SN
SCIENCE NEWS MAGAZINE
SOCIETY FOR SCIENCE & THE PUBLIC
DECEMBER 23, 2017 & JANUARY 6, 2018

Pterosaur Hatchlings Didn't Fly

Arrow of Time Reversed

Dead Sea Scrolls' Protectors

Why Men Get Asthma Less

OUT WITH A BANG

Neutron stars collide and other top stories of 2017

Out of Africa

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VOL. 192 | NO. 11

ScienceNews

2017 Year in Review

News

11

4

Departments

COVER The debris cloud from two merging neutron stars (illustrated) forged a lot of heavy elements. *CI Lab/NASA Goddard Space Flight Center*

2017 delivered humility, and proved our potential

The Top 10 science stories of 2017, selected by *Science News* staff and presented in this year-end issue, have the potential to make you feel small and certainly humble. Our No. 1 story of the year (Page 18) takes place an unfathomably distant 130 million light-years away, where a neutron star smashup produced, by some estimates, 10 Earth masses worth of gold — wow! That's enough for many trillions of trillions of wedding bands. A bit closer to home, in a solar system just 39 light-years away, seven Earth-sized worlds, at least three of them potentially habitable, had astrobiologists buzzing (Page 25). That story, No. 5, forces us to dismiss any lingering notions that Earth is unique.

Here on Earth, but also in remote and unfamiliar territory, an iceberg the size of Delaware broke away from the fourth largest ice shelf in Antarctica, earning our No. 3 spot (Page 22) and offering scientists a chance to study newly forming ecosystems. This year was heavy with science events (Page 32) — both energizing and fear-provoking. A vast stretch of the United States stopped in wonder as the moon slid between us and the sun, turning day into dark. And the destructive power of nature was on full display during hurricanes, earthquakes and wildfires that pay no heed to human life or property.

Other stories that made our Top 10 list cover topics not necessarily grand in scale but deep in complexity. Our No. 2 story, on gene editing in viable human embryos (Page 21), reminds us of the many intricacies of human biology. Each of us somehow emerges from fragile strands of DNA into breathing, yearning individuals. And the beginnings of our species are also humble. *Homo sapiens* may have emerged piece by piece beginning about 300,000 years ago, according to our No. 4 story (Page 24). Despite all efforts, there is still so much left to figure out about ourselves and our world. Stories No. 9 and No. 10 show how much we don't know, for instance, about head trauma and the Zika virus (Page 30).

Yet in spite of our small size and humble beginnings, we have demonstrated through scientific advances in 2017 that we humans are a mighty force. Desiring to detect gravitational waves from some of the most impressive cosmic phenomena, scientists spent decades creating instruments sensitive enough to spot distance shifts smaller than a proton. After two neutron stars collided, researchers numbering in the thousands collaborated on a global scale to make sense of the data. When that Antarctic iceberg calved, scientists mobilized quickly to learn as much as possible about the remaining ice.

We've found innovative ways to treat challenging diseases (the U.S. Food and Drug Administration's approval of CAR-T cell therapy for certain blood cancers is our No. 8 story, on Page 29). We've gathered some of the clues necessary to begin to understand how climate change might affect nutrient availability (story No. 7, on Page 28). And despite our complex biology, we have figured out how to edit our DNA, changing our own lives and those of our children.

We might not have the power to collide neutron stars or to produce more gold than we could ever mold into jewelry, but with science, we have the tools to shape our lives and our planet. I'm both anxious and excited to see what we will do in 2018. — *Elizabeth Quill, Acting Editor in Chief*

THE SCIENCES AND LIBERAL ARTS AT OBERLIN COLLEGE

A science education is more valuable when broadened with liberal arts studies. An effective scientist needs to communicate with colleagues possessing a different (or no) scientific background. A liberal arts education (subjects like literature, philosophy, economics, sociology, history, and political science) helps to communicate scientific issues to managers, sponsors, and colleagues with less scientific expertise.

- The **$50,000 Nexial Prize** is awarded annually to the graduating senior at Oberlin who in addition to being a top science major, also excels at liberal arts studies. Unique to Oberlin, there is no other award in higher education that celebrates a liberal arts educated scientist.
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Excerpt from the December 30, 1967 issue of *Science News*

50 YEARS AGO

Viable synthetic DNA

[Scientists] produced in a test tube a totally artificial copy of a type of DNA virus.... The particular type of viral DNA (called Phi X174) the researchers made is an extremely simple molecule of only five or six genes. Their achievement, however, lays the foundation for eventual synthesis of more complex DNAs.

UPDATE: As predicted, that lab-made DNA molecule gave way to more complex forms, including whole genomes, and even semisynthetic organisms, albeit small ones (*SN: 4/16/16, p. 6*). In 2014, researchers reported endowing an *E. coli* bacterium with genetic instructions for creating amino acids not found in nature. Now, that semisynthetic strain of *E. coli* has made glowing green proteins with those unnatural molecules, scientists at Scripps Research Institute in La Jolla, Calif., and colleagues report November 30 in *Nature*.

In harbor porpoises (one shown), females have vaginal folds (3-D endocast shown below) that may help them exert control over fertilization.

THE SCIENCE LIFE

It's all about the fit

The battle of the sexes, at least among certain ocean mammals, may come down to well-placed skin folds, suggests research by Patricia Brennan, an evolutionary biologist at Mount Holyoke College in South Hadley, Mass., and colleagues.

In some species, enhanced male-female genital fit has evolved over time in ways that make mating easier. This is an example of what scientists call congruent evolution. In other species, genital anatomy reflects a battle, as shape and form change over time to give one sex an edge in control of fertilization. Fittingly, this is called antagonistic evolution.

Brennan's recent collaboration, examining genitalia of porpoises, dolphins and seals, required extra creativity. In previous studies, her team used saline to inflate preserved penises from birds, snakes, sharks and bats. But the tough, fibroelastic penises of the cetaceans would not inflate with saline alone. So her collaborator, Diane Kelly, a penis biomechanics expert at the University of Massachusetts Amherst, suggested pressurizing the saline with a beer keg.

"We looked at each other and said, 'This could be the best or worst idea we've ever had,'" Brennan laughs. But it worked. The scientists then created vaginal endocasts with dental silicone and made 3-D mathematical models to examine male-female fit. The team, led by marine mammalogist Dara Orbach of Dalhousie University in Halifax, Canada, described the work in the Oct. 11 *Proceedings of the Royal Society B*.

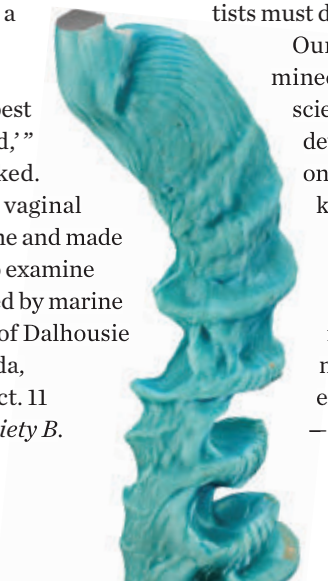
The results show both antagonistic and congruent coevolution. In the model vaginas of short-beaked common dolphins (*Delphinus delphis*) and harbor seals (*Phoca vitulina*), penises encountered no physical barriers to penetration.

But in harbor porpoises (*Phocoena phocoena*) and bottlenosed dolphins (*Tursiops truncatus*), the scientists found vaginal folds that may help females physically exert choice over sperm. By subtly changing body position during sex, females may use those folds to decrease penetration depth, reducing the likelihood of fertilization by unwanted males, Brennan says.

Brennan's work has, understandably, made a splash over the years, attracting media coverage and, in 2013, criticism. Conservative news websites and internet trolls attacked her research, calling it "wasteful government spending." Surprised by the reaction, Brennan responded publicly with an essay in *Slate*, arguing that basic science moves society forward and is a valid and valuable use of public funds. The experience convinced her that scientists must defend basic science.

Our ability to innovate is undermined without curiosity-driven science, she says. Brennan has developed an outreach program on basic science and plans to keep expanding knowledge of vertebrate genitalia. "In every species we have looked," she says, "we have found something weird that nobody else knew." Reason enough to keep discovering.

— Lesley Evans Ogden



FROM TOP: SOLVIN ZANKL/ALAMY STOCK PHOTO; D. ORBACH

From 2015 through 2017, flour tainted by *E. coli* sickened more than 90 people in the United States and Canada, most of whom had eaten raw dough or batter.

FOR DAILY USE

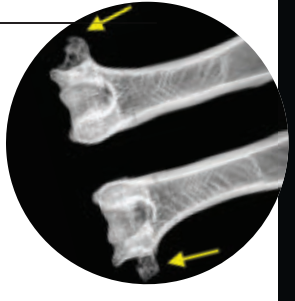
Step away from the cookie dough

Eggs, long condemned for making raw cookie dough a forbidden treat, now share some disease-causing blame with another culprit: flour. The dry pantry staple can harbor strains of *E. coli* bacteria that make people sick, as happened in *E. coli* outbreaks that sickened 63 people in the United States and 30 in Canada from 2015 through 2017.

Pinning down tainted flour as the source of the U.S. outbreak required detailed interviews with people who had fallen ill, researchers recount in the Nov. 23 *New England Journal of Medicine*. Two people remembered eating raw cookie dough before getting sick, says study leader Samuel Crowe, an epidemiologist at the U.S. Centers for Disease Control and Prevention in Atlanta. Both sent Crowe pictures of the bags of flour used to make the batter, and it turned out both bags came from the same plant. Strains of *E. coli* that produce dangerous Shiga toxins were isolated from flour made at the plant. *E. coli* and other bacteria can survive in a dried state for months. Once dry flour mingles with eggs or oil, dormant bacteria can reawaken and start to replicate. — *Laurel Hamers*

RETHINK

Dolly the Sheep's arthritis was normal for her age



This X-ray of Dolly the Sheep's limb bones shows signs of mild arthritis (arrows).

In the scientific version of her obituary, Dolly the Sheep was reported to have had severe arthritis in her knees. That finding and Dolly's early death from an infection led many researchers to think that cloning might cause animals to age prematurely.

But new X-rays indicate that the world's first cloned mammal had the joints of a normal sheep her age. She had only a little arthritis in her hips, knees and elbows, developmental biologist Kevin Sinclair of the University of Nottingham in England and colleagues report November 23 in *Scientific Reports*. The researchers reexamined Dolly's remains after finding that her cloned "sisters" have aged normally without massive arthritis (*SN: 8/20/16, p. 6*). Sinclair and colleagues got the skeletons of Dolly, her naturally conceived daughter Bonnie and two other cloned sheep, Megan and Morag, from the National Museums Scotland in Edinburgh. Megan and Bonnie were both older than Dolly when they died and had more bone damage. Morag died younger and had less damage.

Dolly's arthritis levels were not excessive, says study coauthor Sandra Corr. "If there were a direct link with cloning and osteoarthritis, we would have expected to find a lot worse," says Corr, a veterinary orthopedic specialist at the University of Glasgow in Scotland. Dolly's slightly creaky joints may have stemmed from giving birth to six lambs, including Bonnie. Pregnancy is a risk factor for arthritis in sheep. — *Tina Hesman Saey*

Hanny's Voorwerp, the greenish smudge at left, is glowing thanks to particles of light from a feasting black hole in the galaxy above.

MYSTERY SOLVED

Voorwerp explained

The weird glow of a cosmic blob known as Hanny's Voorwerp was a mystery for close to a decade. Now, Lia Sartori of ETH Zurich and colleagues have come to a two-part solution.

Hanny van Arkel, then a teacher in the Netherlands, discovered the strange green *voorwerp*, Dutch for "object," in 2008 as she was categorizing pictures of galaxies as part of the Galaxy Zoo citizen science project.

Further observations showed that the object was a glowing cloud of gas that stretched some 100,000 light-years from the core of a black hole–containing galaxy nearby. As black holes eat surrounding gas and dust, friction heats the doomed material until it glows white hot, forming an active galactic nucleus, or AGN. When this galaxy's radiation reached the voorwerp, the object glowed. Given the voorwerp's glare, the AGN should have had the brightness of about 2.5 trillion suns. Yet its radio emission suggested it emitted the equivalent of a paltry 25,000 suns. Either the AGN was obscured by dust, or the black hole slowed its eating about 100,000 years ago, dimming the light.

Sartori and colleagues made the first direct measurement of the AGN's intrinsic brightness using NASA's NuSTAR telescope to observe the galaxy in high-energy X-rays that cut through dust. The team found that the AGN is obscured by dust *and* is dimmer than expected; the feeding has slowed way down. The team reports online November 20 at arXiv.org that the AGN is as bright as 50 billion to 100 billion suns.

"Both hypotheses that we thought before are true," Sartori says. — *Lisa Grossman*

CLOCKWISE FROM TOP: GEORGE NAZMI BEBAWI/SHUTTERSTOCK; NASA, ESA, W. KEEL/UNIV. OF ALABAMA *ET AL*, GALAXY ZOO TEAM; S. CORR/UNIV. OF GLASGOW

LIFE & EVOLUTION

Trove of pterosaur eggs unearthed

Hundreds of fossils give clues to flying reptile's development

BY CAROLYN GRAMLING

Hundreds of eggs belonging to a species of flying reptile that lived alongside dinosaurs are giving scientists a peek into the earliest development of the animals.

The find includes at least 16 partial embryos, several still preserved in 3-D. Those embryos suggest that the animals were able to walk, but not fly, soon after hatching, researchers report in the Dec. 1 *Science*.

Led by vertebrate paleontologist Xiaolin Wang of the Chinese Academy of Sciences in Beijing, the scientists uncovered at least 215 eggs in a block of sandstone about 3 meters square. All of the eggs belonged to one species of pterosaur, *Hamipterus tianshanensis*, which lived in the early Cretaceous Period about 120 million years ago in what is now northwestern China.

Previously, researchers had found only a handful of eggs belonging to the winged reptiles, including five eggs from the same site in China (*SN: 7/12/14, p. 20*) and two more found in Argentina. One of the Argentinian eggs also contained a flattened but well-preserved embryo.

One reason for the dearth of fossils may be that the eggs were rather soft with a thin outer shell, unlike the hard casings of eggs belonging to dinosaurs, birds and crocodiles but similar to those of modern-day lizards. Because of that softness, pterosaur eggs also tended to flatten during preservation. Finding fossilized eggs containing 3-D embryos opens a new window into pterosaur development, says study coauthor Alexander Kellner, a vertebrate paleontologist at Museu Nacional/Universidade Federal do Rio de Janeiro.

The eggs weren't found at an original nesting site but had been jumbled and deformed, probably transported by a flood during an intense storm, Kellner says. Sand and other sediments carried by the water would then have rapidly buried the soft eggs, which was key to preserving them, he says. "Otherwise, they would have decomposed."

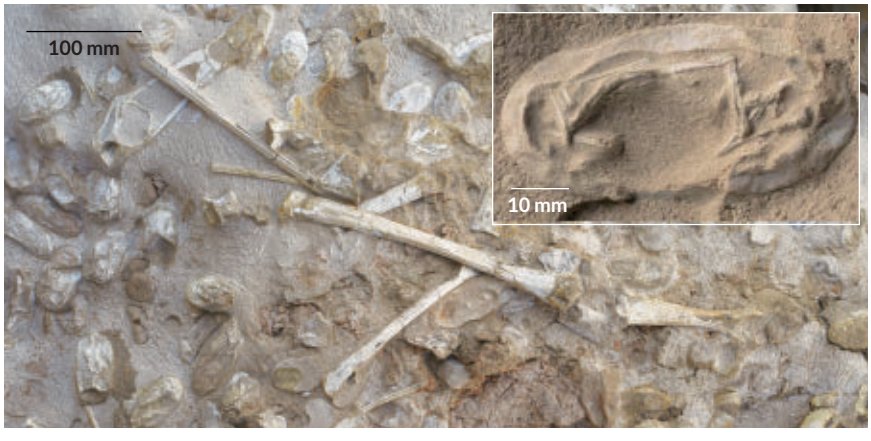
Using computerized tomography, the researchers scanned the internal contents of the eggs. Two of the best-preserved embryos revealed a tantalizing clue to pterosaur development, Kellner says. A key part of a wing bone, called the deltopectoral crest, was not fully developed in the embryos, even in an embryo the researchers interpret as nearly at term. The femur, or upper leg bone, of the embryo, however, was well developed. This suggests that, when born, the hatchlings could walk but not yet fly and may have still required some parental care for feeding, the scientists propose.

Such an interpretation requires an abundance of caution, says D. Charles Deeming, a vertebrate paleontologist at the University of Lincoln in England who was not involved in the study. For instance, he says, there isn't enough evidence to say for certain that the embryo in question was nearly at term and, therefore, to say that it couldn't fly when born. He also raises the point in a commentary published in the same issue of *Science*. "There's a real danger of overinterpretation." But with such a large group of eggs, he says, researchers can make quantitative measurements to better understand the range of egg sizes and shapes to get a sense of variation in animal size.

Kellner says this work is ongoing and agrees that there is still a significant amount of study to be done on these and other eggs more recently found at the site in China. And the hunt is on for more concentrations of eggs there. "Now that we know what they look like, we can go back and find more," he says. "You just have to get your knees down and look." ■

A bone bed in China with a rare collection of fossilized eggs of *Hamipterus tianshanensis* offers a glimpse into the early development of this pterosaur (adult illustrated) that lived during the Cretaceous Period.

Floodwater from an intense storm may have swept away hundreds of *Hamipterus tianshanensis* pterosaur eggs, along with a few scattered remains of adults, and buried the objects in this bone bed in China. One egg (inset) contains a nearly complete pterosaur embryo. Preserved in 3-D, the embryo allows scientists to study the arrangement and development of its bones.



FROM TOP: CHUANG ZHAO; X. WANG *ET AL*./*SCIENCE* 2017

Neutron stars' strange matter probed

Merger provides hints to size, squishiness of these stellar cores

BY EMILY CONOVER

On astrophysicists' charts of star stuff, there's a substance that still merits the label "here be dragons." The poorly understood material is found inside neutron stars — the collapsed remnants of once-mighty stars — and is a territory that's now being mapped out, as scientists better characterize the weird matter.

The first direct detection of two colliding neutron stars, reported in October (see Page 18), has accelerated the pace of discovery. Since the event, several studies have placed new limits on the sizes and masses possible for such stellar husks and on how squishy or stiff they are.

2.2
solar masses
Estimated upper limit of a neutron star's maximum possible mass

"The properties of neutron star matter are not very well known," says Andreas Bauswein, a physicist at the Heidelberg Institute for Theoretical Studies in Germany. The matter inside a neutron star is so dense that a teaspoonful would weigh about a billion tons, so the substance can't be reproduced and studied in a lab.

In the collision, the neutron stars merged into a single behemoth. This remnant may have immediately collapsed into a black hole. Or it may have formed a bigger, spinning neutron star that, propped up by its own rapid rotation, existed for a few milliseconds — or potentially much longer — before collapsing. The speed of the object's demise is helping scientists figure out whether neutron stars are made of material that is relatively soft, compressing when squeezed like a pillow, or stiff, standing up to pressure. This property, called the equation of state, determines the radius of a neutron star of a particular mass.

An immediate collapse seems unlikely, two research teams say. Telescopes spotted a bright glow of light after the collision. That glow could appear only if there were a delay before the merged neutron star collapsed into a black hole, says Princeton University physicist David Radice. When the remnant collapses, "all the material around falls inside of the black hole immediately." Instead, the neutron star lasted at least several milliseconds, the scientists propose.

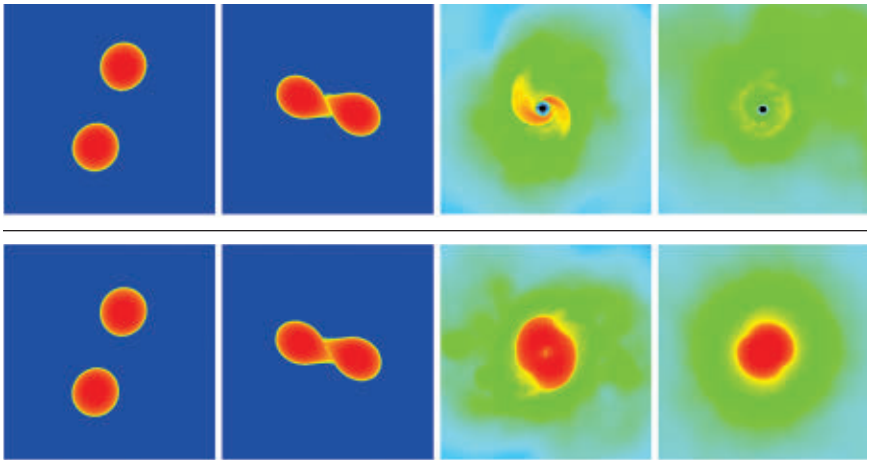
Simulations indicate that if neutron stars are soft, they will collapse more quickly because they will be smaller than stiff neutron stars of the same mass. So the inferred delay allows Radice and colleagues to rule out theories that predict neutron stars are extremely squishy, the team reports November 13 at arXiv.org.

Using similar logic, Bauswein and colleagues rule out some of the smallest sizes that neutron stars of a particular mass might be. For example, a neutron star 60 percent more massive than the sun can't have a radius smaller than 10.7 kilometers. This result appears in the Dec. 1 *Astrophysical Journal Letters*.

Other researchers set a limit on a neutron star's maximum mass. Above a certain heft, neutron stars can't support their own weight and collapse. If this maximum possible mass were very large, theories predict that the merged neutron star would have lasted hours or days. But, in a third study, physicists determined that the collapse came more quickly, on the scale of milliseconds. A long-lasting, spinning neutron star would dissipate its rotational energy into the material ejected from the collision, making the stream of glowing matter more energetic than what was seen, Ben Margalit and Brian Metzger of Columbia University report. In the Dec. 1 *Astrophysical Journal Letters*, the pair concludes that the maximum possible mass of a neutron star is smaller than about 2.2 times that of the sun.

The result also rules out some of the stiffer equations of state because stiffer matter tends to support larger masses without collapsing.

Some theories predict that neutron stars harbor bizarre forms of matter such as free-floating quarks, normally confined within larger particles like protons. Other physicists suggest that neutron stars contain hyperons, particles made with heavier quarks known as strange quarks, which are not found in normal matter. Such odd matter would tend to make neutron stars softer, so pinning down the equation of state with additional neutron star crashes may resolve whether these exotic beasts of physics indeed lurk in this unexplored territory. ■



Merger options Computer simulations indicate that colliding neutron stars can immediately collapse into a black hole (top row) or temporarily stay a neutron star (bottom row). In the aftermath of the first directly detected neutron star smashup, telescopes captured light that could have been emitted only if the collapse was delayed, helping narrow down neutron stars' properties.

A. BAUSWEIN/HITS

HUMANS & SOCIETY

Celibates linked to Dead Sea Scrolls site

Skeletons offer clues to who wrote or protected the documents

BY BRUCE BOWER

A decades-long debate over who once occupied a settlement located near the caves where the Dead Sea Scrolls were found has taken a chaste turn.

Analyses of 33 newly excavated skeletons of people buried at the West Bank site known as Qumran support a view that the community consisted of a religious sect of celibate men. Anthropologist Yossi Nagar of the Israel Antiquities Authority in Jerusalem reported the findings November 16. Preliminary radiocarbon dating of one bone indicates the bodies are about 2,200 years old — close to the same age as the ancient texts, which are estimated to have been written between about 150 B.C. and A.D. 70.

Plus, reexamination of 53 previously unearthed skeletons from Qumran's cemetery found that six of seven people formerly tagged as women were actually men, Nagar said. A small number of children have also been excavated at Qumran.

Nagar identified 30 of the newly excavated individuals as definitely or probably males based on factors that include pelvic shape and body size. The remaining three skeletons lacked enough evidence to assign a sex. At the time of death, the men ranged in age from about 20 to 50 years or older, Nagar estimated.

"I don't know if these were the people who produced the Qumran region's Dead Sea Scrolls," he said. "But the high concentration of adult males of various ages buried at Qumran is similar to what has been found at cemeteries connected to Byzantine monasteries." The Byzantine Empire, founded in A.D. 330, was an extension of the Roman Empire in the eastern Mediterranean.

Earlier investigations at Qumran suggested it was founded over 2,700 years ago. Warfare led to its abandonment before it was settled again for about 200 years, up to around A.D. 68.

Discovery of the Dead Sea Scrolls, which include parts of the Hebrew Bible, from 1947 to 1956 in 11 nearby caves stimulated intense interest in who had occupied Qumran. In February 2017, researchers revealed they had found another cave in the same area that possibly held scrolls or pieces of papyrus and leather intended to be written on.

An influential early theory held that members of an ancient, celibate Jewish sect, the Essenes, lived at Qumran and either wrote the Dead Sea Scrolls or were caretakers of the documents. But over the last 30 years, other possible inhabitants of Qumran have been proposed, including Bedouin herders, craftsmen and Roman soldiers.

Qumran individuals show no signs of war-related injuries and are not predominantly young adult men, as would be expected of a cemetery for soldiers, Nagar said. The Qumran skeletons can't be confirmed as Essenes, but their identity as part of a community of celibate men appears probable, he added.

Extraction and analysis of DNA from the Qumran skeletons would help confirm that they are all, or almost all, male, said Jonathan Rosenbaum, a professor of Jewish studies at Gratz College in Melrose Park, Pa.

Researchers removed small samples of bone from some of the newly excavated Qumran skeletons before reburying the finds in their original resting places. Nagar wasn't sure if any attempts to retrieve DNA from bone samples would be launched. ■

MEETING NOTE

Hidden hoard hints at how elites protected treasures

Long before anyone opened a bank account or rented a safe deposit box, wealth protection demanded a bit of guile and a broken beer jug. A 3,100-year-old jewelry stash was discovered in just such a vessel, unearthed in 2010 from an ancient fortress city in Israel called Megiddo. Now the find is providing clues to how affluent folk hoarded their valuables at a time when fortunes rested on fancy metalwork, not money.

At Megiddo, a high-ranking Canaanite family stashed jewelry in the beer jug and hid it in a courtyard's corner under a bowl, possibly under a veil of cloth, Eran Arie of the Israel Museum in Jerusalem reported November 17. The hoard's owners removed the jug's neck and inserted a bundle of 35 silver items, including earrings and a bracelet, which were wrapped in two linen cloths. Other valuables were added on top, including some 1,300 beads of silver and electrum — an alloy of gold and silver — that had probably been threaded into an elaborate necklace. The jug also held 10 additional pieces of electrum jewelry.

Members of an elite family removed this Iron Age beer jug's neck to stash jewelry inside, a researcher suspects.

A Canaanite city palace stood only about 30 meters from the Iron Age building where the courtyard was, Arie said. Given the lesser building's strategic location, its inhabitants must have held key government positions, he proposed. "For the family that lived there, the hoard represented the lion's share of their wealth." Those family members presumably fled about the time their residence was destroyed in a catastrophic event, perhaps a battle.

The Megiddo hoard was hidden but not buried, giving its owners quick access to their valuables. But no one ever retrieved the treasure. "We will never know why no one returned to claim this hoard," Arie said. — *Bruce Bower*

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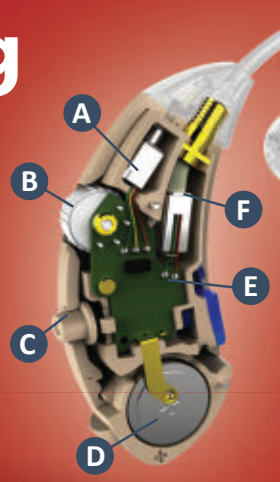

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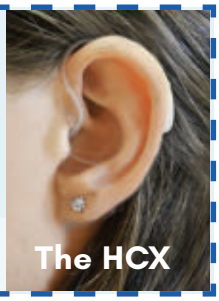

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LIFE & EVOLUTION

Other trees join ash on beetle's hit list

Scientists examine borer's effects on white fringe, olive species

BY SUSAN MILIUS

DENVER — An invasive beetle has unexpected — and potentially troublesome — tastes in trees. Now two studies reported at the annual Entomological Society of America meeting are clarifying the emerald ash borer's dining habits.

The metallic-green Asian beetles (*Agrilus planipennis*) have devastated swaths of forest in North America. For years, researchers believed that only ash trees were at risk. But in 2014, researchers noticed infestations in white fringe trees (*Chionanthus virginicus*), a multistemmed tree native to the southeastern United States with flowers like a cluster of streamers. And after looking at trees related to ashes, researchers reported lab evidence in 2017 that the beetle larvae can grow to adulthood in the Manzanilla variety of commercial olive trees (*Olea europaea*). Whether the beetle poses a serious or slight risk to the overlooked targets is still being researched.

Emerald ash borers, accidentally imported probably in wood packing materials in the 1980s or '90s, have killed hundreds of millions of ash trees in 31 states and two Canadian provinces. Larvae chewing tunnels through trees' internal nutrient channels can doom a tree. It's "a major, major pest," says entomologist Jackie Hoban of the University of Maryland in College Park. "It's so sad — you see entire patches of trees just dead."

Lab tests show that adult ash borers don't eat as much of the olive tree leaves as they do of ash leaves, Donnie Peterson, a forest entomologist at Wright State University in Dayton, Ohio, reported November 6 at the meeting. Adults die prematurely if olive leaves are the only food option. But adults' low interest in this variety of olive doesn't yet mean the trees are safe. Female beetles feeding on ash trees might, in theory, fly to a nearby olive tree to lay eggs.

To compare beetles' preferences for laying eggs on olive versus ash trees will take a larger study. But Peterson's first results are a little worrying. When he put olives and green ashes in a known infested zone, one of the few eggs he found was on an olive tree.

Free-flying beetles do lay eggs on white fringe trees, attacks that long went unreported. But the trees may not be as healthful a feeding site for beetle larvae as ash trees. In indoor tests, fewer larvae survived to their later stages on the fringe trees compared with larvae on white ashes, David Olson of the University of Kentucky in Lexington reported November 5.

Olson works on whether biocontrol strategies developed for ash trees might also work on white fringe trees. So far, the results don't look encouraging. In outdoor tests, the most successful of four tiny parasitic wasp species released in North America did what they're supposed to do: *Tetrastichus planipennisi* used beetle larvae in ash trees as food for baby wasps. Beetle larvae in fringe trees, however, escaped wasp attacks.

Even if fringe trees don't turn out to suffer massive damage, borer feeding could still present a real threat if nurseries shipping trees from infested areas accidentally transport beetles to uninfested territory, Hoban says. The hope is that wasps will help keep beetles in check, and some exceptional ash trees will prove resistant enough to rebuild some sort of population. ■

The emerald ash borer has been attacking ash trees in North America for more than 20 years, but other trees may also be at risk.

DAVID CAPPAERT, MICHIGAN STATE UNIV., USDA (CC BY 2.0)

MATTER & ENERGY

Physicists reverse 'arrow of time'

Quantum test doesn't violate second law of thermodynamics

BY EMILY CONOVER

Your lukewarm cup of coffee won't suddenly heat itself up, no matter how long you put off the trek to the microwave. But the same rule doesn't necessarily apply to quantum systems. Like chilly air warming a mug, heat can spontaneously flow from a cold quantum particle to a hotter one under certain conditions, researchers report November 10 at arXiv.org. This phenomenon seems to reverse the "arrow of time," the idea that natural processes run forward but not in reverse (*SN: 7/25/15, p. 15*).

The existence of an arrow follows from the second law of thermodynamics. The law states that entropy, or disorder, tends to increase over time. That rule explains why it's easy to shatter a glass but hard to put it back together, and why heat spontaneously flows from hot to cold but not in the opposite direction.

The new result, however, "shows that the arrow of time is not an absolute concept, but a relative concept," says study coauthor Eric Lutz, a theoretical physicist at the University of Erlangen-Nürnberg in Germany. Different systems can have arrows of time that point in different directions, Lutz says. While the arrow was apparently reversed for the two quantum particles the researchers studied, for example, the arrow pointed in its typical direction in the rest of the laboratory.

Reversing the arrow of time was possible for the quantum particles because they were correlated — their properties were linked in a way that isn't possible for larger objects, a relationship akin to quantum entanglement but not as strong. This correlation means that the particles share some information. In thermodynamics, information has physical significance (*SN: 5/28/16, p. 10*). "There's order in the form of

correlations," says David Jennings, a physicist at the University of Oxford who was not involved with the research. "This order is like fuel" that can be consumed to drive heat to flow in reverse.

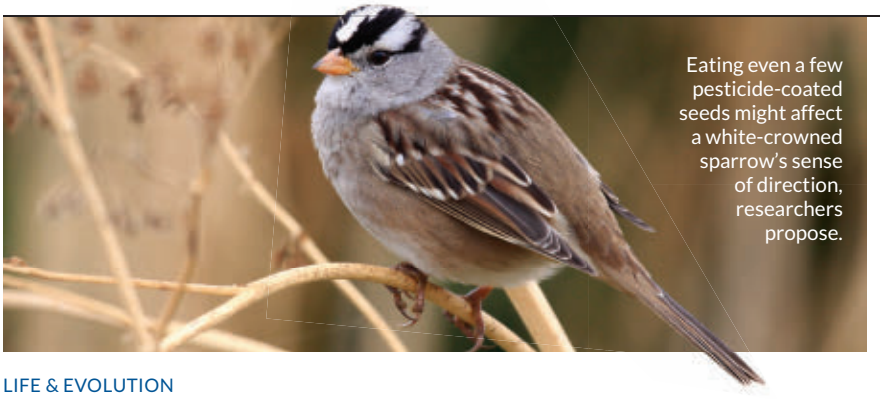
Led by physicist Roberto Serra of the Federal University of ABC in Santo André, Brazil, the experimenters manipulated molecules of chloroform, which are made of carbon, hydrogen and chlorine atoms. The scientists prepared the molecules so that the temperature — judged by the probability of an atom's nucleus being found in a higher energy state — was greater for the hydrogen nucleus than for the carbon. When the two nuclei's energy states were uncorrelated, the heat flowed as normal, from hot hydrogen to cold carbon. But when the two nuclei had strong enough quantum correlations, heat flowed backward, making the hot nucleus hotter and the cold nucleus colder.

"It's not that it's contradicting any laws of physics," says physicist Vlatko Vedral of the University of Oxford, who was not involved with the study. The standard second law of thermodynamics assumes that there are no such correlations. When the second law is generalized to take correlations into account, the law holds firm. As the heat flows, the correlations between the two nuclei dissipate, a process that compensates for the entropy decrease due to the reverse heat flow.

> Heat can spontaneously flow from a cold quantum particle to a hotter one.

"It's a very nice experiment," says physicist Gerardo Adesso of the University of Nottingham in England. But, he says, theoretical physicists had already predicted that such an effect could occur, so "it's not entirely surprising."

Scientists hope to use the weird thermodynamics of quantum particles to create quantum engines that could perform tasks beyond the reach of typical machines (*SN: 3/19/16, p. 18*), such as controlling the direction of heat flow on small scales, Serra says. ■



Eating even a few pesticide-coated seeds might affect a white-crowned sparrow's sense of direction, researchers propose.

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LIFE & EVOLUTION

Common pesticide disorients sparrows

Eating neonicotinoid-coated seeds might affect birds' migration

BY LAUREL HAMERS

MINNEAPOLIS — Pesticides that kill insects can also have short-term effects on seed-eating birds. Ingesting even small amounts of imidacloprid, a common neonicotinoid pesticide, can disorient migratory white-crowned sparrows, researchers report.

Neonicotinoids were designed to be safer than traditional pesticides: toxic to insects but comparatively harmless to other animals. But the new findings add to evidence suggesting that the widely used pesticides, which are chemically similar to nicotine, might be sending ecological ripples beyond the intended targets.

In lab studies, scientists captured wild white-crowned sparrows (*Zonotrichia leucophrys*) that were migrating north and fed them small doses of imidacloprid for three days — the amount that sparrows would get from eating a few pesticide-coated wheat seeds. The birds that ate the pesticide lost weight, study coauthor Margaret Eng reported November 15 at the annual meeting of the Society of Environmental Toxicology and Chemistry North America.

And when placed in a large, inverted funnel used to study birds' migratory orientations, the neonicotinoid-fed birds tried to fly in directions other than north. Birds that consumed sunflower oil instead showed no ill effects.

For the birds that ate the pesticide, the damage was temporary — after two weeks, the birds regained normal function and body weight, Eng, a toxicologist at the University of Saskatchewan in Saskatoon, Canada, and colleagues also reported November 9 in *Scientific Reports*.

Other birds also show temporary behavioral effects in response to neonicotinoids, says toxicologist Thomas Bean of the University of Maryland in College Park, who has carried out similar lab studies in Japanese quail. But extrapolating across species is difficult. In quail, the effects disappeared after a few days, rather than the few weeks it took the sparrows to fully recover.

Preliminary results from field studies appear to support the published lab findings. Eng's team outfitted white-crowned sparrows in the wild with tiny tracking tags. The scientists gave the birds small amounts of pesticide, held the birds for six hours and then released them.

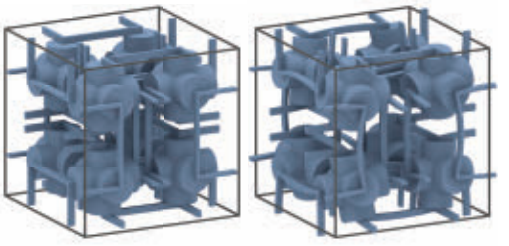
When released, the birds still had traces of the chemicals in their blood plasma, the researchers reported at the meeting. On average, there wasn't a difference between groups in how long birds hung around before resuming migration, but all of the birds that waited an abnormally long time had eaten neonicotinoids. Those birds' flight paths also appeared to be slightly skewed from the route favored by birds that didn't eat the pesticide.

Those analyses are preliminary, cautions Eng, and a closer look at the data could change the story. ■

MATH & TECHNOLOGY

Material acts oddly under pressure

When squeezed, microcube expands rather than contracts



As pressure increases, a metamaterial expands (depicted here bulging out of the right cube).

BY MARIA TEMMING

A newly fabricated material does more than just hold up under pressure. Unlike many ordinary objects that shrink when squeezed, the metamaterial — a synthetic structure designed to exhibit properties not typically found in natural materials — expands at higher pressures.

This counterintuitive material is made up of a grid of hollow 3-D crosses — shaped like six-way pipe fittings — mere micrometers across. When surrounding pressure of air increases, the crosses' circular faces bow inward. Because of the way these crosses are connected with levers, that warping forces the crosses to rotate and push away from each other, causing the whole structure to expand. Jingyuan Qu, a physicist at Karlsruhe Institute of Technology in Germany, and colleagues describe the new material in a paper accepted to *Physical Review X*.

The researchers were "very clever about how they connected this quite complex set of structural elements," says Michael Haberman, a mechanical engineer at the University of Texas at Austin.

Qu's group fashioned a microcube of the metamaterial from a plasticlike substance using a microversion of 3-D printing. When the team placed the material inside a gas chamber and cranked up the air pressure from one bar (about the atmospheric pressure at sea level) to about five bars, the cube's volume increased by about 3 percent.

Until now, researchers have described such pressure-expanding metamaterials only in mathematical models or computer simulations, says materials scientist Joseph Grima of the University of Malta in Msida. The new material provides "much-needed proof" that this type of stuff can actually be fabricated, he says.

Adjusting the thickness of the crosses' faces could make the metamaterial more or less expandable: The thicker it is, the less the structure expands. A metamaterial fine-tuned to stay the same size under a wide range of pressures could be used to build equipment that withstands the crushing pressures of the deep sea or the vacuum of outer space. ■

ATOM & COSMOS

Antimatter excess still not explained

Dark matter may be behind extra positrons hitting Earth

BY EMILY CONOVER

New observations of the whirling cores of dead stars have deepened the mystery behind a glut of antimatter particles raining down on Earth from space.

The particles are antielectrons, or positrons, and may be a sign of dark matter — the unidentified culprit that makes up most of the universe's mass. But more mundane explanations are also plausible: Nearby pulsars, the spinning remnants of exploded stars, might spew positrons, for example. But in the Nov. 17 *Science*, scientists with the High-Altitude Water Cherenkov Observatory, or HAWC, in Mexico call that hypothesis into question.

Though new HAWC observations don't directly support the dark matter explanation, "if you have a few alternatives and cast doubt on one of them, then the other becomes more likely," says HAWC scientist Jordan Goodman of the University of Maryland in College Park.

Earth is bathed in cosmic rays, particles from space that include electrons and positrons. Several experiments designed to detect cosmic rays have found more high-energy positrons than expected (*SN: 5/4/13, p. 14*). Astrophysicists have debated the source of that excess ever since. Dark matter particles annihilating one another could theoretically produce pairs of electrons and positrons, but so can other sources, such as pulsars.

It was uncertain, though, whether pulsars' positrons would make it to Earth in numbers significant enough to explain the excess. HAWC researchers tested how positrons travel through space by measuring gamma rays, or high-energy light, from two pulsars about 800 to 900 light-years away. Those gamma rays are produced when energetic positrons and electrons slam into low-energy light particles, producing higher-energy radiation.

The size and intensity of the resulting gamma-ray glow indicated that the positrons slowly dissipated away from their pulsar birthplaces, getting bogged down by magnetic fields that permeate the galaxy and twist up the particles' trajectories. That sluggish departure suggests the particles wouldn't have made it all the way to Earth, the researchers conclude, and therefore can't explain the excess.

Astrophysicist Dan Hooper of Fermilab in Batavia, Ill., disagrees. He still thinks pulsars are the best explanation for the rogue antimatter. Gamma rays are just one way to study how cosmic ray particles propagate through space. Other methods indicate that pulsars' positrons should be able to make the trek across the galaxy fast enough to get to Earth, he says.

Ruling out pulsars still wouldn't point the finger at dark matter. "I think they've made a good case that these pulsars are not the source," says Gregory Tarlé, an astrophysicist at the University of Michigan in Ann Arbor. He suggests that protons in cosmic rays that interact with the interstellar medium — particles that permeate the spaces between stars — could produce positrons that would explain the observed excess without invoking dark matter or pulsars. ■

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BODY & BRAIN

Hormone may guard men from asthma

Testosterone lessens lung inflammation, mouse study suggests

BY AIMEE CUNNINGHAM

Testosterone may tamp down asthma caused by inhaling pollen, dust or other airborne allergens. That's partly why more women suffer from the lung disease than men, new research suggests.

The male sex hormone acts on immune cells that are part of the body's first line of defense against invaders. The cells are thought to kick-start inflammation in the lungs, which causes airways to narrow in an asthma attack. In mice exposed to an allergen, testosterone reduced the inflammatory response, researchers report in the Nov. 28 *Cell Reports*.

"How male and female sex hormones can affect the immune system is important for understanding the molecular and cellular basis of sex differences in diseases like asthma," says Nicola Heller, an immunologist at Johns Hopkins University School of Medicine who was not involved in the study. Such findings may lead to new treatments and ways to manage symptoms, she says.

In the United States, over 18 million adults and 6 million children have asthma, according to the U.S. Centers for Disease Control and Prevention. Asthma rates are one clue that sex hormones play a role in the disease, which causes wheezing, shortness of breath and coughing. Boys are more likely than girls to have asthma. But at puberty, when sex hormones shift into high gear, the balance changes. By midlife, women are about twice as likely as men to have asthma.

Dawn Newcomb, an immunologist at Vanderbilt University Medical Center in Nashville, and colleagues examined the impact of testosterone on immune cells called group 2 innate lymphoid cells. These cells "can be stimulated very quickly," Newcomb says. In response to an allergen, the cells release proteins called cytokines that rev up inflammation. Male mice exposed to a leaf spot fungus that can trigger asthma symptoms did not produce as much of the cytokines as exposed females. The researchers also determined that testosterone prevents the innate lymphoid cells from multiplying in the lungs. Fewer cells meant fewer cytokines and less lung inflammation.

Adult male mice also started off with fewer of the lymphoid cells in the lungs than adult females, the researchers found. Female mice had about 1½ times as many of these immune cells as males.

In humans, Newcomb and colleagues measured the number of group 2 innate lymphoid cells in the blood of adults with asthma. Women had about twice as many of the cells as did men; there may be more in the lungs as well, Newcomb says.

Next, she says, the researchers plan to investigate how female sex hormones may affect asthma. ■

GENES & CELLS

Bats carry building blocks for SARS

Deadly viral strains may arise when genes mix in the animals

BY TINA HESMAN SAEY

Viruses in bats may have mixed and matched genes to create the virus that gave rise to the deadly SARS outbreak in 2003, a new study suggests. And it could happen again. All of the ingredients needed to create a new SARS virus are found among viruses currently infecting horseshoe bats, researchers report November 30 in *PLOS Pathogens*.

The viruses "are poised to cause future outbreaks," says virologist Ralph Baric of the University of North Carolina School of Medicine in Chapel Hill, who was not involved in the study. "We can't let our guard down."

Severe acute respiratory syndrome, or SARS, is caused by a type of coronavirus. After the first human case of SARS was recorded in 2002 in Guangdong province in southern China, a global epidemic of the disease sickened more than 8,000 people and killed 774 in 2003.

In that outbreak, masked palm civets sold in live animal markets passed the virus to people. It wasn't clear whether civets were the initial source of the virus, or if they caught it from some other animal. Since then, evidence has been building implicating species of horseshoe bats as the origin (*SN: 11/30/13, p. 13*). Until now, though, coronaviruses isolated from bats were genetically distinct from the one that caused the 2003 outbreak, suggesting that bat strains weren't the direct ancestor of SARS.

After five years of surveying bats in a cave in southern China's Yunnan province, Zhengli Shi and colleagues discovered 11 new strains of SARS-related viruses in horseshoe bats (especially in *Rhinolophus sinicus*). Within the strains, the researchers found all the genes to make a SARS coronavirus similar to the epidemic strain, says Shi, a virologist at the Wuhan Institute of Virology of the Chinese Academy of Sciences.

Genetic studies of viruses from horseshoe bats in China suggest that the animals are reservoirs of SARS coronaviruses.

These new strains are more similar to the human version of SARS than were previously identified bat viruses, says Matthew Frieman, a virologist at the

EARTH & ENVIRONMENT

Base of deep-sea food web ID'd

Nitrogen-loving bacteria alter much of dark ocean's carbon

BY CAROLYN GRAMLING

A mysterious group of microbes may be controlling the fate of carbon in the dark depths of the world's oceans.

Nitrospinae bacteria use the nitrogen compound nitrite to "fix" inorganic carbon dioxide into sugars and other compounds for feeding and reproduction. These microbes are responsible for 15 to 43 percent of such carbon fixation in the western North Atlantic Ocean, researchers report in the Nov. 24 *Science*. If these bacteria are present in similar abundances around the world, those rates may be global.

The total amount of carbon that Nitrospinae fix is small when compared with carbon fixation on land by organisms such as plants or in the sunlit part of the ocean, says Maria Pachiadaki, a microbial ecologist at Bigelow Laboratory for Ocean Sciences in East Boothbay, Maine. "But it seems to be of major importance to the productivity and health of the 90 percent of the ocean that is too deep and too dark for photosynthesis." These bacteria likely form the base of the food web in much of this enigmatic realm, she says.

Oceans cover more than two-thirds of Earth's surface, and most of those waters are in the dark. In the shallow, sunlit part of the ocean, microscopic organisms called phytoplankton fix carbon dioxide through photosynthesis. But in the deep ocean, microbes that use chemical energy derived from compounds such as ammonium or hydrogen sulfide are the engines of that part of the carbon cycle.

Little has been known about which microbes are primarily responsible for this dark ocean carbon fixation. The likeliest candidates were a group of ammonium-oxidizing archaea (single-celled organisms similar to bacteria) known as Thaumarchaeota. They are the most abundant microbes in the dark ocean.

But there was no direct proof that these archaea are the main fixers, Pachiadaki says. In fact, previous studies of carbon fixation in the deep ocean suggested that ammonium-oxidizers weren't performing the task quickly enough to match observations, she says. "The energy gained from ammonium oxidation is not enough to explain the amount of the carbon fixed in the dark ocean."

Pachiadaki and colleagues suspected that a different group of microbes might be bearing the brunt of the task. Nitrospinae bacteria that use the chemical compound nitrite were known to be abundant in at least some parts of the dark ocean, but the microbes weren't well studied. So the team analyzed

LIBIAO ZHANG/GUANGDONG INSTITUTE OF APPLIED BIOLOGICAL RESOURCE, CHINA

University of Maryland, Baltimore.

By analyzing the new viruses' complete genetic makeups, Shi and colleagues retraced the steps that might have given rise to the original SARS virus. A few spots in the viruses' DNA seem particularly prone to rearrangement, so remixing happens often. The study suggests that recombination between viruses has shaped the evolution of SARS, Baric says.

Several of the strains could already grow in human cells, Shi's team found. That ability indicates "there's a chance that the viruses that exist in these bats could jump to people," Frieman says. "Whether they will or not is anybody's guess."

Trying to head off that jump by getting rid of the bats is not a solution, agree Frieman and Baric. Bats perform many important ecological tasks, such as eating insects and pollinating some plants. Coronaviruses don't make bats sick, so studying bats' immune systems, Frieman says, could give scientists clues about how to fight the illness. ■

3,463 genomes, or genetic blueprints, of single-celled organisms from 39 seawater samples collected in the western North Atlantic Ocean, at depths ranging from regions below about 200 meters to the ocean's deepest zone below 9,000 meters. The team identified Nitrospinae as the most abundant bacteria. Although still less abundant than Thaumarchaeota, Nitrospinae are much more efficient at fixing carbon.

The new research also shows that nitrite is the primary source of energy for Nitrospinae bacteria. Marine microbiologist Frank Stewart of Georgia Tech in Atlanta says the study "exemplifies how advances in genomic methods can generate hypotheses about metabolism and ecology." These findings suggest that scientists need to rethink how energy and materials cycle in the dark ocean, he says. "While this ocean realm remains underexplored, studies like this are models for how to close our knowledge gap." ■

NATALIE RENIER

LIFE & EVOLUTION

Blue whale 'hand' preferences vary

Favoring the right or left side depends on feeding context

BY MARIAH QUINTANILLA

Blue whales are a tad ambidextrous.

When hunting in deep water, the whales tend to be "right-handed," lunging at krill while twisting 180 degrees or less onto their right side. But when gobbling up the crustaceans near the surface, the whales tend to be lefties, launching themselves upward while performing a larger barrel roll to the left, scientists report in the Nov. 20 *Current Biology*. Rolling to the left at the surface may help the whales better see food with their right eye, the scientists say.

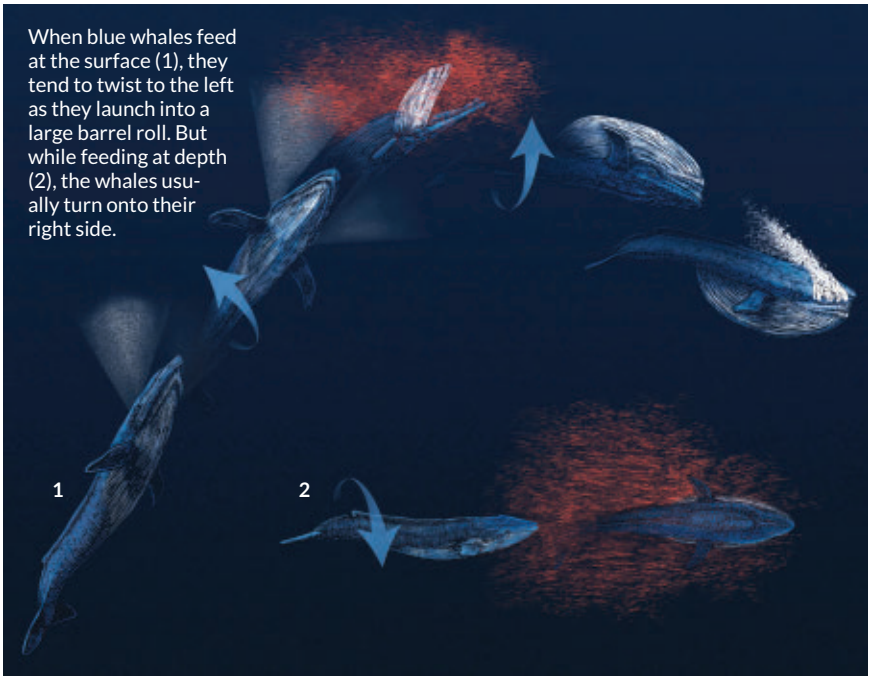
Many vertebrates favor one side of the body over the other for certain tasks. This lateralization, or handedness, helps animals be more efficient at those jobs. The new research, the first to document handedness in blue whales, is the first evidence of a marine mammal favoring a different side of its body depending on feeding depth, the researchers say.

Other whales exhibit handedness, but this study "demonstrates that you really need to consider the context of how animals are feeding in their environment," says Ari Friedlaender, an ecologist at the University of California, Santa Cruz.

From 2010 to 2014, Friedlaender and colleagues monitored blue whales off California using trackers. Of 49 whales, 57 percent preferred to roll to one side than the other. Of whales with a preference, 75 percent tended to go right, and most of these rolls were in deep water.

But when feeding near the surface, whales tended to use a larger, more acrobatic roll to the left. The left-handed roll may be a strategic move to help whales use their right eye to see less-dense patches of krill at the surface, the researchers speculate. The right eye is connected to the left side of the brain, which controls aspects of coordination, motor control and the ability to plan.

Neuroscientist Lesley Rogers of the University of New England in Armidale, Australia, agrees that whales at the surface may do left-handed turns because of the connection between the right eye and the brain's left hemisphere. But she remains cautious until scientists know for sure which eye the whales rely on when spiraling to the left. ■



When blue whales feed at the surface (1), they tend to twist to the left as they launch into a large barrel roll. But while feeding at depth (2), the whales usually turn onto their right side.

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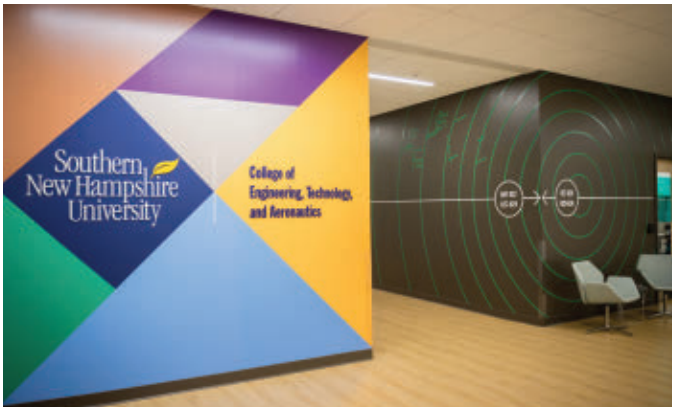

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2017 Year in Review

In science, progress rarely comes in one big shebang. Well, it has now, two years running. The first-ever direct detection of gravitational waves, our top story in 2016, launched a long-dreamed-of kind of astronomy capable of "unlocking otherwise unknowable secrets of the cosmos," as physics writer Emily Conover puts it. 2017's key event: a never-before-seen neutron star collision that immediately validated some theories in physics and killed others. And so a new way to probe cosmic mysteries wins our top spot again this year.

Another turning point is coming, and maybe soon, via CRISPR/Cas9, a biotechnology that holds the promise of curing genetic diseases (and the peril of making permanent, heritable tweaks). Nearly five years after the gene-editing tool debuted, researchers for the first time have used it to alter genes in viable human embryos. That's a big advance, and worthy of the No. 2 spot (Page 21).

Don't be fooled, though. Even eureka moments like these are the fruits of the slow build of progress: Fossil by fossil, paleoanthropologists draw a picture of *Homo sapiens*' earliest days (Page 24). Brain by brain, the extent of damage caused by chronic traumatic encephalopathy — a disease linked to hard head knocks — becomes clear (Page 30).

And crack by crack, one of the biggest icebergs ever recorded calves (Page 22). That story, No. 3 on our list, is not exactly progress, but it's surely an opportunity to make scientific headway. Teams racing to Antarctica's Larsen C ice shelf will have an unprecedented chance to collect real-time data on how the remaining ice reacts and to reveal secrets of a long-hidden ecosystem. Building on those advances, as well as others described in our Top 10 picks, will fuel "aha!" moments — both revolutionary and incremental — well into the future. — *Macon Morehouse, News Director*

NSF, LIGO, SONOMA STATE UNIV., A. SIMONNET

In a galaxy 130 million light-years away, two neutron stars collided. This year, in the first detection of its kind, observatories caught the resulting gravitational waves and light show (illustrated).

Cosmic mysteries unlocked in neutron star collision

By Emily Conover

Thousands of astronomers and physicists. Hundreds of hours of telescope observations. Dozens of scientific papers. Two dead stars uniting into one.

In 2017, scientists went all in on a never-before-seen astronomical event of astounding proportions: a head-on collision between two neutron stars, the ultradense remnants of exploded stars.

The smashup sent shivers of gravitational waves through Earth, and the light show that followed sent shivers of excitement down astronomers' spines. A real-life scientific drama quickly unfolded as night after night, astronomers around the world raced the sunrise, capturing every possible bit of data before day broke at their observatories.

Scientists had long fantasized about using light together with gravitational waves to forge a new kind of astronomy capable of unlocking otherwise unknowable secrets of the cosmos. "Now we're finally here," says Vicky Kalogera, an astrophysicist at Northwestern University in Evanston, Ill.

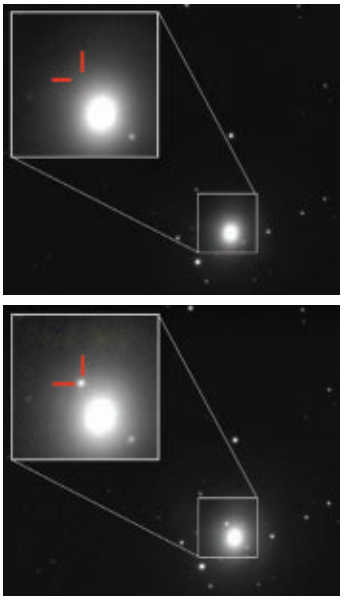
Almost overnight, the discovery vanquished some theories and vindicated others. It has had implications for the origins of the universe's heaviest elements, the mysterious dark energy that makes up about 70 percent of the cosmos and the source of brilliant-but-brief flashes of high-energy light known as short gamma-ray bursts. In the last two decades of astronomy, the detection "is more significant than any other event," says theoretical astrophysicist Avi Loeb of Harvard University.

So frenzied was the excitement over the find that researchers had trouble keeping their discovery under wraps as they raced to analyze data. Social media buzzed with rumors. When a Twitter account that regularly announces targets of the Hubble Space Telescope reported one named "BNS-Merger" (presumably for "binary neutron star"), corners of the internet exploded with speculation (*SN Online: 8/25/17*). Astronomy enthusiasts mined the publicly available logs of astronomical observatories for hints of what telescopes were zeroing in on.

The two neutron stars converged in the galaxy NGC 4993, 130 million light-years from Earth, emitting gravitational waves in the process (*SN: 11/11/17, p. 6*). Those waves, predicted by Einstein's general theory of relativity, stretched and compressed spacetime, traveling outward like ripples on a pond. As the waves began their outbound journey 130 million years ago, Earth was in the midst of the Cretaceous Period: Dinosaurs were large and in charge. Life capable of building the complex detectors necessary for spotting the gravitational rumbles wouldn't arise for many millions of years.

But these spacetime ripples arrived

at Earth at an opportune moment, when detectors were finally prepared to spot them. Decades in the making, these highly-sensitive devices can register spacetime shifts a fraction of the size of a proton. On August 17, 2017, the instruments — the two detectors of the Advanced Laser Interferometer Gravitational-Wave Observatory, LIGO, in Livingston, La., and Hanford, Wash., and Advanced Virgo near Pisa, Italy — spotted the waves and joined forces to triangulate their source. Gamma-ray space telescopes recorded a high-energy light burst less than two seconds later. A worldwide network of telescopes sprang into action to look for light in the region of the sky where LIGO and Virgo predicted the waves came from. Less than 11 hours after the gravitational waves appeared, astronomers spotted a new point of visible light in the sky. That finding kicked off an astronomical free-for-all: "Basically every telescope pointed at this thing," says LIGO member Daniel Holz of the University of Chicago. As a result, he says, "there's just this wealth of information."



In the aftermath of a neutron star collision, telescopes spotted a pinprick of light (bottom, indicated by red lines) not present in the years before (top).

Telescopes captured visible, infrared and ultraviolet light, followed by X-rays and radio waves days later. Each observation was precious: The light faded rapidly and changed colors over time, says Josh Simon, an astronomer with Carnegie Observatories in Pasadena, Calif. "This is a fairly rare occurrence in astronomy," he says. "Most things we look at don't change over time at all."

Observations revealed a previously theorized process dubbed a "kilonova" — thought to be a source of heavy elements like gold, silver, platinum and uranium — which could form as neutron-rich material is ejected from the stars. Light from the collision directly confirmed this hunch for the first time. "My wedding band emerged from a neutron star merger," Loeb marvels.

The intensity of observations outstripped all previous astronomical finds, said astronomer Edo Berger of Harvard University at an October 16 news conference in Washington, D.C. "I don't think there has been anything like this before." Roughly 15 percent of all astronomers were involved in the discovery, estimates astronomer Bryan Gaensler of the University of Toronto. One of the many papers announcing results, published in *Astrophysical Journal Letters*, boasted over 3,000 authors. Additional papers appeared in that journal, as well as in *Science*, *Nature* and *Physical Review Letters*, among others.

Already, this event has ruled out hundreds of theories that provide alternatives to dark energy, a perplexing facet of our universe that is the most common explanation for why the cosmos is expanding faster and faster. Some of these theories aren't consistent with the near-simultaneous detection of light and gravitational waves, several teams reported online October 17 and 18 at arXiv.org (*SN: 11/25/17, p. 10*).

Researchers also made a new measurement of how fast the universe is expanding, a number that could help solve a lingering puzzle. Observations of supernovas suggest that the universe is expanding at 73 kilometers per second for each megaparsec (about 3.3 million light-years). That's significantly faster than measurements made using the cosmic microwave background, ancient light from the early years of the universe (*SN: 8/6/16, p. 10*), which peg the expansion rate at 67 km/s per megaparsec. The new measurement is right in between the previous two, at 70 km/s per megaparsec, researchers reported online in *Nature*. Resolving the impasse will require catching additional neutron star mergers.

Astrophysicists are confident they'll get that chance. "This event is just the first of many that will be discovered in the future," Loeb says. Additional mergers could also tell scientists more about the properties of neutron stars, like how "squishy" their extremely dense matter is, a property known as the equation of state (see Page 7). And pinning down how often such collisions occur will help determine whether neutron stars can explain the abundances of heavy elements observed in the cosmos.

Gravitational waves also topped *Science News*' list of discoveries in 2016. That honor marked the first direct detection of gravitational waves (*SN: 12/24/16, p. 17*), which the LIGO team captured in the aftermath of a merger of two black holes. This year, three pioneers of LIGO, Rainer Weiss of MIT and Kip Thorne and Barry Barish, both of Caltech, received the Nobel Prize in physics for that discovery (*SN: 10/28/17, p. 6*).

With the neutron star collision, gravitational wave hunters continue their streak of successes. The sighting came just days after a detection of two merging black holes — LIGO's fourth and the first made in conjunction with Virgo (*SN: 10/28/17, p. 8*). A fifth black hole merger was reported in November (*SN Online: 11/16/17*). LIGO and Virgo are now shut off for upgrades until the fall of 2018. Additional gravitational wave detectors, like KAGRA in Japan and LIGO-India, are planned for the future, filling out a global network for monitoring the heavens' temblors.

Both the fourth black hole collision and the neutron star crash appeared during a short window of less than a month when all three existing gravitational wave detectors were simultaneously operational. That was a stroke of amazing luck: Three detectors are needed to narrow down the location of a neutron star collision and pinpoint its light.

"It's a little unreasonable how lucky we are," Holz says. "It really was this gift — just a gift." ■

P.K. BLANCHARD, E. BERGER, PAN-STARRS, DECAM

CRISPR gene editing moves into humans, spurs debate

By Tina Hesman Saey

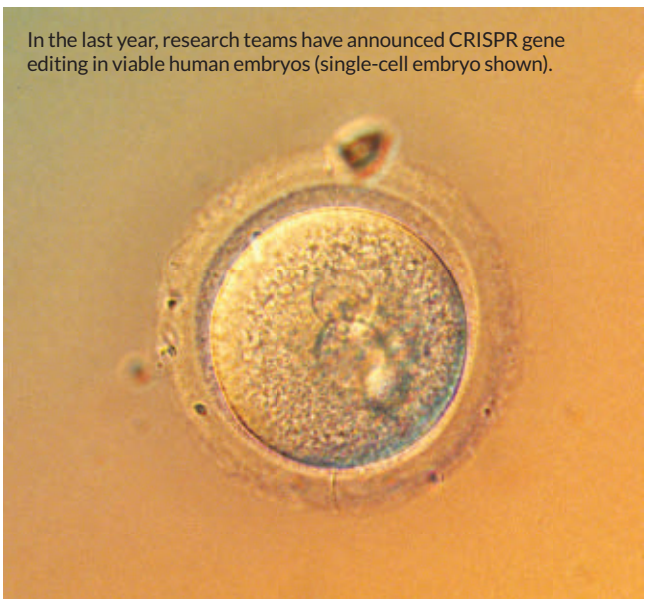
2 Scientists reported selectively altering genes in viable human embryos for the first time this year. For nearly five years, researchers have been wielding the molecular scissors known as CRISPR/Cas9 to make precise changes in animals' DNA. But its use in human embryos has more profound implications, researchers and ethicists say.

"We can now literally change our own species," says Mildred Solomon, a bioethicist and president of the Hastings Center, a bioethics research institute in Garrison, N.Y.

CRISPR/Cas9 is a bacterial immune system (*SN: 4/15/17, p. 22*) turned into a powerful gene-editing tool. First described in 2012, the editor consists of a DNA-cutting enzyme called Cas9 and a short piece of RNA that guides the enzyme to a specific spot that scientists want to edit. Once the editing machinery reaches its destination, Cas9 cleaves the DNA. Cells can repair the break by gluing the cut ends back together, or by pasting in another piece of DNA. Scientists have developed variations of the editor that make other changes to DNA without cutting, including one version described in October that performs a previously impossible conversion of one DNA base into another.

Whether scientists should use CRISPR/Cas9's power to create gene-edited babies is a matter of heated debate. Until March, the battles were mostly academic because previous attempts to edit human embryos were done in embryos that would never develop into a baby (*SN Online: 4/8/16*; *SN Online: 4/23/15*). But in March, Lichun Tang of China's Beijing Proteome Research Center and colleagues reported using CRISPR/Cas9 to correct disease-causing mutations in a small number of viable human embryos. Other groups posted separate reports of CRISPR/Cas9 repair in viable human embryos in August and October.

Rather than edit out problems, a different group led by developmental biologist Kathy Niakan of the Francis Crick Institute in London snipped DNA with CRISPR/Cas9 to intentionally create mutations in human embryos for the first time. Those embryos were used to study the role of a gene important in development (*SN: 10/14/17, p. 8*).



In the last year, research teams have announced CRISPR gene editing in viable human embryos (single-cell embryo shown).

CLAUDE CORTIER/SCIENCE SOURCE

Together, the studies illustrate that the gene-editing technology can make a variety of changes in human DNA that would last a lifetime and stretch across generations. It's the relative ease and permanence that have many people worried that CRISPR/Cas9 could lead to new classes of genetically enhanced people and discrimination against others born with uncorrected genetic diseases. Taken to extremes, that discrimination could extend to people whose parents chose not to (or didn't have the means to) genetically alter their children's athletic power, intellectual ability or other characteristics. In February, a panel of ethicists and other experts convened by the U.S. National Academies of Sciences, Engineering and Medicine warned against using CRISPR to enhance health or other traits. But the panel said using human gene editing to correct diseases, in certain circumstances, could be permissible (*SN: 3/18/17, p. 7*).

No babies have been born with changes made by CRISPR/Cas9 or any other gene-editing technology. But it could be only a matter of time. "I would not be surprised if there were a CRISPR-modified baby somewhere in the world in the next couple of years," said CRISPR pioneer Jennifer Doudna of the University of California, Berkeley on October 26 in San Francisco at the World Conference of Science Journalists. Doudna said she does not support using CRISPR/Cas9 to make gene-edited babies.

Researchers, including Shoukhrat Mitalipov of Oregon Health & Science University in Portland, say improving the technology to make it safer and more effective is important for tackling genetic diseases at their source — the faulty genes. A study from Mitalipov and colleagues, published in *Nature* in August, suggests that making so-called "designer babies" could be harder than people expect (*SN: 9/2/17, p. 6*). Instead of using a piece of DNA that the researchers injected to repair cuts made by CRISPR/Cas9, human embryos used their own DNA from another chromosome as a repair template. That could make adding outside genes to enhance traits more difficult, but fixing some disease-causing mutations would potentially be easier, Mitalipov says. If one healthy copy of the gene exists, the cell, theoretically, would use it as a repair template.

The study soon came under criticism from other researchers. "The evidence for fixing is not there," says Dieter Egli, a developmental biologist at Columbia University. Mitalipov and colleagues have not presented enough data to support their interpretation, he says. Egli and colleagues posted their criticism online August 28 at bioRxiv.org. "The conclusion that the correction occurred is, at best, premature," Egli says. "At worst, it might be false."

Mitalipov and Oregon colleague Paula Amato say they have submitted more evidence to support their claim to *Nature* and hope to publish the data soon. The finding needs to be replicated

by other groups, Amato says, but "at the moment, we stand by our conclusions."

It may also be possible to fix genetic mutations without any cutting. By dulling Cas9's blades, researchers led by David Liu of Harvard University have developed "base editors." The enzyme can grasp DNA but not slice through it. The researchers attached other enzymes that chemically change one DNA base into another. DNA bases are the information-carrying part of the DNA molecule and are often represented by A, C, T and G. In 2016, Liu described a base editor that transforms a C into a T.

Then a team of Chinese researchers used that base editor to correct a mutation in human embryos that causes the blood disorder beta-thalassemia, reported September 23 in *Protein & Cell* (*SN: 11/25/17, p. 7*). In October, Liu and colleagues reported that they'd made another base editor that can do a previously impossible trick: convert an A into a G. The two base editors together may allow researchers to repair most of the single base mutations responsible for causing human diseases, such as sickle-cell anemia, muscular dystrophy and cystic fibrosis.

But before any type of human embryo editing can be used in the clinic, it must be as safe and effective as existing embryo screening methods. Today, doctors working with embryos created through in vitro fertilization can extract a few cells for genetic testing in a process called preimplantation genetic diagnosis, or PGD. Embryos that don't have mutations can be transferred to a woman's uterus to establish a pregnancy. In some rare cases, couples may not produce any healthy embryos. Future gene editing might help these couples have a healthy biological child. For other couples, gene editing could increase the number of healthy embryos available by fixing some that would otherwise be thrown away, Amato says. "If it's shown to be just as safe and effective as PGD, I'd say, 'Why not use it?' " ■

Larsen C ice break invites groundbreaking research

By Carolyn Gramling

3

In 2015, glaciologist Daniela Jansen reported that a large rift was rapidly growing across one of the Antarctic Peninsula's ice shelves, known as Larsen C. When the shelf broke, she and colleagues predicted, it would be the largest calving event in decades.

It was. In July, a Delaware-sized iceberg split off from Larsen C (*SN: 8/5/17, p. 6*). And researchers knew practically the moment it happened.

After Jansen's 2015 paper, a U.K.-led group called Project MIDAS began keeping close track of the rift, aided by new data delivered every six days from a pair of European polar-orbiting satellites known as Sentinel-1. Jansen, of the Alfred Wegener Institute in Bremerhaven, Germany, and glaciologist Adrian Luckman of Swansea University in Wales were among the MIDAS members reporting observations on the team's blog.

To the scientists' surprise, the news media, perhaps anticipating a climate change moment, began to track the trackers. When interviewed, the researchers repeatedly noted that ice shelves calve naturally, and that any link between the new rift and climate change is complicated at best. But the crescendo of public interest still rose, particularly during the spring and summer of 2017 as the final break loomed.

Although surprised by the press frenzy, Jansen says she understands why people were so captivated: "It's just an amazing thing. Even if people are not into polar research, it's fascinating to see it and think about the dimensions of it."

Public interest may have plummeted in the aftermath of the split, but scientists are eager to start the next chapter, Luckman says. "Now we want to understand how the ice shelf will react to this calving event."

A Delaware-sized iceberg calved when a crack in the Larsen C ice shelf reached the Weddell Sea this year. In this satellite image from September, rifts are visible in the ice and clouds cast a shadow on the new iceberg.

NASA EARTH OBSERVATORY, JOSHUA STEVENS, LANDSAT DATA, USGS

By the end of 2017, the race to the southernmost continent was on. It's the first time that researchers have been able to put boots on the ground so quickly after a massive calving event, and they have a lot of questions. Some scientists plan to assess the stability of the remaining ice shelf, others will map the region's seafloor topography and still others want to study the newly exposed ecosystem that's been hidden from the sun for up to 120,000 years (*SN Online: 10/13/17*).

It's an unprecedented opportunity, Luckman says. "We've never had such tools as we have now to really measure what happens after big calving events." The last time a large iceberg calved from Antarctica was in 2002, when a chunk about half the size of the Larsen C iceberg calved from a different ice shelf on the Antarctic Peninsula, Larsen B (*SN: 3/30/02, p. 197*).

"We just didn't have the satellite data to really see what would happen next," Luckman says. Now, he says, scientists have both vastly superior satellite monitoring capabilities and computer simulations to predict how the remaining ice will behave after the loss of so much mass. Current simulations suggest that the

truncated ice shelf will react to this change by flowing faster into the ocean, which will also lead to more calving.

To improve those simulations, Luckman says, scientists need to directly measure changes in the ice shelf, particularly while it is still in its initial response phase. In November, a team led by the University of Leeds in England was the first to journey to the peninsula. To map out subsurface structures in the ice, the team conducted geophysical surveys, including using ground-penetrating radar, on the still-intact part of the ice shelf. Using GPS, the researchers also monitored the shelf's movements.

Another team of scientists, led by marine biologist Katrin Linse of the British Antarctic Survey in Cambridge, is preparing for a separate voyage to the ice shelf in February. Linse and colleagues' mission is to learn what was living on the seafloor in the shadow of the ice. What creatures might inhabit that region is a bit of a mystery. Linse says she expects to find something similar to ecosystems found in the deep sea — a dark, extremely food-sparse environment with no plant life. Such environments can spawn odd creatures, such as carnivorous sponges and bivalves that snatch at the tiniest food sources. It's also possible that the team will find nothing alive, she says.

Meanwhile, the Larsen C iceberg is still in the picture and could present a navigational headache. As of November, the southern edge of the berg was about 25 to 30 kilometers from the shelf, offering a research ship some wiggle room to examine the seafloor, Linse says. But the northern edge was still just two kilometers away, a gap too close for comfort.

The researchers may have little time to examine that ecosystem before it begins to change. Now that sunlight can penetrate the waters, microalgae will quickly begin to grow, providing an abundant food source to any seafloor denizens — and an enticement to new colonizers. In one to three years, species such as krill may become abundant. After several more years or even decades, there may be enough food to support penguins, seals and whales.

Scientists have previously documented a recently exposed Antarctic seafloor ecosystem only after it was already in transition. In 2007, marine ecologist Julian Gutt of the Alfred Wegener Institute led a trip to the Larsen B ice shelf to study the seafloor that had emerged from its ice shadow five years earlier. The researchers found strange new species but also discovered pioneering critters that had already moved in (*SN: 9/7/13, p. 11*).

Gutt plans to return to the region in 2019. That expedition originally planned to map the seafloor along the Antarctic Peninsula, but will now include time to study the biodiversity of the seafloor at Larsen C, plus return to Larsen B. "Each species occurring under the former ice shelf would be interesting," Gutt says. "How can they survive under such unusual conditions?"

Whatever is found, Linse says she will consider her mission a success: "If no communities could thrive, that would be a very interesting result because I expect to find life there."

Even though the Larsen C ice shelf irreversibly broke in 2017, the discoveries are just beginning. ■

W. GERBER/UNIV. OF TÜBINGEN

Rumor has it

Some findings reported in 2017 hint at potentially big discoveries — if the research holds up to additional scientific scrutiny.

Under pressure

Putting the squeeze on hydrogen gas turned it into a long-elusive metal that may superconduct, Harvard University physicists claimed (*SN: 2/18/17, p. 14*). A diamond vise, supercold temperatures and intense pressure made the element reflective — a key property of metals. But other researchers in the field don't buy it; one experiment with a slew of caveats isn't enough to confirm the claim, those scientists say.

Woman warrior?

The skeleton of a 10th century Viking woman buried in full warrior regalia has scientists sparring over women's roles in Viking society (*SN: 10/14/17, p. 6*). Researchers who confirmed the skeleton's sex through DNA analysis contend that the woman was a high-ranking Viking warrior, the first Viking woman warrior known. But other archaeologists argue that the bones — with no obvious signs of injury or strenuous physical activity — are too pristine to have seen battle.

Blink and you'll miss it

A far-flung star's extra wink, spotted in data from the Kepler space telescope and further probed by the Hubble Space Telescope, may be the first evidence for an exomoon — a moon orbiting a planet orbiting a distant star. If it exists, the Neptune-sized candidate moon (dubbed Kepler 1625b i) is roughly 4,000 light-years away and orbits a planet a tad larger than Jupiter (*SN: 8/19/17, p. 15*).

Rooting out hominid origins

The first members of the human evolutionary family may have originated in Europe, not Africa. New analyses of a fossilized jaw (shown) and teeth from *Graecopithecus*, a chimpanzee-sized primate that lived in southeastern Europe roughly 7 million years ago, suggest that it may be the earliest known hominid (*SN: 6/24/17, p. 9*). But more complete fossils are needed to determine whether *Graecopithecus* was truly a hominid.
— Cassie Martin

Fossils join genetic evidence to revise human origin story

By Bruce Bower

Human origins are notoriously tough to pin down. Fossil and genetic studies in 2017 suggested a reason why: No clear starting time or location ever existed for our species. The first biological stirrings of humankind occurred at a time of evolutionary experimentation in the human genus, *Homo*.

Homo sapiens' signature skeletal features emerged piece by piece in different African communities starting around 300,000 years ago, researchers proposed. In this scenario, high, rounded braincases, chins, small teeth and faces, and other hallmarks of human anatomy eventually appeared as an integrated package 200,000 to 100,000 years ago.

This picture of gradual change contrasts with what scientists have often presumed, that *H. sapiens* emerged relatively quickly during the latter time period. Fossils clearly qualifying as human date to no more than about 200,000 years ago and are confined to East Africa. But the discoveries reported this year — including fossils from northwestern Africa — point to an earlier evolutionary phase when the human skeletal portrait was incomplete. Like one of Picasso's fragmented Cubist portraits, *Homo* fossils from 300,000 years ago give a vague, provocative impression that someone with a humanlike form is present but not in focus.

"Speciation is a process, not an event," says paleoanthropologist Bernard Wood of George Washington University in Washington, D.C. "When fossil skulls of, say, Neandertals and *Homo sapiens* look convincingly different, we're seeing the end of the speciation process."

CT scans of Moroccan fossils reveal a modern-looking face (reconstructed at top) but a braincase similar to older, now-extinct *Homo* species (bottom).

Discoveries in Morocco convinced one research team that direct predecessors of *H. sapiens* lived there about 300,000 years ago (*SN: 7/8/17, p. 6*). Fossils and stone artifacts unearthed at the archaeological site Jebel Irhoud display close links to later *H. sapiens* skeletons and tools. Digital reconstructions of a composite Jebel Irhoud skull revealed a modern-looking face and teeth. Other *H. sapiens* skull traits evolved later.

The inside surface of Jebel Irhoud braincases, which were long and low, has a distinctive shape that perhaps represents an early evolutionary step toward later humans' rounded skullcaps, suggests paleoanthropologist Chris Stringer. Stringer, of the Natural History Museum in London, says it's unclear whether the ancient Moroccan population could have traveled far enough to mingle with early *H. sapiens* in other parts of Africa, as the Jebel Irhoud team suspects.

However far Jebel Irhoud folk journeyed, genetic evidence adds to suspicions that they lived around the time that *H. sapiens* originated. DNA extracted from the bones of a boy who lived in southern Africa about 2,000 years ago enabled scientists to estimate that humankind originated between 350,000 and 260,000 years ago (*SN: 10/28/17, p. 16*). Previous genetic comparisons of present-day humans with Neandertals and their close Stone Age relatives, the Denisovans, had placed human origins at 400,000 years ago or more. Many investigators found that estimate difficult to reconcile with a human anatomy that appears to gel much later.

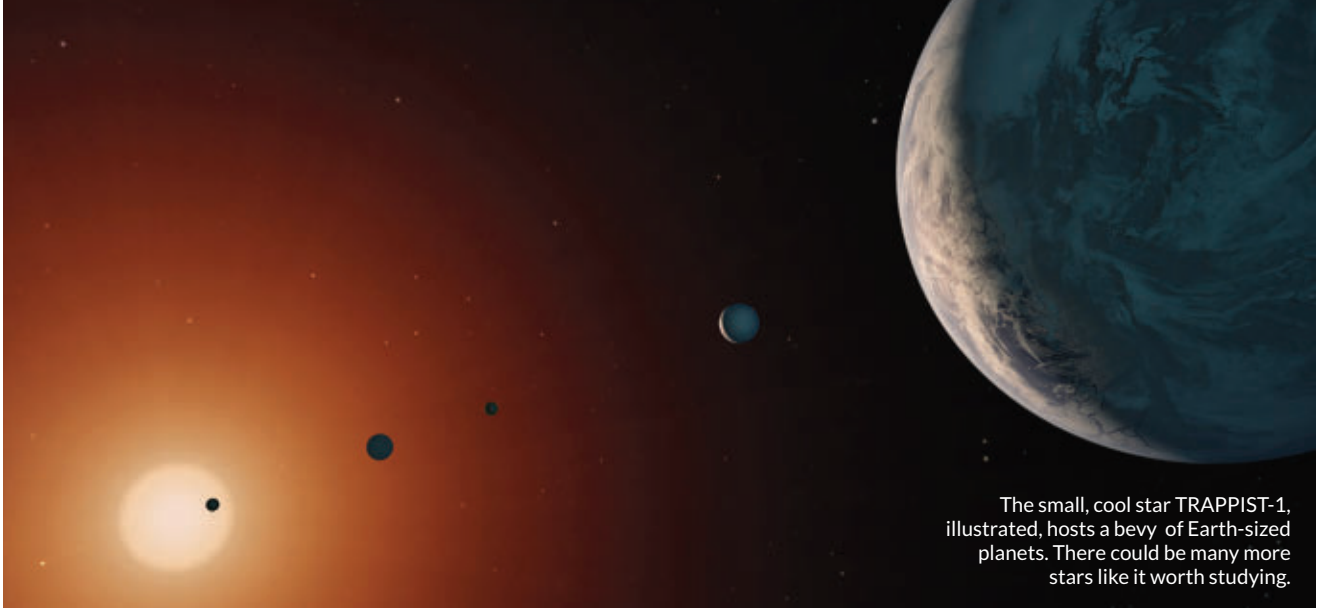
DNA from the long-gone boy offers the best evidence yet for human origins well before 200,000 years ago, evolutionary geneticists argued. That's because the child lived shortly before West African farmers migrated to eastern and southern parts of the continent and blotted out ancient genetic ancestry patterns.

Even with the African boy's DNA as a guidepost, researchers won't easily tag key players in human origins. For example, the Jebel Irhoud crowd lived during a period when possibly several African *Homo* species acquired unexpected mixes of skeletal characteristics reminiscent of even earlier *Homo* species and of people today. Witness the patchwork quilt anatomy of *Homo naledi*. This unusual-looking hominid, known from fossils from South African caves, lived between 335,000 and 236,000 years ago, researchers announced in June (*SN: 6/10/17, p. 6*). That estimate came as a surprise: *H. naledi*'s orange-sized brain and curved fingers resemble those of *Homo* species from around 2 million years ago. But many other features of *H. naledi* — possibly including a brain organized for social emotions and advanced communication (*SN Online: 4/25/17*) — could pass for those of Neandertals and humans.

Discoverers of *H. naledi* proposed that it may have originated around the same time as early forms of *H. sapiens*. Occasional interbreeding of *H. naledi* with larger-brained *Homo* species, perhaps including *H. sapiens*, may have assisted the smaller-brained species' survival, the researchers speculated.

Studies of DNA from living Africans, and from the 2,000-year-old African boy, so far indicate that at least several branches of *Homo* — some not yet identified by fossils — existed in Africa roughly 300,000 years ago, says paleoanthropologist John Hawks of the University of Wisconsin–Madison, a member of the *H. naledi* team who refrains from classifying Jebel Irhoud individuals as *H. sapiens*.

"I would look closely at the possibility that several, maybe many, ancient groups existed in Africa, some as different as *H. naledi*, but some [early] forms of humans like Jebel Irhoud as well," Hawks says. His scenario illustrates how scientists' questions about human origins are changing, and how much we humans still remain a mystery to ourselves. ■



The small, cool star TRAPPIST-1, illustrated, hosts a bevy of Earth-sized planets. There could be many more stars like it worth studying.

JPL-CALTECH/NASA

Seven Earth-sized planets orbit the same ultracool star

By Lisa Grossman

Discoveries of planets around distant stars have become almost routine. But finding seven exoplanets in one go is something special. In February, a team of planet seekers announced that a small, cool star some 39 light-years away, TRAPPIST-1, hosts the most Earth-sized exoplanets yet found in one place: seven roughly Earth-sized worlds, at least three of which might host liquid water (*SN: 3/18/17, p. 6*).

These worlds instantly became top priorities in the search for life outside the solar system. "TRAPPIST-1 is on everybody's wish list," says exoplanet astronomer Lisa Kaltenegger of Cornell University. But the planets and their dim star have also stoked a raging debate about what makes a planet habitable in the first place.

Astrophysicist Michaël Gillon of the University of Liège in Belgium and colleagues found the family of worlds orbiting the ultracool dwarf star, dubbed TRAPPIST-1 for the small telescope in Chile used to discover its planets.

"I don't think the cachet of that system is going away anytime soon," says exoplanet expert Sara Seager of MIT.

The TRAPPIST telescope team first announced in May 2016 that the star had three temperate, rocky planets. Staring at the system with the Spitzer Space Telescope for almost three weeks straight revealed that the third planet was actually four more — all Earth-sized, and three of them are in the star's habitable zone, the region where temperatures are right for liquid water on a planet's surface. A seventh planet was caught crossing the star as well, though follow-up observations showed it is too cold for life as we know it (*SN: 6/24/17, p. 18*).

The number of worlds alone makes the TRAPPIST-1 system a good spot to look for life. An alien observing our solar system would think Venus, Earth and Mars all fall in the habitable zone. But only one is inhabited. The fact that TRAPPIST-1 has so many options increases the odds that the system hosts life, Seager says.

As an ultracool dwarf, TRAPPIST-1 rides the edge of what counts as a star. Such stars burn through their nuclear fuel so slowly that they can live for many billions of years, which gives any life on their planets a long time to grow and evolve. This star's habitable zone is also incredibly close in, offering astronomers many chances to observe the planets orbiting their star.

The three planets in the habitable zone cross in front of the star every 6.10, 9.21 and 12.35 days. If two or more turn out to be habitable, then they could share life among them, either by tossing meteorites back and forth or — in the case of spacefaring civilizations — by deliberate space travel.

Future space-based observatories will be able to see starlight filtering through the planets' atmospheres, if the planets have atmospheres. Gillon and colleagues are looking for signs of escaping hydrogen, a signal that an atmosphere might be there. "We're already preparing," he says.

But ultracool dwarfs are also ill-tempered. They tend to emit frequent, powerful stellar flares, which could rip away a planet's atmosphere, threatening any potential for life. The planet-hunting Kepler space telescope recently watched TRAPPIST-1 for 80 days and saw it flare 42 times. One of those flares was as strong as Earth's 1859 Carrington Event, among the strongest geomagnetic storms ever observed.

But there are other promising systems. Recently, a similar star, Ross 128, only 11 light-years from Earth and much calmer than TRAPPIST-1, was found to have an Earth-mass planet, making it a better place to look for life, researchers reported in November in *Astronomy & Astrophysics*. Whether such stars are good or bad for life is an old and open question (*SN: 6/24/17, p. 18*). TRAPPIST-1's advantage is in its numbers. "We can check it, not just with one planet but with many planets," Kaltenegger says. "You have hotter than Earth, like Earth and colder than Earth. If you wanted Goldilocks, this is the ideal scenario."

TRAPPIST-1 is just an opening act. A bigger, more sensitive observatory called SPECULOOS is expected to be fully operational in the Chilean desert in early 2019, Gillon says. SPECULOOS will seek planets around 1,000 ultracool dwarf stars over 10 years. "We are at the edge of maybe detecting life around another star," he says. "It's really a possibility." ■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Life finds a way

2017 revealed some surprising biology of organisms large and small, from quick-dozing elephants to sex-changing lizards and carbon-dumping sea creatures.

Switch it up

Toasty temperatures trump genetics when it comes to the sex of a bearded dragon lizard (1). Now researchers have found how RNA editing helps turn overheated male embryos into females (*SN Online: 6/14/17*).

Homegrown

Giant larvaceans don't have noses, but they sure know how to blow snot bubbles. The sea invertebrates live in disposable "mucus houses" that, based on recent observations, collect food fast. When these larvaceans ditch a dirty house and "sneeze" themselves a new one, they might send a lot of carbon to the deep sea (*SN: 6/10/17, p. 13*).

Blood and guts

Antarctic-dwelling sea spiders (2) use their long legs for more than creepy-crawling below the ice. Stretches of digestive tract in the creatures' legs do double duty — not only digesting meals, but also pumping an arthropod version of blood and oxygen through the rest of the body (*SN: 2/4/17, p. 13*).

Fluorescent fashion

South American polka dot tree frogs are the first amphibians known to naturally fluoresce. The frogs' intense blue-green glow might play a role in complex courtship and fighting behaviors, biologists propose (*SN: 4/15/17, p. 4*).

Brainless beauty sleep

Upside-down jellyfish are the first brainless animals known to catch some z's, lab experiments suggest (*SN: 10/28/17, p. 10*). The finding raises new questions about when and why sleep evolved.

Pachyderm power nap

For some wild elephants, a good night's sleep ends soon after it starts. Electronic monitoring of two African elephants found that the animals snooze about two hours per day — the shortest sleep requirement recorded for mammals (*SN: 4/1/17, p. 10*).

Heads up

Chop off a hydra's head, and two more grow in its place — or so the ancient Greek myth goes. By fiddling with the cytoskeletons of real-life hydras, researchers found that the pond polyps rely on mechanical forces as well as molecular cues to regenerate head and tentacles in the right places (*SN: 3/4/17, p. 19*).

Balancing act

Flamingos may be more stable standing on one leg than two, especially when asleep, researchers reported (*SN: 6/24/17, p. 15*). The blushing bird's center of gravity is located near its tucked-in knee, which helps with stability. A one-legged stance requires little muscular effort, the scientists say, but others caution that it may not be an energy saver.

Ultimate survivor

Tardigrades (3) are known for withstanding extreme temperatures, intense radiation and even the vacuum of space. Those adaptations could help this hardy lineage survive until Earth is engulfed by the sun in several billion years, researchers estimate (*SN Online: 7/14/17*). An analysis of the microscopic water bears' genetic blueprints offers clues to their survival strategies, and challenges claims that tardigrades are extreme gene swappers (*SN: 8/19/17, p. 13*).

Paint it blue

Scientists borrowed a gene each from Canterbury bells and butterfly peas to breed the world's first true blue chrysanthemums (4). The method could be used to give other flower species the blues (*SN: 8/19/17, p. 12*).

— Cassie Martin

FROM TOP: ARTHUR GEORGES/TEAM POGONA; © TIMOTHY R. DWYER/ARCUS; 3DSTOCK/SHUTTERSTOCK; NAONOBU NODA/NARO

Quantum communication goes global

By Emily Conover

Quantum communication through space is possible thanks to a Chinese satellite that beams particles of light down to telescopes like this one in Xinglong, China (shown here tracking the satellite's location with a laser).

JIAN-WEI PAN

During the world's first telephone call in 1876, Alexander Graham Bell summoned his assistant from the other room, stating simply, "Mr. Watson, come here. I want to see you." In 2017, scientists testing another newfangled type of communication were a bit more eloquent. "It is such a privilege and thrill to witness this historical moment with you all," said Chunli Bai, president of the Chinese Academy of Sciences in Beijing, during the first intercontinental quantum-secured video call.

The more recent call, between researchers in Austria and China, capped a series of milestones reported in 2017 and made possible by the first quantum communications satellite, Micius, named after an ancient Chinese philosopher (*SN: 10/28/17, p. 14*).

Created by Chinese researchers and launched in 2016, the satellite is fueling scientists' dreams of a future safe from hacking of sensitive communiqués. One day, impenetrable quantum cryptography could protect correspondences. A secret string of numbers known as a quantum key could encrypt a credit card number sent over the internet, or encode the data transmitted in a video call, for example. That quantum key would be derived by measuring the properties of quantum particles beamed down from such a satellite. Quantum math proves that any snoops trying to intercept the key would give themselves away.

"Quantum cryptography is a fundamentally new way to give us unconditional security ensured by the laws of quantum physics," says Chao-Yang Lu, a physicist at the University of Science and Technology of China in Hefei, and a member of the team that developed the satellite.

But until this year, there's been a sticking point in the technology's development: Long-distance communication is extremely challenging, Lu says. That's because quantum particles are delicate beings, easily jostled out of their fragile quantum states. In a typical quantum cryptography scheme, particles of light called photons are sent through the air, where the particles may be absorbed or their properties muddled. The longer the journey, the fewer photons make it through intact, eventually preventing accurate transmissions of quantum keys. So quantum cryptography was possible only across short distances, between nearby cities but not far-flung ones.

With Micius, however, scientists smashed that distance barrier. Long-distance quantum communication became possible because traveling through space, with no atmosphere to stand in the way, is much easier on particles.

In the spacecraft's first record-breaking accomplishment, reported June 16 in *Science*, the satellite used onboard lasers to beam down pairs of entangled particles, which have eerily linked properties, to two cities in China, where the particles were captured by telescopes (*SN: 8/5/17, p. 14*). The quantum link remained intact over a separation of 1,200 kilometers between the two cities — about 10 times farther than ever before. The feat revealed that the strange laws of quantum mechanics, despite their small-scale foundations, still apply over incredibly large distances.

Next, scientists tackled quantum teleportation, a process that transmits the properties of one particle to another particle (*SN Online: 7/7/17*). Micius teleported photons' quantum properties 1,400 kilometers from the ground to space — farther than ever before, scientists reported September 7 in *Nature*. Despite its sci-fi name, teleportation won't be able to beam Captain Kirk up to the *Enterprise*. Instead, it might be useful for linking up future quantum computers, making the machines more powerful.

The final piece in Micius' triumvirate of tricks is quantum key distribution — the technology that made the quantum-encrypted video chat possible. Scientists sent strings of photons from space down to Earth, using a method designed to reveal eavesdroppers, the team reported in the same issue of *Nature*. By performing this process with a ground station near Vienna, and again with one near Beijing, scientists were able to create keys to secure their quantum teleconference. In a paper published in the Nov. 17 *Physical Review Letters*, the researchers performed another type of quantum key distribution, using entangled particles to exchange keys between the ground and the satellite.

The satellite is "a major development," says quantum physicist Thomas Jennewein of the University of Waterloo in Canada, who is not involved with Micius. Although quantum communication was already feasible in carefully controlled laboratory environments, the Chinese researchers had to upgrade the technology to function in space. Sensitive instruments were designed to survive fluctuating temperatures and vibrations on the satellite. Meanwhile, the scientists had to scale down their apparatus so it would fit on a satellite. "This has been a grand technical challenge," Jennewein says.

Eventually, the Chinese team is planning to launch about 10 additional satellites, which would fly in formation to allow for coverage across more areas of the globe. ■

Concerns grow that CO_2 rise may steal crop nutrients

By Susan Milius

2017 was a good year for worrying about nutrient losses that might come with a changing climate.

The idea that surging carbon dioxide levels could stealthily render some major crops less nutritious has long been percolating in plant research circles. "It's literally a 25-year story, but it has come to a head in the last year or so," says Lewis Ziska, a plant physiologist with the U.S. Agricultural Research Service in Beltsville, Md.

Concerns are growing that wheat, rice and some other staple crops could, pound for pound, deliver less of some minerals and protein in decades to come than those crops do today. In 2017, three reports highlighted what changes in those crops could mean for global health. Also this year, an ambitious analysis made an almost-global assessment of sources of selenium, a trace element crucial for health, and warned of regions where climate change might cut the element's availability (*SN: 4/1/17, p. 14*).

Crop responses to rising CO_2 might affect nutrition and health for billions of people, Ziska says, but the idea has been difficult to convey to nonspecialists. One complication is that though plants certainly need CO_2 to grow, providing more of it doesn't mean that all aspects of plant biology change in sync. In hoping for a farming bonus, Ziska warns, people often overlook the disproportionate zest of weeds. An outdoor experiment wafting extra CO_2 through a forest has already shown, for example, that poison ivy grew faster than the trees.

In the 2017 *Annual Review of Public Health*, Samuel Myers of Harvard University and colleagues wrote that global shortfalls in human nutrition are already "staggering." More than a billion people aren't getting enough zinc now, raising risks of premature birth, stunted childhood growth and weak immune systems. To estimate future shortfalls, Myers and colleagues turned to nutrient data they published in 2014 in *Nature*.

That report compared staple crops grown in various outdoor setups on three continents at either ambient or enhanced atmospheric CO_2 concentrations. Fancy research piping boosted ambient levels of 363 to 386 parts per million to 546 and 584 ppm. (A moderate scenario puts late-century levels at 580 to 720 ppm.)

Decreases in zinc concentrations, including in rice and wheat, could plunge an additional 150 million to 200 million people into zinc deficiency, the researchers calculate. Likewise, predicted declines in iron content in some grains and legumes look worrisome for countries with anemia rates already higher than 20 percent, such as India and Algeria, Myers and colleagues reported in August in *GeoHealth*. Such high-anemia nations have a lot of people especially at risk, including 1.4 billion young children and women of childbearing age.

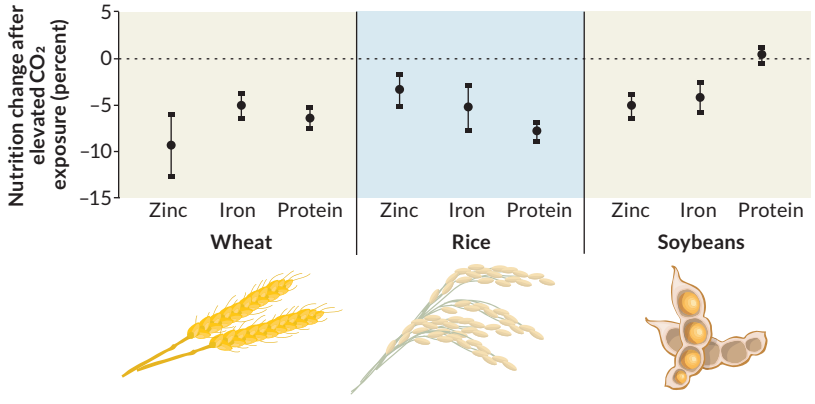
An expanded set of experiments suggested that protein content in rice and wheat could sink by roughly 8 percent, Myers and colleagues wrote in the August *Environmental Health Perspectives*. Thus, rising CO_2 could add some 148 million people worldwide to the roughly 1.4 billion expected to be short of protein by 2050.

Also this year, grazing cattle joined the list of animals facing a protein downturn in their food. (Ziska and colleagues raised the issue for bees in 2016.) For cattle, 22 years and more than 36,000 fecal measurements suggest that plants on U.S. grazing lands have grown poorer in protein, ecologist Joseph Craine of Jonah Ventures, in Boulder, Colo., and colleagues reported April 10 in *Environmental Research Letters*. For every kilogram of plants that cattle ate in 2015, there were 10.6 grams less protein than there had been 22 years before. The yearly loss is equivalent to the protein available in $1.9 billion worth of soy meal — and rising CO_2 is a possible culprit.

Plant reactions will be varied and complex, Ziska points out. An *Artemisia* plant's antimalarial compound, artemisinin, can get more concentrated as CO_2 increases, possibly good news for plant-based medicine. But the mix of urushiols, oils that put the itch in poison ivy, can become more allergy-provoking when exposed to extra CO_2, a test suggested. Ziska is now looking into how much caffeine will turbocharge future coffee beans.

Whatever the changes, concern is growing, says mathematical biologist Irakli Loladze of Bryan College of Health Sciences in Lincoln, Neb. He, Ziska and nine coauthors included nutritional erosion in the 2016 U.S. scientific assessment of the impacts of climate change on human health. To raise the public profile of the issue, though, Myers says, "We have a ways to go." ■

Nutrient tracker Major crops showed some nutrient changes when grown in experimental plots with extra carbon dioxide blown over plants (ranging from 546 to 586 parts per million). Wheat, rice and soybeans (below) showed drops in zinc and iron content, with wheat and rice also having less available protein. But nutrient drops were not universal. Results suggest that sorghum and maize may better preserve nutrients as atmospheric CO_2 increases. And concentrations of phytate, which can interfere with zinc uptake, decreased only in wheat. SOURCE: S. MYERS *ET AL*/*NATURE* 2014



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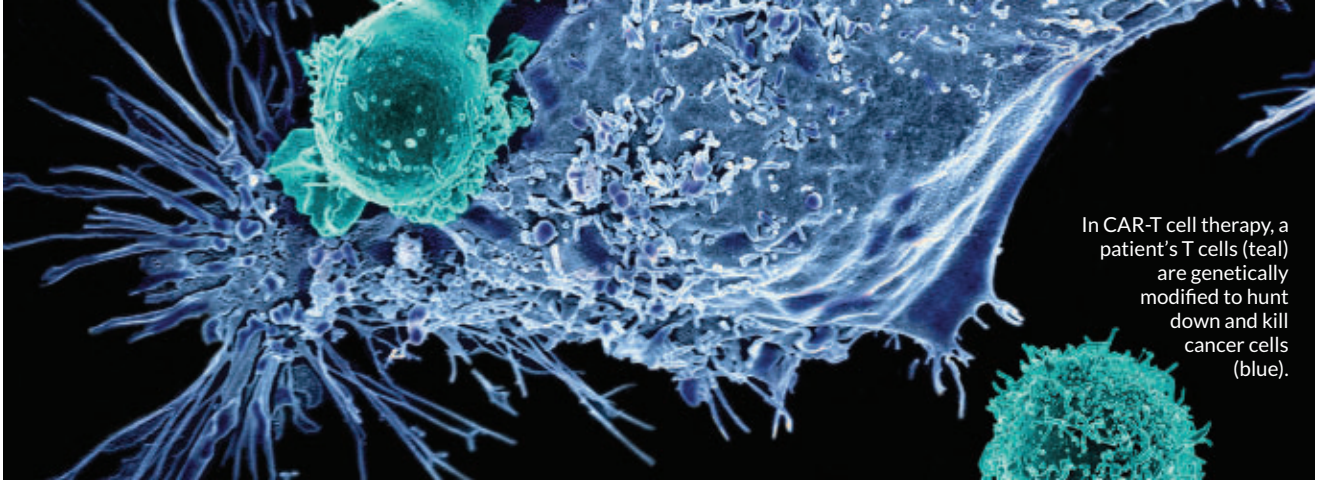


In CAR-T cell therapy, a patient's T cells (teal) are genetically modified to hunt down and kill cancer cells (blue).

PRASAD ADUSUMILLI, ©2017 MEMORIAL SLOAN KETTERING CANCER CENTER

FDA approves gene therapy for two blood cancers

By Laurel Hamers

This year, gene therapy finally became a clinical reality. The U.S. Food and Drug Administration approved two personalized treatments that engineer a patient's own immune system to hunt down and kill cancer cells. The treatments, the first gene therapies ever approved by the FDA, work in people with certain blood cancers, even patients who haven't responded to other treatments.

Called CAR-T cell immunotherapy (for chimeric antigen receptor T cell), one is for kids and young adults with B cell acute lymphoblastic leukemia, or ALL, approved in August (*SN Online: 8/30/17*). The other is for adults with non-Hodgkin lymphoma, approved in October. Other CAR-T cell therapies are in testing, including a treatment for multiple myeloma.

"It's a completely different way of treating cancer," says pediatric oncologist Stephan Grupp, who directs the Cancer Immunotherapy Program at the Children's Hospital of Philadelphia. Grupp spearheaded the clinical trials of the newly approved ALL therapy, called Kymriah.

Researchers are developing many different versions of CAR-T cell therapies, but the basic premise is the same: Doctors remove a patient's T cells (immune system cells that attack invaders) from a blood sample and genetically modify them to produce artificial proteins on their surfaces. Those proteins, called chimeric antigen receptors, recognize the cancer cells in the patient's body. After the modified T cells make many copies of themselves in the lab, they're unleashed in the patient's bloodstream to find and kill cancer cells.

CAR-T cell therapy is particularly exciting because it works well in people who haven't responded to other available treatments, says Renier Brentjens, an oncologist at Memorial Sloan Kettering Cancer Center in New York City. Of the 63 kids and young adults treated in a clinical trial of Kymriah, 83 percent had their cancers go into remission within three months.

Now that these therapies have been clinically approved, there's been an "explosion of interest" in the approach, says Dario Campano, an immunopathologist at the National University Cancer Institute in Singapore. Going forward, he expects to see even more rapid progress in the technology. Fifteen years ago, Campana helped develop the chimeric antigen receptor that's used in Kymriah today. For now, the treatments are approved for use only when other treatments have failed, but someday CAR-T cell therapy could be the first treatment doctors try, he says.

One drawback is the price. Kymriah costs $475,000 for a onetime treatment, according to Novartis, which makes Kymriah. The non-Hodgkin lymphoma treatment made by Gilead Sciences, called Yescarta, is listed at $373,000. The total price tag for treatment could be higher when the costs of dealing with side effects and complications are factored in.

The approach is approved only for blood cancers. Using CAR-T cell therapy on solid tumors will require finding ways to get the T cells past additional cellular roadblocks, Grupp says. ■

Health watch

From the opioid epidemic to air pollution, public health woes captured a lot of attention in 2017. Below are a few key stats behind this year's headlines.

13.4 million

Estimated number of U.S. adults who misused or abused opioids in 2015, according to an August report (*SN: 9/2/17, p. 5*)

19

Number of U.S. children each day who die or are medically treated in an emergency department for gun-inflicted wounds (*SN Online: 6/26/17*)

9 million

People who died from pollution globally in 2015, the *Lancet* Commission on pollution and health announced in October (*SN: 11/25/17, p. 5*)

46 percent

Portion of U.S. adults with high blood pressure, according to a new definition from the American College of Cardiology and the American Heart Association (*SN: 12/9/17, p. 13*)

9 CTE may be common among pro football players

By Laura Sanders

A study this year dealt a new blow to football, one of the hardest hits yet, detailing the extensive damage seen in football players' brains, and not just those who played professionally.

In a large collection of former NFL players' postmortem brains, nearly every sample showed signs of chronic traumatic encephalopathy, or CTE, a disorder (diagnosed after death) that's associated with memory loss, emotional outbursts, depression and dementia. Damaging clumps of the protein tau were present in 110 of 111 brains, researchers reported in *JAMA* (*SN: 8/19/17, p. 15*).

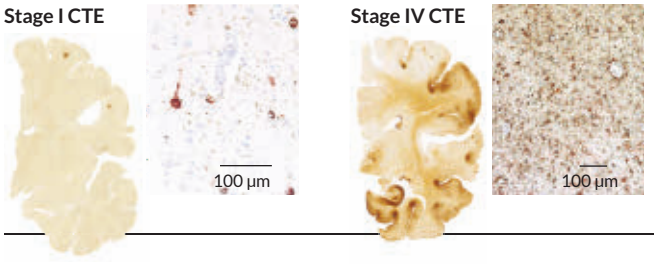
Those startling numbers captured the attention of both the football-loving public and some previously skeptical researchers, says study coauthor Jesse Mez, a behavioral neurologist at Boston University. "This paper did a lot to bring them around," Mez says. "The number of brain donors who have donated since the *JAMA* paper came out has been astronomical."

In a smaller sample of former college and high school football players' brains, three of 14 high school players and 48 of 53 college players had signs of CTE. Many of the brains were donated by relatives who suspected something was amiss. That skewed sample makes it difficult to draw broad conclusions. But the study raises questions about the safety of youth contact sports.

A study of concussed hockey players ages 11 to 14 suggested that young brains may need more time than is usually allotted to heal after a hard knock. Players had troublesome changes in white matter tracts — nerve cell bundles that carry messages across the brain — three months after injury, despite normal thinking and memory abilities, researchers reported in November in *Neurology*.

Scientists would like a way to identify and follow CTE as it progresses. A comprehensive study is now under way to look for CTE markers in living people, and has already hit on one clue. Compared with postmortem brain tissue from healthy people and those with Alzheimer's, tissue from people who had CTE had higher levels of an inflammation protein called CCL11, Mez and colleagues reported in September in *PLOS ONE*. In people with CTE, the more years that a person played football, the more CCL11. CCL11 levels might one day let scientists monitor brain health in people exposed to head trauma. ■

Red and redder Clumps of tau protein (dark red) are more common in the brain as CTE, or chronic traumatic encephalopathy, progresses from mild (left, as seen in the brain of a former college football player) to severe (right, as seen in a brain of a former NFL player).



10 Zika is not gone for good

By Aimee Cunningham

One of the top stories of 2016 went quiet in 2017. Zika shook the Americas in 2016, as reports of infections and devastating birth defects swept through Brazil and Colombia, eventually reaching the United States. In a welcome turn, the number of Zika cases in the Western Hemisphere this year dropped dramatically in the hardest-hit areas. But few scientists are naïve enough to think we've seen the last of Zika. "The clock is ticking for when we will see another outbreak," says Andrew Haddow, a medical entomologist at the U.S. Army Medical Research Institute of Infectious Diseases in Frederick, Md.

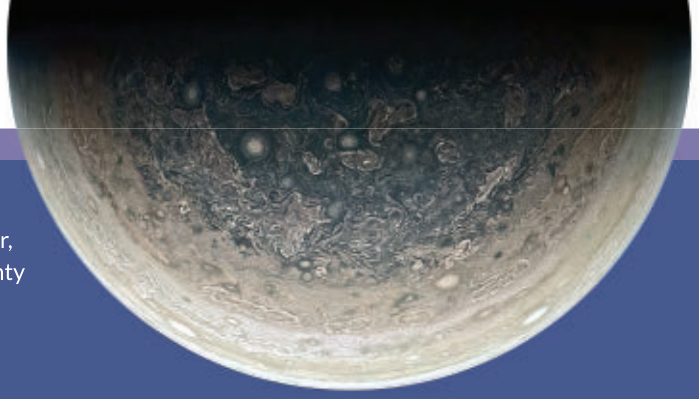
This year has seen progress in learning more about Zika's biology and interactions with its hosts, and in developing a safe and effective vaccine. The epidemic lost steam because many areas have probably developed herd immunity to the virus (*SN: 11/11/17, p. 12*). The large number of people infected with Zika are now presumably immune, providing indirect protection to people who haven't encountered Zika. If the mosquito-borne virus can't find enough people to infect, it can't easily spread.

But Zika gets around in other ways. This year, researchers learned more about how Zika spreads through sexual intercourse. In humans, Zika can persist in semen for close to three months (*SN Online: 2/14/17*). And Haddow and colleagues reported in the August *Emerging Infectious Diseases* that four of eight macaques exposed to the virus vaginally developed infections as did seven of eight macaques that received the virus via the rectum. In the wild, animals are reservoirs for Zika between human outbreaks. A small number of black-striped capuchin monkeys and common marmosets in a region of Brazil with high numbers of human cases were found to carry the virus, the first such report among New World monkeys (*SN: 3/4/17, p. 15*).

Especially concerned about Zika's effects during pregnancy (*SN Online: 3/2/17*), researchers have rushed to develop vaccines (*SN: 3/18/17, p. 12*). In its first test in humans, reported in the *New England Journal of Medicine*, one vaccine based on DNA from the virus elicited an immune response in 100 percent of participants after a three-dose regimen. Another DNA-based vaccine is in a second round of human testing.

Monitoring that tracks Zika and other infectious diseases during pregnancy must also improve, says Denise Jamieson, an obstetrician gynecologist at Emory University School of Medicine in Atlanta. "With Zika, we were reminded about the importance of birth defect surveillance." ■

J. MEZ *ET AL*/*JAMA* 2017



Mission debriefing

Missions to Jupiter and Saturn made big headlines this year, offering closeup views of the two gas giants. 2017 had plenty of other updates from exciting missions of years past.

Juno

The Juno spacecraft has kept a watchful eye on Jupiter (enhanced color image of south pole above) since entering the gas giant's orbit in 2016. This year, Juno had seven planned science flybys of the planet, giving researchers a first intimate look at the Great Red Spot (*SN Online: 7/7/17*) and revealing surprising details about the planet's interior. Measurements of Jovian gravity suggest that Jupiter's core is large and diffuse, and microwave views show that ammonia wells up to the cloud tops from deep in the atmosphere (*SN: 6/24/17, p. 14*). But scientists aren't having all the fun. The public is helping decide where to point a color camera aboard the spacecraft, to learn about the planet's cloud structures and dynamics, among other things (*SN Online: 2/17/17*). Juno will continue collecting data from Jupiter through at least July 2018.

Cassini

After 20 years in space, 13 in orbit around Saturn (*SN: 9/2/17, p. 16*), Cassini went out in a blaze on September 15. The spacecraft burned up like a comet in the planet's atmosphere — but not before sending back unprecedented observations (*SN Online: 9/15/17*). In the months before its death dive, Cassini looped between Saturn and its innermost ring. Data from this unexplored zone will help researchers better define the length of a Saturnian day and learn what the rings are made of and how they formed. Earlier this year, Cassini snapped the closest-ever views of Saturn's atmosphere (*SN Online: 4/27/17*) and revealed that Pan, a tiny moon that orbits amid Saturn's rings, has a ridge around its equator, making it look like a ravioli (*SN: 4/15/17, p. 10*). Simulations suggest that bubbling nitrogen may be the source of a blinking bright spot, or "magic island," that Cassini spotted in the hydrocarbon sea Ligeia Mare on the moon Titan (*SN: 5/13/17, p. 17*). And data published this year from a 2015 dive through plumes from Enceladus indicate that the icy moon harbors molecular hydrogen — a gas that on Earth serves as food for some microbes (*SN: 5/13/17, p. 6*).

Curiosity

The Mars rover celebrated its fifth year exploring the Red Planet in 2017, and is set to continue its run at least through September 2018. While rolling around Mount Sharp, which stands more than 5 kilometers tall at the center of Mars' Gale crater, the robot will sample new rock layers dominated by hematite and clay, as well as one with a lot of sulfate salts. Those sediments may provide answers to scientists' burning questions, including how Mars transitioned from a wet, warm world to what we see today, and whether the planet possesses the chemical building blocks for life (*SN Online: 8/4/17*).

New Horizons

New Horizons had its 15 minutes of fame in 2015 when it whizzed past Pluto, but the spacecraft still has more to offer. In 2017, researchers studying New Horizons' images of Pluto's hazy silhouette alongside simulations suggested that solid particles in the dwarf planet's atmosphere could be to blame for the unexpectedly cold conditions (*SN: 12/9/17, p. 18*). And a splotchy surface complexion is due to periodic collapse of Pluto's atmosphere (*SN: 4/15/17, p. 14*). Unlike its planetary neighbors, Pluto definitely does not have rings, mission scientists reported (*SN: 10/28/17, p. 15*). New Horizons is set to arrive at its next target — an odd Kuiper Belt object dubbed 2014 MU69 — in January 2019. Earlier this year, Earth-based telescopes caught the object, roughly 6.5 billion kilometers away, eclipsing a star (*SN Online: 7/20/17*).

OSIRIS-REx

The spacecraft, which launched in 2016, swung back by Earth on September 22 for a quick gravity assist on its way to Bennu, a carbon-rich asteroid that comes within about 300,000 kilometers of Earth every six years (*SN Online: 9/8/16*). OSIRIS-REx flew within about 17,000 kilometers above Antarctica, using Earth's gravity to slingshot itself toward the asteroid. The craft is slated to reach Bennu on August 17, 2018, where it will orbit the asteroid for about 2½ years, making observations and using a robotic arm to collect a rock sample before journeying home. Researchers hope to analyze the sample to learn more about the early solar system.

Dawn

Orbiting Ceres since 2015, the Dawn spacecraft picked up hints of organic material on the dwarf planet's surface, researchers reported in February — a sign that Ceres may have once had a habitable environment. The evidence came in the form of a pattern of absorbed and reflected light consistent with organics. But without a sample from the surface, researchers can't definitively identify the organic material or say how it formed (*SN: 3/18/17, p. 8*). In October, NASA extended Dawn's mission indefinitely. In stable orbit around Ceres, Dawn will continue circling even after it runs out of fuel late next year (*SN Online: 10/20/17*). — *Cassie Martin*

JPL-CALTECH/NASA, SWRI, MSSS, ROMAN TKACHENKO

SCIENCE MAKING HEADLINES

Science came out of the lab and touched people's lives in some awe-inspiring and alarming ways in 2017. Science enthusiasts gathered to celebrate a total solar eclipse, but also to march on behalf of evidence-based policy making. Meanwhile, deadly natural disasters revealed the strengths and limitations of science. Here's a closer look at some of the top science events of the year.

Great American Eclipse

On August 21, many Americans witnessed their first total solar eclipse, dubbed the "Great American Eclipse." Its path of totality stretched across the United States, passing through 14 states — with other states seeing a partial eclipse. This was the first total solar eclipse visible from the mainland United States since 1979, and the first to pass from coast to coast since 1918 (*SN: 8/20/16, p. 14*). As people donned protective glasses to watch, scientists used telescopes, spectrometers, radio receivers and even cameras aboard balloons and research jets in hopes of answering lingering questions about the sun, Earth's atmosphere and the solar system. One of the biggest: Why is the solar atmosphere so much hotter than the sun's surface (*SN Online: 8/20/17*)? Data collected during the event (composite image from Casper, Wyo., above) may soon provide new insights.

March for Science

On April 22, Earth Day, more than 1 million people in over 600 cities around the world marched to defend science's role in society. Called the first-ever March for Science, the main event was in Washington, D.C., (pictured above, middle). Featured speakers included Denis Hayes, coordinator of the first Earth Day in 1970, and science advocate Bill Nye (*SN Online: 4/22/17*). Attendees advocated for government funding for scientific research and acceptance of the scientific evidence on climate change. The march came on the heels of the Trump administration's first budget proposal, released in March, which called for cutting federal science spending in fiscal year 2018 (*SN: 4/15/17, p. 15*). Some scientists worried that being involved with the march painted science in a partisan light, but others said science has always been political since scientists are people with their own values and opinions (*SN Online: 4/19/17*).

Climate deal announcement

On June 1, President Donald Trump announced that the United States would pull out of the Paris climate accord (*SN Online: 6/1/17*) — an agreement the United States and nearly 200 other countries signed in 2015 pledging to curb greenhouse gas emissions to combat global warming. With the announcement, Trump made good on one of his campaign promises. He said during a news conference that the agreement "is less about the climate and more about other countries gaining a financial advantage over the United States." Nicaragua and Syria signed on to the agreement in late 2017. A withdrawal from the United States would leave it as the only United Nations–recognized country to reject the

STAFF SGT. CHRISTOPHER RUANO/U.S. AIR FORCE

CLOCKWISE FROM LEFT: XINHUA/ALAMY STOCK PHOTO; KCNA VIA KNS/AFP/GETTY IMAGES; STR/AFP/GETTY IMAGES

global pact. President Trump left the door open for the United States to stay in the climate deal under revised terms. A U.S. climate assessment released in November by 13 federal agencies said it is "extremely likely" that humans are driving warming on Earth (*SN Online: 11/3/17*). Whether that report — the final version of which is due to be released in 2018 — will have an impact on U.S. involvement in the global accord remains to be seen.

North Korea nuclear test

On September 3, North Korea reported testing a hydrogen bomb, its sixth confirmed nuclear detonation, within a mountain at Punggye-ri. That test, along with the launch of intercontinental ballistic missiles this year (Korean Central News Agency image from November at top right), increased hostilities between North Korea and other nations, raising fears of nuclear war. As a result of these tests, the United Nations Security Council passed a resolution strengthening sanctions against North Korea to discourage the country from more nuclear testing. As the international community waits to see what's next, scientists continue to study the seismic waves that result from underground explosions in North Korea. These studies can help reveal the location, depth and strength of a blast (*SN: 8/5/17, p. 18*).

Natural disasters

The 2017 Atlantic hurricane season saw hurricanes Harvey, Irma and Maria devastate areas of Texas, Florida and the Caribbean. More than 200 people died from these three massive storms, and preliminary estimates of damage are as high as hundreds of billions of dollars. (Maria's damage on the Caribbean island of Dominica is shown above, bottom right.) The National Oceanic and Atmospheric Administration had predicted that the 2017 season could be extreme, thanks to above-normal sea surface temperatures. The storms offered scientists an opportunity to test new technologies that might save lives by improving forecasting (*SN Online: 9/21/17*) and by determining the severity of flooding in affected regions (*SN Online: 9/12/17*). In addition to these deadly storms, two major earthquakes rocked Mexico in September, killing more than 400 people. More than 500 died when a magnitude 7.3 earthquake shook Iran and Iraq in November. And wildfires raged across the western United States in late summer and fall. In California, fires spread quickly thanks to record summer heat and high winds. At least 40 people died and many more were hospitalized in California's October fires. Rising global temperatures and worsening droughts are making wildfire seasons worldwide last longer on average than in the past, researchers have found (*SN Online: 7/15/15*). — *Kyle Plantz*

BOOKSHELF

Science News' favorite books of 2017

Have you fallen behind on your reading this year? Or maybe you've plowed through your must-reads and are ready for more. *Science News* has got you covered. Here are the staff's picks for some of the best science books of 2017. Find detailed reviews from previous issues at **bit.ly/SN_books2017**

Against the Grain
James C. Scott
Armed with the latest archaeological research, a political anthropologist argues that the rise of civilization came at a big cost. The initial switch from hunting and gathering to agricultural states brought poor diets, labor-intensive work, outbreaks of infectious diseases and other hardships (*SN: 10/14/17, p. 28*). *Yale Univ., $26*

The Great Quake
Henry Fountain
Historical records and interviews with survivors flesh out this tale of how a massive earthquake in Alaska in 1964 provided geologists with key evidence needed to verify the theory of plate tectonics (*SN: 9/16/17, p. 32*). *Crown, $28*

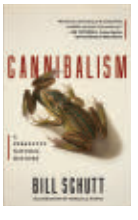
Eclipse
Frank Close
More than just a primer on the science of solar eclipses, this memoir chronicles a physicist's lifetime fascination with the celestial phenomenon and introduces readers to the quirky world of eclipse chasers (*SN: 5/13/17, p. 28*). *Oxford Univ., $21.95*

Rise of the Necrofauna
Britt Wray
Resurrecting woolly mammoths, passenger pigeons and other extinct creatures isn't just a technological problem, as this book explains. "De-extinction" is also rife with ethical dilemmas (*SN: 10/28/17, p. 28*). *Greystone Books, $26.95*

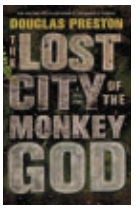
Big Chicken
Maryn McKenna
Antibiotics transformed chicken farming, to the detriment of the birds and of human health, a journalist contends. Widespread use of the drugs fueled the industrialization of poultry production and the rise of antibiotic-resistant bacteria (*SN: 9/30/17, p. 30*). *National Geographic, $27*

Inferior
Angela Saini
A science writer makes a persuasive case that centuries of biased thinking and flawed scientific research have reinforced sexist stereotypes about women (*SN: 9/2/17, p. 27*). *Beacon Press, $25.95*

Caesar's Last Breath
Sam Kean
Through fun historical anecdotes and lesser-known backstories of scientific greats, this entertaining book profiles the chemical elements that make up the air we breathe and traces the history of Earth's atmosphere (*SN: 7/8/17 & 7/22/17, p. 38*). *Little, Brown and Co., $28*



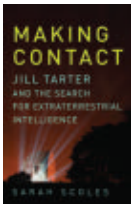
Cannibalism
Bill Schutt
The grisly practice of eating your own kind turns out to be widespread in the animal kingdom, a zoologist explains in this captivating look at cannibalism (*SN: 2/18/17, p. 29*). *Algonquin Books, $26.95*



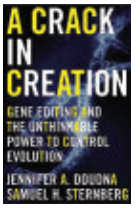
The Lost City of the Monkey God
Douglas Preston
A journalist tags along on an archaeological expedition to search for the real-life remains of a mythological city in this rainforest adventure tale that morphs into a medical mystery (*SN: 2/4/17, p. 28*). *Grand Central Publishing, $28*

The Death and Life of the Great Lakes
Dan Egan
Invasive species, urbanization and other threats have wreaked havoc on the Great Lakes, but this book still finds some glimmers of hope in the scientists who are making headway in resuscitating the ecosystem (*SN: 3/18/17, p. 30*). *W.W. Norton & Co., $27.95*

How to Tame a Fox
Lee Alan Dugatkin and Lyudmila Trut
An experiment to replay animal domestication by selectively breeding wild silver foxes is lovingly retold, including by the researcher who has kept the project alive for nearly 60 years (*SN: 5/13/17, p. 29*). *Univ. of Chicago, $26*



Making Contact
Sarah Scoles
In the face of numerous obstacles, Jill Tarter still managed to spearhead the search for extraterrestrial intelligence for decades, as this biography recounts (*SN: 8/5/17, p. 26*). *Pegasus Books, $27.95*



A Crack in Creation
Jennifer A. Doudna and Samuel H. Sternberg
Two experts, including one of the pioneers of CRISPR/Cas9, discuss the science and ethics of gene editing. *Houghton Mifflin Harcourt, $28*

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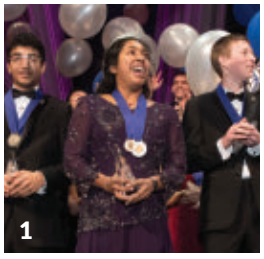
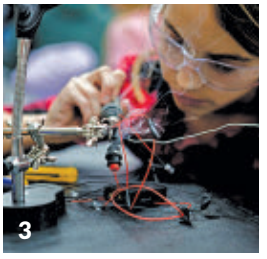
Top 10 Society stories of the year





1 **Regeneron Science Talent Search**
2017 marked the first year in Regeneron's $100 million, 10-year sponsorship of the Science Talent Search, the nation's oldest and most prestigious science and math competition for high school seniors. Indrani Das of Oradell, N.J., won the top award for her study of a possible approach to treating the death of neurons due to brain injury or neurodegenerative disease.

2 **Intel International Science and Engineering Fair (ISEF)**
Nearly 1,800 young scientists selected from 421 affiliated fairs in 78 countries, regions and territories competed at the 2017 Intel ISEF in Los Angeles in May. The Society for Science & the Public was proud to welcome Zimbabwe and Ghana to Intel ISEF for the first time. Ivo Zell of Hessen, Germany, won the first place Gordon E. Moore Award of $75,000.

3 **STEM Action & Research Grants Help Teachers and Nonprofits**
The Society awarded $120,000 in grants to science research teachers to purchase much-needed equipment and $55,000 to 13 innovative organizations supporting community-based science, technology, engineering and mathematics (STEM) projects through our STEM Action & Research Grant Program.

4 **Advocates Named**
In April, the Society named 45 Advocates who will work to expand STEM opportunities for underserved students. The Advocate Grant Program seeks to open the door to scientific research for these students, many of whom are unaware of or unable to take advantage of science fair competitions.

5 **Research Teachers Conference**
In October, 200 science research teachers from across the country received an all-expense-paid weekend to share best practices at the 2017 Research Teachers Conference in Washington, D.C., sponsored by Regeneron.

6 **SN 10 Highlights Scientists to Watch**
For the third year in a row, *Science News* highlighted 10 early- and mid-career scientists on their way to widespread acclaim. This year's SN 10, announced in October, were José Dinneny, Jennifer Dionne, M. Ehsan Hoque, KC Huang, David Kipping, Chong Liu, Lena Pernas, Kay Tye, Christina Warinner and Luhan Yang.

7 **Broadcom MASTERS**
For the first time in the Society's history, one of our own, alumnus Ben Hylak (shown above), spoke to the 30 middle school finalists who competed in the Broadcom MASTERS in October. Faris Irwin Wald of Santa Fe, N.M., won the top award — the $25,000 Samueli Foundation Prize.

8 **New Board Members Named**
This year, the Society was proud to announce the addition of three new members to the Board of Trustees: Feng Zhang (shown above), noted scientist and alumnus of the 1998 and 1999 International Science and Engineering Fairs, as well as the 2000 Science Talent Search; Nobel Prize–winning scientist Martin Chalfie; and distinguished philanthropist and investor Christy Burton.

9 ***Science News for Students* Celebrates Diversity**
Science News for Students continued its series on the need for greater diversity in STEM. This year's focus was on the need for more people of color in science and how people with disabilities are involved in STEM.

10 ***SN*'s Expanded Eclipse Coverage**
Science News' extraordinary coverage of the 2017 total solar eclipse included a series of stories examining what we can learn from the natural phenomenon. The series also included reporting from the path of totality, an online interactive showing future solar eclipse paths and social media coverage.

Bigger Buttons

"My friends all hate their cell phones… I love mine!" Here's why.

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Say good-bye to everything you hate about cell phones. Say hello to the Jitterbug Flip.

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"I had to get my son to program it." Your Jitterbug Flip setup process is simple. We'll even program it with your favorite numbers.

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"My cell phone company wants to lock me in a two-year contract!" Not with the Jitterbug Flip. There are no contracts to sign and no cancellation fees.

Available in Red and Graphite.

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Monthly Minutes	200	600
Personal Operator Assistance	24/7	24/7
Long Distance Calls	No add'l charge	No add'l charge
Voice Dial	FREE	FREE
Nationwide Coverage	YES	YES
30-Day Return Policy[2]	YES	YES

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"My phone's battery only lasts a short time." Unlike most cell phones that need to be recharged every day, the Jitterbug Flip was designed with a long-lasting battery, so you won't have to worry about running out of power.

"Many phones have features that are rarely needed and hard to use!" The Jitterbug Flip contains easy-to-use features that are meaningful to you. A built-in camera makes it easy and fun for you to capture and share your favorite memories. And a flashlight with a built-in magnifier helps you see in dimly lit areas. The Jitterbug Flip has all the features you need.

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Online favorites of 2017

The *Science News* website attracted millions of visitors in 2017. The lists below name the most-read online stories outside of our Top 10 stories of the year (see Page 18), plus the most popular stories for each of our blogs.

SOCIAL MEDIA

Watch it again

Simulations of Cassini's death dive to Saturn (illustrated below) and of Earth's swirling atmosphere (see Page 40), a ladybug's awesome packing skills and more — *Science News* readers saw it all this year. Here are 2017's most-viewed *Science News* videos on Facebook and YouTube. Watch them again at **bit.ly/SN_favorites2017**

1 Cassini's timeline to destruction (*SN Online: 9/11/17*)
2 Light and gravitational waves reveal a neutron star crash (*SN Online: 10/16/17*)
3 How to pack wings like a ladybug (*SN Online: 6/13/17*)
4 Seven times Curiosity proved how awesome Mars used to be (*SN Online: 8/4/17*)
5 Watch the 2017 hurricane season unfold (*SN Online: 11/20/17*)

Join the conversation

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Top stories

1 **The blue wings of this dragonfly may be surprisingly alive**
Tiny tubes between veins in the shimmery blue wings of morpho dragonflies (one shown) may be respiratory networks that help create nanostructures responsible for the dazzling display (*SN Online: 6/30/17*).

2 **Here are the paths of the next 15 solar eclipses**
Did you miss the Great American Eclipse? Find another opportunity using this map of all 15 total solar eclipses from 2017 to 2040 (*SN Online: 8/18/17*).

3 **Mystery void is discovered in the Great Pyramid of Giza**
High-energy particles from space called cosmic rays helped scientists uncover a previously unknown cavity inside one of the world's oldest and largest monuments (*SN Online: 11/2/17*).

4 **Ancient DNA offers clues to the Canaanites' fate**
An analysis of five Canaanites' genetic instruction manuals not only revealed the ancient group's roots, but also identified descendants — modern Lebanese people (*SN Online: 7/27/17*).

5 **New blood pressure guidelines put half of U.S. adults in unhealthy range**
130/80 is the new 140/90. Under this new definition of hypertension, almost half of U.S. adults now have high blood pressure (*SN Online: 11/13/17*).

Top blog posts

CONTEXT | TOM SIEGFRIED
Quantum mysteries dissolve if possibilities are realities
Incorporating "potential" elements of reality in a complete picture of nature might resolve quantum mysteries (*SN Online: 10/1/17*).

SCIENCE TICKER | *SCIENCE NEWS* STAFF
Antarctica's Larsen C ice shelf is within days of completely cracking
The crack in Antarctica's Larsen C ice shelf (see Page 22) grew 17 kilometers at the end of May (*SN Online: 6/1/17*).

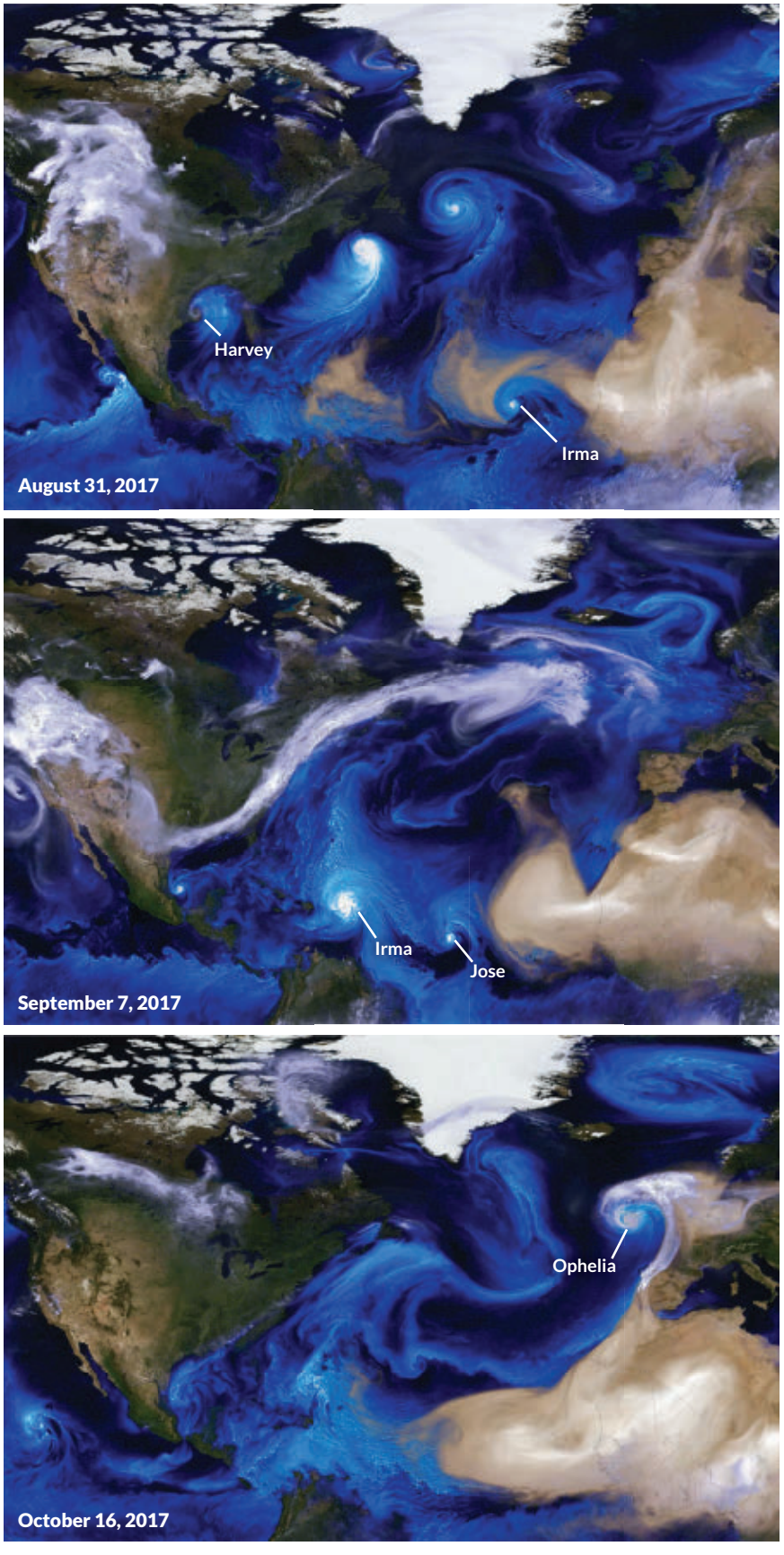
GROWTH CURVE | LAURA SANDERS
Drugs for reflux disease in infants may come with unintended consequences
Infants prescribed proton-pump inhibitors may be at higher risk for broken bones later on (*SN Online: 5/24/17*).

WILD THINGS | SARAH ZIELINSKI
How a dolphin eats an octopus without dying
Dolphins in Australia prep some meals by tossing live octopuses until the creatures are safe to eat (*SN Online: 4/25/17*).

SCICURIOUS | BETHANY BROOKSHIRE
On social media, privacy is no longer a personal choice
Internet users may need to rethink how they control their personal information, data from a defunct social platform suggest (*SN Online: 8/24/17*).

SCIENCE & THE PUBLIC | *SCIENCE NEWS* STAFF
March for Science will take scientists' activism to a new level
Historians called it an "unprecedented" event (*SN Online: 4/19/17*): More than 1 million people marched in support of science on April 22 (see Page 32).

Find links to full versions of these stories at **bit.ly/SN_favorites2017**



Dust (and salt and smoke) in the wind

How do you observe the invisible currents of the atmosphere? By studying the swirling, billowing loads of dust, sea salt and smoke that winds can carry.

A simulation created by scientists at NASA's Goddard Space Flight Center in Greenbelt, Md., reveals just how far around the globe such aerosol particles can fly on the wind, offering a new perspective on the 2017 hurricane and wildfire seasons.

Powered by supercomputers, the complex visualization uses advanced physics and a state-of-the-art climate algorithm known as FV3 to represent in high resolution the physical interactions of aerosols with storms or other weather patterns on a global scale (*SN Online: 9/21/17*). Using data collected from NASA's Earth-observing satellites, the simulation tracked how air currents swept aerosols around the planet from August 1 through November 1.

In the visualization, sea salt (in light blue) snagged by winds sweeping across the ocean's surface becomes entrained in hurricanes Harvey, Irma and Jose, revealing their deadly paths (top and middle panels) before eventually raining out. Wisps of smoke (in gray) from fires in the northwestern United States drift eastward and are funneled up the East Coast, while dust (in brown) from the Sahara billows westward across the Atlantic Ocean toward the Gulf of Mexico.

The simulation also shows how strong winds from Hurricane Ophelia, which formed off the coast of Africa and pulled in Saharan dust, fanned the flames of wildfires blazing across Portugal. Ultimately, the storm transported both dust and smoke particles toward the United Kingdom and Ireland (bottom panel).

Using this satellite's-eye view could help scientists better understand how these aerosols figure into large-scale weather patterns. — *Carolyn Gramling*

NASA GODDARD SPACE FLIGHT CENTER

Watch a video of the swirling aerosols at **bit.ly/SN_aircurrents**

Breakthrough technology converts phone calls to captions.

No Contract No Monthly Fee

New amplified phone lets you hear AND see the conversation.

The Hamilton® CapTel® Captioned Telephone converts phone conversations to easy-to-read captions for individuals with hearing loss.

Do you get discouraged when you hear your telephone ring? Do you avoid using your phone because hearing difficulties make it hard to understand the person on the other end of the line? For many Americans the telephone conversation – once an important part of everyday life – has become a thing of the past. Because they can't understand what is said to them on the phone, they're often cut off from friends, family, doctors and caregivers. Now, thanks to innovative technology there is finally a better way.

A simple idea… made possible with sophisticated technology. If you have trouble understanding a call, captioned telephone can change your life. During a phone call the words spoken to you appear on the phone's screen – similar to closed captioning on TV. So when you make or receive a call, the words spoken to you are not only amplified by the phone, but scroll across the phone so you can listen while reading everything that's said to you. Each call is routed through a call center, where computer technology – aided by a live representative – generates voice-to-text translations. The captioning is real-time, accurate and readable. Your conversation is private and the captioning service doesn't cost you a penny. Internet Protocol Captioned Telephone Service (IP CTS) is regulated and funded by the Federal Communications Commission (FCC) and is designed exclusively for individuals with hearing loss. To learn more, visit www.fcc.gov. The Hamilton CapTel phone requires telephone service and high-speed Internet access. WiFi Capable. Callers do not need special equipment or a captioned telephone in order to speak with you.

Finally… a phone you can use again. The Hamilton CapTel phone is also packed with features to help make phone calls easier. The keypad has large, easy to use buttons. You get adjustable volume amplification along with the ability to save captions for review later. It even has an answering machine that provides you with the captions of each message.

"For years I avoided phone calls because I couldn't understand the caller… now I don't miss a thing!"

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See for yourself with our exclusive home trial. Try a captioned telephone in your own home and if you are not completely amazed, simply return it within 60-days for a refund of the product purchase price. It even comes with a 5-year warranty.

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"Are you kidding? What a great watch at a ridiculous price. Thank you Stauer!"

— Gitto, Hicksville NY

It's Enough to Make You Blue in the Face

Time to take a stand against overpriced watches with the Stauer Urban Blue, **now only $29.**

You need a new watch…the one you are wearing was made when Nixon was in office, but extravagantly-priced watches that add zeros just because of a high falootin' name are an insult to your logic. Why shell out big money so some foreign company can sponsor another yacht race? It's time to put an end to such madness. It's absolutely possible to have the highest quality, precision classic timepiece without the high and mighty price tag. Case in point: The Stauer *Urban Blue*.

Packed with high-end watch performance and style, minus the high-end price tag. It's everything a high-end watch should be: Sturdy stainless steel and genuine leather construction. Precision timing that's accurate to four seconds a day—that's more precise than a 27-jewel automatic watch priced at over $6,000. And, good looking— with simple, clean lines and a striking metallic blue face.

"Blue watches are one of the growing style trends seen in the watch world in the past few years"—WatchTime®

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