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Ulrika Kestere/OFFSET

FROM TOP: NICOLLE RAGER FULLER; L. XIONG ET AL/LIFE 2020; HUNG, CHUNG, CHIH/ISTOCK/GETTY IMAGES PLUS



When a new virus breaks

On December 31, Chinese authorities alerted the World Health Organization to a mysterious respiratory illness afflicting people in Wuhan, China. On January 7, the authorities said they had identified a new virus, a coronavirus in the same family as the common cold, SARS and MERS.

Journalists like me who cover infectious disease sit up and take notice when “new coronavirus,” “SARS” and “MERS” show up in the same sentence. Add “in China,” the starting point for the SARS outbreak, and we start calling sources.

Like everyone else, we want to know if the new coronavirus, known as 2019-nCoV, could become a global threat. Many human disease outbreaks get their start in animals, and this one is no exception, though the exact source is unknown. The virus sprang up in Wuhan, and is now spreading from one person to another. Travelers are carrying the virus around the world. As of January 29, 6,074 cases had been confirmed in 17 countries, and the number is rising.

In 2003, I covered the SARS outbreak, which emerged from an animal market in China. SARS infected more than 8,000 people in 29 countries, killing 774. Those numbers don't convey the confusion and anxiety of being in the midst of the outbreak. I traveled to Toronto, where the virus was tearing through hospitals, infecting patients and staff. In one ward, 40 percent of the nurses fell ill. Hospitals' increased oversight of infection-control procedures finally helped stop the virus.

Hard-learned lessons from SARS seem to be helping now. China has been swifter to let the rest of the world know about the new virus on the loose, releasing the genetic sequence of the virus so that scientists worldwide could study it. “Everyone is saying how quick and transparent the process has been this time around,” molecular biology and senior writer Tina Hesman Saey says. A patient test was created, and efforts to build a vaccine are under way.

Here at *Science News*, we've been covering the outbreak from the beginning, with multiple reporters tracking down answers to questions readers may have and asking a lot of questions of our own. Saey, who holds a Ph.D. in molecular genetics, dove into how coronaviruses work, how easily they spread and whether this one could be as dangerous as SARS or MERS (see Page 6). When *Science News* intern Erin Garcia de Jesus, who has a Ph.D. in microbiology, heard reports that the new virus could have come from snakes, as one study suggested, she dug in (*SN Online*: 1/24/20). Not likely, her sources told her.

This is what journalists call a “developing” story, with the situation changing by the hour. Add in the fact that the outbreak is sparking fear worldwide, and it's no surprise that incomplete or erroneous information is flying around the internet. At times like this, we strive to be extra scrupulous in our reporting, and be clear about the limits of what scientists know and how that affects people's health.

We'll stay on this fast-moving public health story. For the most up-to-date news on the latest science in context, check out sciencenews.org.

—Nancy Shute, Editor in Chief

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SCIENCE WRITER INTERN Erin Garcia de Jesus
CONTRIBUTING CORRESPONDENTS
Laura Bell, Tom Siegfried, Alexandra Witze

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DESIGN DIRECTOR Erin Otwell
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SCIENCE NEWS FOR STUDENTS

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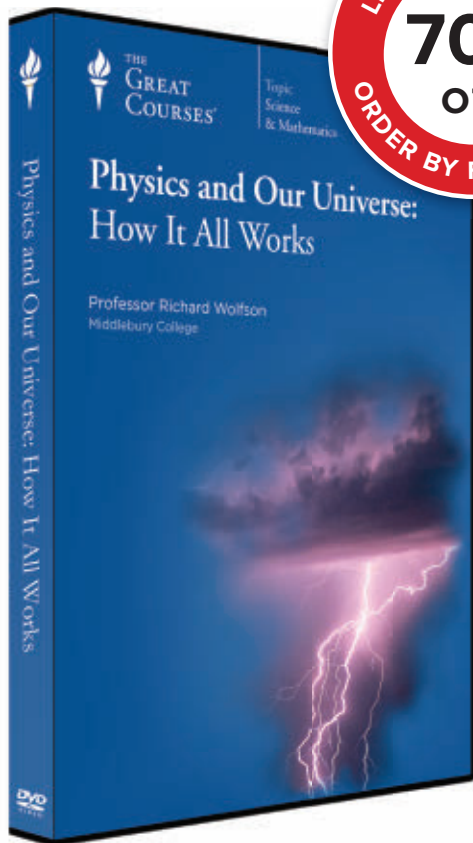
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Excerpt from the February 14, 1970 issue of *Science News*

50 YEARS AGO

Getting set for a black gold rush

Nobody has ever done what the engineers designing the Trans-Alaska Pipeline are faced with: the need to carry hot oil through the Arctic. The Trans-Alaska Pipeline, expected to be completed in 1972, will carry 600,000 barrels of oil a day across Alaska.

UPDATE: Despite protests by environmental activists and Native Americans, the pipeline was completed in 1977. In the mid-1980s, the pipeline moved about 25 percent of all U.S.-produced oil and could deliver more than 2 million barrels per day, according to the U.S. Energy Information Administration. But U.S. oil production has declined since 1988, so the flow has slowed. That allows the oil to cool en route and water to pool in the system, raising fears of corrosion, ruptures and oil spills. The 1,288-kilometer pipeline must by law be dismantled and removed if it's shut down. But after hundreds of thousands of hectares in Alaska were auctioned off in December for oil development, and with millions more still set to be auctioned, a shutdown may not come anytime soon.



THE SCIENCE LIFE

Pulling data from honey to honor a beekeeper father

WASHINGTON—A scientist's sweet tribute to her father may one day give beekeepers clues about a colony's health or warn when crop diseases might strike.

Those are possible applications that undergraduate biochemistry researcher Rocío Cornero sees for her work on honey proteins. Amateur beekeepers often don't know why bees in their hives are stressed, whether it's infection or lack of water or food, says Cornero, whose father kept bees

until his death last year. "What we see in the honey can tell us a story about the health of that colony," she says.

As bees digest pollen, soil and water, bits of proteins from other organisms end up in the insects' stomachs. Honey is basically bee vomit, holding a record of what the bee came in contact with, plus proteins from the bees themselves.

"The information archive in honey is unbelievable," says Lance Liotta, a cell

THE -EST

Earth's oldest known impact crater formed 2.2 billion years ago

A 70-kilometer-wide crater in Western Australia has earned the title of Earth's oldest recorded impact crater.

Yarrabubba crater is 2.2 billion years old, give or take 5 million years, researchers report January 21 in *Nature Communications*. Found on an ancient patch of Earth's crust called the Yilgarn craton, Yarrabubba adds more than 200 million years to the planet's impact record.

The find is rare, as tectonic activity and erosion have wiped away physical evidence of many craters that are older than 2 billion years.

Researchers pinpointed Yarrabubba's age by dating microstructures in recrystallized rock that formed when the impact occurred. That timing put the impact at the end of a glacial period. A computer simulation suggests that a Yarrabubba-sized impact would have released up to 200 trillion kilograms of water vapor into the atmosphere, which the researchers say could have warmed the planet and melted ice sheets. — *Erin Garcia de Jesus*

Yarrabubba crater in Western Australia sits on an ancient piece of Earth's crust called the Yilgarn craton (shown here and in red on the map below).



biologist and Cornero's mentor at George Mason University in Fairfax, Va. But studying the proteins in honey isn't easy. "It's so gooey and sticky," with sugars that gum up lab equipment used to isolate proteins, he says.

So Cornero found a new method for pulling peptides, bits of proteins, out of honey using nanoparticles. Once extracted, the peptides are analyzed by mass spectrometry and compared against a protein database to determine which organisms produced the proteins.

Cornero tested the technique on 13 honey samples collected in Maryland and Virginia by high school students working at George Mason for a summer. Two more samples came from the last honey batches collected by Cornero's father in their hometown of Mar del Plata, Argentina.

The samples contained a wealth of knowledge. One sample had peptides from disease-causing bacteria as well as bee viruses and parasites, such as



Rocío Cornero transfers honey into test tubes for protein analysis.

deformed wing virus and *Varroa* mites. So the bees that made that honey could have trouble in winter, when their immune systems are weaker. Also found in samples were plant virus proteins, a sign that disease may be stalking crops.

Pollen and plant proteins revealed that the bees had pollinated sunflowers, lilacs, olive trees, red clover, potatoes and tomato plants. Such analyses could one day be used to verify claims of honeys being made from wildflowers, clover or orange blossoms.

Cornero described her unpublished work December 9 at the annual joint meeting of the American Society for Cell Biology and the European Molecular Biology Organization. Next, she hopes to develop a test for beekeepers to plunge a dipstick into honey to rapidly gauge a hive's health. "Having my dad as a beekeeper, I know how beekeepers work" and what information they might need, she says. "It would be a great way to honor his work." — *Tina Hesman Saey*



RETHINK

Neandertals dove and harvested clamshells

Often typecast as spear-wielding mammoth killers, some Neandertals were beachcombers and surf divers.

At Moscerini Cave, located on Italy's western coast, Neandertals collected clamshells (some shown above) on the beach and retrieved others from the Mediterranean Sea, say archaeologist Paola Villa of the University of Colorado Museum of Natural History in Boulder and colleagues. Our close evolutionary relatives waded or dove into shallow waters to collect shells that were then sharpened into scraping or cutting tools, the team says January 15 in *PLOS ONE*.

Of 167 clamshells with sharpened edges found in the cave and suitable for study, 40 have shiny, smooth surfaces characteristic of living clams taken from the seafloor, the team says. The remaining shells feature dull, worn surfaces, indicating these finds had washed up on the beach and were gradually worn down before being used by Neandertals. Earlier dating of animal teeth unearthed near the cave's sharpened clamshells suggested Neandertals lived there about 100,000 years ago, a time when *Homo sapiens* weren't in the region.

Consistent with the idea that Neandertals went into the sea, another team last year found that bony growths in the ear canals of as many as 13 of 23 Neandertal skulls are characteristic of swimmer's ear, a condition in people today caused by frequent exposure to cold water and moist air. — *Bruce Bower*

FIRST

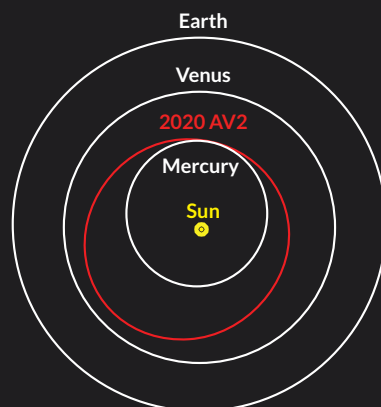
This rare asteroid keeps close orbit around the sun

For the first time, an asteroid has been found orbiting closer than Venus to the sun — a neighborhood where asteroids are thought to be rare and tricky to find.

The space rock, 2020 AV2, orbits the sun once every 151 days along an elongated trajectory that keeps it between the orbits of Mercury and Venus. Such asteroids, called Vatiras, were first predicted in 2012, but no one had found one until now. Asteroids are hard to find inside Earth's orbit. Because of these objects' nearness to the sun, astronomers can search only in periods of twilight. Researchers at the Palomar Observatory in California found 2020 AV2 on January 4, and its orbit was later refined by observers worldwide.

Vatiras probably start in the asteroid belt between Mars and Jupiter before being tugged sunward by gravity from rocky planets. Computer simulations suggest Vatiras make up only 0.22 percent of near-Earth objects, and many eventually crash into a planet or get burned up by the sun. — *Christopher Crockett*

Asteroid 2020 AV2 (orbital path shown) resides between Mercury and Venus.



News

BODY & BRAIN

New coronavirus fuels outbreak

Scientists study how it stacks up against SARS and MERS

BY TINA HESMAN SAEY

Coronaviruses have been giving people colds for ages. But occasionally, a new coronavirus arises to cause serious illnesses and deaths.

That's what is happening with the coronavirus that, as of January 29, has killed at least 132 people and sickened more than 6,000 since the virus emerged in China in December. Travelers have brought the virus, which causes a pneumonia-like disease, to 17 countries, including the United States.

Much is still unknown about the 2019 novel coronavirus, or 2019-nCoV. But lessons learned from previous deadly coronavirus outbreaks, including severe acute respiratory syndrome, or SARS, and Middle East respiratory syndrome, or MERS, may help officials head off some of the more serious consequences from this outbreak.

Coronavirus infections are usually mild, affecting just the upper airways.

Medical staff transfer a patient to Jin Yintan hospital on January 17 in Wuhan, China, the city at the center of the coronavirus outbreak.



But like SARS and MERS, the new virus is different. These coronaviruses latch onto proteins studding the outside of lung cells and penetrate much deeper into the airways than cold-causing coronaviruses, says Anthony Fauci, director of the U.S. National Institute of Allergy and Infectious Diseases in Bethesda, Md.

Lung damage can make these viruses deadly. In 2002 and 2003, SARS killed nearly 10 percent of the 8,096 people who fell ill in 29 countries. Since 2012, MERS has killed about 34 percent of the 2,494 people infected in 27 countries. 2019-nCoV seems less virulent, with an estimated mortality rate of about 4 percent. But that number is a moving target as more cases are diagnosed, Fauci says.

An analysis of the illness in the first 41 patients diagnosed in China suggests that the virus acts similarly to SARS and MERS. But unlike those viruses, the new one rarely produces runny noses or intestinal symptoms, researchers reported January 24 in the *Lancet*. Most of the 41 patients were otherwise healthy, with less than a third having chronic medical conditions that could have made them more vulnerable to infection.

The first recognized cluster of infections came from patients who had visited the Huanan seafood market in Wuhan, which was closed January 1. Coronaviruses originate in animals, but officials have yet to determine the source of the virus.

Bats are considered a source of coronaviruses but don't usually pass the viruses directly to humans. SARS probably jumped from bats into raccoon

dogs or palm civets before leaping to humans. MERS went from bats to camels and then to humans (*SN*: 4/5/14, p. 8). A paper published January 22 in the *Journal of Medical Virology* suggests that the new virus has components from bat coronaviruses. Some evidence suggests the virus crossed into humans only once, in mid-November, and has since spread from person-to-person.

Neither SARS nor MERS has sustained human-to-human transmission the way influenza viruses can, Fauci says. In Wuhan, the new virus has been able to transmit down a chain of up to four people.

Scientists are now calculating how infectious 2019-nCoV is, says Maimuna Majumder, a computational epidemiologist at Boston Children's Hospital and Harvard Medical School. R_0 , pronounced R naught, is the number that describes how many people a newly infected person is likely to pass a virus to. SARS had an R_0 of 2.0 to 4.0 — in a fully susceptible population, an infected person could spread the virus to two to four others. Measles, in comparison, has an R_0 of 12 to 18.

There have been at least four estimates for the new virus's infectivity, ranging from the WHO's estimate of 1.4 to 2.5 to a much bigger 2.4 to 4.1 calculation from Jonathan Read of Lancaster University in England and colleagues. Read's group estimates that only about 5 percent of cases in Wuhan have been identified. The researchers reported these results January 28 at medRxiv.org.

Different methods were used to calculate each estimate. Overlap seen between the estimates is reassuring, says Majumder, who along with a colleague, reported an R_0 of 2.0 to 3.1 on January 27 at the website SSRN.

Similar infectivity to SARS doesn't mean that 2019-nCoV will spread like SARS. "Having SARS in [our] history can help inform some of these decisions that we're going to make now," Majumder says. "Back then, we were less prepared than we are now." ■

Erin Garcia de Jesus contributed to the reporting of this story.



The Deccan Traps eruptions blanketed much of India's Western Ghats mountains in lava about 66 million years ago.

EARTH & ENVIRONMENT

Dinosaur demise linked to asteroid

New timeline exonerates volcanic eruptions in die-off

BY CAROLYN GRAMLING

Massive gas bursts emitted by volcanoes about 66 million years ago probably couldn't have caused a mass extinction that spelled doom for nonbird dinosaurs.

Data on ancient temperatures, combined with simulations of the shifting carbon cycle in the ocean, lend support to the hypothesis that a giant asteroid impact — not toxic gases emitted by the Deccan Traps eruptions — was primarily responsible for the die-off, researchers report in the Jan. 17 *Science*.

About three-quarters of Earth's plant and animal species were killed off during the extinction event at the end of the Cretaceous Period. Sediment deposits linked to the asteroid, which struck in what's now Mexico's Yucatán Peninsula, form a layer called the KPg boundary. This boundary marks the transition from the Cretaceous to the Paleogene Period and implicates the asteroid strike in the extinction (*SN*: 2/4/17, p. 16).

But the Deccan Traps eruptions, which spewed about 500,000 cubic kilometers of lava across much of what's now western India, also occurred within a million years of the extinction. Sussing out the true killer has been challenging because the precise timing of the eruptions has been uncertain. Scientists have focused on dating hardened lava and ash left over from the eruptions, resulting in a range of dates, some before and some after the extinction event.

The real dino killer wouldn't have been the lava — it would have been the volcanic gases: carbon dioxide heating the planet or sulfur dioxide acidifying the oceans. Sudden, huge bursts of those gases could have also come from the asteroid impact. So pinning down the timing of Deccan Traps outgassing could help solve the long-standing debate.

Pincelli Hull, a paleoceanographer at Yale University, and colleagues turned to the temperature record preserved in sediment cores from the seafloor to create a timeline of global temperature shifts spanning several hundred thousand years before, during and after the extinction. The researchers then examined five different scenarios for when the Deccan Traps may have erupted and compared the scenarios with the temperature data.

Only two scenarios matched the observed temperature data, Hull's team found — and neither could have caused the extinction. In one scenario, the bulk of the eruptions occurred several hundred thousand years before the KPg, causing a blip of intense warming that was over long before the die-off. In the second scenario, half of the eruptions occurred before the KPg — but still too



Deep-sea cores collected off Newfoundland in 2012 helped researchers pin down the timing of when Deccan Traps volcanism released carbon dioxide and other gases.

early to explain the extinctions — and half after. That scenario fits temperature data showing minor warming post-KPg, Hull says. Shifts in the ocean carbon cycle due to the extinctions would have muted the eruptions' climate-altering effects.

Those shifts are related to tiny plankton that build carbonate shells. These plankton were so ubiquitous when the Cretaceous began about 145 million years ago that their life cycle — building shells using dissolved calcium carbonate in the seawater, then dying and sinking to the seafloor — profoundly altered the ocean's carbon cycle during the Cretaceous. The sinking shells were responsible for as much as half of the global transfer of carbon from the surface ocean to the deep during the Cretaceous, keeping the carbon cycle humming.

The KPg extinction wiped out almost all plankton, so the dissolved calcium carbonate stayed in the surface ocean. Calcium carbonate is a powerful buffer against acidification, which occurs when the ocean absorbs excess CO₂ from the atmosphere. So even if the second scenario happened, and the volcanoes emitted more CO₂ after the extinction, the oceans likely neutralized a lot of it, muting its effect on global temperatures.

In other words, Hull says, “the mass extinction so affected global ecosystems that it hid the outgassing.”

The study “used really unique methods to try to answer” what caused the extinctions, says geoscientist Courtney Sprain of the University of Florida in Gainesville. “Their conclusions [about the timing of the outgassing] make sense.” That doesn't necessarily mean that previous dates determined for the Deccan Traps lava flows were wrong, she says. The same technological advances that made high-precision dating of the Deccan Traps possible were also responsible for revealing that there might have been a lag between lava flows and outgassing, she says.

Understanding why there might be a timing difference between lava and gas bursts is an active area of research in volcanology, she says. “There are still quite a few questions about how any volcanic system erupts.” ■

FROM TOP: DINODIA PHOTOS/LAMY STOCK PHOTO; PAUL BOWN/UCL

MATH & TECHNOLOGY

PigeonBot controls its wings like a bird

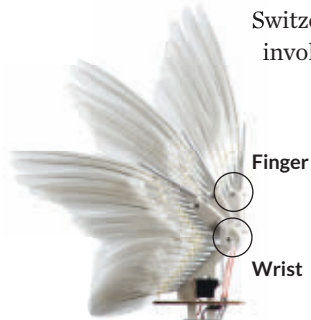
Insights into flight could one day lead to more nimble aircraft

BY MARIA TEMMING

Pigeons may be considered the rats of the sky, but some scientists have found value in these urban birds: the blueprint for a new generation of flying machines.

Using new insights into how pigeons' joints control the spread of wing feathers, the researchers built a robotic pigeon, the PigeonBot, with feathered wings that change shape like the real deal.

This feat paves the way for creating more agile aircraft, says roboticist Dario Floreano of École Polytechnique Fédérale de Lausanne in Switzerland, who was not involved in the work.



Birds modify the shape of their wings by fanning out feathers or shuffling them closer together. Those adjustments allow birds to cut through the sky more gracefully than rigid drones.

With birdlike wings, airborne machines could make tighter turns in cluttered spaces, such as around buildings, and better navigate rough air (*SN*: 2/7/15, p. 18), Floreano says. The new robot, described January 16 in *Science Robotics*, also offers a way to

With two joints, at the wrist and the finger, the wings of a new robotic pigeon (below) can morph into different shapes (three options overlaid, below left).

study the nuts and bolts of bird flight without animal experiments.

Researchers bent and extended the wings of dead pigeons to see how the birds might control wing shape. The angles of two wing joints, the wrist and the finger, most affected the alignment of flight feathers. Orientations of those long, stiff feathers help determine wing shape. The team then built a robot, with real pigeon feathers, whose wrists and fingers morph wing shape as seen in the pigeons.

“What’s really cool about this robot is... you can make manipulations in a robot wing that you could never do or want to do in a bird,” says David Lentink, an engineer and biologist at Stanford University. For instance, Lentink wondered whether a pigeon could steer itself just by bending the finger joint of either wing. “The problem is, of course, I don’t really know how to train a bird to just move its finger — and I actually am very good in bird training,” he says by phone, as two pet birds chirp in the background.

A controllable robotic pigeon solves that problem. In tests, Lentink’s team

BODY & BRAIN

New drug target for heart disease

Therapy in testing aims to reduce lipoprotein(a) levels

BY AIMEE CUNNINGHAM

Routine blood tests may someday feature a new line item: lipoprotein(a).

High levels of this fat- and cholesterol-carrying protein increase the risk of cardiovascular disease. How much lipoprotein(a) someone makes is largely locked in by genetics, and levels remain relatively steady throughout life. That’s in contrast to another cholesterol-carrying protein, low-density lipoprotein, or LDL — commonly called “bad cholesterol” — which changes depending on diet and exercise.

Now, a therapy targeting lipoprotein(a) is in testing. In a clinical trial, the potential

drug, which blocks the ability to make the protein, reduced people’s levels by as much as 80 percent, researchers report in the Jan. 16 *New England Journal of Medicine*. The trial found the drug to be safe.

Another clinical trial is under way to determine whether drastically lowering lipoprotein(a) levels in people who have cardiovascular disease lessens the risk of heart attack and stroke.

Lipoprotein(a) is made up of a particle of LDL plus a protein called apolipoprotein(a). LDL’s link to cardiovascular disease is well-known: When there is too much in the blood, LDL can get into artery walls, stoking an inflammatory immune response that leads to thickened walls and narrowed arteries.

“There are people who have very well-controlled LDL cholesterol levels who do go on to have heart attacks,” says cardiologist Michelle O’Donoghue of Brigham and Women’s Hospital in Boston, who was not part of the study.

As a result, “there’s been a tremendous amount of interest in lipoprotein(a).”

LDL is part of the reason that cardiovascular disease risk is higher with elevated lipoprotein(a) levels. But the apolipoprotein(a) component adds to the risk, says Sotirios Tsimikas, a cardiologist at the University of California, San Diego School of Medicine in La Jolla. That protein appears to provoke a stronger inflammatory reaction than LDL does, hastening plaque development. And apolipoprotein(a) has the potential to prevent blood clots from breaking up — bad news if an artery-blocking clot forms when a plaque ruptures.

Tsimikas and colleagues tested a drug called APO(a)-L_{Rx}, developed by Ionis Pharmaceuticals in Carlsbad, Calif., in a phase II clinical trial designed to determine effectiveness and best dose of treatment. The drug blocks the messenger RNA that provides genetic instructions to make lipoprotein(a).

observed that bending only the finger of one wing eased the robot into a banked turn — the first evidence that birds may sometimes use just their fingers to steer.

In a second study, reported in the Jan. 17 *Science*, Lentink's group used the robot to confirm another insight: how gaps are prevented from forming between feathers on extended wings. In experiments that involved rubbing one bird feather across the top of another — to mimic overlapping flight feathers fanning out — the team found that two feathers initially slid apart easily, but then snagged on each other. Scanning electron and X-ray microscopy revealed that tiny hooks protruding from the top of one feather latch onto ridges on the underside of the other when they slide too far apart. Those hooks unfasten when the feathers slot back together.

To test the effect, the team rotated the robot's feathers so that they wouldn't slide against each other when the wings were extended. In wind tunnel and outdoor flight tests, gaps formed between feathers on the modified robot wings, undermining the wings' stability. ■

The team tested different doses in 286 patients with cardiovascular disease whose lipoprotein(a) levels were at least 60 milligrams per deciliter of blood. People with lipoprotein(a) levels between 50 and 100 mg/dL appear to have a modest increase in the risk for cardiovascular problems, Tsimikas says. Those with levels above 100 mg/dL are at high risk.

At the highest dose of the drug, participants' lipoprotein(a) levels dropped by an average of 80 percent.

To see if the drug can reduce the risk of heart attack and stroke, a phase III clinical trial, by Novartis Pharmaceuticals of Basel, Switzerland, is recruiting patients. The trial will test the drug versus a placebo for about four years in over 7,500 people with cardiovascular disease and lipoprotein(a) levels of 70 mg/dL or higher. If that trial is successful, more research will be needed to see if the drug helps people avoid developing cardiovascular disease in the first place. ■

GENES & CELLS

Antibiotic tolerance hastens resistance

Researchers are rethinking how to treat lingering infections

BY TINA HESMAN SAEY

Bacteria that are down but not yet dead may be more dangerous than previously thought. Even as one antibiotic causes them to go dormant, bacteria may more easily develop resistance to another drug.

Deadly *Staphylococcus aureus* bacteria that could tolerate one type of antibiotic developed resistance to a second antibiotic almost three times as fast as fully susceptible bacteria, scientists report in the Jan. 10 *Science*. The finding may explain why drug cocktails used to quickly knock out infections sometimes fail.

Compared with resistance, "tolerance is not as well-known or as well-publicized," says computational biologist Allison Lopatkin of Barnard College in New York City, who was not involved in the study. But this "work shows it is extremely important."

Antibiotic-tolerant bacteria stop growing in the presence of antibiotics, entering a dormant state. These microbes can't overcome or counteract antibiotics, eventually dying if exposure to the antibiotic continues at a killing dose and if resistance doesn't pop up.

But if tolerant bacteria don't die, they may be the source of lingering or recurring infections, especially in people with weakened immune systems or those with medical implants. Doctors sometimes try drug cocktails to clear this sort of infection.

In previous lab experiments, Nathalie Balaban, a biophysicist at Hebrew University of Jerusalem, and colleagues found that tolerant bacteria were more

likely to develop resistance. This happens in patients, too, the new study finds.

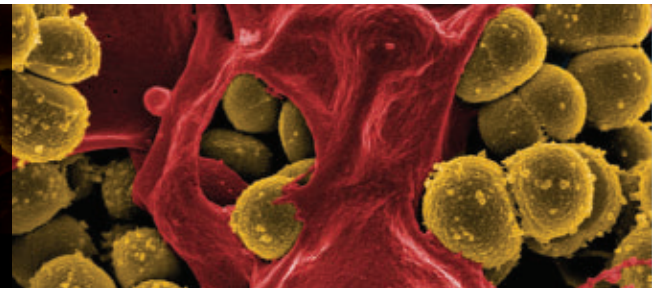
Doctors at Jerusalem hospital used the powerful antibiotic vancomycin to treat two patients with methicillin-resistant *S. aureus*, or MRSA, infections. Within days, both patients' bacteria became tolerant to the drug. One patient was switched to the antibiotic daptomycin. Her bacteria were also tolerant to that drug. Rifampicin was also added. That antibiotic is often held in reserve, because it has side effects and microbes often develop resistance to it quickly, says Andrew Berti, a pharmacist at Wayne State University in Detroit who cowrote a commentary on the study in the same issue of *Science*.

The patient's bacteria quickly became resistant to rifampicin. In lab tests, it took just seven cycles of treatment with rifampicin for the woman's daptomycin- and vancomycin-tolerant bacteria to develop rifampicin resistance. It took more than 20 cycles for nontolerant bacteria to develop resistance.

Balaban thinks it might be useful to start patients on multidrug cocktails immediately to head off both tolerance and resistance. Her team is working with doctors to develop guidelines for giving antibiotics that take both tolerance and a patient's immune system into account.

But clinical labs don't have good ways to identify tolerant bacteria, or know how to combat them, says Elizabeth Hirsch, Berti's coauthor on the commentary and an infectious disease pharmacist at the University of Minnesota in Minneapolis. ■

Being tolerant of at least one type of antibiotic helps deadly methicillin-resistant *Staphylococcus aureus*, or MRSA, bacteria (yellow in this electron micrograph) more easily develop resistance to another antibiotic.



HUMANS & SOCIETY

How early humans populated Africa

Ancient DNA reveals more mixing and mingling of groups

BY BRUCE BOWER

Four ancient youngsters, one pair from about 8,000 years ago and another from about 3,000 years ago, have opened a window on humankind's far older, far-flung African origins.

Analyses of the west-central African children's DNA indicate that at least three major human lineages — ancestral to today's central African hunter-gatherers, southern African hunter-gatherers and all other present-day people — genetically diverged from each other in rapid succession between roughly 250,000 and 200,000 years ago.

A fourth, previously unknown human population also emerged in that time span and left a small genetic mark on modern western and eastern Africans, according to a team led by evolutionary geneticists Mark Lipson and David Reich, both of Harvard Medical School. That human line possessed a small amount of DNA from hominid populations that had originated before the rise of the human species, possibly Neandertals, the researchers report online January 22 in *Nature*.

"This quadruple radiation [of human lineages] had not been identified before from DNA," Reich says.

That genetic evidence fits a scenario in which different *Homo sapiens* populations evolved in different parts of Africa as early as about 300,000 years ago, followed by a mixing and mingling of populations across the continent.

A previous genetic study, led by evolutionary geneticist Pontus Skoglund of the Francis Crick Institute in London, identified a human population originating more than 200,000 years ago that was ancestral to later rainforest hunter-gatherer groups in western and central sub-Saharan Africa. The new study provides further evidence for that ancestral

line: Ancient children in the new study carried a minority of ancestry from those ancient forerunners of rainforest groups.

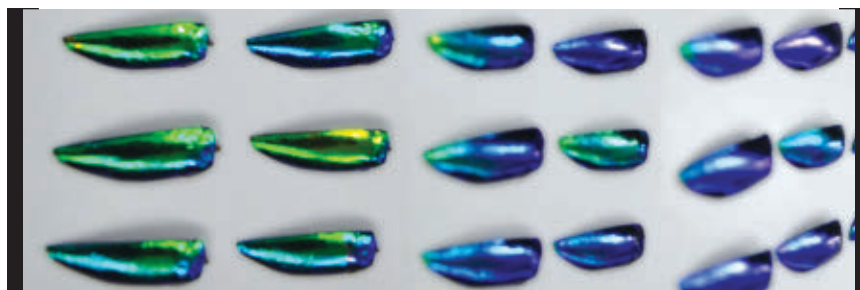
Genetic data in the new study offer "the only ancient DNA record from so far west in sub-Saharan Africa," Skoglund says.

Lipson and Reich's group studied DNA from four children buried at Shum Laka, a rock-shelter in western Cameroon. Based on linguistic and genetic evidence, researchers generally consider that area of Cameroon to have been where Bantu languages, spoken by many Africans today, originated and spread across the continent's southern half after about 4,000 years ago. The Bantu expansion is thought to explain why the majority of people in that swath of Africa now display close genetic connections.

Intriguingly, current Bantu speakers

are not closely related to the Shum Laka children, the researchers say. The ancient kids inherited about two-thirds of their DNA from a previously unknown population distantly related to present-day West Africans. The rest of the genetic material came from the lineage outlined in the earlier Skoglund-led study that was ancestral to hunter-gatherers now living in central Africa. Present-day central African hunter-gatherers have a different ancestry from most Bantu speakers today.

As a result, Bantu speakers across Africa probably didn't descend from the ancient Shum Laka population, the researchers say. But other human groups could have lived in west-central Africa around the same time, including some who conversed in early Bantu tongues, Lipson, Reich and colleagues speculate. ■



LIFE & EVOLUTION

Iridescence may be camouflage for beetles

Iridescence sparkles across many branches of the tree of life. While ostentatious coloration can woo mates, scientists had assumed it can also attract predators. But new evidence suggests iridescence can actually camouflage.

Asian jewel beetles (*Sternocera aequisignata*) boast brilliantly iridescent exoskeletons. To see if iridescence affects whether the beetles are detected by hungry birds, behavioral ecologist Karin Kjærnsmo of the University of Bristol in England and colleagues pinned mealworm-stuffed iridescent beetle wing cases to forest leaves. The team also pinned noniridescent ones artificially colored blue, green, purple, rainbow or black. All together, 886 targets — iridescent and matte — represented the spectrum of colors in the iridescent shell, allowing the team to disentangle the effects of color from the sparkle of iridescence (the wing cases above are tilted in different ways to show the colors that iridescence produces). After two days, the iridescent "beetles" were less likely to have been attacked by birds than all the colors, except black, researchers report online January 23 in *Current Biology*. Birds "killed" 85 percent of purple and blue targets, but less than 60 percent of iridescent targets, Kjærnsmo says.

It's unclear if birds had trouble seeing iridescence or were avoiding it, for example if they associated it with poisonous prey. But Kjærnsmo suggests the rapidly changing colors might disrupt normal image-forming processes.

— Jonathan Lambert

Heat wave blamed for seabird die-off

Named the 'Blob,' it disrupted the common murre's food supply

BY JONATHAN LAMBERT

Common murres are arguably the most successful seabirds in the Northern Hemisphere. The penguinlike seafarers crisscross vast expanses of ocean and can fly faster than any other northern seabird and dive as deep as the length of two American football fields to snatch fish.

But from summer 2015 to spring 2016, the birds experienced a massive die-off.

Over that period, 62,000 dead, dying or emaciated common murres (*Uria aalge*) washed onto beaches from California to Alaska, a study finds. And colonies failed to reproduce during and shortly after that same time. About 10 to 20 percent of the region's population was wiped out, scientists report January 15 in *PLOS ONE*.

A major marine heat wave nicknamed the "Blob" is to blame, the team says. Warmer ocean waters shifted the range and makeup of plankton communities as well as amped up the metabolic demands of fish, shrinking some of the ecosystem's key food supplies and starving murres.

"This study leaves no stone unturned to see what might be affecting these birds," says Andrew Leising, a research scientist at the National Oceanic and Atmospheric Administration's Southwest Fisheries Science Center in La Jolla, Calif., who wasn't involved in the study. The team synthesized a range of data to reveal "the stressors that resulted from the heat wave that combined to really put the smackdown on the forage fish these birds rely on."

When John Piatt, a biologist at the U.S. Geological Survey in Anchorage, Alaska, first heard about dead murres washing ashore in Northern California and Washington in the summer of 2015, he wasn't sure if the events were connected. Occasional murre die-offs aren't unusual. But within months, citizen scientists along the U.S. and Canadian coast began encountering dead murres 10 to 1,000 times as often as normal.

These reports came on the heels



Carcasses of 6,540 common murres were found on this beach near Whittier, Alaska, on January 1 and January 2, 2016.

of the Blob, the largest marine heat wave yet recorded. This patch of warm water formed in late 2013 and grew to more than 4 million square kilometers, stretching from the Baja peninsula to Alaska, by the summer of 2015. The Blob, which has been tied to climate change, languished until mid-2016, heating many parts of the Pacific Ocean 2 to 3 degrees Celsius above normal (*SN: 1/20/18, p. 6*).

To look at the relationship between the Blob and murres, Piatt and colleagues first assessed the extent of the die-off. Citizen scientist observations from over 700 sites revealed that about 62,000 dead or dying murres washed ashore from 2015 to 2016. Since only a fraction of dead murres drift onto monitored beaches, the team estimates a total of 530,000 to 1.2 million murres died.

"The magnitude of this die-off is without precedent," Piatt says.

Widespread reproductive failure also occurred. From 2015 to 2017, there were 22 instances of colonies failing to produce any chicks, while many other colonies produced fewer chicks than normal. "If these birds aren't reproducing, it means

they aren't finding enough food," Piatt says. "And if any bird can find food in the ocean, it's the common murre."

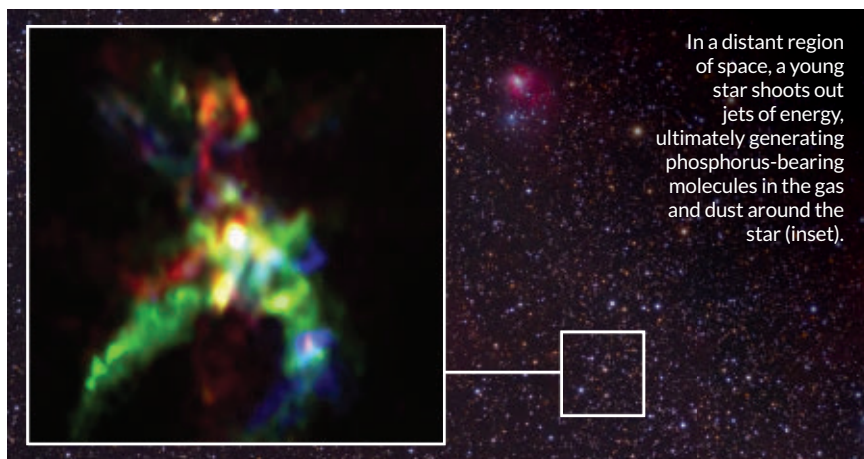
Murres can dive up to 200 meters to snatch sardines, anchovies and other prey broadly labeled forage fish. The Blob made these small fish harder to come by.

In the oceans, energy flows up the food web from the phytoplankton that convert sunlight into carbohydrates. The Blob reduced phytoplankton biomass to levels lower than any year measured since 1997, as the flow of nutrients diminished in the warmer waters. This, in turn, caused reductions in fat-packed zooplankton that forage fish eat. That reduction thinned out the fish, a key ecosystem resource. One study found that the energy content of one common type of forage fish declined by 89 percent on average in 2016, compared with cooler years.

The heat wave pinched murres' food supply in other ways, too. When waters warm, the pace of life increases for cold-blooded fish. Both tiny anchovies and the Pacific cod that eat them need to eat more to sustain a higher metabolism. Simulations of how temperature affects metabolism showed that an increase of 2 degrees above normal in the Gulf of Alaska would have increased the food-consumption needs of predatory fish like Pacific cod by an average of 63 percent.

Large predatory fish suddenly needed about 1.5 times as many fish as they would have without the heat wave, Piatt says. Murres were now facing much stiffer competition over fewer, less-nutritious forage fish.

Whether the murres will bounce back is unknown, says Julia Parrish, a marine scientist at the University of Washington in Seattle. Birds can recover from a bad year or two, she says. But scientists expect massive marine heat waves to become more frequent and intense in the near future, which could overwhelm the birds. Scientists reported in September the emergence of a similarly huge marine heat wave growing along North America's Pacific coast. "Our study offers a window into what that future might hold," Parrish says, "and it's not pretty." ■



In a distant region of space, a young star shoots out jets of energy, ultimately generating phosphorus-bearing molecules in the gas and dust around the star (inset).

ATOM & COSMOS

Phosphorus found in baby star system

Discovery offers clues to how Earth got the ingredients for life

BY ADAM MANN

Phosphorus, a key ingredient of life, has been pinpointed in a cloud of gas and dust around a newborn star for the first time.

Astronomers spotted the star shooting jets of energy that created cavities in the cocoon of gas and dust from which the star formed. Simple phosphorus-bearing molecules — phosphorus monoxide and phosphorus mononitride — were found along the cavities' walls, researchers report in the Feb. 11 *Monthly Notices of the Royal Astronomical Society*. Ultraviolet radiation from the star helped form the molecules, the team suspects.

Phosphorus has been seen around young stars before, but its exact location had never been identified, says study coauthor Maria Drozdovskaya of the University of Bern in Switzerland. The team used the Atacama Large Millimeter/submillimeter Array, a group of radio dishes in Chile, to observe the Milky Way star, located 7,000 light-years from Earth.

Phosphorus monoxide dominated the dust regions closest to the star, outnumbering phosphorus mononitride molecules. As such a star finishes forming, these molecules can freeze and become trapped in ice that later becomes incorporated into comets.

And indeed, phosphorus monoxide was seen in the solar system comet 67P/Churyumov-Gerasimenko, the

team reports, helping link faraway star-forming regions where the molecule forms to our part of the galaxy. The findings add to evidence that comets may have helped deliver phosphorus to Earth.

Comets are thought to be pristine relics from the solar system's past. The Rosetta spacecraft, which studied comet 67P from 2014 to 2016, detected phosphorus and an amino acid in 67P's atmosphere. Clued in by phosphorus monoxide's presence in the protostellar cloud, scientists looked at the data again: Phosphorus monoxide was the main form of phosphorus. "Comets contain the ingredients of life in their most basic form," Drozdovskaya says.

Most of Earth's phosphorus is locked in minerals in the crust. Phosphorus monoxide, however, is water soluble, making it far more biologically available than phosphorus in minerals, says study coauthor Víctor Rivilla of the Arcetri Astrophysical Observatory in Florence. If comets delivered phosphorus monoxide to Earth, perhaps early life was able to access the element in this form.

It's still unclear exactly how the phosphorus molecules formed, or if comets brought them to Earth. "As much as we're making enormous progress — and this paper is an example of that — there are still these giant gaps," says geochemist George Cody of the Carnegie Institution for Science in Washington, D.C. ■

GENES & CELLS

Cancer therapy problem explained

Blocking a protein may stem side effects of CAR-T cells

BY ERIN GARCIA DE JESUS

Techniques to genetically modify patients' immune cells have brought new hope to the fight against hard-to-treat cancers. But the treatments can come with dangerous side effects. Now, researchers have found one reason why.

A particularly messy form of cell death sparks severe inflammation in patients receiving CAR-T cell immunotherapy for blood cancers, researchers report online January 17 in *Science Immunology*. This treatment, approved for certain patients with acute lymphoblastic leukemia and non-Hodgkin's lymphoma (*SN: 12/23/17 & 1/6/18, p. 29*), unleashes immune cells in a patient's bloodstream that are tweaked to produce artificial proteins called chimeric antigen receptors, or CAR. The proteins prime T cells to recognize cancer cells so that the immune cells can hunt down and kill the rogue cells.

Normally as cells die, they shrink and break apart — a highly controlled process with debris easily vacuumed up by the body's natural defenses. During CAR-T cell treatment, however, cancer cells can swell and rupture in a manner typically associated with infection, Bo Huang, an immunologist at the Chinese Academy of Medical Sciences in Beijing, and colleagues found. This explosive cell death, or pyroptosis, causes dead cells to expel their contents. That, in turn, prompts the immune system to produce cytokine chemicals that trigger inflammation.

Cytokine release syndrome, one of the most common side effects with CAR-T cell therapy (*SN: 7/7/18, p. 22*), can cause high fever, rapid heartbeat and multiorgan failure. Although most people survive, some require intensive care. Until now, scientists didn't know what triggered the syndrome. Pinpointing the

root cause could help researchers find ways to stop the onslaught of inflammation, Huang says.

Huang and his colleagues mixed cancer cells isolated from patients who had acute lymphoblastic leukemia with CAR-T cells and looked for signs of cell death. Under a microscope, doomed cancer cells looked swollen. Bubbles protruded from holes on the cell surface — evidence of death by pyroptosis.

Dying cells had high levels of a protein called gasdermin E, or GSDME, which punctures the cell membrane, the team found. Nearby immune cells picked up on distress signals from the exploded cell and released cytokines that set off inflammation, Huang says.

When the production of GSDME was blocked, the cancer cells succumbed in a less messy way: They probably wilted instead of exploding, causing less damage, the team says. Mice injected with CAR-T cells and cancer cells lacking GSDME still had symptoms of cytokine release syndrome, Huang says, but the symptoms were mild and fewer mice died.

The results hint at ways to reduce severe side effects of CAR-T cell therapy, although treatments for people are probably far off. One approach might be to block GSDME to ensure cancer cells die without producing distress signals, Huang says. Another is to find ways to prevent other parts of the immune sys-

tem from responding when edited T cells attack cancer cells, but that could leave patients vulnerable to infection.

“It’s a great step forward,” says Theodore Giavridis, an immunologist and cellular engineer at ArsenalBio, a precision immunotherapy company in San Francisco. If the findings hold up, they would boost understanding of cytokine release syndrome.

But it’s possible that blocking pyroptosis from happening at all will make CAR-T cells less effective, Giavridis says. “With further research, we could better dissect what are exactly the triggers ... and maybe find better ways” to stop inflammation from the therapy, he says. ■

LIFE & EVOLUTION

For pandas, a head is an extra limb

The short-legged bears use odd method of tree-climbing

BY SUSAN MILIUS

AUSTIN, TEXAS — A panda really uses its head to climb.

As the pudgy, short-legged bear climbs, it presses its head briefly against the tree trunk again and again, physicist Andrew Schulz reported January 4 at the annual meeting of the Society for Integrative and Comparative Biology. The head serves as a make-do extra paw, first pressed against one side of the tree and then against the other. This extra pressure helps the bear hold on as it releases and raises an actual paw. Schulz knows of similar behavior in newborn kangaroos, which use their heads to help haul themselves to their mother’s pouch for the first time.

Head moves make sense for panda proportions, said Schulz, speaking for a research collaboration between his university, Georgia Tech in Atlanta, and China’s Chengdu Research Base of Giant Panda Breeding. Pandas have the shortest shoulder height for their body length among the world’s eight living bear spe-

cies. “I like to call them corgi bears,” Schulz said.

How pandas, or any other big mammals, climb hasn’t gotten the analytic attention that techniques of squirrels and other small animals have, Schulz said. Yet rushing up a tree trunk can be a lifesaving move in the wild for pandas attacked by feral dogs. Chengdu researcher James Ayala says he conceived the climbing study to get the first quantitative data on emergency climbing skills in pandas. Such information helps the Chengdu researchers judge young pandas’ chances of surviving in the wild.

For this study, the Chengdu staff built a panda climbing gym: four bark-stripped tree trunks, each a different diameter, holding up a high platform. Researchers videotaped eight young pandas, all at least a year old. The animals had grown beyond the waddling fluffball stage and were basically young teenagers with a bit of growing, and sometimes a lot of learning, left to do.

Some youngsters just didn’t get the tree thing. “No controlled ascent or descent — it was kind of madness every single time,” Schulz said of one young bear.

Others caught on. The champ reached the tree trunk top in eight of 10 attempts. The most successful climbers moved their heads roughly four times as often



Pandas will sometimes climb trees, for instance, to escape packs of feral dogs.

as those who flubbed the tree poles, Schulz said. Even one female born without claws made it up the pole. The head press improves the panda grip and keeps panda weight safely balanced close to the tree.

Head-climbing looks familiar to Nicole MacCorkle, a giant panda keeper at Smithsonian’s National Zoo in Washington, D.C. She wasn’t at the meeting, but she has seen video from the Chengdu climbing tests. The zoo pandas tackle trees this way too, she says.

Although for cubs, sometimes heading up is the easy part. “They’ll climb up fairly quickly into a tree, but it seems like they can’t quite figure out how to get back down,” MacCorkle says. If cubs stay stuck too long, a keeper will come to the rescue, but “typically they work it out for themselves.” ■

MATTER & ENERGY

Quantum math's power to verify

Strategy could check even unsolvable problems' solutions

BY EMILY CONOVER

Imagine meeting omniscient beings who claim to have the solution to a complex problem that no computer can solve. You'd probably be at a loss to check the answer. Now, computer scientists report that quantum mechanics offers a way to quickly verify the solutions to a broad class of problems, including some that are impossible to solve in the first place.

Although the result doesn't have obvious practical applications, its theoretical ramifications have had a ripple effect, answering unsolved questions in physics and math, the team reports in a paper posted January 13 at arXiv.org. "It's a huge deal no matter how you look at it," says theoretical computer scientist Scott Aaronson of the University of Texas at Austin, who wasn't involved in the study.

A computer can go only so far in verifying solutions. But scientists have a few tricks up their sleeves. They concoct scenarios where a "prover" — a computer or person who claims to have a solution — is peppered with questions by someone trying to check the solution, the "verifier."

Imagine you have a friend who claims to have deduced how to tell the difference between Pepsi and Coke, even though you can't distinguish them. To confirm this claim, you — the verifier — might prepare a cup of either Pepsi or Coke and ask your friend — the prover — which one it is. If your friend consistently gives the right answer, you'd be convinced that the cola-identification quandary had been solved.

An "interactive proof," this strategy can reveal additional info that theoretically would allow computer scientists to verify solutions to problems that are too difficult for a computer to convince the scientists of independently. Still more powerful interactive proofs involve multiple provers. That scenario is a bit like a police interrogation of two suspects

in separate rooms who can't coordinate their answers to trick an investigator.

The class of problems that can be verified this way is "big, but not ridiculously big," says study coauthor Thomas Vidick of Caltech. To check the solutions to an even larger set of problems, scientists can imagine adding a twist: The provers share a quantum connection called entanglement, which causes two seemingly independent objects to act in correlated ways.

Until now, it was not known how many problems were verifiable in this way. The new result reveals that it's "an unbelievably huge number," Aaronson says.

That huge group is called recursively enumerable, or RE, problems. "It contains all problems that are solvable by computers and then some," says coauthor Henry Yuen of the University of Toronto. Of course, enacting the method in the real world is implausible, given the lack of omniscient beings to offer up answers.

The result is summed up in the equality $MIP^* = RE$, where MIP^* stands for Multi-prover Interactive Proof with quantum powers. Every problem in RE is also in MIP^* , and vice versa. Though not yet peer-reviewed, "there's no reason to think it's wrong," says computer scientist Lance Fortnow of the Illinois Institute of Technology in Chicago.

And the result is a triple threat: In addition to revealing that MIP^* equals RE, it answered two other questions. The first is a quantum physics puzzle, Tsirelson's problem, which asks whether the types of quantum correlations that could be made using an infinite amount of entanglement could be approximated with a very large but finite amount of entanglement. The answer is no: Sometimes you can't even come close to replicating infinite entanglement with finite entanglement.

In math, the study settles Connes' embedding conjecture, an idea that is mathematically equivalent to Tsirelson's problem. It likewise deals with the question of whether a finite approximation can necessarily replicate something truly infinite. Again, the answer is no.

"It's an incredible achievement," says mathematician William Slofstra of the University of Waterloo in Canada. ■

HUMANS & SOCIETY

Faux vocal tract lets mummy speak from beyond the grave

A replica of a 3,000-year-old mummy's vocal tract has revealed how that mummy might sound if he rose from the dead.

Using CT scans of the Egyptian mummy, researchers mapped the exact shape of the vocal tract, which governs the unique sound of a person's voice. When connected to an artificial voice box, a 3-D printed mold of the vocal tract produces a sound somewhere between the vowels in "bed" and "bad," researchers report January 23 in *Scientific Reports*.

The utterance doesn't quite mimic the original voice, because the mummy's tongue, which affects the shape of the vocal tract, is dried and flattened. And the replica cannot say full words. But using a computer simulation of the vocal tract with a jaw and tongue that move, "we could make him speak," says David Howard, an electronic engineer at Royal Holloway, University of London in Egham.

Enabling a mummy to speak could create more immersive museum exhibitions, the researchers say.

— Maria Temming

ATOM & COSMOS

Astronomers detect a second planet around Proxima Centauri

The planet orbiting the star closest to the sun may have a neighbor.

Proxima Centauri, a star 4.2 light-years from Earth, hosts one potentially habitable planet, Proxima b, that's a bit more massive than Earth (*SN: 9/27/16, p. 6*). Now, astronomers see hints of a much larger planet that is farther from the star.

If it exists, Proxima c appears to be at least 5.8 times as massive as Earth and orbits its star about once every five Earth years, researchers report January 15 in *Science Advances*. Given its distance from Proxima Centauri, the planet is too cold to have liquid water, a test for habitability.

Clues to the planet's existence showed up in data from two telescopes in Chile. The data, which span about 17 years, record the star's back-and-forth motion

relative to Earth. After accounting for the known planet, the team found hints of an additional wobble, likely caused by a second planet gravitationally tugging on the star.

The team emphasizes that more data are needed to confirm the planet. Given its proximity to Earth, Proxima c could be a prime candidate for direct imaging with next-generation supersized telescopes, the scientists say. — *Christopher Crockett*

ATOM & COSMOS

Ancient stardust is the oldest yet to be examined in a lab

Stardust extracted from a meteorite contains specks that are up to about 3 billion years older than the solar system, making them the oldest solids yet dated in a lab.

Unlike most of the other stardust that went into building our solar system, these microscopic grains have remained intact since they were shed by aging stars billions of years ago. The exotic makeup of the silicon carbide grains, from a meteorite found in Australia, tipped scientists off that the minerals were older than the solar system.

Measuring levels of neon-21 in dozens of grains revealed how much older. Neon-21 builds up when silicon carbide is bombarded with high-energy particles called galactic cosmic rays in interstellar space. The higher a grain's neon-21 concentration, the longer it must have drifted in space before being embedded in a hunk of space rock during the solar system's formation about 4.6 billion years ago.

The oldest grains are estimated to be about 7 billion years old, researchers report online January 13 in the *Proceedings of the National Academy of Sciences*.

Finding more extremely old dust lodged in meteorites may give scientists a more complete picture of the Milky Way's distant history. — *Maria Temming*

MATTER & ENERGY

Fastest-spinning object yet made could help spot quantum friction

To detect the quantum friction of empty space, scientists are going for a spin.

A twirling nanoparticle, suspended in a laser beam inside of a vacuum, can measure tiny twisting forces, making it the most sensitive detector of torque yet created. The device could one day detect an elusive quantum effect: vacuum friction.

The suspended nanoparticle can spin more than 300 billion times a minute. "This is the fastest human-made rotor in the world," says physicist Tongcang Li of Purdue University in West Lafayette, Ind.

To measure torque, Li and colleagues hit the nanoparticle with a second laser, which they switched on and off at regular intervals. The laser was circularly polarized, meaning that the light's electromagnetic waves rotated over time, and this twist imparted a torque on the nanoparticle. The researchers estimated the amount of torque by measuring how the particle's speed changed as that second laser switched on and off.

When operated for 100 seconds, the sensor could measure torques as small as about 0.4 trillionths of a quadrillionth of

a newton-meter, the researchers report January 13 in *Nature Nanotechnology*. For comparison, one newton-meter is the approximate amount of torque needed to twist a cap off a soda bottle.

The device is so sensitive that it could be used to observe the minuscule impact of vacuum friction, in which an object spinning rapidly in empty space feels drag — despite being surrounded by nothingness. The never-before-seen effect is predicted to arise from interactions of the spinning object with electromagnetic fields that, according to quantum mechanics, appear and disappear constantly, even in empty space.

— *Emily Conover*

GENES & CELLS

Hairy cells in the nose may play a role in causing allergies

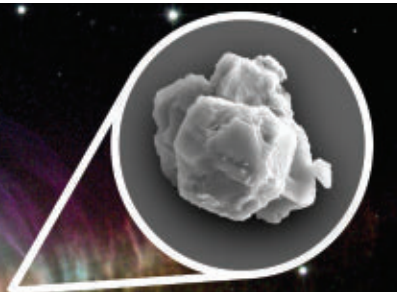
Some hairy cells in the nose trigger sneezing and allergies to dust mites, mold and other substances, work in mice suggests. When exposed to allergens, these "brush cells" make chemicals that lead to inflammation, researchers report January 17 in *Science Immunology*. Previously, only immune cells were thought to make such chemicals.

Brush cells, far more common in the nose than in other tissues, may help the body identify when pathogens or noxious chemicals have been inhaled, says Lora Bankova, an allergist and immunologist at Brigham and Women's Hospital in Boston.

Bankova and colleagues discovered that, when exposed to certain molds or to dust mites, brush cells in mice's noses churn out inflammation-producing lipids called cysteinyl leukotrienes. The cells also made the lipids when encountering ATP, a chemical used by cells for energy that also signals when nearby cells are damaged, as in an infection. Mice exposed to allergens or ATP developed swollen nasal tissue; mice that lacked brush cells had much less inflammation.

Such inflammation may lead to allergies in some cases. The team hasn't confirmed that brush cells in human noses respond to allergens in the same way. — *Tina Hesman Saey*

Bits of dust expelled by aging stars (like those in the Egg Nebula plume, shown) and brought to Earth on a meteorite are the oldest solids dated in a lab. One 8-micrometer dust grain is shown.



FEATURE

HOW TO LICK CAT ALLERGIES



MARTIN POOLE/GETTY IMAGES PLUS

Many efforts are afoot to soothe people's sneezes

By Erika Engelhaupt

Time magazine's list of Best Inventions of 2006 included an unusual creation. It wasn't a gadget; it was a cat.

"Love cats but your nose doesn't?" the magazine asked. "A San Diego company is breeding felines that are naturally hypoallergenic." There was a 15-month waiting list for the "sniffle-proof kitties," which sold for \$3,950 or more.

The company selling the cats, Allerca, had tapped into a tantalizing dream for allergy-prone cat lovers: the hypoallergenic cat. Given that just two genes are responsible for making cats a problem for many people, it seemed like a no-brainer to engineer cats that lacked those genes, or to simply breed cats with versions of the genes that made the animals less allergenic.

But so far, itchy-eyed cat lovers have been left disappointed.

By 2010, Allerca had stopped taking orders — and lawsuits were lining up. The sniffle-proof kitties never materialized. Some angry customers said they never received a kitten, others were sent a cat that triggered their allergies.

But for all those who haven't given up hope, there may be new options around the corner. An allergic owner might pop open a can of allergy-fighting food — for the cat. Or maybe vaccinate the cat to produce fewer allergens. And allergy shots for owners might shift from burdensome weekly or monthly injections to a shot that offers immediate relief.

The new gene-editing technology called CRISPR/Cas9 might even come to the rescue, delivering the ultimate dream to those who can afford it: a cat that doesn't produce allergens at all. One company has made some progress applying CRISPR/Cas9 to cats.

Success in taming cat allergies could bring good news for people whose allergies have nothing to do with cats. If any of the cat allergy-fighting measures prove safe and effective, they could be deployed against other allergens, especially airborne ones like pollen, dog dander or dust mites. With up to 30 percent of the world's population suffering from airborne allergens, that's plenty of runny noses to dry up.

When it comes to cat allergies, the main culprit is Fel d1, a small protein produced primarily in cats' salivary and sebaceous glands. Fel d1 is found in flakes of dead skin, or dander, and is spread to hair when a cat licks itself. Thus it's not cat hair that people are allergic to, just hair coated in cat spit.

A singular target

As allergens go, Fel d1 gets around. It sticks to hair and clothing, so it's readily transported from place to place. It lasts for weeks or months before breaking down. It's light and easily goes airborne, making it even more insidious. In fact, even houses without a cat tend to have a little Fel d1 in their dust, says immunologist Martin Chapman, president and CEO of Indoor Biotechnologies, a company in Charlottesville, Va., that tests for allergens and allergies.

All cats produce some amount of Fel d1, but that doesn't mean that all cats are equally allergenic. In tests of hundreds of cats, Indoor Biotechnologies found levels ranging from just 5 micrograms of Fel d1 per gram of fur to 2,000 micrograms. Variations in two key genes drive that variability, but no

one knows exactly which versions of the genes result in low-allergen cats.

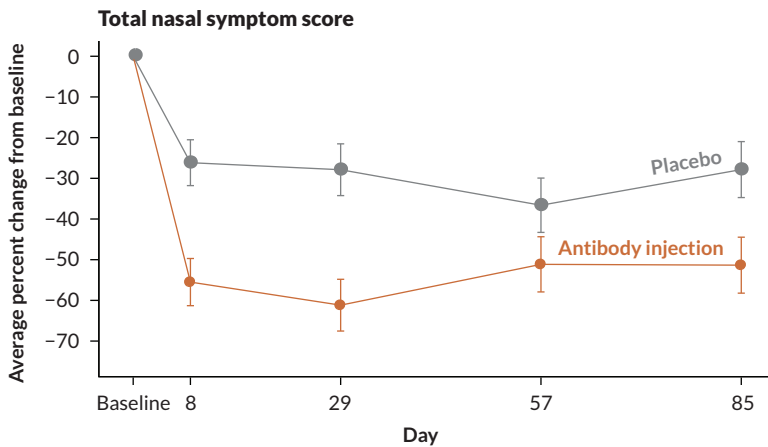
And it's not clear what function Fel d1 serves in cats. Lions and other big cats have their own version of the protein, Chapman says. So it seems to have stuck around during cat evolution — which suggests the protein does something.

Male cats that haven't been neutered tend to have the highest Fel d1 levels, which have been linked to male hormones. Based on that association and the protein's similarity to other molecules, Fel d1 might be a pheromone, a chemical used to communicate via scent. But whether cats need the protein to be healthy is unknown.

All this uncertainty has made allergies to cats difficult to tackle. For now, the options are limited. People can take antihistamines and other medications to reduce symptoms, but the drugs don't stop the allergy.

Traditional allergy shots, also known as immunotherapy or desensitization therapy, aim to retrain a person's immune system to be less sensitive to the allergen. But those shots are a commitment; a patient may need up to 100 injections over three to five years. Some people can avoid needles by taking under-the-tongue daily drops of the same U.S. Food and Drug Administration-approved allergens as in the injections. But this

All cats produce some amount of Fel d1, but that doesn't mean that all cats are equally allergenic.



Easier shots For people with cat allergies, one injection of an antibody that binds to the protein Fel d1 provided more relief from nasal symptoms than did a placebo shot. SOURCE: J.M. ORENGO ET AL/NATURE COMMUNICATIONS 2018

treatment is an off-label use, so is often not covered by insurance.

“Desensitization therapy has been the only therapy for decades,” says Gerald Nepom, director of the Immune Tolerance Network in Seattle, a

A personal quest

I’ve always been a cat person. So when I married Jay, who’s allergic to cats, among other things, I had a problem. Whenever Jay spent time around a cat, his eyes would start to itch and his nose would run.

But Jay loves cats, too. Like many allergy sufferers, he tried all the allergy treatments. For a couple of years, he got monthly allergy shots. He now uses daily nasal steroids and the antihistamine cetirizine. Eventually, his allergies didn’t seem so bad, and we wondered if he could tolerate a cat. I’d been seeing a lot of claims about hypoallergenic cat breeds, and was skeptical but curious.

We’re both biologists by training, so we dove into the scientific literature. We didn’t find much. One small study in *Veterinary Sciences* from 2017 reported on mutations in Siberian cats that could potentially lower their Fel d1 levels or render the protein less allergenic. It was the barest of hints, but we decided to visit a Siberian cat breeder in Georgia and see if we might luck out.

That day we brought home Stoli, a nearly 17-pound sweetheart, on a trial basis. Jay’s allergic reaction to him was occasional and mild, and over a few months the sniffing

research group funded by the National Institutes of Health. Exactly how desensitization works is still not fully understood. But the basic idea is that exposing the immune system to small amounts of allergens causes the body to make antibodies that block part of the allergic response. Unfortunately, Nepom says, desensitization generally doesn’t eliminate all symptoms, and the effects aren’t always permanent.

All the newer approaches being studied focus on Fel d1, either by directly neutralizing it or by blocking its interaction with the human immune system. The competition is fierce to devise an effective solution to cat allergies because of the large potential market — about 10 percent (some estimate 20 percent) of people are allergic to cats.

The opportunity to apply lessons learned to other allergies is a strong incentive as well.

Improving immunotherapy

One problem with traditional immunotherapy is that it attempts to stop one of the later steps in the allergic response, the histamine-producing part



Siberian cats, like the author’s cat, Stoli (shown), are considered hypoallergenic by some people. But there’s no evidence that any cat breed is universally low in Fel d1.

seemed to diminish even more. We thought we’d found our low Fel d1 cat!

Then in the course of reporting this story, I decided to test Stoli, sending off a fur sample to Indoor Biotechnologies. The result: Stoli’s fur tested at 790 micrograms per gram of fur — pretty darn high.

Maybe the immunotherapy that Jay has endured over the years gets more credit than Stoli’s genes. It’s OK. Despite those test results, we are definitely keeping the cat. —Erika Engelhaupt

known as the immunoglobulin E, or IgE, response. But that's only one part of the body's response to an allergen.

"We now see allergy as an immune-activation symphony," Nepom says. Rather than a strict chain of single events, it's more like an orchestra with many molecular players performing on cue.

Today, Nepom says, allergy researchers are getting a better handle on the role of each player. "This is like figuring out which part of the orchestra is creating the problem. Is it the horn section or the strings, or do you have a single oboe player going rogue?" Knowing that could help researchers target players in the immune system more efficiently.

For example, one research group funded by the Immune Tolerance Network is wrapping up a clinical trial under the name CATNIP to test what's called an "allergen-plus" approach. Scientists combine small amounts of Fel d1 with an antibody that blocks a substance important to triggering the allergic response. The substance is a protein called TSLP, or thymic stromal lymphopoietin, which may be one of those rogue oboists, because it helps spark and maintain allergic reactions. The idea, if it works, is that a patient would develop a long-lasting tolerance from a one-year course of allergy shots, instead of the three to five years of current therapies.

Other parts of the allergic response are prime targets, too, says immunologist Jamie Orengo of Regeneron Pharmaceuticals in Tarrytown, N.Y. (Regeneron is a major financial supporter of the Society for Science & the Public, which publishes *Science News*.)

The company has designed antibodies that are highly specific to Fel d1. The antibodies bind to and lock up the allergen before an allergic person's immune system has a chance to react to it. It's an amped-up version of traditional immunotherapy, one that could also be targeted to other allergens, Orengo notes.

"We don't have to rely on the human body; we can make those antibodies in the laboratory instead of waiting for them to be generated by the person naturally," Orengo says. Her team reported in 2018 in *Nature Communications* that tests in mice and in people allergic to cats showed a reduction of allergy symptoms after just one treatment that was equivalent to years of conventional immunotherapy, with the majority of people achieving as much as a 60 percent reduction in nasal symptoms.

One shortcoming: While this approach is very

fast-acting, it doesn't retrain the person's immune system. A patient receiving the treatment would need periodic boosters, perhaps every few months.

Special cat food

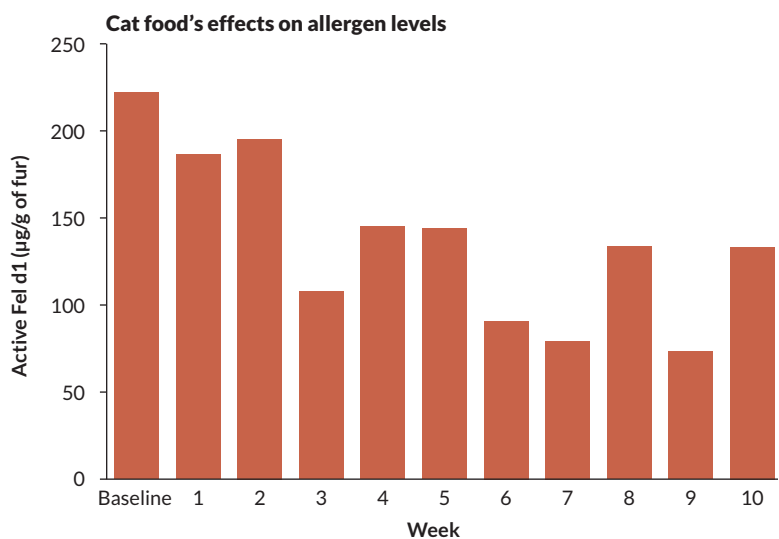
Since saliva is the biggest source of Fel d1, researchers at Nestlé Purina are testing cat food containing an antibody that binds to the protein in saliva as the cat eats. The antibody blocks binding sites on the allergen, essentially rendering it unrecognizable to the human immune system. The antibody doesn't prevent the cat from producing the allergen.

"In fact, this was an important strategy behind our research," says immunologist Ebenezer Satyaraj, who's leading the research at the Purina Institute in St. Louis. "We didn't want to stop the production of Fel d1 because currently it is not clear what role it has in the cat."

Tests so far suggest that the food can knock down the amount of active allergen on cat hair by about half (*SN: 8/31/19, p. 5*). That may be enough to offer relief to some people with mild to moderate allergies; the company expects to market the cat food to consumers sometime this year. But people with severe allergies or asthma may be unable to tolerate any amount of Fel d1 without symptoms, says Michael Blaiss, executive medical director of the American College of Allergy, Asthma and Immunology.

Vaccinate the cat

There are cat lovers out there who'd probably be happier letting the cat get the shots. So another



Edible antibody When 105 cats ate an experimental Purina pet food containing a Fel d1 antibody, levels of the allergen dropped below baseline levels over a 10-week period. SOURCE: E. SATYARAJ ET AL/IMMUN., INFLAMM. AND DISEASE 2019



Tom Lundberg breeds Siberian cats in Oregon. He cautions that breeding two cats that are naturally low in the allergen Fel d1 doesn't guarantee their kittens will also have low levels of the protein. His advice: If you need a low-allergen cat, get it tested and meet the cat before bringing it home.

new approach aims to vaccinate cats against their own Fel d1. The vaccine stimulates the cat's immune system to produce antibodies that bind to Fel d1. That binding cloaks the protein so that human immune cells no longer recognize it and react.

Researchers at HypoPet AG in Zurich studied an inactive fragment of a virus with dozens of Fel d1 molecules. "If you make the allergen look like a virus, the immune system thinks it is a virus," says Martin Bachmann, chief scientific officer of HypoPet and an immunologist at the University of Bern in Switzerland. This Trojan horse then triggers the cat's immune system to start seeing Fel d1, which it normally ignores, as an invader.

In an initial test in more than 50 cats, three injections of the vaccine given three weeks apart stimulated the production of antibodies specific to the allergen, reducing cats' Fel d1 secretion by more than half without harming the cats, the researchers reported in July 2019 in the *Journal*

of Allergy and Clinical Immunology. The company is planning further safety testing, Bachmann says. HypoPet is working with U.S. and European Union regulators to bring the vaccine to market.

The hypoallergenic cat

Producing a cat that makes no allergens at all is still the goal for some researchers. The fact that some cats are naturally low in Fel d1 suggests that they could be bred, as Allerca tried and failed to do a decade ago. But frustratingly, you can't just breed two cats with low Fel d1 levels and get a litterful of hypoallergenic kittens.

Cat breeder Tom Lundberg has bred Siberian cats for more than a decade in Oregon, with the explicit goal of breeding low-allergen cats. Lundberg himself is allergic to cats. He became fascinated by Siberians after owning one that he wasn't allergic to. A second one gave him a "snotty nose and itchy eyes," he says.

Because he has long measured his cats' allergen levels and tracks the results of breeding, Lundberg can confirm that there's no way to guarantee that all the kittens in a litter will hit the genetic jackpot. He and his wife, Meredith, now sell the cats they breed based on their Fel d1 levels. Those tested with the lowest levels command the highest prices, up to \$5,200 for a kitten in the "extremely low" range of less than 1 microgram of Fel d1 per gram of fur. Only about 1 in 15 of the kittens he breeds from low-allergen cats are in that category, Lundberg says. He has received hundreds of calls from people giving up Siberian cats that breeders had claimed were hypoallergenic.

"They'll say the kittens were 'bred from hypoallergenic lines,'" he says. "That's like saying corn was bred from corn — it's meaningless." He suggests that anyone interested in buying a low-allergen cat insist on seeing test results. He also notes that buyers with severe allergies may not be able to tolerate any amount of Fel d1.

Indoor Biotechnologies is trying to genetically engineer a cat that makes no Fel d1. "We're working on it," says Chapman, who founded the company. Indoor Biotechnologies has used the gene-editing tool CRISPR/Cas9 to delete the genes that encode the production of Fel d1, called *Ch1* and *Ch2*, in feline cell cultures, and has filed for a patent on the technique.

Next, the company will try knocking out the genes in cat salivary tissues in a lab dish and make sure Fel d1 is no longer being made, says Nicole Brackett, a postdoctoral scientist at the company. She has analyzed the DNA sequence of the *Ch1* and

Allergy treatments There is no permanent cure for cat allergies, though a number of available treatments can reduce many allergy sufferers' symptoms. New treatments aim to do a better job against symptoms or stop the allergy process in its tracks.

Treatment	Available now?	Action	Pros and cons
Antihistamines	Yes	Block histamine production	Newer drugs like cetirizine (Zyrtec) and fexofenadine (Allegra) cause less drowsiness than previous drugs; may not eliminate symptoms
Nasal steroids	Yes	Reduce inflammation in the nose	Reduce sneezing, congestion and runny nose; only treat symptoms
Traditional allergy shots or drops	Yes	Exact mechanism unknown; may increase helpful antibodies	The only current therapy that reverses some allergies; requires many shots over several years
Allergy shots of lab-made antibody	No	Block immune system's recognition of allergen	Fast-acting prevention of allergic response; boosters required
Pet food with antibodies	No	Cuts amount of active Fel d1 allergen in cat saliva	No shots needed; does not eliminate all Fel d1
Vaccine for cats	No	Prevents human immune system from recognizing cat allergen	Does not eliminate all Fel d1; more testing needed to confirm safety for cats
Genetic engineering of cats	No	Removes genes that direct Fel d1 production in cats	With no Fel d1, nearly all cat allergies would be eliminated; effects on cats are unknown

Ch2 genes of 50 cats and plans to do the same for 200 additional cats, narrowing down the best gene region to target using CRISPR/Cas9.

If the genetic trick works, engineered cats would lack part or all of the genes needed to make Fel d1. Since some cats naturally produce very little Fel d1 with no ill health effects, the thinking is that preventing cats from making the protein is unlikely to harm them. But scientists won't know for sure until someone tries it. "That's precisely the reason to do the experiment," Chapman says.

Typically, producing such a cat would require deleting the gene from an embryo, which would then be implanted in a female cat and carried to term. But Chapman doesn't want to get into the breeding business. Instead, he hopes to ultimately edit the genes of adult cats, much like gene therapies being developed now for humans, which use a harmless virus to deliver gene-editing tools. Recent experiments have successfully edited the genes of adult mice and even people with sickle cell disease, for instance (*SN: 12/21/19 & 1/4/20, p. 28*).

If such a virus could deliver a genetic tool that edits the genes for Fel d1 — maybe by having a veterinarian inject it into the cat's salivary glands, or as a topical application to reach the sebaceous glands in the skin — "that would be exciting," Chapman says.

One of the researchers working to wipe out cat allergies won't be standing in line for any injections, however. Bachmann, of HypoPet, says that he and his son are allergic to cats. When asked if he would try any of the new allergy treatments, he replied no. "I don't love cats that much," he says. "I'm more a dog person." ■

Explore more

■ B. Bonnet *et al.* "An update on molecular cat allergens: Fel d1 and what else?" *Allergy, Asthma & Clinical Immunology*. April 10, 2018.

Erika Engelhaupt is a freelance science writer based in Tennessee and the author of the upcoming book Gory Details.



KEEPING THE LIGHTS ON

The U.S. power grid needs work to handle climate change

By Maria Temming



Derek Krause likes to be prepared. The 59-year-old retired fire chief used to teach courses on how to be self-sufficient in the wake of a natural disaster. So last October, when he and his wife arrived home to find their Oakland, Calif., neighborhood blacked out, Krause was ready with solar panels and battery backup.

Most people weren't so fortunate. While solar power kept Krause's lights on and refrigerator and Wi-Fi running over the three-day outage, the neighbors drove around in search of ice and lined up to buy generators. "My wife said, 'It's sort of like the movie *The Purge*,'" Krause recalls. "Your security system doesn't work, your garage doesn't work, your phone doesn't work, and streetlights and the traffic signals don't work. Good luck; you're on your own."

That October outage was part of a series of deliberate blackouts that plunged millions of Californians into darkness. Pacific Gas and Electric shut off the power to prevent

Power grid 2.0 Under climate change, power lines are more likely to be lashed by storms, bake in heat waves and spark wildfires in dry terrain. Revamping parts of the grid (numbered above) could make it safer in severe weather.

1. Burying power lines underground could keep them safe from storms and prevent them from igniting fires.
2. Sensors that recognize electrical signatures of potential problems, like trees hitting power lines, could warn repair crews before damage happens.
3. Neighborhoods could form energy islands: microgrids that share electricity from rooftop solar panels when the main grid goes down.
4. Installing more generators near crucial facilities, like hospitals, police stations and firehouses, could keep electricity flowing to emergency responders.

power lines from sparking wildfires in dry, windy conditions (*SN Online*: 11/1/19). It was one of many examples of how the U.S. power grid fails to stand up against weather hazards. In July 2019 in New York, the energy company Con Edison unplugged tens of thousands of customers to avoid equipment damage due to overheating during a heat wave. In 2017, Hurricane Harvey — whose severity has been linked to human-driven climate change — ripped through Houston and cut power to more than 300,000 customers (*SN*: 1/20/18, p. 6).

More than half of major U.S. power outages from 2000 to 2016 were caused by natural hazards like hurricanes, heat waves and wildfires, according to research reported July 2018 in *Reliability Engineering & System Safety*. Climate change is making such extreme weather more likely and more intense (*SN Online*: 12/10/19). The aging U.S. power grid is not expected to hold up well to the coming climate stresses: “Americans will likely experience longer and more frequent power interruptions,” the American Society of Civil Engineers predicted in a 2017 report.

Fixer-upper

America’s energy infrastructure is a sprawling network of millions of power lines overseen by a patchwork of grid operators. “There isn’t enough money in the world” to retrofit the entire grid with all new equipment that’s more firesafe and sturdy against storms, says electrical engineer B. Don Russell of Texas A&M University in College Station. “We’re going to have to live with what we’ve got for a long, long time.”

Realistically, there are two main ways to make electricity access more reliable in severe weather: getting smarter about how to patch up precarious parts of the grid, and building backup plans for when the grid fails. Some utilities are using new computer algorithms that pinpoint grid vulnerabilities sooner and figure out the best fixes. Meanwhile, a few communities are taking matters into their own hands by building microgrids, which can get power from solar panels when the electricity supply from the power company gets cut off.

The U.S. power grid is a 19th century system operating under



Electrical network The power grid of the contiguous United States is a vast web of high-voltage transmission lines (shown) that carry electricity from power plants to substations to lower-voltage distribution lines that wend through neighborhoods.

the stresses of a 21st century climate. When the first power lines went up, they were designed to operate with very little babysitting, says Alexandra von Meier, an electric grid researcher at the University of California, Berkeley. It just wasn’t practical for utilities to regularly inspect their entire electrical systems. Instead, utilities have maintained power lines under a run-to-failure mentality — assuming everything is fine until someone calls in to complain about an outage.

Today power companies are bringing new technology to bear on this centuries-old setup to keep better tabs on power lines and identify weather-related hazards before they cause trouble. With earlier warning of potential failures, utilities have been able to repair equipment more proactively and can better judge which lines should be powered down during weather conditions that boost fire risk. For instance, companies can use drone surveillance to keep a closer eye on trees near lines that could ignite a wildfire on a blustery day.

Russell and colleagues have developed a system that more directly monitors power lines for potential fire hazards. The system relies on sensors at substations — facilities where high-voltage lines that travel long distances meet low-voltage lines that snake through neighborhoods. These sensors monitor how electricity is flowing through power lines connected to the substation. The system can recognize subtle electrical signatures of malfunctioning wires, electrical switches, insulators and other components days or weeks before those components break and cause an outage. These electrical signals also contain clues about where the problem is — sometimes down to the exact location on an individual power line.

To create the system, described in November 2019 at the Grid of the Future Symposium in Atlanta, Russell’s team analyzed data recorded during device failures at a dozen power companies’ substations over 15 years. That allowed the researchers to tease out the electrical fingerprints of different equipment malfunctions. To date, over 20 utilities in the United States, as well as several in Australia, have deployed the Texas A&M automated system at their substations. “We have hundreds... if not thousands of examples where we [have found] a piece of failing equipment” or other ignition risks, Russell says. Those include power lines getting yanked down or brushing against trees, as well as components melting or sparking.

Utilities can also make the grid more reliable by redesigning parts of it and adding new equipment in vulnerable areas. That might involve running some lines underground in areas prone to wildfires, or building new power lines that provide detours for electricity if other lines go down during a storm. But renovations are expensive. Burying wires can cost between \$300,000 and \$1.25 million per kilometer, compared with \$80,000 to \$240,000 for overhead wires, according to a 2019 World Bank report. And figuring out which upgrades will keep the power on for the most people is a complex puzzle.

The number of possible new installations and renovations across a network of power lines is often so high that a computer cannot simulate every combination of upgrades to

calculate how many customers would benefit. “If you have on the table 100 or 150 or more different things you could do to your system and you look at all the possible combinations... very quickly the number of combinations exceeds the number of atoms in the universe,” says computer scientist Russell Bent of Los Alamos National Laboratory in New Mexico.

To tackle this problem, Bent and colleagues developed a computer program that doesn’t simulate every possible combination. Instead, it strategically samples upgrades from the pool of options that a utility has funding for and evaluates how the utility’s network would fare in different disasters — such as earthquakes and hurricanes — with each upgrade option. The system judges the benefit of each option by the fraction of “critical loads,” such as hospitals and police stations, served during the disaster, as well as the overall fraction of customers served.

The program might think, “I’ve got a solution that costs \$50 million, and it gives me the resilience benefit I’m looking for. Therefore, I should not be considering any solution that’s more expensive,” Bent says. Splitting a grid into smaller chunks and identifying optimal upgrades for each also helps the computer system determine which potential solutions to consider for the network.

Bent’s team ran scenarios for hypothetical power line networks in urban and rural distribution systems, describing the results online at arXiv.org in January 2018. Those results are slated to be published in the *INFORMS Journal on Computing*. For the rural network with long power lines that would be expensive to duplicate, the program was more likely to suggest installing extra localized backup generators. For urban networks with shorter lines, the program tended to favor building backup power lines. Utilities that belong to the U.S. National Rural Electric Cooperative Association can now use the Los Alamos group’s tool online to see what upgrades it recommends for their systems.

Going off grid

Strategic upgrades to make the grid more climate-ready are likely to roll out slowly. “There are very few [legal] requirements for what those in the industry have to do to comport with climate change,” says Robert Verchick, who studies disaster and climate change law at Loyola University New Orleans. So companies often don’t invest in building more climate-ready systems until a disaster has already struck. When companies do decide to upgrade or add on to their existing systems, the work can take years.

In some locations, people have pressured utilities into action. After Superstorm Sandy cut power to over a million Con Edison customers in New York in 2012, a group led by the Sabin Center for Climate Change Law at Columbia University successfully petitioned the New York Public Service Commission to make Con Edison account for sea level rise, heat waves



Oakland resident Derek Krause powered through an October 2019 blackout imposed amid high wildfire risks in northern California by using rooftop solar panels and a backup battery (shown behind him).

and other effects of climate change in any planned renovations. Other communities could push their public utility commissions to impose similar requirements, Verchick says.

But no amount of strategic repair or new infrastructure will make the power grid perfect. “There are always [weather] possibilities that are beyond the control of any utility company,” says von Meier, of UC Berkeley. Inevitably, preemptive shutdowns or weather-related blackouts will leave some in the dark.

People whose homes have solar panels and battery backup, like Oakland resident Derek Krause, can sometimes silo themselves off from the main grid and run independently during outages. Solar energy is growing in popularity; the number of residential, business and utility solar panel installations in the United States have about doubled since 2016, reaching 2 million in May 2019, according to the U.S. trade group Solar Energy Industries Association. But that’s still small potatoes: Solar power accounted for about 90 billion kilowatt hours of electricity in the United States in 2018, compared with over 2,600 billion kilowatt hours generated by fossil fuels.

Rather than each house forming a little energy island, von Meier and colleagues believe that the more energy-efficient approach is for a city block to share a community microgrid powered by rooftop solar panels. Von Meier’s team simulated how much energy demand could be met by rooftop solar when houses were cut off from the main grid for different durations and times of year. The researchers based their analysis, presented at the April 2018 IEEE Green Technologies Conference in Austin, Texas, on real-world power consumption data from Austin homes over one year. The team compared hypothetical, 30-home microgrids with rooftop solar panels against identical city blocks where each home ran separately on solar power.

The simulation played through outages lasting four hours, one day and eight days, starting on each day of the year, at either midnight or in midafternoon. On average, a block-sized microgrid met a greater fraction of its total energy demand

The U.S. power grid is a 19th century system operating under the stresses of a 21st century climate.

than about 70 percent of the individual homes. Block-scale microgrids can meet more energy demand, overall, because power use in individual homes tends to vary more over time than the power use of an entire block, the researchers argue. Turning on a single appliance can change a home's energy demand by a lot. That same appliance has a much smaller effect on a 30-home block.

Block-sized microgrids may not be more efficient in all cases. But this kind of simulation offers a way for developers to judge the benefits of potential neighborhood microgrids with different energy demands and generation capacities. The researchers are preparing to field-test their microgrid idea in a soon-to-be-selected city block in Oakland, and plan to start building the microgrid within two years.

"Microgrids are certainly a very important and rapidly developing solution" to power outages, says Gregory Reed, who studies power grid technology at the University of Pittsburgh. Some university campuses, airports and other businesses have built their own microgrids. The Blue Lake Rancheria tribe in northwestern California has constructed a solar-powered microgrid on its reservation, which supplied electricity to the tribe and its neighbors when PG&E powered down last October. The Native American tribe's \$6.3 million microgrid was built with funding from its casino plus a state grant.

"Microgrids are an expensive proposition," Reed says. "People who can afford microgrids... they're leaving behind a whole part of the population that can't."

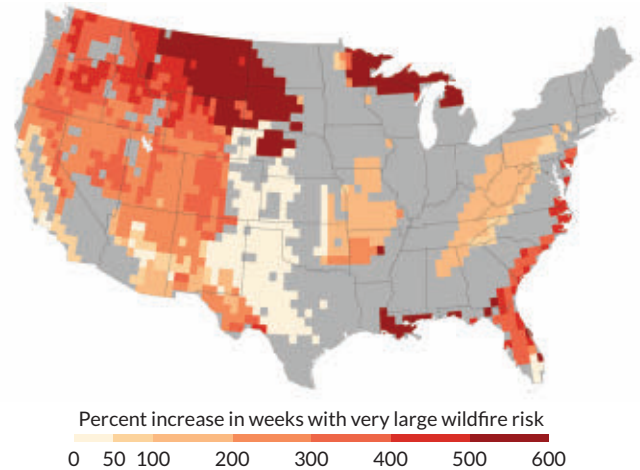
Power to the people

Extreme weather has already left some people with no choice but to go off-grid. Take the small mountain community of Adjuntas, in central Puerto Rico. "It's an extremely peaceful place to live," says Arturo Massol-Deyá, who was born and raised there. "Everyone knows each other."



After Hurricane Maria obliterated Puerto Rico's power grid in 2017, the nonprofit Casa Pueblo began building rooftop solar systems on homes and businesses in the mountain town of Adjuntas (aerial view shown) to help the community become more energy self-sufficient.

Tinderbox terrain Climate change is expected to increase the number of weeks in a year when weather conditions favor very large wildfires. This map shows the percent increase from 1971–2000 to 2041–2070. The most severe upticks are expected in the West, Southeast and parts of the Great Lakes region.



But in 2017, Hurricane Maria laid waste to Puerto Rico's power grid, causing the largest blackout in U.S. history. Six months after the storm, more than 100,000 Puerto Ricans were still without electricity. "Our neighborhood was without power for four months," Massol-Deyá says. "But the rural communities... were without power for almost a year." The only place in town with power was a local environmental nonprofit that Massol-Deyá runs, called Casa Pueblo, thanks to its rooftop solar panels.

Casa Pueblo became an "energy oasis" where people recharged their devices, Massol-Deyá says. The organization also powered the local radio station and installed solar power systems in the homes of people who needed power for dialysis equipment or respiratory machines.

Puerto Rico's government-owned power company has released a plan to build a new-and-improved power grid across the island, featuring eight smaller grid networks that can operate independently in an emergency. But Massol-Deyá's team hasn't been waiting around for change. Because Adjuntas has a high poverty rate, Casa Pueblo has outfitted dozens of homes in Adjuntas, along with the fire station, eldercare facility, barbershop and other businesses with solar power. The system held up during January's string of earthquakes, Massol-Deyá says. Now the organization is gearing up to build a solar-powered microgrid to supply businesses in the town's main square.

Massol-Deyá hopes that other communities will also become more self-sufficient with local, renewable energy resources. Reliable electricity is not just a convenience, he says. "It's for survival." ■

Explore more

- Rosemary Lyster and Robert R.M. Verchick. "Protecting the power grid from climate disasters." October 12, 2017. Sydney Law School Research Paper No. 17/86.

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EXPERIENCES

Board game captures the beauty and ferocity of marine life

Maybe somewhere there's an ocean where the transparent parasite *Invisy McSuckFace* is scrounging for its next meal. The bloodsucker might have to flee from the terrifyingly fast swordfish-shark hybrid *Zoomy killa* or dodge dozens of tentacles from schools of the octopus-like *Grabbo clique*. But more likely, these critters exist only in *Oceans*, a strategy board game by North Star Games that masterfully translates the wonders and complexities of marine ecology to a tabletop setting.

The game, on sale this spring, is a sequel to North Star's popular *Evolution* game, and the core experience is similar. Two to four players — or in some editions of the game, six — vie to keep species alive and well-fed, with acquired food ultimately converted into points. On each turn, a player deploys a trait card to create a new species or grant new abilities to existing ones. These traits, such as “apex predator” or “filter feeder,” correspond to skills and physical features that help real marine critters survive and find food. Some species may be reef foragers, for example, while others are more aggressive, stealing food from other species.

Building a roster of creatures that interact well with each other or with other players' species in the ecosystem is essential to achieving victory. And in that way, the game mimics real evolutionary pressures, with players responding to the dominant sea creature and finding new ways to tap into the oceans' bounty. Is an apex predator taking over the seas? Keep your prized species safe by employing a squid's trusty defense tactic — shooting ink at an enemy — or take advantage of the predator's prowess by eating the animal's scraps. As the game progresses, randomly selected scenarios can alter the game dynamics, incentivizing players to adapt to a shifting environment. For example, the “fertile” scenario rewards players for creating many new species, while the “epizootic” event simulates a disease outbreak by cutting down populations of some species.

Just as players think they have the ecosystem figured out, the Cambrian explosion hits. For the rest of the game, players use two traits per turn and can access the “Deep” deck, full of the most bizarre characteristics of marine life and mythical sea creatures. “*Oceans* is really exploring this space between the known world, what science knows, and the unknown,” says lead designer Dominic Crapuchettes. While Deep cards cost points to play initially, the benefits of becoming a fearsome kraken or a whale that has mastered bubble nets to corral prey (*SN: 11/9/19, p. 7*) are often worth the gamble.

North Star consulted marine biologist Brian O'Neill of the University of Wisconsin-Whitewater in the design of the game, and



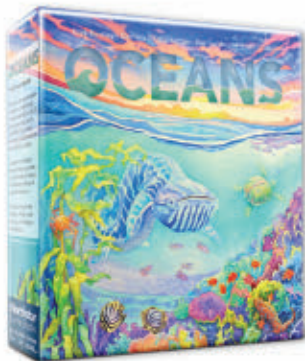
In *Oceans*, the “apex predator” trait makes a species a force to be reckoned with, like this imagined whale-shark hybrid seen on one card.

the scientific background pays off in a cohesive and (mostly) scientifically accurate experience. For instance, the Cambrian explosion ushers in a burst of rapid evolution and biodiversity, much like the real-life event about 541 million years ago (*SN: 4/27/19, p. 14*). And a species's traits usually interact in ways that make biological sense: “Inking” and “schooling” both make a creature harder to attack, and “speed” gives aggressive species a boost.

But that's not always the case. “The thing I'm struggling with is giving things biological traits that don't make any sense,” earth and climate writer Carolyn Gramling noted when *Science News* staffers tried the game. For example, it's possible to create a species that is both parasitic and symbiotic with the same creature, or even an apex predator that's also a filter feeder, though that may be as questionable strategically as it is biologically.

Scientific quibbles aside, *Oceans* excels at evoking a sense of wonder. The striking watercolor art by illustrator Catherine Hamilton, on the game board and many of the trait cards, invites players into a vibrant ecosystem. The game rewards both careful planning and quick thinking, which prevents the frustrating feeling of dreading a certain loss after an early mistake (a common occurrence in *Oceans*' predecessor, *Evolution*). And there's a welcome dash of humor: Reading the in-game guide to scientific names resulted in *Science News* staffers developing creative names for their species, including *Invisy McSuckFace*.

Those familiar with *Evolution* will feel right at home in *Oceans*' less punishing but equally nuanced gameplay. And for those who are new to strategy games, *Oceans* is a good introduction: It's intuitive enough to pick up the basics after a few turns, but nuanced enough to be enjoyable after dozens of games. As players battle for survival, they'll soon find that the ocean is, as *Science News* staff writer Jonathan Lambert put it, “red in tooth and tentacle.” — *Mike Denison*



Oceans, created by North Star Games, will go on sale this spring.

Society supports STEM mentors through Advocate Program

In the summer, teachers typically receive a well-deserved respite. Charmain Brammer, a teacher at SUCCESS Academy in Saint George, Utah, however, spends her summers meeting with students she’s mentoring, encouraging their involvement in the sciences.

Charmain works with 10th–11th grade students to develop projects for the school’s science fair. She was named a Society Advocate for the third year in a row and is also serving as a Lead Advocate for the 2019–2020 school year for a second consecutive year. Through Society for Science & the Public’s Advocate Program, educators receive a grant and training to support them as they mentor a group of at least three students beyond their normal cohort of students.

“The grant allows me to give more time to individual students who don’t have the support at home to be successful in completing a project,” she said. “That’s the biggest thing the grant allows, that individualized instruction time. I don’t think there’s anything that can help them more than that to enter a science fair.”

The students who conducted science research under Charmain’s mentorship have placed in several regional science fairs, and one student competed at the International Science and Engineering Fair, a program of the Society. “It’s important for people to know there’s more going on than just our local sports teams,” Charmain said.



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SOCIAL MEDIA

Career moves

Flipping a molecular switch can turn Florida carpenter ants (shown below) from soldiers into foragers, **Jake Buehler** reported in “Molecular switch can alter an ant’s job” (SN: 12/21/19 & 1/4/20, p. 14). The story reminded Twitter user **@KingFilosofer** of a popular saying about adapting military technology for peaceful civilian use: “Turning swords into plowshares!!!”



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What’s the matter?

The source of matter’s dominance over antimatter in the universe might be revealed by tiny subatomic particles called neutrinos, **Emily Conover** reported in “Neutrinos linked to cosmic puzzle” (SN: 12/21/19 & 1/4/20, p. 12).

The story stated that matter and antimatter existed in equal measure in the early universe, and that when they come together, they annihilate each other. “No problem there,” reader **Eric Brunner** wrote. If nothing intervened to disrupt the balance between matter and antimatter, the universe would have been left with nothing but energy. Based on Albert Einstein’s equation $E = mc^2$, **Brunner** thought that for energy to survive, matter must also survive. “Is my logic incorrect?” he asked.

It is incorrect, **Conover** says. In Einstein’s special theory of relativity, the equation $E = mc^2$ indicates that the energy contained in the mass of an object is equal to that object’s mass multiplied by the speed of light squared. The equation indicates the possibility of converting the energy of that mass into other forms of energy, **Conover** says. “That’s what happens when a particle and its antiparticle annihilate. The annihilation typically results in two particles of light called photons. Photons have no mass and therefore are not typically considered matter particles, but they do have energy,” she says.

Promise for PTSD

The U.S. Food and Drug Administration approved a ketamine-based nasal spray for treatment-resistant depression in 2019, **Laura Sanders** reported in “New drug approved for severe depression” (SN: 12/21/19 & 1/4/20, p. 33).

Reader **Barbara Wilson** asked if ketamine could help people diagnosed with post-traumatic stress disorder, or PTSD, which may be accompanied by depression. “Flashbacks might be relieved, if memory of violent events is muffled,” she wrote.

Researchers are studying whether ketamine can help ease PTSD symp-

toms, **Sanders** says. Already there have been some positive signs: One small study, for example, found a dose of ketamine reduced the severity of people’s PTSD symptoms after 24 hours, she says. Those results were published in 2014 in *JAMA Psychiatry*.

One reason to suspect ketamine might work for PTSD has to do with the drug’s possible effects on memory. “Memory is slippery,” **Sanders** says. “Each time we remember something, that memory is vulnerable to being changed, scientists suspect. Ketamine might be one way to alter memory.” But there will need to be a lot more evidence of this effect before we really understand how ketamine interacts with PTSD. “This is a fast-moving field that I’m eager to follow,” **Sanders** says.

Whiskey business

Evaporated droplets of different American whiskeys leave behind unique patterns not seen in other tested liquors, **Maria Temming** reported in “Bourbon brands leave singular designs” (SN: 12/21/19 & 1/4/20, p. 44).

A Reddit user noted that scientists didn’t test how chill filtering may have affected the patterns. The process cools and filters whiskey, **forswearThinPotation** says. “I’m guessing it has an impact on the physiochemical properties during evaporation.”

The patterns are very sensitive to anything that can influence the whiskeys’ chemical composition, says fluid dynamics researcher **Stuart Williams** of the University of Louisville in Kentucky. “Factors like temperature, humidity, chemical additives and filtration will impact the final pattern,” he says.

Williams’ team has yet to conduct a study looking at how all of these factors affect the patterns. “There are thousands of chemicals in whiskey, and it would be difficult to systematically isolate each one,” he says. “We are currently working on creating synthetic liquids that create similar structures [with far fewer chemicals].”

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How bacteria create floral works of art

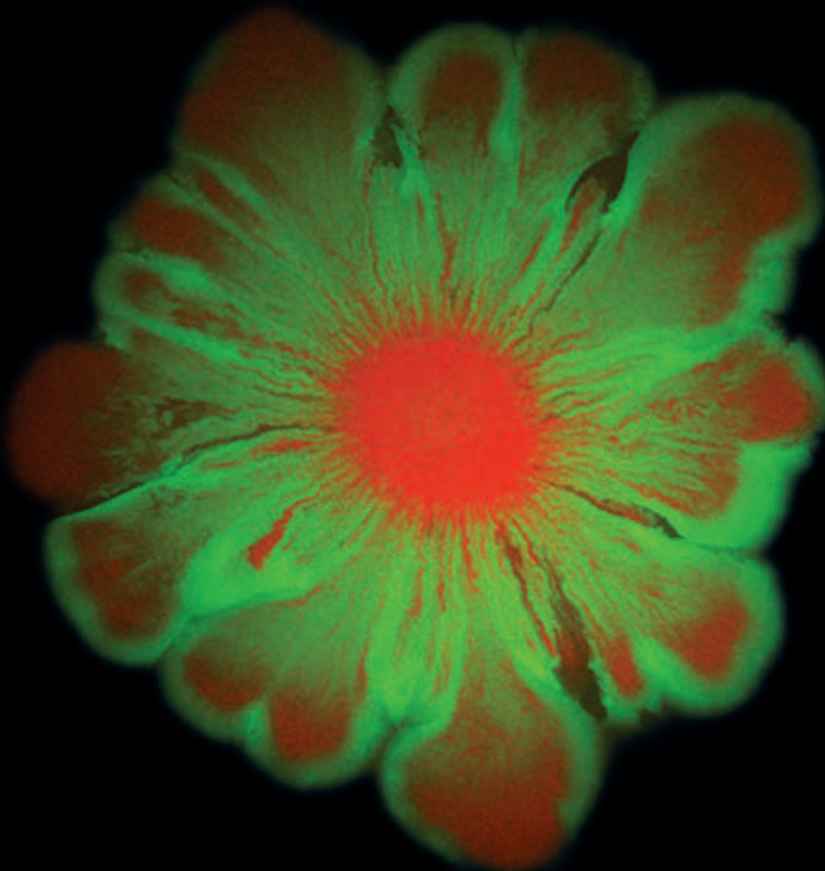
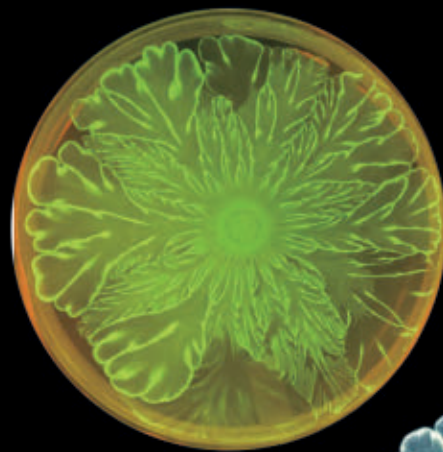
When sticky bacteria meet roaming bacteria in a petri dish, friction between the two can cause flower patterns to bloom (examples shown).

Escherichia coli bacteria growing on a gelatin-like substance called agar tend to stick to the surface, and colonies of the microbes don't spread very far. But colonies of *Acinetobacter baylyi* expand in rapidly growing circles as the bacteria crawl on hairlike pili over the agar's surface. Neither type of microbe is very exciting to look at on its own, says Lev Tsimring, a theoretical physicist at the University of California, San Diego. But "when we mixed them together, we saw these absolutely mind-blowing structures growing."

Physical interactions between the two bacterial types create floral patterns, he and colleagues found. Mobile *A. baylyi* push *E. coli* forward, "sort of like a snowplow," Tsimring says. But sticky *E. coli* (colored green in the bottom image) dig in their heels, so to speak, holding back a wave of *A. baylyi* (red) like an elastic band wrapped around a balloon, he says. In some areas where there are fewer *E. coli* forming a barrier, the more agile *A. baylyi* break through, painting petals as they shove their reluctant neighbors forward. Those advances tend to occur at fairly regular intervals, creating roughly symmetrical blossoms.

The petal shape that forms depends on how fast *A. baylyi* bacteria move, how well *E. coli* are stuck to the surface and the proportions of each type of bacteria at the colony edges. *E. coli* must outnumber *A. baylyi*, or the speedy bacteria will blow right past their more sedentary partners. Tsimring's team describes the math behind the blooms January 14 in *eLife*.

Such equations have been used to show how chemical reactions might produce Turing patterns — repeating designs found in nature, such as spots on animals' coats (*SN*: 7/17/10, p. 28). But mechanical forces matter, too, these results suggest. — *Tina Hesman Saey*



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- ☀️ In A.D. 321, Constantine declared "Sun Day" as a day to rest and worship Sol Invictus. Upon converting, Constantine kept Sunday as the new Christian day of rest (instead of Saturday).
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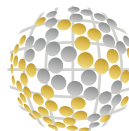
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