

Testing CRISPR in Humans | Radioactive Cloud Mystery

ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ AUGUST 31, 2019

Microbes and Mental Illness

Could strep infections
spark OCD in children?





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ScienceNews



Features

16 Threads of Time

Using tools that were once part of ancient spindles and looms, textile archaeologists are starting to understand how people made fabrics in the past. *By Amber Dance*

22 When Strep Plays Mind Games

COVER STORY A potential link between strep throat and the sudden onset of obsessive-compulsive disorder in children raises questions about how infections can alter the brain. *By Rachel Zamzow*

News

6 CRISPR enters human testing for cancers and blood disorders

7 Dust no longer hides giant, star-forming galaxies of the early universe

8 Scientists search for practical ways to prevent mass shootings

9 Warmer oceans and overfishing boost mercury buildup in fish

10 Legless larvae leap long distances with springlike action

Maya battles raged earlier than thought

11 A magnetic midlife crisis may keep a star from slowing down with age

Meet a new kind of planet: ultrahot Neptune

12 Monkeys can keep track of lists that guide later choices

A new study questions whether the human placenta is home to bacteria

13 Trees watered with acid rain get extra thirsty

14 A radioactive cloud is tied to a possible accident at a Russian nuclear facility

A prehistoric predator raked up its meals from the seafloor



Departments

2 EDITOR'S NOTE

4 NOTEBOOK

Putting size limits on dark matter; cat food may one day help people's allergies

28 REVIEWS & PREVIEWS

How to counteract threats to humans' existence

30 FEEDBACK

32 SCIENCE VISUALIZED

Chandra's 20 years in space marked with new images

SOCIETY UPDATE

Science fair prize rewards young inventors

COVER When obsessive-compulsive disorder comes on suddenly in a child, some researchers wonder if an infection is to blame. *Victor_Tongdee/iStock/Getty Images Plus, adapted by E. Otwell*



You can tell a magazine by looking at its cover

We ask a lot of our magazine cover. It needs to tell readers that this is *Science News*, not some piece of junk mail. It has to clearly convey information on what's inside. And it must be visually alluring, so you just *have* to pick it up and peek inside.

This week's cover, "Microbes and Mental Illness," is one example of how the designers on our visuals team deploy their creative skills to meet that challenge. It highlights a feature story on PANDAS, or pediatric autoimmune neuropsychiatric disorders associated with streptococcal infections (Page 22). It's a rare condition characterized by the sudden onset of obsessive-compulsive disorder in children. Some researchers think it's sparked by a streptococcal infection, which also can cause strep throat, while others say there's not enough evidence to support that link.

When most people see the term "PANDAS," they think of furry black-and-white bamboo eaters. So a cover saying "Here's a story about PANDAS" could be misleading. Images can often convey what a short headline cannot. But in this case, neither bacteria nor OCD is easy to telegraph visually. To solve that problem, design director Erin Otwell chose a green splotchy background that gives the feel of a sea of tiny microbes, then added a silhouette of a child standing alone to convey the uncertainty and isolation that can accompany a mysterious illness. She also made sure that the green was a change of pace from our recent covers, thus making your coffee table more colorful.

This cover also features our *Science News* nameplate. We've sported many nameplates since our founding in 1921, and it's fun to dig into the archives and see how they've morphed through the years (check out the handsome 1928 cover above). After several years with a sleek "SN" monogram, we reclaimed our full name in July. We're proud of who we are and what we do, and no words convey that better than *Science News*. — *Nancy Shute, Editor in Chief*



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Editorial/Letters: feedback@sciencenews.org

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Science News (ISSN 0036-8423) is published 22 times a year with double issues in May, July, October and December by the Society for Science and the Public, 1719 N Street, NW, Washington, DC 20036.

Print, online and tablet access: Activate your subscribing member account, including digital access, at www.sciencenews.org/activate. Subscribing memberships include 22 issues of *Science News* and are available for \$50 for one year (international rate of \$68 includes extra shipping charge). Single copies are \$3.99 (plus \$1.01 shipping and handling). Preferred periodicals postage paid at Washington, D.C., and an additional mailing office.

Postmaster: Send address changes to *Science News*, PO Box 292255, Kettering, OH 45429-0255. Two to six weeks' notice is required. Old and new addresses, including zip codes, must be provided.





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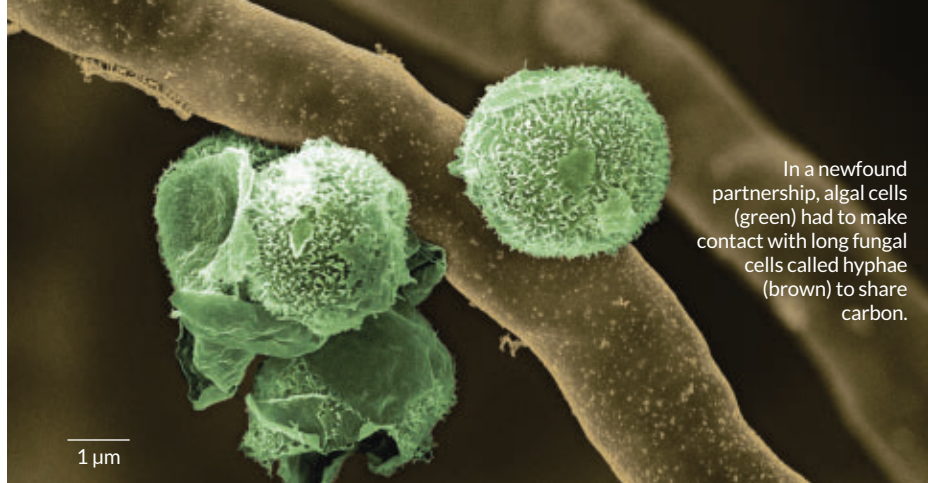
Excerpt from the September 6, 1969 issue of *Science News*

50 YEARS AGO

Scanner solves puzzle

The secret of what enables the agile gecko lizard to stroll upside-down across glass and perform other remarkable sticky-footed feats has been revealed.... Microscopic suction cups provide *Gekko gekko* his phenomenal grip. Using a scanning electron microscope, ... [Joseph F.] Gennaro observed that the chevron-shaped pads on the lizard's toe were composed of an array of brushlike structures [that are] called setae... capped by minute suction cups which help the lizard cling to the surface.

UPDATE: Gennaro was partly correct. Gecko feet don't have suction cups, but the feet have enough tiny setae — hundreds of thousands — to increase adhesion via van der Waals forces, which are very weak forces between molecules. Collectively, the hairs create enough adhesive force for the reptiles to stick even to slick surfaces, scientists discovered in 2000. Gecko feet have inspired new materials and technology, such as a robotic gripper for grabbing space junk (*SN Online*: 6/28/17) and hand pads to help people climb glass panes (*SN Online*: 11/18/14).



In a newfound partnership, algal cells (green) had to make contact with long fungal cells called hyphae (brown) to share carbon.

FIRST

A fungus is caught with algae inside its cells

In a lab dish in Michigan, a soil fungus and a marine alga formed a beautiful friendship. Scientists grew the *Mortierella elongata* fungus with a photosynthetic alga called *Nannochloropsis oceanica*. This odd couple kept each other going when nutrients like nitrogen and carbon were scarce. After about a month, the fungi and algae got even cozier.

Algal cells set up shop within the fungal

cells, making it the first fungus known to harbor algae inside itself, researchers report July 16 in *eLife*. In lichens, another symbiotic pairing of fungi and algae, the algae stay outside the fungal cells.

Scientists found that the fungi passed more than twice as much nitrogen to their algal partners as the algae sent to the fungi. Both exchanged carbon, but the algae had to touch the fungi to make those deliveries.

It's unclear if this mutually beneficial alliance exists in the wild. But both partners are found around the world, and might meet in tidal zones. — *Tina Hesman Saey*

RETHINK

Dark matter particles can't be so big, or they'd kill us

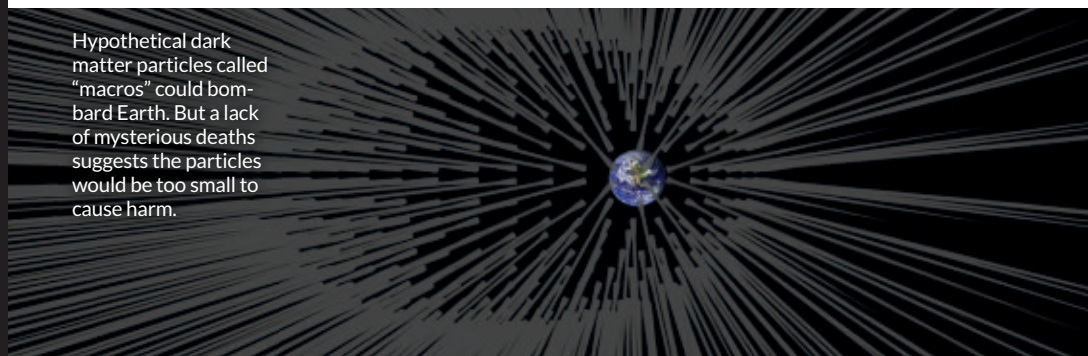
The fact that no one seems to have been killed by speeding blobs of dark matter puts limits on how large and deadly these particles can be, a new study argues.

Physicists think invisible dark matter must exist because of its gravitational effects on visible matter across the cosmos. But no one knows what dark matter is made of. For decades, scientists have hunted for a lead candidate — weakly interacting massive particles, or WIMPs — with no success (*SN*: 6/23/18, p. 13).

So physicists are turning to other possibilities (*SN Online*: 4/9/18). Glenn Starkman of Case Western Reserve University in Cleveland and colleagues have focused on macroscopic dark matter, or macros, first proposed by physicist Edward Witten in the 1980s (*SN Online*: 10/7/13). Witten proposed that macros were made up of subatomic particles called quarks, like ordinary matter is, but combined in a way never before observed.

Theoretically, macros could have almost

Hypothetical dark matter particles called "macros" could bombard Earth. But a lack of mysterious deaths suggests the particles would be too small to cause harm.



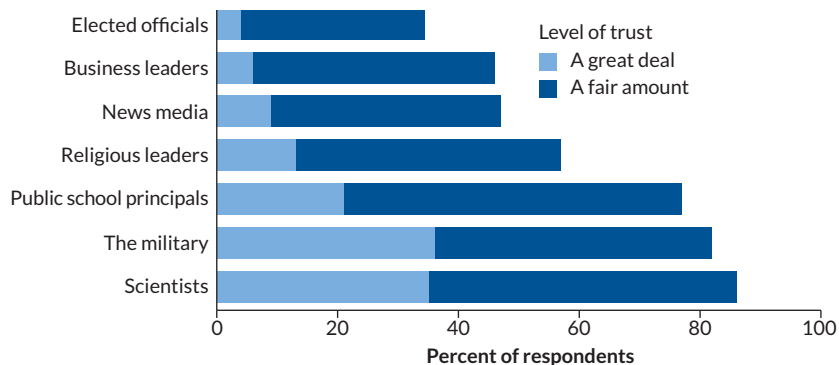
FROM TOP: ZHI-YAN DU, COLORED BY IGOR HOUWAT, JPL-CALTECH/NASA

SCIENCE STATS

Public trust in the goodwill of scientists is rising

For the U.S. public at large, scientists are generally seen as a trustworthy bunch. In fact, 86 percent of adults hold at least “a fair amount” of confidence that scientists work for the public good, according to a survey released August 2 by the nonpartisan Pew Research Center in Washington, D.C. That’s far better than how respondents felt about the motivations of politicians or journalists. And that general trust in scientists’ goodwill is up from 76 percent in 2016. The survey questioned 4,464 adults over January 7–21. — *Katy Daigle*

How much confidence do you have in each to act in the public’s best interest?



SOURCE: PEW RESEARCH CENTER

any size and mass. Because dark matter scarcely interacts with regular matter, these particles would zip around almost unimpeded. So Starkman and physicists Jagjit Singh Sidhu of Case Western and Robert Scherrer of Vanderbilt University in Nashville did a thought experiment using human flesh as a dark matter detector. If a macro as small as a square micrometer zipped through the body at hypersonic speed, the particle would deposit about as much energy as a typical metal bullet, the team calculated. But the damage would be different: A macro would heat the cylinder of tissue in its wake to about 10 million degrees Celsius — vaporizing the tissue and leaving a path of plasma.

“It’s like if you were in *Star Wars*, and a Jedi hit you with their lightsaber, or someone shot you with their phaser,” Starkman says. But there’s no cause for alarm, he says. “If someone had died of this, we would have heard.”

The fact that no one has reportedly suffered a mysterious lightsaber-like wound led Starkman and colleagues to

set limits on how many such particles could be zooming around. And because the amount of dark matter in the universe is finite, then macros — if they exist — must be extremely dense, smaller than a few micrometers and heavier than 50 kilograms, the team reports July 18 at arXiv.org. “The odds of dying from this are less than 1 in 100 million,” Starkman says.

As wacky as this may sound, physicist Katherine Freese says the calculations were worth doing. “Looking for macros in already existing detectors, such as the human body, is a good idea,” says Freese, of the University of Michigan in Ann Arbor. Though she wasn’t involved in the macro research, she and colleagues did a similar thought experiment with WIMPs in 2012. “But weak interactions are so weak as to be harmless,” she says.

Starkman and Sidhu plan to look for smaller macro tracks in granite slabs in a cemetery near Case Western. Those tracks would appear as cylinders of black obsidian running straight through the rock. — *Lisa Grossman*

TEASER

Cat food may one day help allergy sufferers

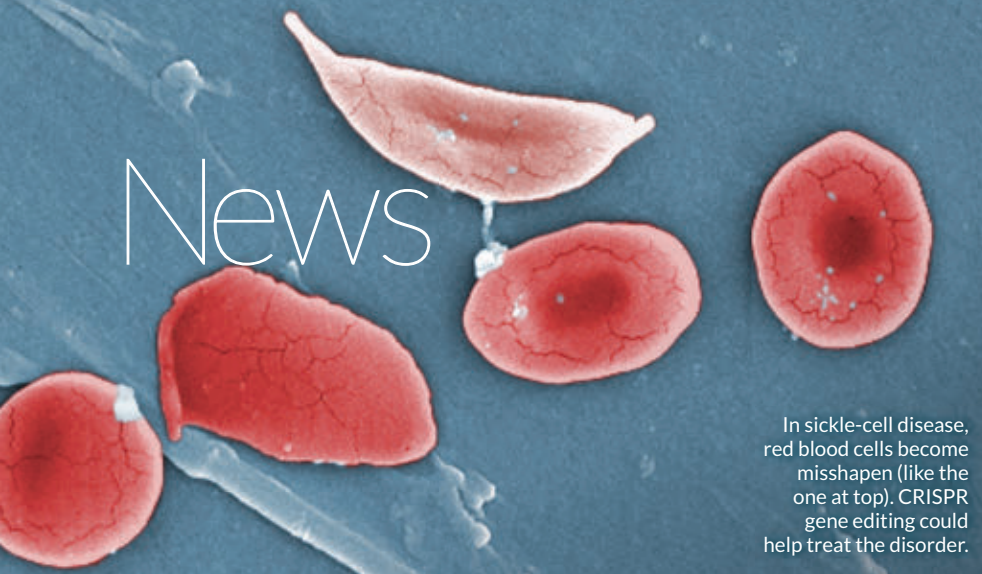
People who sneeze and snuffle near cats might one day find partial relief in a can of cat food. Industry research suggests that feeding cats an antibody to the main allergy-causing protein renders some of the protein, Fel d1, unrecognizable to the human immune system.

After 105 cats were fed the antibody for 10 weeks, Fel d1 amounts on the cats’ hair dropped by an average 47 percent, researchers from pet food-maker Nestlé Purina report in the June *Immunity, Inflammation and Disease*. In a pilot study, 11 allergy-sufferers had reduced nasal symptoms and less-itchy eyes when exposed to hair from cats on the antibody diet versus from cats on a standard diet. Those results were presented in Lisbon, Portugal, in June at the European Academy of Allergy and Clinical Immunology Congress.

Cats produce Fel d1 in their salivary and sebaceous glands, and transfer it to their fur when they groom. Cats also excrete the protein in their urine. Up to 20 percent of people suffer cat allergies. Oral antibodies for cat allergies don’t work in humans, so this unusual approach is interesting, says allergist and immunologist Michael Blaiss at the Medical College of Georgia in Augusta. Products with the antibody are not yet for sale. — *Erika Engelhaupt*



Most cat allergies are triggered by the Fel d1 protein, carried in cat saliva. Industry research aims to disable the protein at its source.



In sickle-cell disease, red blood cells become misshapen (like the one at top). CRISPR gene editing could help treat the disorder.

GENES & CELLS

CRISPR enters human clinical trials

The gene editor targets cancer, blood disorders and blindness

BY TINA HESMAN SAEY

Since its debut in 2012, CRISPR gene editing has held the promise of curing most of the over 6,000 known genetic diseases. Now it's being put to the test.

In the first spate of clinical trials, scientists are using CRISPR/Cas9 to combat cancer and blood disorders in people. In these tests, researchers remove some of a person's cells, edit the DNA and then inject the cells back in, now hope-fully armed to fight disease.

Researchers are also set to see how CRISPR/Cas9 works inside the body. In an upcoming trial, people with an inher-ited blindness will have the molecular scissors injected into their eyes.

Those tests, if successful, could spur trials for Duchenne muscular dystrophy, cystic fibrosis and other diseases affecting millions of people.

"CRISPR is so intriguing," says Laurie Zoloth, a bioethicist at the University of Chicago Divinity School, "and so elegant."

But questions remain about whether CRISPR can live up to the hype. Other previously promising technologies have fallen short. For instance, conventional gene therapies, which insert healthy copies of genes to replace or counteract disease-causing versions, have suffered severe setbacks, says Ronald Conlon, a geneticist at Case Western Reserve University in Cleveland. A gene therapy for blindness worked only temporar-

ily, and some kids who had therapy for immune defects developed cancers (*SN: 1/1/11, p. 24*). Most devastatingly, partici-pants have died in gene therapy trials.

CRISPR's reputation was tarnished last year after a researcher in China edited embryos that went on to develop into two baby girls (*SN: 12/22/18 & 1/5/19, p. 20*). The current CRISPR trials don't have the same ethical challenges — the therapies are being tested in adults and children, and won't lead to changes that can be inherited, says Alan Regenberg, a bioethi-cist at Johns Hopkins Berman Institute of Bioethics. Still, he says, there's reason for caution when working with humans.

Zeroing in

CRISPR/Cas9 is a re-engineered virus-hunter, originally developed by bacteria (*SN: 4/15/17, p. 22*). In 2012 and 2013, scientists described how the system could be tweaked to cut DNA in precise locations, and then demonstrated how to deploy it in human and animal cells. A piece of RNA — a single-stranded genetic molecule similar to DNA — is the CRISPR part and guides an enzyme called Cas9 to particular spots in the genome. The enzyme slices through both strands of the DNA double helix. Cuts can disable genes, snip out troublesome DNA or even repair a problem.

But CRISPR sometimes goes to the wrong spot, resulting in unwanted edits,

or "off-target effects" (*SN: 9/3/16, p. 22*). Even with intended cuts, unwanted errors can arise. "We don't always fully understand the changes we're making," Regenberg says. "Even if we do make the changes we want to make, there's still question about whether it will do what we want and not do things we don't want."

Still, CRISPR is more precise than con-ventional gene therapy and therefore may have the power to treat some diseases for which gene therapy hasn't worked well, says Conlon, who discussed challenges to gene editing for cystic fibrosis in the June *Genes & Diseases*. But another big hurdle, he says, is getting CRISPR into the cells where it is needed.

Dishing up data

Delivery is less of a problem for the gene-editing therapies in trials to treat cancer and blood disorders, Conlon says. Blood-forming stem cells are taken out of people, and the cells are edited in lab dishes, where problems can be checked.

University of Pennsylvania researchers have given two people with recurring can-cers a CRISPR/Cas9 therapy, a university spokesperson said. One person has multi-ple myeloma; the other, sarcoma. As part of an ongoing trial, both received T cells, a type of immune cell, programmed with CRISPR to go after cancer cells. Similar trials are under way in China.

Trials are also under way for two blood disorders: sickle-cell disease and beta-thalassemia. Both result from defects in the gene for hemoglobin, the oxygen-carrying protein in red blood cells. The therapy is designed to mimic a fix that nature has already devised, says David Altshuler, Vertex Pharmaceuticals' chief scientist. A form of hemoglobin that helps fetuses grab more oxygen from the mother's blood isn't produced after birth. But some people have a harmless genetic variant that causes fetal hemoglobin to be produced throughout life. "People like that who also inherited a sickle-cell mutation or a beta-thalassemia mutation weren't sick," Altshuler says.

The fetal hemoglobin compensates for the disease-causing defect, some-thing Vertex, a cystic fibrosis drugmaker

headquartered in Boston and London, hopes to use to sickle-cell sufferers' advantage. Vertex and CRISPR Therapeutics, a company in Cambridge, Mass., are testing whether CRISPR/Cas9 cuts can mimic the genetic variant that keeps fetal hemoglobin turned on for life and ease symptoms in people with the blood disorders. Scientists check for off-target cuts and mutations at the desired cutting site before giving cells to participants via a bone marrow transplant, Altshuler says.

The companies announced in February that they had treated one person for beta-thalassemia. Another person has undergone the same type of therapy for sickle cell disease, researchers said in July. The companies have not yet announced results from these trials.

Into the eye

Still, many genetic diseases affect the whole body or organs that can't be removed and edited in a lab. No one

knows whether CRISPR can work well in the human body. But a clinical trial using the gene editor to treat Leber congenital amaurosis 10, an inherited type of blindness, may help answer the question. The disorder is caused by a mutation in the *CEP290* gene that leads to a nonfunctional protein. When the protein doesn't work, rod cells in the outer retina die and light-gathering photoreceptors can't renew themselves, resulting in blindness.

There is a gene therapy, approved in 2017 by the U.S. Food and Drug Administration, for a type of Leber congenital amaurosis caused by a mutation in the *RPE65* gene. But *CEP290* is too big to put into a virus to do conventional gene therapy, says Charles Albright, chief scientist of Editas Medicine in Cambridge.

In July, Editas and global pharmaceutical company Allergan opened recruitment for a blindness gene-editing trial. In the trial, two guide RNAs will lead Cas9 to make two cuts that will snip out

the troublesome piece of DNA.

The first people to get the experimental therapy will be adults who are nearly blind, he says. Small amounts of the CRISPR editor will be injected under the retina to test for safety. It's uncertain whether the low doses will improve vision. If the doses prove safe, later volunteers will get higher doses. Scientists may also test the therapy in children.

Editing as few as 10 percent of retinal cells may help restore some sight, Albright says. In animal tests, CRISPR edited up to about 60 percent of cells in mice and almost 28 percent in monkeys, scientists reported in the February *Nature Medicine*.

When it comes to gene editing, researchers are banking on happy endings, Zoloth says. "Everyone who thinks seriously about human suffering should really be wanting this to happen and should be optimistic... about medicine's capacity and its power." ■

ATOM & COSMOS

Giants of the early universe found

Astronomers locate massive, active galaxies hidden by dust

BY MARIA TEMMING

Astronomers may have finally laid eyes on a population of enormous but elusive galaxies in the early universe.

These hefty, star-forming galaxies are shrouded in dust, which hid them from previous searches using starlight. Now observations of radiation emitted by that dust have revealed dozens of giant, active galaxies from when the universe was younger than 2 billion years, researchers report online August 7 in *Nature*. The galaxies may be the precursors to heavyweight galaxies seen later in the universe's 13.8-billion-year history.

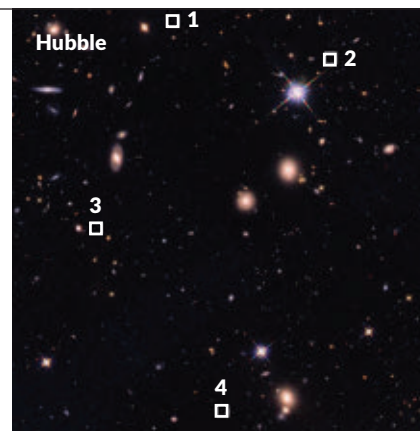
Big, inactive galaxies have been found dating to about a couple billion years after the Big Bang. But the formation of those gentle giants has been a mystery. Astronomers expect that such massive,

inactive galaxies would originate from big, star-forming powerhouses, but surveys hadn't uncovered a population of such star-forming progenitor galaxies.

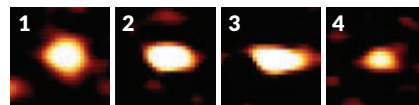
Using the Atacama Large Millimeter/submillimeter Array, or ALMA, in Chile, astronomers identified 39 star-forming galaxies from when the universe was about 1 billion to 2 billion years old. These galaxies, which boast an average mass of about 40 billion suns and each form about 200 new suns per year, are about as common as the large, inactive galaxies seen slightly later in cosmic history.

"This is definitely a plausible population that could give rise to the quiescent galaxies," says Karl Glazebrook, an astronomer at Swinburne University of Technology in Melbourne, Australia.

The newfound galaxies are embedded in that era's most massive dark matter halos, blobs of invisible, unidentified particles that surround galaxies. The finding suggests that those galaxies are the ancestors of today's biggest galaxies, which now sit in the most massive dark matter halos, says study coauthor and astronomer Tao Wang of the University of Tokyo.



ALMA



Dust obscures massive, star-forming galaxies of the early universe from telescopes like Hubble (top). But ALMA peered at radiation emitted by that dust to find such galaxies (bottom).

Caitlin Casey, an astronomer at the University of Texas at Austin, cautions that the analysis gives only rough age estimates for the uncovered galaxies. Further investigations with ALMA or the upcoming James Webb Space Telescope could help cinch the galaxies' precise ages. ■

HUMANS & SOCIETY

How to study mass shootings

Scientists grapple with the best way to tackle the problem

BY BRUCE BOWER

Two decades ago, two students opened fire at Colorado's Columbine High School, killing 12 of their classmates and a teacher before turning the guns on themselves. In the aftermath, psychologist James Garbarino of Loyola University Chicago interviewed one of the shooters' parents and brother to try to understand why a troubled young man would carry out such carnage.

But Garbarino came up empty. "It's very hard to see how any one thing led to the Columbine event," he says. In fact, 20 years after that shocking tragedy, there is still no established science to predict who might become a mass shooter (*SN: 4/14/18, p. 14*). And the attacks keep happening. So far in 2019 alone, the United States has witnessed nearly two dozen mass shootings, including especially deadly back-to-back attacks in El Paso, Texas, on August 3 and in Dayton, Ohio, on August 4 that left 32 people dead, including the Ohio gunman.

The most recent killings have renewed widespread speculation about why certain young males, for the most part, decide to spray bullets across crowded spaces.

But some scientists are also now thinking more broadly about the issue. Some say testing a range of public policy approaches to see which ones best prevent mass public shootings, rather than exploring motives for homicidal rampages, offers the most potential. A preventive research program on public shootings would search for practical policy prescriptions aimed at heading off imminent attacks.

Researchers need to focus on identifying

Researchers need to focus on identifying ways to stop mass shootings before they happen.

ing ways to stop mass shootings before they happen, says Philip Cook, an economist and sociologist at Duke University. Mass shooters often communicate threats to others in person or online shortly before acting, researchers have found. So, studies of how best to respond

to such threats on social media or in daily life could help to refine proposed "red flag" laws aimed at taking guns from those deemed dangerous, Cook says.

Studies also could explore ways of limiting the tendency of mass shootings to occur in clusters, Cook says,

noting that researchers similarly have tracked media coverage of suicides and come up with recommendations to prevent copycat suicides.

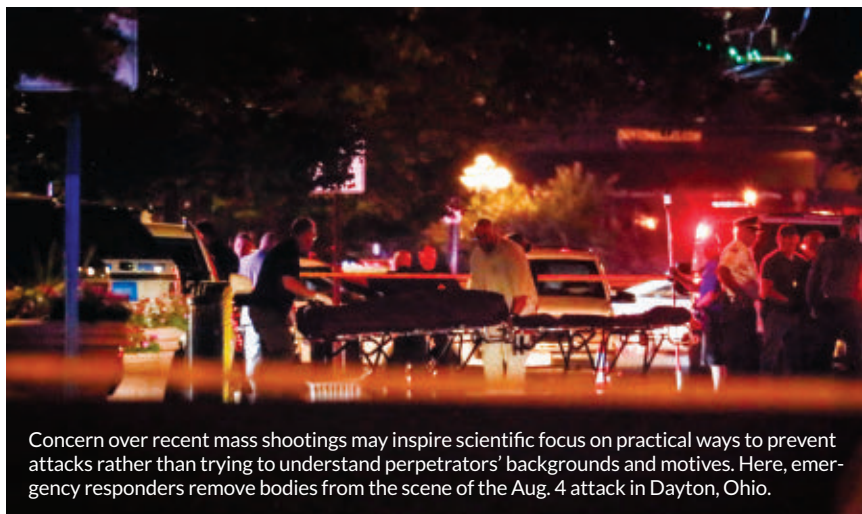
"Other lines of inquiry that do not focus on the individual may also be useful," says Cook, who has studied crime and its prevention since the 1970s. Such research includes tracking links between shootings and vicious political rhetoric, charting trends in hateful and violent online communication, and examining population-wide links between gun violence and the availability of high-capacity magazines.

On an individual level, mass shooters do appear to share certain traits. Psychologist Jillian Peterson and sociologist James Densley, both affiliated with the think tank The Violence Project in

St. Paul, Minn., conducted an analysis of more than 150 mass shootings — defined as involving the indiscriminate killing of at least four people in public — in the United States from 1966 to 2018. The duo found four commonalities among many perpetrators: childhood violence or trauma, linked to later mental ailments such as depression and anxiety; a work crisis or other grievance shortly before the shooting, accompanied by abrupt behavior changes; modeling an attack on what previous shooters had done; and ready access to public sites and guns, often obtained from family members.

Still, those factors aren't enough to predict a mass shooting. Most people with histories of childhood trauma, depression and anxiety, personal grievances and gun access don't commit crimes, much less mass public shootings. "Even though the problem of mass shootings is enormous, the number of people who commit such acts is so small — a fraction of the population — that untangling a developmental pathway is likely beyond our reach at this time," says clinical psychologist Theodore Beauchaine of Ohio State University in Columbus.

For now, he says, researchers asked to explain why mass shootings happen need to keep one word in mind: humility. "We know a lot about violent behavior in general," he says, "but not about mass shootings." ■



Concern over recent mass shootings may inspire scientific focus on practical ways to prevent attacks rather than trying to understand perpetrators' backgrounds and motives. Here, emergency responders remove bodies from the scene of the Aug. 4 attack in Dayton, Ohio.

Overfishing can boost mercury in fish

Climate change also contributes to the metal's buildup in seafood

BY CAROLYN GRAMLING

Climate change and overfishing may hamper efforts to reduce toxic mercury accumulations in the fish and shellfish that end up on our plates. New research suggests that warmer ocean waters and fishing's effects on ecosystems alter how much mercury builds up in seafood.

Fishing practices may have increased methylmercury levels in the tissue of Atlantic cod caught in the Gulf of Maine by as much as 23 percent over a roughly 30-year period, researchers estimate. That's despite decreases in atmospheric mercury levels over the same time period, from the 1970s to the 2000s. The finding is based on simulations of mercury emissions and ecosystem changes related to fishing. The work reveals how changes in the diet of cod, driven by the rebound of once-overfished herring, play an important role in determining how much mercury accumulates in the fish, the team reports online August 7 in *Nature*.

The scientists also simulated the effects of warming seawater on mercury bioaccumulation, incorporating changing emissions and temperatures as well as mercury accumulations measured in Gulf of Maine Atlantic bluefin tuna since 1969. Those simulations suggest that warming seawater could be responsible for as

much as a 56 percent increase in methylmercury concentrations in the tuna.

"This is really the first investigation to look at migratory marine fish and the potential impacts of temperature and overfishing" at the same time, says study coauthor Elsie Sunderland, an environmental chemist at Harvard University. Scientists have long assumed that when it comes to mercury piling up in seafood, the only factor that matters is how much is being sent into the sky, she says.

Mercury emissions come from human activities such as burning coal and natural sources like volcanoes. When that inorganic mercury rains back onto Earth, microbes convert it into organic methylmercury, which clings to organic matter. When creatures eat that matter, the metal gets stored in fatty tissues. As animals higher on the food chain eat mercury-laden dinners, more and more of the metal accumulates in the predators.

That accumulation can be deadly: Methylmercury poisoning can cause cognitive damage, kidney failure and death.

The good news is that emissions are no longer on the rise. From 1990 to 2010, mercury emissions from human activities decreased from 2,890 megagrams per year to 2,280 Mg/yr. And emissions continue to decline.

But, surprisingly, that decline hasn't led to a straightforward decrease in the mercury measured in fish. Some fish in the Gulf of Maine, such as the cod, showed increases in mercury in their tissues over time, the team found. Others, including spiny dogfish, showed decreases.

Sunderland, along with biogeochemist Amina Schartup of the Scripps Institution of Oceanography in La Jolla, Calif., and colleagues, zoomed in on the Gulf of Maine, where water temperatures are among the fastest-rising in the world.

The team looked at methylmercury levels in seawater, sediments and species in the ecosystem. The team also compared these data with changes in the diets

of Atlantic cod and spiny dogfish, based on records of the stomach contents of the two species from the 1970s and 2000s.

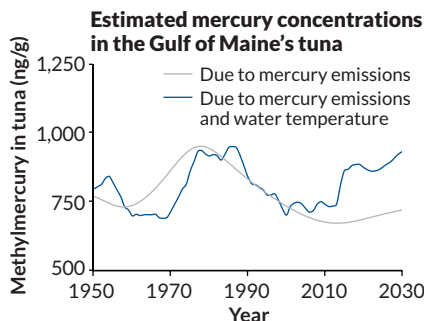
Mercury differences between the two fishes relate to diet changes resulting from humans' fishing habits, the researchers' simulations suggest. Cod and dogfish both prefer to eat herring, but in the 1970s, herring populations collapsed due to overfishing. Cod turned to smaller herring, which have lower mercury levels; dogfish turned to mercury-laden squid. But then herring populations rebounded after the 1970s. Dogfish went back to herring and ate fewer squid, and the fish's mercury increases slowed. Cod, however, saw a dramatic increase in mercury accumulation as the fish ate larger herring again.

Seawater temperatures in the Gulf of Maine also appear to alter mercury accumulation. Using calculations of energy expenditure, growth and prey consumption for Atlantic bluefin tuna, the researchers estimated how much warming waters increase fish activity. More active fish consume more food and accumulate more mercury, which could explain higher than expected mercury levels measured in the fish given declining emissions, the scientists suggest.

William Cheung, a marine ecologist at the University of British Columbia in Vancouver, says the next step is to link these findings to public health and to make projections for future seafood safety. "Historically, we've only looked at these problems individually: climate change, overfishing, contamination," he says. "We may be underestimating the level of risk and impacts."

Efforts to project those risks are made trickier by some uncertainty in future mercury emissions. In December 2018, the U.S. Environmental Protection Agency proposed weakening mercury regulations, suggesting that they are no longer "appropriate or necessary."

Yet those regulations "are a tremendous environmental success story," Sunderland says. Rolling regulations back could undo a lot of the good that they have done, she says. "The situation would be much worse without them." ■



Toxic fish Based on mercury emissions alone, mercury levels in Atlantic bluefin tuna should have dropped since the 1970s (gray line), simulations suggest. But when water temperatures are taken into account, estimated tuna mercury levels show an increase since 2000 (blue), when temperatures started to rise.

LIFE & EVOLUTION

Built-in latch lets legless larvae leap

High-speed film reveals details of a gall midge's acrobatics

BY SUSAN MILIUS

No legs? No problem. Some insect larvae can jump as far as 36 times their body length. High-speed video reveals how.

First, an *Asphondylia* gall midge larva fastens its body into a fat, lopsided O by meshing together front and rear patches of microscopic fuzz. The rear part of the larva swells and starts to straighten like a long, overinflating balloon. The fuzzy surfaces then pop apart. Like a suddenly

released spring, the larva flips up and away in an arc of somersaults, researchers report online August 8 in the *Journal of Experimental Biology*.

Jumping may not be typical in the wild, says evolutionary ecologist Michael Wise of Roanoke College in Salem, Va. Midges grow from egg to adult inside a growth, or gall, that they trick silverrod plants into forming. As Wise was trying to coax out some immature larvae, he realized that the young, no bigger than rice grains, could not only vault out of a lab dish but also travel a fair distance across the floor.

He contacted evolutionary biomechanist Sheila Patek of Duke University. Her lab specializes in resolving never-before-seen subtleties of animal motion, typically using high-speed video.

Filmed jumps were too great to be explained by a larva's muscles, Wise, Patek and colleagues concluded. Blobby larvae were flipping themselves around

with power equal to or greater than the oomph of high-power vertebrate flight muscles.

For small animals with constraints on muscles, "it actually works better to put energy into a spring," Patek says. Creatures can load energy into the spring gradually until whatever is latching the spring slips off. Then the suddenly freed spring powers extreme motion.

Microscope images revealed hairlike structures on the larval surfaces that could touch, suggesting that the projections might stick together as a latch. Such structures might inspire innovations in adhesives, the researchers say.

Larvae aren't the only organisms using latches for fast moves, says Simon Poppinga of the University of Freiburg's Botanic Garden in Germany, who studies plant biomechanics. He and colleagues recently showed that Chinese witch hazel trees build up forces in the fruit that suddenly shoot out a seed rotating a bit like a bullet from a rifle. Unlike gall midge launches, these tree latches break when they let go. So the seed's leap is fast and dramatic, but not repeatable. ■



To spring upward, a gall midge larva latches itself into a loop and swells its rear until the latch pops open and the larva lifts off.

HUMANS & SOCIETY

Maya warfare flared up early

Major conflicts erupted long before the civilization's demise

BY BRUCE BOWER

In 697, flames engulfed the Maya city of Witzna. Attackers from a nearby kingdom in what's now Guatemala set fires that scorched stone buildings and destroyed wooden structures. Many residents fled the scene and never returned.

This surprisingly early instance of Maya warfare has come to light thanks to sediment core data, site excavations and hieroglyphic translations, geologist David Wahl of the U.S. Geological Survey in Menlo Park, Calif., and colleagues report August 5 in *Nature Human Behavior*.

The Maya Classic period ran from about 250 to 950. Many investigators

have assumed that intense military conflicts occurred between 800 and 950, contributing to the demise of the Classic Maya. And that before 800, conflicts were small-scale raids aimed at taking high-status captives for ransom or sacrifice.

Wahl's group first noted that hieroglyphics on a stone slab at the Classic Maya city of Naranjo state that the city's forces attacked and burned Witzna for a second time on May 21, 697. The inscriptions give no details about a first attack.

The conflagration was big enough to leave a mark on the landscape. A lake sediment core extracted about two kilometers from Witzna's ceremonial center has an unusually thick layer of burned wood radiocarbon dated to between 690 and 700, the researchers say. That layer marks the largest fire documented in the core, which spans the last 1,700 years. Signs of reduced human activity, including low erosion rates, appear in layers post-dating the fire. Excavations revealed signs

of fire damage to many Witzna structures, including the royal palace, that occurred between about 650 and 800.

The findings "link a significant burning event at Witzna to abandonment of the site a century or more earlier than has been reported elsewhere in the Maya lowlands," says anthropological archaeologist Andrew Scherer of Brown University. By linking the burning and abandonment to the timing of an attack, Wahl's team argues against the possibility that an escalation of slash-and-burn farming caused the fire, Scherer contends.

Still, the extent of Classic Maya warfare is poorly understood, says archaeologist Elizabeth Graham of University College London. Rules of war seemed to change after the attack. After about 800, hand-held spears gave way to projectile devices that enabled longer, more powerful spear throwing, Graham has found. Before 800, the Maya may have thought it dishonorable to kill from a distance, she suspects. ■

ATOM & COSMOS

Old star spins more like a youngster

Rotation speed may not be a reliable clue to stellar age

BY LISA GROSSMAN

Stars may keep some of their youthful vigor as they age.

Astronomers have spotted a star in its twilight years that spins much faster than expected. The discovery supports a new idea that, rather than continually slowing with age, some stars have a magnetic midlife crisis that keeps them on a roll, astronomer Travis Metcalfe of the Space Science Institute in Boulder, Colo., reported July 30 at the TESS Science Conference.

“This process of slowing rotation ... that we assumed happened indefinitely over the lifetime of a star may be interrupted in the middle of a star’s life,” he said.

Metcalfe studied 94 Aquarii Aa, a star in a triple-star system about 69 light-years from Earth in the constellation Aquarius. The star’s color and brightness suggest that the star is in the subgiant stage of its life cycle, which happens near the end of a sunlike star’s life as it starts running out of fuel.

But pinpointing a star’s age is difficult. Theories of stellar evolution predict that young stars rotate quickly but slow down as they age and lose angular momentum, a process called spinning down. Scientists often use that spin rate to estimate a star’s age. Recently, though, data have emerged that raise questions about whether that aging scenario is correct.

NASA’s Kepler space telescope, which watched stars for signs of orbiting planets from 2009 to 2018, tracked how oscillations, or “starquakes,” ripple through a star’s interior, a method called asteroseismology. Ripple speeds are closely linked to a star’s mass and interior structure. Because structure changes over a star’s life, asteroseismology is a good way to estimate age. In 2016, Metcalfe and colleagues reported in *Nature* that Kepler was finding old stars that rotated too fast for their ages. Young stars followed the spin-down trends, but around middle

age, stars’ spin speed leveled off.

As an aging subgiant, 94 Aquarii Aa made a good test case. Metcalfe used NASA’s Transiting Exoplanet Survey Satellite, or TESS, the successor to Kepler that launched in 2018, to estimate age and mass using asteroseismology. The star is about 6.2 billion years old, he found, and 1.2 times as massive as the sun. (In comparison, the sun is 4.5 billion years old.)

If it had been spinning down its whole life, a star of that mass should now be rotating once every 78 days. But previous measurements made from ground-based telescopes indicate that 94 Aquarii Aa rotates once every 47 days.

“The only way to explain a star of that age having that rotation period is that this stalled rotation [decline] has to kick in around middle age,” Metcalfe said. “It’s a smoking gun.” He hopes to repeat the experiment with hundreds more stars over the course of the TESS mission.

A star’s spin-down may slow because of a midlife change in the star’s magnetic field. The magnetic field drives the star’s stellar wind, which carries mass and angular momentum away from the star, contributing to the spin-down. But if the magnetic field changes its geometry around the middle of the star’s life, shifting from dominating the entire star to a more small-scale field, that could weaken the magnetic field’s control over the star’s rotation, Metcalfe said.

“This is the first time we’ve seen convincing evidence that you have to invoke [the stalled slowdown] to explain the rotation of a subgiant,” says astronomer Jason Curtis of Columbia University. Astronomers had a lot of skepticism about Metcalfe and colleagues’ previous work using Kepler data, Curtis says, but “every time they look at it from a different angle, it becomes more convincing.”

The new result might mean that scientists can no longer use spin speed to guess star ages, Curtis says. “If that stops working in old stars, that’s a bummer.” ■

MEETING NOTE

‘Ultrahot Neptune’ discovered

Astronomers have spotted a new kind of planet: a Neptune-sized world sitting close to its star. The scorchingly hot planet, LTT 9779b, could be in the midst of transforming from a gas giant to a naked rocky core, astronomer James Jenkins reported July 29.

LTT 9779b, about 260 light-years from Earth, was discovered by NASA’s Transiting Exoplanet Survey Satellite, or TESS, which launched in 2018 (*SN: 5/12/18, p. 7*). TESS data show that the planet swings around its star once every 19 hours.

Most known planets with such close orbits are either small enough to be rocky like Earth or gas giants the size of Jupiter and larger, said Jenkins, of the University of Chile in Santiago. At 4.6 times Earth’s size, LTT 9779b is in the middle of those two extremes. The planet’s proximity to its star should heat the planet to about 2,000 kelvins (about 1725° Celsius), making it the first known “ultrahot Neptune,” Jenkins said.

One explanation for how planets get cozy with their stars is that a planet forms far away from its star and migrates inward over time (*SN: 5/12/18, p. 28*). A planet with a thick, gaseous atmosphere might lose more and more gas as it approaches the star, as heat evaporates the atmosphere or as the star’s gravity steals the gas away.

At about 2.5 million kilometers from its star, LTT 9779b — which has a thick atmosphere that makes up about 9 percent of the planet’s mass — may be about as close as a planet can get before its star gobbles up the atmosphere. (Earth is about 150 million kilometers from the sun.) If so, ultrahot Neptunes might be a bridge between hot Jupiters, which are gas giants like Jupiter but have closer-in orbits, and scorched rocky worlds, Jenkins said. — *Lisa Grossman*



Rhesus macaques in the lab can learn and remember the order of items in a list, a mental feat that may prove handy in the wild.

LIFE & EVOLUTION

Monkeys can keep track of listed items

Basic logic may help the primates monitor social relationships

BY BRUCE BOWER

Monkeys can keep strings of information in order by using a simple kind of logical thought.

Rhesus macaques learned the order of items in a list through repeated exposure to pairs of items plucked from the list, say psychologist Greg Jensen of Columbia University and colleagues. The monkeys drew basic logical conclusions about pairs of listed items, akin to assuming that if A comes before B and B comes before C, then A comes before C, the team concludes July 31 in *Science Advances*.

Importantly, the size of rewards given to monkeys for correctly identifying the higher-ranking item in a pair didn't always provide reliable guidance to the animals about the item's ranking on the list, Jensen's group says.

Previous studies have suggested that a variety of animals, including monkeys, apes, pigeons, rats and crows, can discern the order of a list of items (*SN*: 7/5/08, p. 13). But debate persists about whether nonhuman creatures can actually develop an internal knowledge about what items come before others in a list.

Jensen and colleagues designed experimental sessions in which four rhesus macaques completed as many as 600 trials per session to determine the order of seven images in a list. Images

included a hot air balloon, an ear of corn and a zebra. Each item came with a different-sized reward.

In some sessions, the size of the reward for a correct answer was proportional to an image's rank on the list, with a high-ranking image netting a bigger reward; in other sessions, high-ranking images came with the smallest rewards. Rewards consisted of larger or smaller gulps of water delivered through tubes to the moderately thirsty primates.

Rhesus macaques consistently learned list orders in both reward conditions, making relatively few errors by the end of the sessions. The monkeys learned lists slightly faster when given rewards proportional in size to an item's ranking.

Jensen's study adds to evidence suggesting that, like humans, monkeys can mentally link together pairs of items into lists that guide later choices, says Regina Paxton Gazes, a psychologist at Bucknell University in Lewisburg, Pa.

That's probably a valuable ability in the wild because many animals need to monitor where group mates stand in the social pecking order, she says. "An ability to construct, retain, manipulate and reference ordered information may be an evolutionarily ancient, efficient [mental] mechanism for keeping track of relationships between individuals." ■

BODY & BRAIN

Placentas may not harbor bacteria

In a new study, many microbes' presence was contamination

BY LAURA SANDERS

Contrary to other reports, the human placenta is largely free of microbes, a study finds. That result follows years of debate over whether the organ that nourishes and protects a fetus also holds bacteria.

Dueling evidence has been accumulating both for and against the idea that microbes are present in placentas. Amid the back-and-forth, Stephen Charnock-Jones, a molecular biologist at the University of Cambridge, and colleagues were busy collecting thousands of placenta samples as part of a study on maternal and fetal health. But the team became interested in the possibility that microbes dwell in the placenta. "We thought, 'This is an objective thing we can test,'" Charnock-Jones says.

His team examined samples from over 500 placentas, which were collected after delivery. Samples came from healthy pregnancies and ones that involved complications, and both vaginal and cesarean deliveries. The team washed the tissue in salt solutions and froze it, and then used two methods to search for bacterial DNA.

There were few signs of bacteria in placentas, the researchers conclude online July 31 in *Nature*. Instead, much of the detected bacterial DNA came from lab tools, the birth canal and the salt solution in which the samples were washed.

Some scientists suspect that microbes in the placenta play a role in the health of the mother or baby. But the new findings call that idea into question.

To focus on the most reliable bacterial signals, the team tossed out any bacteria that showed up in only one of the two tests. Similarly, the researchers ruled out signals that showed up only when a particular batch of salt solution or other reagents, or a particular lab tool, such as a DNA-sequencer machine, was used.

"It doesn't matter what month, what

reagents, which technician,” Charnock-Jones says. “None of that should matter if it’s a real signal.”

As an extra control, a small amount of *Salmonella bongori* bacteria, which are not usually found in people, was added to some samples. The tests detected these bacteria, but not much else, with one exception. In about 5 percent of samples, researchers found group B *Streptococcus* bacteria, which can be dangerous for fetuses and newborns. The team doesn’t know if the presence of the strep is a sign of disease. Those samples weren’t tied

to poorer health outcomes, though the overall number of those cases was small.

The study is “very persuasive,” says Roberto Romero, an obstetrician and gynecologist at the National Institute of Child Health and Human Development’s Perinatology Research Branch, which is housed at Wayne State University in Detroit. “More and more evidence is emerging that, probably, the signals we observe represent contamination.”

Maternal-fetal medicine specialist Kjersti Aagaard of Baylor College of Medicine in Houston disagrees. The

analyses may have excluded some important bacteria, she says. For instance, several types of vaginal bacteria were classified as “contamination.” But it’s possible that those bacteria existed in the placenta before the trip down the birth canal, says Aagaard, who has reported evidence for microbes in the placenta (*SN: 6/28/14, p. 6*). Bacteria known to be in the vagina have also been found in the uterus, which connects to the placenta, she says. “Why would we disregard [those bacteria] and toss them out, when the biology makes perfect sense?” ■

EARTH & ENVIRONMENT

Trees in acidified soils gulp more water

Acid rain could contribute to droughts, forest experiment hints

BY CAROLYN WILKE

A forest watered by acid rain may be less able to slake its thirst. That’s one finding from a decades-long experiment in the Appalachian Mountains, where the U.S. Forest Service has been dousing a 34-hectare patch of forest with an acidifying fertilizer since 1989. The chemical served as a proxy for acid rain, which is created when sulfur- and nitrogen-containing compounds released by industrial activities, agriculture and the burning of fossil fuels acidify raindrops.

In most years from 1989 to 2012, the acidified forest soaked up about 5 percent more water than a neighboring untreated patch — and up to about 10 percent more in two of the years, researchers report July 31 in *Science Advances*. Levels of cal-

cium in the water that permeated the soil of the acidified forest also declined over the study period. That drop in calcium, a nutrient plants need to retain water, could explain the forest’s water guzzling.

“We didn’t expect that plants actually will respond so strongly to acidification,” says Lixin Wang, an ecohydrologist at Indiana University-Purdue University Indianapolis. That might be cause for concern, he says: Thirstier plants could contribute to droughts or leave less water available for people and other animals.

Wang and colleagues used Forest Service data to calculate water uptake by subtracting how much flowed out of the forest in streams from how much water fell as precipitation. Trends in water use were also reflected in soil moisture data.

Acid rain dissolves minerals in soil and depletes calcium. Calcium regulates the cells that open and close the stomata, pores through which plants release water. Without enough calcium, plants can’t control this water loss as well.

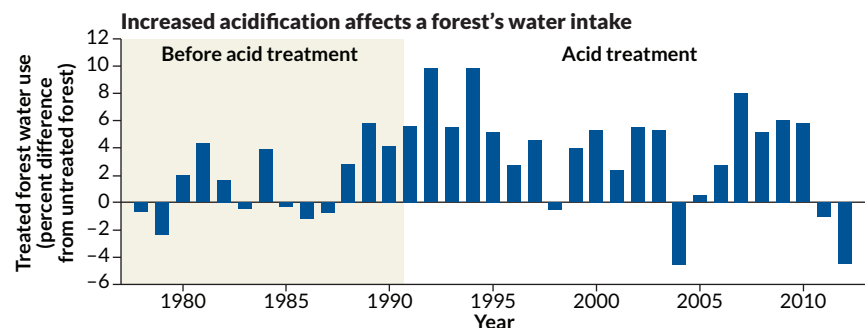
It’s not clear if other types of forest, with different trees or soils, would show similar results. Fernow Experimental Forest near Parsons, W.Va., where the study was conducted, grows from a silty loam of sandstone and shale, and is packed with deciduous trees, such as cherry, maple and oak.

Still, “this is not a small [amount] of water we’re talking about,” says Matthew Lanning, an ecohydrologist in Wang’s lab. It adds up to about 13.6 million extra liters of water per year on average used by the treated watershed, Lanning says.

The observations make sense based on tree biology and soil chemistry, says Salli Dymond, a forest hydrologist at the University of Minnesota Duluth. But how the scientists calculated the trees’ water use gives Dymond pause. “They’re very simple calculations, and this simplicity could mask a piece of the story.” For instance, the measured increase in water use with acidification may be within the natural range of variation.

But if the findings hold up, the study may point to legacy effects of acid rain that we didn’t already know about, says Charles Driscoll, a biogeochemist at Syracuse University in New York. Soils are typically slow to recover calcium that they have lost, he says. ■

Growing thirst A forest receiving an acidifying treatment tended to use more water than a similar untreated forest in an experiment that ran from 1989 to 2012. The first two years of data were not included in the treatment period because the soil may not have been fully acidified.



MATTER & ENERGY

Radioactive cloud linked to Russia

2017 plume in Europe blamed on processing of used nuclear fuel

BY EMILY CONOVER

It was a nuclear whodunit: A cloud of radioactive material hung over Europe, but no one knew where it came from.

The plume persisted for a few days in September and October 2017, detected by an atmospheric-monitoring network in Europe. Although the radioactivity was not at levels dangerous to human health, the cloud raised alarm before dissipating.

"We were stunned," says radioecologist Georg Steinhauser of Leibniz University Hannover in Germany. "We had never seen anything like this before."

Scientists speculated that a Russian nuclear facility, the Mayak Production Association near Ozersk, was the source. Now, Steinhauser and colleagues lay out evidence for that claim in a study published online July 26 in the *Proceedings of the National Academy of Sciences*. The cloud may have been accidentally released in a failed attempt to make material for an experiment on neutrinos, subatomic particles that are spit out in certain types of radioactive decay.

The monitoring network spotted small amounts of ruthenium-106, a version, or isotope, of the element ruthenium. The radioactive isotope is not found naturally on Earth. Detectors in Romania tracked the plume as it moved west. These detectors measured some of the highest ruthenium levels, but the cloud's shape indicated that it did not originate inside Romania. Simulations of the atmosphere show that air masses could have traveled from Mayak to Romania in several days.

The neutrino experiment, called SOX, would have involved placing a powerful radioactive source — the isotope cerium-144 — next to a detector at Gran Sasso National Laboratory near L'Aquila, Italy. SOX's aim was to look for a hypothesized neutrino called a sterile neutrino emitted from the isotope. Mayak agreed to make cerium-144 and send it to Italy.

Producing that isotope required processing spent fuel from a nuclear

reactor. Spent fuel has many radioactive isotopes, including ruthenium-106. Normally, spent fuel is left to cool for many years before processing, so that some of the most hazardous isotopes decay. But SOX needed relatively fresh fuel. "This was essentially something that had never been done before," says Jonathan Link, a Virginia Tech physicist who was once a member of the SOX experiment.

During the 2017 plume, a second radioactive isotope, ruthenium-103, was also detected. By comparing relative amounts of the two isotopes, Steinhauser's group determined that the element had to have come from fuel that was only a couple years old, consistent with the neutrino source production requirements.

An explosion at a nuclear reactor would release various radioactive elements, but processing of nuclear fuel involves isolating individual elements and could result in the release of specific isotopes, such as ruthenium-106.

In an e-mail obtained by *Science News*

that was sent to SOX collaborators on December 8, 2017, SOX leaders wrote, "we learned that during the purification of the material unexpected problems occurred, yielding to a loss of activity as well as an increase of impurity levels." After Mayak failed to make cerium-144, SOX was canceled. When reports of the plume came out, "I already suspected ... that I knew what happened," Link says.

The new study refutes an alternative explanation — that a satellite with a radionuclide battery burned up on entry in Earth's atmosphere. If a satellite were the cause, measurements at higher altitudes should have showed higher ruthenium concentrations, Steinhauser says. But the team found the opposite.

Rosatom, the Russian state atomic energy corporation that oversees Mayak, denies there was an accident. "Both the national regulator and experts from an independent international inquiry inspected the Mayak facility back in 2017 and found nothing to suggest that the ruthenium-106 isotope originated from this site, nor found any traces of an alleged accident, nor found any evidence of local staff exposure to elevated levels of radioactivity," the agency said in a statement. ■

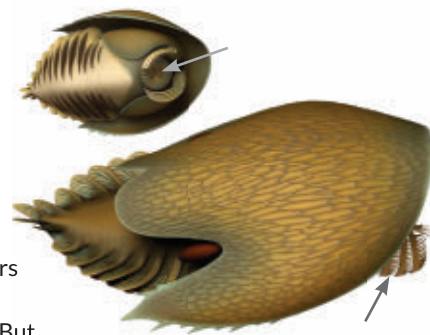
LIFE & EVOLUTION

Ancient sea predator raked in the prey

A fierce predator terrorized the seafloor 508 million years ago. Dubbed *Cambroraster falcatus*, the predator was about 30 centimeters long — which to the tiny prey of the Cambrian Period probably seemed monstrous enough. But

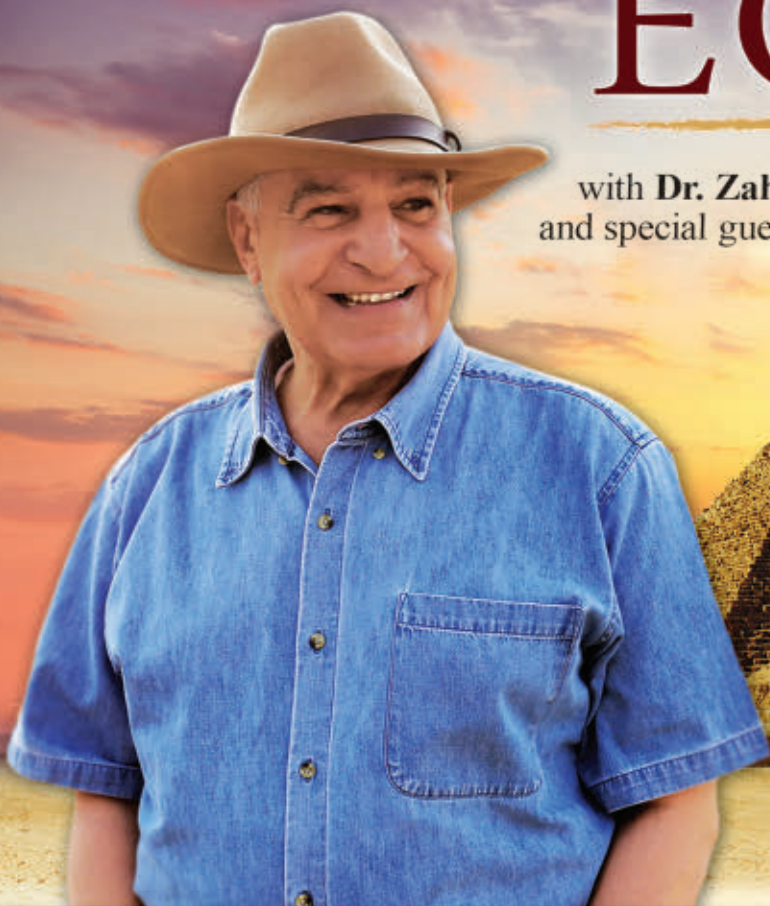
C. falcatus also had a round mouth lined with serrated plates (arrow, top illustration), a pair of jointed limbs that ended in rakelike claws (arrow, bottom) and a shield-shaped carapace that gave it a distinct resemblance to a horseshoe crab.

Paleontologists found fossils of the critter, an extinct type of arthropod called a radiodont, in Canada's Burgess Shale. *C. falcatus* may have used its claws to rake through sand and form a kind of basket to trap worms, arthropods and even small fish, researchers report in the Aug. 14 *Proceedings of the Royal Society B*. Previous Cambrian finds sketched a relatively simple ecosystem, says Jean-Bernard Caron of the Royal Ontario Museum in Toronto. A shrimplike predator called *Anomalocaris* was at the top, while smaller, specialized arthropods like trilobites scuttled along the seafloor. But *C. falcatus* occupied its own niche, Caron says, with adaptations that "allowed it to feed on anything living in the mud." — Carolyn Gramling



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THREADS OF TIME

Archaeologists are learning how ancient clothing, shrouds and even Viking sails might have been made

By Amber Dance



Norse sails loomed off the shores of the Holy Island of Lindisfarne, along the northeastern coast of Great Britain, on June 8, 793. The seafaring invaders sacked the island's undefended monastery.

The Viking Age had begun.

For more than 270 years, the sight of red-and-white-striped Viking sails heralded an incoming raid. Those mighty sails that drove the explorers' ships were made by craftspeople, mostly women, toiling with spindles and looms.

"There would have been no Viking Age without textiles," says archaeologist Eva Andersson Strand, director of the Centre for Textile Research at the University of Copenhagen, in old Viking territory.

Yet textiles have not received much attention from archaeologists until recently. Andersson Strand is part of a new wave of researchers—mostly women themselves—who think that the fabrics in which people wrapped their bodies, their babies and their dead were just as important as the clay pots in which people preserved food, or the arrowheads with which hunters took down prey.

These researchers want to know how ancient spinners and weavers, from Viking territory and elsewhere in Europe and the Middle East, fashioned sheep's coats into sails—as well as diapers, shrouds, tapestries and innumerable other textiles. Since the Industrial Revolution, when fabric crafts migrated from hearth to factory, most people have forgotten how much work it once required to create a tablecloth or wedding veil, or 120 square meters of sailcloth to propel a longboat across the water.

Textile making is "one of the major industries, and always has been," says Lise Bender Jørgensen,

Ancient art depicting female textile workers, as on this Greek oil flask from about 550 B.C., supports the idea that spinning and weaving were primarily women's work.

an archaeologist at the Norwegian University of Science and Technology in Trondheim. Today, the annual global market for yarns and fabrics is worth nearly \$1 trillion.

Before the 1764 invention of the mechanical spinning jenny, people twisted fibers — flax or wool, for example — together by hand to spin a strong thread. The person doing the spinning would pinch a few strands from a mass of fibers and hook it to a hand-length stick called a spindle. A small, round weight, called a whorl, helped the spindle turn. By dangling the turning spindle, the spinner could twist the fibers into long threads.

Weavers then attached these threads to a loom, crisscrossing the fibers. That mesh could be loose and open, or tight and dense, depending on the fabric desired.

People have been using fibers for millennia, for string and rope as well as thread, and probably started spinning around the fourth century B.C., says Margarita Gleba, an archaeologist at the University of Cambridge. Loom-based weaving, which evolved from basketry, happened as early as the seventh millennium B.C. in Turkey. Back then, the threads were made by splicing (see Page 19).

The ancient textile industry has been difficult to study. Unlike pottery or arrowheads, organic textiles rapidly degrade. Archaeologists interested in what people wove and wore in the past make do with scraps of material preserved by luck — for example, if the fabric happened to be buried in bogs or salt mines.

While some researchers have analyzed the bits of fabric they can find, Andersson Strand is more interested in the production process and its context — the cultural and economic impact. She wants to know what life was like for the people who made textiles thousands of years ago. How much of women's time was taken up with spinning and weaving? Did textile workers specialize in one part of the process? And did techniques vary by culture?

To understand the work of European spinners and weavers from centuries past, she has turned to the remains of tools that once created those fabrics. Made of clay, stone or bone, the whorls that twirled the spindles and the loom weights that kept the threads taut during weaving are abundant at many archaeological sites.

Andersson Strand uses experimental archaeology to learn what kind of threads and fabrics — fine or coarse, dense or airy — would result from different tools. Her findings are helping archaeologists infer from the leftover tools what textiles people might have created and traded.



“She’s really made the textile tools speak,” Bender Jørgensen says. But not all scholars agree that the tools determine the fabric. Some researchers suggest that the individual crafter, inaccessible to archaeologists, was a more important factor in how spun threads turned out.

In the pits

Andersson Strand built her first loom in 1988 as an archaeology graduate student at Lund University in Sweden. Archaeologists had excavated loom weights from several Viking pit houses, which had no windows, just a hole in the roof. Andersson Strand wondered whether it would have been possible to weave with the only illumination coming from a single skylight.

She constructed a loom like the Vikings would have used, a warp-weighted loom. The vertical threads of a woven fabric are called the warp, and the horizontal strands are the weft. Loom weights attached to the warp threads hold them down, providing tension. The weaver passes the weft threads back and forth, over and under the warp, to create the fabric.

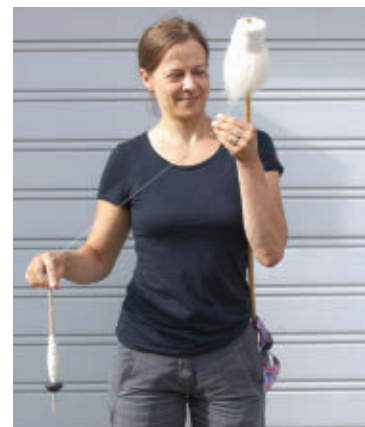
With the loom, Andersson Strand got down into a cellarlike pit reconstructed by students and started crafting. “Those houses were excellent for weaving, actually,” she says. Plenty of light came through the skylight. The effort helped convince her to focus on textile tools as a window into the world of ancient fabrics and the people who made them.

“People thought I was quite crazy,” she says. At that time, archaeologists didn’t think much about whorls and loom weights as functional objects. Researchers didn’t record crucial details, like weight and width, and sometimes tools were misclassified.

Andersson Strand wrote to one excavation director to ask if she could study textile tools found at the site — not only whorls and loom



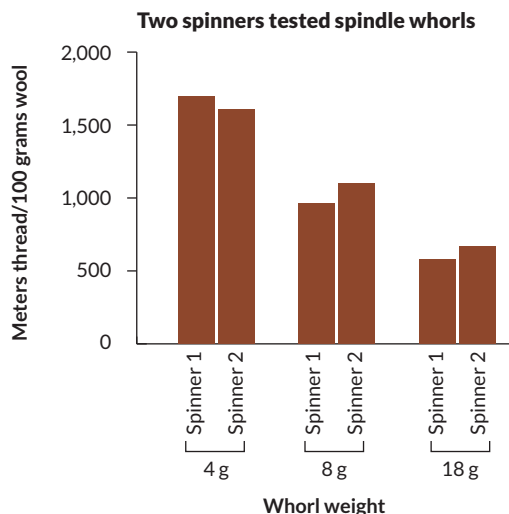
Researchers in Slovakia built a warp-weighted loom to weave a twill fabric like one that dates to between 800 and 400 B.C. found in the Hallstatt salt mines in Austria. Loom weights (left, shown dangling at the loom’s base) hold the vertical threads taut.



Katrin Kania, a textile archaeologist based in Germany, shows how a spinner makes thread. Here, she pinched a bit from a mass of fibers, attaching it to the spindle in her right hand. A whorl at the spindle’s bottom helps the tool spin and create thread.

Tool makes the textile The size of the spindle whorl determined the length of thread that two spinners independently produced. For both spinners, the lighter whorls produced longer, thus thinner, thread.

SOURCE: E. ANDERSSON STRAND/TOOLS, TEXTILES AND CONTEXTS 2015



weights but also other rarer specimens such as the wool combs used to align fibers before spinning. The director welcomed Andersson Strand but warned her that he had no idea if wool combs had been found at the site. “I didn’t know that tool existed,” she recalls him saying.

Nonetheless, she amassed a dataset of more than 10,000 different tools, mostly loom weights and spindle whorls, from several sites in Sweden and one in Germany, from the years A.D. 400 to 1050.

Andersson Strand found some surprises at a Viking trading center called Birka, thought to have been the first real town in what is now Sweden. It’s likely that the local king ordered Birka built in the mid-700s on an island west of modern-day Stockholm. Traders visited from Europe and beyond, bringing beads, Arabic silver and other goods (*SN*: 4/18/15, p. 8). Birkans, in return, offered iron and furs.

Andersson Strand predicted that Birkan textile workers would have spent their time — a lot of their time — spinning and weaving coarse fabrics, such as sailcloth. Finer fabrics probably arrived via trade.

But at Birka, she found a puzzling range of tool sizes and weights, and tested what the ancient whorls could do. Because today’s tools and textiles are different, Andersson Strand recruited textile crafters trained in ancient techniques to test replicas of the ancient tools.

She discovered that the heavier the whorl, the thicker the resulting thread. That finding makes sense:

Heavy whorls would snap thin threads; light-weight whorls wouldn’t turn properly when dangling from a thicker thread.

Andersson Strand reported in her 2003 book, *Tools for Textile Production — From Birka and Hedeby*, that because Birkan sites contained such a wide range of tools, Birkan weavers must have created a broad repertoire of threads and fabrics — both coarse sailcloth, as she had predicted, and the fine material, presumably remnants of clothing, found in nearby graves.

Turning back the clock

From the Viking Age, Andersson Strand turned her attention further back in time to the Bronze Age, between 3000 and 1100 B.C., and farther south to the Mediterranean. She and collaborators collected data on 8,700 tools from 29 sites in Europe and the Middle East.

The researchers wanted to reproduce the full process of textile manufacture, from raw fibers to woven fabrics. Because the final product could be influenced by the fibers, the tools or the individual crafters, the team recruited two craftswomen to see if each created different textiles.

The crafters started with Shetland wool, thought to be closest to that used by Bronze Age spinners. For tools, a ceramicist re-created cone-shaped whorls in three weights: four grams, eight grams and 18 grams (about the weight of seven pennies). These proportions were based on clay whorls found in Nichoria, a Bronze Age site in Greece. The two spinners produced similar woolen thread, with the lighter whorls making thinner threads.

Next, the craftswomen turned to weaving. They arranged some of the threads they had made on a warp-weighted loom, using reconstructed weights, based on ones from Turkey. The women were asked to make a simple tabby weave that was common during the Bronze Age. In a tabby, or plain, weave, each weft thread goes over one warp thread and under the next, then over and so on across the fabric. The next weft thread reverses the pattern.

The two spinners made similar fabrics from the woolen threads, Andersson Strand and colleagues reported in a 2015 book, *Tools, Textiles and Contexts: Textile Production in the Aegean and Eastern*



Loom weights suggest Italians made twills, like this from the seventh century B.C. (top); Greeks, instead, made simpler tabby weaves, like this from the fifth century B.C. (bottom).

Mediterranean Bronze Age. The tools and materials, not the crafter, seemed to be the crucial factors determining the final product.

In both the Viking and Bronze Age experiments, crafters kept track of how long the work took. From that data, Andersson Strand estimates it would have taken four women, working 10-hour days, a full year to spin and weave 120 square meters of fabric for one large Viking sail.

From tools to textiles

With these experiments, tools left lying around ancient workshops are telling their stories. Archaeologists can figure out what fabrics could have been woven, even though not a thread remains. The heft of a loom weight reveals how many threads it could have held; the width of the loom weight indicates how closely spaced those strands would have been. Based on their analyses, Andersson Strand and colleagues developed methods to work from loom weight to fabric type.

“We can never say it’s exactly this fabric or that fabric, but we can give the range of fabrics that could have been produced,” Andersson Strand says. For example, a particular loom weight found in Turkey and dating to 3800 to 3350 B.C. weighs 870 grams, a bit lighter than a quart of milk. Andersson Strand and colleagues calculated it would have been suitable for a coarse fabric made with thick threads. Another loom weight from 1750 to 1300 B.C. Turkey—which weighed 177 grams, comparable to a cue ball—would work best with thinner threads requiring low tension, the group reported in the *Oxford Journal of Archaeology* in 2009.

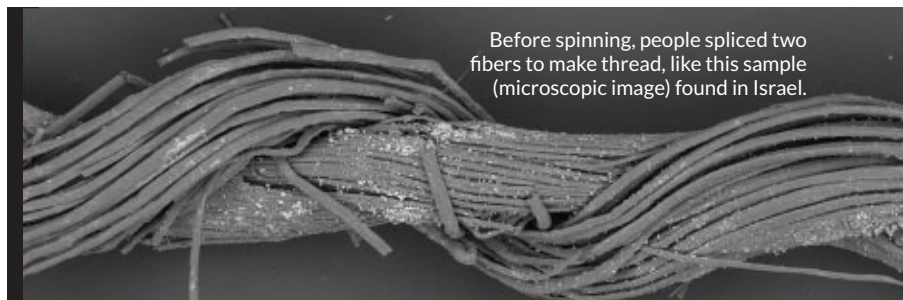
That’s only a starting point for the kinds of questions Andersson Strand wants to address. “It’s more what the textiles tell us about the society—that is what really fascinates me,” she says.

She recently analyzed loom weights from the Greek island of Crete to learn what textiles might have been made or traded at three palaces dating from 1900 to 1700 B.C. Based on the tools present at a palace site in Knossos, workers there probably used thin threads to make dense fabrics. Weavers in a palace in Phaistos probably worked with a wider variety of threads, mostly fine ones, and had to cram the horizontal weft threads tightly to make solid cloth. And from a palace in Quartier Mu came a range of textiles, Andersson Strand reported in 2018 in the *Proceedings of the 11th International Cretan Congress*.

The use of fine threads suggests that workers needed high-quality, well-prepared wool or flax.

But archaeologists haven’t found many spindle whorls at these three sites. Perhaps, Andersson Strand and colleagues speculated, the Cretans did their spinning elsewhere. That would fit with ancient writings suggesting that textile workers were specialized—spinners and weavers toiled separately.

Other researchers are using Andersson Strand’s methods to infer past textiles from excavated tools at other sites. Gleba has been analyzing the textile industry of Italy and Greece of the first millennium B.C. The Greeks used lighter loom weights than Italians did. The lighter weights would have been appropriate for tabby weaves. The bigger, heavier Italian weights could have been suited for a technique that creates diagonal ridges, for a



Before spinning, people spliced two fibers to make thread, like this sample (microscopic image) found in Israel.

The earliest textiles

While most textiles degrade before archaeologists get a glimpse, occasional scraps survive to offer clues to how they were made.

The first threads were not spun with a spindle, but spliced together by hand, says archaeologist Margarita Gleba of the University of Cambridge. Stone Age weavers used long plant fibers—such as flax, hemp or nettle—that could be layered together or joined end to end. Only after 4000 B.C., when crafters started using wool with its shorter fibers, did spinning become necessary, Gleba says. Some craftspeople still use splicing in Asia, and though the technique was discontinued in Europe, it lasted longer there than scholars had once thought. In May in *Archaeological and Anthropological Sciences*, Gleba reported finding spliced fibers in European textiles made during the Bronze Age and into the first millennium B.C.

The earliest preserved woven textiles were dug up at the Turkish site of Çatalhöyük, which was inhabited from about 7100 to 5950 B.C. These scraps, described in the 2018 *Archaeological Textiles Review*, were preserved by fire: They were buried beneath the floors of houses that later burned, which converted much of the textile to pure carbon, which was less likely to degrade. The scraps are plain tabby weave from spliced plant fibers. Turkey also hosts some of the oldest loom weights ever found, including 11 clay, doughnut-shaped ones unearthed at the site of Ulucak. Together, these finds indicate “that somebody had invented the loom, [by] sometime in the middle of the seventh millennium B.C.,” says archaeologist Lise Bender Jørgensen of the Norwegian University of Science and Technology in Trondheim. — *Amber Dance*

Katrin Kania compared threads created with five different spindles. The middle spindle was the hardest to use, earning the nickname, “spindle from hell.”



more complex twill fabric. Gleba examined textile scraps, mostly from graves, that support the weaving patterns suggested by the tools, as she reported in 2017 in *Antiquity*.

Spinning for science

Of the three factors that influence a final textile, Andersson Strand thinks the tools and materials are more important than the person doing the work. But Katrin Kania, a freelance textile archaeologist in Erlangen, Germany, thinks the textile worker is most crucial to spun threads.

A spinner herself, Kania says, “I spin a thin yarn almost no matter what [tool] you hand me.”

So Kania conducted her own experiments, recruiting 13 experienced volunteer spinners, plus one beginner. Kania purchased two different kinds of wool, German Merino and Tyrolean Bergschaf, to test the influence of raw materials.

She provided five different spindles, varying the weight and dimensions to change how they turned. Participants called one tool, with a thin clay cylinder for a whorl, the “spindle from hell” because it required constant flicking to keep it in motion.

Kania asked the spinners to create whatever thread felt natural with each tool, and then she gathered the products to analyze thickness, length, evenness and twist angle. The different types of wool didn’t make much difference to the final product. Nor did the spindles.

But the individual spinner did have an effect; each volunteer stuck to a personal range of yarn thickness regardless of the tool, Kania reported in 2015 in *Archaeological and Anthropological Sciences*. “The spinner is the main factor of what comes out,” she says.

Tereza Štolcová, a textile archaeologist at the Institute of Archaeology of the Slovak Academy of Sciences in Nitra, agrees that the tool alone doesn’t predetermine the thread. But she thinks the tools do matter and that Andersson Strand’s calculations are helpful for narrowing down what textiles people might have created in the past — so long as

researchers understand the estimates offer only a range of threads or fabrics possible, not a certain deduction.

Andersson Strand doesn’t deny the role of the individual craftsperson in the final product. But, she notes, it’s important to consider the ancient textile worker in context. It wouldn’t be practical for one woman to spend four years creating a sail on her own; instead several women would need to work together. To do that, they would need consistent threads and consistent weaves. The way to achieve that would be for everyone to use the same version of a tool in the same manner.

Weaving a tapestry of the past

Between the tools and the textiles, archaeologists are building a picture of life for the ancient European textile worker, and how those fabrics might have been used. That worker was most often a female, based on ancient artwork that depicts women spinning and weaving, historical writings and the presence of textile tools in women’s graves. But men and children were probably involved at times, Gleba says.

If the weaver were a Viking, she might have spent long days in a pit house, passing the weft threads back and forth to make all the fabrics needed in her community. If she lived in a Greek palace, she might have ordered prespun threads of fine quality. She probably specialized, focusing on just spinning or just weaving. Women may have worked side by side to produce wider fabrics on large looms.

Wherever she worked, she was highly skilled and very busy. And chances are she carefully selected the right tools for the fabric she was making.

Not all textiles would have required specialists; there would have been a thriving home-based industry as well. To fuel a community’s need for textiles, hand spinners might have carried a spindle everywhere, turning to it at any spare moment — much like people today with their smartphones. ■

Explore more

- Eva Andersson Strand and Marie-Louise Nosch (eds.). *Tools, Textiles and Contexts*. Oxbow Books, 2015.
- Margarita Gleba and Susanna Harris. “The first plant bast fibre technology: identifying splicing in archaeological textiles.” *Archaeological and Anthropological Sciences*. May 2019.

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In the Same Way Addiction Sufferers Crave Substances, Their Family Members Crave Them

Sterling Shumway and Spencer Bradshaw discovered that individuals struggling with substance use disorders and their family members have similar brain patterns. The family member with SUD and the loved one are both trying to keep one person alive. Through their work, Shumway and Bradshaw hope to find ways to help family members of those with substance use disorders find their own recovery, which can give their loved one a better chance too.



When strep plays MIND GAMES

Tracking how a common bacterial infection might spark a faulty immune reaction in the brain **By Rachel Zamzow**

One night in December 2013, Hans Korbmacher awoke in a fury. The book-loving, introverted 10-year-old was feverish, agitated and gnawing on his tongue. He headed downstairs, leaped onto an ottoman and threw his hands over his head, startling his parents. He was “clearly not present,” says his mother, Heather Korbmacher.

When the same thing happened two weeks later, she thought fevers may have induced Hans’ bizarre behavior. A nurse said it could be the flu. Meanwhile, Hans’ condition worsened. He was anxious and volatile. His handwriting, once a model of penmanship, morphed into angry scribbles. And he became a peculiarly picky eater.

Korbmacher, a behavioral specialist for schools in Bellingham, Wash., tried to manage Hans’ symptoms on her own. “It was working OK during those first five months, until it was absolutely not,” she says. Extreme rages came weekly and then daily, keeping Hans out of school. He punched holes in walls and ripped down curtains. The worst part: Hans was acutely aware that something was very wrong. He pleaded with his parents to make it stop. “He would beg us to kill him,” Korbmacher says.

Several doctors’ appointments later, a psychiatrist suggested that Hans’ symptoms stemmed from obsessive-compulsive disorder, or OCD. The diagnosis seemed off base to Korbmacher until she read online about a rare form of OCD with a mouthful of a name: pediatric autoimmune neuropsychiatric disorder

associated with streptococcal infections, or PANDAS for short. Hans had all but one of the listed symptoms.

Korbmacher immediately had Hans tested for a strep infection. A throat swab came back negative, but blood tests revealed that he had four times the typical levels of immune molecules that the body produces in response to a strep infection.

PANDAS is as puzzling for researchers as it is for the families that struggle with it. Scientists studying the condition propose that the string of psychiatric symptoms is triggered by infection with Group A *Streptococcus*, one of the most common childhood illnesses (*SN*: 3/2/19, p. 7). In some children, a faulty immune response to the infection may mistakenly attack brain cells, causing behavior to go haywire.

But researchers have yet to nail down which brain cells are harmed. And it's not clear why countless children get strep, yet so few develop PANDAS symptoms. With so much uncertainty about how strep could affect the brain, some experts doubt whether PANDAS is a separate disorder from OCD and whether it's truly triggered by strep. Amid the debate, families searching for help get mixed messages.

Researchers have begun to fill in some gaps in understanding, and some say the field is on the cusp of explaining the biology underlying PANDAS. "We're at a point where the basic science research is just progressing at lightning speed," says Susan Swedo, the developmental pediatrician who coined the term PANDAS. But other researchers are much more reserved, saying a heap of work still remains.

Support for a connection between the body's reaction to an infection and changes in mental health comes from recent studies linking infections and inflammation with several more common psychiatric disorders, including schizophrenia, depression, Alzheimer's disease and autism (see Page 24). As scientists delve deeper into these intriguing links, the hope is that new ways to detect and treat these conditions will come into focus.

A questioned discovery

Swedo described PANDAS in the 1990s while studying a childhood condition called Sydenham chorea. The rare disorder can occur with rheumatic fever, the heart condition that can develop when a Group A strep infection goes untreated. Patients with Sydenham chorea uncontrollably jerk their limbs and bodies.

Swedo found reports suggesting that some patients with Sydenham chorea also have psychiatric problems. "Those children were noted to have a lot of obsessional fears about contamination, about harm coming to their parents," says Swedo, a scientist emeritus at the National Institutes of Health



Some children with PANDAS symptoms experience an abrupt decline in fine motor skills, such as drawing. On the left is a drawing done during an acute episode. On the right is the same child's art after a treatment.

in Bethesda, Md., and chief science officer of the PANDAS Physicians Network. The children "had separation anxiety, emotional [instability] and even frank psychotic symptoms."

Swedo and colleagues found that some children with Sydenham chorea displayed obsessive symptoms that came on suddenly. The researchers observed a similar abrupt onset of symptoms in some children with OCD. In many of these children, surges in obsessive behaviors followed strep infections.

After evaluating a separate group of 109 children with sudden-onset OCD, Swedo's team determined that 50 of the youngsters represented a distinct subgroup whose symptoms appeared out of the blue and then waxed and waned over time, seemingly in step with strep infections. The researchers published their findings in 1998 in the *American Journal of Psychiatry*.

To date, a PANDAS diagnosis is defined solely by its symptoms. There is no definitive lab test. (One company markets a PANDAS blood test, but evidence suggests it doesn't actually work.) Swedo says it's possible that as many as 1 in 400 children in the United States have the condition. But strep expert Ellen Wald, who also thinks that PANDAS is a distinct condition, disagrees with that estimate. "My guess is that it's quite a bit lower than that," says Wald, a pediatrician at the University of Wisconsin School of Medicine and Public Health in Madison.

Some experts aren't convinced that PANDAS is even real. After Swedo first described PANDAS, skeptical clinicians aired concerns in medical journals, questioning whether the

Standout symptoms

There is no lab test to directly diagnose PANDAS, and the condition is not listed in psychiatry's *Diagnostic and Statistical Manual of Mental Disorders*. Researchers propose five criteria for a child to get a PANDAS diagnosis:

- Presence of obsessions, compulsions and/or tics
- Unusually abrupt onset and/or a recurring course of symptoms
- Symptom onset before puberty
- Presence of additional neuropsychiatric symptoms, such as extreme separation anxiety, aggression and sensory sensitivities
- Symptom onset and/or exacerbations associated with strep infections

evidence supports calling PANDAS a condition. With missives lobbed back and forth between the skeptics and PANDAS proponents as recently as July, little has been resolved.

Jonathan Mink, a pediatric neurologist at the University of Rochester Medical Center in New York, is a skeptic. He says he sees around 25 patients with suspected PANDAS each year but has yet to come across a case that checks off all the criteria for the condition. Mink argues that these patients most likely have traditional OCD or Tourette syndrome, a tic disorder that involves compulsive movements or outbursts.

But parents are often disappointed with diagnoses without a clear-cut cause, Mink says. PANDAS offers a straightforward trigger. “Everybody knows about strep infections,” he says.

The link between strep and PANDAS is tenuous at best, say Mink and pediatric neurologists Donald L. Gilbert of Cincinnati Children’s Hospital and Harvey Singer of Johns Hopkins School of Medicine in a commentary in the August 2018 *Journal of Pediatrics*. The research that came after Swedo’s initial reports is a mixed bag; some studies find that strep occurs just as often in children diagnosed with OCD or Tourette syndrome as it does in children meeting PANDAS criteria.

These conflicting results led Swedo and other PANDAS researchers in 2012 to propose a broader condition called pediatric acute-onset neuropsychiatric syndrome, or PANS. The new diagnosis describes children who suddenly develop dramatic obsessive symptoms and other psychiatric signs with or without a preceding infection.

Wald says it may never be possible to prove without question that PANDAS stems from strep. The time between infection and the onset of psychiatric symptoms may vary from weeks to months. By then, standard strep throat swabs would come back negative. But that doesn’t negate the possibility that a strep connection, or that PANDAS itself, exists, she says. “It’s

sort of time for us to say there are many unknowns here, but let’s try to keep an open mind and really try to learn about how common it is and how [to] approach it.”

Rogue immunity

Researchers studying PANDAS are focusing on wayward immune pathways that may underlie the condition. When foreign particles such as strep bacteria invade, the body unleashes proteins called antibodies to target and neutralize the threat. But sometimes this defense system turns on its host, resulting in autoimmune conditions, such as multiple sclerosis and lupus.

Since strep infections are so common, most children may have anti-strep antibodies circulating in their bloodstream from time to time. But in the case of PANDAS, these antibodies are thought to attack the brain.

In particular, some studies suggest that the rogue antibodies target a cluster of brain structures called the basal ganglia that governs motor control and emotions and has been implicated in OCD. A lab study reported in 2006 showed that antibodies from the blood of PANDAS patients latch onto tissue collected from human basal ganglia. And in a brain-imaging study of 17 PANDAS patients published in 2015 in the *Journal of Child Neurology* that same region showed signs of inflammation. Similar inflammation was seen in a small study in adults with traditional OCD reported in 2017 in *JAMA Psychiatry*.

The connection to antibodies also comes from rats exposed to strep. The animals showed deposits of antibodies in the basal ganglia as well as spikes in the brain chemical dopamine, researchers reported in 2012 in *Neuropsychopharmacology*. The exposed rats also exhibited behavioral quirks that mimic PANDAS symptoms, such as faulty motor control and compulsive grooming. The findings suggest that antibodies binding to this region disrupt brain signaling and may change behavior, too.

But for Mink and other skeptics, the existing data are still too shaky to mark PANDAS as a separate condition with autoimmune roots. A big problem is that studies searching for specific cells targeted within the basal ganglia and elsewhere in the brain have yielded inconsistent results. “That’s where I think the evidence is so weak that I find that there’s little to really support this as a hypothesis,” Mink says.

By contrast, researchers studying an autoimmune condition called anti-NMDA receptor encephalitis, which also spurs psychiatric symptoms, can point to a protein on certain cells in the brain where rogue antibodies bind. In this condition, antibodies attack receptors for the brain chemical glutamate. The attack brings on an array of symptoms including seizures and hallucinations.

The latest PANDAS data, however, offer a new cellular suspect. In a study reported in *Brain, Behavior and Immunity* in 2018, researchers looked for antibody binding in a part of the basal ganglia called the striatum. The team focused on cells called cholinergic interneurons. Other work has shown that those cells are depleted in the brain in patients with Tourette syndrome.

Mind-body connection

Early evidence reviewed in June in *Nature Reviews Neurology* suggests that immune factors, such as autoimmunity, inflammation or even infections, play a role in several conditions once thought to be primarily psychiatric, including those below.

Schizophrenia Studies suggest that patients with schizophrenia experience chronic inflammation, an imbalance of inflammatory molecules and overactive microglia, the primary immune cells of the brain.

Depression As with schizophrenia, depression has been tied to shifts in inflammatory molecules and microglial activation. New data also suggest that some antidepressants work, in part, by reducing inflammation.

Alzheimer’s disease Excess inflammation and overactive microglia may play a role in the neurodegenerative disease. Infections with herpes simplex virus also have been linked with an increased risk of developing Alzheimer’s (SN: 7/21/18, p. 10).

Autism Children whose mothers get bacterial or viral infections during pregnancy have a greater chance of developing autism. In some cases of autism, mothers’ antibodies may have attacked the developing fetal brain.

Infusing blood serum from five children meeting PANDAS criteria into the striatum of mouse brains, the researchers found that antibodies known to respond to strep attached to about 80 percent of cholinergic interneurons. In mouse brains given serum from children with no PANDAS symptoms, the same antibodies latched onto less than half of the cells. Preliminary work from the same laboratory suggests that cholinergic interneurons fire less when tagged by these antibodies.

Taken together, the findings may explain what anti-strep antibodies do in the brain, says lead researcher Chris Pittenger, a psychiatrist and neurobiologist at the Yale School of Medicine. But the results also raise questions: Are the findings biologically meaningful if antibodies from children without PANDAS also attached to a sizable portion of the striatal interneurons?

Pittenger doesn't expect these findings to apply to all children with PANDAS. The condition may comprise several subtypes with distinct profiles of antibodies and neural targets. "I would call it one small step in what I hope will be a clarification of what's going on in PANDAS and which kids actually have what pathology," he says. Another step, Pittenger says, is to see if serum from children with traditional OCD or Tourette's also binds excessively to cholinergic interneurons.

Breached barrier

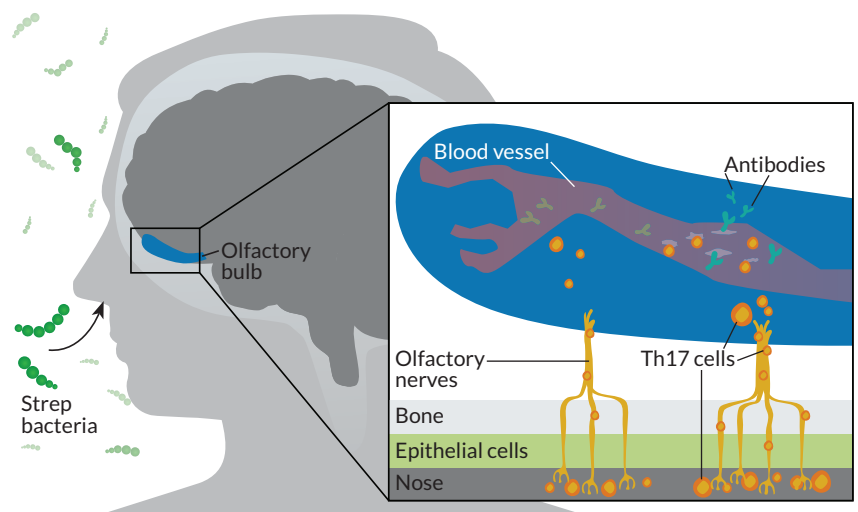
Another team of researchers wants to know how antibodies circulating in the blood cross the blood-brain barrier to reach the brain. That border of tightly connected blood vessels typically wards off invading molecules.

Exploring one possible pathway into the brain, neuroscientist Dritan Agalliu and colleagues at Columbia University Irving Medical Center infected the nasal passages of mice with strep bacteria and tracked the movements of a type of immune responder, T cells called Th17 cells.

"These T cells are sort of these double-edged sword cells," Agalliu says. Like antibodies, Th17 cells help fight off infections, but can sometimes bring harm to healthy cells. In particular, Th17 cells release inflammatory molecules that can poke holes in the blood-brain barrier, which researchers have seen in multiple sclerosis.

After several rounds of strep, Th17 cells originating in the mouse equivalent of tonsils accumulated in the animals' brains, Agalliu's team reported in 2016 in the *Journal of Clinical Investigation*. Most of the T cells pooled in the olfactory bulb, a brain region that receives odor signals from nerve cells, or neurons, extending from the nasal passages. Th17 cells responding to strep may travel along this neuronal highway to infiltrate the brain, Agalliu says.

The researchers also found a leaky blood-brain barrier and deposits of antibodies in the olfactory bulb, suggesting that the Th17 cells could carve a path for the antibodies to enter the brain. To confirm this idea, the researchers repeated their



Leaky vessels In one hypothesis, Th17 immune cells, which respond to repeated strep infections, travel from the nose along nerve cells to the brain's olfactory bulb. There, the Th17 cells cause leaks in the blood-brain barrier, allowing strep antibodies to leave the bloodstream and enter the brain. SOURCE: T. DILEEPAN ET AL./J. CLIN. INVESTIG. 2016

experiment in mice genetically engineered to lack Th17 cells. The preliminary results show that antibodies can't access the brain in these mice. Th17 cells may be key to allowing antibodies into the brain.

Agalliu's work also hints at why so few children with strep show signs of PANDAS. Successive strep infections may be partly responsible, Agalliu says. His team found that Th17 cells opened a pathway to the brain only after mice were infected with strep at least three times.

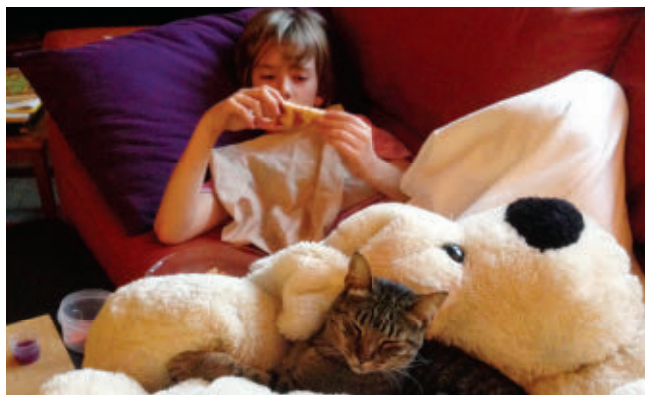
Another likely contributor is a genetic predisposition (*SN: 9/2/00, p. 151*). In their latest unpublished work, Agalliu and colleagues have identified several genetic variants that stand out in children with PANDAS symptoms. The affected genes all regulate parts of the immune system, such as the ability to dampen an immune reaction. In children with PANDAS, Agalliu says, "the immune response seems to be persistent for a longer period of time than what we normally see."

Seeking treatment

As researchers try to untangle the biological roots of PANDAS, families faced with alarming symptoms grapple with uncertainty about how to help their children. Clinicians still disagree on the right treatment approach, and only a few options have been studied in rigorous trials. Proposed treatments are backed mostly by case reports and small trials, many of which lacked a placebo comparison group.

Many PANDAS experts tout the use of antibiotics to treat the strep infections that may underlie the condition. In her own experience, Swedo has found that starting antibiotics at the first signs of PANDAS is enough to reverse the condition altogether in patients whose strep infections are still active but maybe hadn't been detected and treated.

"It's really remarkable how much of a difference prompt treatment of that infection can be," she says. Some clinicians even recommend extended courses of antibiotics to



After PANDAS struck Hans Korbmacher at age 10 (above), he was kept out of school by extreme anxiety and emotional outbursts. But in the months after receiving IVIG, or intravenous immunoglobulin, he started to improve. Today Hans is a healthy and active 15-year-old (right).



fend off future infections. But there's no compelling evidence that long-term antibiotics are warranted, Mink says. Strep infections tend to respond well to a single round of antibiotics, and unnecessary use could bring on side effects such as severe diarrhea. Chronic use also invites antibiotic resistance. "It's a public health concern as well as an individual health concern," he says.

For particularly severe cases, clinicians may turn to a more invasive treatment aimed at resetting a malfunctioning immune system. The procedure, intravenous immunoglobulin, or IVIG, is an infusion of antibodies stripped from the blood of thousands of healthy donors. The goal is for the new antibodies to bind to and disable the patient's harmful ones. IVIG is also used to treat Guillain-Barré syndrome and other autoimmune conditions.

This was the approach Hans Korbmacher's doctors took after seven months of antibiotics did little to improve the boy's condition. In October 2015, nearly two years after his initial symptoms emerged, Hans received IVIG. Heather Korbmacher started noticing changes in her son about two weeks later.

One morning, she found Hans sitting peacefully at the dining room table eating breakfast. He was wearing shorts and a T-shirt instead of pajamas, the only clothes his sensitive skin could stand at the height of his illness. As Korbmacher uttered a passing "I love you" to her son, Hans said he loved her too — something she hadn't heard in over a year. "I just stood

there and cried because I knew that my son was back," she says.

Hans improved gradually over the next six months. He is now 15 and fully recovered, says Korbmacher, who wrote a book about her family's experience. "He is healthy in his body and healthy in his mind and able to access his life again."

IVIG was a game changer for Hans, according to his mother. But the procedure is not without risks. Patients receiving IVIG may have allergic reactions and headaches severe enough to require hospitalization. And it's costly. Korbmacher was stuck with an estimated \$17,000 out-of-pocket cost until she convinced her insurance company to cover the procedure.

The scientific evidence backing IVIG to treat PANDAS is also unsettled. A 1999 clinical trial in 29 PANDAS patients reported in the *Lancet* found that the therapy suppressed obsessive-compulsive behaviors and anxiety. But a more recent trial in 35 children, published in 2016 in the *Journal of the American Academy of Child & Adolescent Psychiatry*, failed to show that IVIG performed any better than a placebo.

Swedo, who led both trials, says crucial design flaws stunted the later study. For example, any patient whose symptoms did not noticeably improve could receive an extra infusion of IVIG at the end of the trial. Researchers at the University of Arizona are planning a new trial with a more rigorous design to address these disparate results.

Some proposed PANDAS treatments are less controversial. PANDAS advocates and skeptics alike support the use of cognitive behavioral therapy and neuropsychiatric drugs such as selective serotonin reuptake inhibitors, which have been shown to be effective in treating childhood OCD. However, these treatments haven't been tested in controlled trials with PANDAS patients.

Moving forward, it's most important to get clearer data in the hands of clinicians who are seeing patients with suspected PANDAS, Mink says. For example, the field still lacks a natural history study to follow children who meet PANDAS criteria without any type of intervention. Though it would be hard to convince families to simply watch and wait, this approach would help determine whether a distinct PANDAS population truly exists, and what defines it, before treatments are tested.

Mink, who gets hate mail when he shares his skepticism publicly, says he's open to shifting his stance if compelling findings arise. "There are reasonable people that have differing opinions here," he says. "But what we really need to resolve those opinions is not going to be who speaks the loudest or who has the most advocacy groups on their side. It's really going to come down to what's the evidence." ■

Explore more

- Katrin Pape *et al.* "Immunoneuropsychiatry — novel perspectives on brain disorders." *Nature Reviews Neurology*. June 2019.

Rachel Zamzow is a freelance science writer based in Waco, Texas.

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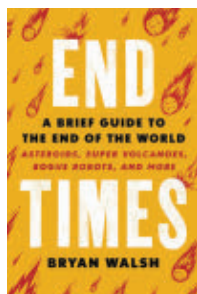


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End Times
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Now is the time to prepare for disasters that could end the world

Imagine if an asteroid as long as Central Park struck New York City. The impact would wipe out the city's population, and the effects of the

energy released — thousands of times more energy than was unleashed by the nuclear bomb dropped on Hiroshima, Japan — would be felt globally. Thermal radiation would start fires around the world, boiling the oceans and kicking off a rapid change in climate that would probably kill off hundreds of species, humans included (*SN*: 4/27/19, p. 10).

That might sound like the setup for a Hollywood disaster movie, but it's not total fiction. A similar scenario played out about 66 million years ago when an asteroid is believed to have hit the Yucatán Peninsula and devastated the dinosaurs.

The probability of such a big asteroid hitting Earth in any given year is a very small 0.000005 percent. But that's no reason not to take the threat seriously, given the catastrophic consequences, science journalist Bryan Walsh persuasively argues in his new book, *End Times*.

Walsh believes an asteroid hurtling toward Earth, supervolcanoes, nuclear war, human-caused climate change, disease epidemics and bioengineered pathogens are among the greatest risks facing the future of humankind. These existential threats, he writes, are “the disasters that could end the human story in midsentence.” But we could eliminate or minimize those threats now, he argues.

In each chapter, Walsh investigates a different risk. He visits scientists in their labs, reviews research studies and pulls from his reporting experiences as a writer and editor at *Time* magazine to put each threat in context, including

what scientists are doing to combat the danger.

To understand asteroids, he spends a night at Mount Lemmon Observatory in Tucson, Ariz., where astronomers are tracking space rocks that might intersect with Earth's orbit. In theory, there are ways to deflect an incoming asteroid before it slams into Earth, such as trying to change the asteroid's speed or approach. Walsh suggests that countries with space programs spend more on planetary defense and start practicing asteroid deflection. NASA and the European Space Agency have plans to do just that: In 2022, they intend to crash a spacecraft into an asteroid to try to alter its trajectory.

Describing such plans to counter extinction threats is what makes *End Times* stand out. It's not just another doomsday book. Walsh offers insight into some options that are within reach, such as carbon-capture technology to pull carbon dioxide out of the air to curb the effects of climate change (*SN*: 12/22/18 & 1/5/19, p. 18). He also discusses more theoretical solutions that scientists have thought up, like how to cool magma beneath a supervolcano to prevent an eruption. Drilling nearly 10 kilometers into the belly of a supervolcano to inject cold water may not really be practical and could cost about \$3.5 billion. But offering solutions that seem fantastical is still important, Walsh argues, “because doing so demands that we step outside our brief human time frame.” Thinking big about how we could protect the future of our species might lead to more feasible plans of action.

End Times isn't all doom and gloom. Walsh adds some lightness to otherwise grim visions of humankind's future by sprinkling in humor and colorful anecdotes throughout the book, like a story about his visit to an insect food fair. He learned how eating bugs could be a viable food option if a small

group of humans were to survive a catastrophic event. “It might actually take the end of the world for me to eat the tarantula tempura, a battered, fist-sized arachnid on a plate that I can still see in my nightmares,” he writes.

Ultimately, *End Times* serves as a wake-up call, letting people know that “we're not helpless in the face of those threats,” Walsh writes. “Whether we endure or die will come down chiefly to our own decisions.” Let's hope we make the right ones. — *Kyle Plantz*

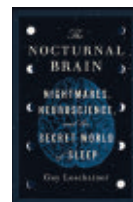
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IZAL GUERRA

Eighth-grader
Toa Alta, Puerto Rico

YOUNG INVENTOR

Society for Science & the Public and The Lemelson Foundation reward young inventors

Inspired by his love of video games, Izal Guerra wanted to create a device that would allow people who are visually impaired experience the fun, too. His gadget evolved into something that would not only help them recreationally, but also assist with practical day-to-day tasks. Guerra, an eighth-grader from Toa Alta, Puerto Rico, ended up creating a special pair of eyeglasses that uses a range of sounds to help those with mild to severe visual impairment better navigate their surroundings.

His invention recently won a Lemelson Early Inventor Prize at his local science fair. The prize rewards young inventors whose projects exemplify the ideals of inventive thinking by identifying a challenge in the community and creating a solution that will improve lives.

Guerra was motivated to help the estimated 1.3 billion people around the world who face challenges due to blindness and visual impairment. So he invented “Gafas de Ecolocación,” which roughly translates from Spanish to Echolocation Glasses.

The device, made from a repurposed virtual reality headset connected to speakers and sensors, uses sounds to signal how close an object is. The closer the object, the more acute the sound emitted from the device.

Guerra believes his invention could help the visually impaired be more mobile, eliminating the need for a probing cane, and he hopes that his device can be both affordable and accessible to those who need it.

“My most fulfilling moment was seeing the Echolocation Glasses work while testing it with an actual blind person,” he says. “It made me extremely happy and proud of myself.”

In February, the Society announced that The Lemelson Foundation will give the \$100 Lemelson Early Inventor Prize to an outstanding inventor in up to 270 Society-affiliated science fairs with middle school participants throughout the United States and its territories.



After finishing his Echolocation Glasses prototype (bottom), Izal Guerra presented his project at his local science fair (middle).

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Bygone boot print?

No nation governs the moon's surface, but NASA has issued guidelines for protecting artifacts still there from the Apollo missions, **Maria Temming** reported in "Lunar leftovers" (SN: 7/6/19 & 7/20/19, p. 26). NASA outlines how far future spacecraft should land from the Apollo sites so that rocket exhaust doesn't, for example, "wipe Neil Armstrong's first boot print off the face of the moon," **Temming** writes. Reader **Robert Struble** wondered if the first boot print is even still there. "Wouldn't that print have been obliterated when the lunar module blasted off?" he asked.

The descent stage served as a launchpad for the returning module and could have helped shield nearby footprints from the most violent gas flow, as well as keeping most of the exhaust high off the ground, says **Philip Metzger**, a planetary scientist at the University of Central Florida in Orlando. But since the first footsteps were at the base of the ladder, they would've been walked over

repeatedly by the Apollo 11 astronauts. "It is likely that the very first footstep onto the moon was destroyed before they left the moon," **Metzger** says.

Packaging problems

Biodegradable food packaging that contains industrial compounds called per- and polyfluoroalkyl substances, or PFAS, could introduce those persistent chemicals into compost, **Carolyn Wilke** reported in "Food containers may pollute compost" (SN: 7/6/19 & 7/20/19, p. 7). Online reader **Mark S.** was more concerned about PFAS leaching into food.

PFAS can move from containers to food. A 2008 study in *Food Additives & Contaminants: Part A* showed that the compounds entered microwave popcorn from packaging. "Temperature, if food is oily or water-based, and how long food touches the material play a role in the amount of PFAS that end up in food," **Wilke** says. It's unknown if compostable containers release enough PFAS into food to cause health concerns.



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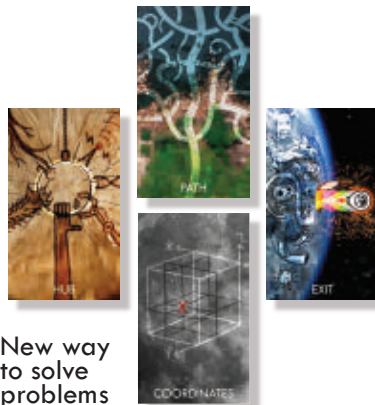
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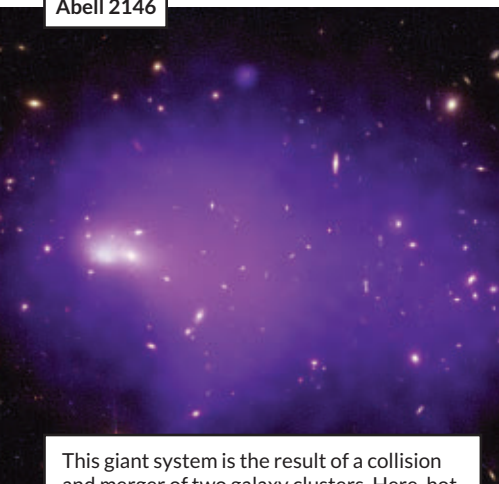
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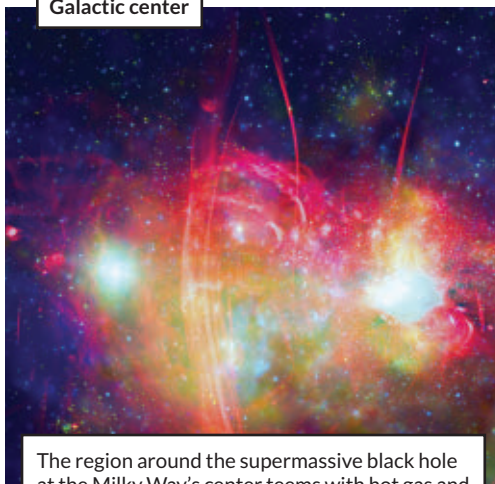
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Abell 2146



This giant system is the result of a collision and merger of two galaxy clusters. Here, hot gas glows in X-rays (purple).

Galactic center



The region around the supermassive black hole at the Milky Way's center teems with hot gas and stars (X-rays in green and blue; radio data in red).

30 Doradus



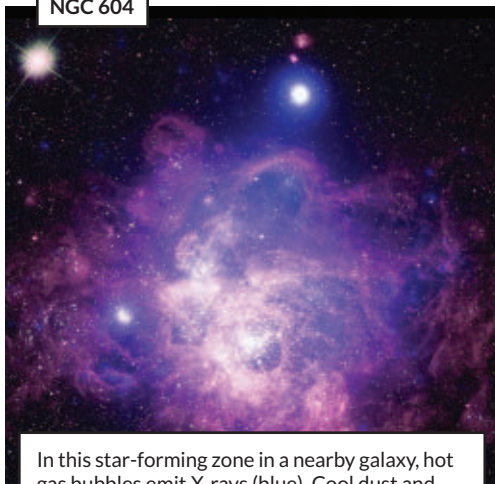
This area is one of the largest star-forming regions near the Milky Way. Colors show X-rays of varying intensities from stars.

Cygnus OB2



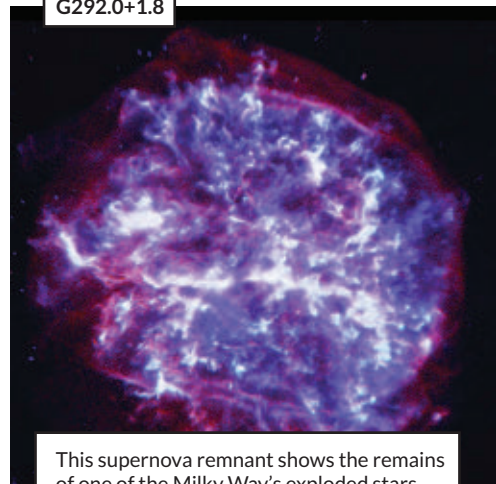
Massive stars in this star cluster in the Milky Way create winds that slam into gas and dust, producing X-rays (red and blue points).

NGC 604

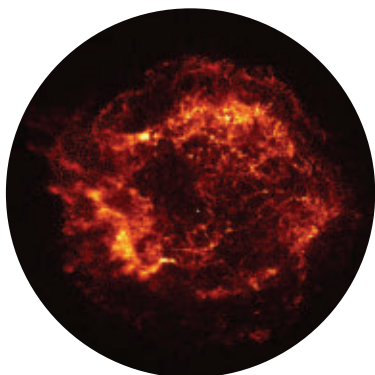


In this star-forming zone in a nearby galaxy, hot gas bubbles emit X-rays (blue). Cool dust and warm gas (purple) show up in optical data.

G292.0+1.8



This supernova remnant shows the remains of one of the Milky Way's exploded stars. Colors are X-rays of varying intensities.



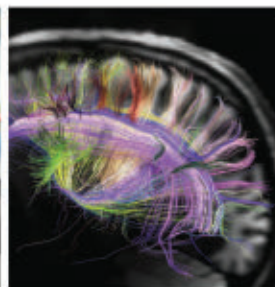
NASA's Chandra X-ray telescope turns 20

For the last two decades, the Chandra X-ray Observatory has orbited Earth, taking in high-energy X-rays that can be detected only from above the planet's atmosphere.

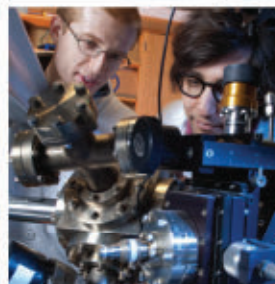
To celebrate Chandra's 20th anniversary, NASA has released six images (above) that highlight the breadth of what those X-rays can reveal; each image combines X-ray data with optical, radio or other observations.

One of the telescope's first images (left) was released 20 years ago this month, on August 26, 1999. It reveals X-rays from the supernova remnant Cassiopeia A, found about 11,000 light-years away from Earth, as well as X-rays from the dense neutron star that formed after Cassiopeia A's star exploded.

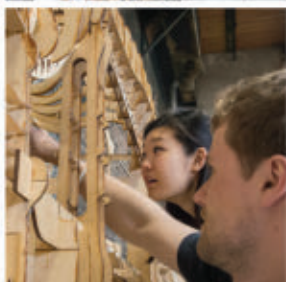
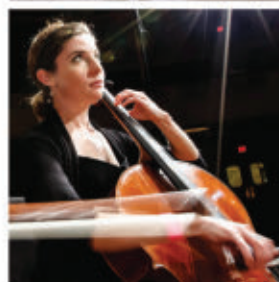
"Chandra remains peerless in its ability to find and study X-ray sources," Chandra X-ray Center director and astrophysicist Belinda Wilkes said in a statement. "Since virtually every astronomical source emits X-rays, we need a telescope like Chandra to fully view and understand our universe." — *Lisa Grossman*



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