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SCIENCE NEWS MAGAZINE
SOCIETY FOR SCIENCE & THE PUBLIC

FEBRUARY 2, 2019

Strange
New Worlds
Orbit Nearby
Stars

Heart-Fixing
Stem Cells a
No-Show

Lessons
From
Kilauea's
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The
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of Worm
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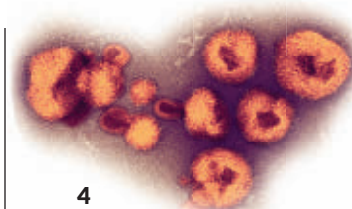
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We spent New Year's Eve in the Kuiper Belt

We started 2019 at *Science News* with a bang, providing live coverage of discoveries more than 6.5 billion kilometers from Earth.

NASA's New Horizons spacecraft has been heading for the outer reaches of our solar system since it launched in 2006. After surveying Jupiter and Pluto, its next task was to investigate the mysterious space rock 2014 MU69, dubbed Ultima Thule, orbiting in the Kuiper Belt some 1.6 billion kilometers beyond Pluto.

The flyby was inconveniently scheduled for the early hours of New Year's Day, but that didn't dissuade our intrepid journalists.

Astronomy writer Lisa Grossman and digital director Kate Travis spent weeks developing a coverage plan for our digital platforms, including the *Science News* website, Twitter and Instagram. Lisa wrote background material in advance so it could be fact-checked and edited. On December 31, she left holiday celebrations with relatives in Minneapolis to travel to the New Horizons mission's base at the Johns Hopkins University Applied Physics Laboratory in Laurel, Md.

Lisa started reporting at 2 p.m. on New Year's Eve, and for the next 24 hours posted live updates on Twitter and Instagram with photos and video, as well as lengthier reports on our website, edited by Kate.

Scientists celebrated at 12:33 a.m., when the spacecraft should have made its closest approach to MU69. But they hadn't yet gotten a confirmation signal. You could feel the tension during the wait, Lisa says, and the euphoria when New Horizons finally phoned home at about 10:30 a.m. EST on New Year's Day.

"My favorite moment was when they got the signal back from the spacecraft on the morning of the first and knew everything had gone well," Lisa says, "followed closely by seeing that blurry bowling pin picture and learning that their speculation about how MU69 was spinning was probably correct."

Researchers think continued study of this unusual object will provide clues to the origins of the planets (Page 7). The spacecraft will transmit data from the flyby for the next 20 months and will scope out other Kuiper Belt objects.

Lisa and Kate have no regrets about working over the holiday, and their efforts

Astronomy writer Lisa Grossman on the scene for the New Horizons flyby.



paid off. Online audiences were engaged throughout, and the stories sparked lively conversations on the @ScienceNews Twitter feed. Lisa even met Brian May, lead guitarist for the band Queen and a Ph.D. astrophysicist, who came to the Applied Physics Lab for the flyby and wrote a song honoring the expedition.

Our adventure in the Kuiper Belt is a great example of how our digital publishing platforms let us provide timely, in-depth coverage of major news. The goal, as always, is to deliver *Science News* goodness on the platforms that work best for our readers. — *Nancy Shute, Editor in Chief*

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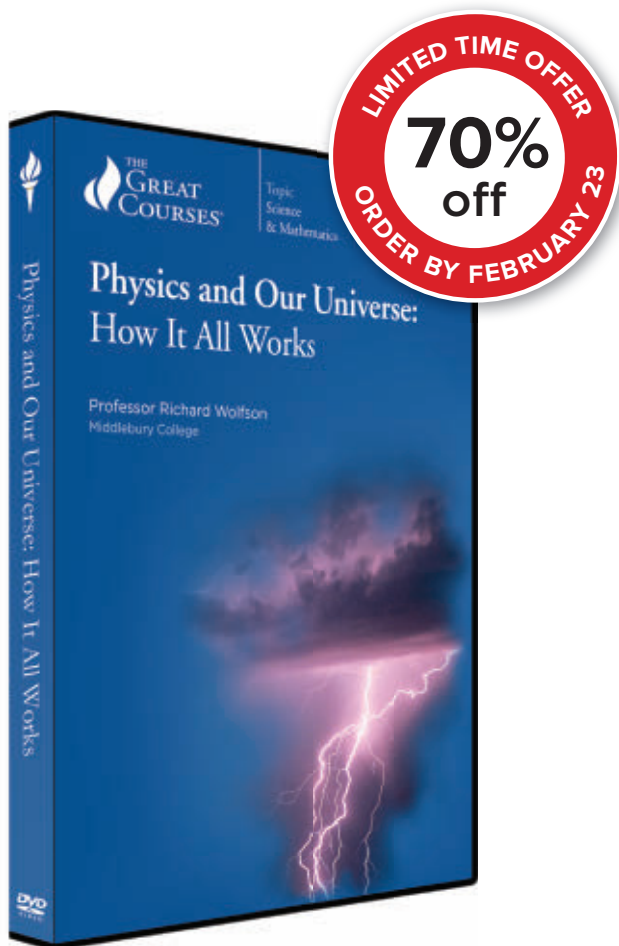
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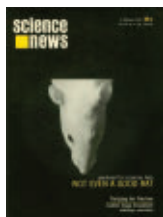
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Excerpt from the February 8, 1969 issue of *Science News*

50 YEARS AGO

Messing with the mousetrap

The Federal Council for Science and Technology ... recommends a 10-year national earthquake research program to find ways to predict when and where quakes will strike and... [how to] defuse and prevent earthquakes, or at least modify them. Basically, the idea is simple: Inject fluid into underground rock, release the strain and produce a gradual series of tiny earthquakes or tremors instead of one violent jolt.

UPDATE: Creating small quakes to prevent a big one doesn't really work. It would take dozens, if not thousands, of small quakes to release the same energy unleashed in a large quake. Pumping fluid into the ground — a common practice in oil, gas and geothermal energy production and wastewater disposal — can actually boost earthquake risk. A 2017 quake of magnitude 5.5 in South Korea may have been caused by fluid injections to generate geothermal power (*SN*: 5/26/18, p. 8). A recent rise in Oklahoma quakes has been linked to wastewater injections (*SN Online*: 11/30/16).

THE SCIENCE LIFE

DNA guided Lassa outbreak response

When an outbreak of a viral hemorrhagic fever hit Nigeria in 2018, scientists were ready: They were already in the country testing disease-tracking technology, and within weeks helped steer officials toward the most appropriate response.

Lassa fever, which is transmitted from rodents to humans, pops up every year in West Africa. But 2018 was Nigeria's worst season on record. By mid-March, there were 376 confirmed cases — more than three times as many as by that same point in 2017 — and another 1,495 suspected. Health officials weren't sure if the bad year was caused by the usual strains that circulate, or by a more transmissible form that warranted a stronger response.

Technology developed in the last few years for analyzing patient DNA in the field helped answer that question mid-outbreak, confirming the cases were being caused by pretty much the same strains transmitted from rodents to humans in past years. That rapid finding allowed Nigerian health officials to focus efforts on rodent control and safe food storage, rather than sinking time and money into measures aimed at stopping unlikely human-to-human transmission, researchers report in the Jan. 4 *Science*.

As they were reporting their results to the Nigeria Centre for Disease Control, the scientists also were discussing the data with other virologists and epidemiologists

Lassa virus (shown in a colorized micrograph) caused an unexpectedly large outbreak in Nigeria last year.

RETHINK

Queenless bees lay eggs in other colonies

Even honeybee queens have rebellious kids.

In a colony of European honeybees (*Apis mellifera*), only the queen typically lays eggs. Other females, her daughters, maintain the hive and feed the young. But at times a colony experiences periods of queenlessness, when the old queen has died or left and a new one isn't ready to take her place. When this happens, some workers left behind seize the chance to lay their own eggs — and sometimes in an entirely new colony, scientists report in the December *Ecology and Evolution*.

With no queen around to release chemicals that stunt workers' ovarian growth, these “rebel workers” can lay eggs — a behavior discovered in 2012 by evolutionary biologist Karolina Kuszewska of Jagiellonian University in Kraków, Poland, and colleagues. These rebels produce only males, which live only to mate. A departed queen's replacement comes from a group of her daughters born to fight one another until only one survives.

Rebel workers are more adventurous than normal workers. Kuszewska's team has now found that about 21 to 39 percent of rebel bees flew to other colonies, while only about 3 to 8 percent of normal workers did. Rebels were also more likely to infiltrate colonies with no queen. This might be a form of “reproductive parasitism,” the rebels shift the duty of raising their sons to another colony. — Yao-Hua Law



When a queen dies or leaves a colony, rebel workers that are left behind can lay eggs.

FRONT TOP: AMI IMAGES/SCIENCE SOURCE; K. KUSZEWSKA

in online forums. This kind of real-time collaboration can help scientists and health workers “see the bigger picture about pathogen spread,” says Nicholas Loman, a microbial genomicist at the University of Birmingham in England who was not involved in the work.

Portable DNA sequencers, some as small as a cell phone, have allowed scientists to read the genetic information of viruses emerging in places without extensive lab infrastructure. Looking for genetic differences between patient samples can give clues to how a virus is being transmitted and how quickly it’s changing over time — key information for getting outbreaks under control. If viral DNA from several patients is very similar, that suggests the virus is being transmitted between people; if the DNA is more distinct, people might be picking up the virus from other animals.

The technology has been used amid Ebola and Zika outbreaks. But Lassa offers a unique challenge, says study coauthor Stephan Günther, a virologist at the Bernhard Nocht Institute for Tropical Medicine in Hamburg. Unlike



Scientists in Nigeria analyzed DNA from Lassa patients to learn how the virus was spreading.

Ebola or Zika, Lassa has a lot of genetic variation between strains. So while the same small regions of DNA from various strains of Ebola or Zika can be picked out for analysis, it’s hard to accurately target similar regions for comparison among Lassa strains.

Instead, Günther and his team used a tactic called metagenomics: They collected breast milk, blood plasma and cerebrospinal fluid from Lassa patients and sequenced all the DNA within — human, viral and anything else lurking. Then the team picked out the Lassa virus DNA.

All told, the scientists analyzed Lassa virus DNA from 120 patients, far more

than initially intended. “We went to the field to do a pilot study,” Günther says. “Then the outbreak came. And we quickly scaled up.” Earlier relationships in Nigeria helped make that happen: The team had been collaborating for about a decade with researchers at the Irrua Specialist Teaching Hospital and had been working alongside the World Health Organization and the Nigeria Centre for Disease Control.

Analyzing and interpreting the data generated by the metagenomics approach was a challenge, especially with limited internet connection, Günther says. Researchers analyzed 36 samples during the outbreak — less than a third of their total dataset, but still enough to guide the response. The full analysis, done after the outbreak, confirmed the initial findings.

Metagenomics could help in wider disease surveillance. Pathogens like Ebola and Zika pop up in unexpected places, “and take too long to be recognized,” Loman says. Sequencing all DNA in a sample could speed up detection. — *Laurel Hamers*

THE NAME GAME

Studies can be *in vitro*, *in vivo* and now ‘in fimo’ — in poop

Feces contain valuable scientific information. Researchers can track enzyme activity or hunt for DNA to gather clues about overall health.

Microbiologist Aadra Bhatt of the University of North Carolina at Chapel Hill wanted a term for that research — like “*in vivo*” (research done in living organisms) and “*in vitro*” (research done in a petri dish).

She and colleagues argue in an upcoming issue of *Gastroenterology* for “*in fimo*,” from the Latin *fimus* for manure or excrement. They reject “*in feces*” because the term “*feces*” originally referred to the dregs in a wine cask. Bhatt hopes *in fimo* gains a place in the lexicon for poopetuity. — *Laurel Hamers*

FIRST

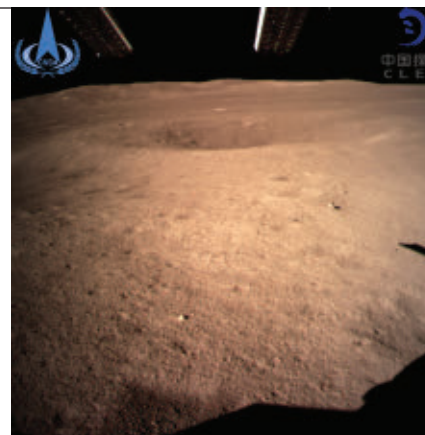
A Chinese craft reaches the farside of the moon

China’s Chang’e-4 is the first spacecraft to land on the moon’s farside.

The lander touched down at 9:26 p.m. Eastern time on January 2, and a rover dubbed Yutu-2, or Jade Rabbit-2, rolled off the craft several hours later, the China National Space Administration says. The rover will explore part of the 186-kilometer-wide Von Kármán crater inside the roughly 2,500-kilometer-wide South Pole–Aitken basin. The basin, one of the oldest impact features in the solar system, could contain exposed parts of the moon’s interior that might reveal details of the moon’s formation and early history (*SN: 11/24/18, p. 14*).

Chang’e-4 will measure rock and soil composition, use ground-penetrating radar to probe just below the surface and take panoramic landscape images. The spacecraft will also measure charged particles and radiation, which could inform future astronaut missions, and test if plants and insects can grow together on the moon.

Because the moon always shows the same face to Earth, it is impossible to communicate directly with the farside. A relay satellite launched in May 2018 is beaming signals between Chang’e-4 and Earth (*SN Online: 5/20/18*). — *Lisa Grossman*



This is one of the first images of the moon’s farside taken by the Chang’e-4 lunar probe.

GENES & CELLS

Shortcut improves photosynthesis

Genetic engineering boosts tobacco plants' growth

BY MARIA TEMMING

A genetic hack to make photosynthesis more efficient could be a boon for agricultural production, at least for some plants.

This feat of genetic engineering simplifies a complex, energy-expensive operation that many plants must perform during photosynthesis known as photorespiration. In field tests, tobacco genetically modified in this way grew more than 40 percent larger than unmodified plants. If it produces similar results in other crops, the genetic tweak could help farmers meet the food demands of a growing global population, researchers report in the Jan. 4 *Science*.

Streamlining photorespiration is “a great step forward in efforts to enhance photosynthesis,” says Spencer Whitney, a plant biochemist at Australian National University in Canberra not involved in the work.

Now that the agricultural industry has mostly optimized the use of yield-boosting tools including pesticides, fertilizers and irrigation, researchers are trying to micromanage and improve plant growth by designing ways to make photosynthesis more efficient (*SN*: 12/24/16, p. 6).

Photorespiration is a major roadblock to achieving such efficiency. It occurs in many plants — such as soybeans, rice and wheat — when an enzyme called Rubisco, whose main job is to help transform carbon dioxide from the atmosphere into sugars that fuel plant growth, accidentally snatches an oxygen



Modifying tobacco's genetic instructions for photosynthesis increased the growth of tobacco plants (one at left) compared with unmodified plants (right) in field tests.

molecule out of the atmosphere instead.

That Rubisco-oxygen interaction, which happens about 20 percent of the time, generates the toxic compound glycolate, which a plant must recycle into useful molecules through photorespiration. This process comprises a long chain of chemical reactions that span three compartments in a plant cell as well as the liquid in between. All told, completing a cycle of photorespiration is like driving from Maine to Florida by way of California. That waste of energy can cut crop yields by 20 to 50 percent, depending on the plant species and environmental conditions.

Using genetic engineering, researchers have now designed a more direct chemical pathway for photorespiration that is confined to a single cell compartment — the cellular equivalent of a Maine-to-Florida road trip straight down the East Coast.

Paul South, a molecular biologist at the U.S. Department of Agriculture in Urbana, Ill., and colleagues embedded genetic directions for this shortcut, written on pieces of algae and pumpkin DNA, in tobacco plant cells. To prevent the glycolate from taking its normal route through the cell, the researchers also genetically engineered the cells to not produce a chemical that allows glycolate to travel between cell compartments.

Unlike previous experiments with human-designed photorespiration pathways, South's team tested its photorespiration detour in plants grown in fields under real-world farming conditions. Genetically altered tobacco produced 41 percent more biomass than tobacco that hadn't been modified.

“It's very exciting” to see how well this genetic tweak worked in tobacco, says Veronica Maurino, a plant physiologist at Heinrich Heine University Düsseldorf in Germany not involved in the study. But “you can't say, ‘It's functioning. Now it will function everywhere.’”

Experiments with different types of plants will reveal whether this fix creates the same benefits for other crops as it does for tobacco. South's team is running greenhouse experiments on potatoes with the new set of genetic modifications and plans to do similar tests with soybeans, black-eyed peas and rice.

The vetting process for such modifications to be approved for use on commercial farms, including more field testing, will probably take at least another five to 10 years, says plant biochemist Andreas Weber, also at Heinrich Heine University Düsseldorf and coauthor of a commentary that appears in the same issue of *Science*. In the meantime, he expects researchers will continue trying to design even more efficient photorespiration shortcuts. But South's team, Weber says, “has now set a pretty high bar.” ■

41

percent

Increase in biomass of genetically modified tobacco compared with normal tobacco

New Horizons swings by Ultima Thule

The Kuiper Belt object appears to be two rocks stuck together

BY LISA GROSSMAN

The results are in: Ultima Thule, the distant Kuiper Belt object that got a close visit from the New Horizons spacecraft on New Year's Day, looks like two balls stuck together.

Ultima Thule is the clearest example of a contact binary, two separate objects that are now joined together, ever explored by a spacecraft, principal investigator Alan Stern of the Southwest Research Institute in Boulder, Colo., said January 2 at a news conference held at the Johns Hopkins University Applied Physics Laboratory in Laurel, Md.

That shape is enough to lend credence to the idea that planetary bodies grow up by the slow clumping of small rocks. Ultima Thule, whose official name is 2014 MU69, is thought to be among the oldest and least-altered objects in the solar system, so knowing how it formed can help reveal how the planets formed (*SN Online*: 12/18/18).

"Think of New Horizons as a time machine... that has brought us back to the very beginning of solar system history, to a place where we can observe

the most primordial building blocks of the planets," Jeff Moore, who leads New Horizons' geology team, said at the news conference.

New Horizons reached MU69 after a journey of almost 13 years and more than 6.5 billion kilometers. MU69 makes its home in the Kuiper Belt, a loose confederation of thousands of space rocks of various sizes that orbit the sun at distances greater than the solar system's planets. New Horizons flew past its first Kuiper Belt object, dwarf planet Pluto, in 2015 (*SN*: 8/8/15, p. 6).

At its closest approach, New Horizons swooped to within 3,500 kilometers of MU69, more than three times as close as the probe got to Pluto. But even before New Horizons got that close, the view of MU69 from about 28,000 kilometers away showed that the object is about 31 kilometers long and has two spherical lobes, one about three times the size of the other, that are connected by a narrow neck.

The lobes' spherical shape is best explained by collections of small rocks glomming together to form larger rocks,

said Moore, of NASA's Ames Research Center at Moffett Field, Calif. The collisions between the rocks happened at extremely slow speeds, so the rocks accreted rather than breaking each other apart. The final collision was between the two spheres, which the team dubbed "Ultima" (the bigger one) and "Thule" (the smaller one).

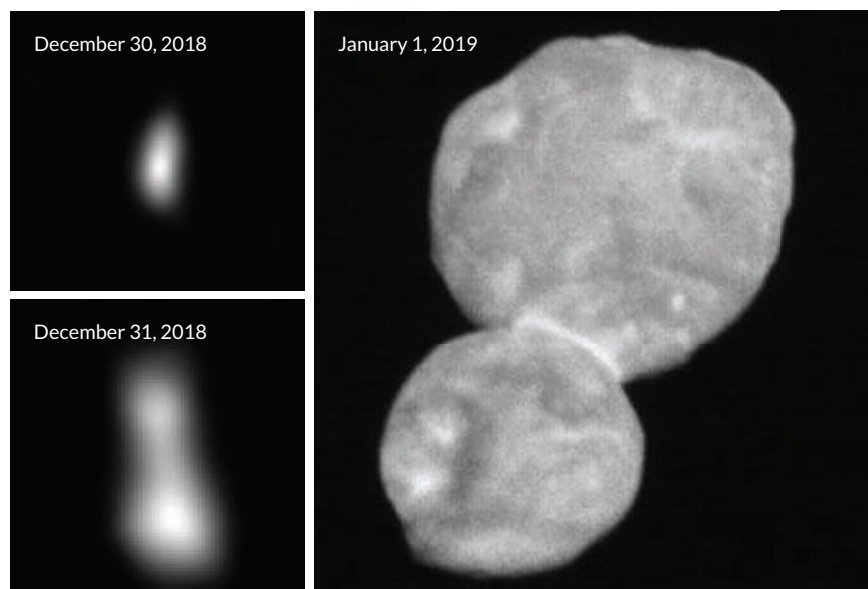
That collision probably happened at no more than a few kilometers per hour, "the speed at which you might park your car in a parking space," Moore said. "If you had a collision with another car at those speeds, you may not even bother to fill out the insurance forms."

New Horizons also gleaned other information from its flyby. MU69's neck appears brighter than much of the rest of the surface. That observation could be explained by small grains of surface material rolling downhill to settle in the neck; small grains tend to reflect more light than large ones, New Horizons deputy project scientist Cathy Olkin of the Southwest Research Institute said at the news conference. Even the brightest areas reflected only about 13 percent of the sunlight that hit them, though. The darkest reflected just 6 percent, about the same brightness as potting soil.

New Horizons also detected that MU69 has a reddish color. The science team thinks the rusty hue comes from radiation altering exotic ice, frozen material like methane or nitrogen rather than water, although the team doesn't know exactly what that ice is made of yet.

The spacecraft is still sending data back to Earth, and will continue transmitting details of the flyby for the next 20 months. Even as New Horizons team members shared the first pictures from the spacecraft's flyby, data were arriving with additional details about MU69's surface composition.

While in the outer solar system, New Horizons will observe another 24 to 35 Kuiper Belt objects, although none as closely as MU69. "This is the initial reconnaissance of the Kuiper Belt," says New Horizons project scientist Hal Weaver of the Johns Hopkins Applied Physics Laboratory. "We want to do it right." ■



As New Horizons approached 2014 MU69, the space rock's shape came into focus. On January 1, the spacecraft snapped an image revealing MU69 to be two spherical rocks fused together.

BODY & BRAIN

Implant uses light to soothe bladders

In rats, a wireless device lessened frequent urges to urinate

BY MARIA TEMMING

A new wireless implant may someday help people who suffer from overactive bladder get through the day with fewer bathroom breaks.

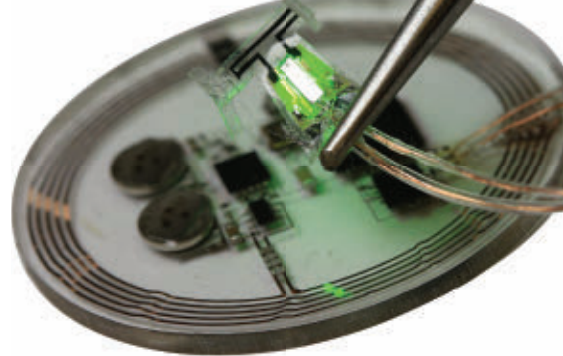
The implant uses a technique for controlling cells with light, known as optogenetics, to regulate nerve cells in the bladder. In experiments in rats with medication-induced overactive bladder, the device alleviated animals' frequent need to pee, researchers report online January 2 in *Nature*.

Optogenetics has traditionally been used for manipulating brain cells to study how the mind works, but the new implant is part of a recent push to use the technique to tame nerve cells throughout the body (*SN: 1/30/10, p. 18*). Similar optogenetic implants could help treat disease

and dysfunction in other organs, too, the researchers say.

"I was very happy to see this," says Bozhi Tian, a materials scientist at the University of Chicago not involved in the work. Roughly 33 million people in the United States have overactive bladder. One treatment is an implant that uses electric currents to regulate bladder nerve cells. But those implants "stimulate a lot of nerves, not just the nerves that control the bladder," Tian says. That can interfere with the function of neighboring organs, plus continuous electrical stimulation can be uncomfortable.

The new optogenetic approach targets specific nerves in only one organ and only when necessary. To control nerve cells with light, researchers inject a harmless virus carrying genetic



An implant, slightly larger than a quarter, uses light to manipulate nerve cells in a rat bladder to treat frequent, sudden urges to pee.

instructions for bladder nerve cells to produce a light-activated protein called archaerhodopsin 3.0, or Arch. A stretchy sensor wrapped around the bladder tracks the wearer's urination habits, and the implant wirelessly sends that information to a program on a tablet computer.

If the program detects the user heeding nature's call at least three times per hour, it tells the implant to turn on a pair of tiny LEDs. The green glow of these micro light-emitting diodes activates the light-sensitive Arch proteins in the bladder's nerve cells, preventing

LIFE & EVOLUTION

Midge threatens Antarctica

Invasive fly's waste may alter a nutrient-sparse ecosystem

BY SUSAN MILIUS

Some of the scariest poop in Antarctica comes from an all-female invader species about the size of an ant. Scientists are fretting about what the waste from these debris-eating midges may do to the continent's once nutrient-sparse moss banks.

The midge *Eretmoptera murphyi*, a tiny fly that can't actually fly, hitchhiked onto the Antarctic island of Signy probably sometime in the 1960s during plant-introduction experiments that would never be allowed today. In moss banks where the midges now thrive, midge excretions boost nitrogen concentrations to levels similar to those where another major nitrogen source, seals, come ashore, says polar and alpine ecologist Jesamine Bartlett of the University



A debris-eating species of flightless midge (one shown) invaded an Antarctic island and may shake up a mossy world.

of Birmingham in England.

Bartlett has calculated that the midges triple or quadruple the usual nitrogen in moss banks, which seals don't visit. Bartlett, who also works with the British Antarctic Survey in Cambridge, reported the results December 19 in Birmingham at a British Ecological Society meeting.

Midges are a shock to the ecosystem because Antarctica doesn't have the usual earthworms and other voracious detritus-feeders that quickly break down dead plants and other organic debris, as the midges do. The insects have "the potential to change the way the ecosystem

functions quite drastically," says systems ecologist Peter Convey, also of the British Antarctic Survey, who collaborates with Bartlett. Extra nutrients could offer opportunities to more invaders.

These disruptive midges may not be native to Antarctica, but they "are tough as anything," Bartlett says. Typically found on the subantarctic island of South Georgia, they can withstand being frozen in a block of ice. When the ice melts, the midges soon start wriggling again.

Conveniently for the invaders, they are an all-female species. "You only need one lady to be dropped off" for a population to get a foothold, Bartlett says. If conditions become harsh, a female can lay her big, jellylike glob containing 40 to 50 eggs even before fully emerging from her own pupal stage to adulthood.

Eggs need about two years to reach motherhood themselves. Eggs hatch in about a month into the first of four larval stages with a soft wormy body, a hard head capsule and eye pits for rudimentary visual tasks. When larvae graduate to the pupal stage and grow an adult body,

the cells from sending so many full-bladder alerts to the brain.

John Rogers, a materials scientist and bioengineer at Northwestern University in Evanston, Ill., and colleagues tested implants by giving rats a drug to cause overactive bladder. Over the next several hours, the implants successfully detected when rats passed water too frequently, and lit up green to bring the animals' urination patterns back to normal.

Shriya Srinivasan, a medical engineer at MIT, is impressed with the short-term effectiveness of the implant. But, she says, longer-term studies may reveal complications with the treatment.

For instance, she says, a patient might develop an immune reaction to the foreign Arch protein, crippling the protein's signal-blocking action. But if proven safe and effective in the long term, Srinivasan says, similar optogenetic implants that sense and respond to organ motion may also help treat heart, lung or muscle tissue problems. ■

the high-priority gonads form early. In a late stage, the pupae in their protective cases take on a crusty look "as if they've been tempura fried," Bartlett says. Legs come free of the pupal case before full adulthood, allowing a pupa to crawl.

If the mere specks of larvae hitchhike unnoticed on boots and establish themselves in other parts of Antarctica, there could be "serious repercussions," says ecologist Melodie McGeoch of Monash University in Melbourne, Australia, who wasn't part of the midge study.

Warming due to climate change may create new homes in Antarctica for midges, making the invasion even more of a cause for concern. Ice-free patches could expand by more than 17,000 square kilometers by 2100, close to a 25 percent increase from 2014, a 2017 study in *Nature* predicted. That estimate uses a pessimistic warming scenario, says Jasmine Lee of the University of Queensland in Brisbane, Australia, an author of the study in *Nature*. However, she adds, it's "the one the globe is currently tracking." ■

GENES & CELLS

Stem cells absent in mouse hearts

Lack of self-repair may also apply in humans, scientists say

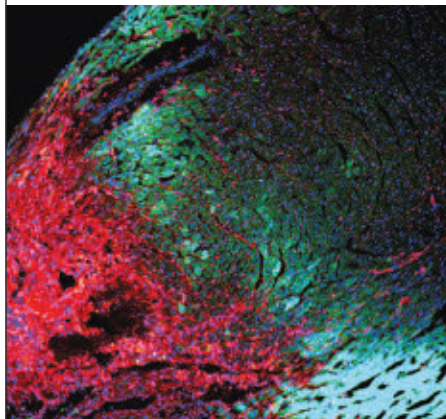
BY TINA HESMAN SAEY

There's some bad news for people who have suffered heart attacks: Healing may not come from within.

Researchers have debated for years whether hearts have their own stem cells available to produce new heart muscle cells and help the organ repair itself after injury. Now that debate may finally be over. After following the fate of dividing cells in the hearts of mice, scientists have concluded there are no heart stem cells.

Instead, heart attacks and other injuries to the organ signal immune cells and scar-forming cells called fibroblasts to divide and attempt to close the wound, the researchers report in the Dec. 26 *Proceedings of the National Academy of Sciences*. Human hearts probably also lack stem cells, evidence suggests.

"This study is fairly definitive that there is not a population of stem cells within the heart that gives rise to new muscle," says Deepak Srivastava, a developmental biologist and cardiologist at the Gladstone Institutes in San Francisco who wasn't involved in the study.



After a heart attack, a mouse's heart is awash with dividing cells (red) at the injury site. Rather than heart-repairing stem cells, the newcomers are immune cells and cells that form scar tissue, a new study finds.

Scientists thought the heart might have stem cells because previous research indicated that a small number of heart muscle cells are made throughout life, says Hans Clevers, a stem cell biologist at Hubrecht Institute in Utrecht, Netherlands, who led the new study. Still, only about 1 percent or less of heart muscle cells get replaced annually, according to that previous work.

But exactly where those new muscle cells come from was a mystery. Scientists had three major theories: that the new heart cells are born from stem cells within the organ itself; that the cells are born from stem cells that enter the blood from elsewhere in the body and integrate into the heart; or that heart muscle cells divide and produce more of themselves.

Clevers' group created mice in which dividing cells in the heart made a red fluorescent protein that allowed the researchers to track the cells. Then the team analyzed which genes were turned on in those cells to figure out their identities. There was no evidence of stem cells. And only existing heart muscle cells, called cardiomyocytes, made new muscle cells.

Those heart muscle cells divided and made new cells infrequently; only 11 of about 8 million cardiomyocytes were caught dividing in 1.5-year-old mice. That rate didn't improve after a heart attack, something scientists thought might happen if the heart had reason to repair itself. After an injury, "you come back one month, two months, a year later, but you see not a single new cardiomyocyte," Clevers says.

Instead, rapidly dividing immune cells flood into the site of the injury, accompanied by dividing fibroblasts, which make connective tissue and create a scar over a wound. Understanding the scarring process may lead to ways to limit heart attack damage, Clevers says, but he doubts that the heart can repair itself.

Srivastava, however, says heart self-repair may not be a lost cause. He and colleagues are working on ways to coax heart muscle cells to produce more of themselves. ■

GENES & CELLS

Weak spot in mosquito eggs found

Vital protein may be key to controlling the insects' numbers

BY TINA HESMAN SAEY

Mosquito researchers may have hatched a new plan to control the bloodsuckers: Break their eggshells.

A protein called eggshell organizing factor 1, or EOF1, is necessary for the eggs and embryos of some mosquito species to develop properly, a study finds. Genetically disrupting production of that protein in *Aedes aegypti*

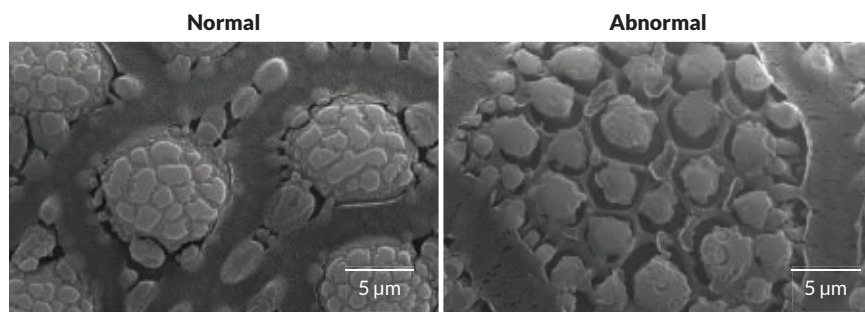
mosquitoes caused about 60 percent of their normally dark eggshells to be pale. And shells lacking EOF1 often collapsed and were more porous than normal. In experiments, almost no mosquito embryos in EOF1-disrupted eggs hatched into larvae, scientists report January 8 in *PLOS Biology*.

EOF1 is produced only by *Aedes*, *Anopheles* and *Culex* mosquitoes, bio-

chemist Jun Isoe of the University of Arizona in Tucson and colleagues discovered. Some species of those mosquitoes can transmit life-threatening diseases such as malaria, Zika, dengue and West Nile virus. The protein could be a good target for genetic engineering techniques or insecticides, which may help control populations of disease-carrying mosquitoes without killing harmless insects, the team speculates.

"This is truly outside-the-box thinking, and I like that," says entomologist Joe Conlon, a technical adviser for the American Mosquito Control Association, a group based in Mount Laurel, N.J., that gives advice about controlling mosquitoes and other disease-spreading insects.

But many hurdles stand between the research and creating an effective control strategy based on EOF1, Conlon says. The genetic technique that the scientists used to disrupt production of the protein is too cumbersome for widespread use, for example, and a chemical to disable just EOF1 has yet to be found. Still, knowing more about mosquito reproduction may prove helpful in other ways, he says. ■



In these scanning electron microscope images, an *Aedes aegypti* mosquito eggshell that lacks a protein called EOF1 (right) has round surface structures that are six times larger than those on a shell with normal amounts of the protein (left). Abnormal eggs are leaky, fragile and they collapse.

BODY & BRAIN

Missing protein linked to infertility

Mouse experiments offer new clues to endometriosis

BY AIMEE CUNNINGHAM

Missing protein may help explain why some women with endometriosis are infertile.

Infertile women with the disorder had lower amounts of a protein called histone deacetylase 3, or HDAC3, in cells from the lining of the uterus than did fertile women without endometriosis, a study finds. And mice engineered to have a decreased amount of HDAC3 in the lining of the uterus were sterile, researchers report in the Jan. 9 *Science Translational Medicine*.

The work brings scientists a step closer to understanding what drives

infertility in women with endometriosis, says Linda Giudice, a reproductive endocrinologist at the University of California, San Francisco who was not involved in the study. Such research could potentially offer ways to improve these women's ability to become pregnant, she says.

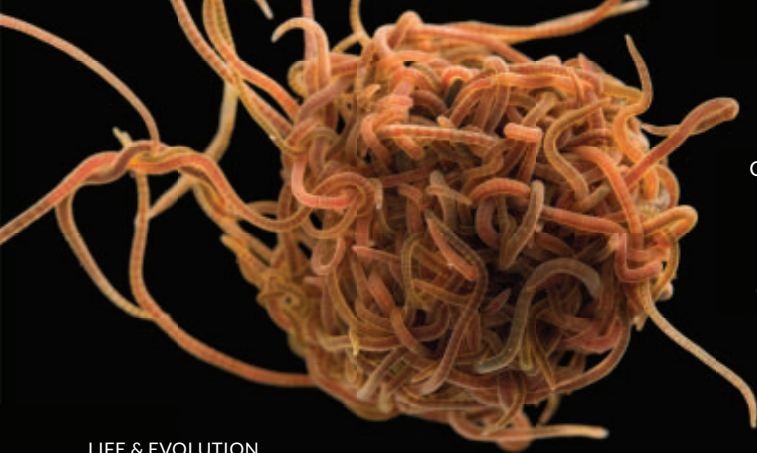
Endometriosis — in which tissue from the lining of the uterus invades other parts of the body, such as the ovaries, bowels and lining of the pelvis — can cause severe pain and infertility. Researchers don't know why endometriosis strikes. Women whose menstruation began before age 10, were of low birth weight or were exposed to a synthetic estrogen called diethylstilbestrol, or DES, in the womb are at an increased risk for the disorder. Having affected family members also puts one at risk.

The disorder is estimated to affect up to 10 percent of women of childbearing age. Among women with infertility, the

prevalence may be as high as 50 percent.

Reproductive biologist Jae-Wook Jeong of Michigan State University's Grand Rapids campus and his colleagues demonstrated that mice with sufficient amounts of HDAC3, which plays a role in increasing or decreasing genes' activity, are fertile. But in mice lacking the protein, the uterus is unable to receive an embryo, which must nestle into the organ's tissue for protection and nourishment during development. The embryo drifts in the empty space within the uterus, making pregnancy impossible.

The researchers also found that mice lacking HDAC3 had more collagen, a structural protein, in the uterus. Collagen is found in the abnormal, fibrous areas that develop in endometriosis. Learning more about HDAC3's role in how the fibrous areas arise, Jeong says, may lead to new treatments for the disease. ■



California blackworms can writhe around each other and tangle themselves into a small, twitchy marvel of collective behavior.

LIFE & EVOLUTION

Worm blobs act like a fluid and a solid

Scientists are learning how the animals move collectively

BY SUSAN MILIUS

TAMPA, FLA. — Blobs of worms flow like a fluid, plop like a solid and fascinate scientists.

A worm is as solid as any other animal. But a mass of California blackworms tangled together flows through a tube like a liquid. Pouring, heating and otherwise playing with worm blobs shows that a mass of worms has properties of both fluids and solids, Saad Bhamla reported January 5 at a Society for Integrative and Comparative Biology meeting.

A blob can hold itself together like a solid: When released to fall a short distance onto a hard surface, it plops instead of splashing, said Bhamla, a biophysicist at Georgia Tech in Atlanta. Video from his lab also revealed a worm blob version of melting. In a container of water where a hot spot develops, the blob starts fraying and “melts” away as some blackworms disentangle themselves and swim off, while others collectively move to a spot with a lower temperature. Chilling water causes the blob to solidify again as the animals rejoin the ball.

Blobs of worms that ooze along as a mass might help the study of biological physics, Bhamla said. Unlike some more famous group behaviors, such as birds flocking or fish schooling, worms in a blob nudge against each other and transfer forces directly. Such contact matters in some of biophysics’ profound questions about how little bits of soft matter come together as multicellular life.

Aquatic California blackworms (*Lumbriculus variegatus*) in the lab aren’t the only worms that know how

to gather together. Other moisture-sensitive worms will clump into tangles when stranded in dry places.

Worms that join a blob may have a better chance of escaping death from dehydration when marooned out of water, Yasemin Ozkan-Aydin, also of Georgia Tech, proposed January 6 at the meeting. In experiments exposing blackworms to air, a loner is usually dead within an hour. In a thousand-worm mass, though, about 20 percent of worms are still alive after 18 hours.

Ozkan-Aydin’s tests of blob behavior inspired abundant musing from meeting attendees on such mysteries as how the blobs stay together. Biologist Colleen Unsworth of the University of Akron in Ohio wondered whether there were signs of specialized roles in a blob, as with ants that serve as anchors when a colony builds a living bridge. To these and most questions, Ozkan-Aydin said that she hadn’t yet worked out a good way to track individuals and that much about worm blobs is still unknown.

Solenopsis invicta fire ants also mass together as a living material, a collective behavior that has long fascinated David Hu, also of Georgia Tech. Arrays of ants trap enough air for a colony to turn into its own life raft that floats in a flood.

In a talk on January 5 about fire ants’ collective constructions, Hu noted that they, like worm blobs, have qualities of both a solid and a fluid. Viscosity analyses show that dropping a penny into a mass of ants would be like dropping the coin into yogurt. Good to know in case anyone wants to grab a spoon and dig in. ■

BODY & BRAIN

Autism tied to fast neuron growth

Disorder traced to early stage of nerve cell development

BY LAURA SANDERS

Young nerve cells derived from people with autism are precocious, growing bigger and developing sooner than cells taken from people without autism.

That finding, described January 7 in *Nature Neuroscience*, hints that in some cases neurons veer off course early in brain development to cause the disorder.

As a proxy of brain growth, researchers led by Simon Schafer of the Salk Institute in La Jolla, Calif., transformed skin cells from people with and without autism into stem cells that then developed into neurons in the lab.

Compared with cells derived from five people without autism, cells from eight people with autism grew bigger, with longer and more elaborate branches. And a group of genes important for brain development switched on sooner.

Trouble in the autism-derived cells began just as the cells were on the cusp of becoming nerve cells, at the neural stem cell stage. Certain spots of cells’ chromatin, tightly packed genetic material, were more open and accessible than they should have been, an unfolding that can lead to abnormally active genes. The results show that open chromatin “can have major effects on neuronal development,” says neuroscientist David Amaral of the University of California, Davis.

When autism-derived cells were forced to skip the neural stem cell stage, the cells grew normally. That finding bolsters the idea that a discrete event at a particular time — opening of chromatin at the neural stem cell stage — may set the brain up for autism, says coauthor and neuroscientist Rusty Gage, also of the Salk Institute.

The studied cells came from people with one type of autism. Experiments should also be done with cells from people with different forms of autism, says UCLA neuroscientist Luis de la Torre-Ubieta. ■

ATOM & COSMOS

TESS brings in first haul of exoplanets

Since July, the telescope has spotted several strange worlds

BY LISA GROSSMAN

The next generation exoplanet hunter is coming into its own. NASA's Transiting Exoplanet Survey Satellite, or TESS, has found more than eight confirmed planets in its first few months of observing — and some are unlike anything ever seen before.

"The torrent of data is starting to flow," TESS principal investigator George Ricker of MIT said January 7 at a meeting of the American Astronomical Society.

TESS launched in April and began science observations in July. It's NASA's follow-up to the Kepler space telescope, which went dark in October after almost a decade of observing. Like Kepler, TESS watches for dips in starlight as planets cross, or transit, in front of their stars.

Unlike Kepler, which stared at a single patch of sky for years, TESS scans a new segment every month. Over two years, TESS will cover the entire 360 degrees

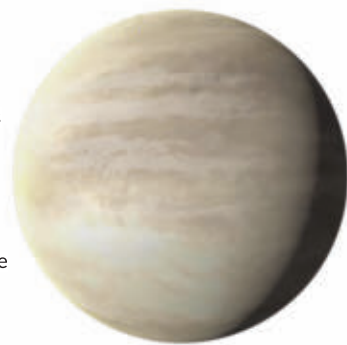
of sky visible from Earth's orbit.

In the first four segments, TESS has spotted more than eight confirmed planets and more than 300 unconfirmed ones, said Xu Chelsea Huang of MIT. Several of them are downright strange.

Take HD 21749b. Only 53 light-years away, it has one of the lowest known temperatures for a planet orbiting a bright, nearby star, scientists noted at the meeting and in a paper posted January 1 at arXiv.org. "If we want to study atmospheres of cool planets, this is the one to start with," Huang said.

"Cool" is a relative term. The planet's orbit takes 36 Earth days, the longest known orbital period for exoplanets transiting bright stars within 100 light-years of the sun. Astronomers estimate that the planet's surface is 150° Celsius, too hot for liquid water. And its density suggests that HD 21749b has a thick atmosphere unlike Earth's life-friendly one.

Pi Mensae c (illustrated) is a little more than twice the size of Earth and has a density similar to pure water.



But the planet is still worth checking out, says astronomer Diana Dragomir of MIT, a member of the TESS team. The planet is "tepid" compared with most of the scorched worlds whose atmospheres astronomers can probe right now, she says, which makes it closer to an Earthlike system. Smaller, cooler, more Earthlike worlds are few and far between.

Finding more longer-period planets "helps you explore the diversity of planets that are out there," says astronomer Paul Dalba of the University of California, Riverside, who was not involved in the TESS discoveries. Because TESS spends such a short stretch of time looking at each segment of sky, astronomers expect most of its planets to have years that are shorter than an Earth month. "The fact

ATOM & COSMOS

Fast radio burst is another repeater

Finding 2 duplicating events indicates there are likely more

BY LISA GROSSMAN

Astronomers have spotted a second repeating fast radio burst, and it looks a lot like the first. Finding a second repeating burst two years after the discovery of the first suggests that there could be many more of the mysterious signals in the cosmos.

Called FRB 180814.J0422+73 and about 1.6 billion light-years away from Earth, the burst is one of 13 newfound fast radio bursts, or FRBs — brief, bright signals of radio energy that come from distant galaxies. The FRBs were detected in 2018 by the Canadian Hydrogen Intensity Mapping Experiment, or

CHIME, in British Columbia. Astronomers reported the discoveries January 7 at the American Astronomical Society meeting and in the Jan. 9 *Nature*.

Most FRBs erupt once, last for a few milliseconds and are never seen again. So astronomers have puzzled over what causes them (*SN: 8/9/14, p. 22*).

"If you have something that flashes for a millisecond in the sky, and there's nothing that happens for many years, it's really hard to study," says CHIME team member Shriharsh Tendulkar of McGill University in Montreal.

Then in 2016, astronomers discovered the first repeating FRB when they realized that a series of bursts all came from a single source, called FRB 121102. Astronomers tracked the signal to its host galaxy and determined the FRB was coming from an extremely magnetic environment, such as the region around a black hole (*SN: 2/3/18, p. 6*). Of the more than 60 FRBs detected, no

other was known to repeat — until now. Now, scientists are searching for more.

"Imagine you saw a unicorn," says Tendulkar. "Then suddenly you discover another one. You know now there is a population of these. There is hope for discovering a lot more."

The CHIME team detected the first of the repeating FRB's signals on August 14, with four more coming over the next two months from the same spot on the sky. It wasn't until the third burst, on September 17, that the team realized the burst might be a repeater, Tendulkar says.

The researchers noticed an odd similarity between the two repeating FRBs. Most FRBs are just a sharp blip, akin to a single note played on a trumpet. But some of the individual bursts in both repeaters were made up of multiple sub-bursts that descended in frequency, like the "wah wah wah wah" of a sad trombone.

"We've seen this in 121102, and we can't explain it," says astronomer Emily

that we're already getting one that's longer-period I think is just really exciting, showing that TESS isn't just for the shortest-period exoplanets," Dalba says.

Other planets in TESS' first haul are equally exotic. Pi Mensae c, first reported in September, orbits its star every 6.27 days, and is about 2.14 times Earth's size and 4.8 times Earth's mass, giving it a density similar to pure water.

The weirdest thing about this super-Earth is the company it keeps, Huang said. The star that Pi Mensae c orbits also hosts a planet 10 times the mass of Jupiter that orbits every 5.7 years. That planet, Pi Mensae b, revolves on a wildly eccentric orbit, swinging between the distance of Earth and the distance of Jupiter from its star. "This is the most extreme system we know of that has this type of architecture," Huang said.

Theories of how planets develop such wonky orbits suggest that this super-Jupiter should have booted Pi Mensae c out of the system. "We are really surprised that the inner super-Earth actually survived," Huang said. "It's a mystery we really want to understand." ■

Petroff of ASTRON, the Netherlands Institute for Radio Astronomy, in Dwingeloo, who was not involved in the new work. The fact that both repeaters behave similarly could suggest that they have similar origins, she says.

Astronomers' theories for what causes FRBs are almost as numerous as known FRBs themselves. For now, it's unclear if the repeating bursts and single bursts both come from the same kinds of sources, or even if one-offs might also repeat if watched for long enough.

"It's the wild, wild west out there," Tendulkar says. "We have tantalizing clues, but it's hard to make definitive conclusions."

CHIME is likely to catch a lot more FRBs. The telescope was still being tested when it caught the 13 new ones, so it was not operating at peak performance. "They just barely turned on the telescope," Petroff says, "and they're already finding things." ■

ATOM & COSMOS

Cosmic 'Cow' baffles scientists

Far-off flare may point to a new way stars can die

BY LISA GROSSMAN

A mysteriously brief and bright burst whimsically called the "Cow" may reveal an entirely new type of stellar death.

Details of that stellar doom are hazy. Scientists are debating whether the flare-up, seen in 2018, was from a black hole eating a strange star or from an old, massive star exploding in a weird supernova.

Hawaii's Asteroid Terrestrial-impact Last Alert System telescope detected the explosion, officially named AT2018cow. "It was immediately dubbed, to avoid this mouthful of letters, the Cow," astronomer Daniel Perley said January 10 at the American Astronomical Society meeting.

The Cow appeared in a galaxy about 200 million light-years away from Earth in the constellation Hercules and was especially bright for being so distant. That brightness suggested the event was about 10 times as luminous as a typical supernova. It also appeared suddenly, going from invisible to peak brightness in two days. "This combination of being very fast and very luminous is very unusual," said Perley, of Liverpool John Moores University in England.

Other telescopes followed up, observing in a variety of wavelengths of light. "The Cow has become one of the most intensely observed cosmic events in history," Caltech astronomer Anna Ho said.

Those observations revealed that the Cow was surrounded by dense material

moving at a tenth of the speed of light. The burst lasted for several months, growing gradually dimmer. While dimming overall, it sometimes grew brighter in small irregular jumps, suggesting something continually fed energy to the explosion from the inside, Perley said.

One possible explanation for the Cow: a star getting torn apart by a black hole. But the star and black hole would have to be out of the ordinary. The flare was so short and ramped up so quickly that the star must have been only a fraction of the mass of the sun — perhaps a white dwarf, the end stage of stars like the sun. Astronomers have never seen a white dwarf shredded by a black hole before.

The black hole could have been between 100,000 and a million times the mass of the sun, which is almost as much as the black hole at the center of the Cow's host galaxy. Astronomers would have to explain how such a massive black hole ended up in the galactic outskirts.

Another option is a new kind of supernova. The fast, high-energy light that the Cow emitted could be explained by fast-moving debris fleeing the explosion and plowing through dense material, said astrophysicist Raffaella Margutti of Northwestern University in Evanston, Ill.

Margutti and Ho think the supernova, if it occurred, could have produced a fast-spinning black hole. If that black hole gathered up material from the explosion's debris, that would release the kind of energy Ho's team observed. Astronomers have seen stars die in supernovas before and have detected the black holes that such explosions can leave behind. "But the connection between the deaths and the formation of the corpse has not really been made," Ho says. ■



Using several telescopes, scientists saw a cosmic flare brighten and fade. In 2003 (left), the Cow, as the flare is known, was nowhere in sight (arrow points to where the flare later appeared). In June 2018, the Cow outshone its galaxy (center). A month later, the flare had faded (right).

MATH & TECHNOLOGY

Levitation tech reaches new heights

Gadget uses sound waves to move particles in all 3 dimensions

BY MARIA TEMMING

A new machine uses ultrasonic waves to make particles dance in midair like marionettes on (invisible) strings.

Unlike other devices that use sound radiation to manipulate matter, the new acoustic tweezers can move several objects in different directions at once (*SN*: 4/19/14, p. 8). This kind of levitation technology, described in the Jan. 2 *Proceedings of the National Academy of Sciences*, could assemble microelectronics or maneuver small objects inside the body for medical treatment.

In the new device, an array of 256 speakers, each about 1 centimeter wide, faces another, identical speaker array across a distance of 23 centimeters. The speakers emit sound waves at frequencies too high to hear, creating an intricate sound field between the two arrays. This sound field has high inten-

sity sound regions that repel particles and pockets of relative quiet that trap particles. By controlling the timing of the ultrasonic waves released by each speaker, researchers can shift these quiet, particle-toting regions around in three dimensions.

While laser tweezers can steer much smaller microscopic objects, sound waves can hoist micrometer- to centimeter-sized cargo (*SN*: 10/27/18, p. 16). The new device's 40-kilohertz sound waves can juggle up to 25 foam beads at a time, each 1 to 3 millimeters across. A future version that emits higher frequencies could nab smaller objects, like cells that are mere micrometers across.

The device's ability to move many particles in all three dimensions is

The device's sound waves can juggle up to 25 foam beads at a time, each 1 to 3 millimeters across.

"excellent progression" in acoustic levitation technology, says Christine Démoré, an ultrasound scientist at Sunnybrook Research Institute in Toronto who was not involved in the work.

Because sound waves travel through tissue, acoustic tweezers may someday deliver drugs to specific organs, clear out kidney stone debris or steer implanted medical devices to new locations inside the body, says study coauthor Bruce

Drinkwater, an ultrasonic engineer at the University of Bristol in England.

The technology could also facilitate hands-off construction of delicate microelectronic components, says study coauthor Asier Marzo, a computer scientist at the Public University of Navarre in

Pamplona, Spain. Or it could be used to manipulate levitated particles into free-floating 3-D images to create futuristic displays a la Princess Leia in *Star Wars* (*SN*: 2/17/18, p. 16). ■

NEWS IN BRIEF

HUMANS & SOCIETY

Paint specks in teeth illuminate a medieval woman's artistry

Remnants of a rare blue pigment found in the dental tartar of a woman buried about 1,000 years ago at a medieval monastery in Germany indicate that she may have been an elite scribe or book painter.

The pigment flecks come from ultramarine, made by grinding lapis lazuli stone imported from Afghanistan into powder, say archaeologist Anita Radini of the University of York in England and colleagues. Elaborately illustrated religious manuscripts made during Europe's Middle Ages were sometimes decorated with rare and expensive materials, including aquamarine. The new discovery, reported January 9 in *Science Advances*, supports recent historical research suggesting that it wasn't just monks who produced these books. Nuns did, too.

Based on the distribution of pigment

in her mouth, the woman was probably licking the end of a brush to create a fine point while painting, the researchers say.

Less likely scenarios, the group says, include the woman preparing paint for herself or other bookmakers, consuming powdered lapis lazuli for its alleged healing powers or ritually kissing painted figures while reading from prayer books. —Bruce Bower

MATTER & ENERGY

Weird type of zirconium soaks up neutrons like a sponge

When radiochemist Jennifer Shusterman and colleagues got the first results of their experiment, the researchers were surprised by what they saw: Atoms of a weird version of the element zirconium had enthusiastically absorbed neutrons.

That form, or isotope, of zirconium was zirconium-88, distinguished by the number of neutrons it contains. Typical zirconium has about 50 neutrons; zirconium-88, which is radioactive and

not found naturally on Earth, has fewer neutrons than normal, with 48.

When irradiated with low-energy neutrons from a nuclear reactor, each zirconium-88 atom had a high probability of absorbing a neutron into its nucleus, causing the element to transform into zirconium-89. The reaction was about 85,000 times as likely to occur as predicted, Shusterman, of Hunter College of the City University of New York, and colleagues report online January 7 in *Nature*. Only one other isotope, xenon-135, is known to be better at capturing neutrons.

Previously studied versions of zirconium are much more reluctant to take on another neutron, with absorption probabilities about a millionth that of zirconium-88, or less. Isotopes with a high neutron capture probability can help control nuclear reactors by sopping up loose neutrons to slow the rate of reactions. It's not clear if zirconium-88 will find a purpose. —Emily Conover

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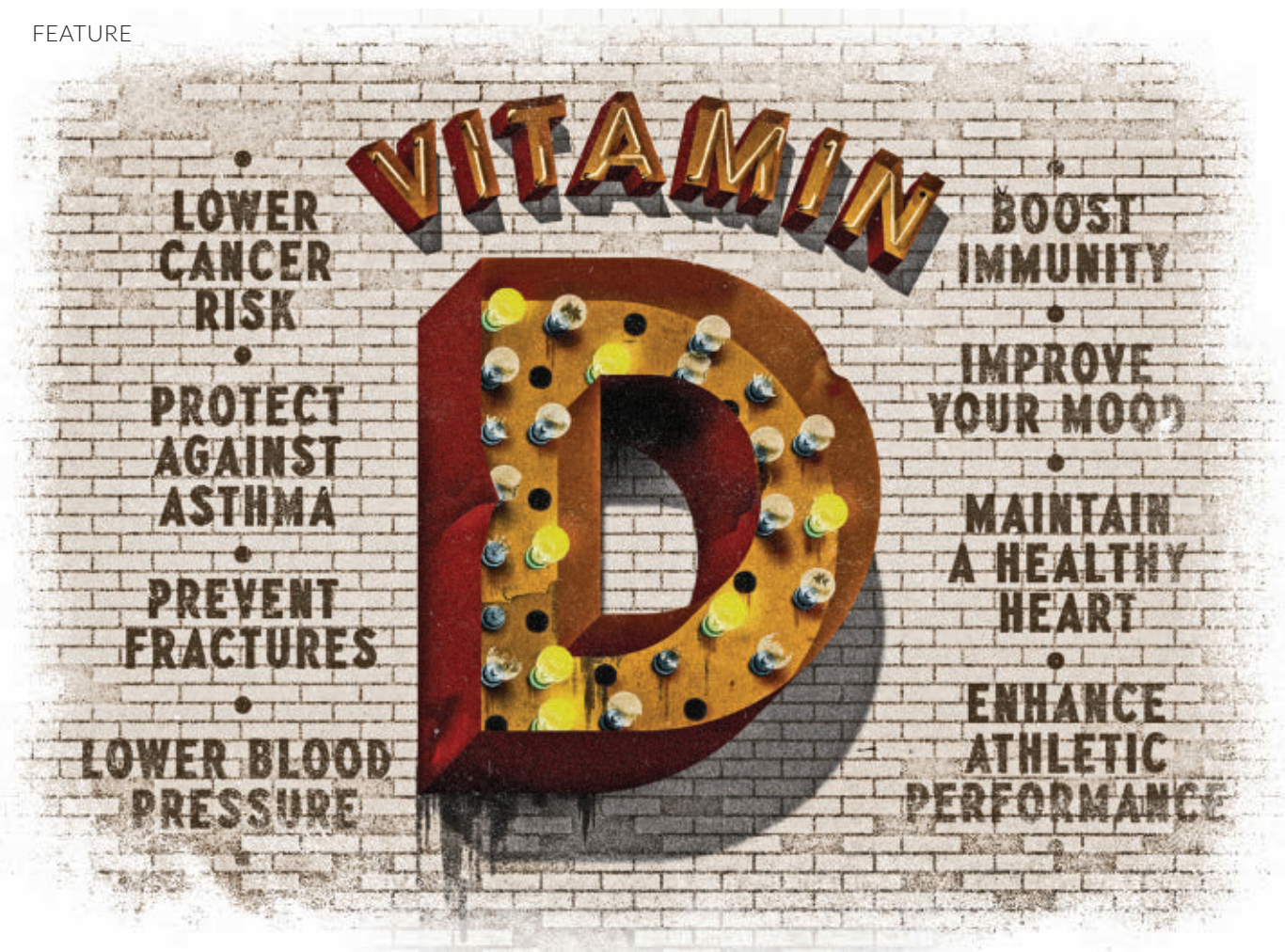


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D is for Discouraging

The celebrity supplement may be losing its luster **By Laura Beil**

In the supplement world, vitamin D is a bit like a Kardashian. Its fame seemed to come out of nowhere about a decade ago, garnering so much press so fast that it's hard to remember a time when people weren't talking about it.

Vitamin D had long been known for protecting bones, but its star began to rise in the early 2000s after researchers made connections hinting that vitamin D was good for a lot more than our skeletons. It appeared to help protect against a lengthy list of ailments, including multiple sclerosis, asthma, depression, heart disease and cancer. The vitamin also was said to improve athletic performance.

Organizations like the Vitamin D Council — the 2003 brainchild of a psychiatrist who became a vitamin D enthusiast — began to actively promote

the benefits to the public and to physicians, while selling test kits for vitamin D blood levels. Doctors checked for it; patients demanded testing. Researchers latched on.

But with more research comes more scrutiny, and most recently, a series of seemingly tarnishing findings. On November 10, the *New England Journal of Medicine* published the largest study so far to test vitamin D supplements' protection against cancer and heart disease. The results were generally interpreted as inconclusive at best and disappointing at worst. One 2017 review of the evidence for cardiovascular benefits concluded that studies of people taking vitamin D "have failed to show clear improvements in blood pressure, insulin sensitivity or lipid parameters." Even the vitamin's reputation for helping bones took

a hit last April from the U.S. Preventive Services Task Force. The independent group, which makes health policy recommendations, concluded that when it comes to preventing fractures, there is not enough evidence to recommend for or against supplementation.

Today, enthusiasm for the vitamin, at least in scientific circles, is fading, says Clifford Rosen, an osteoporosis researcher at the Maine Medical Center Research Institute in Scarborough. “I think even in the bone world, where we know vitamin D may have some effect, the studies aren’t very compelling.” Which leads to the question: Is the sun finally setting on vitamin D?

Shining a light

The answer, as with most matters of nutrition, is complicated.

One thing is indisputable: The body must have vitamin D. Throughout most of human history, rickets was a feared childhood disease. As babies became toddlers, their legs and arms would sometimes bend like willow branches. Even affluence offered no protection: Some victims were the sons and daughters of the Medici family, the powerful dynasty of the Italian Renaissance. Finally, in the early 1900s, doctors figured out the cause — insufficient sun. In 1919, a German doctor showed that rickets could be treated by exposing an affected arm to ultraviolet lamps. Remarkably, sun exposure on one arm healed both.

The cure came not from sunshine itself, but from vitamin D, an essential chemical that the body makes in the presence of UV light. For discovering the mechanism of vitamin D formation, German chemist Adolf Windaus won a Nobel Prize in 1928. Over the following decades, foods were increasingly fortified and rickets gradually disappeared in most places. Vitamin D became little more than a mention on milk cartons and bottles of orange juice.

In the body, this essential nutrient travels a convoluted path, starting with a substance in the skin called 7-dehydrocholesterol. In the presence of sunlight, that chemical is transformed into vitamin D, or cholecalciferol, and enters the bloodstream. When it reaches the liver, vitamin D is converted into another chemical, 25-(OH)D, or 25-hydroxycholecalciferol. In the kidneys and other organs, 25-(OH)D changes into the active form of vitamin D, called calcitriol. Calcitriol, a hormone, is so named because it encourages calcium absorption through the wall of the intestine into the bloodstream.

Vitamin D’s primary job is to help the body absorb calcium from food. Rickets occurs when bones are starved of calcium. Vitamin D also aids in the uptake of phosphorus, another bone-strengthening nutrient.

“For a long time, it was thought the benefit was mainly on bone health,” says Walter Willett, an epidemiologist and nutrition researcher at the Harvard T.H. Chan School of Public Health. Then scientists began to discover that a broad array of tissues contain proteins that serve as welcome mats for the vitamin. “There were receptors for vitamin D in almost every organ in the body, not just in bones,” Willett says. “What was vitamin D doing in places other than bone?”

By the late 1990s, scientists were finding links between low sunlight exposure and a variety of diseases, some of them surprising. Several studies noted that the farther north a person lived — a proxy for less intense sun — the higher the risk of multiple sclerosis and other autoimmune conditions. In one early study, published in *Cancer Epidemiology, Biomarkers and Prevention*, women who lived in the sunnier parts of the United States had breast cancer rates that were 25 percent to as much as 65 percent lower than women who lived farther north. Another study that made headlines in 2008, from *Archives of Internal Medicine*, reported that Americans in the lower quarter of vitamin D blood levels had a 26 percent higher chance of death over the nine years studied than those with the highest levels of vitamin D.

In other words, a lot of early research suggested that people with abundant vitamin D — or at least with the best chances of sun exposure — appeared to be healthier. Problem is, there may be other reasons that less sun correlates with certain diseases, says JoAnn Manson, chief of preventive medicine at Harvard-affiliated Brigham and Women’s Hospital in Boston. People may not be going outdoors because they are ill, for example, or less inclined to exercise.

The amount of sun “may not be causally related in any way to these health outcomes,” Manson says. Or a low vitamin D blood level could be a consequence of obesity; the vitamin is soluble in fat, so it can become sequestered inside adipose tissue. The detriment to health may not be from low vitamin D directly, but from excess body weight, too little physical activity or other known influences on a person’s health.

The central question today is not whether the body needs vitamin D — it absolutely does — but whether the average person should be taking



This girl had rickets, as shown by her misshapen right leg. Affluence was no protection from this disease of insufficient vitamin D and, in fact, may have promoted the disease because pampered children were discouraged from playing outside.

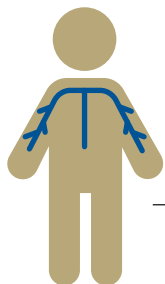


UV-B light from the sun reacts with 7-dehydrocholesterol in skin and creates **cholecalciferol** (vitamin D3).

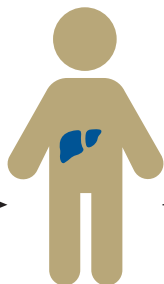
Vitamin D2 and D3 are consumed through foods and supplements.



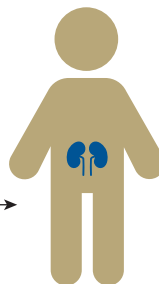
Does a body good? The body makes vitamin D when exposed to ultraviolet light, or absorbs it from food. Once in the bloodstream, vitamin D undergoes several transformations into a hormone that helps strengthen bones. Research showing its effects on other organs is coming up short.



Cholecalciferol is circulated through the blood to the liver.



The liver converts cholecalciferol to **25-hydroxycholecalciferol**.



The kidneys then convert 25-hydroxycholecalciferol to the active hormone **calcitriol**.

Calcitriol benefits:

- Increases absorption of calcium and phosphorus in the intestines
- Increases bone mineralization

Potential connections under study:

- Immune system
- Cancer
- Heart disease
- Multiple sclerosis
- Depression

a supplement. There is widespread public belief that it's a good idea. According to market research firm Euromonitor International, annual U.S. consumer spending on vitamin D has risen from \$248 million in 2008 to more than \$1 billion today.

One of the first randomized controlled trials to study vitamin D supplementation, by researchers at Creighton University in Omaha, Neb., was published in 2007. In that study, 1,179 women over age 55 were randomly assigned to take about 1,500 milligrams daily of calcium, calcium plus 1,100 international units, or IUs, of vitamin D (that's about twice the recommended dietary allowance, or RDA), or a placebo. Writing in the *American Journal of Clinical Nutrition*, the researchers reported a dramatically lower (more than 50 percent) cancer incidence after four years among the women in the vitamin D with calcium group compared with those who took a placebo — at least when the results analyzed women who had stayed in the study for a year or more. There were 18 cancers diagnosed after the second year in the placebo group compared with eight among women who took calcium plus vitamin D. The finding made sense because around this time, a growing number of laboratory studies demonstrated that the vitamin had anticancer properties in lab animals.

"People tended to glom on to positive results because they wanted them to be true," says Steven

Abrams, a pediatrician at the University of Texas at Austin and a member of a 2010 Institute of Medicine panel that evaluated vitamin D (*SN*: 7/16/11, p. 22). "Negative studies were buried, harder to find."

In 2010, a headline in the *New York Times* read, "Vitamin D, Miracle Drug: Is It Science, or Just Talk?" The story described a clinical trial named VITAL that was just starting at Brigham and Women's Hospital, with Manson as one of the study leaders. At almost 26,000 participants, VITAL would become the largest randomized trial to measure whether men over 50 and women over 55 who took a daily vitamin D supplement of 2,000 IUs were protected from cancer and heart disease. (The study also tested fish oil supplements.) Importantly, more than 5,000 volunteers were African-American. People with darker skin may have a harder time making vitamin D in sunlight because they don't absorb as much UV light, the driver of vitamin D formation. VITAL became one of the most anticipated vitamin D studies.

\$1 billion

U.S. consumer spending on vitamin D today



\$248 million

U.S. consumer spending on vitamin D in 2008

D-flating news

VITAL trial results were released in November in Chicago at the American Heart Association's annual scientific sessions and published in the *New England Journal of Medicine*. Fish oil supplements offered some benefits, preventing heart attacks, but not stroke. Extra vitamin D offered no heart protection (*SN*: 12/8/18, p. 9).

As for cancer prevention, the study produced “a complex finding,” Manson says. Over the entire five years, there was no reduction in the risk of being diagnosed with breast, prostate or colon cancer, but the overall risk of dying from cancer was slightly lower. In all, 154 deaths from cancer occurred in the vitamin D group versus 187 in the placebo group. When the analysis was narrowed to those who were in the trial for at least two years, the researchers saw a 25 percent reduction in death from cancer with vitamin D. Perhaps vitamin D makes tumors less likely to grow and spread, Manson says. If that’s true, any benefit would take time to appear. “This warrants further study,” she says.

The VITAL results were the latest of a string of largely discouraging news. In 2017, scientists had reported the results of a study testing whether monthly high doses of vitamin D could prevent heart problems. About 5,000 people from the general population of New Zealand were randomly assigned to receive the vitamin D boost or a placebo. In *JAMA Cardiology*, the researchers reported that supplementation made no difference.

As a safeguard against bone fractures, vitamin D has not fared much better. Because the vitamin is necessary for bone health, many doctors recommend supplements for older people to help prevent breaks and falls. Yet the U.S. Preventive Services Task Force concluded last spring that the evidence for this advice was still inconclusive. Another blow came in October, when researchers reported in *Lancet Diabetes and Endocrinology* that a review and summary of studies so far “suggest that vitamin D supplementation does not prevent fractures or falls, or have clinically meaningful effects on bone mineral density.”

That’s not as surprising as it may seem, even given vitamin D’s claim to fame in bone health, says Catharine Ross, a nutritional biochemist at Penn State who chaired the 2010 vitamin D panel. Bone is built early in life, she says. Later in life, the body works to preserve that bone. Much of that preservation isn’t orchestrated by vitamin D itself, but by the hormone calcitriol, whose production is limited by the liver and kidneys. In other words, more vitamin D on the front end doesn’t necessarily mean more of the hormone on the back end.

The news for cancer from studies other than VITAL has also been inconsistent. On the supportive side of the ledger, a compilation of studies on colorectal cancer, published last June

in the *Journal of the National Cancer Institute*, found a clear elevation in risk for people with the lowest blood levels of the vitamin. People who had a vitamin D blood level below 12 nanograms per milliliter had a colorectal cancer risk 31 percent higher over five years than those whose blood levels were twice as high.

Yet a 2017 study found that the big reduction in cancer incidence announced in 2007 by Creighton University researchers didn’t hold up. In contrast to the 2007 trial, this one, reported in *JAMA*

by many of the same Creighton researchers, found no difference in cancer risk among postmenopausal women who took vitamin D and calcium and those who took a placebo.

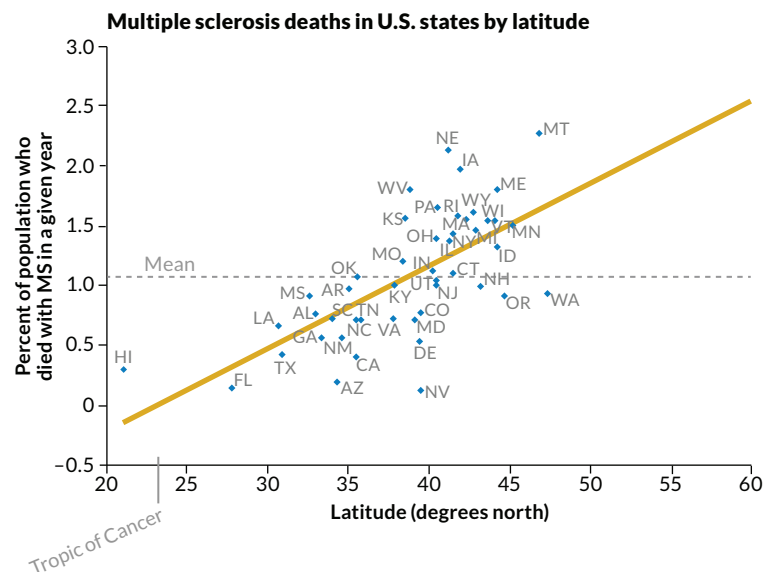
Overall, “there have been enough systematic reviews and large randomized controlled trials suggesting that vitamin D does not have an effect in the primary prevention

“People tended to glom on to positive results because they wanted them to be true.”

STEVEN ABRAMS

of cancer,” says Cindy Davis, director of grants and extramural activities at the Office of Dietary Supplements, part of the National Institutes of Health. She names a long list of groups that have looked at the research, including the Institute of Medicine (now the National Academy of Medicine), the Agency for Healthcare Research and Quality, the U.S. Preventive Services Task Force and

Help for MS Evidence that vitamin D might help protect against multiple sclerosis has been building. One recent report found generally higher death rates from MS in northern U.S. states, where sunlight is less intense and winter days are shorter, compared with southern states. (In the graph below, a few states are excluded because of low population numbers.) Researchers are now testing whether vitamin D supplementation added to MS treatment might help people with the disease.



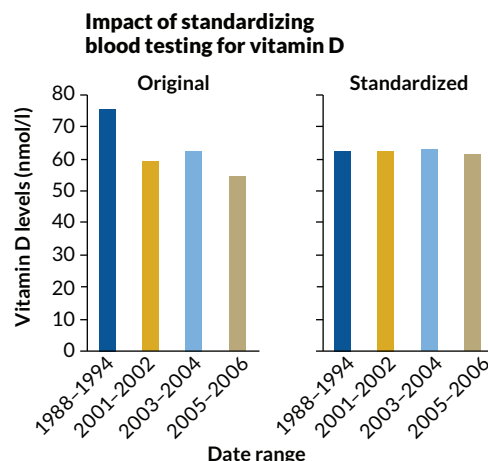
SOURCE: G.E. DAVIS AND W.E. LOWELL/J. PHOTOCHEM. AND PHOTOBIO. B: BIOL. 2015

the World Cancer Research Fund International.

“They’ve all said that there’s not enough evidence, or that the evidence suggests that vitamin D supplementation does not appear to be protective” against cancer formation, Davis says.

But Willett, the Harvard nutrition expert, thinks studies so far have been too short to meaningfully address the cancer question. Most tumors unfold quietly over decades, so even a five-year study might not be long enough. It would take a decade or more for solid answers. “People can smoke for 20 years and there’s no effect on cancer risk,” he says. He points to the recent colorectal cancer review suggesting a big reduction in risk with higher blood levels of vitamin D. “If that was a drug, it would be a blockbuster.”

He also says that there are diseases, such as multiple sclerosis, that have held up over time as being associated with sunlight or vitamin D. One of the latest studies appeared in April in *Neurology*. Researchers from Harvard and the University of British Columbia in Vancouver measured the risk of multiple sclerosis across a lifetime of sun exposure. People who lived in areas with the highest amounts of UV light had a 45 percent lower risk of the disease than those who lived in areas



Results may vary Controversy has surrounded vitamin D testing, which has lacked rigorous standards. Analysis by one method (left) suggested that vitamin D levels were falling among Americans. Yet a more standardized analysis of the same samples (right) showed very little difference. SOURCE: N. BINKLEY ET AL./J. STEROID BIOCHEM. MOL. BIOL. 2017

with the lowest sun exposure, and the protection appeared to be much more pronounced among people who reported high summer sun in childhood and adolescence. Studies are now testing whether adding various doses of vitamin D to regular treatments can help people with MS. Other studies are testing prevention or treatment of asthma, diabetes and depression.

Testing tumult

Judging by the market, millions of health-conscious consumers aren’t waiting for science to work everything out. Some researchers worry that promotion of vitamin D has created a misguided “more is better” mind-set. At high doses, “there are some studies that do show harm,” says Davis, of the NIH Office of Dietary Supplements. Participants in the VITAL study, which included a daily dose of 2,000 IUs, did not appear to have any major side effects. But some pills are sold at much higher amounts, as high as 50,000 IUs to be taken weekly.

And some pills contain the less-accessible form of vitamin D produced by plants, called D2, not the version made by the human body, called D3. Nothing about vitamin D is simple. Its effects probably have a U-shaped curve for some diseases, Davis says. Too little or too much in the bloodstream can be harmful, but most levels in the middle are fine.

One paper published in 2018 in *Cancer Research* examined 19 studies of vitamin D’s association with prostate cancer. That analysis found that higher levels of vitamin D were associated with



Sunshine on my shoulder

The National Academy of Medicine advises a vitamin D intake of 600 to 800 international units per day to achieve blood levels of 20 nanograms/milliliter of the nutrient (one of the lower recommended thresholds). To make enough from the sun, depending on the latitude and season, about 10 minutes outside in shorts and a T-shirt will do for a light-skinned person. People with darker skin need more time.

Recommended minimal vitamin D blood level

National Academy of Medicine	20 ng/ml
Endocrine Society	30 ng/ml
Vitamin D Council	50 ng/ml

an increased risk of prostate cancer, although the researchers say this could be due to detection bias — perhaps the men with high vitamin D were more health conscious and more likely to get screened for the disease.

Which gets back to the thorny issue of whether it's necessary to check your vitamin D levels, which can cost from around \$50 to more than \$100 if it's not covered by insurance. Testing has grown exponentially, Willett says, yet “we still don't know what target number we should be aiming for.”

Public health officials recommend blood levels above 20 ng/ml. The Endocrine Society, which represents doctors, states that some adults are deficient if their levels are below 30 ng/ml. Advocates like the Vitamin D Council set higher thresholds.

In addition to disagreement over a target number, there is controversy over which form of vitamin D to measure, and how to measure it. Davis says testing is tricky because the vitamin goes through several steps to get to its active form. The best marker of vitamin D status is 25-(OH)D, she says. That's the form that the liver makes (not the kind that enters the bloodstream from the skin). But until recently there were no standards for measuring 25-(OH)D.

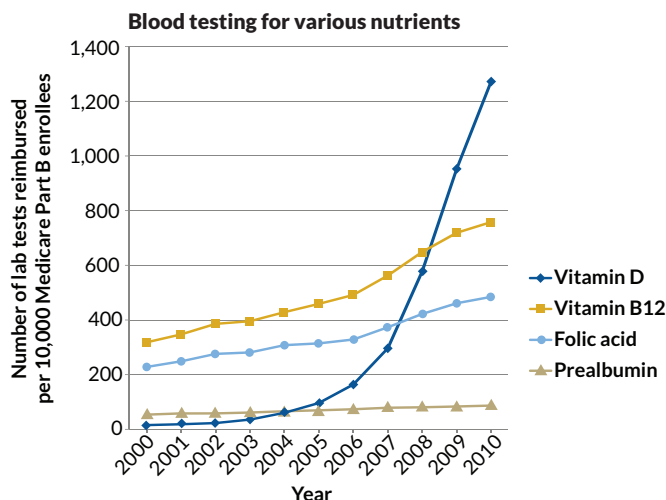
A 2017 report in the *Journal of Steroid Biochemistry and Molecular Biology* pointed out how results can vary from test to test: One method suggested a decline in vitamin D levels in the American population from the late 1980s to the early 2000s; another, testing blood from the exact same people, showed no change. Same samples, different test, different results. As the authors note, “the vitamin D field is in chaos.”

Willett doesn't see much value in focusing on blood test numbers. Even if you don't know your exact levels, taking 1,000 or 2,000 IUs “is a reasonable thing to do,” he says, given studies finding that the level is safe and showing evidence of benefit against cancer death.

Rosen, from the Maine Medical Center, doesn't think the supplements will make a dramatic difference in health, but agrees that a 2,000-IU supplement won't do harm either. “When I go and talk to doctors I say, ‘How many [of you] are taking vitamin D?’ The hands go up,” he says. Most of them. When he asks why, the doctors respond, “‘Eventually it's going to be proven that it prevents

“If people could master the basics, they wouldn't have to worry about supplements.”

DENA HERMAN



Testing bonanza With growing publicity on potential health benefits of vitamin D, testing for the nutrient surpassed testing for other nutrients in older Americans after 2008. SOURCE: S. SHAHANGIAN ET AL/ARCH. PATHOL. LAB. MED. 2014

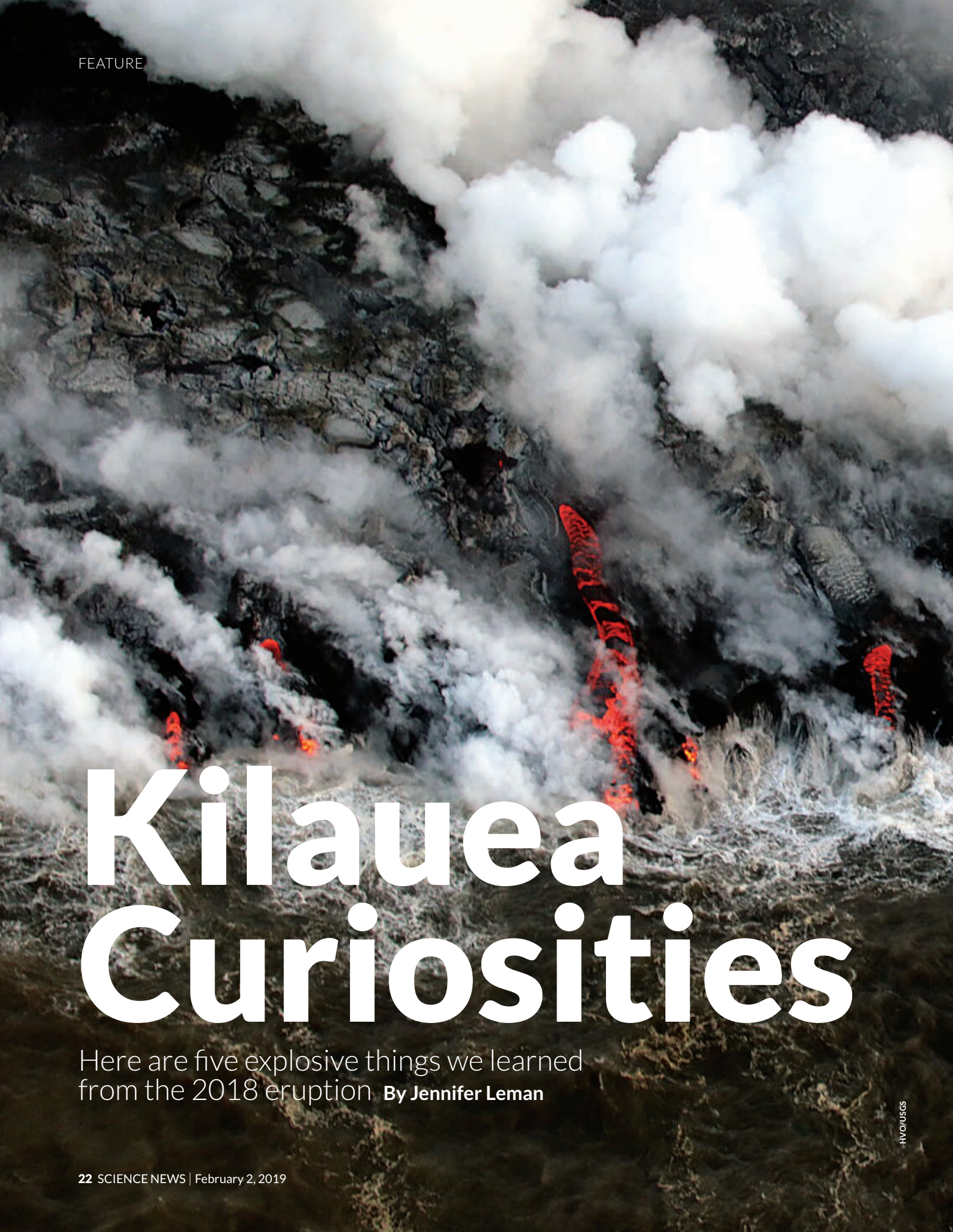
something.” Belief in vitamin D runs deep.

That said, there are certain populations that doctors already know may need supplements to reach even minimally adequate levels: babies who are exclusively breastfed, some people with dark skin, some who live in northern latitudes and people who don't have much exposure to daylight because they live in institutions such as nursing homes or hospitals.

Amid the uncertainty, clinicians are left to advise patients. By nature, researchers zero in on just a few specifics in their studies. “But the world isn't like that. The world is very complicated,” says Dena Herman, a nutrition researcher at the UCLA Fielding School of Public Health. In the end, people have to consider their own personal circumstances, she says. Herman doesn't immediately suggest supplements when a patient appears to have inadequate levels of vitamin D. Often these patients are overweight, which could be affecting their vitamin D levels. “I usually recommend they get more physically active and get in the sun first,” she says. “If people could master the basics, they wouldn't have to worry about supplements.” ■

Explore more


■ Robert Scragg *et al.* “Association of sun and UV exposure with blood pressure and cardiovascular disease: A systematic review.” *Journal of Steroid Biochemistry and Molecular Biology*. November 6, 2018.



FEATURE

Kilauea Curiosities

Here are five explosive things we learned
from the 2018 eruption **By Jennifer Leman**



Fire and fury Kilauea's eruption last summer, its largest in 200 years, gave scientists a front-row seat to the volcanic processes that power the planet. In this image from August 5, lava heated to 1000° Celsius pours into the Pacific Ocean, sending a mixture of volcanic gases and evaporated seawater into the air.

After a stunningly volatile 2018, Hawaii's Kilauea volcano, which had been continuously erupting since 1983, finally seems to be taking a break. Following 35 years of nonstop activity, no lava is currently flowing from the Big Island's most famous volcano.

Scientists thought they knew Kilauea pretty well. It's one of the most closely monitored volcanoes in the world, with instruments watching the volcano's every move since the early 1900s. But the 2018 eruption still managed to offer up surprises.

"Everybody's chewing on all the great data collected from this eruption," says Christina Neal, the head scientist at the U.S. Geological Survey's Hawaiian Volcano Observatory on the Big Island. "That will go on for years and years." Neal coauthored a study published online December 11 in *Science* describing some of the initial findings.

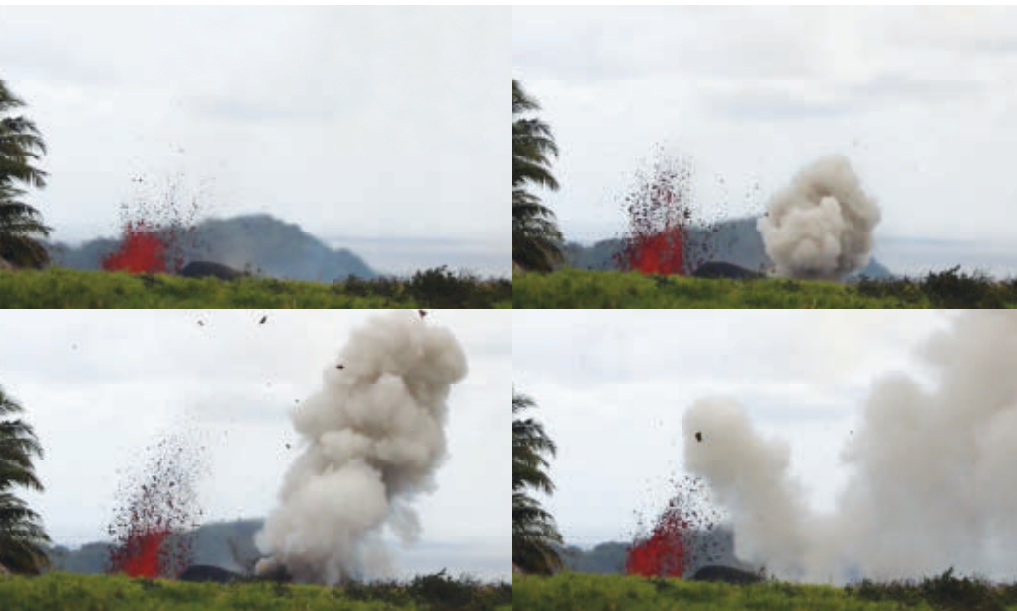
The latest episode started last May, as lava drained from the summit crater, flowing out at a rate of 50 meters per day.

The molten rock gushed through underground tunnels and out linear eruption vents, or fissures, along an area called the lower East Rift Zone. By the time the eruption ended in August, Kilauea had destroyed more than 700 houses, covered 35.5 square kilometers of land and added almost 300 hectares of seafloor along the island's southeast coast.

In addition, more than 825 million cubic meters of earth from the area around the summit crater collapsed, deepening Kilauea's caldera. That's enough material to fill about 300,000 Olympic-sized swimming pools, Kyle Anderson, a USGS geophysicist in Menlo Park, Calif., said December 11 in Washington, D.C., at an American Geophysical Union meeting.

With the massive collapse, the cliff-hugging Jaggar Museum, Hawaii Volcanoes National Park's popular museum and research station, suffered damage and is closed indefinitely.

No one knows what's next for the volcano, but five early findings from Kilauea's latest outburst, described on the following pages, show some of Kilauea's distinctive impacts.



Big blasts Most of the fissures on the lower East Rift Zone produced incandescent spouts of molten basalt lava (red, in this series of images). Silica-rich andesite, however, rocketed out of a fissure (gray plumes), producing more explosive eruptions.

1. Really old lava explains why some fissures were extra explosive

On May 13, lava suddenly exploded from a new fissure along the lower East Rift Zone. “There was this really loud banging that sounded like cannon shots,” says Christoph Kern, a geochemist at the USGS Cascades Volcano Observatory in Vancouver, Wash. Kern was working in the rift zone at the time.

Blocks of rock and ash flew hundreds of meters into the air. “It was reminiscent of a war zone,” Kern says. One man, who had not evacuated from his nearby home, suffered a shattered leg after he was struck by molten rock blasted from the fissure.

When the lava cooled enough for researchers to collect samples, the scientists were shocked. Kilauea “erupted a magma like we’ve never seen before” in Hawaii, says Cheryl Gansecki, a volcanologist at the University of Hawaii in Hilo.

“When I first got the analysis back, I told my student, ‘You’ve made a mistake; go do it again,’” she says. The molten rock was andesite, which is not usually found in Hawaii.

The Hawaiian Islands are dominated by basalt, a dark volcanic rock rich in iron and magnesium. Andesite contains more

silica and gas bubbles than basalt. That extra gas makes eruptions extra explosive. Andesite is commonly ejected from volcanoes in regions where tectonic plates slip beneath one another, such as in the Andes in Chile or the Cascades in the Pacific Northwest. Hawaii, however, isn’t near a tectonic plate boundary; its volcanoes are fueled by a “hot spot,” a plume of magma that rises from Earth’s interior.

The andesite was also much older than lava erupted from nearby fissures, Gansecki says. She suspects the andesite might have evolved from basaltic magma that was trapped underground during a previous eruption or from very deep molten rock that gradually crept up toward Earth’s surface over time. When basaltic magma cooks beneath Earth’s surface for a long time, some crystals may slowly solidify and settle out of the liquid, changing the overall chemistry of the rock.

“We kind of knew that these magmas were sitting around a little bit and then getting pushed to the surface,” but seeing a lava type with minerals this changed on the island was a first, Gansecki says. Being aware that these pockets of older, gas-rich magma exist will help scientists better prepare for the potential of explosive eruptions at Kilauea.



Fume side of the fissure Toxic gases quickly choked and killed plants downwind of the lava flow in the lower East Rift Zone (left side of this image). Upwind, tropical vegetation largely escaped the harsh conditions (lower right).

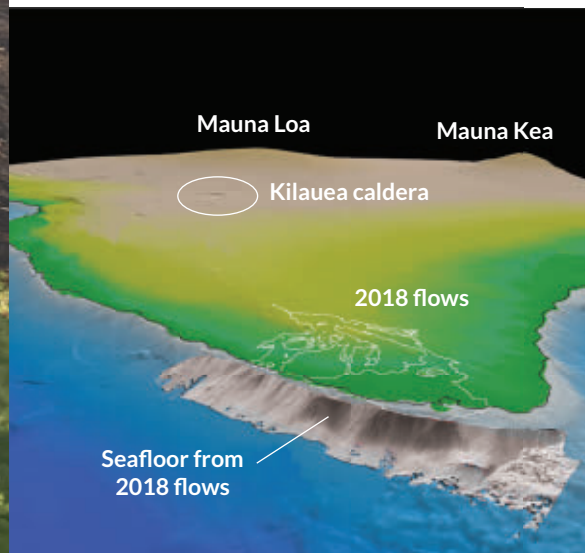
2. Lava traveled far and fast

The 2018 eruption peeled back Earth's layers to reveal that Kilauea's plumbing system — from the summit crater to 24 active fissures — is very clearly connected, says geophysicist Ingrid Johanson of the USGS Hawaiian Volcano Observatory.

Scientists tracked the volcano's activity in exquisite detail. Within minutes of a collapse at the summit, tiltmeters, which measure small vertical shifts in Earth's surface, registered pressure pulses along the East Rift Zone. Within hours, scientists saw increased levels of lava gushing out of fissures more than 40 kilometers from the summit.

Volcanologists witnessing collapses at the summit were able to warn colleagues who were inspecting lava flows along the lower East Rift Zone. "Word would go out to the field geologists: 'Be on guard in a couple of hours; we think there's going to be a pulse,'" Johanson says.

Surges in lava flow can cause a river of molten rock to spill over the sides of a fissure's channel — a danger to geologists working near the fissures. Fortunately, no researchers were injured by these overflows.



Flowing far On Hawaii's Big Island, Kilauea's caldera, drained of its lava lake in early May, spurred months of eruptions up to 40 kilometers away, along a system of fissures on the southeastern part of the island. The lava added close to 300 hectares of new seafloor (dark gray) along the southeast coast.



Going, going, gone

The lava lake that once bubbled inside Kilauea's summit crater (top, shown on April 13, 2018) drained in early May, spurring a series of collapse events that deepened the caldera by more than 500 meters (bottom, July 28).



3. The caldera collapsed in stages

This most recent activity gave scientists a rare chance to study the collapse of a caldera. Only seven other caldera collapses have been observed worldwide since 1900 — and never with this level of detail, Anderson says. In 2014, for instance, Iceland's Bárðarbunga volcano experienced a similar “piston-style” caldera collapse, in which a large block of land sinks down into a volcano's magma

chamber below. But that remote collapse was obscured by snow and ice, making it difficult to monitor.

Surprisingly, 62 small collapses rattled Kilauea from mid-May to late August rather than a single, big one. Each collapse spurred more than 700 earthquakes and caused the crater floor to sink further, pushing the surrounding land out and up. By the end, the center of the volcano was more than 500 meters

lower than when it started — more than the height of the Empire State Building.

The collapses seemed to happen at regular intervals — roughly every 25 to 35 hours, Kern says. That was the amount of time it took for enough pressure to build inside the magma chamber, at which point gas escaped through cracks around the summit crater, sending rock and ash into the air. With the pressure release, the caldera sank further.

4. Microbes moved in quickly

Where the eruption flowed into the ocean, marine life sprouted along newly deposited lava flows surprisingly fast. Using a remotely operated vehicle to explore the seafloor, researchers in September found bright yellow, potentially iron-oxidizing microbes in areas of hydrothermal activity about 650 meters deep, just offshore.

"I wondered if we were in the right place," says geologist Chris German of Woods Hole Oceanographic Institution in Massachusetts. "But I could see the fresh walls of lava still steaming on the shoreline." It had been only 100 days since lava first entered the water. "We really were in the right place, and it had

been colonized," he says. German and colleagues are now trying to identify the species of microbe.

Studying these new ecosystems may help explain how life could form in hydrothermal environments elsewhere in the solar system, such as Saturn's moon Enceladus (*SN*: 5/13/17, p. 6). On Earth, hydrothermal activity is common where tectonic plates meet — not a good analog for alien worlds, which appear to lack plate tectonics. But other worlds can be volcanically active, German says. Observing hydrothermal systems fueled by Kilauea and other volcanoes that aren't along tectonic boundaries could reveal a lot about the conditions on other celestial bodies.



New life Just months after Kilauea's lava flowed into the sea, yellow tufts of microbes (shown here) lined the edges of the freshly deposited earth.

5. Sulfur dioxide gas levels went through the roof

In 2018, Kilauea belched out some of the highest levels of sulfur dioxide ever measured at the volcano. The island was swamped by such high levels of the gas that Hawaii County's Civil Defense issued island-wide air quality warnings.

Such high levels are "something that we don't often see," Kern says. Volcanic smog, also called vog, is a gaseous mixture composed mostly of water vapor, sulfur dioxide and carbon dioxide. One of many hazards associated with volcanic eruptions, the emission of sulfur dioxide can irritate the skin and eyes and, if inhaled, choke airways (*SN*: 7/7/18, p. 32).

In some instances, as much as 100 to 200 kilotons of the gas were released per day. Before the heightened activity, Kilauea emitted roughly five kilotons of sulfur dioxide daily, mostly through the summit crater's lava lake.

Now, Kilauea appears to be in a hiatus. It's producing much less sulfur dioxide, about 35 tons per day, and seismic activity has plummeted. There hasn't been much land movement, save for swelling around the East Rift Zone's Puu Oo vent, which indicates that magma could still be creeping deep below. Nobody expects the volcano to stay quiet forever, Neal says. "We're in this lull, and we just don't know what is going to happen next." ■

Explore more

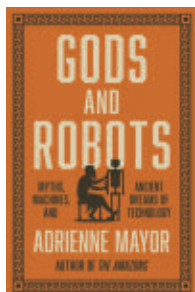
- Christina A. Neal *et al.* "The 2018 rift eruption and summit collapse of Kilauea volcano." *Science*. December 11, 2018.

Jennifer Leman is a freelance science writer and former intern at Science News.



Gurgling gases

A scientist with the U.S. Geological Survey measures fumes along a fractured, ash-covered road in Leilani Estates, on the lower East Rift Zone. Noxious gases, such as sulfur dioxide and carbon dioxide, caused closure of Hawaii Volcanoes National Park from May 11 to September 22.



Gods and Robots
Adrienne Mayor
PRINCETON UNIV.,
\$29.95

myths expressed hopes and fears about human-made life long before conversational robots and computer chess champions flexed their algorithms. Mayor argues that myths influenced, and were influenced by, real animated machines invented by ancient engineers.

Many Greek myths focused on what Mayor calls *biotechné*, or “life through craft.” Consider Talos, a giant bronze robot in the epic third century B.C. poem “Argonautica,” which tells the story of Jason and the Argonauts. Hephaestus, blacksmith for the gods, created the automaton Talos to guard a kingdom on the island of Crete. When Jason’s crew arrives, Talos breaks rocks off a cliff and heaves them at the sailors. When the sorceress Medea fixes a disorienting glare on Talos, the giant

BOOKSHELF

The allure of robots goes back to antiquity

Artificial intelligence and robotics are hot scientific fields today. But even in the brave new world of AI, there’s nothing new under the sun, writes classics and science history scholar Adrienne Mayor in *Gods and Robots*.

In a breezy and thought-provoking account, Mayor describes how ancient Greek, Roman, Indian and Chinese

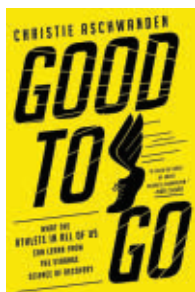
stumbles, cuts his ankle on a rock and, in a sense, bleeds out. A single internal vein carried Talos’ life force, a substance called ichor that in Greek myths granted immortality to the gods.

Talos’ tale demonstrates how the Greeks used biological knowledge to inform myths of manufactured beings and to ponder a future in which technology could produce artificial life. Talos’ anatomical weak point was chosen for a biological reason, Mayor argues. Ancient medical texts on bloodletting procedures describe a thick ankle vein as best suited for draining blood from patients. In early versions of the myth, a nail in Talos’ ankle sealed in the fluid that animated his body.

Other parts of the book recount how Greek myths imagined robotic servants and a beautiful but deceitful artificial maiden programmed to unleash disasters on humankind. Her name was Pandora. She offered a warning about the dangers of life that’s “made, not born,” Mayor writes.

Mayor also explores accounts of actual self-moving machines. Egyptians, for instance, created a seated female statue that stood up, tilted over to pour milk from a vessel and sat down. Gears, weights and other parts may have moved the nearly 4-meter-tall figure, known only from a description.

As Mayor explains, ancient civilizations told tales of a conflicted desire to transcend death and create artificial life. Those same longings inspire some of today’s humanoid bots and brain-computer interfaces. But, she cautions, modern algorithmic entities have weak points, just as Talos did. — *Bruce Bower*



Good to Go
Christie Aschwanden
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on a protein-packed smoothie, squeeze into compression tights or shell out some money for an expensive shakeout on a vibrating device. Sports recovery has become an industry worth hundreds of millions of dollars. But which, if any, of these methods actually work?

In *Good to Go*, science writer and athlete Christie Aschwanden places everyone’s exercise-recovery darlings under the microscope of scientific skepticism. Recovery is relatively simple. It’s just about getting the body ready to perform again, hopefully harder, faster and better. And yet, she notes, athletes have “managed to make every aspect of it ... vastly more complicated, expensive and time-consuming.”

In a fascinating, whirlwind investigation into recovery

BOOKSHELF

Tackling the real science of sports recovery

A tough workout, a long hike or a day reorganizing the garage can leave a body tired, sore and injured. Some kind of recovery is clearly in order. But relaxing on the couch with Netflix and some chips is so passé.

Instead, a sore athlete might stand naked in a chamber of air chilled to well below –100° Celsius. She could slurp

techniques, Aschwanden subjects herself to rigorous workouts followed by infrared saunas, cupping and drifting in a sensory deprivation tank.

When there’s no real research available to assess a claim, Aschwanden uses her skills obtained from previous lab work to design an experiment. She brings runners into a lab to find out, for instance, if her recovery beverage of choice — beer — really works. (It has liquid, carbs and some minerals. What could possibly go wrong?) The result is both enjoyable and insightful, as she picks apart her own experiment’s results.

The book offers a useful introduction to how scientific research works — and why, in sports science, it often doesn’t. Such insights make *Good to Go* appealing to more than just gym rats and weekend warriors. It’s for anyone who wonders how scientific studies happen, and how they influence the claims on products found in grocery stores and athletic stores alike.

Aschwanden’s take is clear-eyed, but also sympathetic. We all want to believe our recovery regimens work. Many of the effects we feel might be the placebo effect, Aschwanden concludes, but that’s not necessarily bad. What the body needs most to recover is rest and time, she discovers, and “your only choice is about what you’ll do in the meantime.” Fancy gadgets are fun, but old-fashioned rest, say, sitting down for a good book about recovery, might give a sore body the respite it needs to mend. — *Bethany Brookshire*



✓Yes



✓Yes



xNo



✓Yes



✓Yes

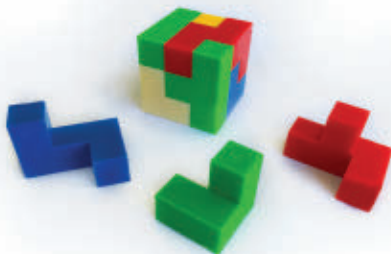


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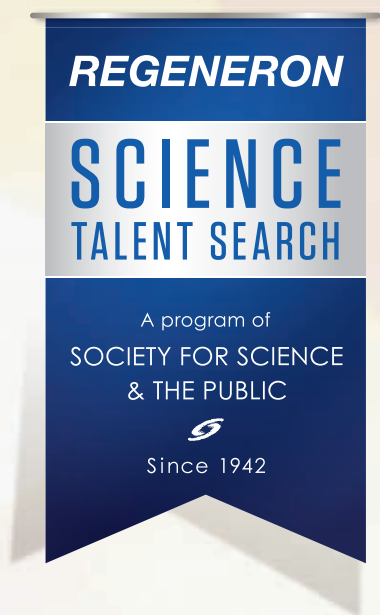
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DECEMBER 8, 2018

Gut connection

*Abnormal proteins tied to Parkinson's disease may form in the gut before traveling through the body's nervous system to the brain, **Laura Beil** reported in "Parkinson's pathways" (SN: 12/8/18, p. 22).*

The vagus nerve offers a connection between nerves in the gut and those in the brain. **Beil** reported on one study that showed that people who had their vagus nerve cut above the stomach had a lower Parkinson's incidence starting five years postsurgery than people who did not have the surgery. Reader **Terrence Kerwin** wondered why there was a delay between the surgery, known as a vagotomy, and the drop in Parkinson's disease risk.

"It's possible that by the time of the vagotomy, abnormal proteins may have already reached the peripheral nervous system," **Beil** says. From there, the proteins can continue to the brain. So rates might not diverge immediately.

Reader **Alecia Flores** wanted to know more about fecal transplants as a potential treatment for Parkinson's.

While growing evidence suggests a gut connection to the disease, the role of the microbiome remains unclear. At this point, fecal transplants are used only for treating infections caused by antibiotic resistant *Clostridium difficile* bacteria. But researchers hope that the transplants or some other gut intervention could someday be a viable treatment option for Parkinson's, **Beil** says.

Stealth mode

*The wings of cabbage tree emperor moths are covered in tiny scales that absorb sound waves sent out by hungry bats, **Jennifer Leman** reported in "Moth's stealth wings thwart bats" (SN: 12/8/18, p. 10). Reader **Gypsy Troy** thought the finding might be useful for developing anti-tracking technology for military jets.*

Jets and other aircraft are detected using radar, which relies on radio waves. The moths, on the other hand, evade sonar, says bioacoustician **Marc Holderied** of the University of Bristol in England.

But his group's moth research might

someday be useful for submarines.

"Marine antisonar stealth coating is a very well-established field," he says. "Whether and how our discovery could inspire the experts in this field remains to be seen. We would be really pleased if our discovery of how moths do this could help make future stealth coatings thinner or lighter."

Weighty matters

*Scientists will soon rely on a fundamental constant of nature, Planck's constant, to define the mass of a kilogram, **Emily Conover** reported in "It's official: Kilogram will be redefined" (SN: 12/8/18, p. 7).*

Reddit user **zalurker** wondered if the new definition of a kilogram's mass would resolve confusion about the units of weight on other planets.

In short, no, **Conover** says. Weight is a force, not a mass. A person's weight depends on gravity and so will be different on different planets. "But for masses, the new definition will make it easy to compare with anyone anywhere in the universe," she says.

If we were to ever communicate with aliens, they would probably use different units of mass. Because Planck's constant is the same everywhere in the universe, "aliens also have access to it, so they could use it to convert their units of mass into kilograms," **Conover** says.

True stripes

*Saturn's icy moon Dione has long, thin, bright lines near its equator that run surprisingly parallel to each other for tens to hundreds of kilometers, **Lisa Grossman** reported in "Dione's singular stripes" (SN: 12/8/18, p. 32).*

Scientists don't know what made the stripes, which don't track with Dione's topography. Reader **Tom Ostwald** suggested that the stripes might not be on the moon at all. "Could they be evidence that Dione has rings?" he asked.

Grossman doubts that the lines could be rings, or shadows of rings. "The images were taken from many different angles over the course of the Cassini mission, so any 3-D qualities of the lines should have shown up," she says.

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Fossils show that some pterosaurs may have sported a fluffy coat

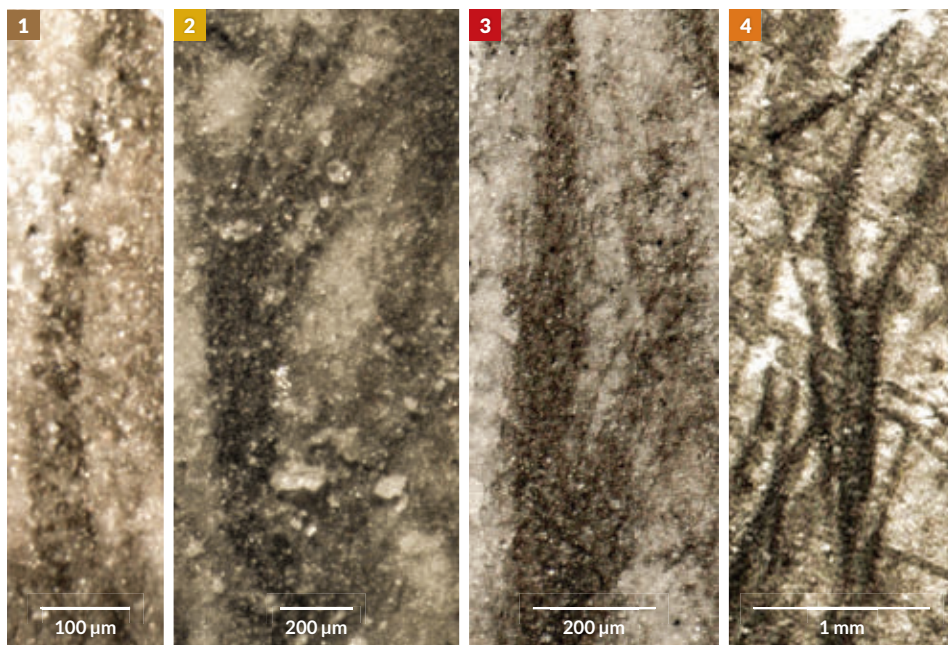
Think of pterosaurs, the flying reptiles that were distant cousins to dinosaurs, and you may imagine a fearsome, leathery creature. But new fossil evidence suggests that some pterosaurs were fluffy, covered in an array of fibrous structures, including possible precursors of feathers.

Paleontologist Zixiao Yang of Nanjing University in China and colleagues identified four types of filaments called pycnofibers on two fossilized pterosaurs (one at right), dated to about 165 million to 160 million years ago. Examples of each fiber type are shown in the fossil images below.

One type (No. 1) was a single fiber that covered much of the animal (as indicated in the illustration at bottom right) and may have resembled fur. The other fibers (Nos. 2, 3, 4) had branching structures springing from a central filament — a key feature of feathers, the team reports in the January *Nature Ecology & Evolution*. Those fibers were only on certain parts of the body, including the head, wings and tail. Other pterosaur fossils have had hints of hair, but evidence for branching filaments was inconclusive.

The discovery adds to evidence that featherlike structures may have been more common during the age of the dinosaurs than thought. Theropod dinosaurs, the lineage that includes modern birds' ancestors and *Tyrannosaurus rex*, were once the only group known to have anything resembling feathers. But such filaments have recently been found in another dino lineage.

It's not clear what the new finding means for the big picture of feather evolution. Pycnofibers may have evolved independently in pterosaurs. Or the fibers may have had the same evolutionary origin as real feathers. That could mean the common ancestor of dinosaurs and pterosaurs had precursor feathers of a sort — making the origin of feathers even fuzzier. — *Carolyn Gramling*



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