

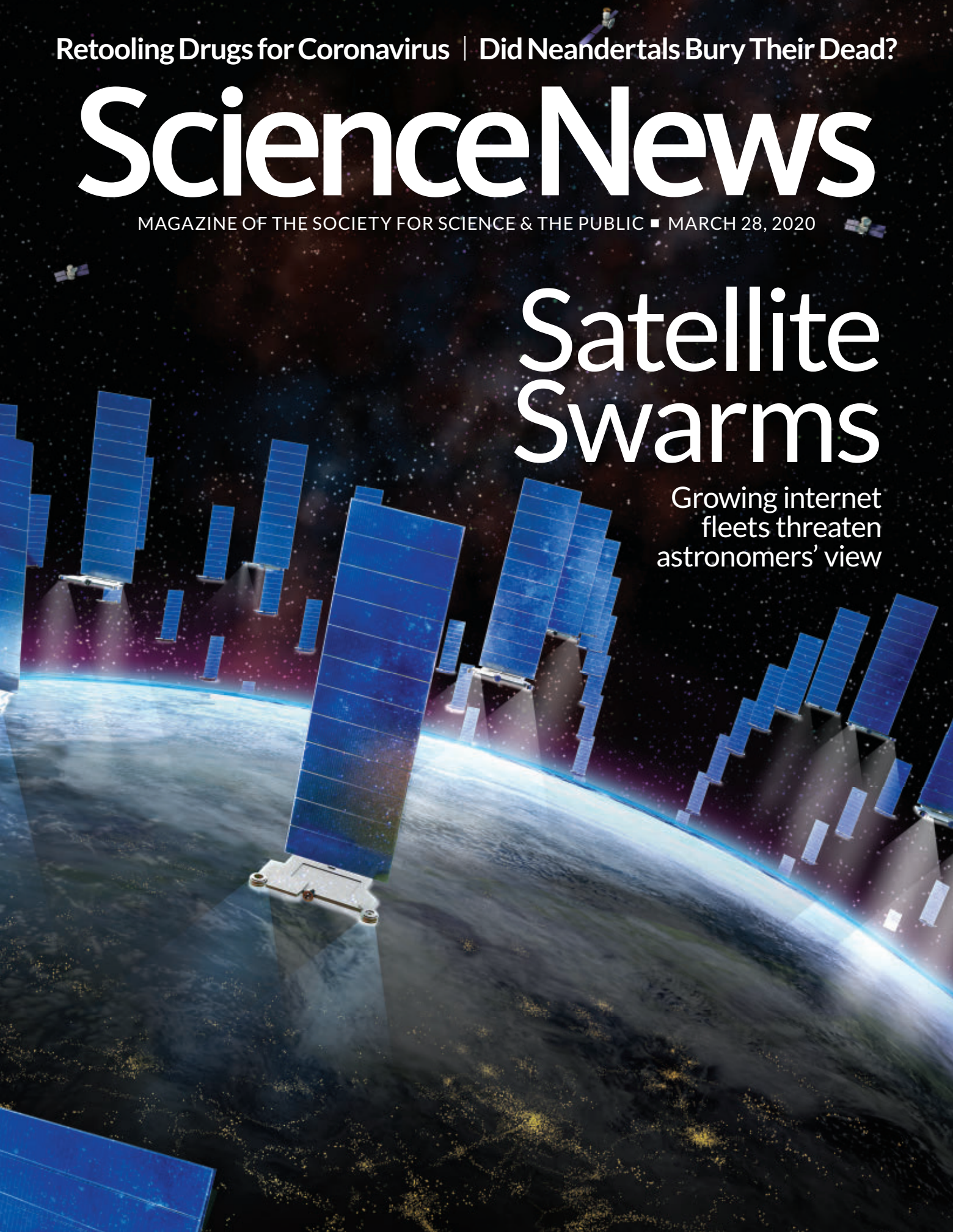
Retooling Drugs for Coronavirus | Did Neandertals Bury Their Dead?

# ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ MARCH 28, 2020

## Satellite Swarms

Growing internet fleets threaten astronomers' view



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# ScienceNews



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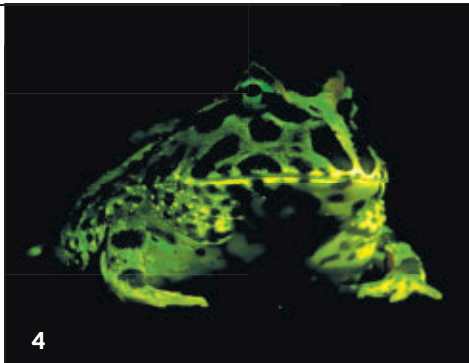
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## When coronavirus is both work and worry

When the news first surfaced in December of a flulike outbreak in China, a lot of us here at *Science News* felt our spidey senses tingle. China has sparked earlier outbreaks of diseases that travel from animals to people, notably SARS, which emerged from a live-animal market in 2002 and killed 774 people worldwide. I covered that outbreak, and it was scary. The virus spread easily, had about a 10 percent fatality rate and overwhelmed hospitals trying to quell it. SARS, short for severe acute respiratory syndrome, was ultimately stopped by rigorous infection control and quarantines — classic public health responses.

So far this new coronavirus appears to have a lower case fatality rate than SARS but is harder to intercept, because in most cases the symptoms are milder, raising the odds that people infected with the virus, called SARS-CoV-2, can spread disease without even realizing that they are ill. That may be the case with an Episcopalian reverend in Washington, D.C., who was diagnosed after presiding over services attended by more than 500 people.

The *Science News* office is less than two miles from that minister's church. News of this coronavirus case, the first in Washington, D.C., was announced on March 8. I had dinner at a restaurant a few blocks away from the church on March 6 and got my hair cut nearby on March 7. This brings the epidemic close to home in a personal way.

Of course, we are all worried about the health of our families, friends and colleagues, and how we can keep them safe amid the uncertainty. At the same time, the *Science News* team is deeply invested in providing rigorously accurate news and context on the outbreak, such as Tina Hesman Saey's deep dive into efforts to repurpose existing drugs to combat the new virus (Page 20). We need to figure out how to stay healthy while also covering the pandemic, which the U.S. Centers for Disease Control and Prevention says could continue into next year.

Before the new coronavirus, we had started working on systems that would make it possible for us to do our jobs outside of our Dupont Circle townhouse. Back then, the complications we were preparing for were the basics, a snow-storm or a busted HVAC system. Now we're hustling to deploy an electronic production system so that we can work remotely if the schools close, or if we're quarantined at home, or if, God forbid, one of us gets sick. Some old-school publishing practices, like hand-correcting proofs on paper, are going by the wayside. And our weekly Thursday teatime, an enjoyable chance to step away from our screens and visit with colleagues, may become "virtual tea" so that we can still enjoy the pleasure of each other's company — from a safe distance.

Rest assured that you will continue to find our coverage of coronavirus and news from across the sciences in these pages, as well as at [sciencenews.org](http://sciencenews.org). And our coronavirus update newsletter will send the latest to your inbox twice a week: Sign up at [www.sciencenews.org/special-newsletter](http://www.sciencenews.org/special-newsletter).

Stay safe; we'll stay on the beat to keep you informed. And we'd love to hear from you. Let us know what you'd like to know about the outbreak by e-mailing us at [feedback@sciencenews.org](mailto:feedback@sciencenews.org). — *Nancy Shute, Editor in Chief*

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

50 YEARS AGO

## Ten years to metric

Australia is taking its first brisk steps toward conversion to a fully metric system of weights and measures over the next 10 years.... The arguments for conversion to metric in Australia have been similar to those given elsewhere: The metric system is used by countries representing 90 percent of the world's population; three-fourths of world trade is carried out in metric measurements.

**UPDATE:** Five years into Australia's metrication, the U.S. Congress passed the Metric Conversion Act in a bid to move the country away from an imperial system based on measures such as the foot and the pound. But the voluntary process failed to gain public support. Some U.S. industries along with science agencies made the switch, but inconsistencies have led to mishaps. In 1999, the Mars Climate Orbiter burned up in the Red Planet's atmosphere because of a unit mix-up between NASA and Lockheed Martin (*SN*: 10/9/99, p. 229). Today, only the United States, Liberia, Myanmar and a handful of island nations use versions of the imperial system.

RETHINK

## Glowing frogs and salamanders are surprisingly common

Many animals, from fish and corals to parrots, have a sometimes-hidden skill: gleaming blue, green, yellow or red under certain kinds of light. But when it came to amphibians, experts knew of only one salamander and at least three frogs that fluoresced — until now.

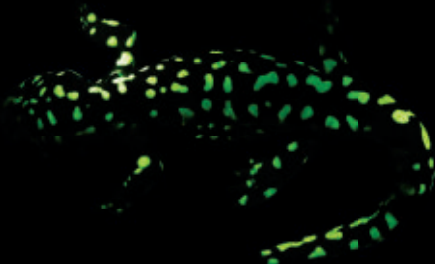
Jennifer Lamb and Matthew Davis, biologists at St. Cloud State University in Minnesota, shone both ultraviolet and blue light on 32 amphibian species, including salamanders, frogs and a caecilian, at various life stages. To the researchers' surprise, all of the specimens lit up in brilliant colors, Lamb and Davis report February 27 in *Scientific Reports*.

The four amphibians previously known to fluoresce did so under ultraviolet light. But in the study, the effect was strongest under blue light. Among four-legged creatures, the ability to absorb higher-energy blue light and emit lower-energy light had previously been documented only in marine turtles. The new finding suggests that biofluorescence is widespread among amphibians.

The team also found that different species glow in different patterns. Some, such as the eastern tiger salamander (*Ambystoma tigrinum*), reveal strips or blotches of color. In others, like the marbled salamander (*A. opacum*), bones and parts of their undersides light up.

The team didn't test how amphibians are able to glow, but the animals may rely on fluorescent proteins or pigment-containing cells. If there are multiple mechanisms among amphibians, then the ability probably evolved independently in different species, rather than being passed down by a common ancestor. Biofluorescence may help salamanders and frogs find one another in low light: Their eyes contain cells that are highly sensitive to green or blue light.

Scientists could use blue lights to search the wilderness for amphibians, particularly those that blend into their surroundings or hide in leaves. Lamb already has prowled her family's woods at night with blue light in hand and spotted the telltale glow. — *Erin Garcia de Jesus*



Different amphibian species glow in different colors and patterns. The yellow-colored spots of the eastern tiger salamander (*Ambystoma tigrinum*), for example, fluoresce green under blue light (right).

ALL: J. LAMB, M. DAVIS



FOR DAILY USE

## Buying local is greener than e-shopping

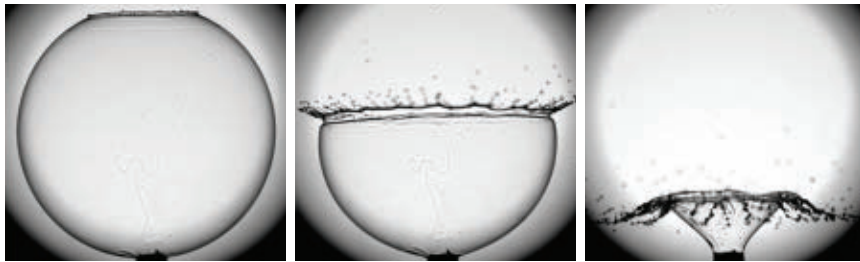
Shopping locally may help people reduce their carbon footprint.

Computer simulations of shopping trips and deliveries allowed researchers to estimate carbon dioxide emissions per item bought by different means in the United Kingdom.

On average, emissions for deliveries from local shops were equivalent to about 0.07 kilograms of CO<sub>2</sub> per item. That's less than half the 0.18 kilograms associated with an item ordered from an online retailer that delivers from a package distribution center, researchers report online February 26 in *Environmental Science & Technology*. Local deliveries also resulted in lower emissions than the average 0.1 kilograms per item for shopping in person.

To reach these estimates, the researchers simulated thousands of instances of someone purchasing a cartful of items, such as household and personal care products, either in person or online. To reflect real-world shopping and delivery conditions, the team factored in emissions estimates for activities such as powering warehouses, transporting items and walking versus driving to a store.

Local shop deliveries tend to be greener than those from online retailers because people usually buy a bunch of stuff at once from a local store, but order items piecemeal from online retailers, the researchers say. Bundling items for single delivery could help curb emissions. — *Maria Temming*



THE EVERYDAY EXPLAINED

## The forces behind the sound of a bubble's pop

Put your ear next to a soap bubble, and you might hear a quiet, high-pitched “pfttt” as it bursts.

Scientists now have characterized the sound of that bubble swan song using an array of microphones and have analyzed the physics behind the sound of popping bubbles.

The burst begins with a rupture in a bubble's soapy film (*SN: 1/21/17, p. 32*). The rupture grows as the film retracts, altering the forces from the film pushing on the air within the bubble, physicist Adrien Bussonnière and colleagues report in the Feb. 28 *Physical Review Letters*. These shifting forces cause pressure changes — sound — that

microphones can pick up. Additionally, as the film retreats, soap molecules get packed together near the edge of the film, changing the film's surface tension, which also alters the forces on the air and affects the sound.

To study blink-and-you'll-miss-it events like bubble bursts, scientists typically turn to high-speed video. But the new study illustrates how acoustics can reveal the changing forces that produce certain sounds, including potentially the rumble from within a volcano or the buzzing of a bee, says Bussonnière, of Université de Rennes 1 in France. “Images cannot tell the whole story.” — *Emily Conover*

Radio waves (blue) trickle from a cavity in X-ray-emitting gas (pink) around a massive galaxy (white, at top). The radio waves likely come from electrons sped up by a black hole eruption.

THE -EST

## Black hole blast is the most powerful known

Say hello to the Krakatoa of black hole eruptions.

Hundreds of millions of years ago, a supermassive black hole in a faraway galaxy blew out gas into intergalactic space. The black hole flare-up was about five times as powerful as the previous record holder, releasing roughly 100 billion times as much energy as the sun is expected to emit in its entire lifetime, researchers report in the March 1 *Astrophysical Journal*.

Eruptions from enormous black holes are powered by the release of pent-up energy in encircling disks of hot gas. The newfound eruption came from a beast of a galaxy at the center of the Ophiuchus cluster, a gathering of galaxies nearly 400 million light-years from Earth.

In 2016, researchers noticed the edge of a cavity in the cluster's hot, X-ray-emitting gas, about 400,000 light-years from the central galaxy. The excavated region appears to be more than a million light-years across.

To suss out the cavity's origin, the researchers pored through data from several radio telescopes and found that the cavity glowed with radio waves, likely from electrons accelerated to near the speed of light. The team suggests that the electrons got revved up by a powerful outburst at least 240 million years prior from a supermassive black hole at the heart of the cluster's central galaxy. — *Christopher Crockett*

On the outskirts of Canberra, the Orroral Valley Fire blazed on January 28, 2020.

EARTH & ENVIRONMENT

## Australian fires tied to climate change

Intense heat wave in 2019–2020 boosted the wildfire risk

BY CAROLYN GRAMLING

Human-caused climate change made southeastern Australia's devastating wildfires in June 2019 to March 2020 at least 30 percent more likely to occur, researchers report March 4.

A prolonged heat wave that baked the country in 2019–2020 was the primary factor raising the fire risk, climate scientist Geert Jan van Oldenborgh and colleagues said March 3 during a news conference. The researchers also linked the heat wave's extremity to climate change, said van Oldenborgh, of the Royal Netherlands Meteorological Institute in De Bilt. Such an intense heat wave in the region is about 10 times as likely now as it was in 1910.

Van Oldenborgh also noted that climate simulations tend to underestimate the severity of such heat waves, suggesting that climate change may be responsible for even more of the region's high fire risk. "We put the lower boundary at 30 percent, but it could well be much, much more," he said.

The same week that the findings were released, southeastern Australia was declared free of wildfires for the first time in more than 240 days, the New South Wales Rural Fire Service

announced March 2 on Twitter. Across Australia, the fires had burned through an estimated 19.4 million hectares, killing at least 34 people and destroying about 6,000 buildings since early July. An estimated 1.5 billion animals also died.

The new research was conducted by the World Weather Attribution group, an international consortium of scientists who investigate how much of a role climate change might be playing in extreme weather events. Given the quick turnaround time, the study has not yet been peer-reviewed. "We wanted to bring the scientific evidence [forward] at a time when the public is talking about the event," said climate modeler Friederike Otto of the University of Oxford.

The group examined how climate change altered the Fire Weather Index, an estimation of the risk of wildfires. Climate simulations show that the probability of a high Fire Weather Index during the 2019–2020 season increased by at least 30 percent, relative to the fire risk in 1910. That is primarily due to the increase in extreme heat; the study could not determine the impact of climate change on extreme drought conditions, which also helped fuel the blazes.

19.4  
million

Estimated hectares burned by Australia's 2019–2020 wildfires

Researchers previously suggested that an El Niño–like weather pattern known as the Indian Ocean Dipole, which was in a strong positive phase in 2019, may have played a role in exacerbating the dry conditions (*SN*: 2/1/20, p. 8). Global warming may make such extreme positive phases of this pattern more common. The new study confirmed that the 2019 positive phase made drought conditions more extreme, but could not confirm this particular phase's relationship to the high Fire Weather Index.

"It is always rather difficult to attribute an individual event to climate change," but this study is nicely done, says Wenju Cai, a Melbourne-based climate scientist at the Commonwealth Scientific and Industrial Research Organization. The link to climate change is reasonable, if not particularly surprising, he says.

The year 2019 was Australia's hottest and driest since modern record keeping in the country began in 1910. Summers Down Under also appear to be lengthening: The Australia Institute, a Canberra-based think tank, released a report March 2 that found that Australian summers from 1999 through 2018 lasted longer by a month, on average, than they did about 50 years ago.

Temperature observations going back to 1910 show that southeastern Australia's temperatures have risen by about 2 degrees Celsius on average, van Oldenborgh and colleagues report. Climate simulations underrepresented that warming, however, showing an increase of only 1 degree C in that time.

Climate modelers previously have struggled to reconcile the disparity between recorded temperatures and simulated heat waves. Simulations tend to underestimate the severity of the events. The team noticed a similar underestimation in simulations of the 2019 heat waves in Europe. Conditions not generally factored into regional climate simulations, such as land-use changes, may be responsible for the disparity. Changes in vegetation cover, for example, can have an impact on how hot or dry a region gets. ■



# Gut cells implicated in peanut allergies

Discovery could lead to new ways to curb serious reactions

BY LAURA SANDERS

Severe peanut allergies may stem from parts of the digestive tract.

A surprisingly large pool of cells involved in allergic reactions to peanuts resides in the stomachs and small intestines of allergic adults, scientists report in the March 6 *Science Immunology*.

“This is the first time that we actually see what is happening in the gut” in people with peanut allergies, says immunologist Cecilia Berin of the Icahn School of Medicine at Mount Sinai in New York City. Studies in mice hinted that certain allergy molecules are made in the gut, but there has been scant evidence in people, she says. Identifying the gastrointestinal tract as a prime location for allergy molecules is “a huge step forward.”

The findings may point to treatments for food allergies, which affect an estimated 3 to 6 percent of people in the United States.

The study focused on an elusive, rare antibody called immunoglobulin E, or IgE. Usually present in very small numbers in the body, IgE can sense invaders such as parasites and cause massive immune reactions designed to purge the threat. But in people with allergies, the antibody can go rogue and target harmless substances, such as peanut proteins.

Immunologists Ramona Hoh and Scott Boyd, both of Stanford University School of Medicine, and colleagues studied tissue from the digestive tracts of 19 allergic adults. These people were about to start a clinical trial designed to test the effects of precise doses of peanut protein on allergies, one of several such trials (*SN*: 12/22/18 & 1/5/19, p. 12).

The researchers began by studying RNA in cells from esophagus, stomach and duodenum samples. Cells use this genetic material to make proteins, including antibodies such as IgE. Tallying up the various RNA molecules in each sample indicated which antibodies

were present, and where. The method also let the researchers estimate how many cells were churning out IgE.

Stomach and intestine tissue from the allergic patients was teeming with cells that make IgE. In the stomach, for instance, people without allergies had very few IgE-producing cells. People allergic to peanuts had hundreds of times more.

“There was so much of it there,” Hoh says. “That’s something we were all really surprised about.”

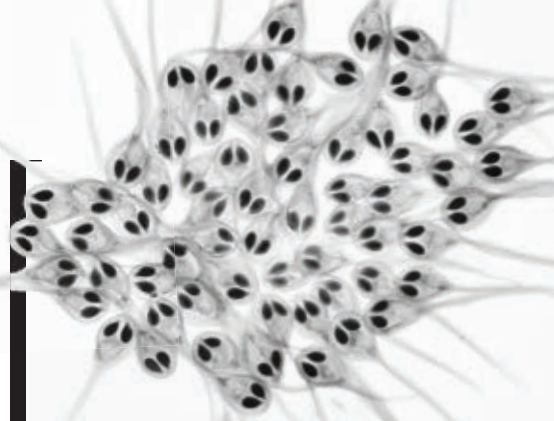
By comparing the IgE-producing cells, called B-lineage cells, the researchers figured out that many were closely related. This kinship suggests the cells are made locally in the stomach and intestine, as opposed to flooding in from other body parts, such as lymph nodes or the spleen.

In many cases, these cells seemed to have morphed from making a different, harmless type of antibody to producing IgE. It’s not clear why these cells might be more likely to make this switch in the guts of people with peanut allergies.

The analyses also point out similarities among some of the allergic participants’ peanut-sensing IgEs: They seem to recognize similar parts of the peanut protein. Designer antibodies that could block those spots, and prevent IgE from getting there first and setting off a reaction, might be a way to curb peanut allergies.

A similar idea — using antibodies to keep IgE away from cat proteins that spark allergies — is showing promise for cat allergies (*SN*: 2/15/20, p. 16).

Hoh, Boyd and colleagues plan to study IgE levels in some people with peanut allergies after they’ve participated in the clinical trial aimed at easing their allergies. So far, researchers don’t know when these antibody-producing cells first show up in the stomach and intestines, or whether the cells would start to disappear as allergies fade. ■



## LIFE & EVOLUTION

### Animal gets by without help from mitochondria

In the muscle of some Pacific salmon lives a parasitic creature that thrives without working mitochondria, the energy-producing part of cells thought to be integral to animal life, a study suggests.

Mitochondria convert food and oxygen into energy through aerobic respiration. Mitochondria carry many of the instructions for aerobic respiration in their own genome, separate from the rest of an organism’s DNA housed in the cell nucleus. But when evolutionary biologist Dorothée Huchon of Tel Aviv University and colleagues analyzed the DNA of a microscopic parasite called *Henneguya salminicola*, the mitochondrial genome was missing. Microscopy revealed the animal — a type of cnidarian, the group that includes jellyfish and coral polyps — has mitochondria-like structures, though the researchers doubt the structures are capable of aerobic respiration.

The loss may be an adaptation to a low-oxygen home, the team reports online February 24 in the *Proceedings of the National Academy of Sciences*. The parasite jumps between two hosts during its life cycle: salmon and probably annelid worms (*H. salminicola* spores are shown in the microscope image above). The parasite may rely on its hosts for energy, instead of its own mitochondria. Shedding unnecessary and cumbersome DNA through evolution might have helped the parasite save energy.

A few single-celled eukaryotes, organisms with complex cells, lack functioning mitochondria, but scientists assumed that more complex animals couldn’t get by without them. — Jonathan Lambert

## ATOM &amp; COSMOS

## Rover peers beneath moon's farside

Layers may hold clues to why the nearside looks so different

BY LISA GROSSMAN

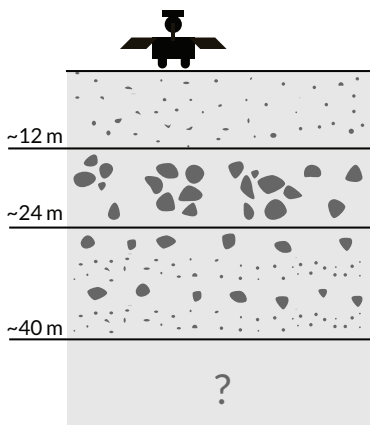
The farside of the moon is a lunar layer cake. New data from China's Chang'e-4 lander and its Yutu-2 rover reveal alternating layers of coarse rock and fine soil down to a depth of 40 meters, suggesting a history of violent impacts, scientists report February 26 in *Science Advances*.

Chang'e-4, the first spacecraft to land on the farside, touched down inside the 186-kilometer-wide Von Kármán crater in January 2019 (*SN*: 2/2/19, p. 5). As Yutu-2 explored the crater, the rover sent radar pulses into the ground to probe the material beneath its wheels.

Lunar scientist Chunlai Li of the Chinese Academy of Sciences in Beijing and colleagues analyzed what lies beneath the roughly 106-meter path that the rover took in its first two lunar days (about two Earth months) of collecting data. The team discovered a layer about 12 meters thick of fine soil, or regolith, closest to the surface.

"It's like being on very clean sand," says study coauthor Elena Pettinelli of Roma Tre University in Italy. "It's like you're on the beach."

**Lunar layers** Yutu-2 is using radar to probe the subsurface of the moon's farside. The rover has so far found three layers: fine soil down to about 12 meters, coarser rock with embedded boulders down to about 12 meters below that, and then sublayers of coarse and fine materials for another 16 meters or so. Below that is a mystery. SOURCE: C. LI ET AL./SCIENCE ADVANCES 2020



Below that fine soil, the rover found another layer of about 12 meters of coarser material embedded with larger rocks, like cherries in a fruitcake. And lower still was a series of alternating coarse and fine materials, spanning depths of about 24 meters down to 40 meters — the limit of the rover's radar.

All of those layers were probably created by material ejected by successive impacts, the researchers say. The base of the crater began as a smooth sheet of hardened lava from long-ago volcanic activity. That lava has been pummeled repeatedly and covered by material, called ejecta, that is scattered when meteorites and other objects slam into the moon and leave craters behind.

"That's a really violent process," says lunar geologist Daniel Moriarty of NASA's Goddard Space Flight Center in Greenbelt, Md., who was not involved in the study. Some of the ejecta could have come from as deep as the moon's mantle (*SN*: 6/8/19, p. 7). The top layer of smooth sand is probably the result of the surface being pulverized by micrometeorites and cracked by extreme temperature shifts over time, Moriarty says.

Chang'e-4 and Yutu-2's view of the moon's subsurface is different from their predecessors'. Chang'e-3 and its Yutu rover landed on the moon's nearside in 2013, and Yutu's radar was blocked by dense volcanic rock at a depth of just 10 meters or so. The nearside's volcanic floodplains are probably closer to the surface than those on the farside.

Future work could help figure out why the moon's nearside is awash in smooth plains of volcanic rock, while the farside is more rugged and cratered. "One of the biggest driving questions in lunar science for a while has been, why does the nearside look so different from the farside?" Moriarty says. "If people can use what they found to unravel some of the volcanic history of the farside, that would be helpful." ■

## ATOM &amp; COSMOS

## Molecular oxygen in another galaxy

Astronomers try to explain the molecule's high abundance

BY KEN CROSWELL

For the first time, astronomers have found molecular oxygen — the same gas humans need to breathe — in a galaxy outside the Milky Way.

Oxygen is the third most common element in the cosmos, after hydrogen and helium. So astronomers once thought molecular oxygen, O<sub>2</sub>, would be common in the space between stars. But no one had ever seen molecular oxygen beyond our galaxy — until now.

Junzhi Wang, an astronomer at Shanghai Astronomical Observatory in China, and his colleagues spotted the molecule's calling card in a galaxy named Markarian 231. Lying 560 million light-years away in the constellation Ursa Major, Markarian 231 is the nearest galaxy to Earth that has a quasar, where gas whirls around a supermassive black hole and gets so hot that it glows brilliantly.

Using radio telescopes in Spain and France, the astronomers saw radiation at a wavelength of 2.52 millimeters, a signature of O<sub>2</sub>'s presence, the team reports in the Feb. 1 *Astrophysical Journal*.

It's the most molecular oxygen ever seen outside the solar system. Previously, astronomers had seen the molecule in just two star-forming clouds within the Milky Way, the Orion Nebula and the Rho Ophiuchi cloud. Astronomers think the shortage of interstellar O<sub>2</sub> is due to both oxygen atoms and water molecules freezing onto dust grains, locking up the oxygen. In stellar nurseries, though, shocks from bright newborn stars can rip water ice from the dust, freeing oxygen atoms to find each other and form molecules.

But even in the Orion Nebula, molecular oxygen is rare, with hydrogen molecules outnumbering oxygen molecules a million to one. Hydrogen also dominates in Markarian 231. But molecular oxygen

spans the outskirts of the galactic disk at abundances more than 100 times greater than in the Orion Nebula.

“There is no known explanation for an abundance of molecular oxygen that high,” says Gary Melnick, an astrophysicist at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., who was not involved in the work. To confirm that the radiation really arises from O<sub>2</sub>, Melnick says, the team should look for a second wavelength from the molecule.

That won’t be easy, Wang says, because other molecules also emit radiation at those wavelengths. To shore up the case for O<sub>2</sub>, the scientists went through the many molecules that give off wavelengths similar to the one detected. Nobody had ever seen any of those molecules in space — except for O<sub>2</sub>. “It is guilty by elimination, if you will,” says team member Paul Goldsmith, an astronomer at the Jet



Astronomers found molecular oxygen about 560 million light-years from Earth in the galaxy Markarian 231, shown in this Hubble Space Telescope image.

Propulsion Laboratory in Pasadena, Calif.

One possible explanation for all the O<sub>2</sub> is that Markarian 231 goes through a more vigorous version of the Orion Nebula’s oxygen-forming process. The galaxy is a prolific star factory, spawning new stars 100 times as fast as the Milky Way and spewing out 700 solar

masses of gas per year. High-speed gas from the galaxy’s center may slam into gas in the disk, shaking water ice from dust grains so that molecular oxygen can form. In turn, oxygen could keep the galaxy hyperactive: Radiation the molecule emits helps cool the gas so that some of it can collapse and create even more stars. ■

## ATOM & COSMOS

# Magma ocean tied to early magnetism

Silicates may fill in a gap in the history of Earth’s magnetic field

BY CHRISTOPHER CROCKETT

Billions of years ago, Earth’s magnetic field may have gotten a jump-start from a turbulent magma ocean swirling around the planet’s core.

Earth has generated magnetism for almost the planet’s entire history (*SN*: 3/2/19, p. 13). But it’s never been clear how Earth created this magnetic field roughly 2.5 billion to 4 billion years ago during the Archean Eon. Now, computer simulations suggest that a deep layer of molten rock-forming minerals known as silicates might be the answer.

“There’s a few billion years of Earth’s history where it’s difficult to explain what was driving the magnetic field,” says Joseph O’Rourke, a planetary scientist at Arizona State University in Tempe who was not involved with this work. This new result, he says, is a “vital piece of the puzzle.”

Today, Earth’s magnetism is likely generated in the planet’s outer core, a layer of liquid iron and nickel. Heat escaping from

the solid inner core drives flows of fluid that create circulating electric currents in the outer core, turning Earth’s innards into a gigantic electromagnet. The outer core, however, is a fairly recent addition, appearing roughly a billion or so years ago. Ancient rocks preserve evidence of a planetwide magnetic field much earlier than that. So, some other mechanism must have been at work during the planet’s formative years.

One candidate for Earth’s first go at a magnetic field is a sea of liquid rock hypothesized to once have surrounded the young planet’s nascent core. To see if this ocean of molten silicates is a viable option, Lars Stixrude, a geophysicist at UCLA, and colleagues developed computer simulations to estimate the electrical properties of silicates at the extreme temperatures and pressures thought to have existed at the bottom of Earth’s mantle during the Archean.

The team found that, at pressures more than 1 million times Earth’s surface

atmospheric pressure and temperatures comparable to those on the surface of the sun, silicates conduct electricity well enough to produce a planetwide magnetic field. The strength of that field, the team reports February 25 in *Nature Communications*, roughly matches measurements of fossil magnetic fields in rocks that are about 2 billion to 4 billion years old. Around the end of the Archean, the team suggests, the magma ocean would have cooled and solidified, possibly handing over magnetic field duties to an increasingly turbulent core.

The study is “an extremely important step forward in understanding the history of Earth’s magnetic field,” O’Rourke says. What’s more, it might also be relevant to other worlds today. “It’s not just a curiosity of ancient history,” he says.

Super-Earths, rocky planets a few times as massive as Earth, might retain enough internal heat to sustain a deep silicate ocean for much longer than our planet did. These planets are among the most common worlds found outside the solar system. The mechanism behind Earth’s early magnetic field, the team speculates, may therefore operate in big rocky planets throughout the universe. ■

## EARTH &amp; ENVIRONMENT

# Cost of sea level rise could be steep

By 2100, annual losses could surpass 4 percent of global GDP

## BY MEGAN SEVER

Rising seas that swamp cities and coastal infrastructure could cost the world more than 4 percent of the global economy each year by 2100—far more than previously estimated—unless urgent action is taken both to reduce greenhouse gas emissions and prepare for the impacts of sea level rise, a new study finds.

That worst-case scenario, which assumes that large amounts of polar ice will melt, would add up to trillions of dollars. That’s “not peanuts,” says study coauthor Thomas Schinko, a climate economist and deputy director of the Risk and Resilience program at the International Institute for Applied Systems Analysis in Laxenburg, Austria. “This would lead to a completely different world.”

Given the risks, it’s hard to imagine that people won’t make any effort to adapt to a world with more flooding and coastal erosion, Schinko says. So the worst-case scenario is “not a very realistic scenario.” But the shocking number shows policy makers what could happen if they don’t act soon, he says.

If countries lower greenhouse gas emissions enough to prevent the global temperature from rising more than 2 degrees Celsius above preindustrial

levels, but do nothing else to prepare for rising seas, costs are projected to be more than 3 percent of global gross domestic product each year by 2100, Schinko and colleagues found. If countries both lower emissions and prepare for sea level rise, costs can be limited to about 0.4 percent of global GDP, or less.

The new study, published in the January *Environmental Research Communications*, goes beyond previous research that estimated about 1.3 percent of global GDP in losses from up to a meter of sea level rise on average. But where previous studies relied on one type of economic model, the new study uses three types of macroeconomic models to test how energy policies and emissions scenarios might play out on the global economy and in specific countries over the next eight decades.

The researchers also considered how those economic impacts might change if coastal communities prepare for the increased risk of inundation, for example, by building dikes or sea walls (*SN: 8/17/19, p. 16*). The team’s computer simulations adjusted as time went on, including local sea level rise changes and impacts from earlier years in estimating costs for later years. And the team looked at the economic effects of direct losses, such as destroyed infrastructure, and

indirect costs, such as job losses and disrupted supply chains that can result from damage to businesses. Previous studies had not taken all of these factors into account simultaneously.

Regardless of the scenario, global GDP losses will probably be relatively low overall through 2050, the models show, amounting to less than 0.4 percent annually, on average. But then, costs start to escalate to varying degrees depending on how much the world reins in emissions and prepares for rising seas.

The bottom line, Schinko says, is that if we don’t do anything now, the effects and the costs of rising seas will skyrocket over the latter half of this century.

Losses from sea level rise would be spread unevenly across the world. With no preventive action, China, for example, could lose up to 12 percent of its GDP each year by 2100; for China’s 2019 GDP, that amounts to about \$1.7 trillion. Losses in Japan could hit 8 percent annually; Europe, up to 6 percent annually.

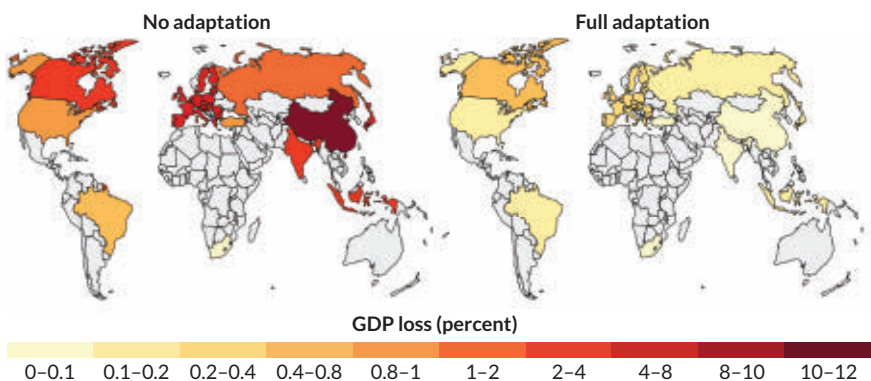
The models do have some limitations. For example, compound floods—flooding made worse by additional high tides or heavy rainfall—are not well-represented in the simulations, says coastal engineer Robert Nicholls of the University of East Anglia in Norwich, England. Compound floods are probably the biggest problem arising from sea level rise, he says.

Sea level rise projections themselves also are a moving target. Projections based on ice melt, depending on atmospheric greenhouse gas levels, vary from 25 centimeters to close to a meter by 2100. But climate simulations are becoming increasingly sophisticated in incorporating more expected impacts from rising temperatures, such as changes in ocean circulation patterns and thermal expansion of seawater.

Overall monetary damages from climate change could be much worse than what the new study predicts, Schinko says. “In this study, we’re only talking about the economic impacts of coastal flooding due to sea level rise, not droughts or wildfires ... not salinity intrusion or loss of land” or other hazards like severe storms. ■

**Looming losses** Economic costs from sea level rise could be high by 2100 if greenhouse gas emissions continue unchecked and countries don’t prepare for rising seas (left). But if coastal communities adapt to wetter conditions, losses would be more limited (right).

### How sea level rise might impact economies around the world by 2100





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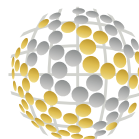
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## ATOM &amp; COSMOS

# Black hole can't sway physics constant

Fine-structure constant passes test near Milky Way's center

BY EMILY CONOVER

Even on a black hole's turf, an essential constant of nature holds steady.

According to standard physics, the fine-structure constant, which determines the strength of the interaction of electrically charged particles, is the same everywhere in the universe. Some alternative theories, however, suggest that the constant might be different in certain locales, such as the extreme gravitational environment around a black hole. But when put to the test near the supermassive black hole at the center of the Milky Way, the number didn't budge, physicists report in the Feb. 28 *Physical Review Letters*.

The fine-structure constant is one of an assortment of unchanging numbers found in physics formulas, such as the mass of an electron or the speed of light. Importantly, the fine-structure constant doesn't have units, making it more fundamental than other constants. Scientists don't know why it has the value it does — about  $1/137$ . But its size seems crucial: If that number were much different, atoms wouldn't form (*SN: 11/12/16, p. 24*).

Experiments on Earth have previously shown that the fine-structure constant doesn't vary over time. "What's interesting here is to try to search for variation somewhere else in the universe, in a totally different environment," says physicist Aurélien Hees of SYRTE at l'Observatoire de Paris.

Using observations of light from five stars that cruise around the supermassive black hole at the center of the galaxy, Hees and colleagues searched for hints of an altered fine-structure constant. When the starlight is separated into different wavelengths, it shows features called absorption lines, which indicate particular wavelengths of light that are absorbed by certain atoms. If the fine-structure constant were altered at the galaxy's center, the distance between those absorption lines would differ from measurements of those absorption lines made on Earth.

But the absorption lines agreed with expectations. The researchers calculated that the fine-structure constant near the black hole agreed with its earthly value

to better than a thousandth of a percent.

It's the first time scientists have looked for a variation of the constant in the general vicinity of a black hole, says Wim Ubachs of Vrije Universiteit Amsterdam, a physicist who has searched for changes in various constants of nature.

A 2010 study gave tentative hints that the fine-structure constant might vary as scientists look farther out into space, with the number increasing or decreasing in certain directions, but the evidence for that phenomenon is not conclusive. So scientists are probing the constant in a variety of ways, including near a black hole.

"The work is very important because it denotes the beginning of a new type of study," namely, searching for variation of the fine-structure constant at the center of the galaxy, says physicist John Webb of the University of New South Wales in Sydney.

In previous research, Webb and colleagues found no variation while probing the fine-structure constant in an environment that's even more gravitationally extreme: the surface of dense dead stars called white dwarfs. So if the new research had found any indication of change in the steadfast constant, Webb says, "I would have been very surprised." ■

## EARTH &amp; ENVIRONMENT

## Colorado River is slowly drying up

Climate change is threatening to dry up the Colorado River — jeopardizing a water supply that serves some 40 million people and irrigates farmland across the U.S. Southwest.

Computer simulations suggest that, on average, a regional temperature rise of 1.4 degrees Celsius over the last century reduced the annual amount of water flowing through the river by over 11 percent. Warmer weather meant less snow cover, exposing darker ground that absorbed more sunlight. In turn, more water on the ground evaporated before feeding the river, researchers report online February 20 in *Science*.

To forecast the future, the team combined its simulations with models that predict temperatures under different scenarios. If fossil fuel emissions are curbed so that atmospheric carbon dioxide concentrations level off by midcentury, annual river flow would drop 14 to 26 percent compared with the average annual flow during the last century. If emissions continue apace, the flow would drop 19 to 31 percent. — *Maria Temming*



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## Monthly shots can keep HIV in check

Injections may be a better option than daily pills for some people

BY JONATHAN LAMBERT

People living with HIV are a step closer to having a once-a-month treatment.

There is no cure for HIV, the virus that causes AIDS. But combination antiretroviral therapy, or ART, can halt viral replication, nearly eliminating the virus from the bloodstream and prolonging life expectancy (*SN: 11/23/19, p. 16*). For the therapy to work, people must stick to a daily regimen of two or more pills, which experts say can be a challenge for many.

Now, results of two large clinical trials suggest that a monthly shot of antiretroviral drugs works just as well as daily pills, researchers report online March 4 in two studies in the *New England Journal of Medicine*. If approved by U.S. regulators,

the therapy could be a more convenient treatment for the estimated 1.1 million people with HIV in the United States.

“From a patient perspective, these results are very positive,” says Elizabeth Tolley, an epidemiologist at FHI 360, a public health nonprofit in Durham, N.C. Stigma can make people reluctant to keep HIV drugs at home or to take them in front of a loved one, she says.

The injectable ART is a long-acting combination of cabotegravir and rilpivirine. Both studies were Phase III clinical trials — the gold standard for getting regulatory approval for a new drug. One enrolled 566 participants who had never tried ART. They first took a pill version, which included a combination of other HIV drugs, for 20 weeks to

get the virus under control. Then, the participants either transitioned to once-a-month shots or continued using pills.

The other trial enrolled 616 participants whose HIV had been controlled by ART pills for at least six months.

In both trials, people were randomly assigned to get the monthly shot or pills. After 48 weeks, there was no difference in people’s viral loads for each treatment, suggesting that monthly shots work just as well as pills. Most patients reported some pain or swelling with the shot.

“There are pluses and minuses” to each option, says Marc Siegel, an infectious disease physician at George Washington University in Washington, D.C., who wasn’t involved in either trial. A “patient won’t have to remember to take a pill every day, though they will have to visit the doctor’s office once a month.” Shots may be more feasible for those who struggle with housing instability and don’t have a place to store pills, he says. ■

## Yellow spots help spiders lure lunch

Insect pollinators may mistake some orb weavers for flowers

BY YAO-HUA LAW

Many orb weaver spiders sport yellowish stripes or spots on their undersides, and for a good reason. The yellow tempts insects into a spider’s web, a new study suggests.

Orb weavers get their name because they spin and sit on circular webs. But why such stealthy predators would have bright, conspicuous coloring has been a puzzle. Scientists have hypothesized that the bright colors might serve to warn the spiders’ predators, to help the spiders blend into vegetation or to attract prey.

In the new study, researchers examined whether the yellow coloration on a species of golden orb weaver, *Nephila pilipes*, attracts flying insects. This spider sits on its web day and night with its underside — mottled and striped

yellow on black — facing open space. The team took more than 250 females from a field site in Taiwan and either left the webs vacant or replaced the female with a cardboard spider. Cardboard models had paper strips of yellow, blue or black glued on.

After nearly 1,800 hours of filming the faux arachnids, the team found that during the day, yellow-striped models lured more than twice as many insects, including bees and flies, as any other fake spider or empty web. Yellow worked just as well at night in attracting moths, Po Peng of Kaohsiung Medical University in Taiwan and colleagues report online February 11 in *Functional Ecology*.

The team then scoured zoological databases for associations between yellow markings and prey attraction in orb weavers. Surveying dozens of distantly related species revealed that yellow stripes or spots were more likely to have evolved in orb weavers that sit on their webs in open, bright spaces, where visual baits may be more effective.

The research “reinforces that the color yellow lures insects,” says Nathalia



Yellow patterns on the undersides of many orb weaver spiders, like this *Nephila pilipes*, seem to attract flying insects.

Ximenes, a behavioral ecologist at the University of São Paulo in Brazil who studies orb weaver coloration but was not involved in the work. Scientists don’t yet know why the insects were attracted to yellow. Perhaps prey mistake a spider for a yellow-flecked flower, a hypothesis supported by the fact that most of the prey attracted in the study were pollinators. ■

## EARTH &amp; ENVIRONMENT

## Thirdhand smoke wafts in theaters

Even nonsmoking areas may be polluted with tobacco residues

BY MARIA TEMMING

“Nonsmoking” doesn’t necessarily mean smoke-free.

A new study monitoring airborne contaminants inside a nonsmoking theater indicates that hazardous cigarette fumes wafting off moviegoers can degrade air quality. Those pollutants include the carcinogen benzene and toxic aldehydes, such as acrolein, formaldehyde and acetaldehyde.

Such thirdhand smoke, released from tobacco residue on people’s skin, hair and clothing, is an important public health concern, researchers report March 4 in *Science Advances*. But it’s not yet clear whether the exposure levels seen in the study are enough to cause serious health problems, or how much people can protect themselves from thirdhand smoke in public.

The experiment took place in a well-ventilated, nonsmoking theater in Mainz, Germany, which showed four to five films per day. Over four days, the researchers used a mass spectrometer to take a chemical inventory of pollutants leaving the theater through ceiling vents.

These measurements revealed that concentrations of tobacco-related compounds in the theater spiked when new crowds entered — especially for R-rated flicks and late showings, perhaps because audience members were more likely to have been smoking or hanging around smokers before arrival. Previous research has found traces of thirdhand smoke in supposedly nonsmoking areas, but this is the first study to catch people in the act of transferring the pollution.

Environmental engineer Drew Gentner of Yale and colleagues compared observed levels of thirdhand smoke components with the amounts of those chemicals that would have been emitted if someone were smoking in the theater.

During R-rated films, audiences were exposed to one to 10 cigarettes’ worth of hazardous compounds per hour, though

the exact amount that each audience member might inhale would depend on their position relative to the folks emitting pollutants. On average, audiences were exposed to eight cigarettes’ worth of benzene and four cigarettes’ worth of acetaldehyde per hour. Differences in exposure levels arise because some chemicals detach from people’s clothes and bodies more easily than others.

“This is clearly showing that we’re getting another exposure to tobacco smoke chemicals in places where we just don’t expect them,” says Peter DeCarlo, an air quality scientist at Johns Hopkins

University. “The next step is really understanding what that means in terms of health.” The relative risk for each person will depend on their moviegoing habits and the air pollution they encounter elsewhere.

Even if thirdhand smoke poses a significant risk, theaters aren’t likely to ban smokers or their friends and family.

Rather, the findings may inform how smokers behave at home, where thirdhand smoke is expected to be more potent due to more confined spaces and poorer ventilation, says environmental chemist Hugo Destaillats of Lawrence Berkeley National Laboratory in California. People may think twice about smoking in the house, even when no one is around, if they know the risks that smoke poses even after a cigarette is stubbed out. ■



## EARTH &amp; ENVIRONMENT

## Sea turtles may confuse plastic with food

To a sea turtle, plastic debris might smell like dinner.

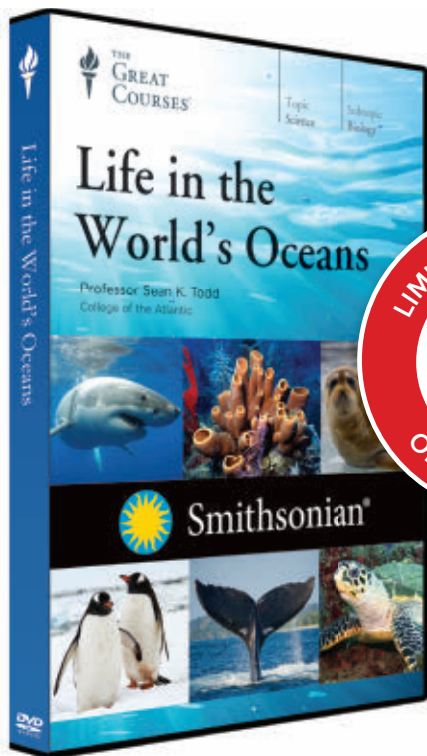
Plastic that’s been stewing in the ocean emits a chemical that, to some birds and fish, smells like food (*SN*: 12/10/16, p. 16). That chemical, dimethyl sulfide, is also made by phytoplankton, a food source for many marine animals. Now, scientists have found that the smell of plastic also may lure loggerhead sea turtles (one shown above).

Fifteen captive loggerheads (*Caretta caretta*) in tanks were exposed at the water surface to a slew of scents, including the largely neutral scent of water, food such as shrimp, and new and ocean-soaked plastic. The reptiles largely ignored water and clean plastic smells. But loggerheads increased their sniffing above water — a foraging behavior — in response to food or ocean-soaked plastic. The response might explain why sea turtles get entangled in or eat plastic, which can prove deadly. — Jonathan Lambert





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## HUMANS &amp; SOCIETY

# Foot arch supported upright walking

Curve evolved in hominids by about 3.4 million years ago

BY ERIN GARCIA DE JESUS

The arch across the width of the foot may play an unappreciated role in enabling people to walk upright, a study suggests.

Bones in the middle of the foot, called metatarsals, are arranged in a curve known as the transverse tarsal arch. That bend stiffens the foot lengthwise and may have evolved more than 3.4 million years ago, scientists report online February 26 in *Nature*. The arch may have been an important step toward human ancestors gaining the ability to walk and run on two feet, the team says.

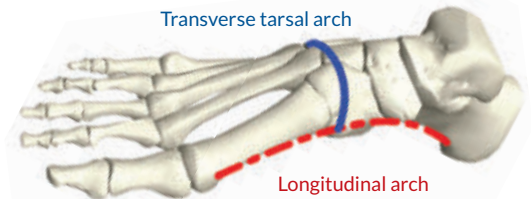
Scientists already knew that an arch on the inside of the foot that runs from ball to heel, called the longitudinal arch, makes the foot more rigid, thanks to the arch's shape and elastic tissues stretching beneath the foot like the string of a bow. How much the other arch helps

make feet more firm was unknown.

But it turns out that the role that the transverse arch plays in foot stiffness is like what happens when a piece of paper is somewhat curled. “Hold [a dollar bill] with your fingers at one end of its length, and it flops down,” says Madhusudhan Venkadesan, a mechanical engineer at Yale. “But press down with your thumb to slightly curl it along the width, and the bill will stiffen and become straighter.”

Knowing how human feet evolved to walk and run could help experts design better prostheses or better treat people with flat feet. Most prosthetic feet, for instance, are designed for walking. People who want to run need something different — a stiff prosthesis shaped like a curved blade.

Venkadesan and colleagues tested the stiffness of three types of curved



A human foot has two arches that help enable upright walking. The longitudinal arch runs along the inside of the foot, and the transverse tarsal arch crosses the top of the foot.

structures, including a thin, elastic sheet, mechanical structures mimicking feet and two feet from cadavers. A transverse arch made materials more rigid. When the researchers cut tissues between the bones that make up the transverse arch in cadavers, the foot's stiffness went down by up to 54 percent.

The study is “exciting for those of us that live and die for foot evolution,” says Patricia Kramer, a paleobiomechanist at the University of Washington in Seattle. The study is a good example of combining traditional biological anthropology with engineering principles to better

## HUMANS &amp; SOCIETY

# Distant cousin had hands for tools

*Paranthropus* hominid may have made stone implements

BY BRUCE BOWER

*Paranthropus boisei*, an African hominid that lived between about 2.3 million and 1.2 million years ago, may have strong-armed its way into stone-tool making with a deft touch.

That's the implication of the first hand, arm and shoulder fossils discovered from the same *P. boisei* individual, say paleobiologist David Green and colleagues. The fossils suggest that this species combined powerful arms suited to tree climbing with grasping hands capable of fashioning stone implements, the researchers report in the April *Journal of Human Evolution*.

*P. boisei*, a distant cousin to modern humans, lacked a thick, powerfully

gripping thumb characteristic of its hominid contemporary *Homo erectus*, a prolific maker of sophisticated stone tools. But the newly described hand bones suggest that *P. boisei* gripped well enough to make and use simple stone and bone tools, just as other members of the human evolutionary family may have as early as 3.3 million years ago (*SN*: 6/13/15, p. 6). That's long before the emergence of the *Homo* genus, which appeared around 2.8 million years ago. But reports of toolmaking before *Homo* originated are controversial.

“This is the first evidence that creatures that were almost certainly not our direct ancestors could have made tools,” says Bernard Wood, a paleoanthropologist at George Washington University in Washington, D.C. “So we can no longer assume — nor should we ever have assumed — that only *Homo* could make tools,” says Wood, who wasn't involved in the research.

It may be tempting to argue that only *H. erectus*, which had a brain approaching

twice the average size of *P. boisei*'s, could have made teardrop-shaped, double-edged hand axes that date to around the same time as the two hominid species. Those tools demanded more skill and planning than earlier, simpler cutting implements. But the case is not closed, says Green, of Campbell University School of Osteopathic Medicine in Buies Creek, N.C. “We'll need to find tools that can be confidently associated with *P. boisei* and assess its technical abilities before assuming that *H. erectus* was the superior toolmaker.”

Excavations and surveys from 2004 to 2010 at Kenya's Ileret site produced the new *P. boisei* finds. Fossils were found in sediment that dates to between 1.53 million and 1.51 million years ago.

A large male skull discovered in 1959 is the best-known *P. boisei* fossil. Dubbed Nutcracker Man, the individual had wide cheekbones that projected forward and a bony crest atop its braincase that once anchored huge chewing muscles. Nutcracker Man may have eaten mainly

understand aspects of the foot, she says.

But while it's clear that the transverse arch is important for stiffness, exactly how important will need further study, Kramer says. Experiments with the mechanical mimics of human feet, for instance, didn't account for the parts of the foot that touch the ground — details that might be important in calculating the foot's overall stiffness, she says. "A modified human foot does not tell you how a [hominid] foot worked, but it could be used to validate a model that then is modified to represent a [hominid] foot."

The team also examined hominid fossils, searching for the first appearance of curved arches. Nonhuman primates have much flatter feet than people do. But by about 3.4 million years ago, a humanlike transverse arch had developed in a foot from an unidentified hominid species.

The appearance of that arch "probably played a big part in us becoming bipedal," Venkadesan says. The structure "adds an essential and missing ingredient for the stiffness of human feet." ■

grasses and flowering plants known as sedges.

Suggestions that another member of the *Paranthropus* genus, *P. robustus*, crafted stone tools, based on isolated finger bones unearthed in South Africa's Swartkrans cave complex, go back more than 30 years (*SN*: 5/28/88, p. 344). Parts of two arm bones and two leg bones from an adult male *P. boisei* have turned up since then at Tanzania's Olduvai Gorge (*SN*: 1/11/14, p. 13). But the Ileret discoveries offer the first look at bones from throughout a *P. boisei* individual's upper limb. As a result, researchers can more confidently reconstruct what types of arm and hand movements that hominid could perform.

Stone artifacts are abundant at ancient *Homo* sites, a sign that our genus relied far more heavily on toolmaking than *P. boisei* did, says Neil Roach, a biological anthropologist at Harvard University who was not involved with the research. No stone artifacts have been clearly linked to *P. boisei* fossils. ■

GRAEME BARKER



#### HUMANS & SOCIETY

## Neandertal burial debate revived

### Possible grave discovered in a cave in Iraqi Kurdistan

BY BRUCE BOWER

The excavation of a Neandertal's partial skeleton in Iraqi Kurdistan has revived a debate over whether Neandertals intentionally buried their dead.

Analyses of the fossils, unearthed from Shanidar Cave, and the surrounding sediment indicate the individual was placed at the bottom of a shallow depression that someone had dug, scientists report in the February *Antiquity*.

The discovery follows Shanidar excavations from 1951 to 1960 that yielded fossils from 10 other Neandertals, including a skeleton known as the "flower burial" for the ancient clumps of pollen surrounding the remains. Archaeologist Ralph Solecki, who led those digs, concluded that the pollen showed that the Neandertals had buried their dead and scattered flowers in funeral rituals.

Burying the dead, a behavior typically associated only with *Homo sapiens*, implies compassion for group members, care and mourning for the dead, and perhaps spirituality and belief in an afterlife.

Critics have suggested, however, that Neandertals sleeping in the cave could have died from exposure or injuries caused by falling rocks before natural processes covered the bodies with dirt and plants. To complicate matters, Solecki's work occurred before professional standards for excavations were set.

The newfound Neandertal, an adult dubbed Shanidar Z, lay next to the flower

Excavations in Iraqi Kurdistan's Shanidar Cave have added to previous fossil evidence suggesting that the site contains intentionally buried Neandertals.

burial and in a manner that strengthens the argument that the cave contains one or more burial sites. "We are pretty convinced that at least some of the Shanidar individuals were intentionally deposited," says Emma Pomeroy, an archaeologist at the University of Cambridge.

In 2016, Pomeroy's team unearthed a rib, a lower-back bone and hand bones, presumably from a Neandertal. Further fossils from the same individual, found from 2017 to 2019, included a flattened skull that has Neandertal traits, such as large brow ridges, and a left hand that had been curled under the head.

Preliminary dating of soil suggests Shanidar Z lived between 70,000 and 60,000 years ago. Shanidar Z lay at the bottom of a depression, where slightly compacted soil indicates the hole was intentionally dug. Sediment containing Shanidar Z and nearby Neandertals shows no signs of exposure to rockfalls, Pomeroy and colleagues say.

Microscopic remnants of ancient plants and pollen were found in sediment near Shanidar Z, Pomeroy says. Further work will determine what types of plants were present and whether burrowing rodents brought plants into the cave.

"As with all previous claims for Neandertal intentional burials, there are no smoking guns," says archaeologist Dennis Sandgathe of Simon Fraser University in Burnaby, Canada. Shanidar Z was not arranged in any special way and no obvious offerings were placed with it. But the body being in an intentionally dug depression leaves open the possibility of intentional burial, he says. ■

## BODY &amp; BRAIN

**Travel restrictions barely slowed the new coronavirus' spread**

Travel restrictions imposed as the new coronavirus took China by storm slowed the spread of COVID-19 by only a few days within China and a few weeks internationally, according to a new study.

On January 23, Chinese officials shut down travel in and out of Wuhan, where the outbreak began. But by then the virus had already spread to other Chinese cities. As a result, the travel ban delayed the outbreak's progression within China by only three to five days, researchers report online March 6 in *Science*. The study simulated the travel ban's impact using population data, travel patterns and models of disease transmission.

The ban initially had a larger impact internationally. The simulation suggests there were 77 percent fewer cases imported from mainland China than would be expected absent the ban. But starting in mid-February, the number of international cases rose as other cities in China where the virus had become established began to fuel spread to other countries.

In February, 59 airlines stopped or curtailed flights to and from mainland China. It's hard to pinpoint how much travel was reduced, but the researchers analyzed the potential impact of a 90 percent drop. This scenario could slow the epidemic's progression by only a matter of weeks.

The study suggests that many people exposed to the virus have traveled undetected. Travel restrictions would make a meaningful difference only when combined with robust measures to control infection in the community, such as the quick diagnosis and isolation of new cases, the researchers say.

— *Aimee Cunningham*

## BODY &amp; BRAIN

**Brain waves common during sleep are present in awake sheep**

Here's something neat about sleeping sheep: Their brains have fast zags of neural activity similar to those found in sleeping people. Here's something even neater: These bursts, or spindles, zip inside awake sheep's brains, too. The



Awake sheep have bursts of brain activity called spindles that are seen in sleeping people.

finding raises the possibility that spindles also exist in awake people's brains, researchers report March 2 in *eNeuro*.

Neurobiologist Jenny Morton of the University of Cambridge and colleagues studied six Merino sheep with implanted brain electrodes. As the sheep slept, spindles raced across their brains.

Electrodes also caught spindles during the day, when sheep were awake. These spindles looked different from those seen at night, Morton says, with different densities. Day spindles were also less abundant and more localized in the brain.

The purpose of sleep spindles isn't settled. One idea is that the bursts lock new memories into the sleeping brain.

Spindles may help the brain handle certain kinds of information during the day, not just at night, Morton says.

In humans, changes in spindles have been tied to aging and to diseases including Alzheimer's. Studying spindles in sheep may reveal details about these disorders, the scientists say. — *Laura Sanders*

## HUMANS &amp; SOCIETY

**Ancient South Asians withstood a colossal volcanic eruption**

Stone tools found in central India suggest that ancient people carried on after a massive explosion of Indonesia's Toba volcano about 74,000 years ago, researchers say. While the eruption was Earth's largest in the last 2 million years, scientists have disagreed about its ef-

fects on human populations and climate.

Studying tools from a site called Dhaba, the researchers found that the tool-making style stayed largely unchanged from about 80,000 to 48,000 years ago. Toolmakers were striking sharp-edged flakes from prepared chunks of rock both before and after Toba erupted.

The finding, published February 25 in *Nature Communications*, adds to skepticism about claims that Toba's ashy outburst triggered a planetary chill that nearly wiped out humankind.

Instead, the researchers say, people must have maintained their way of life in the area, despite the likelihood that ash from the volcanic blast temporarily blocked out the sun. Ash layers from the eruption have been unearthed about 700 meters east of Dhaba. — *Bruce Bower*

## ATOM &amp; COSMOS

**Rings may explain puffy planets**

Some puzzling planets called superpuffs could be Saturns in disguise.

These exoplanets appear very large given their masses, suggesting that they have densities like cotton candy (*SN: 12/12/15, p. 4*). "People had been thinking of complicated ways to explain these mysterious planets," such as dust storms leaving a planet, says theoretical astrophysicist Anthony Piro of the Carnegie Observatories in Pasadena, Calif.

But Piro and exoplanet scientist Shreyas Vissapragada of Caltech propose a simpler explanation in the April *Astronomical Journal*: Some superpuffs may sport wide rings that make the planets appear bigger than they really are.

The pair considered 10 superpuffs detected by the Kepler space telescope and ran computer simulations to see if the planets' girths could be due to rings. Because superpuffs sit close to their stars, the rings would need to be entirely rocky, unlike Saturn's icy rings, to avoid melting away. And the proposed rings can't extend too far from a planet, or the rocks' gravity would pull the rings together into moons.

This scenario could fit for seven of the 10 superpuffs examined, the researchers report. — *Lisa Grossman*



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# REPURPOSED REMEDIES FOR CORONAVIRUS

A patient who recovered from COVID-19 is discharged from a Wuhan hospital on February 18.

Research on similar viruses points to drugs that may work against the new disease **By Tina Hesman Saey**

**A**s the new coronavirus makes its way around the world, doctors and researchers are searching for drugs to treat the ill and stop the spread of the disease, which has already killed more than 3,800 people since its introduction in Wuhan, China, in December.

The culprit virus is in the same family as the coronaviruses that caused two other outbreaks, severe acute respiratory syndrome and Middle East respiratory syndrome. But the new coronavirus may be more infectious. In early March, the number of confirmed cases of the new disease, called COVID-19, had exceeded 100,000, far surpassing the more than 10,600 combined total cases of SARS and MERS.

Health officials are mainly relying on quarantines to try to contain the virus' spread. Such low-tech public health measures were effective at stopping SARS in 2004, Anthony Fauci, director of the U.S. National Institute of Allergy and Infectious Diseases, said January 29 in Arlington, Va., at the annual American Society for Microbiology's Biothreats meeting.

But stopping the new virus may require a more aggressive approach. In China alone, about 300 clinical trials are in the works to treat sick patients with standard antiviral therapies, such as interferons, as well as stem cells, traditional Chinese medicines including acupuncture, and blood plasma from people who have already recovered from the virus.

Researchers are not stopping there. They also are working to develop drugs to treat infections and vaccines to prevent them (*SN: 3/14/20, p. 6*). But creating therapies against new diseases often takes years, if not decades. With this new coronavirus, now known as SARS-CoV-2, nobody wants to wait that long. Thanks to their experience developing treatments against the MERS coronavirus, as well as other diseases, such as HIV, hepatitis C, influenza, Ebola and malaria, researchers are moving quickly to see what they can borrow to help patients sooner.

Finding new uses for old drugs is a good strategy, especially when racing to fight a fast-moving disease for which there is no

treatment, says Karla Satchell, a microbiologist and immunologist at Northwestern University Feinberg School of Medicine in Chicago.

“Repurposing drugs is absolutely the best thing that could happen right now,” Satchell says. Potentially, drugs that combat HIV or hepatitis C might be able to put the new coronavirus in check, too. “Those drugs exist. They’ve been produced. They’ve been tested in patients,” she says. Although these drugs aren’t approved to treat the new coronavirus disease, they’re a great place to start. One of the most promising candidates, however, hasn’t yet been approved for any disease.

### Early focus

Scientists have been quick to reveal the new coronavirus’ secrets. When SARS emerged in 2002, researchers took about five months to get a complete picture of the virus’ genetic makeup, or genome. With the new virus, Chinese health officials first reported a cluster of mysterious pneumonia cases in Wuhan to the World Health Organization on December 31. By January 10, the new coronavirus’s full genome was made available to researchers worldwide in public databases.

A virus’s genome is one of the most valuable tools scientists have for understanding where the pathogen came from, how it works and how to fight it. The first thing that coronaviruses have in common is that their genetic material is RNA, a chemical cousin to DNA.

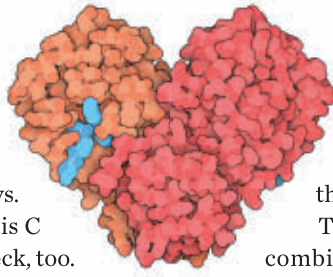
Researchers immediately began comparing the new coronavirus’s genome with SARS and MERS viruses and other RNA viruses to determine whether drugs developed to combat those disease-causing organisms would work against the new threat. As a result, some potential Achilles’ heels of SARS-CoV-2 have already come to light.

One target is the virus’s main protein-cutting enzyme, called M protease. RNA viruses often make one long string of proteins that later get cut into individual proteins to form various parts of the virus. In the new coronavirus, the M protease is one of 16 proteins that are linked like beads on a string, says Stephen Burley, an oncologist and structural biologist at Rutgers University in Piscataway, N.J.

The virus can mature and infect new cells only if M protease can snip the string of proteins free, he says. Stop the protease from cutting and the virus can’t reproduce, or replicate.

Existing drugs might be able to stop the virus’s M protease, two research groups proposed online January 29 at bioRxiv.org. One group suggested four drugs, including one used to treat hepatitis C and two aimed at HIV. A second group named 10 candidates, including an anti-nausea medication, an anti-fungal drug and some cancer-fighting drugs.

HIV and hepatitis C are both RNA viruses that need a protease to cut proteins free from long chains. Drugs that inhibit those proteases can reduce levels of the HIV and hepatitis C viruses to undetectable. Some of those drugs are now being tested against



M protease (model shown) is a key enzyme for the new coronavirus’ survival and may be an Achilles’ heel. Drugs (blue) might be able to nestle into the enzyme and stop viral replication.

the new coronavirus in clinical trials in China.

The HIV drug Kaletra, also called Aluvia, is a combination of two protease inhibitors, lopinavir and ritonavir. Kaletra’s maker, the global pharmaceutical company AbbVie, announced on January 26 that it is donating the drug to be tested in COVID-19 patients in China. Kaletra will be tested alone or in combination with other drugs. For instance, researchers may combine Kaletra with Arbidol, a drug that prevents some viruses from fusing with and infecting human cells. Arbidol may be tested on its own as well.

But the HIV drugs may not work against the new virus because of two differences in the proteases. The coronavirus protease cuts proteins in different spots than the HIV protease does, say Guangdi Li of the Xiangya School of Public Health of Central South University in Changsha, China, and Erik De Clercq, a pioneer in HIV therapy at KU Leuven in Belgium. Secondly, the HIV drugs were designed to fit a pocket in HIV’s protease that doesn’t exist in the new coronavirus’s protease, the researchers reported February 10 in *Nature Reviews Drug Discovery*.

Yet a few anecdotal accounts suggest the HIV drugs may help people with COVID-19 recover. Doctors at Rajavithi Hospital in Bangkok reported in a news briefing February 2 that they had treated a severely ill 70-year-old woman with high doses of a combination of lopinavir and ritonavir and the anti-influenza drug oseltamivir, which is sold as Tamiflu. Within 48 hours of treatment, the woman tested negative for the virus.

Her recovery may be due more to the HIV drugs than to oseltamivir. In 124 patients treated with oseltamivir at Zhongnan Hospital of Wuhan University, “no effective outcomes were observed,” doctors reported on February 7 in *JAMA*. Clinical trials in which these drugs are given to more people in carefully controlled conditions are needed to determine what to make of those isolated reports.

### Viral weak spots

Researchers may be able to exploit a second weakness in the virus: its copying process, specifically the enzymes known as RNA-dependent RNA polymerases that the virus uses to make copies of its RNA. “Those enzymes are absolutely essential,” says Mark Denison, an evolutionary biologist at Vanderbilt University School of Medicine in Nashville. If the enzyme doesn’t work, “you can’t make new virus.”

Denison and colleagues have been testing molecules that muck with the copying machinery of RNA viruses. The molecules mimic the nucleotides that RNA polymerases string together to make viral genomes. Researchers have tested chemically altered versions of two RNA nucleotides — adenosine and cytidine — against a wide variety of RNA viruses in test tubes and in animals. The molecules “get incorporated into the viral RNA and either stop it from growing or they damage

it by introducing mutations,” Denison says.

One of the molecules that researchers are most excited about is an experimental drug called remdesivir. The drug is being tested in people with COVID-19 because it can stop the MERS virus in the lab and in animal studies. The drug has also been used in patients with Ebola, another RNA virus.

Remdesivir has been given to hundreds of people infected with Ebola, without causing serious side effects, but the drug hasn’t been as effective as scientists had hoped, virologist Timothy Sheahan of the University of North Carolina at Chapel Hill said January 29 at the Biothreats meeting. In a clinical trial in Congo, for example, about 53 percent of Ebola patients treated with remdesivir died, researchers reported November 27 in the *New England Journal of Medicine*. That’s better than the 66 percent of infected people killed in the ongoing Ebola outbreak, but other drugs in the trial were more effective.

Several tests of remdesivir in lab animals infected with MERS have researchers still hopeful when it comes to the new coronavirus. In studies in both rhesus macaques and mice, remdesivir protected animals from lung damage whether the drug was given before or after infection. Molecular pathologist Emmie de Wit of NIAID’s Laboratory of Virology in Hamilton, Mont., and colleagues reported the monkey results February 13 in the *Proceedings of the National Academy of Sciences*.

“Remdesivir appears to be one of the most promising antiviral treatments tested in a nonhuman primate model to date,” the team wrote. The results also suggest remdesivir given before infection might help protect health care workers and family members of infected people from getting severe forms of the disease, Sheahan says.

Denison, Sheahan and colleagues tested remdesivir on infected human lung cells in the lab and in mice infected with MERS. Remdesivir was more potent at stopping the MERS virus than HIV drugs and interferon-beta, the researchers reported January 10 in *Nature Communications*.

But the question is still open about whether remdesivir can stop the new coronavirus.

In lab tests, it can. Both remdesivir and the antimalaria drug chloroquine inhibited the new virus’s ability to infect and grow in monkey cells, virologist Manli Wang of the Wuhan Institute of Virology of the Chinese Academy of Sciences and

colleagues reported February 4 in *Cell Research*. Remdesivir also stopped the virus from growing in human cells. Chloroquine can block infections by interfering with the ability of some viruses — including coronaviruses — to enter cells. Wang and colleagues found that the drug could also limit growth of the new coronavirus if given after entry. Chloroquine also may help the immune system fight the virus without the kind of over-reaction that can lead to organ failure, the researchers propose.

In China, remdesivir is already being tested in patients. And NIAID announced February 25 that it had launched a clinical trial of remdesivir at the University of Nebraska Medical Center in Omaha. The first enrolled patient was an American evacuated from the *Diamond Princess* cruise ship in Japan that had been quarantined in February because of a COVID-19 outbreak.

Ultimately, nearly 400 sick people at 50 centers around the world will participate in the NIAID trial, which will compare remdesivir with a placebo. The trial may be stopped or altered to add other drugs depending on results from the first 100 or so patients, says Andre Kalil, an infectious disease physician at the University of Nebraska Medical Center.

Researchers considered many potential therapies, but based on results from the animal and lab studies, “remdesivir seemed to be the one that was more promising,” Kalil says.

In the early patient studies, figuring out when to give remdesivir to patients might not be easy, Sheahan says. Often drugs are tested on the sickest patients. For example, those in the NIAID trial must have pneumonia to participate. By the time someone lands in the intensive care unit with COVID-19, it may be too late for remdesivir to combat the virus, Sheahan says. It may turn out that the drug works best earlier in the disease, before viral replication peaks.

“We don’t know because it hasn’t really been evaluated in people how remdesivir will work, or if it will work at all,” Sheahan cautions.

The drug seems to have helped a 35-year-old man in Snohomish County, Wash., researchers reported January 31 in the *New England Journal of Medicine*. The man had the first confirmed case of COVID-19 in the United States. He developed pneumonia, and doctors treated him with intravenous remdesivir. By the next day, he was feeling better and was taken off supplemental oxygen.

**Repurposed drugs that might treat COVID-19** Several drugs are in testing to target various parts of the new coronavirus.

Name	Designed to treat	Evidence for	Evidence against
Remdesivir	RNA viruses (MERS, Ebola)	Lab tests against the COVID-19 virus; animal tests against MERS; tests in people with Ebola	Not as helpful as other drugs against Ebola
Lopinavir/ritonavir	HIV	HIV and the new virus have a similar enzyme; anecdotal evidence in COVID-19 patients	The enzymes work differently; the new virus doesn’t have the pocket that the HIV drugs fit into to block the enzyme
Chloroquine	Malaria	Lab tests against COVID-19	No data
APN01 (ACE2 protein decoy)	SARS	Tests in animals infected with other viruses; tests in people with lung damage	It didn’t completely protect people with acute respiratory distress syndrome



That's just one case, and the company that makes remdesivir has urged caution. "Remdesivir is not yet licensed or approved anywhere globally and has not been demonstrated to be safe or effective for any use," the drug's maker, biopharmaceutical company Gilead Sciences, headquartered in Foster City, Calif., said in a statement on January 31.

But global health officials are eager to see the drug tested in people. "There's only one drug right now that we think may have real efficacy, and that's remdesivir," WHO's assistant director-general Bruce Aylward said during a news briefing on February 24. But researchers in China are having trouble recruiting patients into remdesivir studies, partly because the number of cases has been waning and partly because too many trials of less-promising candidates are being offered. "We have got to start prioritizing enrollment into those things that may save lives and save them faster," Aylward said.

### Decoy defense

Another strategy for combating COVID-19 involves distracting the virus with decoys. Like the SARS virus, the new virus enters human cells by latching on to a protein called ACE2. The protein studs the surface of cells in the lungs and many other organs. A protein on the surface of the new virus binds to ACE2 10 to 20 times as tightly as the SARS protein does.

Researchers at Vienna-based Apeiron Biologics announced February 26 that they would use human ACE2 protein in a clinical trial against the new coronavirus. When released into the body, the extra ACE2 acts as a decoy, glomming on to the virus, preventing it from getting into cells.

ACE2 isn't just a virus's doorway to infection. Normally, it helps protect the lungs against damage, says Josef Penninger, an immunologist at the University of British Columbia in Vancouver and a cofounder of Apeiron. Penninger and colleagues reported the protein's protective qualities, based on studies with mice, in *Nature* in 2005.

During a viral infection, the protein is drawn away from the cell surface and can't offer protection. Penninger thinks that adding in extra ACE2 may help shield the lungs from damage caused by the virus and by immune system overreactions. The protein is also made in many other organs. Penninger and colleagues are testing whether the new virus can enter other tissues, which might be how the virus leads to multiple organ failures in severely ill people.

The decoy protein drug, called APN01, has already been through Phase I and Phase II clinical testing. "We know it's safe," Penninger says. Now researchers just need to determine whether it works.

### Persistent problem solving

No one knows whether any of these approaches can help stem the spread of COVID-19.

"Right now, we need lots of people working with lots of ideas," Satchell says. Similarities between the viruses that cause SARS and COVID-19 may mean that some drugs could



This man in Wuhan, China, recovered from COVID-19 and is donating plasma for critically ill patients. The plasma contains antibodies that may fight the virus.

work against both. "There is a hope that several small molecules that were identified as inhibitors of the SARS protease would represent reasonable starting points for trying to make a drug for the 2019 coronavirus," Burley says.

"The open question is, can you produce a drug that is both safe and effective quickly enough to have an impact?" SARS was stopped by traditional infection-control measures in 2004, before any virus-fighting drugs made it through the development pipeline.

But had a decision been made then to spend \$1 billion to make a safe and effective drug against SARS, Burley says, such a drug might be working now against the new coronavirus, eliminating the need to spend hundreds of billions of dollars to contain this new infection.

An investment in SARS would not have paid off for people with MERS, which is still a danger in the Middle East. The MERS virus is too different from SARS at the RNA level for SARS drugs to work against it.

But a future coronavirus might emerge that is similar enough to SARS and SARS-CoV-2 to be worth the cost, Burley says. Even if the current outbreak dwindles and disappears, he says, governments and companies should keep investing in drugs that can stop coronaviruses.

"I'm quite certain that the economic impact of the epidemic is going to run into the hundreds of billions," he says. "So you would only need a 1 percent chance of something that was treatable with the drug to show up in the future to have made a good investment." ■

### Explore more

■ World Health Organization. Global research on coronavirus disease (COVID-19). [bit.ly/WHOCOVID-19research](https://bit.ly/WHOCOVID-19research)

# An Obstructed View



## Expanded global internet access may hinder astronomy research **By Christopher Crockett**

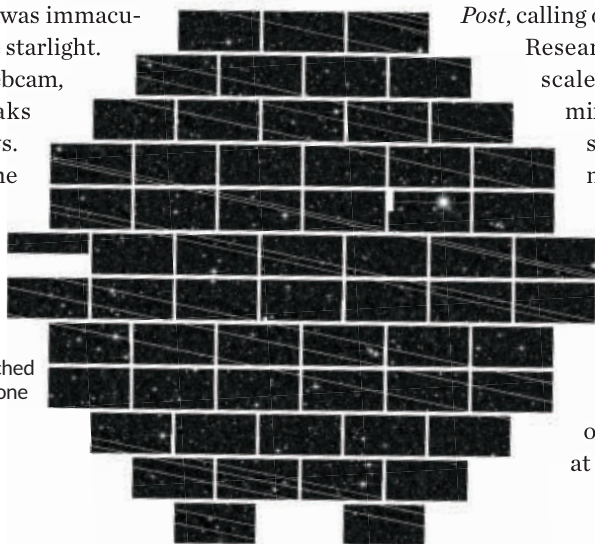
**A**stronomer Cliff Johnson was peering into deep space before dawn when something close to Earth interrupted his view.

He and colleagues were searching for dwarf galaxies snuggled up to the Milky Way using the Victor M. Blanco 4-m Telescope in Chile. The team was remotely operating the scope from a room at Fermilab in Batavia, Ill., about 8,200 kilometers away.

“We had a nice clear night,” says Johnson, of Northwestern University in Evanston, Ill. Through outdoor webcams at the observatory, the team could spy on the scene in the high Chilean desert. The sky was immaculate: inky black with dots of white starlight.

“All of a sudden, through this webcam, we started seeing these streaks popping through,” Johnson says. Dashes of white light shot across the view, like laser fire from a sci-fi

Through a webcam at Chile’s Cerro Tololo Inter-American Observatory, Cliff Johnson, watching from Illinois on November 18, had a view of a clear night sky — until he didn’t (above). Newly launched Starlink satellites left 19 trails of light in one of his telescope images (right), obtained during a five-minute exposure on the Victor M. Blanco telescope.



battle cruiser. The intruders flew right across the telescope’s gaze: In a five-minute exposure with the scope’s camera, 19 white lines defaced the picture. It didn’t take long to realize the culprit.

A week earlier, on November 11, 2019, the aerospace company SpaceX had launched 60 Starlink satellites to join its growing fleet of satellites built for global broadband internet access. That flock of satellites in low Earth orbit had photobombed Johnson’s image.

SpaceX plans to send up more than a thousand satellites in its first round of launches to provide near-continuous internet service to the United States and Canada by the end of 2020 and to all corners of the globe in 2021.

These “mega-constellations” of satellites have triggered alarm bells: “Elon Musk’s satellites threaten to disrupt the night sky for all of us,” warned the *Washington Post*, calling out SpaceX’s celebrity CEO.

Researchers have begun to quantify the scale of the problem, and the news is mixed. Most of the new satellites will stay hidden to unaided eyes for much of the night, and small telescopes won’t often notice much difference. But large telescopes, especially those dedicated to sweeping the entire sky, may run into problems, reports a study posted on arXiv.org on March 4.

Astronomers discussed the issue on January 8 during panel sessions at an American Astronomical Society

meeting in Honolulu. The group is concerned that hunting for asteroids that might impact Earth will be hampered, and flickering satellites could be mistaken for exploding stars.

“The issue of mega-constellations in astronomy is a serious issue,” said Patrick Seitzer, an astrophysicist at the University of Michigan in Ann Arbor who studies orbital debris. Tens of thousands of new internet satellites could blanket Earth in the coming years, many of them brighter than nearly every other artificial object circling the planet. Or as Seitzer put it: “Cheer up, the worst is yet to come.”

### Shockingly bright

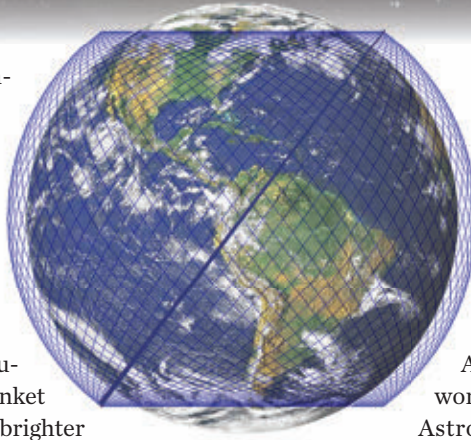
Artificial satellites have been getting in astronomers’ way since the launch of Sputnik 1 in 1957 (*SN: 10/19/57, p. 245*). Today, NASA estimates that roughly 20,000 known human-made objects larger than a softball — satellites, rocket bodies and other flotsam — are orbiting Earth. The number will keep growing, despite concerns about the risk of collisions that could put equipment and astronauts in danger. From observatories in Chile, Seitzer noted, there are about 600 to 700 overhead objects visible at any given time at night.

Sunlight reflected off metal surfaces and solar panels on those satellites can shine into a telescope and either mimic or hide things in deep space. Astronomers so far have been able to deal with that interference by taking multiple images and combining them for a cleaner composite picture. In some cases, image-processing algorithms can also recover data lost to intruding light. That’s getting harder, though, as more satellites are put into space. Plummeting launch costs, largely due to reusable rocket technology, have made low Earth orbit more accessible than ever.

SpaceX, based in Hawthorne, Calif., launched its first 60 Starlink satellites in May 2019. A second batch went up in November and three more batches were sent aloft in the first two months of 2020. Eventually, the company says, it will have an initial fleet of 1,584 Starlinks in orbit, providing near-continuous internet service to most of the world’s populated areas.

“It’s estimated that 3.6 billion people don’t have access to the internet, and the U.N. considers broadband access as a key enabler to economic development,” Patricia Cooper, vice president of satellite government affairs at SpaceX in Washington, D.C., said at the January meeting. “We think space-based internet could be of real use to those goals.”

That internet service will be delivered via pizza box–sized ground devices that relay information back and forth to the satellites. To reduce delays in data transmission, the satellites will fly relatively close to Earth — several dozen times closer than typical communication satellites in geosynchronous orbit, an orbit in sync with Earth’s rotation. That connectivity comes with a cost, astronomers say — the clarity of our night skies.



For its initial Starlink fleet, SpaceX is launching 1,584 satellites into a web of 72 orbits (illustrated) 550 kilometers above Earth. Future expansions could add tens of thousands more at other altitudes.

“There is nothing bad about having internet delivered through these satellite mechanisms,” said Chris Impey, an astronomer at the University of Arizona in Tucson. “But of course, we’re worried about the side effects.”

Astronomers immediately noticed that the Starlink satellites launched in May were shockingly bright, much brighter than similarly sized objects already in orbit. Even SpaceX was surprised, Cooper said. The culprit seems to be surfaces that scatter light diffusely, but the company is still trying to figure out precisely what makes the satellites so dazzling against the sky.

When a batch is launched, the satellites appear to people on the ground as a “string of pearls” tracing the sky. But that effect is temporary. SpaceX launches its satellites into a relatively low orbit so that engineers can run diagnostics for a few weeks before moving the satellites to a higher operational orbit, where they spread out around the globe and appear fainter. Still, that distance may not be enough for the satellites to fully fade into the background.

Even when farther away, Starlink satellites “are brighter than 99 percent of all objects that are now in Earth orbit,” Seitzer said. He has been running computer simulations to quantify how much these satellites might affect astronomical observations. For SpaceX’s initial planned fleet of 1,584 Starlink satellites, Seitzer estimated that up to nine satellites would be visible to telescopes at the Cerro Tololo Inter-American Observatory in Chile for about an hour after twilight and an hour before dawn — and likely for longer during summer nights. In the middle of the night, the satellites vanish in Earth’s shadow.

“Astronomers could handle that” and work around the interference in their observations, Seitzer said — if only that was the total number of new satellites expected to launch. But 1,584 satellites is just the beginning for SpaceX, and other communication companies have their own internet satellites planned.

### Uncertain future

SpaceX has permission from the U.S. Federal Communications Commission to launch and operate 12,000 Starlink satellites. And the company has filed with the International Telecommunication Union in Geneva for permission to broadcast to and from 30,000 more. Meanwhile, several other companies are keen to jump into the internet satellite market. Amazon, for example, has filed with the FCC for permission to operate 3,236 satellites. Communications company OneWeb has initial plans for 650 satellites, though CEO Adrián Steckel

told *Ars Technica* in February that he has long-term hopes for as many as 5,260.

“This could easily grow to 50,000 or more,” Seitzer said. Instead of six to nine Starlink satellites in view at a time, astronomers might need to dodge a couple hundred bright satellites during twilight hours.

But Seitzer’s simulations assume that the satellites will be at SpaceX’s current operational altitude of 550 kilometers. London-based OneWeb, which launched 34 satellites in early February, adding to the six it launched in 2019, is putting its constellation in a 1,200-kilometer orbit, which SpaceX is also considering for later launches. At that height, the satellites might appear fainter from Earth. But that also means more of the orbit can be seen from the ground, leading to larger numbers of satellites visible and for longer into the night.

At the Cerro Tololo observatory, higher-orbit satellites would be visible all night long in the month of December, Seitzer said, when many would not disappear in Earth’s shadow. “I don’t like that equation,” he said. “I’d rather have the damage confined to a small time rather than have it go all night.”

The actual damage to any one scientist’s research depends on what’s being studied. For Cliff Johnson, the Starlinks in his November 18 image doubled the amount of unusable picture elements, or pixels, from about 10 to 20 percent.

“It’s annoying, but it’s not necessarily hurting the science all that much,” he says, referring to his work. Despite their name, the dwarf galaxies he’s searching for appear relatively large through a telescope and so a few satellite streaks won’t obliterate one image. And Johnson’s survey always takes multiple images of any one patch of sky, so there’s a chance to fill in lost pixels. “That’s not the case across the whole astronomical community,” Johnson says.

For astronomer Krzysztof Stanek of Ohio State University in Columbus, hordes of bright satellites in his telescope views could be a disaster. Stanek helps run the All-Sky Automated Survey for Supernovae, a network of 24 telescopes that scan the skies for exploding stars. On January 15, recently launched Starlink satellites flew in low orbit over one of the telescopes Stanek’s team was using, leaving streaks that remained in an image even after data processing that usually smooths over such blemishes.

“We have an image with about 10 trails comparable in brightness to what a distant supernova would be,” Stanek says. While that’s not yet typical, “I am extremely concerned that, once [SpaceX reaches] the projected size of the network, there will be multiple satellite trails crossing any given field of view at all times.”

**Rubin’s dilemma**

Already, scientists working on the Large Synoptic Survey Telescope — recently rechristened the Vera C. Rubin Observatory (*SN Online: 1/10/20*) — are anticipating trouble. Starting in 2022, the Rubin Observatory, also in Chile, will take images every three days of the entire sky for 10 years.

But reflected light from satellites could mess with twilight observations required for searching for Earth-threatening

asteroids that might approach from the direction of the sun, says Tony Tyson, an astrophysicist at the University of California, Davis and chief scientist for the observatory. The arXiv.org study suggests that 30 to 50 percent of exposures taken around the beginning and end of the night will be “ruined.”

The new satellites also could jeopardize a study of how dark matter has evolved over cosmic history. That study depends on sensitive observations of faint galaxies that some satellite trails can mimic.

Recent experiments have shown that Starlinks are just too bright for Rubin’s detectors, Tyson says. Pixels are like little buckets of light that can overflow, leading to image streaks that completely mask light from the cosmos and to “ghost streaks” caused by electrical interference with neighboring pixels, all of which hinders data cleanup.

The observatory’s researchers are working on a three-pronged fix. They are developing new algorithms to recover some lost data in defaced images. The team is also looking into slowing the rate at which information is read from the image detectors, which can reduce electrical interference between pixels at the cost of slowing observations just a bit.

Finally, the group is testing whether it’s possible to sidestep the satellites altogether. The survey will use artificial intelligence to shift the telescope’s gaze from one patch of sky to another, while keeping bright objects like the moon and satellites away from the telescope’s view. However, a fully populated Starlink

**Internet satellite players**  
Several firms have sent up or announced plans to launch satellites into orbit to expand internet access worldwide. The satellite numbers below are estimates based on company data and news reports.

Space X	Up to 42,000
OneWeb	650–5,260
Amazon	3,236
Lynk	Several thousand
Facebook	Thousands
Boeing	1,396–2,956
Telesat	292–512
Russia’s space agency, Roscosmos	640 (internet and other satellites)
China’s Aerospace Science and Technology Corporation	156



Starlink satellites are launched 60 at a time in stacks like the one shown here. The stack sits at the top of a rocket. Once in orbit, the satellites disperse around the planet.

system could give the AI a headache.

“It works like a charm for maybe 1,000 [Starlink] satellites,” Tyson says. “Once you get above 10,000 satellites, it starts failing, and by the time you get to 50,000 satellites, it ends up in a wild goose chase.” The team is working with SpaceX to include Starlink orbit details within the AI itself, though it’s unclear how much that will improve things.

### Cosmic Wild West

SpaceX has said it will fix the brightness problem, and some astronomers are cautiously optimistic about the company’s willingness to engage. One of the 60 satellites launched January 6 was coated with a substance to make the satellite darker than its siblings, and astronomers will be watching to see if that helps. But if the dark coating works and makes the satellite sufficiently faint to optical astronomers, scientists who use infrared telescopes might not be thrilled — a dark satellite absorbs more heat, making it brighter to those telescopes.

Researchers who are less impressed by SpaceX’s response wonder why the company darkened only one satellite in its fleet. “If they were serious about it, they would have stopped launching more satellites,” at least temporarily, Stanek says. “They would conduct a good scientific study of their impact, and then maybe they would start launching again.”

Cooper, the SpaceX representative, confirmed at the January Honolulu meeting that the company will continue launching unmodified satellites — a fourth batch went up January 29 followed by a fifth on February 17. A sixth launch is scheduled for mid-March. The company did not respond to e-mail requests for further comment. OneWeb also did not respond to requests for comment, while an Amazon representative said the company is not granting interviews at this time.

Private companies face little international oversight on their



OneWeb’s satellites (one illustrated, top) are boxy and flanked by two solar panels. SpaceX’s Starlinks (bottom) are flat with a single solar panel that unfolds like an accordion.

activity in space, so there is no guarantee that SpaceX will continue to work on the problem or that other companies will collaborate with researchers on ways to minimize the potential damage.

And that’s the rub: When it comes to rules on private companies, space is the Wild West. Negotiations to establish regulations would require cooperation among many countries, possibly mediated by the United Nations, and that could take many years to work out. The International Astronomical Union said in a Feb. 12 statement that it will regularly brief meetings of the U.N. Committee on the Peaceful Uses of Outer Space to bring “the attention of the world government representatives to the threats posed by any new space initiative on astronomy and science in general.” But the satellite launches are happening now, so astronomers can only hope that private companies are receptive to their concerns.

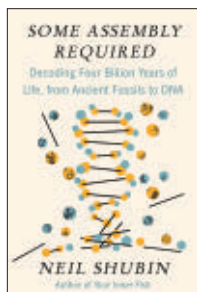
Scientists also realize they have to balance their desire for clear skies with the potential benefits of expanded internet for those without access. At the January meeting, Pamela Gay, an astronomer with the Planetary Science Institute who is based in Edwardsville, Ill., asked speakers at one of the conference panels: “How do we argue to save the skies but not allow low-cost internet to be an option to remote places?”

Panel members agreed that a swarm of low-orbit satellites is the most cost-effective way to establish fast, reliable internet across the globe. But the astronomers also hope companies will think of the night sky as a natural resource to be protected, like a national park, and minimize the disturbance from internet satellites.

“We can have these two things together,” said Ruskin Hartley, executive director of the International Dark-Sky Association in Tucson. “We need to come up with a way that we can help bring the social groups of the world to technology and innovation that protects the heritage of dark skies around the world.” ■

### Explore more

- Olivier R. Hainaut and Andrew P. Williams. “On the impact of satellite constellations on astronomical observations with ESO telescopes in the visible and infrared domains.” arXiv.org. Posted March 4, 2020.



**Some Assembly Required**  
Neil Shubin  
PANTHEON, \$26.95

BOOKSHELF

## Genetics fills in evolution's story

When descendants of ancient fish first hauled themselves onto dry land, they didn't do so with lungs evolved specifically for that reason. The need to breathe air ultimately led to a

change in the function of an organ the fish already had. Likewise, when birds took to the air millions of years later, they did so using feathers that may have originally evolved as insulation or as a way to attract mates.

In *Some Assembly Required*, Neil Shubin, a paleontologist, explores these and other great evolutionary innovations, as well as the invisible genetic changes that made them possible. The book is an impressive chronicle of what genetic research over the last few decades has done to complement the story of evolution, a tale once told through fossils, anatomy and physiology alone.

For instance, studies show that the genes fish need to build swim bladders — the organ that helps control buoyancy — are the same ones lungfish and humans use to build lungs. Such

repurposing, of both genes and anatomical features, is a recurrent theme in the tree of life, Shubin notes.

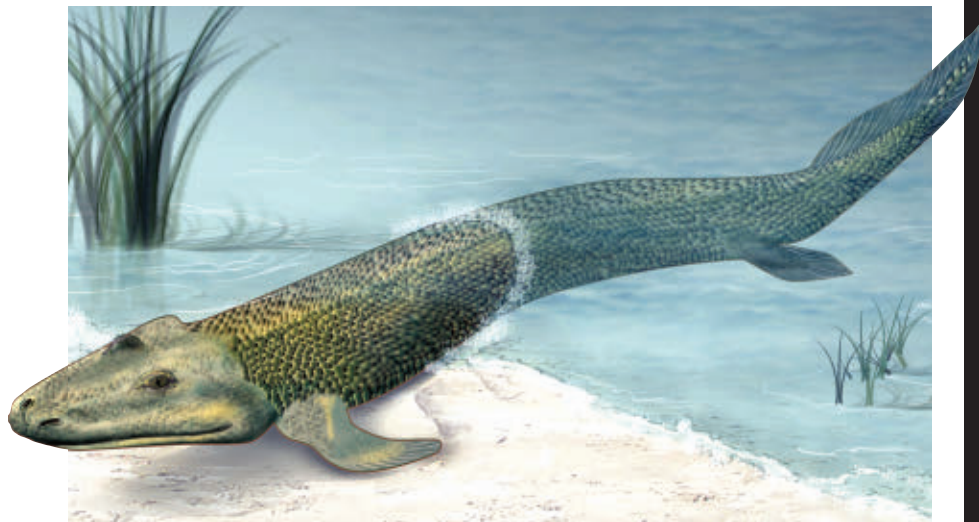
In some cases, genetic mutations trigger the production of new proteins, which can either serve new functions or perform old tasks more efficiently and, in turn, enhance the survival of the organism. In other cases, mutations cause genes to be switched on or off earlier or later in development and at different places in an embryo. These changes can alter the development of skulls, fins, limbs and other anatomical features, and sometimes result in totally new features.

Many of these tweaks may arise when genes duplicate themselves, a process that allows one copy of a gene to retain its original function but frees up the additional copy to change and gain a new purpose. For instance, research suggests that the gene *NOTCH2NL*, which originated via duplication of a more primitive gene and is found in humans but not monkeys, triggers the growth of brain cells when inserted into the DNA of lab mice. The gene probably contributes to humans' big brain, scientists have proposed.

Viral infections have also led to

evolutionary changes in the host, Shubin points out. Syncytin, a protein that plays a vital role in the placenta of mammals, is a viral protein that lost its ability to infect other cells. At some point in the evolution of mammals, the protein was incorporated into its hosts' genetic code and put to work, creating intercellular pathways that enable nutrients and other substances to flow between mothers and embryos.

By taking a historical perspective and recounting the gradual accumulation of knowledge about genes and their effects, Shubin transforms a complicated topic into a smooth and fascinating read. — *Sid Perkins*



Neil Shubin recounts big moments in life's history, including animals' colonization of land. *Tiktaalik roseae*, which lived 375 million years ago, took early steps toward a terrestrial lifestyle.

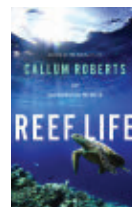
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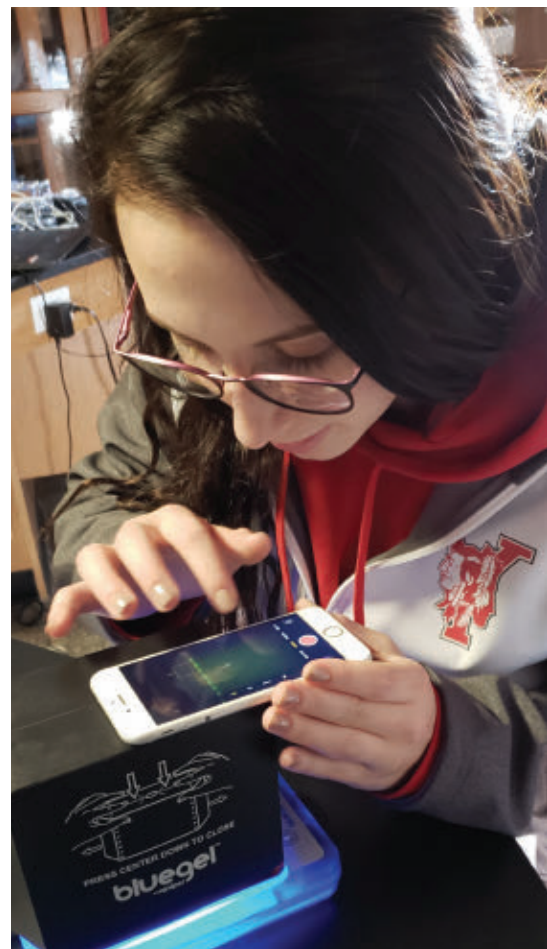
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# Nurturing STEM talent starts with teachers

The Society for Science & the Public is committed to investing in the next generation of young STEM talent, and one way the Society does this is through its STEM Research Grants Program. The program supports educators who are implementing fresh and innovative teaching methods to inspire students to pursue original STEM research projects. The Society recently caught up with 2019 grantee Amy Melby, who has taught science at Yuma High School in Yuma, Colo., for the last 12 years. The \$4,000 STEM Research Grant allowed Amy to purchase new equipment—an autoclave, a chronograph and an iPad. One of her students, Logan Klein (below left), made use of them for his research and went on to compete at the International Science and Engineering Fair this past May.



“ My students are excited that they have the opportunity to do science with quality scientific equipment. I anticipate that my new students will select basic projects at first and that I’ll be able to guide them to develop more advanced projects later. I am excited for when students say, ‘I wish I could do that,’ and now I can say, ‘Yes, you can do that and here’s the equipment you need!’ ”





FEBRUARY 15, 2020

### Coronavirus questions

*Lessons from outbreaks of coronaviruses that cause SARS and MERS may help scientists get a handle on the ongoing outbreak of a novel coronavirus, Tina Hesman Saey reported in "New coronavirus fuels outbreak" (SN: 2/15/20, p. 6).*

Reader **Inge Revuelta** wondered about scientists' calculations of how infectious the new coronavirus is — its  $R_0$ . "I would like to know if this estimated number has any real practicality considering that the community of experts in this field has failed to reach a consensus on its accuracy," **Revuelta** wrote.

The  $R_0$  can vary over time as people in a population become immune to the virus, or as public health measures are put in place, **Saey** says. "The number has practical implications. It helps public health officials anticipate how big an outbreak might be and plan responses. It also indicates whether public health measures are working," she says. Travel restrictions in Wuhan, China, seemed to reduce the virus' spread, decreasing the  $R_0$ , according to a study posted online February 18 at medRxiv.org.

Reader **Diana Lutz** wondered if the new coronavirus could become seasonal like the flu. "Are MERS and SARS seasonal?" she asked.

Like influenza and common cold viruses, the new virus could stick around infecting people if control efforts fail, but it is unknown if the virus will become seasonal (*SN Online: 3/4/20*). Severe acute respiratory syndrome, or SARS, is not seasonal and has not caused an epidemic since the initial outbreak in 2002. Middle East respiratory syndrome, or MERS, does not seem to reliably be seasonal, at least not the way influenza is, **Saey** says. "Camels may carry the MERS virus year-round, but some researchers have detected a peak in infections about six months after the winter calving season," she says. "That's typically when young camels catch MERS and may be more likely to pass it to people later on." More MERS cases in people occur April through July, studies have shown, but people may catch the virus at other times of year.

### Feline fascination

*New research may reduce house cats' allergen levels or make people less reactive to their feline friends, Erika Engelhaupt reported in "How to lick cat allergies" (SN: 2/15/20, p. 16).*

Reader **Mark Friedman** wondered if there was an at-home test available to measure a cat's allergen levels. "How hard could it be to create a chemical card test that could be touched with cat saliva?" **Friedman** asked.

Such a home test kit doesn't appear to exist, **Engelhaupt** says. When she wanted to get her cat's allergen levels tested, the only option she could find was to send hair samples to Indoor Biotechnologies, a company that does consumer testing for a fee.

**Martin Chapman**, founder of Indoor Biotechnologies, says that the company about 15 years ago experimented with a rapid test for the feline protein that triggers allergies in people. But the test, which analyzed dust and could analyze hair and saliva samples, showed negative results at high allergen concentrations. "Not good," **Chapman** says.

A saliva-based test is an interesting idea and could have a market, **Engelhaupt** says, especially as new allergen treatments come out; cat owners may want to monitor their cats' levels.

### Speeding space rock

*Asteroid 2020 AV2 is the first found orbiting closer to the sun than Venus, Christopher Crockett reported in "This rare asteroid keeps close orbit around the sun" (SN: 2/15/20, p. 5).*

Reader **Antonia Musgrave** asked how fast 2020 AV2 travels.

The asteroid has a range of speeds, from roughly 126,000 kilometers per hour to 170,000 km/h, **Crockett** says. That's because its orbit — from just inside Venus' orbit to Mercury's orbit and back — is elliptical. "The asteroid speeds up as it gets closer to Mercury's orbit, and then slows down as it goes out to Venus' orbit," he says. For comparison, Earth orbits the sun at about 108,000 km/h.

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## Killifish can pause the clock on aging

When the ponds in which they live dry up, African turquoise killifish embryos can put their development on hold during a state of suspended activity called diapause (an embryo in this state is shown above). While in this limbo, the embryos effectively don't age, scientists report in the Feb. 21 *Science*.

"Nature has identified ways to pause the clock," says geneticist Anne Brunet of Stanford University. Knowing how killifish press pause could help scientists treat aging-related diseases or learn how to preserve human organs long-term.

The killifish (*Nothobranchius furzeri*) live in ponds that disappear for months during the dry season, leaving the fish without a home (*SN*: 9/29/18, p. 4). For adults that typically live only four to six months, the vanishing ponds aren't much of a threat. But killifish embryos can outlast these dry spells by halting their development. It's unknown

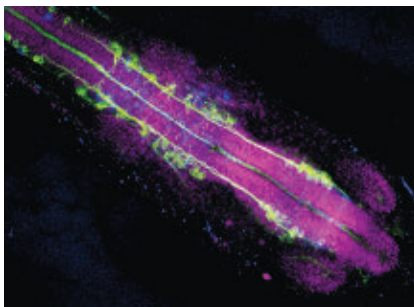
how long diapause can last in the wild, but in a laboratory, embryos can stay in this state from five months to two years.

In the lab, Brunet and colleagues compared killifish that went through diapause with those that didn't. Diapause didn't decrease an adult fish's growth, life span or ability to reproduce — a sign that the animal didn't age while in the state, the team found. Analyses also revealed genes involved in controlling diapause, including the gene *CBX7*, which repressed

genes linked to metabolism but turned on those important for maintaining muscle and staying in diapause.

"We have always looked at diapause as more passive — nothing happens there," says molecular geneticist Christoph Englert of the Leibniz Institute on Aging—Fritz Lipmann Institute in Jena, Germany. But the new genetic insights change that view, he says. — *Erin Garcia de Jesus*

In diapause, killifish put cell proliferation and organ development on hold. Multiple cell types are colored in this close-up of an embryo.



# » GEOLOGIC ROAD TRIP OF THE MONTH

## MOUNT SCOTT

Upon entering the wildlife refuge on OK 49, Mount Scott (elevation 2,464 feet) is visible straight ahead to the northwest. Two miles west of the refuge's east entrance, the road to the top of Mount Scott turns north off OK 49 and ascends more than 1,000 feet to the summit. Shortly after starting the climb, the road passes through what appears to be a river of large boulders of Mount Scott Granite. Some are as large as 10 feet in diameter. Although the boulders appear to have rolled here, they formed in place or very nearly so as the granite weathered along fractures. Two miles from OK 49, the summit road passes through granite that is cut by curved exfoliation fractures. These formed as a result of expansion of minerals by near-surface weathering or the release of confining pressure as the overlying rocks were eroded. Along the entire length of the drive, weathered and fresh granite is exposed on the left, and numerous scenic pullouts are on the right.

Many geologic features of the Wichita Mountains can be seen from the top of Mount Scott. To the southeast, the rounded, grass-covered hills beyond Lake Elmer Thomas are resistant mounds of Carlton Rhyolite. To the east, the flat to gently rolling country east of Lake Lawtonka is Permian-age Hennessey Shale. The Slick Hills, formed mostly of Early Paleozoic carbonates and Cambrian volcanic rocks, are visible to the north beneath the wind turbines. OK 58, described in a separate road guide, passes through the valley due north of Mount Scott. The Meers Fault, last active about



*One of the most spectacular views in Oklahoma is from the top of 2,464-foot-high Mount Scott. South of Lake Elmer Thomas, the rolling hills covered with yellow coreopsis wildflowers are in the Carlton Rhyolite.*

—Photograph by Judy Reynolds

1,250 years ago, passes between the Slick Hills and Mount Scott. Most of the eastern Wichita Mountains are visible to the west.

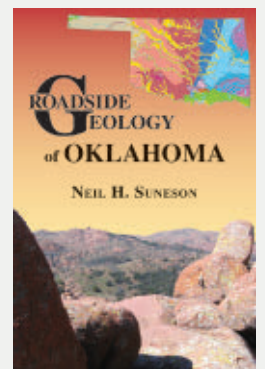
About 3 miles to the west of the top of Mount Scott, the south-dipping treeline on the flanks of Mount Sheridan is visible. The treeline marks the contact between the overlying Mount Scott Granite (bare rocks) and underlying Mount Sheridan Gabbro (vegetated). This contact and associated treeline are also present on the north and east sides of Mount Scott and are visible from OK 58 on the east side of Lake Lawtonka. A similar treeline, albeit slightly less distinct (and not visible from here), marks the contact between the unvegetated Quanah Granite and vegetated Glen Mountains Layered Complex just south of Quanah Parker Lake and at Burford Lake. The high granite knobs between Mount Sheridan and Mount Scott are Mount Scott Granite. Jed Flat, the broad flat area to the southwest, is in Permian-age Post Oak Conglomerate.



*Large slabs of granite that resemble the skin of an onion illustrate a type of weathering known as exfoliation. (34.746445 / -98.534917)*

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# OWN A LEGEND

*The White Buffalo stone is as rare as its namesake, and we've given it an even rarer price.*

To Native Americans, the buffalo was a symbol of sacred life and abundance, inspiring a legend of a white buffalo calf appearing during difficult times to usher in a new age of hope and peace. So sacred is this prophecy, that the Lakota tribe has named a rare and beautiful stone after the white buffalo calf.

To say this stone is as rare as a white buffalo is an understatement. There are a lot of imitations in the market, but don't be fooled. You want the real thing. And, we have it. White Buffalo is found in only one mine worldwide, the Otteson Mine located in Tonopah, Nevada. Which is where we went. The family-owned and operated mine is located near the Yomba Shoshone Tribe of the Yomba Reservation and is roughly 200 miles from Battle Mountain.

We were able to secure these authentic desert gems for a remarkable price. You could easily spend as much as \$900 for a White Buffalo pendant in sterling silver. But, our philosophy is to pass our good fortune on to our customers, which is why you can own a piece of Native American history for under \$100.

The **White Buffalo Collection** celebrates the unique and rare beauty of this legendary stone. Generous cabochons of White Buffalo are set in filigreed sterling silver settings with an antiqued finish that beautifully complements this stone's distinctive white background and black matrix.

**100% Satisfaction Guaranteed.** Experience the bold and captivating beauty of the White Buffalo. If you aren't completely happy, send it back within 30 days for a complete refund of the item price.

**LIMITED RESERVES.** This collection is so much more than beautiful jewelry. Each piece is a Native American artifact steeped in meaning and history. It's time you owned a legend.

• *Authentic White Buffalo • Antiqued-finish .925 sterling silver settings • Ring: whole sizes 5-10*

## White Buffalo Collection

- |                                      |                  |              |                            |
|--------------------------------------|------------------|--------------|----------------------------|
| A. Ring (20 carats)                  | <del>\$395</del> | \$99*        | Save \$296                 |
| B. Pendant (35 carats)               | <del>\$395</del> | \$99*        | Save \$296                 |
| C. 18" Bali Naga Woven Silver Chain  |                  | \$149        |                            |
| D. Earrings (30 ctw)                 | <del>\$395</del> | \$129*       | Save \$266                 |
| <b>Pendant, Chain &amp; Earrings</b> | <del>\$939</del> | <b>\$299</b> | <b>Save \$640 BEST BUY</b> |

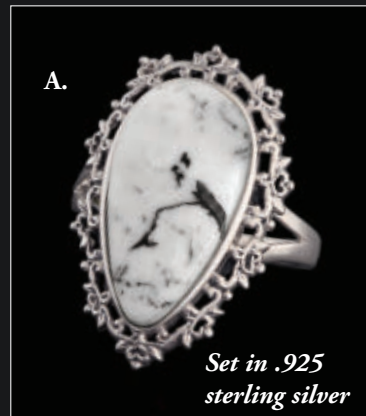
You must use the insider offer code to get our special prices.

## 1-800-333-2045

Your Insider Offer Code: **WBC137-01**

Please use this code when you order to receive your discounts.

\* Special price only for customers using the offer code versus the price on [Stauer.com](http://Stauer.com) without your offer code.



*The rare White Buffalo stone is only found in one place on earth.*



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Rating of A+