripple effects that reduce carbon emissions, ***Christie Aschwanden*** *reported in "Reducing your emissions"* (SN: 5/9/20 & 5/23/20, p. 34)*.*

Reader **John Tilson** thought the story placed responsibility for combating climate change on individuals instead of on manufacturers. "We as consumers are always made to feel it's our fault," **Tilson** wrote. "I suggest we blame and fix the source of the problem."

The intention was to show things that consumers can do, not to lay blame at their feet. "There is a shared responsibility and capacity to address climate change for various actors," says **Diana Ivanova**, a research fellow at the University of Leeds in England who has studied emissions-reduction options. "Quantifying the carbon footprints of consumption does not mean that consumers are the sole actors with responsibility. Instead, if industry cleaned their activities and governments adopted strong climate policies, this will reduce the carbon footprint of consumers."

COVID-19 Q&A

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

"China recently reported in *JAMA Network Open* that [the coronavirus] was found in semen," reader **Larry Busack** wrote. "Does this indicate that embryos could be created that are infected or that have the virus as part of their DNA or RNA?"

Researchers in China detected the coronavirus's genetic material in semen, but the team did not determine whether infectious virus was present. There's no evidence that the virus can infect sperm or eggs, or that semen can transmit the virus to another person.

That said, it's possible virus bits could become embedded in an embryo's genetic material if a virus's RNA or DNA makes it into sperm or an egg. That's how human DNA has become riddled with remnants of past viral infections. Researchers can use the viral "fossils" to understand how long humans and our ancestors have been infected with certain types of viruses. Not all viruses can infiltrate the DNA of sperm or eggs, however, and the ones that can rarely do. There are no known coronavirus fragments in human DNA.

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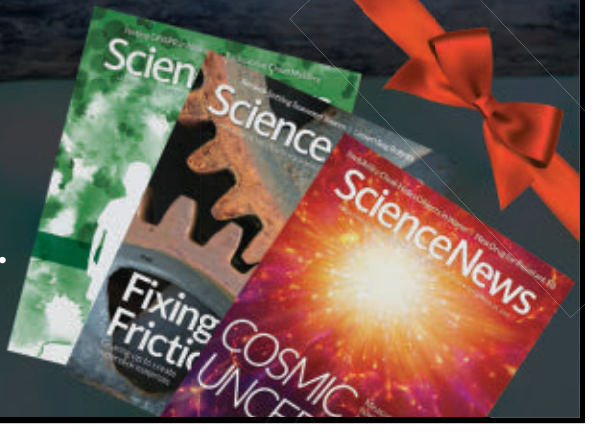

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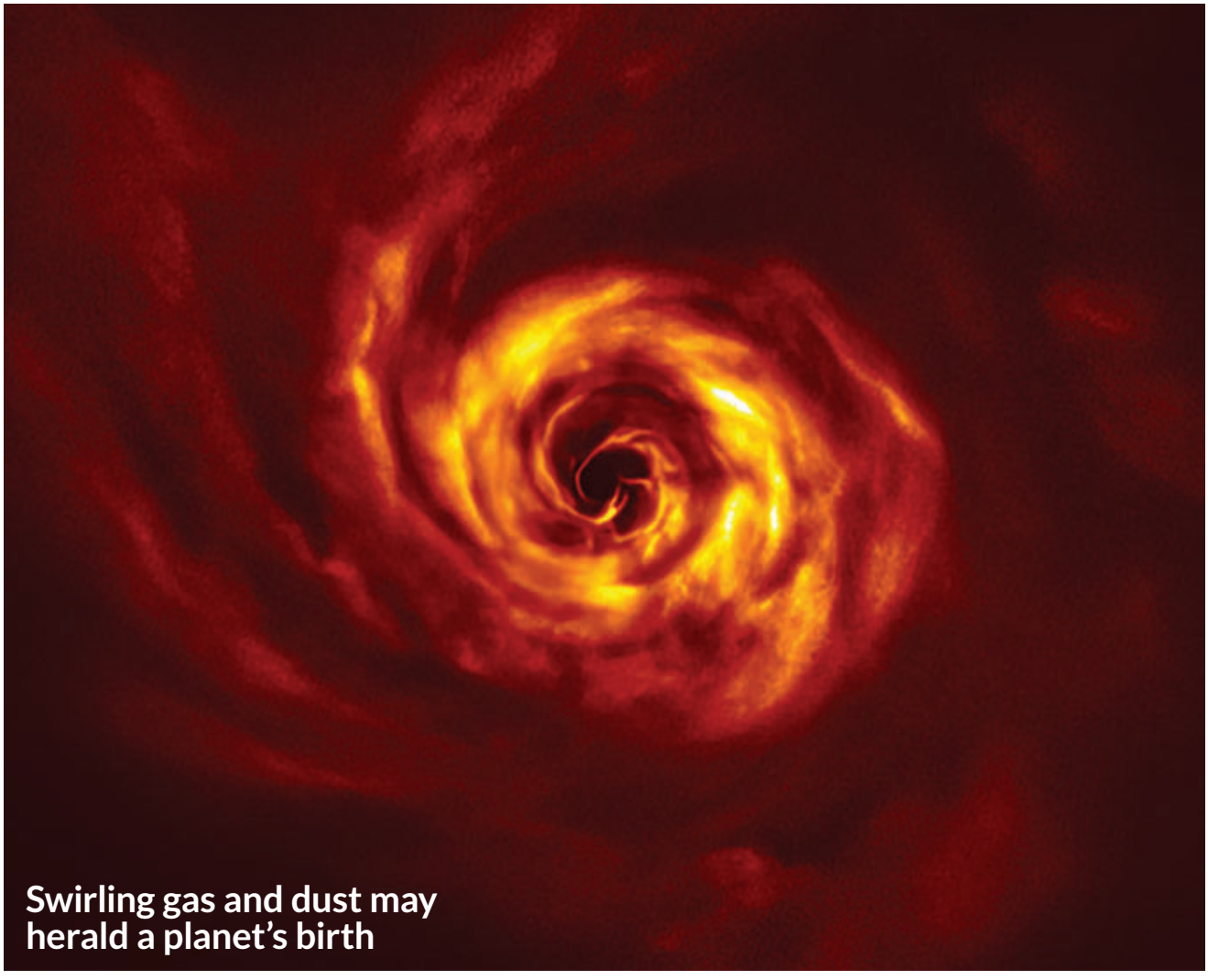
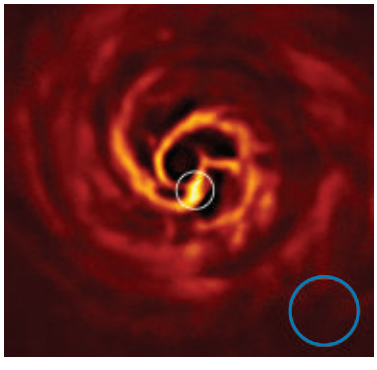


Swirling gas and dust may herald a planet's birth

Astronomers think they've captured the first direct evidence of a planet forming around a young star.

A spiral disk of gas and dust (above) surrounding the star AB Aurigae (which has been blacked out in the center of the image) contains a small "twist" near the center, infrared telescope images show. That twist "is the precise spot where a new planet must be forming," says astrophysicist Emmanuel Di Folco of the University of Bordeaux in France.



Previously, astronomers have spotted gaps and large-scale spirals (*SN: 7/7/18, p. 16*) that are thought to be created by unseen planets forming in disks of gas and dust around young stars. Theories of how planets coalesce and gather material from these disks predict that planets' motions would further twist the surrounding gas and dust like swirling skirts, pinpointing a planet's location.

Now, Di Folco and colleagues have used observations from the Very Large Telescope and the Atacama Large Millimeter/submillimeter Array, both in Chile, to find a spiral and zero in on one such twist (circled in white at left) around AB Aurigae. (For scale, the blue circle represents the size of Neptune's orbit.) The researchers describe the finding in the May *Astronomy & Astrophysics*.

"It was amazing. It was exactly as we were expecting from the theoretical predictions of planet formation," Di Folco says.

The star, about 520 light-years away from Earth in the constellation Auriga, is just 4 million years old, about a thousandth of the age of the sun. "It's really a baby," Di Folco says.

The potential planet's mass is not known, but it probably would have to be a gas giant like Jupiter rather than a rocky world like Earth to make such big waves in the disk. And it might not be alone — there's a hint of another planet near the disk's outer edge. — *Lisa Grossman*

A. BOCCALETTI *ET AL/ASTRONOMY & ASTROPHYSICS* 2020, ESO

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when we take these steps:

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- Wearing a cloth face covering in public

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