SN
SCIENCE NEWS MAGAZINE
SOCIETY FOR SCIENCE & THE PUBLIC
MARCH 16, 2019

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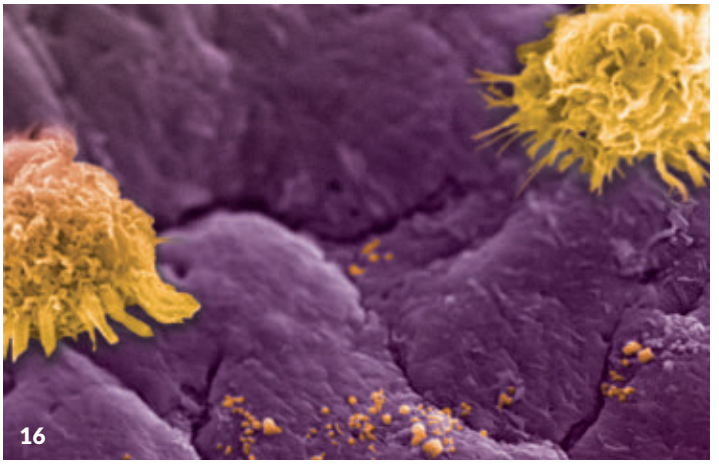
ScienceNews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SOCIETY UPDATE
Teachers awarded STEM Research Grants

COVER Spectacled eiders usually sit on ice between food dives. With less ice, birds must work harder. *Steven J. Kazlowski/Alamy Stock Photo*

FROM TOP: MATT LANDRY AND E. TASCIOTTI/HOUSTON METHODIST RESEARCH INST.; JENS PETERSEN/WIKIMEDIA COMMONS (CC BY 2.5); B. SCHULZ PAULSSON

How newsy science becomes *Science News*

Helping people stay up to speed on the latest advances in science is a big part of our mission at *Science News*. We're aiming for sophisticated and succinct, in a way that works for readers' busy lives. That means making tough decisions on which of the countless scientific papers being published are worthy of coverage and what breaking news has science that needs explanation and context. Disease outbreak? Volcanic eruption? We're on it.

That winnowing process starts with our beat reporters talking to sources and reading embargoed journal articles. The reporters then pitch our news editors in person or via e-mail. If a potential story gets the thumbs up, the reporter interviews the scientists who did the research and other experts in the field, writes the story and sends it to the news editors. The visuals team tracks down photos and creates data visualizations. Editors and writers work together to come up with headlines that will sing on our website and on social media.

After several rounds of editing, a story makes it to our digital editors, who publish the story on www.sciencenews.org and post it to social media. But only a selection of the stories published online make it into the magazine. Managing editor Erin Wayman performs that triage.

"Every issue's news section reflects the range of research done in science," Wayman says. "Some studies have vital, imminent real-world implications, such as the clinical trial in Congo that's testing potential Ebola therapies amid the ongoing outbreak there." You'll find that story, by Aimee Cunningham, on Page 9.

And then there are stories that surprise us, like those that show how much we still have to learn about our planet. A great example is the story by Emily Conover on how physicists used subatomic particles called muons to study the inner workings of a storm (Page 10). "It turns out the voltages in a thundercloud are about 10 times higher than we previously thought," Wayman told me. "That's one of the things I love most about my job — I'm always learning something new."

We hope you'll enjoy the selection. And we invite you to visit our website if you just can't wait until the next issue. — *Nancy Shute, Editor in Chief*

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Excerpt from the March 15, 1969 issue of *Science News*

50 YEARS AGO

Number of donors drops

Both laymen and surgeons have become faint-hearted about heart transplants.... The rejection and infection problems remain unsolved, and although Dr. [Denton A.] Cooley has performed the greatest number of transplants in the world, he has had to stop operating for lack of donors.

UPDATE: Candidates for heart or other organ transplants still far outnumber donors. Every day, 20 people on average die while waiting for a transplant in the United States. Scientists hope to remedy the shortage using organs harvested from animals. To keep a human body from rejecting nonhuman cells, scientists are turning to gene editing (*SN: 10/14/17, p. 26*). So far, baboons given genetically modified pig hearts have survived for about six months (*SN Online: 12/5/18*). Others are growing organs, creating a sterilized scaffold from an animal or cadaver organ and repopulating the scaffold with the organ recipient's cells (*SN: 5/18/13, p. 14*). Pigs have survived several weeks after being implanted with lab-grown lungs (*SN: 9/15/18, p. 8*).

THE SCIENCE LIFE

Extinct red wolf genes live on in coyotes

Mysterious red-coated canids in Texas are stirring debate over how genetic diversity should be preserved.

"I thought they were some strange-looking coyotes," wildlife biologist Ron Wooten says of the canids on Galveston Island, where Wooten works. But DNA evidence suggests the large canids might be descendants of red wolves, a species declared in 1980 to be extinct in the wild.

A small red wolf population from a captive breeding program lives in a North Carolina conservation area. But those wolves have had no contact with other canids, including those in Texas. So maybe, Wooten thought, red wolves never actually went extinct in the wild. "There was no way I could let this go," he says.

He contacted evolutionary geneticist Bridgett vonHoldt of Princeton University. She and colleagues have amassed genetic data on about 2,000 North American canids, mostly coyotes and wolves.

VonHoldt often receives photos of wolf-like animals, along with requests to identify what species they belong to — an exercise she describes as "challenging, and possibly misleading." Instead, she asks for tissue

Some canids on Galveston Island in Texas carry DNA from red wolves, thought to be extinct in the wild for almost 40 years. This family group was photographed in 2013.

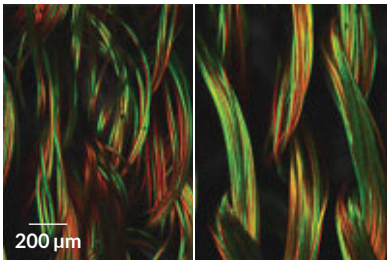
TEASER

Test fabric becomes more breathable as you sweat

Someday, the same shirt could be part of your summer and winter wardrobes, using fabric that alternates between being breathable and insulating.

Unlike other heat-accommodating cloth, which has to be flipped inside out to switch from warm to cool (*SN: 2/17/18, p. 5*), a new dual-use fabric adapts to how much the wearer is sweating. The material could make for better sportswear or be used in clothing for babies, who can't articulate when they're too hot or too cold.

The fabric, described in the Feb. 8 *Science*, is knitted from yarn composed of many polymer fibers coated in carbon nanotubes. The closer these nanotubes are together, the better the fabric conducts a person's body heat as infrared radiation.



When it's cool and dry, fibers inside a new type of fabric are loose (as seen in the fluorescent microscopy image, left) and trap heat. When hotter, the fibers constrict (right), allowing heat to escape.

Under cool, dry conditions, the fibers become loosely wound, and the fabric traps much of the heat radiating off a person's body. But if the wearer sweats, that humidity causes the polymer fibers to constrict into tight bundles. This brings carbon nanotubes on neighboring fibers closer together, improving conductivity and opening spaces to boost breathability.

Raising the humidity around the fabric increases the amount of heat that passes through it by up to about 35 percent, the study finds. — *Maria Temming*

FROM TOP: JOHN WOODHOUSE AUDUBON; R. WOOTEN; X.A. ZHANG *ET AL*/*SCIENCE* 2019

samples so her team can analyze the DNA. "Many pictures I don't give a second thought to," she says. But the photos of the Galveston Island canids were "a little bit different.... It just doesn't look typical of a standard coyote."

She was also drawn in by Wooten's concern for the animals' welfare. The canids live on an increasingly urbanized island and sometimes cross into people's yards or end up as roadkill. "He really, really cares, and I wanted to help," vonHoldt says.

Wooten took tissue samples from the bodies of two canids killed by cars. He later lost one of the samples and so instead sent the scalpel he had used on the animal's carcass.

VonHoldt's team compared genetic profiles from the Galveston animals with profiles from four groups of wild coyotes, Yellowstone's gray wolves, Canada's eastern wolves and captive-bred red wolves from a Washington zoo. The DNA analysis revealed that the two Galveston specimens were mostly coyote but carried genetic variants shared with only the red wolves, the researchers reported in the December *Genes*. Since the red wolves — and thus their DNA — were thought to be extinct in the wild, the researchers dubbed the stretches of red wolf DNA ghost genes.

These ghosts are worth keeping around, vonHoldt says, urging conservation measures that preserve not just species but genetic diversity at every level. Saving the ghost DNA could let some part of red wolves live on in the wild, much the way that Neandertals are still present in the 1 to almost 3 percent of Neandertal DNA carried by modern people of Asian and European ancestry (*SN Online: 10/10/17*).

Conservation efforts are mostly geared toward saving rare or endangered species, not preserving genetic diversity within common species, such as coyotes, vonHoldt says.

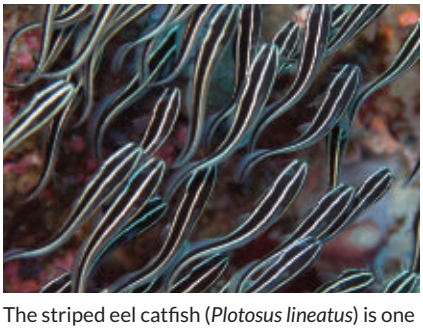
Wooten agrees the Texas canids are a treasure to be protected: "We have buried genetic gold in Galveston."
— Tina Hesman Saey

FUTUROLOGY

Europe names 66 most worrying invasive species

The venomous striped eel catfish, North America's fox squirrel and 64 other species are considered invasive threats to native species in the European Union, scientists report in the March *Global Change Biology*. Emphasis on the word "threat." None of these species has been found yet in the EU, except in captivity.

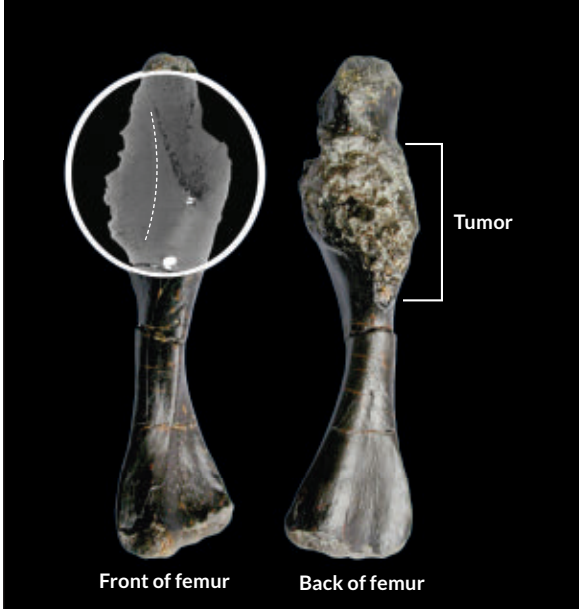
But many of the most worrying are expected to invade EU territory within 10 years, likely due to human activity. Species could stow away on a ship or an airplane, or escape from a zoo or a lab.



The striped eel catfish (*Plotosus lineatus*) is one of eight species considered a "very high risk" for invading parts of the European Union.

Scientists whittled down a European watch list from 329 invasive species to 66 using a technique called horizon scanning. Experts scored the likelihood of each creature arriving in the EU in the next decade, establishing itself and changing local ecosystems.

The eight most threatening species include East Asia's voracious northern snakehead, a fish that has wreaked havoc in U.S. waters since the early 2000s. Other "very high risks" are the aggressive rusty crayfish, a species native to the Ohio River that can spread fungus or diseases harmful to local species, and Asia's golden mussels, prone to accumulating on native plants and clogging pipes. *— Stephanie Parker*



A fossilized femur of *Pappochelys rosinae*, an ancient turtle relative, has the oldest bone cancer yet discovered. A micro CT scan of the front of the femur (circled at left) reveals the extent of the tumor's growth (area to the left of the dotted line).

THE –EST

Rare find: an ancient turtle relative's tumor

A 240-million-year-old case of bone cancer has turned up in a fossil of an extinct turtle relative. Dating to the Triassic Period, the fossil is the oldest known example of this cancer in an amniote, a group that includes mammals, birds and reptiles, scientists report online February 7 in *JAMA Oncology*.

The fossilized femur from a shellless turtle relative, *Pappochelys rosinae*, was found in southwest Germany in 2013. A growth on the bone led a team of paleontologists and physicians to analyze the fossil with a micro CT scan, a technique that provides a detailed, 3-D view inside an object.

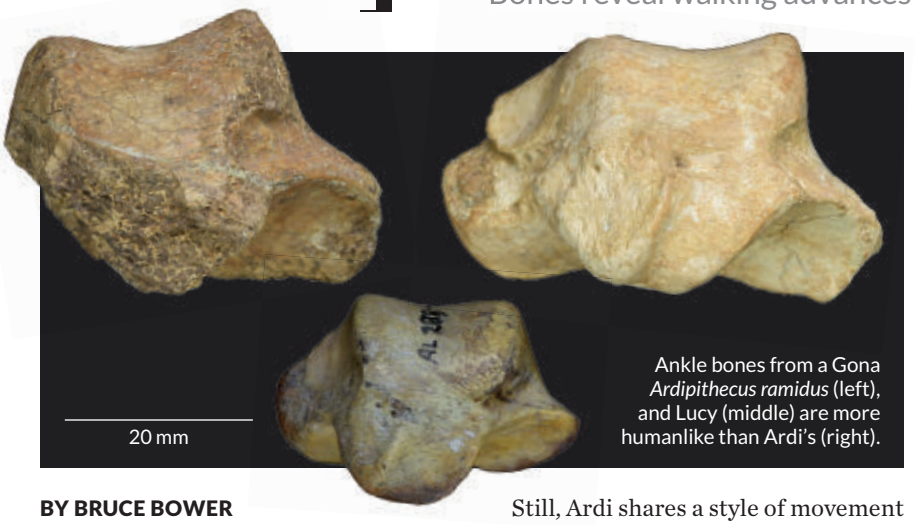
"When we saw that this was not a break or an infection, we started looking at other growth-causing diseases," says paleontologist Yara Haridy of the Museum für Naturkunde in Berlin. The verdict? Periosteal osteosarcoma, a malignant bone tumor.

"It is almost obvious that ancient animals would have cancer, but it is so very rare that we find evidence of it," Haridy says. This tumor from the Triassic offers evidence that cancer is "a vulnerability to mutation deeply rooted in our DNA."
— Aimee Cunningham

HUMANS & SOCIETY

New *Ardipithecus ramidus* fossils found

Bones reveal walking advances more than 4 million years ago



Ankle bones from a Gona *Ardipithecus ramidus* (left), and Lucy (middle) are more humanlike than Ardi's (right).

BY BRUCE BOWER

Fossils unearthed from an Ethiopian site not far from where the hominid Ardi's partial skeleton was found suggest that her species was evolving different ways of walking upright more than 4 million years ago. The new fossils demonstrate that other members of *Ardipithecus ramidus* had a slightly more efficient upright gait than Ardi's (*SN Online: 4/2/18*), paleoanthropologist Scott Simpson and colleagues report in the April *Journal of Human Evolution*.

Discovered through field surveys and excavations in Ethiopia's Gona Project area from 1999 through 2013, the new fossils are the first from the hominid species since 110 *Ar. ramidus* fossils, including Ardi's remains, were found about 100 kilometers away (*SN: 10/24/09, p. 9*). These Gona remains, which date from 4.8 million to 4.3 million years ago, include 42 lower-body fossils, two jaw fragments and a large number of isolated teeth. Several leg and foot bones, along with a pelvic fragment, a lower backbone and possibly some rib fragments, came from one individual.

Unlike Ardi, the fossil individual at Gona walked on an ankle that better supported its legs and trunk, says Simpson, of Case Western Reserve University in Cleveland. And only the Gona hominid could push off its big toe while striding on two legs.

Still, Ardi shares a style of movement with the Gona hominids that is unlike that of any other hominid or living primate, the researchers say. The fossils found at Gona and at Ardi's site suggest grasping, opposable toes, flat feet and other skeletal features that would have made the hominid a capable, but not acrobatic, tree climber, probably limited to moving on all fours across low-hanging branches. Ardi's kind was also built for walking slowly over relatively short distances.

Skeletal modifications that improved upright walking at Gona increase the probability that *Ar. ramidus* evolved into the first known *Australopithecus* species around 4.2 million years ago (*SN: 4/15/06, p. 227*), Simpson's team says. Humanlike walking first appeared in *Australopithecus*, with the best fossil evidence coming from *A. afarensis*, a species best known from Lucy's famous, 3.2-million-year-old partial skeleton.

It's also possible, the researchers say, that Ardi's kind may have evolved apart from *Australopithecus* into a line of hominids that fell short of humanlike walking abilities (*SN: 5/5/12, p. 18*).

"I had a tough time seeing Ardi evolving into *Australopithecus*, but the Gona fossils make that transition easier to envision," says paleoanthropologist Jeremy DeSilva of Dartmouth College, who did not participate in the new study. In particular, the shape of an *Ardipithecus* ankle bone from Gona shows that its foot, unlike Ardi's, was positioned directly under the shin bone, similarly to people today. ■

FROM TOP: S.W. SIMPSON *ET AL/JOURNAL OF HUMAN EVOLUTION* 2019; CLAY BOLT

LIFE & EVOLUTION

Rediscovered: The world's largest bee

Everything about Wallace's giant bee is goliath, from its roughly 7.5 centimeter wingspan to its massive mandibles. Yet it's been 38 years since *Megachile pluto* was officially sighted in the wild. But after a two-week trek to its Indonesian island habitat in January, a team finally found a lone female. "She was the most precious thing on the planet to us," says Eli Wyman. The Princeton University entomologist used a blade of grass to lure her out of her tunnel bored into a termite nest. Next up: protecting her habitat from deforestation. — *Jeremy Rehm*

Read more about the rediscovery of Wallace's giant bee at **bit.ly/SN_giantbee**

ATOM & COSMOS

Magma could keep Martian lake liquid

Underground heat might explain pool of water buried under ice

BY LISA GROSSMAN

If Mars conceals a lake beneath its south polar ice cap, the planet must also have a hidden chamber of magma to keep the water liquid, a new analysis suggests.

Signs of a 20-kilometer-wide lake, buried beneath about a kilometer and a half of ice near Mars' south pole, were first reported in 2018 by a team led by planetary scientist Roberto Orosei (*SN: 8/18/18, p. 6*). The discovery kicked off a debate over what it would take to keep the lake liquid in such a frigid environment.

Now, planetary scientists Michael Sori and Ali Bramson have considered various scenarios, including dust mixed in the ice cap to improve its insulating abilities and episodes of past volcanism on the Red Planet. The only way to create enough heat to explain the liquid water is if a subsurface pool of magma exists deep beneath the lake, the pair reports online February 12 in *Geophysical Research Letters*.

"We tried to do our due diligence and think of all sorts of alternative factors that could raise the temperature," Sori says. "The magma stuff was the only one that did it. None of the other factors really even came close."

The possible lake — the first report of so much liquid water existing on Mars today — appeared as a bright reflection in the radar data from the European Space Agency's Mars Express orbiter. The Martian environment, though, is too cold for water to remain liquid on its own. Orosei, of the National Institute of Astrophysics in Bologna, Italy, and his colleagues had suggested that salts dissolved in the water could keep its melting point low, allowing the lake to exist as a briny sludge.

Conditions beneath the ice are still too cold, an average of –68° Celsius, to explain the lake's existence just with salts, argue Sori and Bramson, both of the University of Arizona in Tucson. But their calculations show that if about 300,000 years ago, a volcano released magma into a chamber at least 5 kilometers wide and buried about 10 kilometers beneath where the lake appears to be, that pool could generate enough heat to still be melting salty ice today. Without salt, the magma chamber would have to be larger or closer to the surface, the researchers say.

If the magma chamber is real, it would mean that Mars has been geologically active much more recently than planetary scientists thought (*SN: 3/4/17, p. 12*). Previous studies suggested that the most recent geologic activity near Mars' south pole was millions of years ago, at least.

The chamber's existence could also potentially be a blow to the purported lake's habitability: If the lake is only a few hundred thousand years old, that doesn't give life much time to have gotten started.

Sori and Bramson remain neutral on whether their findings make the lake more or less likely to exist. "Honestly, we're not sure," Bramson says. The researchers suggest that future searches look for either the magma chamber or the lake. So far, other radar searches using NASA's Mars Reconnaissance Orbiter have not spotted the lake (*SN: 12/22/18 & 1/5/19, p. 29*).

The jury is out among other researchers, too. The new research doesn't rule out that salts may play a role in melting the Mars ice, says planetary scientist Bethany Ehlmann of Caltech, who was not involved in either study. But, she says, "this paper is a nice contribution that explores an alternative hypothesis."

Orosei stands by his team's observations. Theoretical arguments showing how difficult it is for liquid water to be present beneath the ice, he says, do not prove the water is not there. "We are just entering a long and exhausting debate," he says. ■

NASA

ATOM & COSMOS

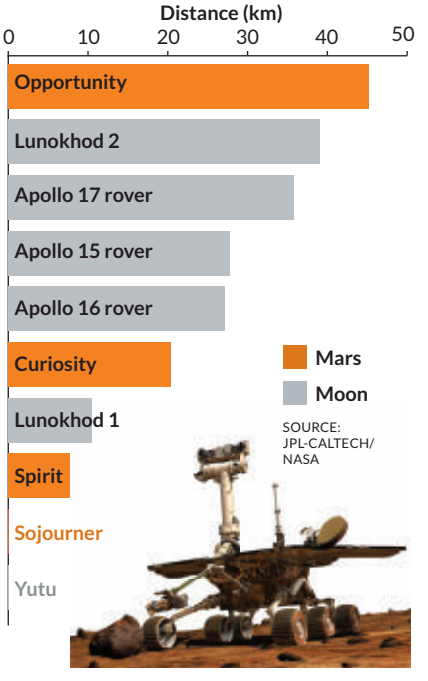
Farewell, Opportunity

Opportunity has finally run out of, well, opportunities. After months of trying to revive the veteran Mars rover in the wake of a blinding dust storm, NASA has given up on ever hearing from it again. One last attempt to reach Opportunity failed February 12, and NASA officials announced the end on February 13.

But the rover will not be forgotten. Opportunity landed on Mars in 2004 for a mission that was supposed to last just 90 Martian days. Instead, over 15 years, Opportunity journeyed 45.16 kilometers — breaking the record for longest rover trek on any world other than Earth (see graph below). Along the way, the rover found abundant evidence that water once flowed and pooled on the Red Planet's surface.

What was expected to be a quick survey of a small area "turned out to be this overland expedition across another planet, with mountains and valleys and vistas and storms and sand dunes, adventure after adventure stretching on for years," says mission principal investigator Steve Squyres of Cornell University. "Nobody expected that." — *Lisa Grossman*

Driving distances of Mars and moon rovers



HUMANS & SOCIETY

How megaliths spread across Europe

Giant stone monuments are traced back to northwest France

BY BRUCE BOWER

From simple rock arches to Stonehenge, tens of thousands of imposing stone structures dot Europe's landscapes. The origin of these megaliths has long been controversial. A new study suggests that the constructions first appeared in France and spread across Europe in three waves.

The earliest megaliths were built in what's now northwestern France as early as about 6,800 years ago, says archaeologist Bettina Schulz Paulsson of the University of Gothenburg in Sweden. Knowledge of these stone constructions then spread by sea to societies along Europe's Atlantic and Mediterranean coasts, she contends in a study published online February 11 in the *Proceedings of the National Academy of Sciences*.

"European megaliths were products of mobile, long-distance sea travelers," Schulz Paulsson says.

About 35,000 megalithic graves, stone circles, standing stones and stone buildings or temples still exist, many near coastlines. Radiocarbon dating has suggested that these structures were built between about 6,500 and 4,500 years ago.

Scholars a century ago thought that megaliths originated in the Near East or the Mediterranean area and spread elsewhere via sea trading or land migrations by believers in a megalithic religion. But as absolute dates for archaeological sites began to emerge in the 1970s, several researchers argued that megaliths emerged independently among a handful of European farming communities.

Schulz Paulsson used statistical tests to identify a model that explained the origin and spread of megaliths at 154 sites. Her calculations relied on 2,410 radiocarbon dates. Some sites included presumed megalith precursors, such as small graves dug into the ground or large earthen monuments, that aided in reconstructing where and when megaliths spread.

Rock structures may have spread across Europe in three waves. This stone grave on Sardinia in Italy dates to about 5,000 years ago.

The earliest megalithic graves consisted of two or more standing stones topped by a third stone or by a mound of earth. That construction style spread from northwest France down the Atlantic coast and into the Mediterranean between about 6,800 and 6,000 years ago, Schulz Paulsson says. Large earthen graves without stones were built shortly before the rise of megaliths and appear only at sites in northwest France, pegging that region as the likely birthplace of megalithic graves, she contends.

A second type of megalith gained widespread popularity about 6,000 to 5,500 years ago, Schulz Paulsson

B. SCHULZ PAULSSON

BODY & BRAIN

Scans find key sign of consciousness

A complex brain activity pattern comes with awareness

BY LAURA SANDERS

A conscious brain hums with elaborate, interwoven signals, a study finds.

Scientists uncovered that new signature of consciousness by analyzing brain activity of healthy people and of people who were not aware of their surroundings. The result, published online February 6 in *Science Advances*, makes headway on a tough problem: how to accurately measure awareness in patients who can't communicate.

Other methods for measuring consciousness have been proposed. But because of its size and design, the new study was able to find a particularly strong signal. The research "produced clear, reliable results that are directly relevant to the clinical neuroscience of consciousness," says cognitive neuroscientist Michael Pitts of Reed College in Portland, Ore.

Consciousness is a squishy concept. It slips away when we sleep and can be distorted by drugs or lost in accidents. Though scientists have proposed many biological explanations for how our brains create consciousness, a full definition is still elusive.

By finding a clear brain signature of awareness, the new work "brings us closer to understanding what consciousness is," says study coauthor Jacobo Sitt of INSERM in Paris.

Sitt and colleagues scrutinized functional MRI data that captured the brain activity of 125 people as they rested inside scanners at research institutes in Paris, New York City and Liège, Belgium. Forty-seven participants were healthy. The rest had unresponsive wakefulness syndrome, in which their eyes were open but they showed no signs of awareness, or were in a minimally conscious state, in which they could follow simple instructions such as moving their eyes on command.

Two distinct patterns of brain activity emerged. The first was a complex pattern characterized in part by opposites. When one neural spot was active, others were not. This pattern didn't follow the brain's anatomy; signals ping-ponged far away from their known anatomical connections. The second pattern, however, was simpler and more closely constrained by the brain's anatomy. (The scientists found two other patterns, but those didn't correspond to consciousness.)

The brains of people who were fully conscious spent more time exhibiting the complex pattern. People with unresponsive wakefulness syndrome spent more time in the simple pattern, while those in the minimally conscious state

finds. Thousands of "passage graves," consisting of a narrow stone passage connected to one or more burial chambers covered in earth or stone, were built at coastal sites in Portugal, Spain, Ireland, England, Scotland and France. Sea voyagers plying established trade routes must have linked those areas and led to a major change in burial practices, signified by the proliferation of passage graves, Schulz Paulsson says.

After about 5,500 years ago, passage graves reached Scandinavia and north-central Europe, and other megalithic structures spread to more coastal sites. In England, massive boulders were raised about 4,400 years ago at Stonehenge.

These general trends in the spread of megaliths appear likely, says archaeologist Alasdair Whittle of Cardiff University in Wales. It's not surprising that sea travel was involved, since megaliths are found in England and Ireland as well as in continental Europe, he says. More radiocarbon dates are needed to specify, for example, when people in France built huge earthen mounds that later became spots for megalith construction. ■

split the difference, spending time in both states to varying degrees.

The team then looked for these signals in a group of 11 patients in London, Canada, some of whom were conscious but unable to communicate. Sure enough, patients who were aware of their environment spent more time in the complex state of brain activity. When a different group of 23 patients was anesthetized, their brains spent less time in the complex state, suggesting that it does come along with consciousness.

People flitted between the two distinct states occasionally. Healthy people's brains sometimes slipped into the simple form of behavior, perhaps representing temporary "mind blanks," the team says. And unconscious patients exhibited the complex pattern now and then. Whether the brief blips come with a temporary increase in consciousness is unknown, Sitt says. If so, "is it a window of opportunity of communication?" he asks. ■

BODY & BRAIN

Ebola outbreak is a testing ground

Clinical trial in Congo is evaluating four therapies

BY AIMEE CUNNINGHAM

Amid the second largest Ebola outbreak ever, the hunt for a lifesaving treatment is on. A clinical trial in Congo is gathering evidence on experimental therapies to provide a proven option the next time the deadly virus emerges.

The first multidrug clinical trial of Ebola therapies, which began in November, is comparing three different antibody treatments and one antiviral drug. One of these therapies was tested briefly during the 2014–2016 outbreak in West Africa, the largest ever, and has shown promise.

With the trial data, though, "we'll be able to say, ideally, that this drug or that drug actually does work, not just we think or hope it does work," says Richard Davey, one of the principal trial investigators and the deputy clinical director at the U.S. National Institute of Allergy and Infectious Diseases in Bethesda, Md.

Death rates from Ebola range from 25 to 90 percent. In the current outbreak, about 63 percent of those infected have died, or 546 out of the 869 cases reported as of February 23.

The multidrug trial began at a treatment unit in the city of Beni, with plans to add additional units. Enrollees get one of the four therapies plus standard supportive care, including painkillers. Scientists will compare death rates between groups to determine each drug's effectiveness. If the trial doesn't enroll enough patients to get statistically significant results, it will continue recruiting patients in future outbreaks.

In Congo, public health efforts against Ebola infection include posters with information on stopping the spread of the disease.

LIANNE GUTCHER/WHO

The antibody treatments "jump-start the immune system to have an immediate presence of antibodies directed against the virus," Davey says. One, called mAb114, was cloned from a sample taken from an Ebola survivor. The treatment targets a protein on Ebola's surface and hampers entry into cells. All macaques given a lethal dose of Ebola and treated with mAb114 survived even when the drug was given five days after infection, researchers reported in *Science* in 2016.

The two other antibody treatments, REGN-EB3 and ZMapp, each contain three different antibodies. Certain dosing regimes of REGN-EB3 prevented death in all or most macaques infected with Ebola, researchers reported in 2018 in the *Journal of Infectious Diseases*.

ZMapp showed some benefit in a study conducted at the end of the West African outbreak. Eight of 36 patients receiving the drug and supportive care died, compared with 13 of 35 patients who received only supportive care, researchers reported in 2016 in the *New England Journal of Medicine*. That trial was too small to really demonstrate that the drug works better than supportive care alone.

The antiviral drug under study, called remdesivir, or GS-5734, appears to target a step in the virus's "owner's manual" for making copies of itself. The drug suppressed replication and in certain doses helped Ebola-infected macaques survive, researchers reported in 2016 in *Nature*.

People not yet exposed to Ebola but considered at high risk in Congo and surrounding countries are receiving an experimental vaccine, rVSV-ZEBOV, to prevent infection. Nearly 81,000 people have gotten the shot so far.

"The one silver lining" of this outbreak is the availability of the vaccine and the therapeutics, says infectious disease epidemiologist Mosoka Fallah of the National Public Health Institute of Liberia in Monrovia. "As much as it is a bleak situation, it is hopeful." ■

MATTER & ENERGY

Lightweight insulator can take the heat

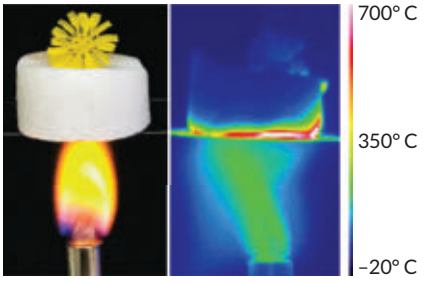
Porous aerogel is at least 99 percent air yet extremely durable

BY MARIA TEMMING

A new, nearly weightless insulation material can withstand extreme heat that would destroy other materials.

The porous aerogel is at least 99 percent open space, with the rest made up of an atomically thin ceramic called hexagonal boron nitride. The design proved extremely durable under high temperatures and rapid temperature shifts of more than 1,000 degrees Celsius, researchers report in the Feb. 15 *Science*.

"It's notoriously hard to make materials that are not just lightweight but can also be heavily heat resistant," says Deep Jariwala, an engineer at the University of Pennsylvania who coauthored a commentary on the study in the same issue of *Science*. The ultralight insulator may be especially well-suited to shielding components on spacecraft, which must endure big temperature swings when turning toward or away from the sun or re-entering Earth's atmosphere, he says.



Researchers placed a flower on top of a 2-centimeter-thick piece of insulator and lit a flame underneath. After 15 minutes, the top surface of the aerogel was a mere 45° Celsius, and the flower was only slightly withered.

The aerogel comprises a network of tiny air pockets, with each pocket separated by two atomically thin layers of hexagonal boron nitride. Much like how double-pane windows prevent heat from escaping a house in winter, the double-layer ceramic barrier makes it difficult for heat to transfer from one air bubble to another. It's also difficult for heat to spread through the material by traveling along the hexagonal boron nitride layers themselves, because that would require following long, circuitous routes, explains study coauthor Xiangfeng Duan, a chemist and materials scientist at UCLA.

Whereas other ceramic aerogels are liable to break down under sudden temperature shifts or extended heat exposure, the new aerogel withstood 500 cycles of rapid heating and cooling from –198° C to 900° C, as well as sitting at 1400° C for one week. A piece of the insulator also protected a flower held over a flame from burning up.

Because the material's structure is so sparse, it's probably not usable on its own, says Julia Greer, a materials scientist at Caltech not involved in the work. The aerogel is resilient in the sense that it's soft and squishable. But to protect the aerogel from tears, it would probably have to be packaged inside a sturdier material, she says. ■

ATOM & COSMOS

Muons size up a storm's power

A thundercloud may store over a billion volts of electricity

BY EMILY CONOVER

An invisible drizzle of subatomic particles has shown that thunderstorms may store up much higher electric voltages than scientists thought.

Using muons, heavier relatives of electrons that constantly rain down on Earth's surface, scientists probed the insides of a storm in southern India in 2014. The cloud's electric potential — the amount of work necessary to move an electron from one part of the cloud to another — reached 1.3 billion volts, the researchers report in a study to appear in *Physical Review Letters*. That's 10 times the largest voltage found by using balloons to make similar measurements.

High voltages within clouds spark lightning. Despite the fact that thunderstorms regularly rage over our heads, "we really don't have a good handle on what's going on inside them," says physicist Joseph Dwyer of the University of New Hampshire in Durham, who was not involved with the study.

Balloons and aircraft can monitor only part of a cloud at a time, making it difficult to get an accurate measurement of the whole thing. But muons zip right through, from top to bottom. "Muons that penetrate the thunderclouds are a perfect probe for measuring the electric potential," says physicist Sunil Gupta of the Tata Institute of Fundamental Research in Mumbai, India.

Gupta and colleagues studied muon behavior with the GRAPES-3 experiment in Ooty, India, which observes about 2.5 million muons every minute. During thunderstorms, that rate drops, as muons, which are electrically charged, tend to be slowed by a storm's electric fields.

Using computer simulations of a thunderstorm, the team determined the electric potential necessary to explain the drop in muons spotted during the 2014 storm. The team also estimated the storm's electric power: It was similar to the output of a large nuclear reactor, at around 2 billion watts.

"With anything that's new, you have to wait and see what happens with additional measurements," Dwyer says. The simulated thunderstorm was simplified, consisting of one region of positive charge and one region of negative charge. Real thunderstorms are more complex.

If confirmed, such high voltages could explain a puzzling observation: Some thunderstorms send bursts of high-energy light, called gamma rays, upward (*SN: 5/30/15, p. 12*). But scientists don't fully understand the processes within thunderstorms that could create such energetic light. If the storms reach the billion-volt level, that could account for the mysterious light. ■

X. XU ET AL/SCIENCE 2019

BODY & BRAIN

Trans fatty acids ban works in NYC

Levels drop dramatically in frequent restaurant-goers

BY AIMEE CUNNINGHAM

New Yorkers fond of eating out in the last decade weren't just saved from doing the dishes. Their blood levels of artificial trans fats, which are linked to heart disease, dropped following a 2006 citywide ban on restaurants using the fats.

Analysis of blood samples from adults — taken before and after the ban for a health and nutrition survey that queried participants on their dining habits — suggests that trans fat levels plunged by about 57 percent overall among New Yorkers. The samples, 212 from 2004 and 247 from 2013–2014, revealed a drop from 49.2 to 21.3 micromoles per liter.

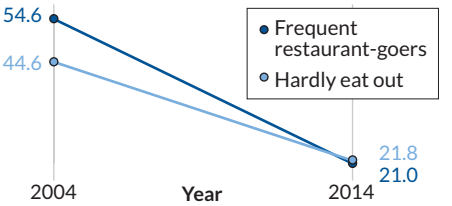
New Yorkers who ate out four or more times a week saw an even bigger decrease: about 62 percent, Sonia Angell of the New York City Department of Health and Mental Hygiene in Queens and colleagues report online February 21 in the *American Journal of Public Health*.

Artificial trans fats, or trans fatty acids, end up in foods, like doughnuts, that are fried, baked or cooked in partially hydrogenated vegetable oils. The fats increase the amount of low-density lipoprotein, or "bad" cholesterol, in the body while lowering high-density lipoprotein, the "good" cholesterol. A 2 percent increase in calories from trans fatty acids in a person's diet is associated with a 23 percent rise in the occurrence of coronary heart disease, a previous analysis reported.

Cutting artificial trans fats in the diet "decreases the risk of heart disease," says Jennifer Pomeranz, a public health lawyer at New York University not involved in the study. "This is really a great success of local policy making."

The drop mirrors what happened nationally after the U.S. Food and Drug Administration in 2006 required companies to include artificial trans fats in food nutrition labels. That probably contributed to the lower amounts found in New Yorkers, the researchers say. Levels of the fats dropped by about 51 percent in those who ate out the least. But the big drop for frequent diners indicates that the ban had its own impact, the researchers say. ■

Change in New Yorkers' trans fatty acid levels (micromoles/liter), 2004 and 2014



Ban bonus Blood levels of trans fatty acids declined in New York City residents from 2004 to 2014. Those who ate out the most had the biggest drop — about 62 percent — suggesting a 2006 ban on the fats in restaurant foods worked, researchers say.
SOURCE: M. WRIGHT *ET AL/AM. J. OF PUBLIC HEALTH* 2019

LIFE & EVOLUTION

Tiny *T. rex* relative fills in key time gap

96-million-year-old fossil narrows when tyrannosaurs got giant

BY JEREMY REHM

Even *Tyrannosaurus rex* had humble beginnings. A new dinosaur dubbed *Moros intrepidus*, or "the harbinger of doom," is one of the smallest tyrannosaurs yet discovered from the Cretaceous Period. Analyses of its fossilized leg show that the creature stood only 1.2 meters at the hip and weighed about 78 kilograms — about the size of a mule deer, researchers report February 21 in *Communications Biology*.

Dating to around 96 million years ago, the fossil is the oldest Cretaceous tyrannosaur found in North America. Its discovery helps fill in a 70-million-year gap in tyrannosaur evolution leading up to the ferocious giants like *T. rex*.

Teeth from early, petite tyrannosaurs have been found in rocks in North America dating to the Late Jurassic Period around 150 million years ago, when large predators called allosaurs topped the food chain. Tyrannosaurs are next seen in the North American fossil record 70 million years later, when they've become the colossal top predators. When the dinos sized up within that period is a mystery.

Paleontologist Lindsay Zanno and her colleagues dug for 10 years around Emery County in Utah, searching for clues. That's where the team discovered *M. intrepidus*' long, thin leg, a characteristic indicative of a swift runner, quite unlike later titanic tyrannosaurs.

"What *Moros* shows is that the ancestral stock of the big tyrannosaurs was small and fast," says Thomas Carr, a vertebrate paleontologist at Carthage College in Kenosha, Wis., not involved in the study. And it "suggests that the tyrannosaurs became giant some time in that 16-million-year stretch between *Moros* and the earliest of the big guys."

By comparing *M. intrepidus*' fossil traits with other tyrannosaurs, the researchers determined that it emerged from Asia. *M. intrepidus* was part of a great migration that included mammals, lizards and dinosaurs moving between modern Siberia and Alaska during drops in sea level, the authors suggest.

Eventually, the Cretaceous Period's warming climate probably killed off the allosaurs, but not tyrannosaurs, says Zanno, of North Carolina State University in Raleigh. "They rapidly increase in size and go on really quickly to become the dominant predators of Late Cretaceous ecosystems," she says. Finding other tyrannosaurs from the 16-million-year time gap will help better narrow the timing of that growth spurt. ■

FROM TOP: E. OTWELL; JORGE GONZALEZ, © L. ZANNO

Standing only 1.2 meters at the hip, the newly discovered *Moros intrepidus* (illustrated) is one of the smallest known tyrannosaurs.

HUMANS & SOCIETY

Beliefs on intelligence can affect grades

STEM professors' views may widen the racial achievement gap

BY BRUCE BOWER

Beliefs among some university professors that intelligence is fixed, rather than capable of growth, contribute to a racial achievement gap in STEM courses, a study suggests.

Over a two-year period, the disparity in grade point averages separating Asian and white STEM students from black, Hispanic and Native American peers was nearly twice as large in courses taught by professors who regarded intelligence as set in stone versus malleable, psychologist Elizabeth Canning and colleagues report online February 15 in *Science Advances*. Canning, of Indiana University in Bloomington, also presented these findings February 15 at the annual meeting of the American Association for the Advancement of Science.

Professors may subtly communicate stereotypes about blacks, Hispanics and Native Americans allegedly being less intelligent than Asians and whites, say Canning and colleagues. Black, Hispanic and Native American undergraduates may respond by becoming less motivated or more anxious, leading to lower grades.

Even small dips in STEM grades — especially for students near pass/fail cutoffs — can accumulate across the 15 or more science, technology, engineering and math classes needed to become a physician or an engineer, Canning says. That could jeopardize access to financial aid and acceptance to graduate programs.

"Our work suggests that academic benefits could accrue over time if all students, and particularly underrepresented minority students, took STEM classes with faculty who endorse a growth mind-set," Canning says.

This is the first study to link teachers' mind-sets about intelligence to students' academic performance. Related research suggests that women and racial minorities achieve fewer advanced degrees in fields where, according to academics, success hinges on innate brilliance (*SN Online: 1/15/15*).

Canning's group examined links between the mind-sets of 150 college STEM faculty — including professors, lecturers, postdoctoral instructors and graduate teaching assistants — and grades earned by more than 15,000 undergraduates taking courses from those instructors at a large, public university. Classes included more than 1,600 black, Hispanic and Native American students.

Instructors rated how much they agreed with statements that people in general, and their students in particular, have a certain amount of intelligence that can't be changed. Beliefs did not appear to be linked to instructors' race, sex, age, field of study or teaching experience.

All students tended to perform worse in courses led by professors with fixed mind-sets, compared with students taught by professors with growth mind-sets. But grades suffered most among blacks, Hispanics and Native Americans. On average, Asian and white STEM

ATOM & COSMOS

LIGO will get a quantum upgrade

Updates could lead to daily gravitational wave detections

BY EMILY CONOVER

Gravitational wave detectors are going quantum. A planned revamp of the Advanced Laser Interferometer Gravitational-Wave Observatory, LIGO, relies on finessing quantum techniques, LIGO scientists announced February 14. That $35 million upgrade could let scientists catch a gravitational wave every day. LIGO's tally of 11 events could be surpassed in a week, researchers said in a news conference at the annual meeting of the American Association for the Advancement of Science.

Starting up in 2024, the revved-up detector, known as Advanced LIGO Plus, will seek to wrangle a quantum rule, the Heisenberg uncertainty principle, to improve the machine's ability to detect ripples in spacetime. The Heisenberg uncertainty principle states that it's impossible to precisely measure certain properties, such as the position and momentum of an object, at the same time.

In LIGO, this translates to a give-and-take in the light monitored to detect gravitational waves. At each of LIGO's two detectors, in Livingston, La., and Hanford, Wash., laser light bounces back and forth within two 4-kilometer-long arms arranged in an "L." To determine whether a gravitational wave is passing through, scientists measure the brightness of the light where the arms meet and the beams recombine (*SN: 3/5/16, p. 22*).

Due to quantum mechanics, that light fluctuates in two ways: in its phase (the timing of the light wave) and in its amplitude (which determines the light's intensity). This variation muddles LIGO's measurements, making it more difficult to pick out the subtle signals of a gravitational wave. So in LIGO's next round of operation, to begin in April, researchers will for the first time use quantum "squeezed" light, in which the fluctuations in the light's phase are decreased. LIGO will better capture waves of higher frequencies — ripples that would have a higher pitch if converted into sound.

"That's exciting, but it comes with a

The gravitational wave detector LIGO (shown) will begin using quantum techniques in April, with more quantum upgrades to follow in 2024.

LIGO LAB/MIT AND CALTECH

students earned 0.14 GPA points higher on a 4.0 scale than underrepresented minority STEM students. But in courses taught by faculty with a moderate to extremely fixed mind-set, the racial achievement gap grew to 0.19 GPA points (an average GPA of 2.71 for underrepresented minorities versus 2.90 for Asians and whites). In courses taught by faculty endorsing a growth mind-set, the gap was 0.10 GPA points (an average GPA of 2.96 for underrepresented minorities versus 3.06 for Asians and whites).

These findings "call for a more in-depth study of what professors with different mind-set beliefs are doing in their classrooms and how this [affects] the motivation of their students," says psychologist David Geary of the University of Missouri in Columbia.

Canning is studying ways to help teachers develop growth mind-sets. Faculty who do frequent assessments to see what students have mastered and where they need help will develop an appreciation for students' ability to gain insights into complex material given more personalized instruction, Canning suspects. ■

penalty," physicist Michael Zucker of Caltech and MIT LIGO Laboratory said in the news conference. Fluctuations in the power of the light are increased, which makes measuring lower-frequency gravitational waves more difficult. "It doesn't excuse you from Heisenberg's uncertainty principle."

But in Advanced LIGO Plus, scientists will use a system that will make the best of both worlds, squeezing the light one way for lower-frequency ripples and another for higher-frequency signals to improve the machine's performance overall. "That is another step in complexity," says physicist Hartmut Grote of Cardiff University in Wales. Grote helped pioneer light-squeezing techniques in a smaller gravitational wave detector called GEO 600, in Germany.

A detector in India, called LIGO-India, is expected to turn on at around the same time as Advanced LIGO Plus and use the same quantum techniques. ■

MATH & TECHNOLOGY

O'Keeffe's 'art acne' diagnosed

New imaging technique could help curators track destruction

BY JEREMY REHM

Like pubescent children, the paintings of Georgia O'Keeffe have been breaking out with "acne" and now scientists know why.

Tiny pimples, which can cause paint to crack and flake off like dry skin, were spotted in the artist's paintings years ago. The culprit, researchers say, are metal soaps that result from chemical reactions in the paint. The team has also developed a 3-D image–capturing computer program, described February 17 at the annual meeting of the American Association for the Advancement of Science, to help art conservators track these blemishes.

O'Keeffe's works aren't the only ones to develop such pustules. Metal soaps, which look a bit like white, microscopic insect eggs, form on about 70 percent of all oil paintings. Scientists in the late 1990s determined that these soaps form when oil paint's negatively charged fats, which hold the pigments together, react with positively charged metal ions in the paint. This reaction creates liquid crystals that slowly aggregate beneath a painting's surface, causing paint layers to gradually bulge, tear and flake off.

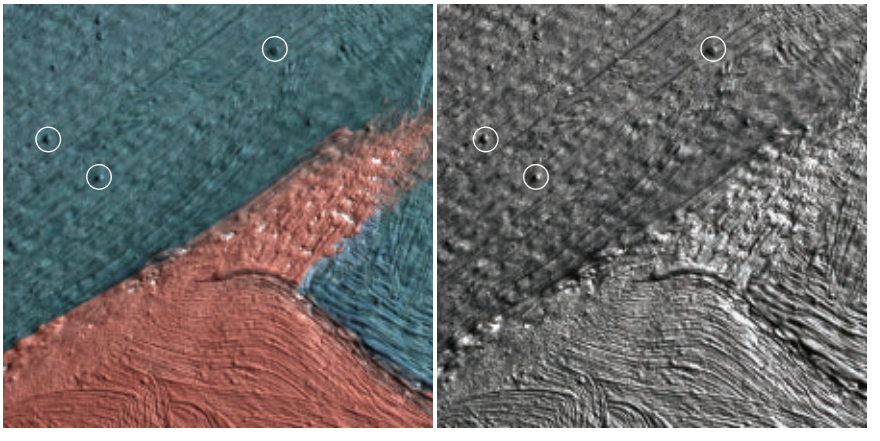
Marc Walton, a materials scientist at Northwestern University in Evanston, Ill., and colleagues wondered what factors lead to crystal formation, such as relative humidity, light levels or temperature. "To be able to answer those questions, we have to look at it from a macroscopic point of view," Walton says.

His Northwestern colleague Oliver Cossairt, a computer scientist, designed a computer program that shines particular patterns of light from a cell phone or computer tablet's screen onto a small section of a painting and then collects the reflected light in the device's camera.

The program removes color information, which can camouflage small distortions. Software relying on machine learning distinguishes the knobby structures from other textures such as brushstrokes and creates a sort of medical report by determining the location, size and density of the blisters.

The team is using the technology to observe test paintings, watching how light, humidity and temperature affect blister size and rates of development.

"You see paintings with this kind of knobby, bubbly surface, and you don't know if that has happened in five years, 50 years or more," says art conservation scientist Kenneth Sutherland of the Art Institute of Chicago. The new technique "starts to give you a way of monitoring how quickly [the bubbles] are forming and, more specifically, answer questions about what factors are influencing it and how we can control or minimize it." ■



A computer program analyzes closeup images of paintings, such as Georgia O'Keeffe's painting "Pedernal" (left). Stripping away the color (right) can help reveal damaging pimples (circles).

DALE KRONKRIGHT/© GEORGIA O'KEEFFE MUSEUM

EARTH & ENVIRONMENT

Chemicals in home decor found in kids

Semivolatile organic compound exposure linked to health problems

BY MARIA TEMMING

Furniture and flooring may not be such notorious polluters as gas-guzzlers, but these indoor consumer products can be a source of potentially dangerous chemicals. Kids living in homes with all vinyl flooring or couches that contain flame retardants have much higher concentrations of chemicals called semivolatile organic compounds in their blood and urine than other children, new data show.

These chemical compounds are commonly used in electronics, furniture and other household trappings (*SN: 11/14/15, p. 10*). "Many of these chemicals have been implicated in adverse health outcomes in children — things like ADHD, autism ... even cancer," said Heather Stapleton, an environmental health researcher at Duke University, in a news conference February 17 at the annual meeting of the American Association for the Advancement of Science.

"It's important that we understand the primary sources of these chemicals in the home," she said.

Stapleton and colleagues investigated the in-home exposure to semivolatile organic compounds of 203 children ages 3 to 6. They collected dust and air samples and bits of items such as couch cushions from the kids' homes, and urine and blood samples from the children.

Children living in homes with all vinyl flooring had concentrations of a by-product of the plasticizer benzyl butyl phthalate in their urine of about 240 nanograms per milliliter on average. Meanwhile, those levels in kids living in homes with no vinyl flooring were only about 12 nanograms per milliliter on average.

Even the highest exposures to benzyl butyl phthalate were under the safety threshold set by the U.S. Environmental Protection Agency. But it's unclear how the levels of this chemical in children's bodies would change over time, Stapleton says. Contact with benzyl butyl phthalate has been linked to respiratory and reproductive disorders.

Children from homes with sofas that contain flame-retardant polybrominated diphenyl ethers, or PBDEs, had concentrations of these compounds in their blood serum of about 108 parts per billion on average — about seven times higher than other kids. Stapleton's team still needs to assess how these concentrations compare with EPA safety levels. Exposure to PBDEs has been linked to lower IQ and hyperactivity, as well as cancer and other diseases.

There's long been a "tacit assumption" among researchers that home furnishings don't release these compounds quickly enough for them to significantly accumulate in residents' bodies, says Glenn Morrison, an environmental engineer at the University of North Carolina at Chapel Hill not involved in the work. The new findings undercut that assumption, he says. Showering and washing clothing more frequently may help curb people's susceptibility of picking up these chemicals, he says, but "there's a limit to how well those things work." ■

HUMANS & SOCIETY

Mongolians got milk, plaque shows

Proteins in tooth tartar reveal clues to 3,000-year-old diet

BY CAROLYN GRAMLING

Ancient people living in what's now Mongolia drank milk from cows, yaks and sheep — though as adults, they couldn't digest lactose. That finding comes from the humblest of sources: ancient dental plaque.

Modern Mongolians are big on dairy, milking seven kinds of animals, including cows, yaks, camels and reindeer. But how far into the past that dairying tradition extends is difficult to glean from the usual archaeological evidence: Nomadic lifestyles mean no kitchen trash heaps preserving ancient pots with lingering traces of milk fats. Christina Warinner and her colleagues turned to skeletons from 22 burial mounds belonging to the Deer Stone people, who lived in Mongolia's eastern steppes around 1300 B.C.

Hardened dental plaque, or tartar, on the teeth contained traces of milk proteins, Warinner, a molecular anthropologist at the Max Planck Institute for the Science of Human History in Jena, Germany, said February 16 at the annual meeting of the American Association for the Advancement of Science. Those proteins showed that the people drank milk from cows, yaks, goats and sheep, but not camels or reindeer.

Ancient Mongolians' DNA also revealed that they weren't able to digest lactose as adults. Instead, the Deer Stone people, like modern Mongolians, may have relied on bacteria within the gut, known as the gut microbiome, to break down the lactose, Warinner said.

Milk proteins within dental plaque from ancient human teeth suggest that people in Mongolia have been milking cows, sheep and other animals for at least 3,000 years.

C. WARINNER

Warinner's team previously detected milk proteins in the tooth tartar from European Bronze Age skeletons dating back to 3000 B.C. (*SN: 10/14/17, p. 18*). The hardened plaque preserves tiny evidence of all sorts of events in a person's lifetime, from drinking milk to inhaling pollen to working in a dusty artistic environment (*SN: 2/2/19, p. 14*). ■

ATOM & COSMOS

Ultima Thule is shaped like two lumpy, conjoined pancakes

Visions of a space snowman have fallen flat. New images of Ultima Thule released February 8 indicate that the faraway space rock is much thinner than originally thought. Rather than two spheres stuck together (*SN: 2/2/19, p. 7*), the object, officially called MU69, is shaped more like a couple of lumpy pancakes that melded together in a frying pan.

NASA's New Horizons spacecraft flew by the Kuiper Belt object on New Year's Day, and the spacecraft continued snapping shots past its point of closest approach. The new images were taken from a vantage point almost 9,000 kilometers beyond MU69.

By observing how MU69 blocked out the light of background stars in a sequence of images, scientists mapped the shape of the hidden bits of the space rock that weren't lit up by the sun's rays. That information, combined with pictures taken from different angles earlier in New Horizons' flight, allowed the researchers to visualize MU69's girth. — *Emily Conover*

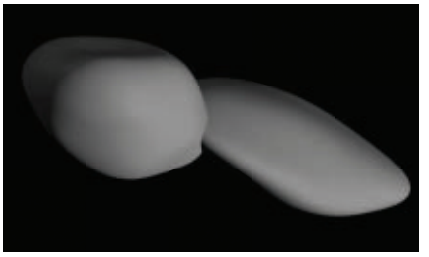
MATH & TECHNOLOGY

New 2-D material uses light to quickly and safely purify water

Using light, a prototype "green" material can purify enough daily drinking water for four people in just one hour. In tests, the material killed nearly 100 percent of bacteria in 10 liters of water, researchers report online February 7 in *Chem*.

This material, a 2-D sheet of graphitic carbon nitride, is a photocatalyst: It releases electrons when illuminated to create oxygen-based chemicals that destroy microbes. The design avoids pitfalls of other similar technology. Today's most effective photocatalysts have metals that can leach into water as pollutants. Others are nonmetallic, like the 2-D sheets, but are less efficient because they hold onto electrons more tightly.

Materials scientist Guoxiu Wang of the University of Technology Sydney and colleagues created ultrathin sheets of graphitic carbon nitride and added chemical groups such as acids and ketones that lure electrons toward the sheets' edges. There, the electrons jump onto oxygen atoms in water to form such microbe-dissolving oxygen chemicals as hydrogen peroxide.



This simulation shows what scientists think Ultima Thule looks like from the side.

SWRI, JHU-APL, NASA

The design killed 99.9999 percent of bacteria, including *E. coli*, in a 50-milliliter water sample. That's as efficient as the best metal-based photocatalyst. And it killed microbes more quickly than previous metal-free photocatalysts, which take over an hour to achieve what the new design did in 30 minutes.

The team then attached the nanosheets to the inside surface of plastic bags, purifying 10 liters of water in an hour.

The carbon and nitrogen composition should make the material inexpensive, Wang says. The researchers plan to work with engineers to scale up the design for commercial use. — *Jeremy Rehm*

EARTH & ENVIRONMENT

Another crater may lurk beneath Greenland's ice sheet

Greenland's ice may be hiding more than one crater left by long-ago meteorite impacts.

An analysis of satellite and airborne images of the topography beneath the ice sheet has revealed a large, craterlike structure buried under two kilometers of ice. It's just 183 kilometers southeast of Hiawatha, another possible impact crater, described last year (*SN: 12/8/18, p. 6*).

The newly discovered depression is about 36.5 kilometers across, slightly larger than Hiawatha, which stretches 31 kilometers in diameter, researchers report online February 11 in *Geophysical Research Letters*.

Like Hiawatha, the new feature consists of a ring-shaped rim surrounding a depression with a peak at its center — consistent with a crater carved out by the impact of a large meteorite, says study coauthor Joseph MacGregor, a glaciologist with NASA's Operation IceBridge.

Unlike Hiawatha, there's little chance of collecting geologic data from the new structure to confirm or deny an extraterrestrial origin: Instead of sitting at the edge of the ice sheet, the new depression is closer to the center of the ice.

Without more direct geologic data, scientists can't determine the newly discovered depression's age or determine whether the two craters might be related to the same event. — *Carolyn Gramling*

BODY & BRAIN

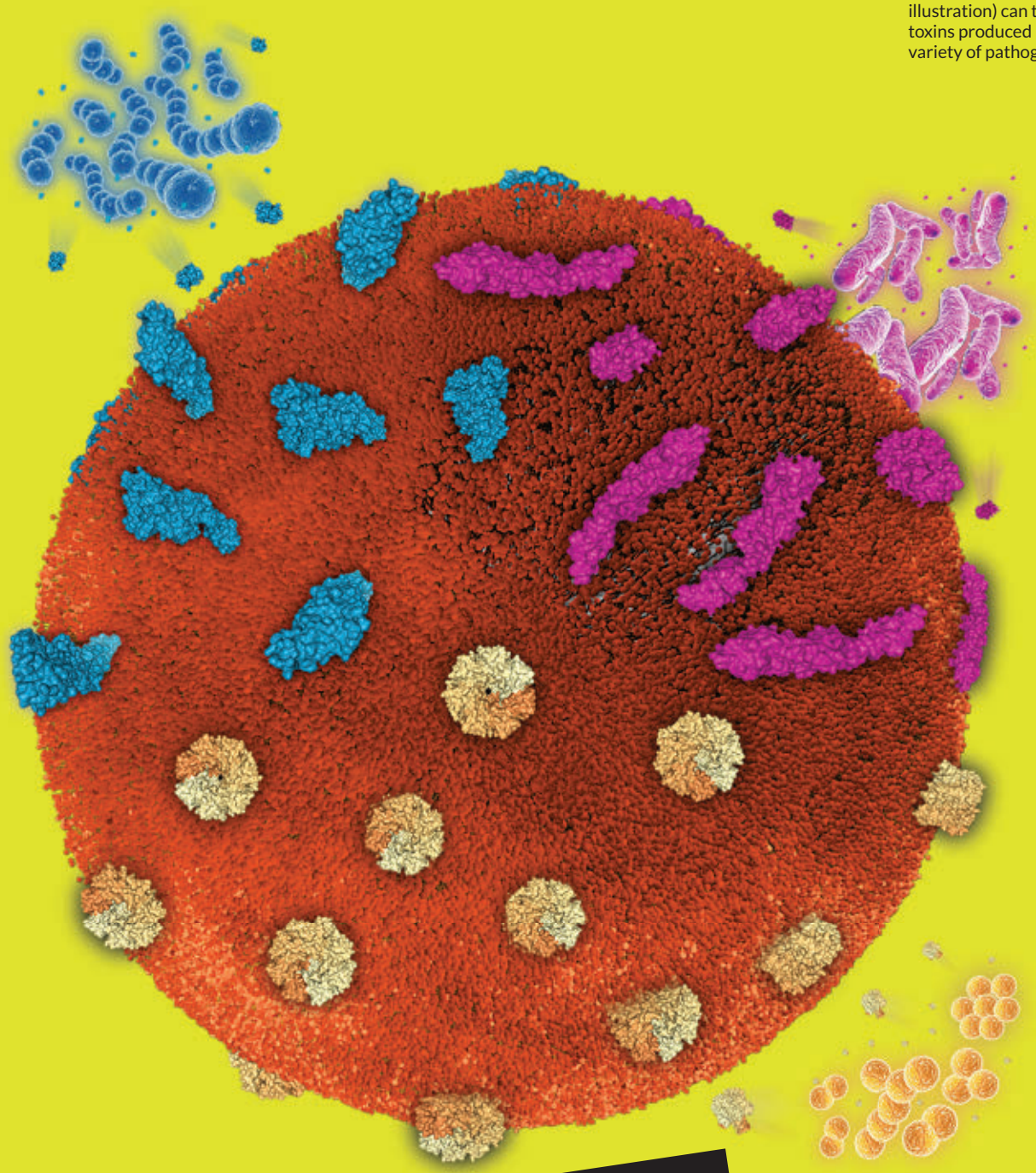
Brain cells combine info on place and taste to make food maps

Sometimes a really good meal can make an evening unforgettable. A new study of rats, published online February 18 in the *Journal of Neuroscience*, may help explain why.

A select group of nerve cells in a rat's brain holds information about both flavors and places, becoming active when the right taste hits the tongue when the rat is in a certain location. These double-duty cells could help animals overlay food locations onto mental maps.

Researchers implanted electrodes into the hippocampus, an area of the brain that is heavily involved in both memory formation and mapping. Rats then wandered around an enclosure, allowing researchers to identify "place cells" that become active only when the rat wandered into a certain spot. At the same time, researchers occasionally delivered one of four flavors (sweet, salty, bitter and plain water) via an implanted tube directly onto a wandering rat's tongue.

Some of the active place cells also responded to one or more flavors, but only when a rat was in the right spot within its enclosure. When the rat moved away from a place cell's preferred spot, that cell no longer responded to the flavor. A mental map of the best spots for tasting something good would come in handy for an animal that needs to find its next meal. — *Laura Sanders*



A single nanosponge (large sphere in this illustration) can trap toxins produced by a variety of pathogens.

L. ZHANG LAB/UC SAN DIEGO

NANOHEALERS

Tiny particles cloaked in cell membranes sop up blood toxins and calm inflammation

By Esther Landhuis

To take his fledgling lab to new heights, Liangfang Zhang hatched a plan that he considered brilliant in its simplicity. It involved procedures that many of his peers found a little out there. But if he could make his idea work, it would clear a major hurdle to safely ferry therapies through the body on nanoparticles one-thousandth the width of a human hair.

Yet back in 2010, the young nanoengineer could not convince the National Institutes of Health, the main funder of U.S. biomedical research, to support the project. Zhang applied for funding four or five times over several years, to no avail.

"It felt quite lonely," he says. "But I just felt this is very unique stuff. And it may become a big thing."

Pulling funds from other projects and from the start-up package he received to set up his lab at the University of California, San Diego, Zhang did the experiments for his breakthrough paper, published in 2011 in the *Proceedings of the National Academy of Sciences*. He and coworkers created a new class of nanoparticles, made from carbon-containing polymers, that could slip through blood vessels in a mouse without triggering an immune reaction. While immune responses are important for killing disease-causing pathogens, the same reactions are a nuisance when they clear out molecules made to deliver lifesaving drugs.

Then, instead of just viewing their particles as a drug-delivery system, which most other researchers were focused on, Zhang and his team made a surprising pivot. They repurposed the particles to act as "nanosponges" that trap and remove toxins from the blood. In lab experiments, the nanosponges worked against toxins unleashed by *E. coli* and some of the harder-to-fight bacteria. Nanosponges also slowed harmful inflammation in mice with a form of rheumatoid arthritis and diverted HIV and Zika from the cells those viruses normally infect, the researchers reported last year.

Nanosponges, which have not yet been tested in people, do their under-the-radar cleanup because of an offbeat idea: The synthetic nanoparticles are coated with membranes from living cells, which helps them blend in. And a single nanosponge can root out a slew of mischief-makers without knowing much about them individually. Many toxins that attack red blood cells, for example, will cling instead to nanoparticles coated with bits of those very cells. Zhang's team at UC San Diego and others have created a growing arsenal of nanosponges cloaked in membranes of red or white blood cells, each of which absorbs its own set of toxins.

Zhang's work "opened up the whole field" of membrane-coated nanoparticles, says Omid Farokhzad, a physician-scientist at Brigham and Women's Hospital in Boston who studies nanoparticles as medicine (*SN: 11/11/16, p. 22*). Many labs are now "building on the platform that Zhang's group developed."

Wild work-around

When Zhang was a postdoc at MIT more than a decade ago, nanoparticle research was all about drug delivery. In 1995, the U.S. Food and Drug Administration approved the first nanotherapy, which carried an anticancer drug. Since then, about 50 other nanodrugs, for treating cancer, hemophilia, multiple sclerosis and other diseases, have made their way into patient care.

Nanoparticles are about one three-thousandth the size of red blood cells, yet each tiny particle can carry thousands of drug molecules. To get a drug where it needs to go, nanoparticles must hide from the immune system. When immune cells encounter foreign material — even nano-sized stuff — the cells try to destroy the invader and remove it from the body. Nanomedicine researchers thought they'd found a solution by coating their particles with a clear, thick liquid called polyethylene glycol, or PEG. Immune cells would "see" the particles as water and not react, Zhang says.

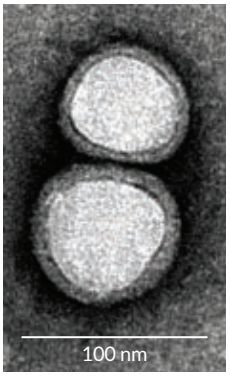
Yet PEG was not ideal. More than a decade ago, patient studies began to reveal that PEG-coated particles can cause people to produce antibodies against PEG, which can trigger unwelcome immune responses. Other approaches, such as outfitting particles with a "don't eat me" protein that tumor cells use to avoid immune attacks, haven't worked either. Then Zhang had a flash of insight: "How about disguising the particles as if they belong in the body?"

Trained as a chemical engineer, Zhang was not bound by many biologists' need to figure out what is going on. "Engineers want to get it done. We want to make it work," he says. "After making it work, then we may study the reasons."

The concept of cloaking a human-made particle with bits of unpredictable biological membranes "was very unorthodox" at the time, recalls Che-Ming Jack Hu, the graduate student in Zhang's lab who took on the project. Today, Hu heads his own nanotechnology lab at Academia Sinica in Taipei City, Taiwan. "People didn't know what to make of the idea." But Hu, a bioengineer, found the notion of mixing natural and synthetic materials exciting.

"How about disguising the particles as if they belong in the body?"

LIANGFANG ZHANG



The two nanosponges in this electron microscopy image are coated with membranes from red blood cells.

Protect and repair

To keep the immune system off guard, Zhang and Hu set out to disguise the particles in membranes from circulating red blood cells.

Early experiments were nightmarish. "The lab was just setting up. We didn't have a lot of resources," Hu recalls. He needed blood from mice, but the group didn't yet have approval to purchase animals. The researchers turned to neighboring labs. "We'd tell them, 'If you're going to kill those mice, can we take some of their blood?'" Hu says.

Drawing blood from the animals was not easy for Hu and coworkers, who were used to dealing with chemicals and polymers. "All of a sudden, we were taking these dead mice and sticking a syringe into the heart to take their blood," he says. At first "we got very little." Mouse blood, the team learned, clots quickly.

With practice, the researchers were soon collecting a milliliter of blood from each mouse. Hu separated out the red blood cells, stripped their membranes, then nudged the membrane pieces onto nanoparticles.

Each milliliter of blood contained some 5 billion red blood cells, and a cut-up membrane from a single red blood cell could coat several thousand nanoparticles. Injected into live mice, the hybrid particles spread through the body and stayed intact for three days. "We kind of got lucky," Hu says of those early efforts.

Soon after, a team at the Houston Methodist Research Institute in Texas reported a similar feat, coating nanoparticles with the membranes of white blood cells of the immune system. Like the UC San Diego group, the Houston researchers felt they were going out on a limb by mixing synthetic particles with parts of live cells. "People in the nano field were telling me I was crazy," says nanoengineer Ennio Tasciotti, the team leader.

Tasciotti's group covered its particles with membranes from various kinds of white blood cells, or leukocytes. The particles "were look-alikes of a leukocyte," Tasciotti quips. Leukocytes are expert scavengers that take "the VIP path" to go wherever the infection or foreign invader is, Tasciotti says. When leukocytes touch down on the surface of blood vessels, the lining opens to allow the cells to enter.

The "leukolike" particles could avoid attack by macrophages, which gobble up foreign substances, the researchers showed in a set of experiments published in 2012. The researchers used the particles to carry a cancer drug across a layer of endothelial cells, which make up the lining of blood vessels.

Tasciotti's team has since replaced synthetic nanoparticles with natural ones, made from thin sheets of fat cells that form spherical blobs called liposomes, the researchers reported in 2016 in *Nature Materials*. With no artificial parts, Tasciotti says, his leukocyte-coated liposomes, or "leukosomes," so far tested in lab animals, could face an easier path to FDA approval for use in patients.

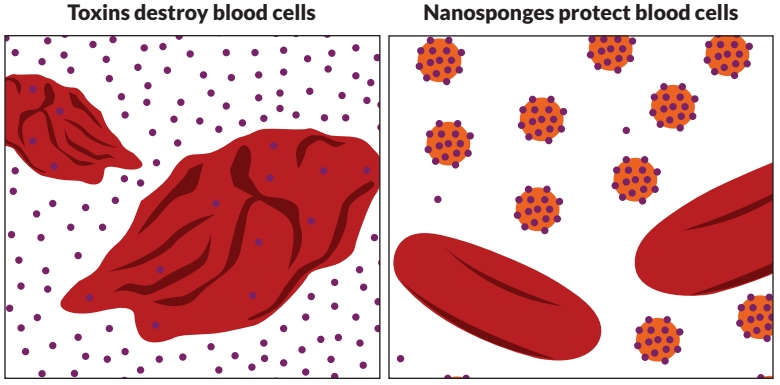
Even when the leukosomes weren't carrying a drug, they interacted with living tissues in helpful ways, Tasciotti says. In 2017 in *Nanoscale*, he and colleagues reported that leukosomes could relieve inflammation and help repair damaged tissue in the gastrointestinal tract of mice that had a form of inflammatory bowel disease.

Toxin traps

While the Houston team and other labs were tinkering with nanoagents to deliver cancer drugs and heal tissues, Zhang ventured into infectious diseases.

As he and Hu brainstormed uses for their membrane-coated particles, they came upon a key realization. Unlike PEG-coated nanoparticles that just sneak through the body, Zhang and Hu's nanoparticles are enclosed within biological membranes from cells that normally interact with tissues and with a plethora of chemical messengers and molecules in the body. Perhaps, then, these interactive membrane-coated particles could put up a fight against toxins, the biological weapons of pathogens.

In 2011, as antibiotic resistance was gaining recognition as a serious public health threat, Zhang learned about pore-forming toxins. These small proteins are released by many pathogens, including MRSA, the strain of *Staphylococcus aureus* that



Diversion Toxins (purple) kill blood cells by attaching to and puncturing the cells' surface (left). Nanosponges protect the blood cells by ensnaring the toxins (right).

FROM TOP: C.-M.J. HU/ACADEMIA SINICA; C. CHANG

resists most antibiotics. Many of these toxins puncture and kill red blood cells, Zhang says.

Some researchers were taking aim at particular toxins by developing antibodies, specialized proteins produced by immune cells to recognize and bind to specific foreign objects. To Zhang, aiming at one type of toxin at a time seemed tedious. Toxins could come from various sources — MRSA, other bacteria, even animal venom. If a single drug could counteract all the toxins, Zhang says, "that would be really cool."

Puzzling over this possibility, Zhang and Hu saw new potential in their nanocreations. Rather than merely acting as camouflage for the nanoparticles, the red blood cell membranes might be able to trap toxins. Toxins "like to poke holes in red blood cells," Hu says. But if toxins go after the nanoparticles, the toxins "get stuck" on the nanoparticles' membranes and can no longer harm cells. Instead, the troublemakers are carried to the liver and broken down.

Vaccinating mice with red blood cell nanoparticles protected the animals from toxins produced by MRSA and showed potential to protect against toxins from *E. coli*, poisonous snakes and bees, the UC San Diego team reported in 2013 in *Nature Nanotechnology*. Zhang, Hu and colleagues have since expanded their collection of nanosponges to include particles covered in membranes from three types of white blood cells — macrophages, neutrophils and T cells.

In a 2017 mouse study in the *Proceedings of the National Academy of Sciences*, macrophage-coated particles trapped and rendered powerless some of the molecules that drive inflammation leading to sepsis, an uncontrolled response to infection that kills about 6 million people worldwide each year.

Last September, the team reported in *Nature Nanotechnology* that neutrophil nanosponges sop up toxins that cause rheumatoid arthritis in mice. And in lab dish experiments reported in November in *Advanced Materials*, nanosponges coated with T cells diverted HIV from actual T cells, the cells this virus typically attacks, eventually causing AIDS.

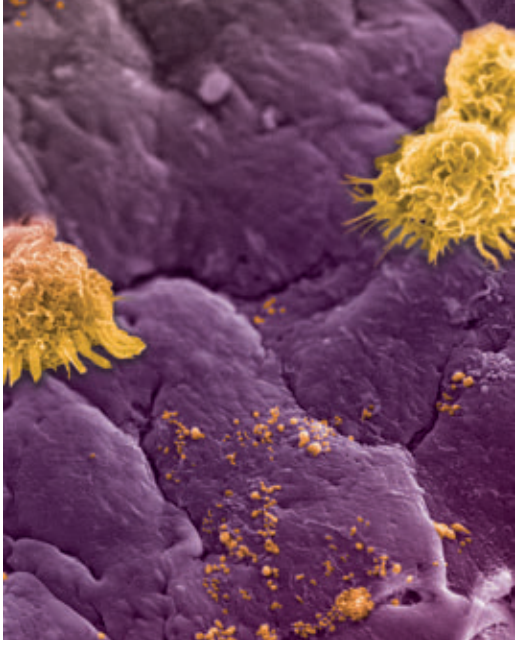
"It's a very versatile approach," says Ankur Singh, a bioengineer at Cornell University. "You don't have to synthesize a new class of materials each time. You could in principle go with an FDA-approved [particle] and put different cell membranes on the surface."

But he raises a possible caution with the studies targeting rheumatoid arthritis, an autoimmune disease. Neutrophil membranes often contain proteins called autoantigens, which cause an immune reaction. If such membranes are used to coat nanoparticles, some autoantigens could exacerbate unwanted immune processes that drive rather than fight disease. Further experiments should test diverse patient tissues, Singh suggests.

For now, Cellics Therapeutics, a San Diego–based biotech start-up that Zhang cofounded in 2014, hopes to launch a patient study with the red blood cell nanosponges. Sepsis and pneumonia top the list of about a dozen conditions that could make good targets for the nanosponges.

But the road to FDA approval is uncertain. "It remains challenging to develop even the simplest of nanoparticles," says Farokhzad at Brigham and Women's Hospital. Particles with human and synthetic components add "enormously to the complexity of the system," he says. "But you're also adding enormously to the promise of the system."

Today, Hu's group in Taiwan is taking the nanosponge concept in a new direction. The researchers made nanoparticles coated with membranes from red blood cells and used the particles to trap influenza viruses. The method, reported in 2017 in *ACS Applied Materials and Interfaces*, might one day improve diagnosis of influenza and other viral infections. "If you think of biological processes — how cells communicate, how viruses infect cells — all these things happen at the nanoscale," Hu says. ■



Nanoparticles dubbed leukosomes (small yellow speckles) are designed to mimic white blood cells called leukocytes (large yellow clusters). In this false-color microscope image, leukosomes accumulate on an inflamed blood vessel (purple).

MATT LANDRY AND E. TASCIOTTI/HOUSTON METHODIST RESEARCH INST.

Potential targets

The list of nanosponges being tested in lab dishes and mouse studies is growing. Here are some targets being explored. The type of nanosponge coating is in parentheses.

Bacterial infections
- Sepsis (red blood cell, macrophage)
- Pneumonia (red blood cell)
- Skin and soft tissue infection (red blood cell)

Viral infections
- HIV (CD4 T cell)
- Zika (mosquito host cell)
- Influenza (red blood cell)

Autoimmune diseases
- Rheumatoid arthritis (neutrophil)
- Autoimmune hemolytic anemia (red blood cell)
- Immune thrombocytopenic purpura (platelet)

Venom
- From snakes and other animals (red blood cell, white blood cell, platelet)

Explore more

- Y. Jiang *et al*. "Engineering biological interactions on the nanoscale." *Current Opinion in Biotechnology*. November 1, 2018.

Esther Landhuis is a freelance science journalist based in the San Francisco Bay Area.

The Case of the Arctic's MISSING ICE

The mystery is whether ice-free will become the Bering Sea's new normal

By Carolyn Gramling

Cameras, like this one, set up in the Chukchi and Bering seas, record how much light reaches through the melt ponds that sit atop sea ice. More light means more algal blooms grow below the surface.

K. FREY

Peggy's data were a bit of a shock.

From an anchored vantage point in an expanse of the southeastern Bering Sea west of Alaska, Peggy, or mooring M2, had monitored conditions in the water for 25 years. A line of sensors extended down more than 70 meters to where Peggy was tethered to the seafloor, collecting information on temperature, salinity and other properties of the water.

Most years, the waxing and waning of floating sea ice follows a consistent seasonal pattern that is reflected in Peggy's data. By November, sea ice migrates in through the Bering Strait or forms in some parts of the Bering Sea. As a by-product of the sea ice formation, a large mass of cold, salty water begins to pool near the seafloor. In the spring, phytoplankton bloom, and by early summer, the sea ice begins to melt away. The cold pool, however, lingers through the summer.

With an average temperature just below zero degrees Celsius — a few degrees colder than the surrounding water — that deep, cold pool is central to the Bering Sea ecosystem. The cold pool is where Arctic cod take refuge, hiding from predators such as Pacific cod and pollock, which are less tolerant of the cold. The Arctic cod get fat on large, shrimp-like copepods and spawn their young. In turn, the fish keep polar bears and seals well-fed.

But in the winter of 2017–2018, the sea ice never appeared. And Peggy's data, along with that of other moorings, revealed that the cold pool was

AWOL too. Alarm trickled through the ocean science community, researchers who study everything from the physics of the Bering Sea to the small creatures that live on the seafloor and the larger marine mammals at the top of the food chain. In December in Washington, D.C., at the American Geophysical Union's annual meeting, these researchers gathered to present their data, trade stories and ponder what it all means.

Were these findings a fluke? "We don't yet have enough data" to say whether the Bering Sea is increasingly likely to be ice-free, says Jacqueline Grebmeier, a biological oceanographer at the University of Maryland's Center for Environmental Science in Solomons. But Grebmeier, who has studied seafloor life in the Arctic for more than 30 years, has "a gut feeling," she says, that it's not a one-off incident. "I think it's the beginning of change."

If last year's events represent a new normal for the Bering Sea, then a cascade of changes are in store for the complicated ecosystem that has long thrived in those waters — and for the fishing and tourism industries that rely on the area's bounty.

Open waters

At their closest point, Alaska and Russia are separated by the 82-kilometer-wide Bering Strait. To the north of the strait lies the Chukchi Sea, on the edge of the Arctic Ocean; to the south is the Bering Sea, extending down to Alaska's outflung arm of islands, the Aleutians.

In the summer, the Bering Sea is largely ice-free, but in winter, ice forms in the northern Bering Sea, or migrates southward through the strait from the Chukchi. The waters reach "freeze-up" when there is at least 20 percent ice cover, scientists say.

There were early signs that conditions in 2017 and 2018 were going to be different. By November 2017, the sea ice was already late. The air above the waves wasn't especially warm. In fact, the air temperature was typical for that time of year, Phyllis Stabeno, a physical oceanographer at the National Oceanic and Atmospheric Administration's Pacific Marine Environmental Laboratory in Seattle, reported at the December meeting. But an unusually persistent wind was blowing from the south, she said, preventing the ice from drifting down from the Chukchi Sea as it would normally.

The wind tapered off by December and January, but by then air temperatures were higher than normal. The Chukchi Sea, normally at least 80 percent covered by thick, tough, icebreaker-testing pack ice by January, still had large open swaths of water. That meant less ice was available to migrate southward through the Bering Strait.

Mooring M8, about 800 kilometers northwest of Peggy, had never recorded so little ice in the winter. M8, taking measurements since 2008, registered temperatures just above the seafloor that were more than 3 degrees C above normal. And Peggy, down by the Aleutians, had never recorded higher summertime water temperatures near the seafloor. That summer, the water never dropped below freezing.

Then, in February, the strong southerly winds began again, and the unusual wind direction persisted through March; scientists suspect those winds kept the Chukchi Sea unusually warm, by pushing warmer waters from the Bering Sea northward. The warmer waters also prevented the formation of sea ice. The ice that did form in the Chukchi and Bering seas was thin and easily pushed back northward by the prevailing winds.

Sea ice, whether migrating in or forming in place, is an anchoring part of the Bering Sea ecosystem. The ice helps determine when and where food becomes available to creatures living in the water or on the seafloor. As the migrating sea ice travels south, it melts. That meltwater is relatively fresh and less dense than the surrounding water. As a result, the waters become stratified, with the layer of fresher water staying on top. That freshwater, full of nutrients, helps give rise to the southern Bering Sea's springtime phytoplankton blooms, which in turn feed copepods and other small floating creatures. When the phytoplankton eventually die and sink to the seafloor, they provide an important food source for creatures living on the bottom.

But the absence of sea ice means that the water doesn't stratify until later in the spring, and so the

The Bering Strait separates the Chukchi Sea, a southern extension of the Arctic Ocean, from the Bering Sea. Sea ice that migrates south through the strait in winter plays an important role in the Bering Sea ecosystem. The black dot on the map above shows where Peggy (pictured) has been moored since 1995 to collect data on water temperature and salinity.

FROM TOP: T. TIBBITTS; NOAA

Spring blooms of phytoplankton add swirls of color to the Chukchi (shown in this satellite photo) and Bering seas. In 2018, the absence of sea ice in the southern Bering Sea delayed the blooms that form the base of the food web for several months.

phytoplankton blooms happen later in the spring. Not every Bering Sea dweller will be quick to adjust to those delays in the ecosystem's food web.

"The timing is important," Grebmeier says. "It's a question of how fast [the animals] can adapt."

And thanks to the winds and warmth, little sea ice managed to form within the Bering Sea, which meant no deep, cold pool near the seafloor. Normally, the cold pool forms as a by-product of sea ice formation, especially in a region just south of St. Lawrence Island. Prevailing winds blowing south from the island create a space of open water called a polynya that freezes quickly in winter. As quickly as the ice forms, the winds blow it away from the island, opening up the water again to more freezing, creating a sea ice production line. All of that ice forming at that one spot pulls a lot of freshwater out of the sea; the water that's left behind is salty and dense and sinks down to the seafloor, forming that pond of cold water that lingers throughout the summer.

Arctic in transition

Although the dramatic absence of sea ice last winter was startling, waters in the Arctic have actually been on a decades-long warming trend. In the southern Chukchi Sea, freeze-up has happened about half a day later each year since 1981, Stabeno and colleagues reported in November in *Deep-Sea Research*. And in the northern Bering Sea, mooring M8's data show particularly stark changes over the last four years. From 1981 to 2014, freeze-up happened on average by the end of December. But since 2014, freeze-up hasn't occurred until January or February — or, in 2018, not at all.

This warming trend has had trickle-down effects on the seafloor dwellers. Species such as bivalves that once carpeted the seafloor surrounding St. Lawrence Island, to the south of the strait, have shifted northward, Grebmeier says.

In 2010, Grebmeier helped establish the Distributed Biological Observatory, an international effort to monitor long-term ecosystem changes in the Arctic by visiting designated "hot spots" year after year in the region, including the Bering and Chukchi seas. Those sites include the

Ups and downs

2018's record-setting low sea ice in the northern Bering Sea and a missing cold pool in the southern Bering took a toll on some species. Blue king crabs, ribbon seals and krill have decreased. Small copepods and urchins fared better.

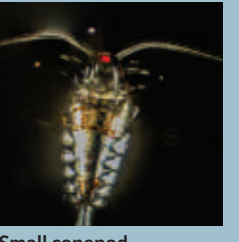
DECREASING

INCREASING

Pacific cod

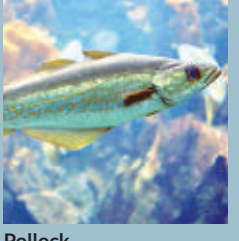
Ribbon seal

Thick billed murre

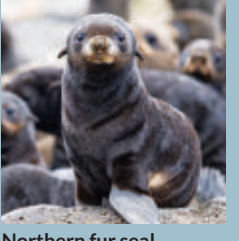


Small copepod

Blue king crab

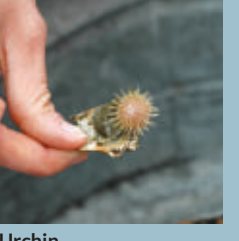


Pollock



Northern fur seal

Krill



Urchin

TOP: NORMAN KURING/NASA'S OCEAN COLOR WEB; ANIMALS, CLOCKWISE FROM TOP LEFT: © JOEL SARTORE/NATIONAL GEOGRAPHIC PHOTO ARK; K. FREY; U.S. FISH AND WILDLIFE SERVICE HEADQUARTERS/FLICKR (CC BY 2.0); MARTIN ALMQVIST/ALAMY STOCK PHOTO; K. FREY; CITRON/WIKIMEDIA COMMONS (CC BY-SA 3.0); DESIGN PICS INC/ALAMY STOCK PHOTO; ØYSTEIN PAULSEN/WIKIMEDIA COMMONS (CC BY-SA 3.0); K. FREY

region just south of St. Lawrence Island, where the cold pool usually forms.

Bivalves on the seafloor there used to provide a nutritious, fatty food for walruses and seals. And spectacled eiders — a kind of sea duck — dove for the mollusks, using the sea ice as a safe, stable launch pad. But over time, those bivalve patches have given way to marine worms, a far less nourishing food, Grebmeier says. For spectacled eiders, which are considered at risk of extinction in the near future, the food shift and the loss of sea ice is a one-two punch. "It takes less energy to sit on the ice and feed on underlying prey than to swim," she says. "So the impact on these organisms is dramatic."

Other creatures in the Arctic have taken a hit as well. Researchers have measured an increase in the populations of small copepods that tiny larval pollock eat. But populations of fattier and more nourishing large copepods are in decline, which is bad news for juvenile fish that need the larger copepods to survive through the winter.

The prey changes have had cascading impacts on the food web: Changes in the distribution and types of fish populations have spelled doom for thousands of seabirds. Last summer was the third year in a row with a massive seabird die-off, Calvin Mordy, a biological oceanographer with NOAA's Pacific Marine Environmental Laboratory, reported at the December meeting. The seabirds showed evidence of starvation, he said, not disease.

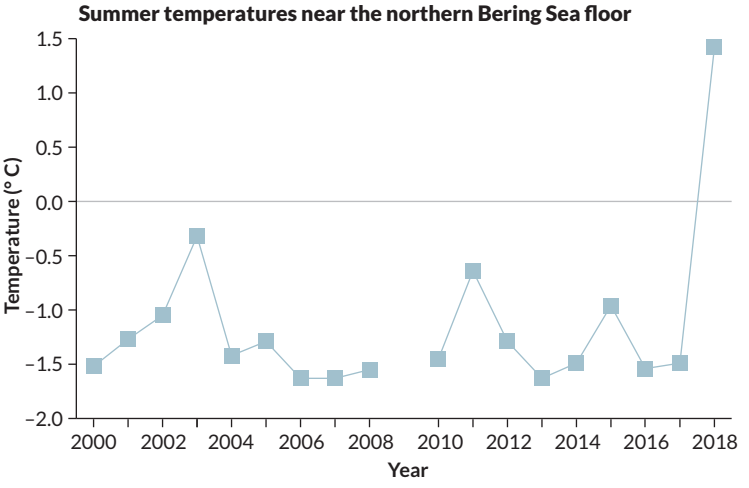
The heat is on

The combination of wind and warmth that led to the record-low sea ice in the Bering Sea, scientists say, was unusual based on past records. The question is how typical these conditions will be in the future, Stabeno says.

The Arctic is warming twice as fast as the rest of the planet, with an average temperature about 1.7 degrees C above the long-term average during 1981 to 2000, according to the 2018 Arctic Report Card, NOAA's annual report on the state of the Arctic. In fact, the five years since 2014 are the five warmest scientists have ever measured, says Emily Osborne, the lead editor of the 2018 report card and a climate scientist with NOAA's Arctic Research Program in Silver Spring, Md. Last year was the second-warmest year on record, exceeded only by 2016, she says. One visible effect of the temperature rise is a sharp decline in summer sea ice cover, with the last 12 years being the 12 lowest on record.

Rising air and ocean temperatures aren't the only sign of change in the Arctic Ocean. The runoff from local rivers is having an impact. "It's the most land-dominated ocean in the world," says Karen Frey, a polar scientist at Clark University in Worcester, Mass. "It's a dumping ground for everything," she adds, from sediment loads carried by rivers to dissolved organic matter to phytoplankton. "All roads lead to the Arctic."

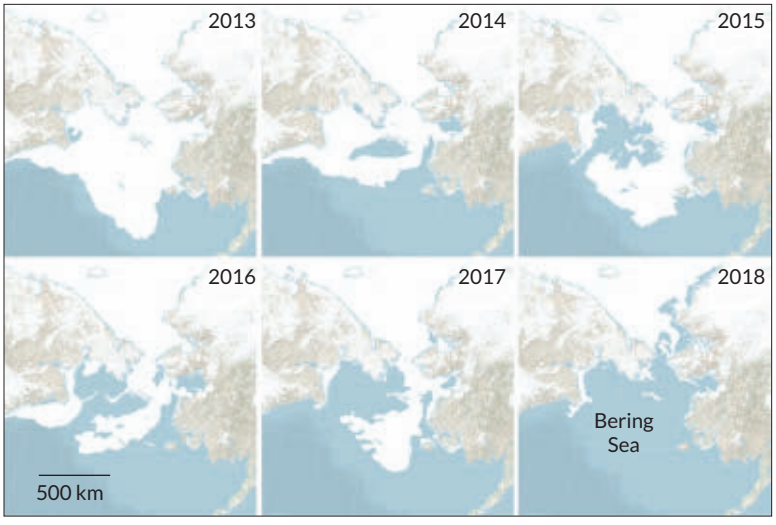
In 2018, the volume of discharge of the eight largest rivers emptying into the Arctic Ocean was about 20 percent higher than it was in the 1980s, due to some combination of factors related to global warming, including increasing degradation of permafrost and increasing rainfall in the High Arctic.



Deep warming Temperatures near the seafloor in the northern Bering Sea tend to hover around −1.5° Celsius in July, forming a "cold pool." But in 2018, the average bottom water temperature was about 1.5°, signaling the absence of a cold pool that year. No data were collected in July 2009. SOURCE: J. GREBMEIER *ET AL/OCEANOGRAPHY* 2018

Polar scientist Karen Frey found that melt ponds above sea ice, like this one on the Chukchi Sea, can act as skylights, helping as much as 70 percent of sunlight reach the water beneath the ice. Frey was an author on NOAA's 2018 Arctic Report Card.

FROM TOP: T. TIBBITTS; K. FREY



April usually means ice in the Bering Sea. But satellite maps from April 2013 through 2018 (top) show a basically ice-free sea last year. Warming waters and decreasing sea ice cover encourage harmful algal blooms, which can hurt tourism and fishing (bottom, a native Alaskan fishes with a drop line on the Bering Sea in Nome, Alaska).

All of that material pouring into the ocean has resulted in a heightened supply of nutrients. The extra nutrients plus the warmer waters and more sunlight shining through — thanks to the missing or thinner sea ice — add up to larger phytoplankton blooms, Frey says. Some of that algal biomass — scientists don't yet know how much — is toxic, akin to the deadly red tides blossoming along Florida's coasts in recent years (*SN: 9/29/18, p. 14*). Such toxins can kill fish, as well as produce neurological damage in humans.

Paralytic shellfish poisoning has increased sevenfold among Alaskans over the last 40 years, with the rise possibly caused by an increase in harmful algal blooms, Frey says. The state now has one of the highest incidences of shellfish poisoning in the world. The frequency and distribution of harmful algal blooms have both increased dramatically in recent years, prompting the first special section on harmful algal blooms included in the 2018 Arctic Report Card.

The culprit algae may have "been present in many areas at low levels that wouldn't be harmful. But the minute you start warming seawater ... and removing sea ice, they adjust," Frey says. "We are just starting to make measurements of harmful algal blooms and starting to understand how those species in the Arctic respond to light. It's a very new question that has yet to be answered."

Frey, as part of the Distributed Biological Observatory program, visited the Bering Sea last July to measure how less sea ice, as well as thinner sea ice, changes the amount of light that reaches the waters to encourage blooms. Even the thinner ice — often covered with small melt ponds — could have a big effect on how much light penetrates, she found.

The melt ponds "are basically skylights" for the waters below, she says. Having melt ponds on the surface of the sea ice can increase transmission of light into the water from perhaps 10 percent to as much as 60 or even 70 percent, Frey reported at the December meeting.

The increase in phytoplankton blooms was particularly dramatic in 2018, the report card notes. Less sea ice and more melt ponds meant more light penetrated the Arctic's waters earlier in the year, prompting blooms in the northern Bering Sea even as the south bloomed later. The northern waters, which normally see blooms in May, bloomed as early as March. The amount of algal biomass in March was about 275 percent higher than the average March biomass for 2003 to 2017.

Scientists are still studying how much the harmful algal blooms may have contributed to excess seabird deaths. Bloom-related toxins have been implicated in other wildlife mass mortality events in the last few years, from walrus to seals to whales — animals that probably ate contaminated fish and shellfish, just like humans, the Arctic Report Card notes. As warming waters and decreasing ice cover create ever more favorable conditions for all algal blooms, the threat of harmful toxins will almost certainly contribute to economic losses for two of the region's biggest industries: fishing and tourism.

"Historically we shouldn't be seeing another year like [2018], but under that argument, this year shouldn't have happened," Stabeno said in December. "What we saw this year was predicted to happen in 2050," she added. "This gives us a view of the future." ■

Explore more

■ NOAA Arctic Report Card. December 2018. https://arctic.noaa.gov/report-card

MAPS: JOSHUA STEVENS/NASA EARTH OBSERVATORY, NATIONAL SNOW AND ICE DATA CENTER; PHOTO: MICHELE AND TOM GRIMM/ALAMY STOCK PHOTO

GEOLOGIC ROAD TRIP OF THE MONTH

NATURAL BRIDGE STATE PARK

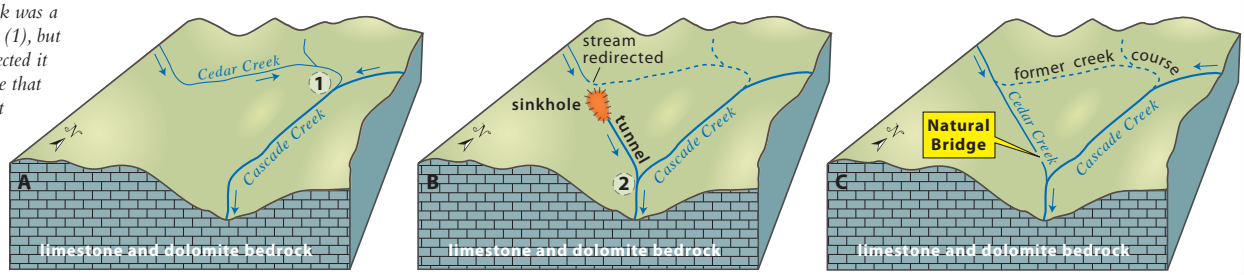
It is estimated that karst, a type of landscape formed by the dissolution of soluble rock such as limestone, dolomite, and gypsum, affects more than 20 percent of America's land surface. It is characterized by sinkholes, springs, caves, and disappearing streams and rivers. Such well-known attractions as Carlsbad Caverns in New Mexico, Jewel Cave in South Dakota (the third-largest cavern in the world), and the roly-poly topography of the Bluegrass Region of Kentucky developed in karst. Setting aside the tourist income related to karst, on average it causes more than $300 million annually in infrastructure damage in the United States, exemplified by a 1981 Florida sinkhole that catastrophically consumed five Porsches, an Olympic-sized swimming pool, and a three-bedroom home in the course of one day.

Believed to have been surveyed by George Washington in 1750 and owned by Thomas Jefferson in 1774, Natural Bridge is considered a unique natural wonder of the modern world.

Karst extends through portions of twenty-nine of Virginia's ninety-five counties, as evidenced by some 4,300 caves and close to 49,000 sinkholes. The best-known karst-related attraction in the Commonwealth is Natural Bridge, famously described by Thomas Jefferson, the third president of the United States, as a "convulsion of nature." However, there is general agreement these days that karst isn't fully responsible for the creation of Natural Bridge. Cedar Creek, the stream that placidly flows under the arch, played a role.

Several million years ago an elongate sinkhole developed near Cedar Creek, redirecting it. Once a tributary to Cascade Creek, Cedar Creek flowed into the sinkhole, becoming a subterranean stream. Eventually this subterranean channel extended its reach by dissolving 470-million-year-old Beekmantown Dolomite and Chepultepec Formation limestone, the final outcome being the creation of a tunnel. Most of the tunnel roof collapsed long ago, leaving Natural Bridge as the only surviving remnant and allowing Cedar Creek to once again flow at the surface and into Cascade Creek.

In the not-too-distant geologic future this remaining tunnel segment will also be reduced to rubble by erosion and weathering, the enemies of all rock. So don't wait. Head to Natural Bridge State Park, in the town of Natural Bridge, to have a look yourself.

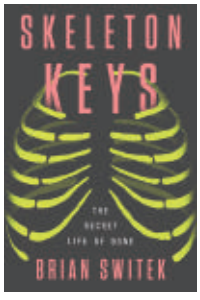


(A) Originally Cedar Creek was a tributary to Cascade Creek (1), but (B) a nearby sinkhole redirected it into a subterranean drainage that developed into a tunnel that eventually joined Cascade Creek farther downstream (2). (C) Eventually the tunnel collapsed, leaving a small remnant as Natural Bridge. Arrows show the direction of streamflow.

BOOKSHELF

‘Skeleton Keys’ unlocks the mysteries of bones

King Richard III’s bones reveal much about the English monarch’s life and death.



Skeleton Keys
Brian Switek
RIVERHEAD BOOKS, $26

At this very moment, voracious cells are eating away at your bones. Not to worry, though — that’s just a normal part of bone maintenance in healthy adults. The formation of new bone cells balances out the removal of old bone cells. Although bone-making cells rev up when a bone breaks or disease sets in, eventually bone-eating cells kick in to make sure a bone doesn’t grow out of control. Bones as active tissues, not fixed structures, is just one of the fascinating topics that writer Brian Switek explores in *Skeleton Keys*.

The microscopic structure of our bones isn’t the only thing that changes throughout our lives; the number of bones changes too. Humans are born with about 270 bones that over the course of our youth and adolescence grow and fuse into 206 bones, give or take a few. And while some of those bones can provide clear evidence of whether a person was male or female, there are, contrary to what we see in many crime dramas, no anatomical characteristics that conclusively indicate a person’s race or country of origin.

Beyond basic biology and modern forensics, *Skeleton Keys* chronicles bone through the ages, from the origins of the precursor of bone in fish more than 450 million years ago to the role of bone in modern paleontology and anthropology. Here, Switek, a self-described “fossil fanatic” who has written three books about fossils (*SN: 9/5/15, p. 28; 5/4/13, p. 34; 1/1/11, p. 34*), puts his expertise to work. As he explains, the physical size and shape of bones help scientists identify what type of creature once hosted those tissues, what the animal looked like and possibly how it moved. Bones are also biological time capsules, often rife with chemical clues that can reveal what an animal ate and where it may have lived as it was growing up.

The author packs a bevy of such facts into illustrative tales of famed skeletons. The bones of Lucy, a hominid that strolled across the Ethiopian landscape more than 3.3 million years ago, indicate that she was well-equipped for walking upright. The skeleton of England’s King Richard III — miraculously found and then unearthed from beneath a city parking lot in 2012 — betrays the abuse the king suffered during and after his death on a battlefield in 1485 (*SN: 3/9/13, p. 14*). Chemical analyses of his bones also chronicle the region where he grew up and the rich diet he consumed during his tumultuous two-year reign (*SN: 9/20/14, p. 17*).

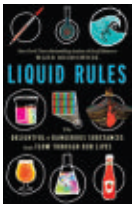
A number of lesser-known skeletons, including that of anthropologist Grover Krantz, who donated his and his dog’s skeletons to the Smithsonian Institution, where they were displayed, pepper this wonderfully engaging read. — *Sid Perkins*

BOOKSHELF

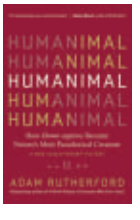
The Atom
Jack Challoner
Colorful images and illustrations introduce readers to the structures, processes and interactions of one of the most fundamental building blocks of matter. *MIT Press, $33*

Earth-Shattering
Bob Berman
From the Big Bang to nuclear accidents, an astronomer describes the local and cosmic catastrophes that have and could shape life on Earth. *Little, Brown & Co., $28*

Ten Drugs
Thomas Hager
A journalist digs into the culture and history of some of the most significant advances in medicine, including the introduction of opium, the first antibiotic and even Viagra. *Abrams Press, $26*



Liquid Rules
Mark Miodownik
On a transatlantic flight, a materials scientist analyzes the liquids he encounters, from the beverage cart to the lavatory, and how humans try to control the fluids around them. *Houghton Mifflin Harcourt, $26*



Humanimal
Adam Rutherford
Using the latest research in genetics and evolutionary biology, a science writer examines what makes humans distinct from other animals. *The Experiment, $25.95*

SOCIETY UPDATE

Society for Science & the Public gives $120,000 to 35 STEM teachers

Middle and high school science teachers across the United States received STEM Research Grants of up to $5,000 from the Society to spend on scientific research equipment — such as digital incubators and microscopes for experiments, computer software for advanced analyses and various lab kits — as well as research-related transportation costs.

CONGRATULATIONS TO ALL!

Maria Agapito | Bard High School Early College–Newark Campus | Newark, N.J. | $1,000

Rocheli Apilan | High School for Health Professions and Human Services | New York, N.Y. | $5,000

Suzanne Banas | South Miami Middle School | Miami, Fla. | $3,000

William Bartenslager | Palm Beach Central High School | Wellington, Fla. | $4,000

ScottiAnn Benton | Jasper County Middle School | Monticello, Ga. | $3,000

Lu Bitter | Pratt High School USD 382 | Pratt, Kan. | $5,000

Dennis Boxrud | Hinckley-Finlayson Public Schools | Hinckley, Minn. | $5,000

Sean Brady | Eleanor Roosevelt High School | Greenbelt, Md. | $4,000

Cheyenne Branscum | Shawnee Middle School | Shawnee, Okla. | $3,000

Molly Carlson | Mauston High School | Mauston, Wisc. | $1,000

Gabrielle Ciarcia | EL Haynes PCS | Washington, D.C. | $5,000

Carrie Cox | Chamberlain High School | Chamberlain, S.D. | $4,000

Cathy Farrar | Marquette High School | Chesterfield, Mo. | $3,000

Yolanda Flores | Navajo Preparatory School | Farmington, N.M. | $3,000

Patricia Griest | Seneca Valley High School | Harmony, Pa. | $3,000

Stephanie Harris | Washington Technology Magnet School | Saint Paul, Minn. | $4,000

Kevin Johnson | Kauai High School | Lihue, Hawaii | $5,000

Jeremy Jonas | Tucson High Magnet School | Tucson, Ariz. | $5,000

Dave Jones | Big Sky High School | Missoula, Mont. | $5,000

Ed Lewis | Moberly High School | Moberly, Mo. | $1,000

David Lockett | Edward W. Bok Academy | Lake Wales, Fla. | $5,000

Samuel Loftus | New Orleans Charter Science and Mathematics High School | New Orleans, La. | $5,000

Priscilla Lumbreras | Granbury High School | Granbury, Texas | $4,000

Reny Mathew | Greyhills Academy High School | Tuba City, Ariz. | $3,000

Amy Melby | Yuma High School | Yuma, Colo. | $4,000

Rachna Nath | ACP Erie | Chandler, Ariz. | $3,000

Jennifer Pefanis | Sanford H. Calhoun High School | Merrick, N.Y. | $1,000

Elizabeth Proctor | Jasper County High School | Monticello, Ga. | $3,000

Julia Riley | Hayfield Secondary School | Alexandria, Va. | $5,000

Todd Spangler | Whitefish High School | Whitefish, Mont. | $3,000

Iquo-Ote Spence | Hallandale Magnet High School | Hallandale Beach, Fla. | $1,000

Gregg Stickler | Rising Sun High | North East, Md. | $3,000

Paul Timm | Lyons-Decatur Northeast Public Schools | Lyons, Neb. | $4,000

Virginia Vilardi | Wetumpka High School | Wetumpka, Ala. | $3,000

John Weisenfeld | Pasco High School | Pasco, Wash. | $1,000

STEM ACTION & RESEARCH GRANTS

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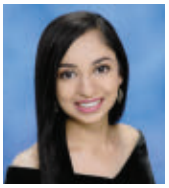
Santa Clara, CA

Adam Ardeishar
McLean, VA

Carolyn Beaumont
Arlington, VA

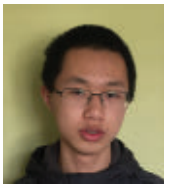
Grace Cai
Potomac, MD



Anjali Chadha
Louisville, KY

Lyron Co Ting Keh
La Crescenta, CA

Samuel Ferguson
West Windsor, NJ



Vincent Huang
Plano, TX

Ana Humphrey
Alexandria, VA

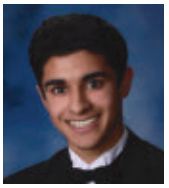
Navami Jain
Charlotte, NC

Aayush Karan
Muskego, WI

Ananya Karthik
Sunnyvale, CA

Preeti Krishnamani
Hockessin, DE

Chirag Kumar
Chappaqua, NY



Varun Kumar
Woodcliff Lake, NJ

Thomas Lam
Jericho, NY

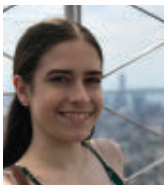
Gabrielle Liu
Nashville, TN

Eish Maheshwari
New Hyde Park, NY

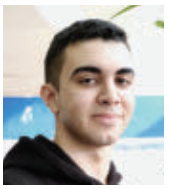
Sai Mamidala
Garnet Valley, PA

Natasha Maniar
Sunnyvale, CA

Braden Milford
Tulsa, OK



Emma Montgomery
Ossining, NY



Ahmad Perez
Brentwood, NY

Brent Perlman
Armonk, NY

Kevin Qian
Rockville, MD

Ronak Roy
San Diego, CA

Eshika Saxena
Bellevue, WA

Ruhi Sayana
Cupertino, CA

Daniel Schäffer
Silver Spring, MD

Justin Schiavo
Roslyn Heights, NY

Rachel Seevers
Lexington, KY

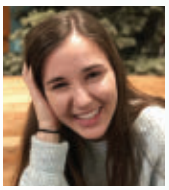
Aditi Singh
Chappaqua, NY

Amol Singh
San Jose, CA

Julia Situ
San Diego, CA

Madhav Subramanian
Jericho, NY

William Wang
Tulsa, OK



Zoe Weiss
Atlanta, GA

Samuel Weissman
Merion Station, PA

Frank Xu
Brookline, MA

Madeleine Yang
Bloomfield Hills, MI

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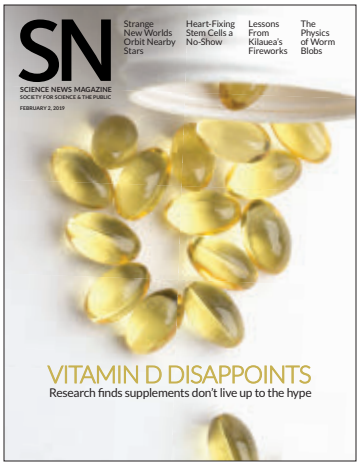

FEBRUARY 2, 2019

SOCIAL MEDIA

Cowabunga

Astronomers spotted a mysterious flare-up 200 million light-years from Earth. Dubbed the "Cow," the flash may have resulted from a star exploding in a new type of supernova, **Lisa Grossman** reported in "Cosmic 'Cow' baffles scientists" (*SN: 2/2/19, p. 13*). Sticking with the bovine theme, Reddit user **deadHD** suggested calling the event that created the Cow a "moopernova."

Join the conversation

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Which way is up?

Initial observations of the Kuiper Belt object MU69, nicknamed Ultima Thule, suggested it had a snowmanlike shape. Ultima Thule's two lobes are connected by a narrow neck that appears brighter than the rest of the space rock's surface, ***Lisa Grossman*** *reported in "New Horizons swings by Ultima Thule"* (SN: 2/2/19, p. 7). "The photo of Ultima Thule was fascinating," reader **Thomas Ostwald** wrote. "However, the explanation of the bright 'neck' as grains that rolled 'downhill' was a shock! Which way is up?"

Scientists consider the "up" direction opposite the pull of gravity on Ultima Thule. It helps to imagine you're standing on the space rock, says **James Tuttle Keane**, a planetary scientist at the California Institute of Technology.

If you were standing on the bigger lobe (Ultima) and far away from the smaller lobe (Thule), you'd primarily feel the gravity of the big lobe and the surface would seem flat, **Keane** says. The pull of gravity would be perpendicular to the surface. The "up" direction would also be perpendicular to the surface, pointing away from gravity's pull.

As you move closer and closer to the neck connecting the lobes, the gravitational pull from Thule would start to have a bigger influence than before. This would change the "up" direction. It would no longer be perpendicular to the surface.

When "up" isn't perpendicular, there's a slope. And so loose material on the surface of MU69 might "slump into" the neck region, **Keane** says. But that is just one of the many ideas scientists have for explaining Ultima Thule's bright neck.

Additional observations indicate that the space rock is actually shaped more like two lumpy pancakes stuck together, rather than two snowballs (see Page 15). That might change scientists' understanding of Ultima Thule's gravitational field "a little bit," **Keane** says. He and colleagues are working on a study to figure out what those changes could be.

Growth spurt

Tweaking tobacco plants' genetic instructions boosted the efficiency of photorespiration. The modified plants grew roughly 40 percent bigger than plants that had not been genetically altered, ***Maria Temming*** *reported in "Shortcut improves photosynthesis"* (SN: 2/2/19, p. 6). Online reader **Alice Friedemann** asked if engineered plants would require more water than normal plants.

Generally, larger plants require more water than smaller plants, says **Paul South**, a molecular biologist with the U.S. Department of Agriculture in Urbana, Ill. These engineered plants "use the same amount of water per a given area or size, but since they are bigger they would use more water" than nonengineered plants, he says.

Deflating vitamin D supplements

Vitamin D supplements may have fewer health benefits than expected, ***Laura Beil*** *reported in "D is for discouraging"* (SN: 2/2/19, p. 16). Reader **Sandra Mack** thought that sunlight may deliver the health benefits that researchers were expecting from vitamin D supplements.

Both sunlight and supplements can make up for deficiencies, **Beil** says. But supplements are used in studies because they safely deliver vitamin D at higher levels. "Researchers still haven't determined whether sunlight can safely deliver high amounts of vitamin D," she says.

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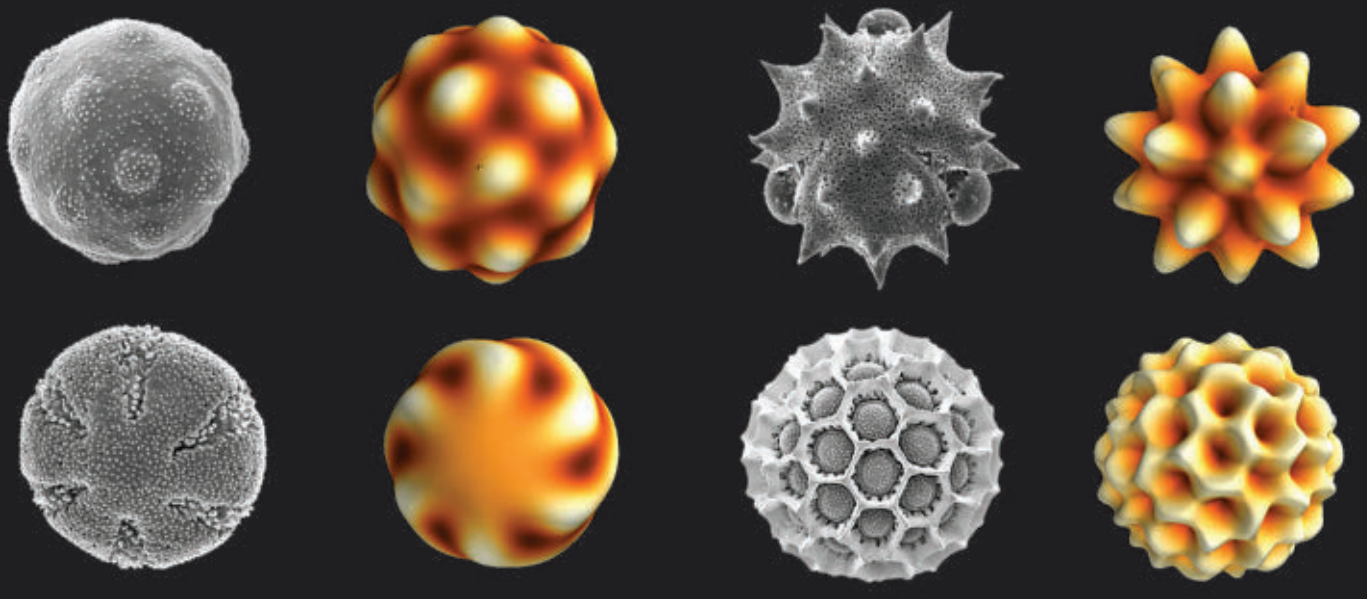
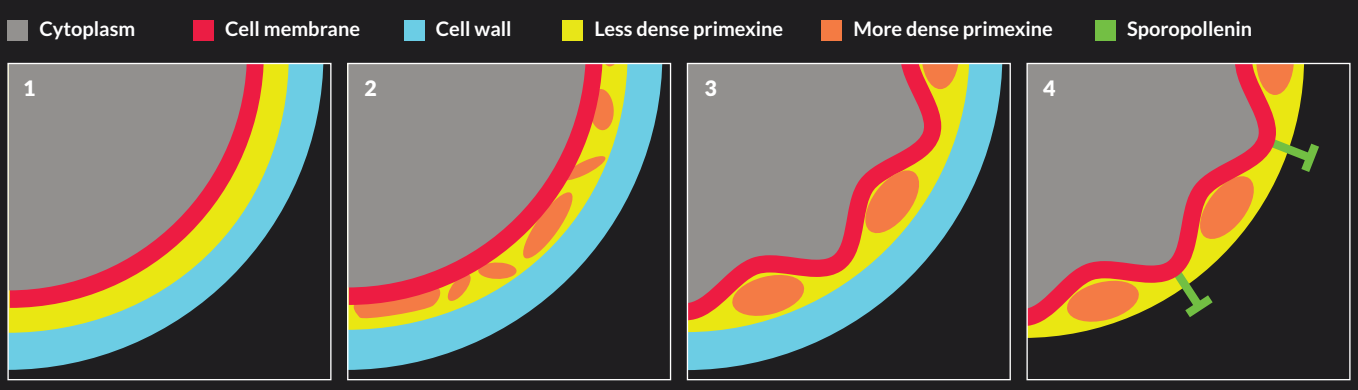




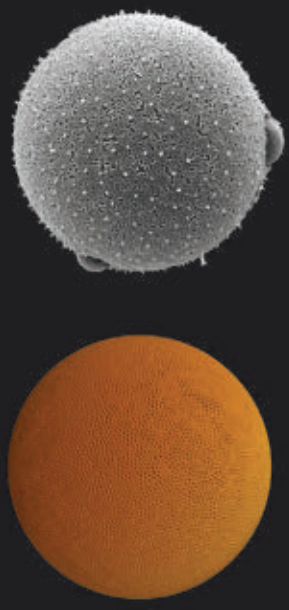
Pollen fashion, explained by physics

Some pollen grains sport a variety of snazzy shapes, adorned with golf ball–like divots, prickly knobs or swirls that evoke a peppermint candy. But these myriad patterns (a selection shown in the scanning electron microscope images and orange simulations at top) may all be due to one simple trick of physics, scientists report in the Feb. 7 *Cell*.

That trick: phase separation, in which a mixture naturally breaks up into separate parts, like cream floating to the top of milk. As pollen develops in a flowering plant, a material called primexine is deposited at the grain's surface, inside a temporary cell wall (box 1 in the diagrams above). Formed from a mixture of materials including cellulose and pectin — the stuff that makes jam set — the primexine clumps (2) into denser and less dense regions "like bad gravy," says biophysicist Alison Sweeney of the University of Pennsylvania.

That lumpiness generates wiggles in the pollen's cell membrane (3), Sweeney and colleagues found. Finally, the temporary cell wall dissolves, and a tough material called sporopollenin reinforces the wiggly pattern (4). The resulting shape, which appears over the course of a few days, varies depending on the composition of the primexine.

Using computer simulations of the process, the scientists reproduced the shapes of lumpy, patterned pollen, which make up about 10 percent of the pollen from cataloged flowering plant species. The remaining 90 percent have smooth surfaces or a foamy appearance (one example at right). The simulation explained those patterns, too: They arose if the phase separation process stopped before the primexine fully separated. — *Emily Conover*



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