

SCIENCE NEWS MAGAZINE SOCIETY FOR SCIENCE & THE PUBLIC

DECEMBER 26, 2015

Listening to Sand Dunes Boom

he

Rocky Vision Charting a MERS Outbreak

Gene Drive Fights Malaria

Pluto up-close, power gene editor, new early human kin and more science stories of 2015 To some, sunglasses are a fashion accessory...

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ScienceNews

Special Section

16 Science News' Top 25 of 2015 **COVER STORY** For the first time, scientists and space enthusiasts saw the face of Pluto. Images of its fantastical terrain landed the New Horizons mission in the No. 1 spot among the top science stories of 2015. The buzz around a gene-editing technology called CRISPR/Cas9 came in a close second. Other big news: discovery of a new *Homo* species, advances in research on aging, evidence that the global warming "hiatus" never happened and other climate woes (Southern Antarctic Peninsula shown).

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COVER To highlight subtle differences in surface features on Pluto, scientists created this false color image in neon hues. JHU-APL, NASA, SWRI



Surprises at new frontier trump a tool's potential power



Lists invite disagreements, as I've said before (see last year's Top 25 science stories, for example). And *Science News* molecular biology writer Tina Hesman Saey was not alone in arguing that the new gene-editing tool CRISPR/Cas9 should snag the top spot this year over Pluto. Readers taking part in a poll ranking our top five picks for science story

of the year also weighed in for CRISPR (see Page 38). Even astronomy writer Christopher Crockett noted, "Well, CRISPR does have the potential to wipe out infectious disease and get rid of invasive species, so I suppose it might have one or two more practical benefits than the exploration of Pluto." But, he added, "need I remind readers which one has ice volcanoes?"

CRISPR/Cas9 is indeed an exciting technological advance with the promise to change the world (with all the ethical baggage that accompanies such power). It has also attracted a lot of attention this year (see Pages 6, 12, 18 and the cover story in our last issue). It elicits deep questions about the power of science and how we might want to limit it. (Is it OK to eliminate a pernicious species like mosquitoes? Should we permanently change human genes in future generations?)

So why is CRISPR No. 2 and Pluto No. 1? For all its promise, CRISPR is a method. It's a story still being written. The practical benefits are yet to come. It could change the world, or not. Pluto, on the other hand, is about expanding knowledge, about seeing what we have never seen before, about discovery at its most basic (see Page 16). Seeing a faraway planet for the first time is whiz-bang; it's a new frontier. And it's not what we expected, as SETI scientist Mark Showalter told Crockett: "No matter what you predict about Pluto, it always seems that it's something more bizarre than what you had in mind."

Pluto also had stunning photos. And ice volcanoes. Even Saey eventually agreed: "It would be heartless of me to suggest that Pluto suffer yet another demotion."

Technology and basic knowledge are both important in science. We are committed to covering both. But my favorite will always be the discovery, the new science, the light shed on what was once dark. — *Eva Emerson, Editor in Chief*

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NOTEBOOK

CIENCE NEWS LETTER



Excerpt from the December 25, 1965, issue of Science News Letter

50 YEARS AGO

Science forecast for 1966

Reports could be forthcoming on the possible role of slow-acting viruses on chronic degenerative neurological diseases in man, such as multiple sclerosis. Both multiple sclerosis and muscular dystrophy could be found closely related to a virus-caused disease "scrapie," in sheep.

UPDATE: Scientists now think that the brain-wasting disease scrapie is caused by prions, warped proteins that trick normal proteins into misfolding, rather than a virus. Prions are also the culprits behind some human neurodegenerative diseases, such as Creutzfeldt-Jakob disease. Proteins involved in Alzheimer's may behave like prions (see Page 26). Scientists still don't know the cause of multiple sclerosis, although some evidence suggests a possible role for prions or bacterial and viral infections, including Epstein-Barr virus. In 1986. scientists discovered that muscular dystrophy results from a genetic mutation.

THE LIST

Diagnostic curiosity shop

V96.00

Unspecified [hot

injuring occupant

air] balloon accident

The latest diagnostic coding system for physicians, the International Classification of Diseases - 10th revision, took effect in October. With it came some curious new codes compiled in Medical Economics magazine. Here is a selection of some hard-to-explain mishaps. - Bruce Bower

Y92.241

W56.22XA

Struck by orca,

Hurt at the library

V91.35

Hit or struck by falling object due to accident to canoe or kayak



V97.33 Sucked into jet





W55.21 Bitten by a cow



V95.40 Unspecified spacecraft accident injuring occupant



V91.07 Burn due to water skis on fire



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HOW BIZARRE

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Roosters topple genetic rules

Researchers caught a rooster doing a hen's job: passing on mitochondrial DNA to his chicks. Mitochondria, the energygenerating organelles inside cells, carry a circular chromosome containing genes needed to make the mitochondria and keep them running. The long-held rule was that these powerhouses of the cell are inherited only from the mother. But some birds in a 50-generation family of White Plymouth Rock chickens at Virginia Tech broke that rule.

For the study, reported in the October *Biology Letters*, researchers determined the genetic makeup of mitochondrial genomes from 12 of the chickens. A mutation in the ND4L gene originated in a rooster, the researchers discovered. He passed the mutation to his chicks.

Scientists don't know how often mitochondria are inherited from fathers in the wild – they've seen it in some plants (SN: 5/16/15, p. 8), sheep and even in one person. Such evidence suggests that fathers bequeath mitochondria to their progeny more often than previously suspected. That finding could muddy the results of the many studies that use mitochondrial DNA to trace maternal lineages and determine evolutionary relationships. - Tina Hesman Saey

Roosters sometimes hand down mitochondria to their chicks, DNA analysis of White Plymouth **Rock chickens** reveals.



THE SCIENCE LIFE Boom goes the sand

It starts as a hum, barely audible above the howl of the winds shimmying between sand dunes. Then it builds. Within seconds, the sound resembles a World War II–era prop plane flying low overhead. But there's nothing there. "It's very mystical and eerie," says Nathalie Vriend, a mechanical engineer and geophysicist at the University of Cambridge.

This resounding roar, called a boom, has intrigued desert explorers for centuries. Yet only recently have scientists demystified the source of booms and softer, shorter-lived burps that emanate from deserts' sandy slopes. Much of the new insight has come from Vriend. Her extremely hands-on research, which includes sliding down towering dunes, has revealed that tumbling sand induces pressure pulses that course above and below the surface to produce a cacophony of peculiar noises.

Vriend wasn't exactly born to be a desert explorer. She grew up in a Dutch village with a climate closer to Seattle than to the Sahara. At Caltech in 2004, she read a magazine article on desert booms and burps — and was inspired to do her Ph.D. research on the topic.

Between 2005 and 2009, Vriend and her colleagues made sporadic summer visits to California's Death Valley and the Mojave Desert, departing campus with a couple of student volunteers at 4 a.m. to make the several-hours trek and complete fieldwork before the heat of the day. Vriend's team induced booms by sliding down the dunes and triggering miniature avalanches. Microphones along the slope captured audible sound, while a network of 48 geophones — essentially microphones placed a few centimeters under the surface of the sand — tracked sound waves propagating underground.

In the October *Physics of Fluids*, Vriend's team reports that booms and burps result from different types of sound waves. The large-scale tumbling of sand down a dune creates primary waves, or P waves, the pulses that travel fastest during an earthquake. The P waves get amplified as they spread through a dune's interior and emerge as a loud boom. (Earthquake P waves have a frequency too low for human hearing.)

Burps are much easier to trigger. Just moving one's hand through the sand shifts the grains enough to generate lower-frequency waves that crawl along the surface, the team found.

"It may not directly save the world," Vriend says, "but it captures people's imaginations." Now based in England, Vriend is studying the physics of avalanches, both the sand and snow variety. -Andrew Grant

science stats Fireworks brighten sky, dampen visibility

Fireworks light up the night sky, but they also fill it with visibility-reducing soot, researchers warn.

Tracking visibility changes at 34 meteorological stations across the United Kingdom, atmospheric scientists from the University of Birmingham in England found that visibility dropped by around 25 percent each year on November's Guy Fawkes Night before returning to normal a day or two later. The nighttime celebration is the country's largest fireworks event. The fiery displays, including bonfires, triple the amount of black carbon in the air, the researchers discovered, reducing visibility and potentially increasing the risk of car crashes.

Similar celebrations, such as New Year's Eve and the Fourth of July, could pose similar risks, the researchers say. — *Thomas Sumner*

percent Average drop in visibility each year in the United Kingdom during Guy Fawkes Night

News]

Mosquitoes designed to repel malaria

Test of gene drive shows it works better in males than females



BY TINA HESMAN SAEY

A new genetic engineering technique may quickly inoculate mosquitoes against malaria, helping to end the spread of the disease in humans.

Using a gene-editing tool known as CRISPR/Cas9, researchers have made a "genetic vaccine" that will continually inject itself into mosquitoes' DNA. Such a vaccine, known as a gene drive, could spread to nearly every mosquito in a population within a few generations (*SN: 12/12/15, p. 16*). The accomplishment, described online November 23 in the *Proceedings of the National Academy of Sciences*, brings researchers one step closer to malaria eradication.

"This work suggests that we're a hop, skip and jump away from actual gene drive candidates for eventual release," says Kevin Esvelt, a synthetic biologist at Harvard University.

Gene drives are engineered pieces of DNA that copy and paste themselves into precise locations in an organism's genome. During mating, a gene drive inherited from one parent inserts itself into the copy of the gene inherited from the other parent, ensuring that future generations will almost always inherit the drive. Normally, a gene has a 50 percent chance of being passed to offspring.

CRISPR/Cas9 is a new gene-editing

system. The editor comes in two parts: a DNA-cutting enzyme called Cas9 and a strand of RNA that guides the enzyme to the location in the genome to be cut. Earlier this year, Valentino Gantz and Ethan Bier of the University of California, San Diego turned the CRISPR editor into a gene drive in fruit flies.

Gantz and Bier teamed up with Anthony James of the University of California, Irvine to build a gene drive in *Anopheles stephensi* mosquitoes. James and colleagues had previously engineered mosquitoes to make antibodies against malaria. "We'd already built the cargo [the antibody genes]," says James. "They had a drive system and wanted to see if it could carry our cargo."

It was a lot of cargo to carry. In addition to the antibody genes and those encoding the Cas9 enzyme and guide RNA, the researchers inserted a gene that would cause mosquitoes' eyes to glow red under fluorescent lights, enabling the team to easily find insects of interest. Getting such a big piece of DNA into the mosquitoes proved difficult; only two of 25,712 larvae screened had the glowing red eyes that indicated they carried the gene drive.

Once in these two mosquitoes, though, the gene drive moved efficiently. In the third generation, 98.9 percent of the progeny of male mosquitoes descended from the original two males carried the gene drive.

That efficiency "is a really good indication that this technology is worth pursuing," says molecular biologist Zach Adelman of Virginia Tech in Blacksburg.

But the new drive got a flat tire in female mosquitoes. In most of the offspring descended from daughters of the original male mosquitoes, eye color indicated that Cas9 cut the target DNA but didn't complete the delivery.

The researchers had engineered the drive to insert itself into the kynurenine hydroxylase, or *kh*, gene. If the drive inserted its cargo as planned, the mosquitoes would have dark, glowing eyes. If the Cas9 enzyme cut the gene but failed to deliver the cargo, the mosquito would glue the cut ends back together, introducing a mutation that would turn the eyes white. All but three of the 1,781 descendants from the females had white eyes or eyes with white patches.

The mutation also eliminates the cutting site for the Cas9 enzyme, making future deliveries of the gene drive cargo to that location impossible.

Female mosquitoes' eggs may end up loaded with Cas9 so that when sperm fertilize the egg, the *kh* gene is cut and glued back together before the cargo can be delivered, the researchers say. That would eventually make the drive useless in the wild, James says. He and colleagues are working to devise a new drive in which Cas9 would be made only in sperm.

This gene drive could be a tool that helps clear malaria and keep it from coming back, James says. Malaria eradication efforts are often thwarted when disease-carrying mosquitoes migrate into an area where mosquitoes have been killed with insecticides or other measures. Gene drive-carrying mosquitoes could breed with interlopers and inoculate them against malaria, holding the scourge at bay.

MATTER & ENERGY Gravity Probe B mission wraps up Papers sum up tests confirming Einstein's general relativity

BY ANDREW GRANT

A grueling but successful effort to test Einstein's 100-year-old general theory of relativity has come to a close more than half a century after it began. Twenty-one papers published online November 17 in *Classical and Quantum Gravity* present a full summation of results from Gravity Probe B, a satellite that in 2011 confirmed Einstein's prediction that Earth dents and whips up the spacetime around it.

"It's very exciting," says principal investigator Francis Everitt of Stanford University. "It's been quite exhausting."

The mission delivered relatively precise measurements of two general relativity phenomena despite mishaps that threatened to render the data useless. "The Gravity Probe B team is the most heroic bunch of scientists I've ever been affiliated with," says Peter Saulson, a physicist at Syracuse University who monitored the mission as part of a NASAorganized advisory committee.

General relativity first earned credibility through Einstein's explanation

BODY & BRAIN

Alzheimer's drugs' unexpected effect

Antibody treatments make mice's nerve cells hyperactive

BY LAURA SANDERS

In an unexpected twist, two antibodies designed to fight Alzheimer's disease made mice's nerve cells misbehave more.

The results, published November 9 in *Nature Neuroscience*, highlight how little is known about how these drugs work, says study coauthor Marc Aurel Busche of Technical University Munich.

The treatment approach relies on antibodies that target amyloid-beta, a protein that builds up in the brains of people with Alzheimer's. One of the tested antibodof Mercury's orbit and measurements of solar eclipses (*SN: 10/17/15, p. 16*). In the early 1960s, Everitt began a quest to test some of the theory's harder-to-test predictions. He planned to measure how much the Earth (and by extension, all objects with mass) warps spacetime, a phenomenon known as the geodetic effect. Everitt also wanted to measure the even feebler frame-dragging effect, in which the spinning Earth should yank and twist the surrounding spacetime.

After delays and false starts, Gravity Probe B was launched in 2004. It tested both effects with four gyroscopes consisting of spinning quartz spheres coated with the metal niobium. Under Newton's laws, the axis of a gyroscope totally isolated from external forces would point in the same direction forever. But because of the geodetic and frame-dragging effects, general relativity predicts that our rotating 6-septillion-kilogram planet should reorient a gyroscope's axis ever so slightly.

But eliminating outside forces is difficult. The ping-pong ball–sized gyro-

ies, bapineuzumab, failed to show benefits in human trials described in the *New England Journal of Medicine* in 2014.

Despite that setback, some researchers say antibodies are still the best option to halt Alzheimer's. The bapineuzumab trial was flawed, says neurologist Dennis Selkoe of Harvard Medical School and Brigham and Women's Hospital. And the new results, which come from mice, have little relevance for ongoing tests of other antibodies in people, he says.

Other antibodies have shown modest benefits in people with Alzheimer's, he adds. Representatives from Eli Lilly and Biogen, pharmaceutical companies that are developing antibody treatments, declined to comment on the new study.

Busche and colleagues found that a single injection of the mouse version of bapineuzumab caused nerve cells in

Earth warps spacetime. The Gravity Probe B satellite (illustrated) measured two phenomena caused by this curvature.

scopes wobbled in unexpected ways. At other times, the axis of a gyroscope suddenly pointed in a new direction. Initially, Everitt's team didn't know what caused the deviations, which were tens to hundreds of times larger than the gravitydriven effects the team hoped to measure.

The scientists identified issues such as electron interactions between the spheres and casings and subtracted those forces out. In 2011, the team announced values for the geodetic and frame-dragging effects that are consistent with general relativity's predictions (*SN: 5/21/11, p. 5*). Confirming frame dragging, which has been measured with great precision by only one other experiment (*SN: 11/27/04, p. 348*), rules out some proposed modifications of general relativity and helps physicists predict the conditions around rapidly spinning black holes.

the brains of mice designed to produce A-beta to become hyperactive. After long-term treatment, nerve cells fired off messages in unison, an unusual form of neural synchrony that's been linked to seizures. Beta-1, an antibody that has not been developed into a drug, also made nerve cells hyperactive. Neither antibody affected nerve cells in normal mice that didn't produce A-beta, suggesting that the hyperactivity depends on the combination of antibody and A-beta.

The results don't mean that clinical trials of antibodies should stop, says Busche. It's unclear how the antibodies stir up trouble in mice, and whether this hyperactivity relates to behavior problems. A big question is whether A-beta-targeting antibodies cause nerve cells to become hyperactive in people — which is not being asked in clinical trials.





EARTH & ENVIRONMENT

Arctic warms up in dark winters

Thinning ice may increase heat-trapping moisture in air

BY THOMAS SUMNER

Even when the Arctic goes dark and cold, thinning ice could keep the North Pole from cooling down.

The loss of insulating ice between the ocean and atmosphere increases the amount of heat-trapping water vapor and clouds in the Arctic air. That extra moisture keeps air temperatures relatively warm during fall and winter and melts even more ice, new climate simulations suggest. This self-reinforcing cycle could partially explain why Arctic warming has outpaced the global average over recent decades, researchers report online November 11 in the *Journal of Climate*.

The heat trapped by the extra moisture is about three times as much heat as is gained during summer when reflective sea ice gives way to dark, light-absorbing open ocean, the researchers estimate. Arctic temperatures, therefore, will continue to rise rapidly "long after the summer ice is out of business," says coauthor David Randall, an atmospheric scientist at Colorado State University.

While the planet as a whole has warmed over the last few decades, the Arctic is heating up roughly twice as fast as lower latitudes (*SN Online: 1/16/15*). This warming imbalance weakens the winds that circle the top of the globe, affecting climate throughout the Northern Hemisphere. For instance, Arctic warming exacerbates summer heat waves in Europe (*SN: 4/18/15, p. 13*).

Scientists have blamed some of the Arctic's warming on increased moisture hovering above the Arctic Ocean. Where that water comes from is a point of contention; some scientists argue that moist air is blown in from the tropics.

Randall and colleagues ran a computer simulation of Earth's climate for the next three centuries, keeping an eye on changes in Arctic air. They found that during autumn and winter, Arctic seawater is warmer than the overlying air. Under normal conditions, sea ice forms a boundary between the water and air. But as the ice thins, the relatively warm seawater heats up the overlying air. Because warmer air can hold more moisture, the amount of water vapor above the Arctic Ocean nearly doubled during the simulation. This water vapor acts like a blanket, preventing some heat (infrared radiation) from escaping into space. The result is that more heat stays close to the Arctic surface and melts more ice, forming a continuous cycle that keeps temperatures relatively warm.

The simulation also predicted that winter temperatures over the Arctic Ocean will eventually become warmer than those over the surrounding continents. This temperature difference would create an air pressure contrast between land and sea that generates low-altitude winds like those seen in winter monsoons in the tropics, though "kind of pathetic" in comparison, Randall says. Those winds would whip seawater into the air, trapping additional heat, the researchers propose.

The work "demonstrates that it's really the Arctic that's causing the Arctic to warm so fast," says atmospheric scientist Jennifer Francis of Rutgers University in New Brunswick, N.J. "There's a lot more going on up there than just this [summer sea ice melting] that we've been hearing about for so long."

Toad-killing fungus thwarted on island

Scientists cure wild tadpoles, rid ponds of deadly Bd infection

BY SUSAN MILIUS

Doctoring whole ponds as well as the tadpoles living in them has turned a disease hot spot back into a healthy home for wild toads.

Majorcan midwife toads now flourish in mountain ponds once infected with the lethal chytrid fungus called Bd (for *Batrachochytrium dendrobatidis*), says Trent Garner of the Institute of Zoology in London. The fungus attacks more than 700 amphibian species on five continents, shriveling or wiping out susceptible populations and even snuffing out species.

Temporarily hospitalizing the wild tadpoles while dosing their ponds with disinfectant was the key to success, Garner, Jaime Bosch of the National Museum of Natural Sciences in Madrid and colleagues have discovered. Four out of five ponds treated in 2013 on the Spanish island of Majorca have remained clear of any signs of Bd, the researchers report in the November *Biology Letters*.

Researchers have previously cured

wild amphibians of chytrid infections but then worried about sending the animals back to their fungus-infested habitats. The Panamanian golden frog, for instance, exists only in captivity because Bd has turned the toad's habitat deadly.

"To the best of my knowledge, we are the first to have cleared infection in the wild," Garner says.

Even before conservationists knew what Bd was, they worried about the survival of Majorca's *Alytes muletensis* toads. But that concern had unintended



Engineered vocal cords show promise

Lab-grown tissue could treat people who have lost their voice

BY CHRIS SAMORAY

Vibrating tissue that hums in tune with normal, human vocal cords has been grown in a lab for the first time.

The bioengineered tissue opens a route to developing new therapies for people who have lost their voice due to surgery or disease. The tissue was tested in dog cadavers and in mice, University of Wisconsin–Madison researchers report in the Nov. 18 *Science Translational Medicine*. Not only did the mice accept the lab-grown vocal cords, or folds, but the tissue also trumpeted a healthy vibrato when researchers pumped air through the dogs' larynges.

"It was really indistinguishable from normal vocal fold vibration," says study coauthor Nathan Welham, a speech language pathologist at UW–Madison's School of Medicine and Public Health.

About 20 million Americans have a voice impairment. In the most serious cases — such as laryngeal cancer — large swaths of vocal cord tissue might be removed surgically. Without the tissue, people are left unable to speak, says Seth Cohen, a laryngologist at the Duke University School of Medicine.

In the lab, Welham and colleagues took cells from connective and layering tissue from the vocal organ of a human cadaver and from people who had had their larynges removed for reasons other than vocal impairment. The cells were cultured and grown using a system similar to the kind used to grow artificial skin. After two weeks, the tissue resembled normal, human vocal folds – specialized, flexible flaps

that produce sound in the larynx. Dogs, like humans, have two vocal folds. A lab-grown fold was grafted next to a fold in a dog larynx. By blowing warm, humid air across the tissue, the researchers found that both the lab and dog folds produced a similar sound and vibration rate of roughly 180 times every second.

Vocal cord tissue was then inserted in mice that had immune systems similar to humans. One group of mice had blood and larynx tissue cells that came from different people. Another group received samples made from a single person. In

> both cases, the mice didn't reject the engineered tissue, a sign that the tissue might work in the human body, too.

> Although this approach can make healthy vocal cord tissue that can restore normal voice function, Welham notes that a number of clinical and approval steps are still needed before the tissue can be used in humans.

But because the vocal fold tissue is so specialized and difficult to replicate using other materials, Cohen says, the study is a step in "moving toward being able to help people where we don't have a good treatment."

consequences. This species of the midwife genus is native only to the one island. (The "midwives" are the dads protectively carrying fertilized eggs wound around their legs.) A well-intentioned effort to breed such a vulnerable species in captivity inadvertently allowed the killer fungus to hitchhike in with imported research animals.

The (sort of) good news was that the researchers could focus on just one amphibian species in the five mountain ponds with particularly bad fungus infestations.

Starting in 2009, the researchers tested ambitious strategies for beating the disease in the wild. First, researchers bushwhacked to the remote ponds — one required rope climbs up and down a cliff. Then they caught as many tadpoles as possible from infected ponds and carried them out in soda bottles rigged with portable aerators. You hike out with two to three bottles of water and tadpoles in a backpack, Garner reminisces. To avoid afternoon heat at the most distant locations, researchers hiked in at night, napping on pondside stones until packing up the tadpoles at dawn for the hours of hiking back.

The first attempt at eliminating the disease failed. Researchers cured the captive tadpoles with the antifungal drug itraconazole but couldn't get rid of the fungus. Bailing water out of the ponds and letting them scorch during the summer wasn't enough. When the rainy season refilled the ponds, researchers helicoptered in the now-healthy tadpoles. But the tadpoles picked up the infection again. Older toads, so evasive they're almost impossible to catch, possibly kept the disease smoldering.

What finally worked was hauling out

tadpoles again, draining the ponds and treating the area with a disinfectant called Virkon S that is used in labs. After months, the researchers returned the cured toad population. For more than two years now, four of the five ponds have had no infected tadpoles. The fifth pond is getting a second treatment.

This experiment shows proof of concept for making a locale safe for returning animals, Garner says. Different disinfectants may work better for other locations, he says, adding that other researchers are pursuing alternatives for fighting Bd.

How this labor-intensive project in island ponds with only one species to worry about might translate to mainland habitats with many amphibians remains to be seen, says herpetologist Joseph Mendelson III of Zoo Atlanta. Nonetheless, he calls it "important work."



cadaver, the engineered

vocal fold (left) sits next

to a dog's vocal fold. Both

folds vibrated at a similar rate when air was blown

over the tissue.

HUMANS & SOCIETY Arrival to South America pushed back People reached Chile by 18,500 years ago, stone tools indicate

BY BRUCE BOWER

Humans foraged near the tip of South America at least 18,500 years ago, researchers say, challenging a popular view in archaeology that people entered South America no earlier than 15,000 years ago.

Excavations in southern Chile indicate that ancient human groups sporadically passed through the area over a 4,000-year stretch starting about 18,500 years ago, say Tom Dillehay of Vanderbilt University in Nashville and colleagues. Discoveries near the Monte Verde archaeological site add to evidence that the earliest New World settlers were not Clovis people, the investigators report November 18 in PLOS ONE. Clovis people hunted big game with distinctive spearpoints and camped at sites with large hearths. Clovis sites date to as early as 13,390 years ago in what is now the United States and Mexico (SN: 8/9/14, p. 7).

Long before that, foragers intermittently stopped at Monte Verde, suspects Dillehay. Work there in the 1970s and 1980s yielded stone tools and other remains of a campsite from about 14,500 years ago. New finds include 39 stone artifacts, nine dating to between at least 18,500 and 17,000 years ago. About a third consist of rock found outside the area, either near the Pacific coast or further inland. Early South Americans acquired various toolappropriate rocks as they trekked across the landscape and may have traded with other groups, Dillehay proposes.

Most of these intentionally modified rocks were for scraping and cutting, the researchers say. A few were possibly flung at prey with slings.

Four artifacts were found

in soil dating to at least 25,000 years ago. But more evidence is needed to confirm that humans visited Monte Verde and other South American sites that long ago (*SN:* 4/20/13, *p.* 9), the scientists say.

The team also identified 12 soil sections with ash from small fires, burned wood and burned or heated animal bones.

The ages for the discoveries come from radiocarbon measures of burned material and soil analyses that estimate when artifacts were buried.

> Archaeologists searching for more pre-Clovis sites should look for simple tools and remnants of small hearths, Dillehay says. Clovis sites, which typically feature separate areas for cooking, toolmaking and other activ-

1 cm

These stone tools

found in Chile date to

between 15,000 and

18,500 years ago.

ities, are easier to spot.

The finds "point to a new kind of site that needs much more study" to understand when people first reached the Americas, says archaeologist Daniel Sandweiss of the University of Maine in Orono.

BODY & BRAIN

Testes battle brain for selenium

In mice, these organs compete when nutrient levels are low

BY LAURA SANDERS

Faced with a shortage of the essential nutrient selenium, the brain and testes duke it out. In selenium-depleted mice, testes hog the trace element, leaving the brain in the lurch, scientists report in the Nov. 18 *Journal of Neuroscience*.

The results are some of the first to show competition between two organs for trace nutrients, says neurochemist Dominic Hare of the University of Technology Sydney. The study "highlights that selenium in the brain is something we can't continue to ignore," he says.

About two dozen proteins in the body contain selenium, a nonmetallic chemi-

cal element. Some of these proteins are antioxidants that keep molecules called free radicals from causing trouble.

Male mice without enough selenium have brain abnormalities that lead to movement problems and seizures, neuroscientist Matthew Pitts of the University of Hawaii at Manoa and colleagues found. Male mice engineered to lack two genes that produce proteins required to properly use selenium had trouble balancing on a rotating rod and moving in an open field. In their brains, a particular group of nerve cells called parvalbumin interneurons didn't mature normally.

Removing the testes before puberty improved these symptoms by leaving more selenium for the brain. Selenium levels in the brains of castrated mice were higher than those in uncastrated mice (though not as high as females).

Selenium is important for both fertility and the brain, so the results make sense, says biochemist Lutz Schomburg of Charité-University Medicine Berlin. "Taking out the brain or the testes will likely benefit the other organ," he says. "The former experiment is impossible to do, but the latter has now nicely been conducted." Schomburg cautions that the results aren't necessarily relevant for people.

That's in part because most people get plenty of selenium. The nutrient is found in crops grown in selenium-rich soil. Brazil nuts are also packed with selenium, as are tuna, halibut and sardines.

Yet some people in parts of China, New Zealand and Europe have low selenium intake, Pitts says. Differences in selenium levels, either due to diet or genetics, may play a role in psychiatric disorders such as schizophrenia, he speculates. Early-onset schizophrenia is more prevalent in men. "Males could be more at risk, because they have an additional organ sucking up resources that could be going to the brain," Pitts says.

How to see with eyes made of rock

Embedded lenses weaken chitons' armor but enable vision

BY SUSAN MILIUS

Certain species of the crawling lumps of mollusk called chitons polka-dot their armor-plated backs with hundreds of tiny eyes. But mixing protection and vision can come at a price.

The lenses are rocky nuggets formed mostly of aragonite, the same mineral that pearls and abalone shells are made of. New analyses of these eyes support previous evidence that they form rough images instead of just sensing overall lightness or darkness, says materials scientist Ling Li of Harvard University.

Adding eyes to armor does introduce weak spots in the shell. Yet the positioning of the eyes and their growth habits show how chitons compensate for that, Li and his colleagues report in the Nov. 20 *Science*.

Li and coauthor Christine Ortiz of MIT have been studying such trade-offs in biological materials that serve multiple functions. Human designers often need substances that multitask, and the researchers have turned to evolution's solutions in chitons and other organisms for inspiration.

Biologists had known that some chiton species sprinkle their armored plates with simple-seeming eyespots. (The armor has other sensory organs too, such as pores even tinier than the eyes.) But in 2011, a research team showed that the eyes of the West Indian

fuzzy chiton (*Acanthopleura granulata*) were much more remarkable than anyone had realized. Their unusual aragonite lenses can detect the difference between a looming black circle and a generally gray field of vision. Researchers could tell because chitons clamped their shells defensively to the bottom when a scary circle appeared but not when an artificial sky turned overall shadowy.

Now Li and colleagues present more direct evidence for how a chiton sees.

They attached a chiton lens to the end of a microscope objective in a water bath. Looking directly through the aragonite lens at a fish-shaped silhouette, the researchers detected a somewhat blurred, but recognizable, shape.

The lens achieves its clarity via tweaks in structure, the researchers found. A chiton lens is made of basically the same material as the unseeing armor around



Armored plates on the backs of these West Indian fuzzy chitons not only protect the soft mollusk flesh underneath but also see rough images thanks to hundreds of small, embedded eyes (inset).

it. But in the lens, the component grains of aragonite are bigger. This means incoming light has to pass through fewer grain-to-grain transitions and less of the material between grains. Reducing grain-to-grain jumps means less scattering of light into a dim haze.

Grains also have orderly internal structures, and the lens grains are more likely

> to be oriented in directions like those of their neighbors. More harmonious orientations reduce the scattering of light and preserve clarity of the incoming image.

> The chiton lenses may be pretty good, but the small number of light-catching receptors in the retina below the lens probably reduces image quality. Based on the number of receptors, the researchers calculated that each eye could report the silhouette only as a ragged, elongated blur. That blur,

however, may be enough for a chiton to recognize an incoming predator.

20 µm

When looking at

a fish, chitons prob-

ably see a pixelated

silhouette because

their small eyes have

few light-catching receptors below

their lenses.

Other techniques could give a better idea of how receptor cells pick up the image, says Dan-Eric Nilsson, a visual scientist at Lund University in Sweden. He would like to see more analysis, such as direct physiological measurements of electrical impulses jolting through individual receptor cells.

Whatever the eyes see, they introduce weak spots in the armor, Li says. Poking parts of chiton shell with probes broke lenses into sunbursts of spreading radial cracks; the same amount of force didn't shatter surrounding armor.

Armor does accommodate those weak spots, Li suggests. The eyes lie in the valleys on the nubbly armor surface. Thus blunt incoming threats probably bang the strong hilltops of the armor before poking the sunken eyes. Also, a chiton grows eyes by the hundreds and keeps producing them as new armor forms along the edges of expanding plates on its back. Eyes crack and erode, but there are lots, and new ones form to continue the vigil.

GENES & CELLS

Human gene edits get limited OK

Altering germ cells should be allowed in research, panel says

BY TINA HESMAN SAEY

WASHINGTON – Human gene-editing research, even on embryos, is needed and should go ahead, with one major caveat: No pregnancies can result, leaders of an international summit on the topic said December 3.

In recent years, scientists have devised increasingly precise molecular scissors for cutting and pasting DNA. These tools, especially the guided scissors known as CRISPR/Cas9, have become so cheap and easy to use that it may be possible to use them to correct genetic mutations that cause disease.

Many see the technology as a medical boon; others, though, say that the prospect of designer babies and tinkering with the DNA of future generations should be out-of-bounds (*SN: 5/30/15, p. 16*). The U.S. National Academies of Sciences and Medicine, the Chinese Academy of Sciences and the United Kingdom's Royal Society convened the summit to discuss the state of the science as well as ethical, legal and regulatory considerations surrounding gene-editing technology.

Gene editing of human body, or somatic, cells, which do not pass genetic information to future generations, is already in clinical trials. Most of those studies have involved older technologies and cells that were edited outside the body and then given to a patient, such as a baby with leukemia treated with edited immune cells (*SN: 12/12/15, p. 7*).

A company called Sangamo Bio-Sciences announced December 1 that clinical trials using gene editing to replace a broken gene in adult hemophiliacs could begin next year. Such research could continue and would fall under current regulations for gene therapy, the 12-member organizing committee of the International Summit on Human Gene Editing said in a statement.

But moral, ethical and safety concerns would make it "irresponsible" to proceed with clinical studies in germline cells — eggs, sperm, embryos and other cells that transmit DNA to future generations, the statement added. That doesn't mean all germ-cell editing would be off-limits. Researchers who edit germ cells in the lab are not doing "germline editing" if no pregnancy results from the cells, said committee chairman David Baltimore of Caltech. The term applies only when edited information is carried into another generation.

The scientists purposely did not call their statement a ban or even a moratorium. Instead, the recommendations should be revisited on a regular basis as research advances and societal opinions evolve. The panel also called for an ongoing forum to discuss human germline editing.

Recommendations from the scientists are not legally binding, but peer pressure could be an effective deterrent. For instance, researchers who violate agreements might not be able to get their work published or could lose funding. Scientists also must still follow their individual countries' laws and regulations on working with embryos. In the United States, such work is not banned, but researchers cannot get government funds to do it.

A study conducted by a separate committee of scientists commissioned by the science academies will produce a report on human gene editing, expected by the end of 2016.



LIFE & EDLUTION Pygmy slow loris hibernates in winter

The pygmy slow loris truly hibernates, making it the first primate found outside Madagascar to do so, a new study says.

"Up until now there were only three species of primate known to hibernate: all lemurs in Madagascar," says Thomas Ruf of the University of Veterinary Medicine Vienna. But in Vietnam, new measurements of wintertime body temperature for pygmy slow lorises (*Nycticebus pygmaeus*, one shown above) show bouts of chilly torpor lasting as long as 63 hours. A plunge in metabolic rate for more than 24 hours counts as hibernation, Ruf says.

There was talk about whether some unique conditions in Madagascar allowed the evolution of primate hibernation only there, Ruf says. But he and his colleagues dismiss that idea December 3 in *Scientific Reports. – Susan Milius*

BODY & BRAIN Gut microbes say when dinner's done

Bacteria send signal to quell host's hunger, rodent study finds

BY CHRIS SAMORAY

Gut bacteria are not polite dinner guests. They fill up fast and tell their host to quit eating, too.

After only 20 minutes, *E. coli* populations that normally live in animal guts produce proteins that can curb how hungry the host is, researchers report online November 24 in *Cell Metabolism*. In rodents, the proteins stimulated brain-body responses that led the animals to eat less. The findings indicate gut microbes could be more involved in regulating food intake in animals, including humans, than previously thought.

"It suggests that the growth and activity of the microbiome might specifically regulate appetite and feeding behavior," says Kevin Murphy, an endocrinologist at Imperial College London.

Food provides nutrients to the gut.

EARTH & ENVIRONMENT

Magnetic poles not about to flip

Earth's weakening field is a return to normal, study finds

BY THOMAS SUMNER

Earth is not heading toward a doomsday reversal of its magnetic field, new research assures.

The planet's magnetic field is about 10 percent wimpier today than when physicists began keeping tabs on it in the 1800s. In the geologic past, such weakening preceded geomagnetic reversals swaps of the north and south magnetic poles. These reversals temporarily make the planet more vulnerable to charged particles blasted off the sun that can disrupt power grids and disable satellites.

But that's not what's happening now. Although weakening, Earth's magnetic field is still strong by historical standards. Retracing the strength of the magnetic There, microbes use the nourishment to maintain population size. In the lab, Sergueï Fetissov and colleagues found that *E. coli* populations stopped growing 20 minutes after receiving nutrients. At the 20-minute mark, the microbes also made some different proteins than before and boosted production of the protein ClpB, which mimics a hormone in humans that acts on appetite. When the *E. coli* stopped growing, they produced "two times as much of this protein," says Fetissov, a physiologist at Rouen University in France.

Proteins from the *E. coli* no-growth stage were then injected in rats. Compared with rats that didn't receive these proteins, those that did ate less and had higher levels of ClpB in their guts. The researchers also found that the protein encouraged the release

Experiments show that gut bacteria like this *E. coli* K12 produce proteins that could influence the appetite of rats.

of peptide YY - a hormone associated with reduced appetite – and stimulated nerve cells that decrease hunger levels.

The *E. coli* proteins seem to influence feeding behavior in the rats. But it's too soon to say whether the results are applicable to humans. "Further work is required to determine how physiologically relevant the findings are," Murphy says.

field over the last 5 million years, geophysicists have discovered that the field has been much weaker in the past than previously thought. The average strength of Earth's magnetic field over that longer time period is about 60 percent of its present-day value, the researchers report online November 23 in the *Proceedings of the National Academy of Sciences*.

Earth's magnetic field "is just returning back to its long-term average," not weakening toward a reversal, says paleomagnetist Dennis Kent of Rutgers University in Piscataway, N.J.

Scientists track Earth's magnetic field through time using lava rocks. Grains of magnetic minerals inside fresh lava become magnetized by the planet's magnetism. Once the lava cools, the grains become records of the magnetic field strength at the time of the eruption.

Decoding that magnetic record can be tricky. The grains are often large enough that the magnetization of one part of a grain can alter the magnetization of the rest of the grain. Therefore, not all grains respond the same way when exposed to the same magnetic field and can record different magnetic signals.

Kent and colleagues counteracted this problem by heating lava grains from the Galápagos Islands in the presence of a known magnetic field, mimicking the formation of the lava rocks millions of years ago. Since the researchers knew the intensity of the field, they could deduce how each grain records magnetism. The team then used the grains' original magnetizations to accurately calculate the strength of the ancient magnetic field. Experiments without this crucial process yielded deceptively strong ancient fields.

A relatively stronger present-day field helps explain why Earth hasn't had a geomagnetic reversal for 780,000 years, says geophysicist Peter Driscoll of the Carnegie Institution for Science in Washington, D.C. Magnetic flips historically happen every 250,000 years or so, but stronger fields are less prone to reversals, he explains.

NEWS IN BRIEF

GENES & CELLS

DNA doubled in conifer ancestors Conifers grew giant genomes thanks to double doses of genetic material. Ancient ancestors of today's pine, cypress and yew trees had extra copies of their entire genome, the set of genetic instructions for an organism, researchers report November 20 in *Science Advances*.

Whole genome duplications are common in plants, but a previous look at Norway spruce DNA found no evidence of such doubling (*SN Online: 5/22/13*). The new study examined the entire set of active genes, or the transcriptome, of 24 conifers and other seed plants and three distantly related plants.

In ancestors of cypress and yew trees, genome duplication occurred about 275 million to 210 million years ago, Michael Barker of the University of Arizona and colleagues calculate. Such a multiplication occurred in the pine family about 342 million to 200 million years ago. The extra DNA may have helped conifers



survive the Permian-Triassic extinction about 252 million years ago, the researchers speculate. – *Tina Hesman Saey*

MATH & TECHNOLOGY

Roses rigged with electrical circuits Garden-variety roses just got an electrical upgrade.

Playing off the thirst of plant vascular systems, a team of Swedish researchers cut roses (*Rosa floribunda*) and set them in water containing specially designed organic molecules that can conduct and process electricity. The molecules linked up to form "wires" in the xylem, which pumps water and nutrients up from plant roots. When zapped with a charge, the wires conducted electricity without damaging the plant, the researchers write November 20 in *Science Advances*. Similar bioelectrical molecules induced roses' leaves to light up and change color.

This isn't the first time researchers have injected plants with electrical materials, but it is the first time they've used the plants' own vascular system to form a circuit. The technology could provide a means of manipulating plant biology for scientific research, to harvest energy or to tweak plant physiology without the need for genetic engineering. — Helen Thompson



This composite image shows the young planet (arrow) in a clearing in its star's disk (gray).

ATOM & COSMOS

First baby photo of a planet

Like a cosmic sonogram, new images showcase an infant world growing in the planetary womb that encircles a young star. This is the first time researchers have observed a young planet actively feeding from the disk of gas and dust in which it lives.

Light from hydrogen gas swirling around the planet gave the baby world away, researchers report in the Nov. 19 *Nature*. The hydrogen is about 10,000° Celsius, nearly two times as hot as the sun's surface. For the hydrogen to be that hot, it must be falling onto a fledgling planet no more than 10 times as massive as Jupiter, astronomer Stephanie Sallum of the University of Arizona and colleagues say.

Other researchers spied the young planet in 2009 and 2010 as a spot of infrared light orbiting the 2-million-year-old star LkCa 15, in the constellation Taurus. The infrared glow probably comes from warm dust encircling the new world.

Superheated hydrogen implies that the planet has not yet finished forming. Two other planets in the system show no signs of glowing hydrogen, which could mean they've finished forming, are not sucking down hydrogen as aggressively or are partially masked by intervening clouds of dust. – *Christopher Crockett*

ATOM & COSMOS

Phobos to create ring around the Red Planet

Poor Phobos. The Martian moon is not only cracking under pressure but will eventually shatter and form a ring around the Red Planet, a new study suggests.

Phobos has spent its life slowly spiraling toward Mars. As Phobos cozies up to its host planet, gravity stretches the moon, which appears to be fracturing already (*SN*: 12/12/15, p. 11). But Phobos' ultimate fate depends on how strongly it is held together. The moon is probably fragile, it turns out, and will crumble and spin into a ring in the next 20 million to 40 million years, say planetary scientists Benjamin Black and Tushar Mittal, both of the University of California, Berkeley. Their findings appear in the December *Nature Geoscience*.

By piecing together data on the moon's composition, density and the state of its largest crater, Black and Mittal inferred that Phobos is a loose conglomeration of rubble. Computer simulations then revealed the moon's grim future. Pieces of Phobos will survive in a new ring around Mars for anywhere between 1 million and 100 million years after breaking apart, but the moon won't be permanently forgotten. Some tightly bound chunks could leave a lasting impact by adding a few craters to the Martian surface. – Christopher Crockett

Introducing the "Just My Height" Adjustable Bed...

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Lately there has been a lot of press about the many benefits of a good night's sleep. When you wake up rested, everything from your memory and focus to your diet and stress levels can improve. Some even believe it can help you live longer. Unfortunately, many older Americans have to choose between comfort and safety in a bed. If it's too high or too low, getting in and out of bed (particularly in the middle of the night) can be dangerous. Hospital type beds feature adjustable heights and railings, but they are hardly comfortable. Now, thanks to innovative design and superior engineering, you get the best of both. Plus, with an infinite number of positions controlled by remote control, you can pick a custom position for sleeping, reading watching TV or just relaxing with your feet up! It looks just like a regular bed... not institutional, and the mattress is luxurious and features a natural bamboo quilted cover that's anti-bacterial, deodorizing and breathable.

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t probably comes as no surprise that the New Horizons mission to Pluto takes the top spot in *Science News*' list of 2015's most important stories. Since New Horizons awoke last December, we've devoted more than two dozen stories in the magazine and on the website – upwards of 10,000 words – to this first-ever visit. No other science news this year garnered so many headlines.

But it's not headlines alone that won this story, or the others, a spot on our list. What's important is how they launched our thinking in a new direction. The outer solar system is no longer seen as a vast area of indistinguishable specks, but instead as a new frontier. Advances in gene editing made us reconsider how far we'll go to rid our bodies of disease. A newly proposed species, *Homo naledi*, challenged our vision of the earliest members of our genus.

No one yet knows how *H. naledi* will rewrite our history, but one thing is certain: Like New Horizons, we have reoriented. We'll start 2016 on a new trajectory, with many new questions to ask. — *Elizabeth Quill*

A world like no other comes into view

Pluto wows with unexpected landscapes and blue skies **By Christopher Crockett**

Mountains of water ice tower thousands of meters over fields of frozen nitrogen and methane. Glaciers etched with channels hint at heat bubbling up from below. A patchwork of new and old terrains — some laid down in the last 10 million years, some as old as the planet itself — blanket the ground. And what appear to be two ice volcanoes punch through the terrain.

The alien landscapes of Pluto and its moons dazzled scientists and nonscientists alike this year. More than eight decades after its discovery, Pluto became much more than a nondescript point of light. It's a dynamic, complex world unlike any other orbiting the sun (*SN*: *12/12/15, p. 10*).

"Seeing a new world for the first time, I mean that's huge," says Cathy Olkin, a planetary scientist at the Southwest Research Institute in Boulder, Colo., and a deputy project scientist on the New Horizons mission. "It's amazing to look at this world and realize I've been staring at it for years through a telescope and all that detail was there."

> Pluto's transformation came courtesy of a robotic spacecraft roughly the size of a grand piano (SN: 6/27/15, p. 16). After traveling for nine and a half years across nearly 5 billion kilometers - roughly the distance to the moon and back 6,700 times – New Horizons

> > made its closest approach to Pluto on July 14, just 12,500 kilometers from its surface, close enough to see features the size of New York's Central Park.

As the spacecraft raced toward this remote outpost at roughly 50,000 kilometers per hour, one thing became abundantly clear: People still love Pluto. On flyby day, the world waited anxiously for news from the Johns Hopkins University Applied Physics Laboratory in Laurel, Md., where hundreds of scientists and journalists had gathered for the planet party of the decade (SN Online: 7/15/15). Pictures of Pluto and its largest moon, Charon, soon graced television screens, newspapers and magazines across the globe. The lonely underdog, kicked out of the planet club in 2006, became a celebrity. Planet or not, "Pluto is the star of the solar system," says mission leader Alan Stern.

As soon as the spacecraft beamed back its first detailed images, it was clear that Pluto had reinvented itself many times during its 4.6-billion-year lifetime (SN: 8/8/15, p. 6). Mountains, ice flows and a region devoid of craters implied that Pluto was geologically alive. The surfaces of some moons in the outer solar system have been reworked as well, but unlike

Pluto, those satellites are under the influence of gravity from a host planet. Tiny Pluto, far from any other world, mysteriously changes itself.

So much about Pluto is alien to Earthlings. On a world where a warm day is about -220° Celsius, the bedrock is made of hardened water ice. But there's also something oddly familiar: Pluto has blue skies. Layers of haze stack on top of one another to build a tenuous atmosphere (SN Online: 10/15/15). The haze scatters sunlight into the nightside, teasing researchers with glimpses of odd landforms faintly illuminated in Pluto's twilight. Within

that atmosphere, ice moves back and forth across hemispheres through the interminable seasons. It appears to snow on Pluto.

Even the five moons held a few surprises. Dramatic canyons slash across Charon, whose dark polar cap has no parallel. Styx, Nix, Kerberos and Hydra tumble and spin like a collection of chaotic tops, a dance seen nowhere else in the solar system (SN: 11/28/15, p. 14). And researchers have uncovered

all these riches after the spacecraft has transmitted only 20 percent of its data. Complex composition data and images with even more detail have yet to be downloaded. "Who knows what's going to show up in that 80 percent," says Mark Showalter, a planetary scientist at the SETI Institute in Mountain View, Calif., who discovered Kerberos and Styx while New Horizons was en route.

Such diversity suggests that even more strangeness awaits in the outer solar system, where the age of discovery is not over. NASA's Juno spacecraft will arrive at Jupiter in July and plans are under way for a mission to the gas giant's ice-encrusted moon Europa (SN Online: 6/18/15). In August, NASA tasked engineers at the Jet Propulsion Laboratory in Pasadena, Calif., with figuring out what it would take to return to either Uranus or Neptune, which haven't been visited since the 1980s.

And then there are the other dwarf planets, such as Sedna and Eris. "It gives me hope for younger people," says William McKinnon, a planetary scientist at Washington University in St. Louis. "When they want to go out and explore Eris or some other world, they're going to find even more amazing things."

New Horizons, meanwhile, is on course for its next stop: 2014 MU69, a 50-kilometer-wide hunk of ice about 1.6 billion kilometers past Pluto (SN Online: 11/5/15). Unlike Pluto, MU69 is probably pristine,

an untouched relic from the dawn of the solar system. There, researchers hope to study an example of one of the fundamental building blocks of the planets.

Once MU69 is far behind it, the spacecraft will eventually stop transmitting data. It will leave the confines of the solar system and sail into interstellar space. Long after humans have vanished, New Horizons will continue drifting through the galaxy, a monument to a people who weren't content to watch those wandering points of light in the sky but reached across billions of kilometers to explore new worlds.

July 11, 2015 New Horizons

Pluto images

through time

June-July 1994

Hubble telescope

June 15, 2015 New Horizons

July 3, 2015

New Horizons







Breakthrough gene editor sparks ethics debate Researchers use CRISPR to edit nonviable human embryos By Tina Hesman Saey

A revolutionary gene-editing technology made headlines this year as much for the ethical and societal issues it raised as for the scientific accomplishments it enabled.

CRISPR (pronounced crisper) burst

on the scientific scene in 2012, when researchers transformed what had originally been identified as a rudimentary immune system in bacteria into one of the most powerful tools in molecular biology. Composed of RNA and an enzyme that slices up invading viruses, CRISPR allows researchers to edit nearly any gene in any organism much more precisely and efficiently than older methods.

Many people hope doctors will soon find a way to use the gene editor to fix mutations that cause genetic diseases, a boon for gene therapy. But that potential also comes with big concerns about the possibility of human germline editing — altering eggs, sperm, embryos or other tissue in such a way that the change could be inherited (*SN: 5/30/15, p. 16*). Those concerns came to the forefront in April when researchers in China announced that they had attempted to use the system to edit nonviable human embryos (*SN Online: 4/23/15*). The experiment was partially successful, but the team concluded that there are still hurdles to overcome before CRISPR is safe for clinical use. Publication of the paper horrified many in the field who were already calling for a moratorium on human germline editing. The wider public started thinking again about designer babies and a real-world *Gattaca*.

In early December, an international summit of experts convened by the U.S. National Academies of Sciences and Medicine, the Chinese Academy of Sciences and the United Kingdom's Royal Society hashed through scientific, ethical and governance issues associated with human gene editing (see Page 12). "We're on the verge of a technological breakthrough that could change the future of mankind, and we should not blindly charge ahead," said U.S. Rep. Bill Foster, a member of the House Committee on Science, Space and Technology.

CRISPR is a major improvement over previous gene-editing

Easier editing Compared with existing gene-editing technology, the CRISPR/Cas9 system is simpler to develop and faster to produce. SOURCE: M. OSBORN/UNIV. OF MINNESOTA

Platform	Year developed	First used in live animals	Time to do an experiment
Zinc finger nucleases	1996	2002	Months/year
TALENs	2010-2011	2011	Week(s)
CRISPR/Cas9	2012	2012-2013	Days

systems because it doesn't require researchers to customize proteins for every DNA cut. Instead, researchers design an RNA that binds to the gene to be edited. The RNA guides an enzyme called Cas9 to the gene, where the enzyme snips the DNA. Depending on the goal, the editing system, officially known as CRISPR/Cas9, can disable or repair a gene or paste a new gene in the specified location. Researchers can create a usable CRISPR system in days, compared with weeks or months for other systems, says Mark Osborn, a molecular geneticist at the University of Minnesota Medical School in Minneapolis.

The technology was first described by Jennifer Doudna of the University of California, Berkeley, Emmanuelle Charpentier of the Max Planck Institute for Infection Biology in Berlin and colleagues. But Feng Zhang of the Broad Institute of MIT and Harvard (*SN: 10/3/15, p. 20*) won the patent rights after submitting evidence that he was the first to devise gene editors based on CRISPR. The researchers' universities are now embroiled in a lawsuit over who invented the technology first.

Almost immediately after the technology debuted, scientists turned to CRISPR to genetically engineer organisms in the lab, including rhesus macaques, mice, zebrafish, fruit flies, yeast and some plants. In October, researchers reported setting a record for the most genes edited at once (SN: 11/14/15, p. 6). That record – 62 genes – removed viruses embedded in pig DNA to make pig organs safer for human transplants. Chinese researchers announced the same month that they had successfully edited dogs with CRISPR, producing a female beagle with a mutation that resulted in more muscular thighs than her unedited littermates (SN: 11/28/15, p. 16).

CRISPR has also been on the lips of scientists, environmentalists and regulators because of an application of the technology called gene drives — engineered genes designed to break typical inheritance rules and get passed to nearly all of a carrier's offspring (*SN: 12/12/15, p. 16*). For more than a decade, scientists have been attempting to construct effective gene drives with the hopes of eradicating mosquito-borne diseases such as malaria and eliminating populations of invasive species. That process becomes much easier with the development of CRISPR.

In March, researchers reported creating a CRISPR gene drive in fruit flies, and in late November and early December, two teams reported the creation of gene drives that could help eradicate malaria. One of the gene drives essentially turns mosquitoes into vaccine distributors for each other (see Page 6); the second sterilizes female mosquitoes (*SN Online: 12/7/15*). Great promise comes with these developments, but there are also fears that gene drive–altered organisms could escape the lab and infect wild animals or could run amok in other ways. The debates aren't anywhere near settled. They have barely begun.



New *Homo* species hauled from a cave in South Africa

Origins of the genus remain fuzzy **By Bruce Bower**

Scientists trying to untangle the human evolutionary family's ancient secrets welcomed a new set of tantalizing and controversial finds this year. A series of fossil discoveries offered potentially important insights into the origins of the human genus, *Homo*. Most notably, a group of South African fossils triggered widespread excitement accompanied by head-scratching and vigorous debate.

If the discoverers of the South African fossils are right about what they have found, then at least some early members of the *Homo* genus possessed an unexpected patchwork of humanlike and apelike features, with legs and feet built for upright walking but shoulders, chests and hips suited to climbing trees. These ancient hominids had brains much smaller than anyone expected, housed in skulls shaped like those of later *Homo* spe-

cies. In the year's most intriguing evolutionary development, Lee Berger of the University of the Witwatersrand in Johannesburg and colleagues reported finding 1,550 fossils from a previously unknown species that they call *Homo naledi* (*SN*: 10/3/15, p. 6).

After noticing fossils on the floor of an underground cave in South Africa, cave explorers alerted Berger to the find. Requests on Twitter and Facebook located six researchers with spelunking experience; each recruit was a slender woman who could fit through a narrow cave passage and navigate a final 12-meter descent

Recently discovered bones from more than 15 individuals have been assigned to a new but still debated species, *Homo naledi*. This fashioned stone, discovered at a 3.3-million-year-old site in Kenya, suggests early hominids used tools before the *Homo* genus evolved.

into the pitch-black chamber. The unusual nature of the effort received global attention, showing that the ways people explore the past can be as compelling as the specifics of what they find.

Once in the chamber, the intrepid band recovered bones from at least 15 individuals. Their brains would have been no larger than those of 2-million- to 4-million-year-old hominids from the genus *Australopithecus*.

Humans descended directly from one particular *Australopithecus* species, says Brian Villmoare of the University of Nevada, Las Vegas. In Ethiopia, he and his team discovered what may be the oldest known *Homo* fossil, dating to 2.8 million years ago (*SN:* 4/4/15, p. 8). The partial jaw shares features with fossil jaws from *Australopithecus afarensis*, a hominid species that died out in Ethiopia around 3 million years ago. Villmoare and colleagues suspect that *A. afarensis*, which includes Lucy's famous partial skeleton, evolved into the human genus.

As expected in a field that deals with partial remains of longextinct species, not everyone agrees with Berger's or Villmoare's conclusions. Shifting soil layers in the cave where *H. naledi* was found make it difficult to find and date the original location of the fossils, so scientists don't know how old the bones are. While Berger contends that *H. naledi* probably inhabited Africa's southern tip more than 2 million years ago, near the time the *Homo* genus originated, it's also possible the fossils are younger. They might belong to a previously known species, *Homo erectus*, or even represent an *Australopithecus* species from that same time period. As for the ancient Ethiopian jaw, critics say it's hard to draw any conclusions without more bones.

There's one big discovery this year that scientists can agree on: The making of stone tools originated before the *Homo* genus did. Sonia Harmand of Stony Brook University in New York led a project that unearthed 3.3-million-year-old stone implements

> in Kenya (*SN: 6/13/15, p. 6*), clear evidence that East African hominids from Lucy's era made them too. Until Harmand's report, stone tools had been dated to no more than about 2.6 million years ago.

> > Debate continues as more fossils are unearthed. Researchers from the Cleveland Museum of Natural History, for example, recently discovered what they are describing as a new species of *Australopithecus* that lived alongside Lucy (*SN: 6/27/15, p. 7*). Others plug that find into Lucy's species. Either way, the back and forth isn't keeping the researchers down. They'll just have to drag a few more skeletons out of the closet.

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All bodies don't act their age

Cells offer new clues to the mystery of growing old **By Meghan Rosen**

Age was all the rage this year, as headlines about a provocative study blared what many people already suspected: People grow old at vastly different rates.

The study, out of Duke University, analyzed the health of nearly one thousand 38-year-olds and found that some resembled people a decade older while others appeared years

younger (*SN: 8/8/15, p. 10*). Researchers determined this "biological age" based on health indicators such as body mass index, blood pressure and cholesterol level. The finding tapped into a mystery that has long captivated scientists and the public alike — "why some people can live to 120 with no disease, and others are already in bad shape at age 70," says molecular biologist Martin Hetzer of the Salk Institute for Biological Studies in La Jolla, Calif.

A handful of recent studies have offered some tantalizing clues. Molecular mayhem within cells, scientists suggested this year, may lie at the root of aging. After examining populations of proteins in the brains and livers of rats, Hetzer and colleagues reported in *Cell Systems* that long-lived brain proteins appear to become damaged over time. "These are proteins involved in essential cellular functions," Hetzer says. Unlike liver cells, brain cells rely on proteins that can survive for an animal's lifetime. Some of those proteins help control messages that pass between brain cells, for example, while others

help keep the cell organized. The breakdown of these proteins could be a key driver of aging, Hetzer says.

As could the unraveling of cells' DNA, a study in *Science* suggested. In healthy young people, long stretches of DNA pack tightly together in neat bundles called heterochromatin. These bundles aren't packaged quite so well in old people, researchers



comparing DNA from the teeth of young and old people found (*SN: 5/30/15, p. 13*). The researchers originally identified the disorganization of DNA bundles in people with a premature-aging disorder known as Werner syndrome. The change in the 3-D architecture of the genome gives proteins easy access to stretches of DNA that are supposed to be tucked away.

Beyond the deterioration of proteins and DNA packaging, the body may age when essential barriers break down. When young stem cells in the brain divide, they build a wall that sequesters junky proteins into daughter cells. (This junk mucks with cellular machinery, a problem for stem cells churning out new brain cells.) But old stem cells aren't so tidy, scientists reported this year in *Science (SN: 10/17/15, p. 10)*. Old stem cells in the brain had worn-out walls inside an organelle called the endoplasmic reticulum. These weakened walls let cellular junk seep back in during division, cutting down on the stem cells' ability to pro-

duce new cells.

Another protective wall, the blood-brain barrier, might also waste away with time. Usually this barrier guards the brain from dangerous toxins in the blood. But MRI scans measuring barrier permeability in living human brains found that old people had leaky walls around the hippocampus, a structure involved in learning and memory (*SN*: 2/21/15, *p. 8*). Researchers linked the leaky walls to damage to pericytes, cells found within the blood-brain barrier and crucial to its formation.

Differences in barrier integrity also showed up among old people. Those with learning and memory problems had more pericyte damage than healthy individuals of the same age, Berislav Zlokovic of the University of Southern California in Los Angeles and colleagues reported in *Neuron*. Breakdown of this brain barrier may kick off some of the cognitive troubles of old age, the authors proposed.

All in all, scientists continue to chip away at the mysteries of growing old. The molecular events iden-

tified this year add to previously discovered signs of aging — the shortening of telomeres, the protective caps on chromosomes, for example, and damage to mitochondria, the energy factories of cells. But the picture isn't complete, or simple. Big questions remain, including how to distinguish healthy aging from disease, as well as the roles of genetics versus environment.

The next major challenge, Hetzer says, will be figuring out which cellular changes are merely a sign of aging and which changes are driving it. Understanding these details could help scientists design antiaging drugs, says geroscientist Felipe Sierra of the National Institute on Aging in Bethesda, Md. "How we age is something we can control," he says. "Trying to convince people to exercise or eat better has not worked, so we need an alternative."

One day, doctors might prescribe drugs that fight aging, just like prescribing drugs for diabetes or high cholesterol. Now that sounds like a story that would make some headlines.



In normal human stem cells (top), DNA packs into tight bundles. But those bundles unravel in cells genetically altered to age prematurely (arrow, bottom), leading to enlarged nuclei.

As ice shelves on the Southern Antarctic Peninsula weaken, glaciers flow faster into the sea.

Warming continues apace

Study suggests climate 'hiatus' didn't exist

By Thomas Sumner

A supposed pause in global warming that has been fodder for climate change doubters never really existed, researchers reported in 2015.

The fuss began when studies showed that decades of warming appeared to have leveled off in 1998. From that year through 2012, Earth's yearly average surface temperature increased at one-third to one-half the average rate from 1951 through 2012. This warming "hiatus," as it came to be known, had climate scientists scratching their heads and climate doubters gloating.

In June, scientists at the National Oceanic and Atmospheric Administration announced that they had finally found the cause of the hiatus, and it wasn't shifting winds or pint-size volcanic eruptions as some scientists proposed. Instead, small biases and gaps in temperature data had created an artificial plateau. The slowdown never existed (*SN: 6/27/15, p. 6*). The biggest culprit, the scientists found, concerned measurements of ocean surface temperatures.

Before World War II, sailors took temperature measurements from water hauled over the sides of ships in buckets. Later, sailors relied on water pumped in to cool ship engines. Today, researchers take more accurate measurements from scientific buoys. On average, buoys record a temperature reading 0.12 degrees Celsius cooler than those from ships. As methods changed, the temperature readings created a false ocean cooling trend that partially canceled out the global trend.

Correcting for these biases and adding more extensive data, including from the Arctic, the researchers found that the Earth's average surface temperature warmed by 0.116 degrees per decade between 2000 and 2014. That's roughly in line with the warming rate recorded over the second half of the 20th century.

Even without the bias correction, the warming hiatus was on flimsy footing, says Stanford statistical climatologist Bala Rajaratnam. In November, Rajaratnam and colleagues argued in *Climatic Change* that the supposed stalling could have been explained by natural variability and didn't negate the longterm trend anyway. The global changes, which threaten to inundate coastal towns and cities as sea levels rise, introduce more extreme weather and alter ecosystems across the globe, are not abating.

"What we're doing right now to the climate is unprecedented,"

says Richard Zeebe, a paleoclimatologist at the University of Hawaii at Manoa.

Carbon dioxide levels in Earth's atmosphere – calculated as a monthly average for the entire globe – reached above 400 parts per million this year, higher than at any point in recorded history. Researchers also announced this year that glaciers along the Southern Antarctic Peninsula that had been mostly stable are now in decline (*SN Online: 5/21/15*), and one of the continent's largest ice shelves, Larsen C, has a rapidly spreading crack (*SN: 7/25/15, p. 8*). Ocean warming and meltwater from vanishing glaciers are contributing to sea level rise, a total of 80 millimeters since 1993. As reflective ice melts into heat-absorbing dark open ocean, warming increases further.

In news from the opposite pole, scientists now predict that the Arctic Ocean will have its first ice-free summer sometime around 2052, almost a decade sooner than previously projected (*SN Online:* 8/3/15). The rapid warming in the Arctic may also cause more deadly heat waves across the Northern Hemisphere (*SN:* 4/18/15, *p.* 13), and a warming Pacific is expected to boost typhoon intensities 14 percent by 2100 (*SN:* 6/27/15, *p.* 9).

To put the pace of change in perspective, Zeebe and colleagues studied a time about 56 million years ago when carbon dioxide levels increased from about 1,000 ppm to between 1,700 and 2,000 ppm. The period's rapid CO_2 rise, and its roughly 5 degrees of warming, seemed like the best contender for matching or exceeding today's CO_2 increase. During that time, little to no ice covered Earth's surface and forests reached from pole to pole.

Using climate simulations and ocean sediment data, Zeebe and colleagues calculated that the period during which carbon dioxide levels increased lasted at least 4,000 years, and the carbon release rate during that time had been at most 1.1 billion tons a year. That rate is just about a tenth of the approximately 10 billion tons of carbon released via fossil fuel burning in 2013 (*SN: 5/30/15, p. 15*). The finding suggests that modern climate change has no close historical analog, says Zeebe.

Even airlines could end up feeling the heat. In January, climate scientists predicted that warming air, which is less dense than cold air, will force airlines to reduce carrying capacity over the coming decades (*SN*: 2/7/15, *p*. 15).

Come again, research results? Scientists tackle the irreproducibility problem By Tina Hesman Saey

Experimental results that don't hold up to replication have caused consternation among scientists for years, especially in

the life and social sciences (SN: 1/24/15, p. 20). In 2015 several research groups examining the issue reported on the magnitude of the irreproducibility problem. The news was not good.

Results from only 35 of 97 psychology experiments published in three major journals in 2008 could be rep-

licated, researchers reported in August (SN: 10/3/15, p. 8). The tumor-shrinking ability of the cancer drug sunitinib was overestimated by 45 percent on average,



U.S. spending on preclinical research that is irreproducible

SOURCE: L.P. FREEDMAN, I.M. COCKBURN AND T.S. SIMCOE/ PLOS BIOLOGY 2015

(SN: 11/14/15, p. 17). And a report in June found that, in the United States alone, an estimated \$28 billion is spent annually on life sciences research that can't be repro-

an analysis published in October showed

duced (SN: 7/11/15, p. 5). There are many possible reasons for the problem, including pressure to publish, data omission and contamination of cell cultures (SN Online: 7/2/15; SN: 2/7/15, p. 22). Faulty

statistics are another major source of irreproducibility, and several prominent scientific journals have set guidelines for how statistical analyses

Mission: Space

Pluto may have hogged the spotlight. But 2015 had plenty of other amazing space mission firsts – and lasts, as scientists said good-bye to two orbiters.

Dawn

The Dawn probe arrived at Ceres March 6, becoming the first spacecraft to orbit a dwarf planet (take that, Pluto!) (SN: 4/4/15, p. 9). Dawn quickly started mapping its new home. Bright patches sitting within craters (SN Online: 9/10/15), which at first glance looked like exposed ice, are probably salt deposits. The craters themselves are also puzzlingly scattered unevenly across the surface (SN: 9/5/15, p. 8).



Rosetta

A leak of oxygen, buried since the solar system's start, was the last thing Rosetta mission researchers expected to detect at comet 67P/Churyumov-Gerasimenko. Finding such oxygen was a first in cometary chemistry (SN: 11/28/15, p. 6). The Philae lander, meanwhile, surprised the world when it awoke June 13 from a nearly sevenmonth slumber (SN Online: 6/14/15). Contact has since been spotty.

Kepler

NASA's premier planet hunter introduced us to Kepler 452b this year, possibly the most Earthlike world yet known (SN: 8/22/15, p. 16). Its 385-day orbit of a sunlike star would be comforting to humans. But at 1.6 times the width of Earth. the exoplanet might not have a solid surface on which they could enjoy

should be conducted. Very large datasets, which have become common in genetics and other fields, present their own challenges: Different analytic methods can produce widely different results, and the sheer size of big data studies makes replication difficult.

Perfect reproductions might never be possible in biology and psychology, where variability among and between people, lab animals and cells, as well as unknown variables, influences the results. But several groups, including the Science Exchange and the Center for Open Science, are leading efforts to replicate psychology and cancer studies to pinpoint major sources of irreproducibility.

Although there is no consensus on how to solve the problem, suggestions include improving training for young scientists, describing methods more completely in published papers and making all data and reagents available for repeat experiments.

it. That's OK. With 1.030 confirmed exoplanets and counting, the Kepler space telescope keeps looking.

MESSENGER

With a spectacular crash, the Mercury orbiter (illustrated) ended its four-year orbit April 30 when it ran out of fuel and smashed into the planet's surface at over 14,000 kilometers per hour (SN Online: 4/30/15). One legacy: a new crater. MESSENGER was the first craft to orbit Mercury, to make complete maps and to spy water ice in the shadows at the planet's poles.

Venus Express

The craft ran out of fuel late last year and began a death spiral into Venus' atmosphere. It sent a final transmission to Earth in January, wrapping up nine years in orbit. But its data speak from beyond the grave. Flashes of infrared light from the planet's surface add to evidence that volcanoes may be erupting there (SN Online: 6/19/15). – Christopher Crockett



Global ocean spans Enceladus Geyser chemistry offers hints of alkalinity **By Alexandra Witze**

As it winds up its studies of Saturn's moon Enceladus, NASA's Cassini spacecraft is offering the best evidence yet that this moon's buried ocean could be a great place to search for extraterrestrial life.

Cassini, which has orbited Saturn since 2004, has swooped past Enceladus more than 20 times. But only recently have measurements confirmed that, beneath the moon's icy shell, an underground ocean spans the entire globe (*SN: 10/17/15, p. 8*). Scientists had suspected for a decade that the moon had a smaller sea, based on geysers spurting near its southern pole, but a widespread ocean means more room for otherworldly microbes to thrive.

Enceladus is freezing — around -200° Celsius at its surface — but heat generated by friction as Saturn's gravitational pull tugs on the moon probably keeps its buried sea liquid. Where the ocean meets underlying rock, temperatures may even soar to a near-boiling 90° (*SN: 4/18/15,* *p. 10*). That's how hot it has to be in some geothermal springs on Earth for silica in rocks to dissolve, producing a milky-looking fluid. Cassini spotted tiny silica particles in one of Saturn's rings, probably delivered there from the bottom of Enceladus' ocean by those gushing geysers, one research team proposes.

On Earth, hot springs are home to bacteria and other creatures; on Enceladus, the chemistry might also be right for life. Using measurements of carbon dioxide and salts from the geysers, scientists calculated that the ocean is probably quite alkaline, similar to household ammonia (*SN: 3/21/15, p. 12*). Alkaline lakes on Earth, like California's Mono Lake, are among the most biologically productive aquatic environments on the planet.

Cassini took its deepest dive through the Enceladus geysers on October 28, a close call that will surely yield science for years to come. The swan song, Cassini's final Enceladus visit, was scheduled for December 19.

Reinventing the treetop of life
Scientists consider deep history of eukaryotes
By Susan Milius

Microbes discovered in Arctic mud could be the closest relatives yet found to the single-celled ancestor that swallowed a bacterium and made life so complicated. Biologists have proposed that this swallowing event, perhaps 1.8 billion years ago, led to complex cells with membranewrapped organelles, the hallmark of all eukaryotes from amoebas to zebras.

Researchers discovered the new phylum of microbes, dubbed Lokiarchaeota, by screening DNA from sediment (*SN:* 5/30/15, p. 6). Though no one has identified an actual cell yet, the new phylum appears to mingle genes similar to those in modern eukaryotes and genes from archaea, the sister group to bacteria. Analyses suggest the cells have dynamic structures that could have engulfed bacteria long ago. (Biologists have proposed representing that merger as a ring of life, rather than a tree.) What happened next in the tale is clearer but still a puzzle.

"We don't have all the existing pieces right now because a lot of the diversity

of microbial eukaryotes remains unexplored," says Patrick Keeling of the University of British Columbia in Vancouver, who studies early eukaryote history. But what scientists have found has radically reshaped the old multicellular-biased tree of life learned by generations of schoolchildren.

This year marked the 10th anniversary of a paper, in the *Journal of Eukaryotic Microbiology*, that served as an obituary for that tree (*SN: 8/8/15, p. 22*). Old



Forget the split Unlike the three-domain tree, the ring conveys that bacteria and archaea merged to give rise to eukaryotes.

textbooks had drawn a eukaryote treetop that branched into three kingdoms of mostly multicellular organisms (plants, animals and fungi) and one hodgepodge kingdom of single-celled beasts called Protista. Beginning in the late 1980s, though, new genetic studies relegated the multicelled kingdoms to mere side branches on five to seven much bigger branches of mostly single-celled protists.

> This new scheme has held up "pretty well," says Sina Adl of the University of Saskatchewan in Saskatoon, a coauthor on the 2005 paper. In the May 22 Science, for example, the Tara Oceans consortium, which surveyed plankton worldwide. classified diversity using the new divisions: SAR, Amoebozoa, Archaeplastida, Excavata and Opisthokonta (to which humans belong). These aren't exactly household names, though – at least not yet. ■



Quantum spookiness is real Experiments close entanglement loopholes By Andrew Grant

Some pesky loopholes no longer plague a crucial test for assessing the weirdness of quantum mechanics. Experiments reported in 2015 definitively demonstrate that the quantum world violates locality, the principle that events sufficiently separated in spacetime must be independent. "It's a landmark result," says Matthew Leifer, a quantum physicist at the Perimeter Institute for Theoretical Physics in Waterloo, Canada.

The experiments execute a test proposed by physicist John Bell in 1964 to evaluate locality by performing the quantum equivalent of repeatedly flipping two coins simultaneously. If locality applies to the microscopic world, then seeing one coin land heads offers no insight into the landing face of the other coin. There would be a limit to how often one coin's face corresponded with the other's. But Bell showed that if the coins were entangled — if they had that mysterious nonlocal connection that Einstein referred to as "spooky action at a distance" — then the limit would no longer hold.

Rather than observing coins, Bell tests seek correspondences between measurements of properties such as particles' spins. Despite dozens of Bell experiments that have found locality violation, ardent skeptics weren't all convinced. No single test had used detectors efficient enough to measure almost every pair of particles that had become entangled *and* had ruled out the possibility that the particles were communicating at light speed. Until now.

European researchers this year performed an experiment with electrons on opposite sides of a university campus, nearly 1.3 kilometers apart (*SN: 9/19/15, p. 12*). In trials lasting 18 days, the team coaxed the electrons into an entangled state 245 times, reliably measuring the electrons' spins every time. The results showed a clear nonlocal connection.

Two subsequent loophole-free tests measured photons rather than electrons and came to the same conclusion but with stronger data, having measured far more entangled particles than the first team (*SN Online: 11/13/15*).

Such tests will continue: One team plans to eliminate the possibility of another local effect by using light from distant galaxies to determine which properties of the particles will be measured.

Epigenome makes its debut Chemical modifications bring DNA to life **By Tina Hesman Saey**

In a landmark event more than a decade ago, geneticists unveiled the human genetic instruction book. This year, the book was turned into a movie adaptation in 3-D: Researchers cataloged how chemical modifications fold, compress and unwind the static DNA over time and how those modifications control when genes are on or off.

The crew of researchers involved in

the Roadmap Epigenomics Project premiered their findings in more than 20 scientific papers published in February (*SN*: 3/21/15, p. 6).

It was a blockbuster effort that would never make it in Hollywood. For one thing, it largely ignores the stars of the genome, the genes, and instead focuses on a dizzying cast of background characters known as epigenetic marks. The researchers cataloged these marks — chemical modifications either of DNA itself or proteins called histones — in more than 100 types of human cells. The epic effort revealed that gene variants associated with Alzheimer's disease are more active in immune cells in the brain than in nerve cells as researchers had assumed. Another plot twist: Tightly packed areas of the genome are more vulnerable to cancer-causing mutations.

Like a classic movie in which viewers notice something new with each showing, researchers using data from this project and other efforts to view the

Big stride for superconductivity Hydrogen sulfide sets temperature record **By Andrew Grant**

After a two-decade hiatus, superconductors are again heating up.

A compound of hydrogen and sulfur, when crushed at more than a million times Earth's standard atmospheric pressure, appears to whisk electrical current along without resistance at temperatures up to 203 kelvins. That's not exactly balmy-it's -70° Celsius-but the current record holder performs its magic at temperatures no higher than 164 kelvins.

A room-temperature superconductor would enable robust energy storage devices, MRI machines that don't require liquid helium coolant and a new generation of levitating trains. But after more than a century of intense research, physicists still aren't sure exactly which compounds are capable of reaching that goal. Any new superconductor, even one that requires high-pressure equipment installed in only a handful of labs worldwide, could lead physicists to more practical materials.

Mikhail Eremets of the Max Planck Institute for Chemistry in Mainz, Germany, and colleagues first reported superconductivity in hydrogen sulfide in December 2014. They took a small sample of the noxious, flammable gas, also known as sulfur hydride, and crushed it between two diamonds at extremely low temperatures. Measurements indicated that the electrical resistance dropped to zero and remained there even when the compound was heated to 190 kelvins (SN: 4/4/15, p. 11).

Though the finding was initially controversial, Eremets' team bolstered the claim six months later by showing that the pressurized hydrogen sulfide expelled magnetic fields, a gold standard sign of superconductivity called the Meissner effect (SN: 8/8/15, p. 12). This time the team saw evidence for superconductivity at temperatures up to 203 kelvins, nearly 40 kelvins higher than a copperbased compound reported in 1994.

"The story is evolving in the right direction," says Ivan Božović, a condensed matter physicist at Brookhaven National Laboratory in Upton, N.Y. Other labs have yet to confirm the Meissner effect, but a team in Japan has reported measuring zero resistance at high temperatures in hydrogen sulfide.

Eremets is already moving on to similar compounds. In August, his team reported that compressed phosphine



Hot advance Pressurized hydrogen sulfide is a superconductor at up to 203 kelvins (-70° Celsius), researchers reported this year. They are now exploring similar materials.

is a superconductor at temperatures up to 103 kelvins. After decades studying relatively complex materials, physicists hope that these simpler compounds of hydrogen provide the ticket to unraveling the mysteries of superconductivity.

Brain

genome in 3-D have made startling discoveries (SN: 9/5/15, p. 18). For instance, researchers found that a gene called FTO, thought to be a major genetic contributor to obesity, isn't involved in fat production. Instead, a genetic variant hiding in the gene's vicinity actually determines what type of fat the body builds (SN: 9/19/15, p. 6). Disorganized DNA may be a cause of aging, researchers also discovered (see Page 20).

The epigenome movie is sure to spark a series of sequels, each one revealing deeper secrets about human biology and suggesting new ways to improve human health.





Esophagus .

Muscle

A-beta behaves like a prion Alzheimer's protein might spread in rare cases By Laura Sanders

Under rare conditions, an Alzheimer'srelated protein may have jumped between people, scientists reported this year (*SN*: 10/17/15, p. 12). If true, that observation, the first of its kind, could recast the way scientists view the disease. "This was a highly unusual finding," says John Collinge of University College London.

Scientists already had hints that the protein in question, amyloid-beta, behaves like an infectious prion, a misshapen protein that coaxes other proteins to misfold and spread from cell to cell. In a study reported in *Nature*, Collinge and colleagues found A-beta buildup in four of eight postmortem brains from people who had received growth hormone injections derived from cadavers. Because A-beta buildup is rare in relatively young people — all were between the ages of 36 and 51 — the finding suggests that the buildup might have been seeded by growth hormone contaminated with A-beta.

This result adds to evidence that prions may be behind Alzheimer's disease as well as other neurodegenerative disorders



Red Planet's slopes ooze brine Orbiter returns best evidence yet for water on Mars By Alexandra Witze

There's water on Mars. Yes, again.

In the most highly publicized Mars discovery of the year, NASA announced that its Mars Reconnaissance Orbiter spacecraft had spotted hydrated salt minerals on the Red Planet (*SN: 10/31/15, p. 17*). The salty streaks appear in the same places as dark, hillside marks that lengthen and shrink with the Martian seasons. Brine probably oozes from the steep slopes, scientists concluded.

Water on Mars has been reported many times in the past, with each discovery adding fresh nuance to scientists' picture of the planet. The brine finding is the most detailed evidence yet such as Parkinson's and Huntington's. But some scientists caution that it's too soon to label these disorders as prion diseases. Prion diseases such as mad cow disease, and the related kuru (a disorder spread through ritualistic brain eating) and Creutzfeldt-Jakob disease in humans, evoke fear of contagion. But, as with these established prion diseases, there's no evidence that Alzheimer's or other neurodegenerative disorders spread through typical, everyday contact, scientists agree.

Yet thinking of neurodegenerative diseases as prionlike may ultimately reveal new ways to stop or prevent them, scientists say. Removing normal proteins before they are corrupted, for instance, might be one way to block neural destruction.

that water flows on the planet's surface today. And liquid water - no matter the saltiness - has exciting implications for whether life could exist on Mars.

Chemical evidence for Martian habitability, both past and present, is piling up elsewhere as well. The Curiosity rover, which has been rolling across the planet since 2012, identified a form of nitrogen in Martian rocks that, on Earth, is used to construct biological molecules (*SN Online: 3/23/15*). Studies of six Martian meteorites, blasted into space by asteroid impacts, reveal that they contain methane, which serves as a food source for microbes on Earth (*SN Online: 6/16/15*).

Knowing whether there really is life on Mars-or ever was-will have to wait until at least 2020, when NASA plans to launch a rover to collect and store rocks that would eventually be flown back to Earth for analysis. In the meantime, scientists' freshest views of Mars are from the sky. The MAVEN spacecraft, flying high through the Martian air, has spotted glowing auroras and puzzling dust clouds (SN: 4/18/15, p. 15). And it has measured, more precisely than ever, how powerful solar storms eroded away Mars' atmosphere (SN: 12/12/15, p. 32), a process that, over billions of years, has caused the Red Planet to lose most of its air.



Pacific Plate slides over slick layer

Mantle might not drive movements after all

By Thomas Sumner

With 6,000 kilograms of dynamite and an ear to the ground, a team of geologists shook the understanding of plate tectonics this year.

Ricocheting vibrations from the dynamite blasts, intentionally set off over two nights in New Zealand, gave geologists their first clear glimpse of the underside of a tectonic plate. The work revealed an underlying layer of partially melted rock, 100 kilometers belowground and 10 kilometers thick, that lubricates the motion of the Pacific Plate (*SN: 3/7/15, p. 6*).

The finding is "remarkable," says geophysicist Simon Klemperer of Stanford University. "Explaining how these plates move is one of the things that held back the identification of plate tectonics for 50 years." The layer contains an estimated 2 percent molten rock, enough to drastically reduce the strength of the rock and essentially grease the overlying plate, like a layer of melted water beneath an ice skater's blades. Because it is sandwiched between the plate and the mantle, the layer also forms a barrier between the two. That

separation challenges the prevailing view that flowing material in the mantle drives plate tectonics, says the geophysicist who led the study, Tim Stern of Victoria University of Wellington in New Zealand. Instead, forces at the edges of tectonic plates, such as the pull of a sinking plate, probably move the rocky slabs across Earth's surface.

Such a sideways yank is what broke apart the Pangaea supercontinent around 200 million years ago, earth scientist Fraser Keppie of Nova Scotia's Department of Energy in Halifax proposed in February (SN: 4/4/15, p. 13). Previous explanations held that a rising plume of magma from the mantle wedged the supercontinent apart. Instead, Keppie contends, as the ancient



Gliding away Partially melted rock (red) appears to separate the Pacific Plate from the mantle below, reducing the force required for the massive plate to slide. Researchers are now looking for similar layers beneath other tectonic plates.

forerunner to the Indian Ocean shrank, Pangaea was pulled from two sides, ripping the continent apart between Africa and North America.

A separate team cruising across the Atlantic Ocean in March and April fired air guns that sent vibrations downward through the seawater and into the ocean crust. That work should reveal whether slick layers are ubiquitous beneath tectonic plates, and further explain how the Earth moves under our feet.

Counter intelligence

Some truisms turned out to be false in 2015 – notably, *Brontosaurus* exists only in pop culture, the speed of light is always constant and fish are cold-blooded. With time and scientific scrutiny, the truth came out.

Welcome back, Brontosaurus

After a century of mislabeled ignominy, the "thunder lizard" reclaimed its iconic genus name. *Brontosaurus* is *Apatosaurus* no more. Subtle differences between skeletons of the massive diplodocids — including the narrower, weaker neck of *Brontosaurus* (illustrated) — restored the dino to its former glory (*SN*: 5/2/15, p. 14).

Photo(n) finish

Light in a vacuum travels at the speed of light — except when it doesn't. Manipulating the structure of a light pulse can slow it down. When a tinkered-with photon races a pristine one, the Franken-photon consistently comes in second by a few micrometers per meter of the distance traveled (*SN*: 2/21/15, p. 7).

Cold fish, warm heart

Most fishes are as cold as the water they swim in. Not the opah (*Lampris guttatus*). It can keep its heart up to 6 degrees Celsius warmer. Unusual gills let the fish use muscle-generated body heat to take the chill off blood that has just picked up oxygen from cold seawater (*SN*: 6/13/15, p. 7). – Macon Morehouse

Cancer genetics grows up Not all mutations are alike, or problematic By Rachel Ehrenberg

Personalized genomics has been heralded as the next big weapon in the war on cancer. But researchers analyzing various tissue types this year, looking for mutations linked to the disease, have found that not all genetic alterations should be targeted equally.

"Genetics is changing oncology for the good," says Benjamin Kipp, an expert in clinical genetics at the Mayo Clinic in Rochester, Minn. "But overinterpretation can harm the patient."

Genetic profiles of tumors offer unprecedented opportunities for both cancer diagnostics and for doctors planning treatment. Bowel cancer tumors with mutations in the *KRAS* gene, for example, respond poorly to the drug cetuximab; the skin cancer drug vemurafenib works only if melanomas have a particular mutation in the *BRAF* gene.

But such genetic testing can be misleading if it isn't conducted alongside tests of healthy cells from the same person, says oncologist Victor Velculescu of the Johns Hopkins University School of Medicine. He led a vast analysis comparing the genetic profiles of tumors and normal tissue of more than 800 cancer patients and found that nearly two-thirds of mutations in the studied tumors — many of which might be used to guide treatment — also showed up in patients' healthy tissues (SN: 5/16/15, p. 10). For those patients, the mutations were probably just benign variants unrelated to the cancer. Analyzing healthy tissue can also reveal whether mutations found in tumors are heritable or not, Velculescu says, which is important for deciding whether a cancer patient's family should receive genetic counseling.

Complicating matters further is the fact that even mutations that have been linked to cancer will not always manifest as cancer. A study published in May examining eyelid skin discovered numerous cancer-associated mutations in normal, healthy patches of the skin (*SN: 6/27/15, p. 8*). Detecting these mutations might lead to great anxiety and unnecessary, sometimes invasive treatments.

As genetic testing of tumors becomes more widespread, best practices will emerge, as will a better understanding



FAT1 RBM10 Other genes

Eye opener Cancer-linked mutations are surprisingly common in healthy eyelid skin. Colors show mutated genes; circles indicate the size of the skin patch carrying the mutation.

of the disease. "We are trying to change the way we look at cancer," says Sameek Roychowdhury, a medical oncologist at the Ohio State University Comprehensive Cancer Center in Columbus. "But we are just seeing the tip of the iceberg."



After analyzing 26,000 decays, a team at the Large Hadron Collider reported evidence for particles composed of five quarks (illustrated).

Collider creates pentaquarks New evidence clinches case for particle quintet By Andrew Grant

Among the haul of subatomic particles discovered in 2015 are two quark quintets. Until recently, quarks, one of the fundamental units of matter, had been known to come only in clumps of three (to form such particles as protons and neutrons) or sometimes two.

Researchers at the Large Hadron Collider near Geneva spotted signs of the "pentaquark" particles while studying the decay of another particle called bottom lambda. About 12 percent of the decays produced particles with properties that could be explained only by a fivequark composition (*SN*: 8/8/15, p. 8).

The discovery is the most convincing of several reported pentaquark sightings since the turn of the century, physicists say, and confirms theoretical research suggesting that quarks cluster in large groups. The new particles will help physicists better understand the strong nuclear force, which holds atomic nuclei together.



Tucked away in the brain, cellular speedometers clock a rat's swiftness. These "speed cells," reported in *Nature* this year, were a missing piece in science's understanding of how the brain creates an internal map of the world.

Two of the authors, Edvard and May-Britt Moser of the Norwegian University of Science and Technology in Trondheim, are well-acquainted with these maps; the Mosers shared a Nobel Prize for discovering specialized mental navigators called grid cells that help orient an animal in space. To be precise, that orientation also requires information about how fast the animal is moving.

In the study, a population of nerve cells fired off signals at rates corresponding to the paces of a moving rat, from a slow walk to a run (*SN: 8/8/15, p. 8*). These speed cells are found along with grid cells in a brain area important for navigation.

As it turns out, grid cells themselves have several talents. Beyond detecting spatial locations, grid cells can map time and distance, scientists found in rats (SN: 12/12/15, p. 12). Because mammals have similar navigation systems, scientists wouldn't be surprised if grid cells and speed cells also help people get around.

In step The firing rate of speed cells (four shown, colored lines) corresponded to how quickly rats moved in an enclosure (gray lines).





Lighting woes add up Artificial illumination disrupts defense, mating By Susan Milius

Add dodging death, flirting and mothering to the tasks artificial light can discombobulate in wild animals.

Street lights take away the street smarts from normally wary moths, researchers reported this year. When bathed in LED illumination, free-flying moths are less likely to plunge or spiral downward at the sound of an incoming predatory bat (*SN Online: 8/4/15*).

Artificial illumination also misleads female cabbage moths into skimping on production of their usual sex pheromone lure. Instead they make an odd blend with too much of the components that repel rather than seduce (*SN:* 6/13/15, p. 9).

Even if partners harmonize, timing can go wrong later. Ample lighting appears to distort the day-length cues that alert Tammar wallabies to changing seasons. Many of the wallabies roaming a welllit Australian naval base mate later than normal, and those delayed mothers miss the usual peak season for birth. Later, they struggle to meet their joeys' greatest demands for milk because plants are





already drying up (SN: 10/31/15, p. 6).

These tallying troubles are just for terrestrial animals so far. Researchers are also calling for increased attention to what artificial lighting does in the sea.

BPA alternatives aren't benign Replacements cause problems in lab animals By Janet Raloff

A popular alternative to bisphenol A isn't as benign as people had thought, at least not in lab animals.

After a growing body of research identified hormone-mimicking effects from BPA — a compound found in some plastics, dental sealants and cash register receipts — consumers began reaching for BPA-free products. But there is now evidence that at least one of the chemical substitutes, bisphenol S, can enter the body and trigger developmental and physiological changes.

A study published this year found

that BPS can boost heart rates and lead to heart-rate variability in rats. Another reported altered brain development and behavior in fish (*SN*: 4/4/15, *p. 10*).

The effects in humans are unclear, but store cashiers who handled receipt paper at work excreted more BPS in their urine after a shift. Researchers also detected the structurally similar compound BPSIP in the blood of cashiers who handled receipts with and without BPSIP and in the urine of some people who don't work as cashiers, suggesting another wide-spread source (*SN: 10/3/15, p. 12*).



Compound swap With consumers seeking BPA-free products, BPS and BPSIP are serving as alternatives. But scientists haven't established the safety of these replacements.



Tracking dogs' beginnings Studies propose new dates, place **By Chris Samoray**

Man's best friend might be much older than anyone thought.

In May, a genetic analysis of an ancient wolf's rib bone suggested that wolves and dogs probably split sometime between 27,000 and 40,000 years ago (*SN: 6/13/15, p. 10*). The new evidence raises the pos-



sibility that dog domestication is quite ancient, corresponding roughly in time to the Neandertal extinction. But it's also possible that these early members of the dog lineage weren't yet tame or living with humans, says Pontus Skoglund, a geneticist at Harvard Medical School who led the study.

The earliest dog domestication probably occurred near present-day Nepal and Mongolia, Laura Shannon of Cornell University and colleagues wrote in a study published in October (*SN: 11/28/15, p. 8*). An analysis of 185,805 genetic markers showed that modern dogs from Central Asia are more diverse than dogs elsewhere. Previously proposed regions for early domestication include the Middle East, Europe, North Africa and Siberia.



Native Americans are Kennewick kin

DNA analysis shows close ties to present-day groups **By Bruce Bower**

Kennewick Man, whose 8,500-year-old skeleton sparked a controversy when it was found in Washington state, was a relative of presentday Native Americans, Kennewick Man's skull is similar to that of Polynesians, but DNA suggests a link to Native Americans.

researchers reported this year. Since the discovery of the skeleton in 1996, Native American tribes have claimed Kennewick Man as their own and requested the bones be handed over for a ceremonial burial. Some scientists argued, though, based on the shape of his skull, that he was more closely related to native Polynesians or a native Japanese group called the Ainu.

Morten Rasmussen of the University of Copenhagen and colleagues wrested DNA from Kennewick Man's skeleton and analyzed it for the first time. They found that Kennewick Man is more closely related to Native Americans in the northern United States than to any other living population (*SN: 7/25/15, p. 6*). Two donors who provided modern DNA for comparison came from a tribe that, with four other tribes, lost a 2004 lawsuit to bury Kennewick Man as one of their ancestors.

More work is needed to determine which of today's Native American tribes, if any, has the closest genetic ties to the ancient American.

Fossil finds

From a spongelike speck to a bird built to terrify, 2015's fossil finds added details, drama – and some real characters – to the story of life on Earth. For the full story on all the creatures from this timeline, visit bit.ly/SN fossilfinds. - Meghan Rosen



600 MILLION YEARS AGO Ancient sponge ancestor Barely the size of a pinhead, this tiny creature had tubular chambers and surface cells that resemble those of modern sponges.



460 MYA Earliest sea scorpion The remains of this sea monster were found in an ancient impact crater in lowa. It grew up to 1.7 meters long and had bristly, serrated limbs (one shown).



300 MYA Texas supershark The oldest known supershark (three views of a piece of skull shown) was 8.5 meters long, larger than today's great whites. It swam in warm seas over what's now Texas.



231 MYA

This croc ancestor, which stretched 3 meters and may have walked on two legs, was a top predator in what's now North



150 MYA Vegetarian T. rex relative This dino had a T. rex's tiny forearms and sturdy legs. But not-so-sharp teeth suggest it ate plants, a sign that not all theropods were carnivores.



69 MYA

New Arctic dino This newfound duck-billed dino joins about a dozen other dinosaurs that roamed the chilly, polar forests and endured long stretches of darkness.



167 MYA Jurassic snakes Four newly identified species suggest that snakes appeared 70 million years earlier than thought. The tip-off: skulls like modern



snakes, with teeth that curve backward.

130.7 MYA Oldest modern birds Feather-flecked, hummingbird-sized fossils of this water wader, found in China, push the earliest record of modern bird relatives back 6 million years.



11.6 MYA Gibbonlike ape ancestor The remains of a small tree dweller, dubbed Laia, suggest that today's apes descended from small primates instead of large ones.



165 MYA Early tree climber Chinese fossils suggest this shrew-sized creature had curved claws for climbing. It's the oldest known tree dweller among docodonts, ancient kin of today's mammals.



120 MYA Four-legged snake An elusive link between snakes and lizards turned up in a German museum specimen. The leggy fossil find hints that snakes might have evolved on land.



3.5 MYA Terror bird This South American predator, one of many prowling the continent, stood 1.2 meters tall and used its extra sturdy beak as a hatchet when hunting.

Carolina Butcher





1 mm

Fluke extinction surprises lab Accident, not competition, wiped out *E. coli* By Tina Hesman Saey

A die-off of bacteria that had been growing for thousands of generations in a carefully controlled lab experiment offered an evolutionary lesson this year: Survival depends not only on fitness but also on luck.

For more than a quarter century, evolutionary biologist Richard Lenski and colleagues have been growing 12 flasks of *E. coli* at Michigan State University. About 31,000 generations in, some of the bacteria in one flask evolved the ability to use a chemical called citrate as an energy source. Bacteria in that flask that couldn't eat citrate went extinct, seemingly because they had been outcompeted, the scientists thought.

But when Lenski and his team replayed evolution, reviving samples stored before the non-citrate eaters vanished, these bacteria survived 40 out of 40 times in a mixed population. An unknown lab accident probably finished them off the first time around, the team concluded this year (*SN: 9/19/15, p. 11*). Unlike in the real world, these bacteria are getting another shot at survival. A 13th flask has been added to the experiment.



A holey hypothesis Gaps in brain nets might store memories By Laura Sanders

Nets that stretch across nerve cells in the brain may store long-term memories, scientists proposed this year (*SN: 11/14/15, p. 8*). The new idea attempts to explain a great mystery — why some memories last a lifetime even though the molecules thought to store them are routinely destroyed and re-created.

In studies in mice, Sakina Palida of the University of California, San Diego and colleagues found that some components of tough, durable webs known as perineuronal nets can last up to 180 days. What's more, these nets of proteins and carbohydrates blanket nerve cells across the brain, not just in select areas. Scientists are giving new attention to the holes in nets (green in the three images above) that envelop nerve cells in the mouse brain.

New synapses — communication links between nerve cells — poke holes in the nets, leaving behind a pattern that could hold long-term memories. Mice that had trouble making holes in their nets were worse at remembering a fearful signal weeks later, early experiments showed.

The proposal may help explain why people don't remember events from their first years of life, Palida says. Early on, nerve cells aren't yet extensively wrapped in perineuronal nets.



Same graph, different shape New algorithm quickly

spots identical networks By Andrew Grant

The fraternity of problems that confound computers has lost a prominent member. Computer scientist László Babai presented a new algorithm this year that efficiently tackles the graph isomorphism problem. It's a type of problem that computers struggle to solve, even though a solution provided in advance is easily verified. Assuming it is confirmed, says Stanford theoretical computer scientist Ryan Williams, this is the biggest advance in the field in more than a decade.

The problem requires computers to compare two graphs, or networks of connected points, and determine whether all points are linked in the same way. Previously, the time required to solve the problem rose nearly exponentially with graph size. Babai's algorithm, born from decades of mathematical effort, keeps the required computing time under control by solving even the hardest cases in what's called quasipolynomial time (*SN: 12/12/15, p. 6*). Babai's proof may provide insights for factoring large numbers and cracking other problems with easy-to-check, hard-to-solve status.

Graph theory The two graphs below might look different, but each circle on the first graph corresponds to one on the second, connecting to the same other circles. Mathematicians call the graphs "isomorphic."



Some of the mysterious radio signals detected by the Parkes telescope, in Australia, originate on Earth.

Brain teasers

In 2015, researchers solved some head-scratching and mind-bending puzzles.

Radio dinner

A class of odd radio bursts first detected by the Parkes telescope years ago came from an advanced civilization — if advanced means people on Earth so eager for a microwaved meal they open the oven before the beep. Whenever a nearby microwave was opened mid-cooking, the scope picked up the odd bursts, called perytons (*SN: 5/16/15, p. 5*).

Math master

No matter how hard anyone tries to set limits, the difference between quantities of two elements within certain sequences can grow without bound. That's what math wizard Paul Erdős proposed in 1932. But not until this year did UCLA mathematician Terence Tao prove the Erdős discrepancy problem (*SN*: 10/31/15, p. 7).

Acid test

Cyanoform is one of the strongest carbon-based acids, at least in chemistry textbooks. But a century of trying to make the acid, which hooks up a central carbon atom with a hydrogen atom and three cyano groups, just made unstable messes. Until now. Temperatures below -40° Celsius allowed the atoms to stick, creating the elusive acid for the first time (*SN*: 10/31/15, p. 11). — *Macon Morehouse*

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Ebola vaccines on the way

Two front-runners show promising results By Meghan Rosen

The race to develop Ebola vaccines closed in on the finish line this year, as scientists tested two candidates that could ultimately be stockpiled for future outbreaks. Both vaccines target a protein made by *Zaire ebolavirus*, the virus that raged through West Africa in 2014 and early 2015, killing more than 11,000 people (*SN: 12/27/14, p. 14*). The epidemic now appears under control, with only a few cases remaining in Liberia.

One vaccine relies on a live, replicating virus to stimulate an immune response in patients. In August, researchers testing it reported results from the largest Ebola vaccine trial to date to show evidence of protection: a study of 7,651 Guinean adults. None of the people vaccinated immediately after a close contact was diagnosed with Ebola became infected with the virus (*SN*: 9/5/15, p. 6).

The other vaccine uses a virus that

can't replicate. In November, Myron Levine, a vaccine researcher at the University of Maryland School of Medicine in Baltimore, and his colleagues demonstrated the vaccine's safety in a trial of U.S. and West African participants. A single high dose was enough to rally molecular troops to fight the virus, the team reported in the *Lancet Infectious Diseases*.

Among the vaccines in the works, Levine says, these two are the frontrunners and may be close to receiving approval from the U.S. Food and Drug Administration. "I'm hoping that in 2016 we see the two main first vaccines approved," Levine says.

BOOKSHELF

Science News' favorite books of 2015

With piles of books published each year, it can be hard to choose the most worthy titles to curl up with at the end of a long day. To help sort through 2015's books, the *Science News* staff offers its must-read picks, many of which have been previously reviewed in the magazine. Read those longer reviews at bit.ly/SN_books2015.



The Invention of Nature Andrea Wulf This biography of Alexander von Humboldt explores how the 19th century

German naturalist's expeditions helped lay the groundwork for our modern understanding of the natural world. *Knopf*, \$30



The Reason for Flowers

Stephen Buchmann The epic history of the evolution of flowers is told alongside the story of their

cultural and economic importance to humankind (*SN*: 7/25/15, *p*. 30). *Scribner*, \$26



The Diet Myth *Tim Spector* More so than a

More so than any fad diet, the key to good health is taking care of your gut microbes, a genetic

epidemiologist persuasively argues (SN: 9/19/15, p. 29). Overlook Press, \$28.95



Black Hole

Marcia Bartusiak It took decades of debate and research for physicists to accept the existence of black holes, a science

writer explains in this lively historical account (*SN*: 5/16/15, p. 26). Yale Univ., \$27.50



How to Clone a Mammoth Beth Shapiro In this thoughtful howto guide, an evolutionary biologist provides an insider's perspec-

tive on the technical and ethical challenges involved in reviving extinct species (SN: 6/13/15, p. 27). Princeton Univ., \$24.95



The Invaders Pat Shipman An anthropologist proposes an intriguing new explanation for the Neandertals' demise: Domesticated

dogs helped modern humans outhunt their Stone Age cousins (*SN*: 4/4/15, *p*. 28). *Harvard Univ.*, \$29.95



The Science of Mom Alice Callahan A writer with a background in nutritional biology serves up the latest scientific research to answer

the tough parenting questions that arise during a baby's first year. *Johns Hopkins Univ.*, \$19.95



Lesser Beasts Mark Essig People and pigs have more in common than meets the eye, a historian explains in this humorous look at

the 11,000-year partnership between humans and swine (*SN*: 6/27/15, p. 26). *Basic Books*, \$27.50



Do No Harm

Henry Marsh In this brutally honest memoir, a neurosurgeon recounts his successes and failures on the operating table.

Thomas Dunne Books, \$25.99



Brooke Borel Culture and biology intersect in this captivating tale of how bedbugs spread around

the world and why the bloodsuckers have resisted scientists' best efforts to eradicate them from people's bedrooms (*SN*: 5/2/15, p. 30). *Univ. of Chicago*, \$26

Infested



Rust

Jonathan Waldman A fascinating look at our centuries-old war against corrosion and the scientists and engineers who have led the

fight (SN: 4/4/15, p. 29). Simon & Schuster, \$26.95

SCIENTIFIC Babel

Scientific Babel Michael D. Gordin A historian retraces how English beat out German, French and Russian to become the language of sci-

ence (SN: 7/25/15, p. 30). Univ. of Chicago, \$30



A Beautiful Question Frank Wilczek A Nobel Prizewinning physicist ponders the link between physics, math and art in this thought-

provoking book (SN: 9/19/15, p. 29). Penguin Press, \$29.95

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Wow! A Simple to Use Computer Designed Especially for Seniors!

Easy to read. Easy to see. Easy to use. Just plug it in!



⁶⁶My name is Dorothy. I am 90 years old. Almost a year ago I invested in the WOW computer. I have been so happy with the helpful service of the VIP program and the knowledgeable agents who have taken my problem calls. This is my first experience with a computer and I must say I was very nervous about getting involved with it. Today I am comfortable with it and am amazed at all I have so easily learned. My one regret is --why did I wait so long!!⁹⁹

Have you ever said to yourself "I'd love to get a computer, if only I could figure out how to use it." Well, you're not alone. Computers were supposed to make our lives simpler, but they've gotten so complicated that they are not worth the trouble. With all of the "pointing and clicking" and "dragging and dropping" you're lucky if you can figure out where you are. Plus, you are constantly worrying about viruses and freeze-ups. If this sounds familiar, we have great news for you. There is finally a computer that's designed for simplicity and ease of use. It's the WOW Computer, and it was designed with you in mind. This computer is easy-to-use, worry-free and literally puts the world at your fingertips. From the moment you open the box, you'll realize how different

the WOW Computer is. The components are all connected; all you do is plug it into an outlet and your high-speed Internet connection. Then you'll see the screen it's now 22 inches. This is a completely new touch screen system, without the cluttered look of the normal computer screen. The "buttons" on the screen are easy to see and easy to understand. All you do is touch one of them, from the Web, Email, Calendar to Games- you name it... and a new screen opens up. It's so easy to use you won't have to ask your children or grandchildren for help. Until now, the very people who could benefit most from E-mail and the Internet are the ones that have had the hardest time accessing it. Now, thanks to the WOW Computer, countless older Americans are discovering the wonderful

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SOCIETY UPDATE

The Science Talent Search has been identifying and celebrating the best and brightest young scientific minds in the United States for 75 years. The Science Talent Search, a program of Society for Science & the Public, is the nation's most prestigious science research competition for high school seniors. Since 1942, first in partnership with Westinghouse and beginning in 1998 with Intel, the Science Talent Search has served as the national stage for the country's best and brightest young scientists to present original research to nationally recognized professional scientists.



2006 Then-Sen. Barack Obama visited with Intel STS finalist

Cindy Wang from Illinois.

2015

1996 STS finalists visited

Capitol Hill.



For the first time, three top winners were named. Noah Golowich, Andrew Jin and Michael Winer each received awards of \$150,000.

STS finalist Brian Greene, now a professor of physics and mathematics at Columbia University, founder of the World Science Festival and author of four New York Times best-selling books.

1980







1965 STS finalists met President

Lyndon Johnson and his dog "Him" at the White House



1972

2015

Nina Tabachnik (now Dr. Nina Schor) was the first woman to win the first-place award in years when only one top award was given; since then many young women have followed her to the front of the stage.

195'

STS finalist Patricia Cummisford at the National Ordnance Lab.





Help us celebrate the 75th anniversary of the Science Talent Search in March 2016! Alumni can reconnect by contacting Carolyn Carson, Alumni Coordinator, at ccarson@societyforscience.org. Additional historical photos are available at bit.ly/STS_history or check out a scrapbook from 1943 at bit.ly/SSP_scrapbook

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Online favorites of 2015

In 2015, the Science News website attracted more than 8 million visitors, who sometimes surprised us with their clicking habits. The lists below recognize the most-read online stories (that don't appear in our Top 25), as well as the most popular blog posts.

Top stories

Aurora shift confirms Ganvmede's ocean

Subtle changes in the aurora on Jupiter's moon Ganymede (illustrated above) clued scientists in to the fact that liquid water flows just beneath the moon's surface (SN: 4/4/15, p. 14).

Ring brings ancient Viking and Islamic civilizations closer together

An engraved ring discovered in a woman's grave in Sweden reveals evidence of close contacts between the Islamic world and ninth century Scandinavians (SN: 4/18/15, p. 8).

How the brain perceives time

New findings hint that the brain has legions of assorted clocks, all ticking at different rates. Scientists are untangling how the clocks harmonize to create our movements, emotions and sense of reality (SN: 7/25/15, p. 20).

Chikungunya is on the move

A crippling mosquito-borne virus has slipped its bonds in Africa and Asia and is invading new continents faster than people can learn to pronounce its name (SN: 6/13/15, p. 16).

Speed of light not so constant after all

Light doesn't always travel at the speed of light. An experiment revealed that focusing or manipulating the structure of light pulses reduces their speed, even in vacuums (SN: 2/21/15, p. 7).

Top blog posts

CONTEXT | TOM SIEGFRIED

Top 10 scientific mysteries for the 21st century

Science has done pretty well for itself since the 1600s, but there are still lots of mysteries left to solve in the 21st century (SN Online: 1/28/15).

CULTURE BEAKER | RACHEL EHRENBERG

Deflategate favored foul play over science

The scandal over underinflated footballs kicked off a teachable moment about the ideal gas law (SN Online: 6/18/15).

GROWTH CURVE LAURA SANDERS

Children's cells live on in mothers Moms and babies harbor little pieces of each other due to a process called fetal-maternal microchimerism (SN Online: 5/10/15).

SCICURIOUS | BETHANY BROOKSHIRE

Serotonin and the science of sex Scientists wrestle over the role serotonin plays in sexual preference, social communication and impulsiveness (SN Online: 4/10/15).

SCIENCE TICKER CHRISTOPHER CROCKETT

NASA moves ahead with a mission to Europa

A spacecraft will head to Jupiter's moon Europa by the 2020s to probe the moon's mysterious, ice-trapped ocean (SN Online: 6/18/15).

WILD THINGS | SARAH ZIELINSKI

Evewitness account of a dolphin birth takes a dark turn

Dolphins appear to be happy-go-lucky animals, but their births can be violent, researchers learned (SN Online: 7/21/15).

Readers tweak our top five

Readers weighed in via a Facebook poll to tell us which of our top stories they considered the most important science news of the year.



- CRISPR used to edit human embryos (No. 2, Page 18)
- New Horizons arrives at Pluto (No. 1, Page 16)
- Scientists discover Homo naledi (No. 3, Page 19)
- Global warming hiatus didn't exist (No. 5, Page 21)
- Age isn't just a number (No. 4, Page 20)

Join the conversation

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Not getting the sleep you need? Is your pillow the problem?

On its 10 year anniversary and with over five million satisfied customers, MyPillow[®] has been selected the Official Pillow of the National Sleep Foundation!

How Well Did You Sleep Last Night?

Did you toss and turn all night? Did you wake up with a sore neck, head ache, or was your arm asleep? Do you feel like you need a nap even though you slept for eight hours? Just like you, I would wake up in the morning with all of those problems and I couldn't figure out why. Like many people who have trouble getting a good night's sleep, my lack of sleep was affecting the quality of my life. I wanted to do something about my sleep problems, but nothing that I tried worked.

The Pillow Was the Problem

I bought every pillow on the market that promised to give me a better night's sleep. No matter how many pillows I used, I couldn't find one that worked and finally I decided to invent one myself. I began asking everyone I knew what qualities they'd like to see in their "perfect pillow", and got many responses: "I'd like a pillow that never goes flat", "I'd like my pillow to stay cool" and "I'd like a pillow that adjusts to me regardless of my sleep position." After hearing everyone had the same problems that I did, I spent the next two years of my life inventing MyPillow.

Mike Lindell Inventor of MyPillow®

MyPillow[®] to the Rescue

Flash forward ten years and MyPillow, Mike Lindell's revolutionary pillow design, has helped 5 million people improve the quality of their sleep. MyPillow has received thousands of testimonials about the relief MyPillow has brought to people who suffered from migraines, snoring, fibromyalgia, neck pain and many other common issues.

Lindell has been featured on numerous talk shows, including Fox Business News and Imus in the Morning. Lindell and MyPillow have also appeared in feature stories in The New York Times and the Minneapolis Star Tribune. MyPillow has received the coveted "Q Star Award" for Product Concept of the Year from QVC, and has been selected as the Official Pillow of the National Sleep Foundation.

MyPillow's patented technology can help with all of the most

common causes of sleep loss and allows you to adjust it to any sleeping position.

"Until I was diagnosed with various sleep issues, I had no idea why my sleep was so interrupted throughout the night. I watch Imus each morning and heard endless testimonials about MyPillow. I took his advice and ordered a MyPillow. Now I wake up rested and ready to conquer the day ahead. Thank you for helping me remember what it's like to sleep like a baby!" - Jacqueline H.



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and that if everyone had one, they would get better sleep and the world would be a much happier place.



Get the Sleep You've Been Dreaming About Save 50% today when you use promo code: "Science6" BUY NOW AT: mypillow.com or call 800.951.2895



SCIENCE VISUALIZED

Male, 35 years old May 27-29

A man who shared a hospital room with the first patient in the South Korean MERS outbreak infected the most people. On May 27, he went to Samsung Medical Center in Seoul, where he had to wait in the emergency room for a bed to become available. Over the next two and a half days, more than 80 people who had passed through the ER contracted the virus.

Male, 68 years old May 15-17

South Korean officials traced the MERS outbreak to a businessman who visited the Middle East in April and early May. Soon after returning, the man was admitted to St. Mary's Hospital in Pyeongtaek, where he infected about 30 people, mostly visitors and fellow patients.

Anatomy of a MERS outbreak

In 2015, South Korea experienced an outbreak of Middle East respiratory syndrome, or MERS. Between May and July, 186 people contracted the MERS virus; 38 eventually died. This diagram shows how quickly the pathogen spread within and between hospitals via a handful of "superspreaders." - Tina Hesman Saey



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Nationwide Coverage	YES	YES
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More minute plans available. Ask your Jitterbug expert for details.

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