SN
SCIENCE NEWS MAGAZINE
SOCIETY FOR SCIENCE & THE PUBLIC
FEBRUARY 18, 2017

Human-Animal Chimeras

Hottest Year on Record

Molecules Tied in Knots

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Celebrity Supernova

30 years after 1987A, astronomers await next nearby stellar explosion

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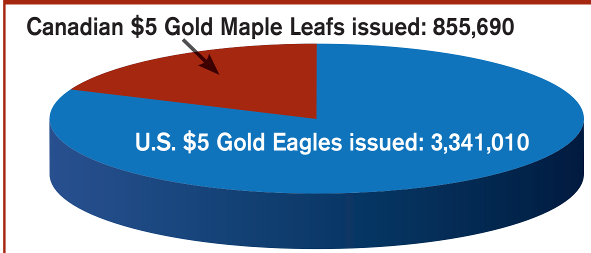

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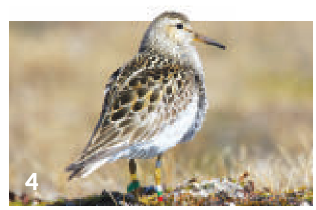
ScienceNews

Celebrity Supernova

News



Departments

COVER A ring of gas lit up by an expanding shock wave surrounds supernova 1987A (illustrated). *ALMA (ESO, NAOJ, NRAO), Alexandra Angelich (NRAO, AUI, NSF)*

CLOCKWISE FROM TOP LEFT: ESO; B. KEMPENAERS/MAX PLANCK INST. FOR ORNITHOLOGY; JEN GUYTON

Supernova story continues, just like science journalism

Some stories are just too good to let go. Ian Shelton first spotted supernova 1987A on the evening of Monday, February 23, 1987. A notice announcing the discovery appeared in the issue of *Science News* that went to the printer that Wednesday — and articles followed in each of the next three issues, with more than a dozen stories about the stellar explosion over the course of the year. "It's like Christmas," said astrophysicist Stanford Woosley. "More exciting than Woodstock," said astrophysicist John N. Bahcall. Thirty years later, we are still writing about 1987A, because there's still so much to say. "The primary ring has only gotten more intriguing with age," Christopher Crockett writes in our anniversary package, beginning on Page 20.

Reading through the 1987A coverage from that first year is like tailing a team of detectives as they pull together disparate details to solve a crime. The first observers thought the exploded star was Sanduleak -69° 202, but by March 7, astronomers were considering a companion star as the culprit. By May, general agreement settled back on Sanduleak. It was also unclear, at first, whether the event was a type 2 supernova or the less common type 1a — the explosion of a matter-thieving white dwarf. Neutrinos emitted from the supernova and detected on Earth presented their own puzzles: Why was there a five-hour time difference between detections at Mount Blanc in Europe and at the Kamiokande detector in Japan? And could the flight time of 1987A's neutrinos reveal whether the particles have mass? (Today we know they do.) Together those early stories are a study in how science progresses. And our reporters were there, doggedly following every lead.

It's a quality that has always distinguished *Science News,* and this issue is no exception. On Page 17, Susan Milius covers the latest update in the saga over fairy circles. Termite warfare might be responsible for these desert bald spots, where vegetation doesn't grow, or they could form as plants monopolize water, preventing others from moving in. Recent work proposes a combination of the two ideas, but advocates of each are not yet convinced. On Page 14, physics writer Emily Conover writes about the latest claim for metallic hydrogen. The topic was hot in the 1970s, and *Science News* has been watching closely ever since.

Here at *Science News*, there's a story behind every story. The writers have changed, but their shared commitment to science journalism, not fluff or hype but the real-deal and sometimes incremental advances, creates a continuity across the years.

The same is true for editors. As I work with the team at *Science News* to finish this issue, my first as acting editor in chief, I am awestruck by the tremendous body of knowledge that has been amassed over the last 90-plus years by team after team of curious, clever and intrepid journalists. There are dozens of stories that span decades. There are stories that are far from over and stories that are just beginning. I am also grateful for the precedents set by those who have come before me. Their hard work and dedication to journalism offers the clues needed to know what's ahead. And so we continue on. There's much more work to be done. *— Elizabeth Quill, Acting Editor in Chief*

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SSP

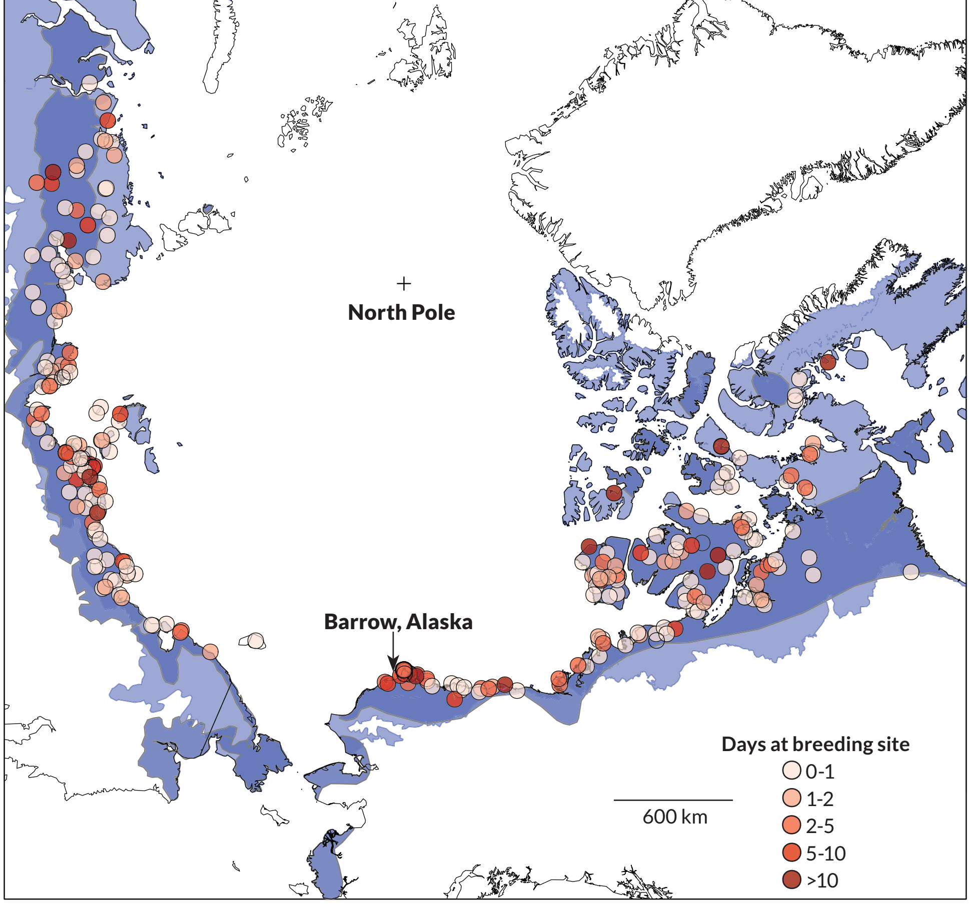
Excerpt from the February 25, 1967 issue of *Science News*

50 YEARS AGO

First germanium integrated circuits

Integrated circuits made of germanium instead of silicon have been reported ... by researchers at International Business Machines Corp. Even though the experimental devices are about three times as large as the smallest silicon circuits, they reportedly offer faster overall switching speed. Germanium ... has inherently greater mobility than silicon, which means that electrons move through it faster when a current is applied.

UPDATE: Silicon circuits still dominate computing. But demand for smaller, high-speed electronics is pushing silicon to its physical limits, sending engineers back for a fresh look at germanium. Researchers built the first compact, high-performance germanium circuit in 2014, and scientists continue to fiddle with its physical properties to make smaller, faster circuits. Although not yet widely used, germanium circuits and those made from other materials, such as carbon nanotubes, could help engineers make more energy-efficient electronics.



In 2012, male pectoral sandpipers visited many sites (dots) throughout the Canadian and Russian Arctic, rather than remaining at a first-stop breeding ground in Barrow, Alaska. Blue areas indicate the birds' breeding range.

RETHINK

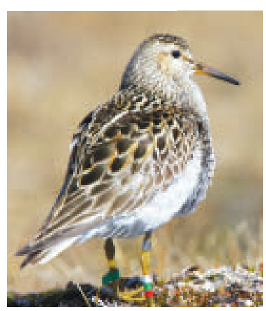
Nonstop sandpipers

After flying more than 10,000 kilometers from South America to the Arctic, male pectoral sandpipers should be ready to rest their weary wings. But once the compact shorebirds arrive at a breeding ground in Barrow, Alaska, each spring, most keep going — an average of about 3,000 extra kilometers.

Scientists thought males, which mate with multiple females, stayed put at specific sites around the Arctic to breed. Instead, in a study of 120 male pectoral sandpipers in Barrow, most flitted all across the region looking for females. One bird flew a whopping 13,045 kilometers more after arriving, researchers report online January 9 in *Nature*.

"We had no clue that they range over such a wide area," says study coauthor Bart Kempenaers, a behavioral ecologist at the Max Planck Institute for Ornithology in Seewiesen, Germany. To track the birds, the researchers placed satellite transmitters on 60 males in 2012 and another 60 in 2014.

"It doesn't seem to be very tough for them to do these flights," Kempenaers says. Competition for a mate, however, is cutthroat. In Barrow, just a few males sire the majority of offspring each year. The new work shows males visited as many as 24 potential breeding sites over four weeks, perhaps to boost their chances of reproducing.



After a long migration from the Southern Hemisphere, male pectoral sandpipers (one shown) fly thousands of kilometers more around the Arctic to visit multiple breeding sites.

Some had better stamina than luck. Kempenaers told of one male's 2,000-kilometer Arctic odyssey: Once the bird reached Barrow, it flew north over the Arctic Ocean before turning around and landing just 300 kilometers from where it started. "There's nothing northwards. There is only the [North] Pole, no land," he says. — *Emily DeMarco*

FROM TOP: B. KEMPENAERS AND MIHAI VALCU/*NATURE* 2017; B. KEMPENAERS/MAX PLANCK INST. FOR ORNITHOLOGY

Watch sandpiper movement on the map at **bit.ly/SN_sandpipers**

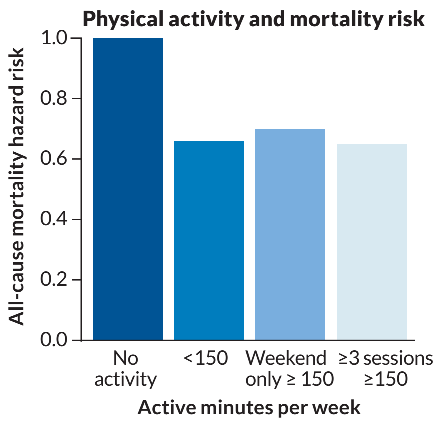
FOR DAILY USE

Any workout is worth it

Any exercise — even the weekend warrior approach, cramming it all into Saturday and Sunday — is better than none. Compared with inactive adults, those who got the recommended amount of weekly exercise, or even substantially less, had about a one-third lower risk of death during the study period, researchers report online January 9 in *JAMA Internal Medicine*.

Gary O'Donovan at the University of Leicester in England and colleagues analyzed data from 63,591 people ages 40 and older, surveyed between 1994 and 2012 as part of the Health Survey for England and the Scottish Health Survey. Adults should be getting 150 minutes of moderate activity (such as walking) or 75 minutes of vigorous activity (such as jogging) spread out across the week, according to the U.S. Centers for Disease Control and Prevention and the World Health Organization.

Measured against people who did absolutely nothing, active people who worked up a sweat three or more times per week, weekend warriors and even those who moved less (60 minutes per week on average) all reduced their risk of dying early. The observational study can't say that exercise caused the reduced risk, just that there's an association. — *Bethany Brookshire*



SOURCE: G. O'DONOVAN *ET AL/JAMA INT. MED.* 2017

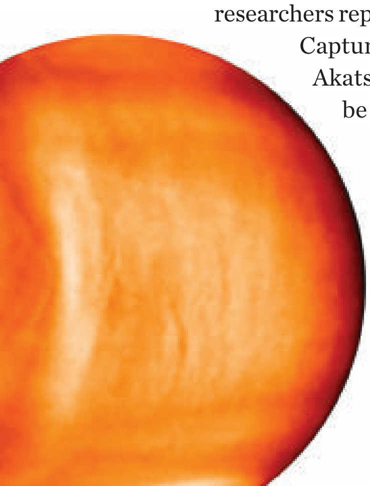
HOW BIZARRE

Surface action on Venus

With scorching temperatures and a mind-numbingly slow rotation (one Venus day lasts 243 Earth days), Venus was already a contender for weirdest planet in the solar system. Now add a giant bow-shaped structure in its atmosphere to its list of oddities. The mysterious 10,000-kilometer-long arc was so big that it appeared to stretch between the planet's poles. And it didn't budge, even as winds in the upper atmosphere whipped along at a brisk 100 meters per second.

The structure, which lasted at least four Earth days, could be a gravity wave, a large disturbance in the flow of air or other fluids, scientists say. It may have formed on Venus when winds in the planet's lower atmosphere slammed into a mountain range, got pushed into the upper atmosphere and got stuck, Japanese researchers report online January 16 in *Nature Geoscience*.

Captured by the Japan Aerospace Exploration Agency's Akatsuki spacecraft in December 2015, the structure could be the largest stationary gravity wave seen in the solar system. If it did shift from the lower to upper atmosphere, there may be more going on at the planet's surface than once thought.
— *Ashley Yeager*



A bow-shaped structure arches vertically across Venus in this infrared image. Whiter colors represent higher temperatures, showing that the odd structure is hotter than other areas of the atmosphere.

Shining light on incubating eggs could make adult broiler chickens less fearful, a new study suggests.

TEASER

Lighting the way to calmer chickens

Fearful, flighty chickens raised for eating can hurt themselves while trying to avoid human handlers. But there may be a simple way to hatch calmer chicks: Shine light on the eggs for at least 12 hours a day.

Researchers at the University of California, Davis bathed eggs daily in light for different time periods during their three-week incubation. When the chickens reached 3 to 6 weeks old, the scientists tested the birds' fear responses. In one test, 120 chickens were randomly selected from the 1,006-bird sample and placed one by one in a box with a human "predator" sitting visibly nearby. The chickens incubated in light the longest — 12 hours — made an average of 179 distress calls in three minutes, compared with 211 from birds incubated in complete darkness, animal scientists Gregory Archer and Joy Mench report in January in *Applied Animal Behaviour Science*.

Chickens exposed to lots of light as eggs "would sit in the closest part of the box to me and just chill out," Archer says. The others spent their time trying to get away. How light has its effect is unclear. On commercial chicken farms, eggs typically sit in warm, dark incubation rooms. The researchers are now testing light's effects in large, commercial incubators. Using light exposure to raise less-fearful chickens could reduce broken bones during handling at processing plants, Archer says. It might also decrease harmful anxious behaviors, such as feather pecking of nearby chickens. — *Aylin Woodward*

CLOCKWISE FROM TOP: A.S. ZAIN/SHUTTERSTOCK; ©PLANET-C; GRAPH ADAPTED BY T. TIBBITTS

GENES & CELLS

Human-animal chimeras created

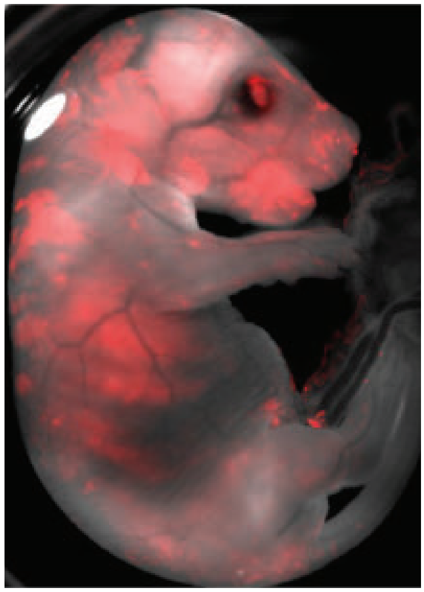
Embryos show possibility of growing transplant organs

BY TINA HESMAN SAEY

Growing human organs in other animals is a small step closer to reality.

Injecting human stem cells into pig and cattle embryos created embryos that incorporate a small number of human cells, scientists report in the Jan. 26 *Cell*. The ultimate goal of the controversial research is to use hybrid, or chimeric, animals to produce human organs for transplant.

Farm animals incubating human organs won't appear anytime soon, says Juan Carlos Izpisua Belmonte, a stem cell biologist at the Salk Institute for Biological Studies in La Jolla, Calif. "I feel we're still far away from that," says Belmonte, who led the work. It has taken his group four years "just to deliver a message that, yes, human cells can integrate into a pig."



Researchers created a mouse embryo that contains rat cells (red). Hybrid, or chimeric, animals may eventually grow human organs to be used in transplants.

While human-animal chimera work is still in its infancy — and faces ethical and funding hurdles — hybrids of rats and mice are already hinting that growing an organ from one species in another is a viable strategy for curing some diseases. Researchers report online January 25 in *Nature* that they grew mouse pancreases in rats.

Mouse insulin-producing cells were extracted from the rat-grown organs and transplanted into diabetic mice, curing their diabetes. Transplanted cells kept the mice's blood sugar levels normal for more than a year. Even though the mice received immune-suppressing drugs for only the first five days following the transplant, the mice's bodies didn't reject the pancreases. That finding raises the hope that animal-grown organs tailored to individual patients could be transplanted without fear of rejection.

Chimeric animals get their name from a fire-breathing monster in Greek mythology that had the head of a lion, a goat's body and a snake's tail. Researchers create patchwork animals by injecting early embryos of one species with stem cells from another species. In 2010, Hiromitsu Nakauchi, a stem cell biologist at Stanford University School of Medicine, and colleagues reported making a mouse that grew a rat pancreas. The researchers were surprised to find that the organ grew to the size of a mouse pancreas instead of creating a much larger rat-sized organ.

The mouse-grown pancreas wasn't big enough to transplant back into a rat. So for the new study, Nakauchi and colleagues reversed the experiment, growing a mouse pancreas in a rat.

Hybrid hurdles

Some people are not excited about the prospect of growing human organs in animals. "People view chimeras as monsters," says Stanford stem cell biologist Hiromitsu Nakauchi, who is attempting to make pigs and sheep that carry human organs intended for transplant.

Part of the discomfort stems from concerns that the chimeras might be "too human," giving pigs human brains or breeding a hybrid animal that could potentially produce a human baby, says Robert Streiffer, a bioethicist at the University of Wisconsin–Madison.

In some countries, creating human-animal chimeras is banned. Researchers in the United States are allowed to conduct human-animal chimera work using private or state funding, but not with federal money.

The National Institutes of Health currently has a moratorium on funding such research. In August, NIH announced intentions to lift the funding ban pending finalization of policies governing such research, but there is no final regulation yet. The proposed rules would expand prohibitions on introducing human stem cells into early nonhuman primate embryos and strengthen bans on breeding any animal that might produce human eggs or sperm, says Carrie Wolinetz, associate director for science policy at NIH. A new oversight committee would also be created to address issues of ethics and animal welfare raised by such research, Wolinetz says. "We're trying to allow the research to move forward responsibly."

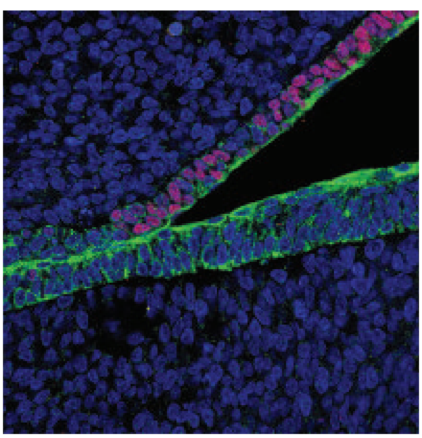
Bioethicist Françoise Baylis wrote in an e-mail that there is no ethical way to continue chimera work because it is based on a faulty assumption that human life is more valuable than that of nonhuman beings. "The hope that one can 'forever' avoid the tough ethical questions by simply ensuring that the nonhuman animals are not 'substantively humanized' is flawed (short-sighted)," wrote Baylis, of Dalhousie University in Halifax, Canada. *— Tina Hesman Saey*

SALK INSTITUTE

The researchers used a genetic trick to ensure that the pancreas was composed mostly of mouse cells, breeding rats that cannot make a pancreas because of defects in the *Pdx1* gene. Normally rats without a pancreas die shortly after birth. But animals that got mouse cells were able to grow a functioning pancreas.

In the study reported in *Cell*, Belmonte and colleagues also worked with rodents, creating mice that grew rat organs. Using the gene-editing tool CRISPR/Cas9, the researchers disabled *Pdx1* and genes involved in heart and eye development so that mice couldn't grow functioning versions of those organs. Rat stem cells injected into mouse embryos filled in, growing functional organs, including one the researchers didn't expect. Rats don't have gallbladders, but rat stem cells introduced into mice embryos are able to form gallbladders, the researchers reported.

This finding illustrates that the host environment has significant control over what happens to stem cells, says Daniel Garry, a transplant cardiologist and stem cell biologist at the University of Minnesota in Minneapolis. "That's pretty cool biology." The result also indicates that it may not be possible to re-create in lab dishes the mechanical forces, chemical signals and other conditions an organ needs to develop properly.



Human cells (green) integrated into pig embryos were able to form cells (red) that give rise to the lining of the gut and other tissues. Tissue from a 4-week-old pig embryo is shown. DNA in both human and pig cells is in blue.

SALK INSTITUTE

In the case of the human-pig chimeras, researchers weren't sure how well the human cells would fare, Garry says. For all scientists knew, human stem cells might take over pig embryos. "That would be very much unwanted," Garry says.

But the Salk researchers and colleagues found that human cells don't incorporate efficiently into pig embryos. Of 2,075 pig embryos injected with human stem cells and transferred to sows' uteruses, only 186 grew for 21 to 28 days — as long as the researchers allowed development to continue. Of those, 67 contained human cells. Most of the chimeric embryos were underdeveloped, indicating that human cells may interfere with normal pig development. Early cattle embryos appeared to accept human cells more easily, but cows are more difficult to work with than pigs.

More work is needed to improve growth of human cells in pig embryos. The Salk researchers hope to use CRISPR/Cas9 to engineer pigs to lack certain organs just as was done with rodents, says Jun Wu, a stem cell biologist on Belmonte's team. Without competition from pig cells, human cells able to supply the missing organs might have a growth advantage and survive better. ■

BODY & BRAIN

Antibody tied to more severe dengue

Study probes why second infection can be worse than first

BY ELIZABETH S. EATON

The playground ditty "first the worst, second the best" isn't always true when it comes to dengue fever. Some patients who contract the virus a second time can experience more severe symptoms. A rogue type of antibody may be to blame, researchers report in the Jan. 27 *Science*. Instead of protecting their host, the antibodies are commandeered by the dengue virus to help it spread, increasing the severity of the disease.

Four closely related viruses cause dengue, a mosquito-transmitted disease marked by fever, muscle pain and other flulike symptoms (*SN: 6/25/16, p. 22*). When a previously infected person contracts a second type of dengue, leftover antibodies can react with the new virus.

Fewer than 15 percent of people with a second infection develop severe dengue disease. Those who do may produce a variant of a type of antibody called immunoglobulin G, says Taia Wang, an infectious diseases researcher at Stanford University School of Medicine.

Wang and colleagues found that dengue patients with a dangerously low blood platelet count — a sign of severe dengue disease — had an abundance of these variant antibodies.

Tests in mice support the connection. "We found that when we transferred the antibodies from patients with severe disease into mice, they triggered platelet loss," Wang says.

It's not known why some people have these alternate antibodies, Wang says. She and her team want to determine that, along with how these antibodies are regulated by the immune system. With further research, screenings may be able to identify people who are more susceptible to severe dengue disease, Wang says.

Anna Durbin, who researches dengue vaccines at the Johns Hopkins Bloomberg School of Public Health, doesn't see a strong connection between this type of antibody and the severity of dengue disease. But she says that the research was interesting in how it connected dengue to a low platelet count, a condition known as thrombocytopenia.

"There's a lot of different theories out there about the role of dengue antibodies and thrombocytopenia, and whether or not the virus itself can enter platelets," Durbin says. "This paper may provide more insight into what is the pathogenic mechanism of thrombocytopenia and dengue, and raises some good avenues for further research." ■

MATTER & ENERGY

Molecular knot is most complex yet

Chemists make braid of atoms with strands that cross 8 times

BY MEGHAN ROSEN

One hundred and ninety-two atoms have tied the knot.

Chains of carbon, hydrogen, oxygen and nitrogen atoms, woven together in a three-stranded braid, form the most complex molecular knot ever described, chemists from the University of Manchester in England report in the Jan. 13 *Science*.

Learning how to tie such knots could one day help researchers weave molecular fabrics with all sorts of snazzy properties. "We might get the strength of Kevlar with a lighter and more flexible material," says study coauthor David Leigh.

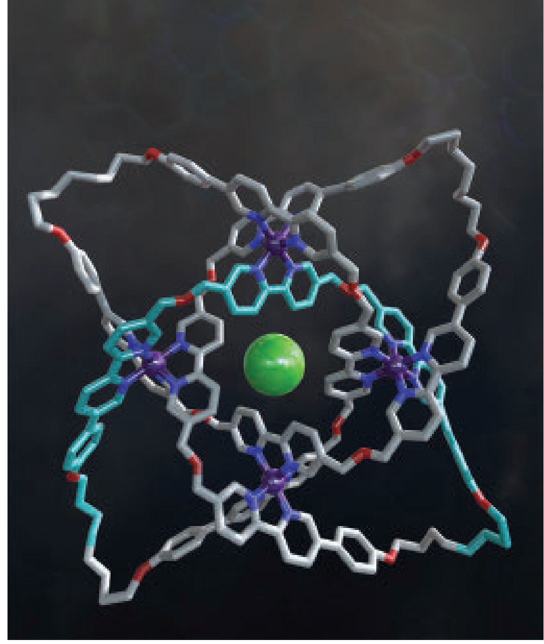
Molecular knot tying has an appeal that's purely intellectual, too, says University of Cambridge chemist Jeremy Sanders. "It's like the answer to why you climb Everest," he says. "It's a challenge."

Mathematicians know of more than 6 billion types of prime knots, which, like prime numbers, cannot be broken down into simpler components. "Prime knots can't be built up by sticking other knots together," Leigh explains. For years, chemists were able to synthesize just one type of prime knot out of small molecules. "We thought that was pretty ridiculous," Leigh says.

That molecular knot was a trefoil, like a three-leaf clover. Jean-Pierre Sauvage and colleagues wove it from chemical strands in 1989. Sauvage won a Nobel Prize in 2016 for work that used the same principles explored in his knots (*SN: 10/29/16, p. 6*).

In the decades since Sauvage's trefoil, chemists have tried to synthesize other types of molecular knots, but "they've always found it incredibly difficult," says chemist Sophie Jackson, also at the University of Cambridge.

Persuading nanoscale strands to interlock in an orderly fashion isn't simple. "You can't just grab the ends and tie them like you would a shoelace," Leigh says. Instead, scientists choose molecular ingredients that assemble themselves.



The most complex molecular knot synthesized by chemists (X-ray crystal structure shown) is formed by linking atoms of carbon, hydrogen, oxygen and nitrogen. A single chloride ion (green sphere in center) and four iron ions (purple spheres) help the knot form but can later be washed away.

In 2012, Leigh and colleagues used the self-assembly technique to make a prime knot called a pentafoil, a star-shaped structure made up of 160 atoms and with strands that cross five times (*SN: 1/28/12, p. 12*). This latest knot, with eight crossing points, is even more intricate.

BODY & BRAIN

Two brain circuits help mice hunt

Lasers illuminate amygdala's role in stalking, biting prey

BY LAUREL HAMERS

The part of the brain that governs emotions such as fear and anxiety also helps mice hunt. That structure, the amygdala, orchestrates a mouse's ability to both stalk a cricket and deliver a fatal bite, scientists report in the Jan. 12 *Cell*.

Scientists made select nerve cells in mice's brains sensitive to light and then used lasers to activate specific groups of those nerve cells. By turning different cells on and off, the researchers found two separate sets of nerve cells relaying hunting-related messages from the amygdala's central nucleus. One set controlled the mice's ability to chase prey. The other affected the ability to deliver a solid chomp to kill a cricket.

"They've found these two behaviors — that are part of something we think of being very complex — are controlled by these two circuits," says Cris Niell, a neuroscientist at the University of Oregon in Eugene who wasn't part of the study. "You flip a switch to chase, you flip a switch to attack."

Ramping up both of those circuits to high power at the same time even led mice to chase and capture a tiny bug-shaped robot that they would normally ignore or avoid.

Scientists don't know how the hunting function relates to the amygdala's better-known role as an emotional control center. "The central amygdala has been conceptualized as a center for emotion and fear and threat detection," says study coauthor Ivan de Araujo, a neuroscientist at the John B. Pierce Laboratory in New Haven, Conn. But the amygdala does help control heart rate and blood pressure, which shift in emotionally charged situations and also need to be closely regulated when an animal is pursuing prey, de Araujo says.

> "You flip a switch to chase, you flip a switch to attack."
> CRIS NIELL

The study also shows how even a complex task like hunting can be coordinated by different groups of very specialized nerve cells, or neurons, working together. In this case, one set of neurons made a signaling pathway that controlled chasing, while

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Leigh's team mixed together building blocks containing carbon, hydrogen, oxygen and nitrogen atoms with iron ions and chloride ions. "You dump them all in, heat them all up and they self-assemble," he says.

Sticky metal ions hold the building blocks in the correct position, and a single chloride ion sitting in the middle of the structure anchors it all together. Then, a chemical catalyst links the building blocks, forming the completed knot. The new knot is the tightest ever created, Leigh says, with just 24 atoms between each crossing point.

It's beautiful, Sanders says. "It's a string of atoms rolled up in a spherical shape, with an astonishing amount of symmetry." Sanders is reluctant to speculate how such a knot might be used, but it's round and very dense, he says. That could give it some interesting material properties.

Leigh suspects that different molecular knots might behave differently, like the various knots used by fishermen and sailors. "We want to make specific knots, see what they do and then figure out how to best exploit that," he says. ■

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another controlled biting. Together, those neurons helped the mice grab dinner.

"Over the years we've become progressively more surprised by the behavioral specificity of these particular pathways," says Anthony Leonardo, a neuroscientist at the Howard Hughes Medical Institute's Janelia Research Campus in Ashburn, Va. "Certainly the evidence is mounting for a very strongly specific role for neurons." Leonardo has found similarly specialized neurons in the dragonfly brain, with groups of neurons that run in parallel to each other controlling different types of movements.

Next, de Araujo says, his lab hopes to figure out what flips the neural switches in a mouse's brain — how seeing or smelling potential prey triggers the amygdala to send the critter after a meal. ■

EARTH & ENVIRONMENT

2016 shattered Earth's heat record

Climate change, El Niño drove high global temperatures

BY THOMAS SUMNER

For the third year running, Earth's thermometer broke a new record: 2016 was the warmest year since record-keeping began in 1880.

Spurred by climate change and heat from a monster El Niño, the global average surface temperature last year was 0.94 degrees Celsius (1.69 degrees Fahrenheit) higher than the 20th century average of 13.9° C (57° F). That figure slightly edges out the previous titleholder, 2015, by 0.04 degrees C (*SN: 2/20/16, p. 13*). Eight months during 2016 set new all-time highs. July and August tied as Earth's warmest months on record, scientists from the National Oceanic and Atmospheric Administration and NASA reported January 18.

This is only the second time that the annual temperature record has been broken three years in a row, Deke Arndt, chief of the monitoring branch of NOAA's National Centers for Environmental Information in Asheville, N.C., said in a news conference. The previous trio — 1939 through 1941 — don't rank within the top 30 warmest years on record, he noted.

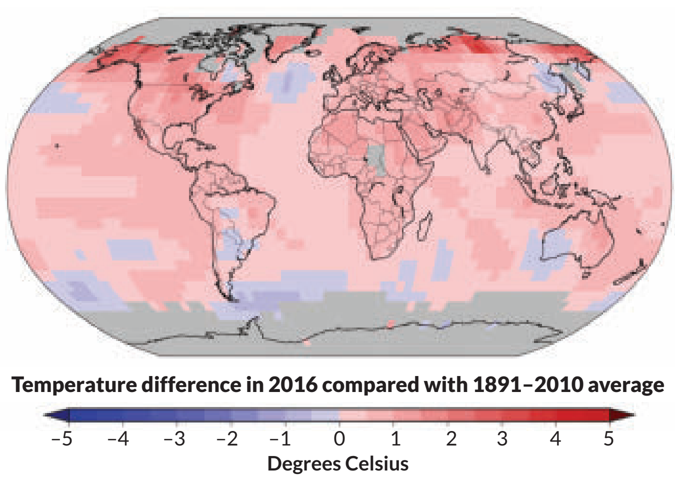
Last year's heat has helped set other records as well. On January 17, for instance, global sea ice extent was at its paltriest in potentially thousands of years, according to observational data from the National Snow and Ice Data Center and sea ice reconstructions.

Greenhouse gases released by human activities such as fossil fuel burning have cranked Earth's thermostat over the last few decades by trapping heat that would otherwise escape into space. All 16 years of the 21st century are among the 17 warmest on record. (1998 ranks as the eighth warmest year.)

Humankind's fossil fuel habit isn't solely to blame for 2016's sweltering heat, says Kevin Trenberth, a climate scientist at the National Center for Atmospheric Research in Boulder, Colo. El Niño, the pile up of warm water in the eastern Pacific, also contributed. The 2015–2016 El Niño, among the three strongest on record, raised global temperatures by releasing pent-up heat from the ocean into the atmosphere (*SN Online: 6/9/16*).

Within a decade or so, as global warming continues, 2016's heat will be par for the course even during non–El Niño years, Trenberth predicts. "The temperature record is like going up a staircase, and now with 2015 and 2016, we've seemed to go up another step," he says. "We'll maybe oscillate around this higher level for a few years, but I don't think we'll ever go back to the values we've seen in previous years." ■

Record breaker
Climate change and remnant warming from the 2015–2016 El Niño helped make 2016 the hottest year on record. Red areas were warmer than their long-term average temperature; blue areas were cooler. Gray represents areas with insufficient long-term data.



NOAA

BODY & BRAIN

Cancer studies fall short in redos

Scientists fail to fully replicate five high-profile findings

BY TINA HESMAN SAEY

An effort to reproduce findings of five prominent cancer studies has produced a mixed bag of results.

In a series of papers published January 19 in *eLife*, researchers from the Reproducibility Project: Cancer Biology report that none of the five studies they sought to duplicate were completely reproducible. Replicators could not confirm any of the findings of one study. In other cases, replicators saw results similar to the original study's, but statistical analyses could not rule out that the findings were a fluke. Problems with mice or cells used in two experiments prevented the replicators from confirming the findings.

"Reproducibility is hard," says Brian Nosek, executive director of the Center for Open Science in Charlottesville, Va., an organization that aims to increase the reliability of science. It's too early to draw any conclusions about the overall dependability of cancer studies, Nosek says, but he hopes redo experiments will be "a process of uncertainty reduction" that may ultimately help researchers increase confidence in their results.

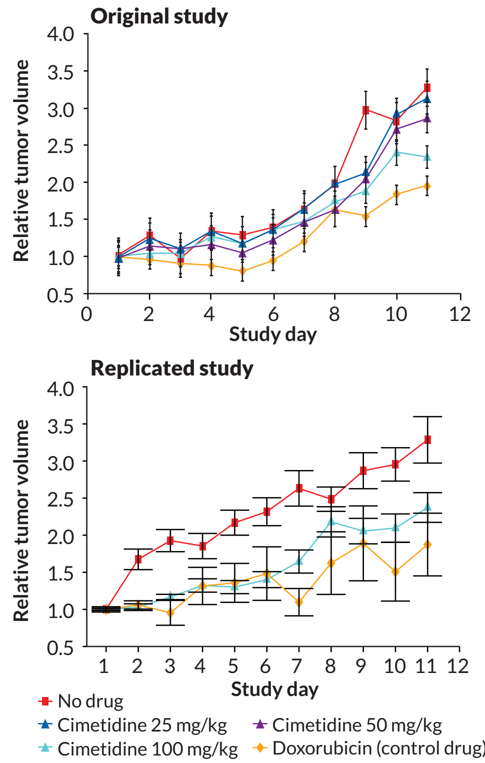
The cancer reproducibility project is a collaboration between Nosek's center and Science Exchange, a network of labs that conduct replication experiments for a fee. Replicators working on the project selected 50 highly cited and downloaded papers in cancer biology published from 2010 to 2012. Teams then attempted to copy each study's methods, often consulting with the original researchers for tips and materials. The five papers published in *eLife* are just the first batch. Eventually, all of the studies will be evaluated as a group to determine the factors that lead to failed replications.

Critics charge that the first batch of replication studies did not accurately copy the originals, producing skewed results. "They didn't do any troubleshooting. That's my main complaint," says cancer biologist Erkki Ruoslahti of Sanford Burnham Prebys Medical Discovery Institute in La Jolla, Calif.

Ruoslahti and colleagues reported in 2010 in *Science* that a peptide called iRGD helps chemotherapy drugs penetrate tumors and increases the drugs' efficacy. In the replication study, the researchers could not confirm those findings. "I felt that their experimental design was set up to make us look maximally bad," Ruoslahti says.

Replicators aren't out to make anyone look bad, says Tim Errington, a cancer biologist at the Center for Open Science. The teams published the experimental designs before they began the work and reported all of their findings. What Ruoslahti calls troubleshooting, Errington calls fishing for a particular result. Errington acknowledges that technical problems may have hampered replication efforts, but that's valuable data to determine why independent researchers often can't reproduce published results. Identifying weaknesses will let scientists design better experiments and conduct research more efficiently, he argues.

Other researchers took issue with the replicators' statistical analyses. One study sought to reproduce results from a report published in *Science Translational Medicine* in 2011. In the original study, Atul Butte, a computational biologist at the University of California, San Francisco, and colleagues developed a computer program for predicting how existing drugs might be repurposed to treat other diseases. The program predicted that an ulcer-fighting drug called cimetidine could treat a type of lung cancer. Butte and colleagues tested the drug in mice and found that it reduced the size of lung tumors. The replication attempt got very similar results with the drug test. But after adjusting the statistical analysis to account for multiple variables, the replication study could no longer rule out a fluke result. "If they want a headline that says 'It didn't replicate,' they just created one," Butte says. Errington says the corrections were necessary and not designed to purposely invalidate the original result. And when replication researchers analyzed both the original and replication studies together, the results once again appeared to be statistically sound.



Drug do-over In 2011, scientists reported that the antiulcer drug cimetidine reduced the size of mice's lung tumors (top). The cancer drug doxorubicin was used as a comparison. A repeat of the test (bottom) also appeared to show tumor shrinkage, but an initial statistical analysis indicated the result might be a fluke. Combining the two tests' results, though, supported the initial finding of cimetidine's anticancer effect.

FROM TOP: M. SIROTA *ET AL*/*SCIENCE TRANSL. MED.* 2011; I. KANDELA *ET AL*/*ELIFE* 2017

A failure to replicate should not be viewed as an indication that the original finding wasn't correct, says neuroscientist Oswald Steward of the University of California, Irvine, who has conducted replication studies of prominent neuroscience papers but was not involved in the cancer replication studies. "A failure to replicate is simply a call to attention," Steward says. Especially when scientists are building a research program or trying to create new therapies, it is necessary to make sure that the original findings are rock solid, he says. "We scientists have to really own this problem." ■

MATTER & ENERGY

Long-standing gold mystery solved

Predicted, actual energy needed for ionization now match

BY EMILY CONOVER

Gold's glimmer is not the only reason the element is so captivating. For decades, scientists have puzzled over why theoretical predictions of gold's properties don't match up with experiments. Now, highly detailed calculations have erased the discrepancy, researchers report in the Jan. 13 *Physical Review Letters*.

At issue was the energy required to remove an electron from a gold atom, or ionize it. Theoretical calculations of this ionization energy differed from measurements. Likewise, the energy released when adding an electron — a quantity known as the electron affinity — was also off the mark. How easily an atom gives up or accepts electrons is important for understanding how elements react with other substances.

"It was well known that gold is a difficult system," says chemist Sourav Pal of the Indian Institute of Technology Bombay, who was not involved with the study. Even gold's most obvious feature, its yellowish color, can't be explained without calling Einstein's special theory of relativity into play. (Relativistic effects shift the energy levels of electrons in gold atoms, causing the metal to absorb blue light and thereby making reflected light appear more yellow.)

With the new study, scientists have finally resolved the lingering questions about the energy involved in removing or adding an electron to the atom. "That is the main significance of this paper," Pal says.

Calculations performed in the 1990s differed from the predicted energies by more than a percent, and improved calculations since then still didn't match the measured value. "Every time I went to a conference, people discussed that and asked, 'What the hell is going on?' " says study coauthor Peter Schwerdtfeger, a chemist at Massey University Auckland in New Zealand.

The solution required a more complete consideration of the complex interplay among gold's 79 electrons. Using advanced supercomputers to calculate the interactions of up to five of gold's electrons at a time, the scientists resolved the discrepancy. Previous calculations had considered up to three electrons at a time. The effects of special relativity and the theory of quantum electrodynamics, which describes the behavior of particles like electrons, were also essential to include in the calculation.

The result indicates that gold indeed adheres to expectations — when calculations are detailed enough. "Quantum theory works perfectly well and that makes me extremely happy," Schwerdtfeger says. ■

GENES & CELLS

Tastier tomatoes through chemistry

Genetic study of heirlooms suggests new flavor strategies

BY SUSAN MILIUS

An analysis of nearly 400 kinds of tomatoes suggests which flavor compounds could return heirloom deliciousness to varieties bred for toughness over taste.

About 30 compounds are important for creating a full-bodied tomato flavor, says Harry Klee of the University of Florida in Gainesville. He and colleagues have identified 13 important molecules that have dwindled away in many mass-market varieties. Some of the flavor compounds deliver such a thrill to the human sensory system that even a modest increase could make a big difference, the researchers report in the Jan. 27 *Science*.

"I think this will definitely help," says Alisdair Fernie, who has studied tomato chemistry at the Max Planck Institute of Molecular Plant Physiology in Potsdam, Germany. "Taste is incredibly complex," so creating more appealing commercial varieties "requires a holistic approach."

Klee and colleagues teamed up with geneticists at China's Agricultural Genomics Institute in Shenzhen, who determined the full genetic makeup of 398 kinds of tomatoes, wild as well as heirloom and commercial. The scientists ran 96 varieties of tomatoes through taste-testing panels, looking for genetic and chemical similarities among those varieties ranked tastiest.

Much of what makes some tomatoes taste better is actually smell, Klee points out. Tongues can detect relatively few qualities, such as sweetness, acidity and softness. Chemical detectors in the nasal passages are far more varied and sensitive. So what puts the "Mmmm" into a tomato is the whoosh of air forced up into the nasal passages as someone swallows. Airborne compounds, known as volatiles, are abundant in tomatoes.

A study of the genetics of flavor in tomatoes (heirlooms shown) suggests ways to breed more taste into supermarket varieties.

Even in the tastiest tomatoes, some of these volatile compounds appear in minuscule levels — only parts per trillion. But humans sense odors so strongly that a little bit goes a long way. Tomatoes should taste noticeably better if researchers can breed just four or five heirloom versions of volatile-producing genes back into commercial varieties, Klee says.

Increasing the sweetness of today's tomatoes may be tougher. About 80 percent of the sugar in commercial tomatoes comes from the leaves and is transferred to the big red globes as they mature (*SN: 7/28/12, p. 18*). Because breeders have maximized the number of fruits on a plant, the plants would need lots of leaves to sweeten every fruit. So the price of sweeter tomatoes would be making them smaller, and fewer.

"Now we come to the real crux of the problem," Klee says. "I have to fix the flavor, but I can't compromise all of the stuff that breeders have done to the modern tomatoes to make them healthier, more productive, more disease resistant and more shippable," he says.

Storing tomatoes in refrigerators also weakens flavor. Tomato researcher Ann Powell of the National Science Foundation says a previous study of Klee's — on how chilling turns genes on and off — is an important companion to the new work. A combination of breeding better plants and coddling them strategically may be the way forward for tastier tomatoes. ■

LIFE & EVOLUTION

Ancient giant otter unearthed in China

Fossils of a giant otter have emerged from an open-pit mine in China. The crushed cranium, jaw bone and partial skeletons of at least three animals belong to an extinct species of otter that lived about 6.2 million years ago, scientists report January 23 in the *Journal of Systematic Palaeontology*.

At roughly the size of a Rottweiler, the 50-kilogram otter would have far outclassed today's giant otter, a river-dwelling South American mammal weighing about 34 kilograms. Scientists named the new species *Siamogale melilutra* for its unusual mix of badger and otter features. (*Melilutra* is a mash-up of the Latin words for both creatures.) Several dental features of *S. melilutra* resemble those of badgers, but other aspects of the teeth and skull make it clearly an otter, researchers concluded after CT scanning and reconstructing the fossil skull. Based on fossils found near the site, scientists believe that the otter probably lived in the shallow lake of a warm, humid swamp. — *Meghan Rosen*

FROM TOP: H. KLEE/UNIV. OF FLORIDA; MAURICIO ANTÓN

Human sleep patterns show flexibility

Cross-cultural data highlight potential dangers in Western habits

BY BRUCE BOWER

Hunter-gatherers and farming villagers who live in worlds without lightbulbs or thermostats sleep slightly less at night than smartphone-toting city slickers, researchers say.

"Contrary to conventional wisdom, people in societies without electricity do not sleep more than those in industrial societies like ours," says Jerome Siegel, a UCLA psychiatrist and sleep researcher who was not involved in the new research.

Different patterns of slumber and wakefulness in each of these groups highlight the flexibility of human sleep. Those patterns also point to potential health dangers in how members of Western societies sleep, conclude evolutionary biologist David Samson of Duke University and colleagues. Compared with other primates, human evolution featured a shift toward sleeping more deeply over shorter time periods, providing more time for learning new skills and knowledge as cultures expanded, the researchers propose. Humans also evolved an ability to revise sleep schedules based on daily work schedules and environmental factors such as temperature.

Samson's team describes sleep patterns in 33 East African Hadza hunter-gatherers over a total of 393 days. These results appear in a paper published online January 7 in the *American Journal of Physical Anthropology*. The team's separate report on slumber among 21 rural farmers in Madagascar over 292 days will appear later this year in the *American Journal of Human Biology*.

Sleep patterns in these groups were tracked with wrist devices that measure a person's activity levels. Both Hadza and Malagasy volunteers slept an average of about 6.5 hours nightly, less than the about seven-hour average for most U.S. adults. Foragers and villagers, who slept in areas with various family and group members, awoke more frequently during the night than has been reported among Westerners. Scalp electrodes worn at night by nine villagers during nine nights revealed biological signs of relatively light sleep compared with Westerners, including shorter periods of slow-wave and rapid eye movement sleep.

But Hadza and Malagasy individuals often supplemented nighttime sleep with one or two daytime naps. Breaks for shut-eye averaged 47.5 minutes for the Hadza and about 55 minutes for villagers. Crucially, Samson says, foragers and villagers displayed more consistent daily cycles of sleep and wakefulness than are characteristic of Westerners. Hadza adults tended to hit the sack — or, more commonly, the mat — shortly after midnight and nap in the early afternoon.

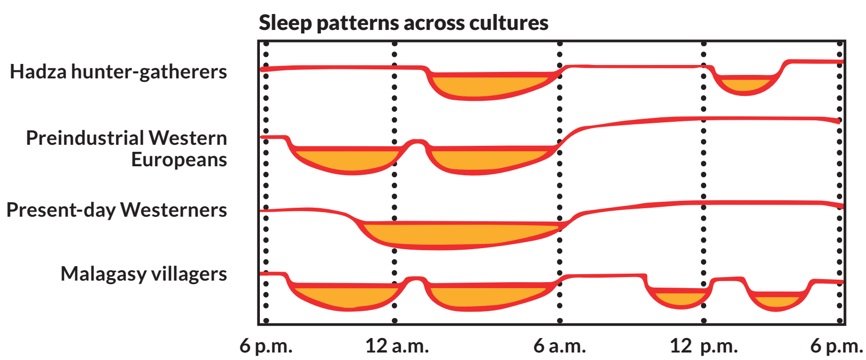
Malagasy villagers napped once or twice during the day's hottest hours, usually starting around noon, and retired in the early evening. At night, they slept in two phases, awakening for around an hour shortly after midnight. Historical accounts describe a similar sleep pattern among Western Europeans between 500 and 200 years ago — two sleep segments, divided by a period of activity or reflection (*SN: 9/25/99, p. 205*).

Nighttime sleep in both Hadza and Malagasy populations became less fragmented as tropical humidity dipped.

Researchers also noted that hunter-gatherers and villagers got plenty of direct sun exposure, unlike many Westerners. Several studies have linked inconsistent sleep-wake cycles and lack of sun exposure to health problems, including inflammation and heart problems, Samson says. "People in modern societies can take lessons from this research by attempting to get lots of light exposure during the day while reducing blue-wave light exposure after dark and dropping inside temperatures by a few degrees at night." Smartphones and other digital devices emit blue-wave light, which can suppress melatonin production and delay sleep.

Effects of wayward sleep patterns or too little sleep on health vary across cultures and regions, says biomedical anthropologist Kristen Knutson of Northwestern University Feinberg School of Medicine in Chicago. For instance, sleeping less than six hours per night may increase appetite, as some studies suggest. But impacts can vary: A sleep-deprived office worker surrounded by fast-food joints is more likely to become obese than a physically active hunter-gatherer faced with a limited food supply.

Samson's research aligns with previous work by Knutson that found that rural Haitians living without electricity sleep an average of about seven hours nightly. In addition, Siegel's team recently reported that nightly sleep averages 5.7 to 7.1 hours in three hunter-gatherer societies, including the Hadza (*SN: 11/14/15, p. 10*). ■



Doze differences Human sleep patterns are shaped by local environments and the ways in which different groups make a living, scientists contend. In the graph above, orange areas show typical sleep times for Hadza hunter-gatherers, preindustrial Western Europeans, present-day Westerners with nine-to-five jobs and villagers in Madagascar with no electricity.

D. SAMSON ET AL/*AM. J. PHYS. ANTHROPOL.* 2017, ADAPTED BY T. TIBBITTS

MATTER & ENERGY

New claim staked for metallic hydrogen

But some physicists doubt report of creating elusive material

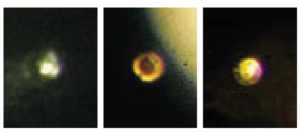
BY EMILY CONOVER

A team of scientists may have given hydrogen a squeeze strong enough to turn it into a metal. But critics vigorously dispute the claim.

Researchers from Harvard report that under extremely high pressures hydrogen became reflective — one of the key properties of a metal. The feat required compressing hydrogen to 4.9 million times atmospheric pressure, the scientists report online January 26 in *Science*.

If correct, the result would be the culmination of a decades-long search for a material that could have unusual properties such as superconductivity — the ability to conduct electricity resistance-free.

But physicist Eugene Gregoryanz of the University of Edinburgh, who works on similar experiments, decries the study's publication as a failure of the journal's review process. Given the evidence presented, Gregoryanz is skeptical that the claimed pressures were reached and notes that the researchers presented results from just one experiment. "How is it possible to do only one experiment and claim such a big thing?" he asks.



While pressed between two diamonds, hydrogen changed from transparent (left) to black (middle) to reflective (right). Reflectivity may mean that the hydrogen turned into a metal.

Physicist Alexander Goncharov of the Carnegie Institution for Science in Washington, D.C., also takes issue with the conclusions. "It's not shown whether they have hydrogen at all at high pressure."

Not everyone is so skeptical. "There's a good chance that it's correct," says theoretical physicist David Ceperley of the University of Illinois at Urbana-Champaign. The pressure at which the hydrogen became reflective is about where physicists have calculated that a metal should form, Ceperley says.

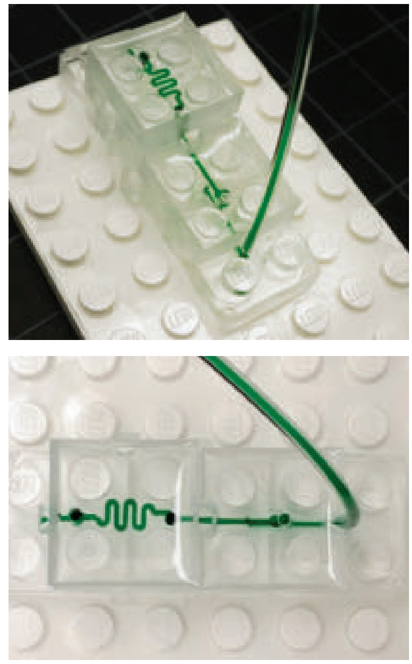
Theorists' calculations also indicate that metallic hydrogen could be a high-temperature superconductor (*SN: 8/20/16, p. 18*). Most superconductors work only in extreme cold, but metallic hydrogen might function even at room temperature. If so, its discovery would raise hopes that metallic hydrogen could be used in power lines, making transmission of electricity vastly more efficient.

To put the pressure on hydrogen, scientists capture it as a gas between the tips of two diamonds and squeeze them together. The predicted pressures to make metallic hydrogen are so high that the "diamonds always break before you can obtain those pressures," says Isaac Silvera, a physicist and study coauthor.

To stave off breakage, the scientists smoothed the surfaces of the diamonds to remove defects and covered the gems in a thin layer of aluminum oxide to prevent hydrogen from diffusing inside and creating cracks. The team also cooled the setup to 83 kelvins (–190° Celsius) or below. As the scientists ratcheted up the pressure, the hydrogen first turned black, indicating a possible semiconducting phase, then became reflective, indicating a metal. The metallic hydrogen could be either a solid or a liquid, Silvera says.

In such experiments, hydrogen can escape from the chamber without the scientists realizing it. Researchers have previously used a technique called Raman spectroscopy, which involves shining a laser through the diamonds and observing the scattered light, to ensure that hydrogen hasn't escaped and to study its evolution. But at the new study's high pressures, lasers could break the diamonds, Silvera says. So the team used lasers only after the sample had reached the metallic state. Still, Silvera says, "we're sure we have hydrogen in there."

Earlier claims of metallic hydrogen have been overturned (*SN: 12/17/11, p. 9*). "It's not the last word," Ceperley says. ■



MATH & TECHNOLOGY

Legos inspire versatile fluid-filled devices

Legos have provided the inspiration for small, fluid-ferrying devices that can be built up brick by brick.

Tools for manipulating tiny amounts of liquid, known as microfluidic devices, can be used to perform blood tests, detect contaminants in water or simulate biological features like blood vessels. These portable devices are small, about the size of a quarter.

Fabricating such devices is not easy. Each new application requires a different configuration of twisty little passages, demanding a brand new design that must be molded or 3-D printed.

To make construction easier, scientists at the University of California, Irvine created Lego-style blocks out of a polymer called PDMS. The bricks have half-millimeter-wide channels that allow liquid to flow from brick to brick with no leaks (shown above). New devices could be created quickly by rearranging standard blocks into various configurations, the scientists report in the March *Journal of Micromechanics and Microengineering*. — *Emily Conover*

FROM TOP: K. VITTAYARUKSKUL AND A.P. LEE/*J. MICROMECH. MICROENG.* 2017; RANGA DIAS, I.F. SILVERA

EARTH & ENVIRONMENT

Sunspot cycle may be ancient routine

Fossilized tree rings record solar ups and downs, study claims

BY THOMAS SUMNER

The sun has been in the same routine for at least 290 million years, new research suggests.

Tree rings from the Permian Period record a roughly 11-year cycle of wet and dry periods, climate fluctuations caused by the ebbing and flowing of solar activity, researchers propose online January 9 in *Geology*. The discovery would push back evidence of today's 11-year solar cycle by tens of millions of years.

The rings of trees dating to about 290 million years ago appear to show evidence of climate variations caused by the 11-year solar cycle.

"The sun has apparently been doing what it's been doing today for a long time," says Nat Gopalswamy, a solar scientist at NASA's Goddard Space Flight Center in Greenbelt, Md.

About every 11 years, the sun's brightness and the frequency of sunspots and solar flares completes one round of waxing and waning. These changes alter the intensity of sunlight reaching Earth and, some scientists think, may affect the composition of the stratosphere and rates of cloud formation. Those effects could alter rainfall rates and therefore tree growth.

Ancient trees may hold clues to similar cycles from long ago. In what is now southeast Germany, volcanic eruptions buried a forest under debris roughly 290 million years ago. Ludwig Luthardt and Ronny Rößler, both paleontologists at the Natural History Museum in Chemnitz, Germany, identified tree rings in the fossilized remains of the trees.

Measuring the widths of the rings — which show how much the trees grew each year — the researchers discovered a cycle in growth rates. The cycle lasted on average 10.62 years, reflecting years-long rises and falls in annual rainfall rates caused by the solar cycle, the researchers propose. The ancient cycle's average length falls within the 10.44- to 11.16-year length of the sunspot cycle seen over the last few hundred years.

Whether the solar and tree ring cycles are connected isn't certain, says paleoclimatologist Adam Csank of the University of Nevada, Reno. Many studies suggest that it is not possible to clearly identify sunspot cycles even in modern tree rings, he notes. Other changes in Earth's climate or periodic insect outbreaks might contribute to tree ring widths, he says. ■

EARTH & ENVIRONMENT

Rocks hint at early oxygen oases

Even with proper conditions, rise of complex life was delayed

BY THOMAS SUMNER

Earth was momentarily ripe for the evolution of animals hundreds of millions of years before they first appeared, researchers propose.

Chemical clues in ancient rocks suggest that 2.32 billion to 2.1 billion years ago, coastal waters held enough oxygen to support oxygen-hungry life-forms including some animals, scientists report online January 17 in *Proceedings of the National Academy of Sciences*. But the oldest animal fossils date to around 650 million years ago, following a period of scant oxygen known as the "boring billion" (*SN: 11/14/15, p. 18*).

"As far as environmental conditions were concerned, things were favorable for this evolutionary step," says sedimentary geologist Andrey Bekker of the University of California, Riverside. Something else must have stalled animals' rise, he says.

Microbes began flooding Earth with oxygen about 2.3 billion years ago during the Great Oxidation Event. This oxygen enabled the eventual emergence of complex life-forms called eukaryotes, a lineage that would later include animals. Scientists have proposed that the Great Oxidation Event wasn't a smooth rise: Levels peaked and then dropped to a lower level during the boring billion before rising again to modern levels. Whether that initial overshoot was enough to support animals was unclear.

Bekker and colleagues tackled this question using a relatively new way to measure ancient oxygen. Rock weathering can wash the element selenium into the oceans. In oxygen-free waters, the selenium settles onto the seafloor. But in water with at least some oxygen, only a fraction of the selenium is deposited. And the selenium that is laid down is disproportionately that of a lighter isotope of the element, leaving atoms of a heavier isotope to be deposited elsewhere.

If ancient coasts contained relatively abundant oxygen, the scientists expected to find more light selenium close to shore and more heavy selenium in deeper, oxygen-deprived waters. Analyzing shales formed under deep waters around the world, the researchers found an abundance of the heavier selenium, suggesting that the lighter version of the element was concentrated closer to shore.

Oxygen levels in coastal waters were at minimum nearly 1 percent of today's levels and "flirting with the limits of what complex life can survive," says study coauthor Michael Kipp, a geochemist at the University of Washington in Seattle. While the environment was probably suitable for eukaryotes, life hadn't evolved the genetic and cellular features to take advantage of the situation, Kipp proposes.

Tracking selenium is such a new technique that "interpretations could change as we better understand how it works," warns geochemist Philip Pogge von Strandmann of University College London. ■

L. LUTHARDT AND R. RÖßLER

LIFE & EVOLUTION

Fairy circle origin stories may merge

Both termites and plants may shape grasslands' bald spots

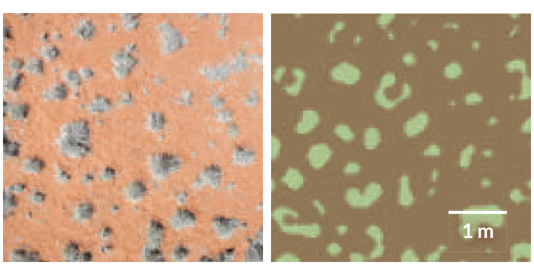
BY SUSAN MILIUS

Called fairy circles, these mysterious patches of bare soil in the Namib Desert in southern Africa form thanks to a mix of fighting termites and competing plants, scientists propose.

Ecologists still don't believe in fairies. But it may take magic to resolve a long-running debate over what causes the oddly regular spots of bare soil called fairy circles. A new approach now suggests combining the two main hypotheses.

Fairy circles, spread in roughly hexagonal arrays, sprinkle arid grasslands in southern Africa and Australia "like a polka dot dress," says ecologist Corina Tarnita of Princeton University. Two persistent ideas fuel debate over what's making the arrays: stalemate warfare between underground termite colonies (*SN Online: 3/28/13*) or bigger plants monopolizing water (*SN: 4/16/16, p. 8*). "What if the reason that this debate is so long-lasting and it's so hard to dismiss the other hypothesis is that both are right to a certain extent?" Tarnita asks.

Termites, by themselves, can in theory cause the mysterious arrangements, Tarnita, Princeton ecologist Robert Pringle and colleagues conclude from a new mathematical model they developed. They linked their insect model with one showing how plant competition might cause fairy circles. The combined approach unexpectedly predicted a previously undescribed clumping pattern among the plants between fairy circles, the team reports in the Jan. 19 *Nature*.



Looking at plants between fairy circles (left), scientists saw about what computer simulations predicted (right) if termite and plant competitions combine to make patterns: regular small clumps of plants mixed with random larger clumps.

In aerial pictures of fairy circles, the plants look like an even sea of vegetation between bare spots. To see if the plant pattern was real, the researchers visited the Namib Desert in southern Africa. Local park personnel "were constantly confused," Tarnita says, because visitors usually study the bare patches. The vegetation between grew as predicted: There were small clumps in roughly hexagonal arrays as seen with the circles themselves and larger random clumps. That confirmation suggests the combined model was working, the researchers say.

Hexagonal arrangements show up repeatedly in nature as creatures crowd together — for instance, as bees arrange cells in honeycombs, Pringle says. In southern Africa, termite colonies might create circular bare spots when insect nibbling prevents plant growth above the nest. Colonies too evenly matched to destroy each other persist as neighboring disks of barren soil, eventually packing into roughly hexagonal arrays.

But plants by themselves can make similar bare spots in harsh conditions, Tarnita explains. When a pioneer plant springs from dry, hot ground, for instance, opportunists follow, taking advantage of such benefits as the scrap of shade a pioneer casts. As these secondary plants grow bigger and suck up more of the limited water, they can create dead zones where nothing sprouts. Over time, these zones form hexagonal patterns, too.

Termites plus plants are probably producing the effect in the Namib Desert, Tarnita says. But the results might not apply to other fairy circle hot spots, such as Australia. The main message of the new paper is that "different processes can lead to the exact same pattern," she says.

Two proponents of the long-standing theories aren't convinced the termite and plant models should be combined. Termite advocate Norbert Jürgens of the University of Hamburg welcomes the part of the new model that shows social insects alone "clearly" can cause fairy circles. But he's not sure the plant clumping between circles indicates anything important. "Yes, of course there are always small-scale patterns among neighboring plants that are caused by feedback mechanisms," he says. "However, these do not cause fairy circles."

Nor does the new paper convert an ecologist advocating plant competition as the driver of fairy circle formation. Just showing that termites by themselves could create arrays with six neighbors isn't enough, says Stephan Getzin of the Helmholtz Center for Environmental Research-UFZ in Leipzig, Germany. "The degree of ordering or regularity that is shown by their insect model is not as strong as the ordering of [real-world] fairy circles," he objects.

What's needed now to resolve the debate isn't necessarily fairy dust. Tarnita says she hopes for outdoor experiments. ■

MATH & TECHNOLOGY

New robot keeps blood pumping

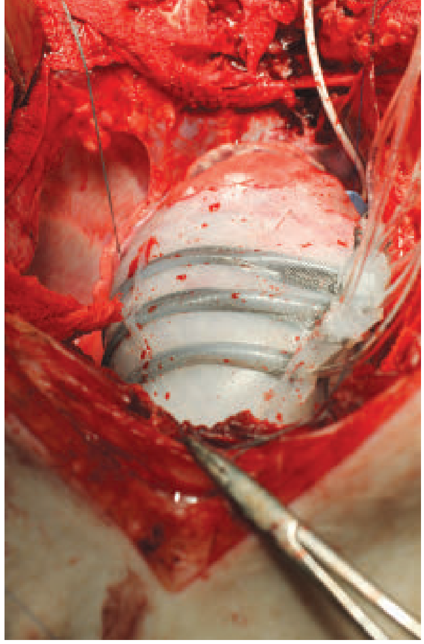
A new squishy robot could keep hearts from skipping a beat.

A silicone sleeve slipped over pigs' hearts helped pump blood when the hearts failed, researchers report in the Jan. 18 *Science Translational Medicine*. If the sleeve works in humans, it could potentially keep weak hearts pumping and buy time for patients waiting for a transplant.

To make the device contract, biomedical engineer Ellen Roche and colleagues lined it with two sets of narrow tubes. One set encircles the sleeve, like bracelets; the other tubes run from top to bottom. When air pumps through the tubes, the sleeve compresses (like a clenched fist) and twists (like wrung-out laundry). Those actions mimic how the layers of the heart contract.

Researchers programmed the sleeve to sync with the heart's motion. And like a healthy heart, the robot sleeve's double squeeze gets blood moving.

Roche's team, which did the work while she was at Harvard University, triggered heart failure in six pigs and then measured the volume of blood pumped by the heart with and without the sleeve's help. Heart failure cut the volume roughly in half, to about 1 liter of blood per minute. But the sleeve restored the pumped volume to about 2½ liters per minute — nearly normal, Roche, now at National University of Ireland, Galway, and colleagues report. *— Meghan Rosen*



A robotic sleeve wrapped around a pig's heart (shown) can pump blood using inflatable tubes (gray) that compress the heart.

E. ROCHE/HARVARD SEAS

LIFE & EVOLUTION

Desert ants look to the sky, rely on memory to navigate backward

Some ants are so good at navigating they can do it backward.

Researchers think that foraging ants memorize scenes in front of them to find their way back to the nest. But that strategy only works when facing forward. Still, some species have been observed trekking in reverse to drag dinner home.

To find out how the ants manage this feat, Antoine Wystrach of the University of Edinburgh and colleagues captured foraging desert ants (*Cataglyphis velox*) near a nest outside Seville, Spain. In a series of tests, the researchers gave the ants cookie crumbles and then released the ants at a fork in the route back to their nest.

Regardless of which direction they took, ants walking backward with cookie bits in tow maintained a straight path. The researchers suspect the ants relied on some sort of sunlight cues. Ants also appeared to peek behind themselves to check and adjust course. After making adjustments, ants maintained their new direction no matter their body orientation. Desert ants combine their celestial compass and long-term visual memories of the route to find their way home, the team concludes online January 19 in *Current Biology*. *— Helen Thompson*

EARTH & ENVIRONMENT

Ancient deluges drenched Sahara

Thousands of years ago, it didn't just rain on the Sahara. It poured.

Grasslands, trees, lakes and rivers once covered North Africa's now arid, unforgiving landscape. From about 11,000 to 5,000 years ago, much higher rainfall rates than previously estimated created that "Green Sahara," say geologist Jessica Tierney of the University of Arizona in Tucson and colleagues. Extensive ground cover, combined with reductions of airborne dust, intensified water evaporation into the atmosphere, leading to monsoonlike conditions, the scientists report January 18 in *Science Advances*.

Tierney's team reconstructed western Saharan rainfall patterns over the last 25,000 years. Estimates relied on measurements of carbon and hydrogen isotopes in leaf wax recovered from ocean sediment cores collected off the Sahara's west coast. Compositions of these substances reflect ancient rainfall rates.

Rainfall ranged from 250 to 1,670 millimeters annually during Green Sahara times, the team says. Earlier estimates — based on pollen studies that did not account for dust declines — reached no higher than about 900 millimeters. Today, Saharan rainfall rates range from 35 to 100 millimeters annually.

Leaf-wax evidence indicates that the Green Sahara dried out from about 8,000 to at least 7,000 years ago before rebounding. That's consistent with other ancient climate simulations and with excavations suggesting that humans temporarily left the area around 8,000 years ago. Hunter-gatherers departed for friendlier locales, leaving cattle herders to spread across North Africa once the Green Sahara returned, the investigators propose. *— Bruce Bower*

LIFE & EVOLUTION

Asteroid barrage not linked to boom in ancient marine life

An asteroid bombardment that some say could have triggered an explosion of marine animal diversity around 471 million years ago actually had nothing to do with it.

Precisely dating meteorites from the salvo, researchers found that the space rock barrage began at least 2 million years after the start of the Great Ordovician Biodiversification Event. So the two phenomena are unrelated, the researchers conclude January 24 in *Nature Communications*.

Some scientists had previously proposed a causal link between the two events: Raining debris from an asteroid breakup (*SN: 7/23/16, p. 4*) drove evolution by upsetting ecosystems and opening new ecological niches. The relative timing of the impacts and biodiversification was uncertain, though.

See the heart-hugging robot in action at **bit.ly/SN_heartrobot**

Geologist Anders Lindskog of Lund University in Sweden and colleagues examined 17 zircon crystals buried alongside meteorite fragments. Gradual radioactive decay of uranium atoms inside the crystals allowed the researchers to accurately date the sediment layer to around 467.5 million years ago. Based in part on this age, the researchers estimate that the asteroid breakup took place around 468 million years ago. That's well after fossil evidence suggests that the diversification event kicked off.

Other forces such as climate change and shifting continents instead promoted biodiversity, the researchers propose. *— Thomas Sumner*

MATTER & ENERGY

New 'smart' fibers curb fires in lithium-ion batteries

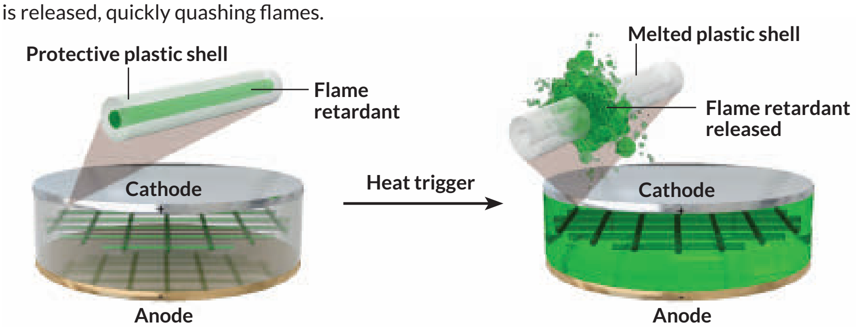
Hoverboards and certain cell phones powered by lithium-ion batteries occasionally go up in flames. Scientists now have a new plan for squelching these fires before they flare out of control: incorporate a flame retardant in the battery that's released if temperatures get too toasty.

Within lithium-ion batteries, ions travel between positive and negative electrodes through a liquid called an electrolyte. But commonly used electrolytes are highly flammable. And if a short circuit in the battery produces enough heat, the electrolyte can ignite.

Simply adding a flame retardant to the electrolyte makes the battery less efficient. So scientists from Stanford University created a "smart" sheet of tiny fibers containing flame retardant, which could be inserted between a battery's electrodes, the researchers report January 13 in *Science Advances*.

Each fiber is reminiscent of an éclair filled with cream, consisting of a plastic shell surrounding flame retardant inside. Under normal conditions, the shell traps the flame retardant so that it can't spill out into the electrolyte. But if the battery heats up too much, the plastic melts and the flame retardant escapes.

In laboratory tests, the flame retardant was released into the electrolyte above 160° Celsius. And when the scientists attempted to ignite the electrolyte in the presence of the flame-retardant fibers, the fibers melted and released their contents, causing the fire to peter out after 0.4 seconds. *— Emily Conover*



Heat triggered Plastic fibers with flame-retardant centers separate the two electrodes of a lithium-ion battery. If the battery gets too hot, the plastic shell melts and flame retardant (green) is released, quickly quashing flames.

K. LIU ET AL/*SCIENCE ADVANCES* 2017

EARTH & ENVIRONMENT

Earth's last major warm period was as hot as today

The last time Earth's thermometer was as high as it is today, sea levels were high enough to drown New Orleans (had it existed at the time), new research suggests.

Ocean surface temperatures around 125,000 years ago were comparable to those today, researchers report in the Jan. 20 *Science*. Previous estimates suggested that this period, the height of the last warm phase in the ongoing ice age, was as much as 2 degrees Celsius warmer. Climate scientists are interested in this warm period because sea levels were six to nine meters above present-day levels. The new results, the researchers say, will now help scientists better predict how Earth's oceans and climate will respond to modern warming.

The global scale of the interglacial warming has been difficult to estimate. Chemical clues inside dozens of seafloor sediment samples collected from around the world provide only regional snapshots of the ancient climate. Combining 104 of these dispersed data points, climate scientist Jeremy Hoffman of Oregon State University in Corvallis and colleagues pieced together a global climate picture.

Average global sea surface temperatures around 125,000 years ago were indistinguishable from the 1995 to 2014 average, the researchers estimate. *— Thomas Sumner*

LIFE & EVOLUTION

Gathering dust helps earwax do its job, researchers propose

NEW ORLEANS — The self-cleaning marvel known as earwax may turn the dust particles it traps into agents of their own disposal.

Earwax, secreted in the ear canal, protects ears from building up dunes of debris from particles wafting through the air. The wax creates a sticky particle-trapper inside the canal, Zac Zachow explained January 7 at the annual meeting of the Society for Integrative and Comparative Biology. The goo coats hairs and haphazardly pastes them into a loose net. Then, by a process not yet fully understood, bits of particle-dirtied wax leave the ear, taking their burden of debris with them.

Earwax may accomplish such a feat because trapping more and more dust turns it from gooey to crumbly, Zachow said. Working with Alexis Noel in David Hu's lab at Georgia Tech in Atlanta, Zachow filmed a rough demonstration of this idea: Mixing flour into a gob of pig's earwax eventually turned the lump from stickier to drier, with crumbs fraying away at the edges.

Jaw motions might help shake loose these crumbs, Zachow said. A video inside the ear of someone eating a doughnut showed earwax bucking along with jaw motions. This dust-to-crumb scenario needs more testing, but Noel suggests that earwax might someday inspire new ways of reducing dust buildup in machinery such as home air-filtration systems. *— Susan Milius*

The Stellar Storyteller

Supernova 1987A shone as a brilliant point of light near the Tarantula Nebula (pink cloud) in the Large Magellanic Cloud, as pictured from an observatory in Chile.

ESO

Thirty years ago, an exploding star electrified astronomers. The thrills continue

By Christopher Crockett

Ian Shelton was alone at a telescope in the remote Atacama Desert of Chile. After three hours getting a picture of the Large Magellanic Cloud, a wispy galaxy that orbits the Milky Way, he was plunged into darkness. High winds had taken hold of the rolltop door in the observatory's roof, slamming it shut.

"This was maybe telling me I should just call it a night," says Shelton, who was a telescope operator at Las Campanas Observatory on that evening of February 23, 1987.

He grabbed the photograph — an 8-by-10 inch glass plate — and headed off to the darkroom (yes, these were the days of developing images by hand). As a quick quality check, he compared the just-developed picture with an image he had taken the previous night.

Shelton noticed a star that hadn't been there the night before. "I thought, this is too good to be true," he says. He stepped outside and looked up. There it was — a faint point of light that wasn't supposed to be there. He walked down the road to another telescope and asked astronomers there what they would say about an object that bright appearing in the Large Magellanic Cloud, just outside the Milky Way.

"Supernova" was the group's response, Shelton says. He ran outside with the others — including Oscar Duhalde, who recalled seeing the same thing earlier in the evening — to double-check with their own eyes.

They were witnessing the explosion of a star, quickly dubbed supernova 1987A. It was the closest supernova seen in nearly four centuries and so bright it was visible without a telescope. "People thought they'd never see this in their lifetime," says George Sonneborn, an astrophysicist at NASA's Goddard Space Flight Center in Greenbelt, Md.

With roughly 2 trillion galaxies in the observable universe, there's almost always a star exploding somewhere. But a supernova close enough to be seen with the unaided eye is a rare event. In the Milky Way, astronomers estimate, one goes off every 30 to 50 years. But the most recent one seen was in 1604. At a distance of about 166,000 light-years, 1987A was the closest since the time of Galileo.

Supernovas are "important agents of change in the universe," says Princeton astrophysicist Adam Burrows. They end the lives of stars and trigger the birth of new ones. They change the fate of entire galaxies by stirring up the gas needed to build more stars. Most, perhaps even all, of the chemical elements heavier than iron are forged in the chaos of the explosion. Lighter elements — "the calcium in your bones, the oxygen you breathe, the iron in your hemoglobin," Burrows says — are created over the star's lifetime and then spewed into space to seed a new generation of stars and planets — and life.

Thirty years after its discovery, supernova 1987A remains a celebrity. It was the first supernova for which the original star could be identified. It offered up the first neutrinos detected from beyond the solar system. Those subatomic particles confirmed decades-old theories about what happens in the heart of an explosion. And today, the supernova's story continues to be written. New observatories draw out more details as shock waves from the explosion keep plowing through interstellar gas. "The supernova has gotten dimmer by a factor of 10 million, but we can still study it," says astrophysicist Robert Kirshner of the Harvard-Smithsonian Center for Astrophysics. "We can study it better and over a wider range of light than we could in 1987."

"The supernova has gotten dimmer by a factor of 10 million, but we can still study it."

ROBERT KIRSHNER

A daily adventure

Communication was a bit slower when 1987A exploded. Shelton's attempts to call the International Astronomical Union in Cambridge, Mass., failed. So a driver took off to La Serena, a town about 100 kilometers away, to alert the IAU by telegram.

Lots of researchers didn't believe the news at first. "I thought, that's got to be a joke," says Stan Woosley, an astrophysicist at the University of California, Santa Cruz. But as word spread via telegram and telephone, it quickly became clear that it was not a prank. Amateur astronomer Albert Jones in New Zealand reported seeing the supernova the same night before clouds moved in. About 14 hours after the discovery, NASA's International Ultraviolet Explorer satellite was already watching. Astronomers around the world scrambled to redirect telescopes both on the ground and in space.

"The whole world got excited," Woosley says. "It was a daily adventure. There was always something coming in." At first, astronomers suspected that 1987A was a class of supernova known as type 1a — the detonation of a stellar core left behind after a star like the sun quietly sheds gas at the end of its life. But it soon became clear that 1987A was a type 2 supernova, the explosion of a star many times heavier than the sun. Observations taken the next day in Chile and South Africa showed hydrogen gas hurtling away from the explosion at roughly 30,000 kilometers per second — about one-tenth the speed of light. After the initial flash, the supernova faded for about a week but then resumed brightening for about 100 days. It eventually maxed out with the light of roughly 250 million suns.

The right track

Despite several surprises along the way, 1987A didn't lead to a fundamental shift in how astronomers thought about supernovas. "It rubbed our nose in the fact that we were on the right track," says astrophysicist David Arnett of the University of Arizona in Tucson. The general idea — suspected for decades and largely confirmed by 1987A — is that a type 2 supernova goes off when a heavyweight star runs out of fuel and can no longer support its own weight.

Stars live in a delicate balance between gravity and gas pressure. Gravity wants to crush a star. High temperatures and extreme densities in the center of a star allow hydrogen nuclei to slam together and create helium, liberating copious amounts of energy. That energy pumps up

Telegram announces 1987A

On February 24, 1987, the International Astronomical Union sent out a telegram that started as follows:

W. Kunkel and B. Madore, Las Campanas Observatory, report the discovery by Ian Shelton, University of Toronto Las Campanas Station, of a mag 5 object, ostensibly a supernova, in the Large Magellanic Cloud at R.A. = 5h35m.4, Decl. = -69 16'...

In astronomy lingo, the telegram provided the brightness (magnitude 5) and coordinates (R.A. for right ascension and Decl. for declination) of the supernova in the Large Magellanic Cloud, shown before (top) and after the explosion (bottom). — *Christopher Crockett*

ESO

the pressure and keeps gravity in check. Once a star's core runs out of hydrogen, it fuses helium into carbon, oxygen and nitrogen. For stars like the sun, that's about as far as they get. But if the star is more than about eight times as massive as the sun, it can keep going, forging heavier elements. All that weight on the core keeps the pressure and temperature extremely high. The star forges progressively heavier elements until iron is created. But iron is not a stellar fuel. Fusing it with other atoms doesn't release energy; it saps energy from its surroundings.

Without an energy source to fight against gravity, the bulk of the star comes crashing down on its core (see Page 24). The core collapses on itself until it becomes a ball of neutrons, which can survive as a neutron star — a hot orb about the size of a city with a density greater than that of an atomic nucleus. If enough gas from the dying star rains down on the core, the neutron star loses its own battle with gravity and forms a black hole. But before that happens, the initial onrush of gas from the rest of the star hits the core and bounces, sending a shock wave back toward the surface, tearing apart the star. In the ensuing explosion, elements heavier than iron are forged; more than half of the periodic table may originate in a supernova.

Newly formed elements aren't the only things a supernova spits out. Theorists had predicted that neutrinos, nearly massless subatomic particles that barely interact with matter, should be released during the core collapse, and in no small quantity. Despite their ghostly nature, neutrinos are suspected to be the main driving force behind the supernova, injecting energy into the developing shock wave and accounting for about 99 percent of the energy released in the explosion. And because they pass through the bulk of the star unimpeded, neutrinos can get a head start out of the star, arriving at Earth before the blast of light.

Confirmation of this prediction was one of the big successes from 1987A. Three neutrino detectors on different continents registered a nearly simultaneous uptick in neutrinos roughly three hours before Shelton recorded the flash of light. The Kamiokande II detector in Japan counted 12 neutrinos, the IMB facility in Ohio detected eight and the Baksan Neutrino Observatory in Russia detected five more. In total, 25 neutrinos were recorded — a deluge in neutrino science.

"That was huge," says astrophysicist Sean Couch of Michigan State University in East Lansing. "That told us beyond a shadow of a doubt that a neutron star formed and radiated neutrinos."

While the neutrinos were expected, the type of star that went supernova was not. Before 1987A, astronomers thought that only puffy red stars known as red supergiants could end their lives in a supernova. These are gargantuan stars. One nearby example, the bright star Betelgeuse in the constellation Orion, is at least as wide as the orbit of Mars. But the progenitor of 1987A, known as Sanduleak -69° 202 (SK -69 202 for short), was a blue supergiant, hotter and more compact than the red supergiant that was widely expected. 1987A didn't fit the mold.

"SN 1987A taught us that we did not know everything," Kirshner says. More surprises came after the launch of the Hubble Space Telescope.

A necklace of pearls

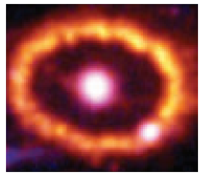
When Hubble was launched in 1990, 1987A was one of its first targets. Early images were fuzzy because of a now infamous defect in the telescope's main mirror (*SN: 4/18/15, p. 18*). Corrective optics installed in 1993 revealed some unexpected details of the fading explosion.

"Those first pictures from Hubble were jaw-dropping," says Shelton, now a teacher in the Toronto area. A thin ring of glowing gas — faintly seen in earlier images from the ground — encircled the site like a Hula-Hoop. Above and below that ring were two fainter rings, the trio forming an hourglass shape.

"No other supernova had shown that kind of phenomenon," says Richard McCray, an astrophysicist at the University of California, Berkeley. Not because it doesn't happen, he says, but because other supernovas were too far away.

The central ring spanned 1.3 light-years across and was expanding at about 37,000 km/h. The ring's size and how quickly it was growing indicated that the star dumped a lot of gas into space about 20,000 years before it exploded. That could explain why SK -69 202 was a blue supergiant when it exploded. Some type of earlier outburst might have whittled the star down to expose hotter, and therefore bluer, layers.

One leading idea for how the rings formed is that SK -69 202 might be the offspring of two stars that were once locked in orbit around one another and then spiraled together. As the stars merged, some excess gas might have been expelled in a ring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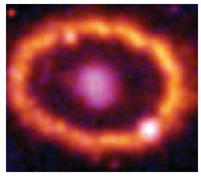
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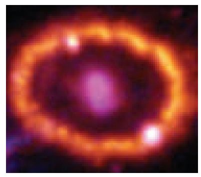
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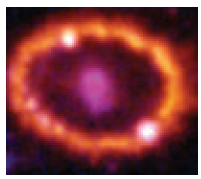
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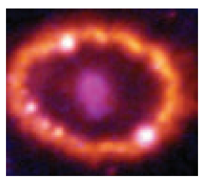
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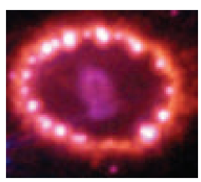
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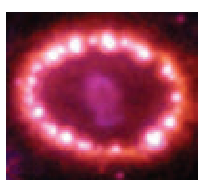
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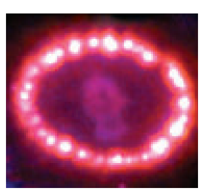

December 6, 2006

Cosmic necklace A ring of hot spots (in images from the Hubble Space Telescope) gradually lit up as a shock wave from supernova 1987A plowed through a loop of gas that had been expelled by the star tens of thousands of years before the explosion.

ALL: NASA, ESA, P. CHALLIS AND R. KIRSHNER/HARVARD-SMITHSONIAN CENTER FOR ASTROPHYSICS, B. SUGERMAN/STSCI aligned with the original orbit while other gas was funneled in the perpendicular direction. Rapid rotation of a single star or powerful magnetic fields also could have directed gas from an eruption into a loop around the star.

The primary ring has only gotten more intriguing with age. In 1994, a bright spot appeared on the ring. A few years later, three more spots developed. By January 2003, the entire ring had lit up with 30 hot spots, all drifting away from the center of the explosion. "It was like a necklace of pearls," Kirshner says, "a really beautiful thing." A shock wave from the supernova had caught up with the ring and started to heat up clumps of gas.

By now, the hot spots are fading and new ones are appearing outside the ring. Given how quickly the spots are waning, the ring will probably be destroyed sometime in the next decade, Claes Fransson, an astrophysicist at Stockholm University, and colleagues predicted in 2015 in *Astrophysical Journal Letters*. "In a way, this is the end of the beginning," Kirshner says.

The elusive neutron star

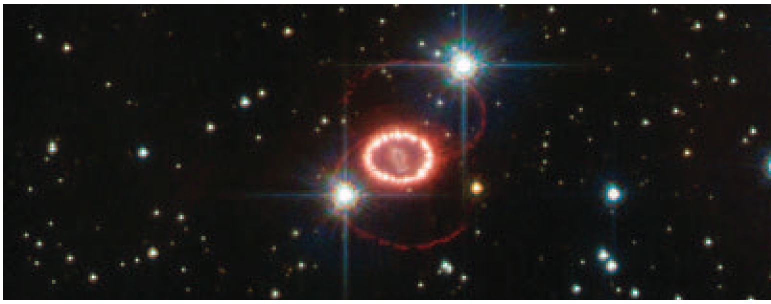
One of the enduring mysteries of 1987A is what became of the neutron star that formed at the heart of the explosion. "It's a cliffhanger," Kirshner says. "Everybody thinks that the neutrino signal means that a neutron star formed." But despite three decades of searching with many different types of telescopes, there's no sign of it.

"It's a bit embarrassing," Burrows says. Astronomers haven't been able to find the pinprick of light from a glowing orb in the middle of the debris. There is no steady pulse from a pulsar, formed by a rapidly spinning neutron star sweeping out beams of radiation like a cosmic lighthouse. Nor is there any hint of heat radiated by dust clouds exposed to the harsh light of a hidden neutron star. "That is one of the things most crucial to closing the chapter on 87A," Burrows says. "We need to know what was left."

The neutron star is probably there, researchers say, but it might be too feeble to see. Or perhaps it was short-lived. If more material rained down in the aftermath of the explosion, the neutron star could have gained too much weight and collapsed under its own gravity to form a black hole. For now, there's no way to tell.

Answers to this mystery and others will depend on new and future observatories. As technology advances, new facilities keep providing fresh looks at the remains of the supernova. The Atacama Large Millimeter/submillimeter Array in Chile, which today combines the power of 66 radio dishes, peered into the heart of the debris with 20 antennas in 2012. ALMA is sensitive to electromagnetic waves that can penetrate clouds of detritus surrounding the supernova site. "That gives us a look at the guts of the explosion," McCray says.

Within those guts lurk solid grains of carbon- and silicon-based compounds that formed in the wake of the supernova, researchers reported in 2014 in *Astrophysical Journal Letters*. These dust grains are thought to be important ingredients for making planets. Supernova 1987A appears to be creating a lot of this dust, suggesting that stellar explosions play a crucial role in seeding the cosmos with planet-building material. Whether that dust survives shock waves that are still ricocheting around the leftovers of the supernova remains to be seen.



A triplet of rings frames supernova 1987A (top) in this Hubble Space Telescope image. The rings, arranged in an hourglass shape (bottom illustration), probably formed from gas blown off the star about 20,000 years before the supernova.

FROM TOP: HUBBLE, ESA, NASA; L. CALÇADA/ESO

The fate of that dust, the whereabouts of the alleged neutron star, the effects from the shock wave that continues to plow through space — these and other unknowns keep bringing astronomers back to 1987A. From Earth, the universe can seem unchanging. But over the last 30 years, 1987A has shown us cosmic change on a human timescale. A star was destroyed, new elements were created and a tiny corner of the cosmos was forever altered. As the closest supernova seen in 383 years, 1987A gave humankind an intimate peek at one of the most fundamental and powerful drivers of evolution in the universe.

"It was a long time coming," Shelton says. "This particular supernova ... deserves all the accolades it gets." But even though 1987A was close, he adds, it was still outside the Milky Way. He and others are waiting for one to go off within this galaxy. "We're overdue for a bright one here." ■

Explore more

- Richard McCray and Claes Fransson. "The remnant of supernova 1987A." *Annual Review of Astronomy and Astrophysics*. September 2016.

Waiting for a Supernova

When a nearby star explodes, observatories plan to be ready

By Emily Conover

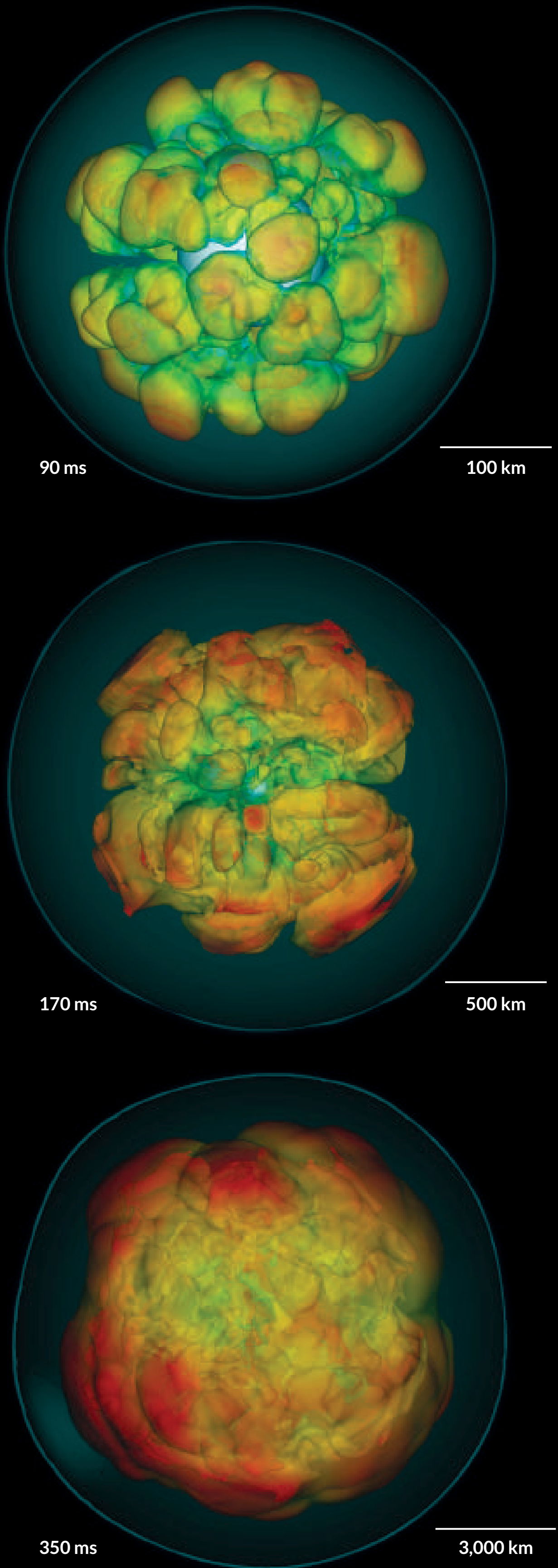
Almost every night that the constellation Orion is visible, physicist Mark Vagins steps outside to peer at a reddish star at the right shoulder of the mythical figure. "You can see the color of Betelgeuse with the naked eye. It's very striking, this red, red star," he says. "It may not be in my lifetime, but one of these days, that star is going to explode."

With a radius about 900 times that of the sun, Betelgeuse is a monstrous star that is nearing its end. Eventually, it will no longer be able to support its own weight, and its core will collapse. A shock wave from that collapse will speed outward, violently expelling the star's outer layers in a massive explosion known as a supernova. When Betelgeuse detonates, its cosmic kaboom will create a light show brighter than the full moon, visible even during the daytime. It could happen tomorrow, or a million years from now.

Countless stars like Betelgeuse — any of which could soon explode — litter the Milky Way. Scientists estimate that a supernova occurs in our galaxy a few times a century. While brilliantly gleaming supernovas in far-flung galaxies are regularly spotted with telescopes trained on the heavens, scientists eagerly hope to capture two elusive signatures that are detectable only from a supernova closer to home. These signatures are neutrinos (subatomic particles that stream out of a collapsing star's center) and gravitational waves (subtle vibrations of spacetime that will also ripple out from the convulsing star).

"These two signals, directly from the interior of the supernova, are the ones we are really longing for," says Hans-Thomas Janka, an astrophysicist at the Max Planck Institute for Astrophysics in Garching, Germany. Unlike light, which is released from the star's surface, stealthy neutrinos and gravitational waves would give scientists a glimpse of the processes that occur deep inside a collapsing star.

Supernovas offer more than awe-inspiring explosions. When they erupt, the stars spew out their guts, seeding the cosmos with chemical elements necessary for life to exist. "We clearly



Stellar swoon A simulation of a supernova tracks the turmoil in the center of a dying star in the moments after its core collapses. The collapse creates a shock wave (blue line) that travels outward, blasting the star apart. Red colors represent material hurtling outward, blues represent inward motion. The surfaces of the lumpy shapes have equal entropy, which is related to temperature.

T. MELSON, H.-T. JANKA AND A. MAREK/*ASTROPHYS. J. LETT.* 2015 wouldn't be here without supernovas," says Vagins, of the Kavli Institute for the Physics and Mathematics of the Universe at the University of Tokyo. But the processes that occur within the churning mess are still not fully understood. Computer simulations have revealed much of the physics of how stars explode, but models are no substitute for a real-life nearby blast.

One inspiration for scientists is supernova 1987A, which appeared in the Large Magellanic Cloud, a satellite galaxy of the Milky Way, 30 years ago (see Page 20). That flare-up hinted at the unparalleled information nearby supernovas could provide. With the detectors available at the time, scientists managed to nab just two dozen of 1987A's neutrinos (*SN: 3/21/87, p. 180*). Hundreds of papers have been written analyzing that precious handful of particles. Calculations based on those detections confirmed scientists' hunch that unfathomably large numbers of neutrinos are released after a star's core collapses in a supernova. In total, 1987A emitted about 10^{58} neutrinos. To put that in perspective, there are about 10^{24} stars in the observable universe — a vastly smaller number.

Since 1987, neutrino detectors have proliferated, installed in exotic locales that are ideal for neutrino snagging, from the Antarctic ice sheet to deep mines across the globe. If a supernova went off in the Milky Way today, scientists could potentially nab thousands or even a million neutrinos. Gravitational wave detection has likewise come on the scene, ready to pick up a slight shift in spacetime stirred up by the blast. Detecting such gravitational waves or a surfeit of supernova neutrinos would lead to a distinct leap in scientists' knowledge, and provide new windows into supernovas. All that's needed now is the explosion.

Early warning

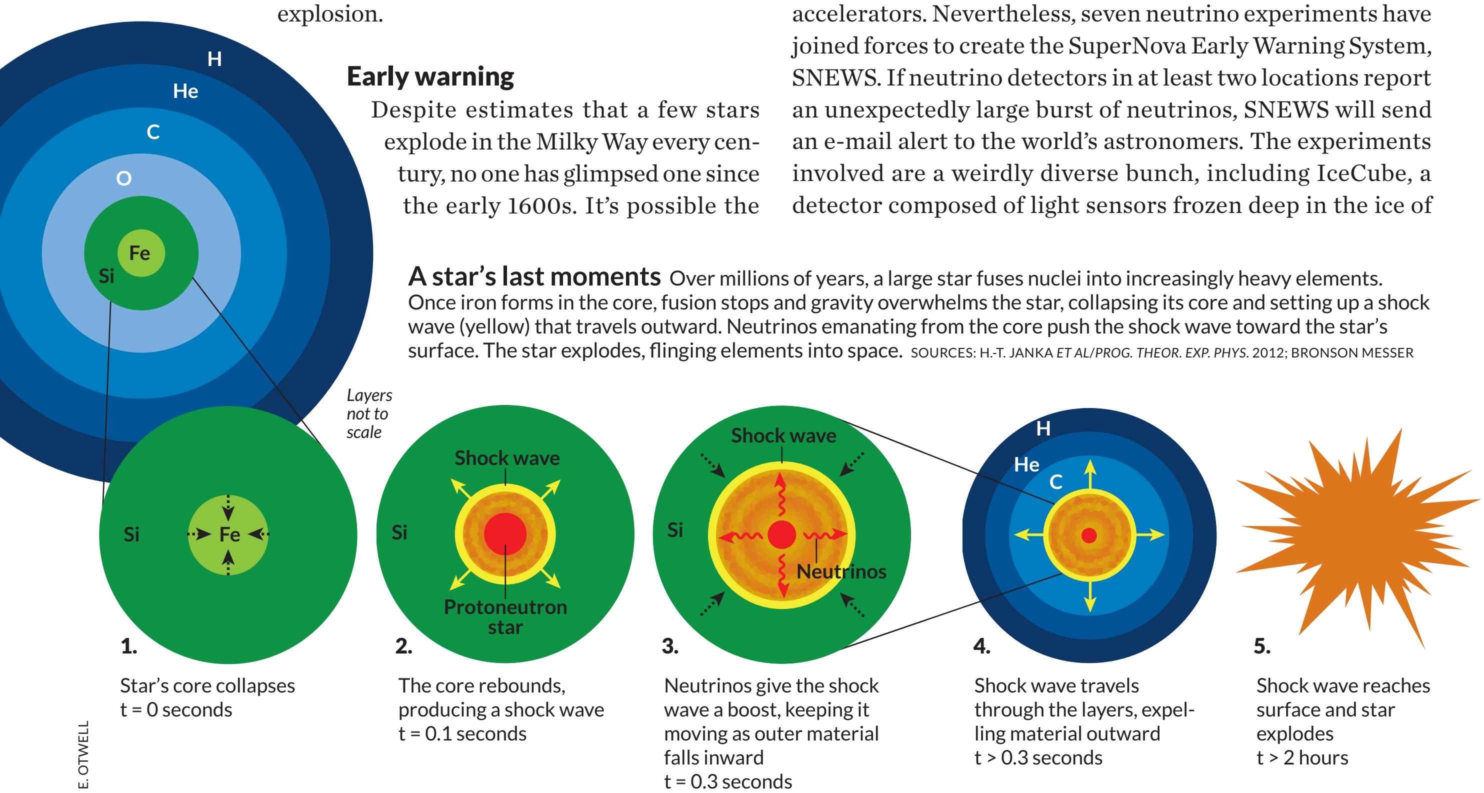
Despite estimates that a few stars explode in the Milky Way every century, no one has glimpsed one since the early 1600s. It's possible the explosions have simply gone unnoticed, says physicist John Beacom of Ohio State University in Columbus; light can be lost in the mess of gas and dust in the galaxy. A burst of neutrinos from a supernova would provide a surefire signal.

These hermitlike elementary particles shun most interactions with matter. Produced in stars, radioactive decay and other reactions, neutrinos are so intangible that trillions of neutrinos from 1987A's explosion passed through the body of every human on Earth, yet nobody felt a thing. For supernovas like 1987A, known as type 2 or core-collapse supernovas, about 99 percent of the explosion's energy goes into the tiny particles. Another, less common kind of supernova, type 1a, occurs when a remnant of a star called a white dwarf steals matter from a companion star until the white dwarf explodes (*SN: 4/30/16, p. 20*). In type 1a supernovas, there's no core collapse, so neutrinos from these explosions are much less numerous and are less likely to be detectable on Earth.

For scientists studying supernovas, neutrinos' reluctance to interact is an advantage. The particles don't get bogged down in their exit from the star, so they arrive at Earth several hours or even more than a day before light from the explosion, which is released only after the shock wave travels from the star's core up to its surface. That means the particles can tip off astronomers that a light burst is imminent, and potentially where it is going to occur, so they can have their telescopes ready.

Most neutrino experiments (there are more than a dozen) weren't built for the purpose of taking snapshots of unpredictable supernovas; they were built to study neutrinos from reliable sources, like the sun, nuclear reactors or particle accelerators. Nevertheless, seven neutrino experiments have joined forces to create the SuperNova Early Warning System, SNEWS. If neutrino detectors in at least two locations report an unexpectedly large burst of neutrinos, SNEWS will send an e-mail alert to the world's astronomers. The experiments involved are a weirdly diverse bunch, including IceCube, a detector composed of light sensors frozen deep in the ice of

A star's last moments Over millions of years, a large star fuses nuclei into increasingly heavy elements. Once iron forms in the core, fusion stops and gravity overwhelms the star, collapsing its core and setting up a shock wave (yellow) that travels outward. Neutrinos emanating from the core push the shock wave toward the star's surface. The star explodes, flinging elements into space. SOURCES: H.-T. JANKA *ET AL*/*PROG. THEOR. EXP. PHYS.* 2012; BRONSON MESSER



E. OTWELL

Antarctica (*SN: 12/27/14, p. 27*); Super-Kamiokande, which boasts a tank filled with 50,000 tons of water stationed in a mine in Hida, Japan; and the Helium and Lead Observatory, or HALO — with the motto "astronomically patient" — made of salvaged lead blocks in a mine in Sudbury, Canada. Their common thread: The experiments are big to provide a lot of material for neutrinos to interact with — such as lead, water or ice.

With light sensors sunk kilometers deep into the ice sheet, IceCube's detector is so huge that it could pick up traces of a million neutrinos from a Milky Way supernova. Because it was designed to capture only the highest energy neutrinos that are rocketing through space, it's not sensitive enough to detect individual neutrinos emitted during a supernova. Instead, IceCube's focus is on the big picture: It catalogs an increase of light in its detectors produced by neutrinos interacting in the ice in time slices of two billionths of a second, says IceCube leader Francis Halzen of the University of Wisconsin–Madison. "We make a movie of the supernova."

Super-Kamiokande is the neutrino detector that can pinpoint the location of the impending stellar paroxysm. It is a successor to Kamiokande-II, one of a few detectors to spot a handful of neutrinos from 1987A. Shortly after a burst of neutrinos from a nearby supernova, the detector could direct astronomers to zero in on a few degrees of sky. If that happens, says neutrino physicist Kate Scholberg of Duke University, "I expect anybody with the capability will be zooming in."

Languages of a supernova

Light and neutrinos are two of several languages that a supernova speaks. In that sense, supernova 1987A was a "Rosetta stone," Beacom says. By scrutinizing 1987A's light and its handful of neutrinos, scientists began piecing together the theoretical physics that explains what happened inside the star. In a future supernova, another language, gravitational waves, could add nuance to the tale. But the explosion has got to be close.

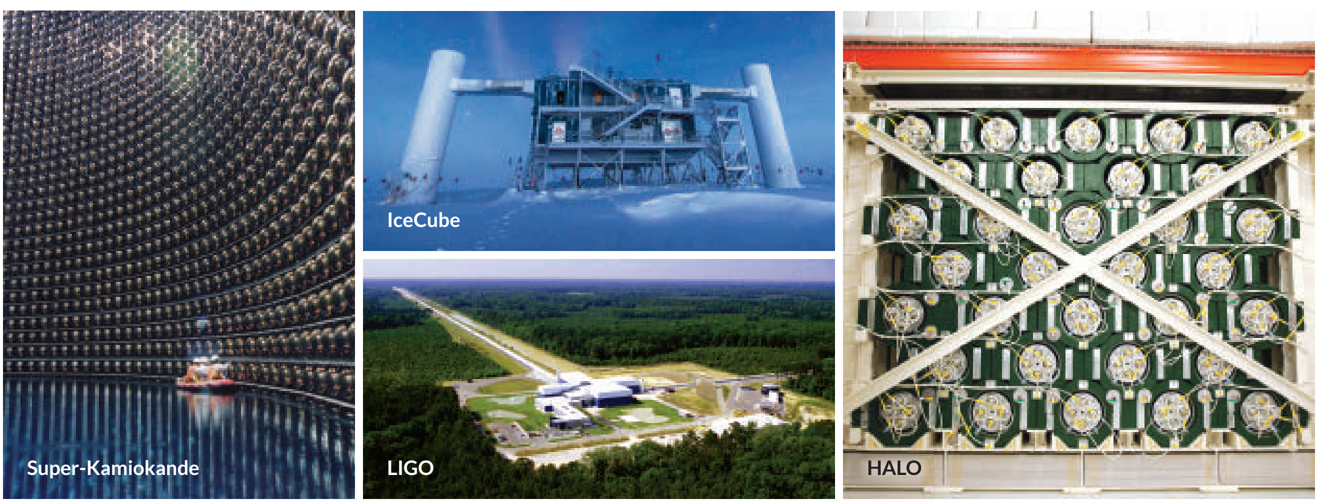
If neutrinos are elusive, gravitational waves border on undetectable. Minute tremors in space itself, predicted by Einstein's general theory of relativity, are generated when massive objects accelerate. In 2016, scientists with the Advanced Laser Interferometer Gravitational-Wave Observatory, LIGO, announced the first direct detection of gravitational waves, produced by two merging black holes (*SN: 3/5/16, p. 6*). That milestone required a pair of detectors so precise that they can sense quivers that squish the detectors' 4-kilometer-long arms by just a tiny fraction of the diameter of a proton.

Gravitational waves from a supernova should be even harder to tease out than those from merging black holes. The pattern of ripples is less predictable. Surveys of the properties of the many supernovas detected in other galaxies indicate that the explosions vary significantly from one to the next, says astroparticle physicist Shunsaku Horiuchi of Virginia Tech in Blacksburg. "We ask, 'Is there a standard supernova?' The answer is 'No.' "

Despite the challenges, finding gravitational waves from supernovas is a possibility because the explosions are chaotic and asymmetrical, producing lumpy, lopsided bursts. An explosion that expands perfectly symmetrically, like an inflating balloon, would produce no gravitational waves. The gravitational wave signature thus can tell scientists how cockeyed the detonation was and how fast the star was spinning.

Gravitational waves might also reveal some of the physics of the strange stew of neutrons that makes up a protoneutron star — the beginnings of an incredibly dense star formed in a supernova. Scientists would like to catalog the compressibility of the neutron-rich material — how it gets squeezed and rebounds in the collapse. "The gravitational wave signature would have an imprint in it of this stiffness or softness," says computational astrophysicist Tony Mezzacappa of the University of Tennessee.

There's a chance the supernova would collapse into an even more enigmatic state — a black hole, which has a gravitational



Various neutrino detectors await signals emitted from a supernova, including Super-Kamiokande in Japan, IceCube in Antarctica and HALO in Canada. They are joined by a gravitational wave observatory, LIGO, with detectors in Louisiana (shown) and Washington state.

CLOCKWISE FROM LEFT: KAMIOKA OBSERVATORY, INST. FOR COSMIC RAY RESEARCH, UNIV. OF TOKYO; FELIPE PEDREROS, ICECUBE/NSF; THE HELIUM AND LEAD OBSERVATORY; CALTECH, MIT, LIGO LAB field so strong that not even light can escape. When a black hole forms, the flow of neutrinos would abruptly drop, as their exit route is cut off. Detectors would notice. "Seeing the moment that a black hole is born," says Vagins, "would be a tremendously exciting thing."

While neutrinos can be oracles of supernovas, a stellar explosion could reveal a lot about neutrinos themselves. There are three types of neutrinos: electron, muon and tau. All are extremely light, with masses less than a millionth that of an electron (*SN: 1/26/13, p. 18*). But scientists don't know which of the three neutrinos is the lightest; a nearby supernova could answer that question.

Supernovas, with all the obscure physics at their hearts, have a direct connection to Earth. They are a source of many of the elements from which planets eventually form. As stars age, they fuse together heavier and heavier elements, forging helium from hydrogen, carbon from helium and so on up the periodic table to iron. Those elements, including some considered essential to life, such as carbon and oxygen, spew out from a star's innards in the explosion.

"All the elements that exist — that are here on Earth — that are heavier than iron were either made in supernovas or other cataclysmic events in astronomy," says physicist Clarence Virtue of Laurentian University in Sudbury, Canada. Gold, platinum and many other elements heavier than iron are produced in a chain of reactions in which neutrons are rapidly absorbed, known as the r-process (*SN: 5/14/16, p. 9*). But scientists still argue about whether the r-process occurs in supernovas or when neutron stars merge with one another. Pulling back the curtain on supernovas could help scientists resolve the dispute.

Even the reason supernovas explode and sow their chemical seeds has been vigorously debated. Until recently, computer simulations of supernovas have often fizzled, indicating that something happens in a real explosion that scientists are missing. The shock wave seems to need an extra kick to make it out of the star and produce the luminous explosion. The most recent simulations indicate that the additional oomph is most likely imparted by neutrinos streaming outward. But, says Mezzacappa, "At the end of the day, we're going to need some observations against which we can check our models."

Hurry up and wait

Supernovas' potential to answer such big questions means that scientists are under pressure not to miss a big break. "You better be ready. If it happens and you're not ready, then you will be sad," Scholberg says. "We have to be as prepared as possible to gather as much information as we possibly can."

If a detector isn't operating at the crucial moment, there's no second chance. So neutrino experiments are designed to run with little downtime and to skirt potential failure modes — a sudden flood of data from a supernova could crash electronics systems in an ultrasensitive detector, for example. Gravitational wave detectors are so finicky that interference as subtle as waves crashing on a nearby beach can throw them out of whack. And in upcoming years, LIGO is scheduled to have detectors off for months at a time for upgrades. Scientists can only hope that, when a supernova comes, everything is up and running.

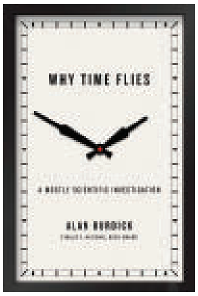
Within a million years, the red supergiant Betelgeuse (orange star, upper left) will explode. It is close enough to Earth for scientists to observe neutrinos and gravitational waves from the blast.

Some even hope that neighboring stars hold off a little longer. "It seems like I'm always telling people that I'd like Betelgeuse to go off one year from now," jokes Bronson Messer, a physicist who works on supernova simulations at Oak Ridge National Laboratory in Tennessee. With each improvement of the simulations, he's eager for a bit more time to study them.

Messer keeps getting his wish, but he doesn't want to wait too long. He'd like to see a supernova in the Milky Way during his lifetime. But it could be many decades. Just in case, Vagins, who's been taking those nightly peeks at Betelgeuse, is doing his part to prepare the next generation. He no longer scans the skies alone. "I've already taught my 6-year-old son how to find that star in the sky," he says. "Maybe I won't get to see it go, but maybe he'll get to see it go." ■

Explore more

- "Core-collapse." Cosmos: The Swinburne Astronomy Online Encyclopedia. bit.ly/core-collapse
- SuperNova Early Warning System: http://snews.bnl.gov



Why Time Flies
Alan Burdick
SIMON & SCHUSTER, $28

BOOKSHELF

Body's perception of time still a puzzle

The topic of time is both excruciatingly complicated and slippery. The combination makes it easy to get bogged down. But instead of an exhaustive review, journalist Alan Burdick lets curiosity be his guide in *Why Time Flies*, an approach that leads to a light yet supremely satisfying story about time as it runs through — and is perceived by — the human body.

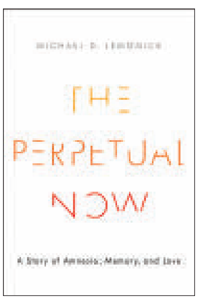
Burdick doesn't restrict himself to any one aspect of his question. He spends time excavating what he calls the "existential caverns," where philosophical questions, such as the shifting concept of *now*, dwell. He describes the circadian clocks that keep bodies running efficiently, making sure our bodies are primed to digest food at mealtimes, for instance. He even covers the intriguing and slightly insane self-experimentation by the French scientist Michel Siffre, who crawled into caves in 1962 and 1972 to see how his body responded in places without any time cues.

In the service of his exploration, Burdick lived in constant daylight in the Alaskan Arctic for two summery weeks, visited the master timekeepers at the International Bureau of Weights and Measures in Paris to see how they precisely mete out the seconds and plunged off a giant platform to see if time felt slower during moments of stress. The book not only deals with fascinating temporal science but also how time is largely a social construct. "Time is what everybody agrees the time is," one researcher told Burdick.

That subjective truth also applies to the brain. Time, in a sense, is created by the mind. "Our experience of time is not a cave shadow to some true and absolute thing; time *is* our perception," Burdick writes. That subjective experience becomes obvious when Burdick recounts how easily our brains' clocks can be swayed. Emotions, attention (*SN: 12/10/16, p. 10*) and even fever can distort our time perception, scientists have found.

Burdick delves deep into several neuroscientific theories of how time runs through the brain (*SN: 7/25/15, p. 20*). Here, the story narrows somewhat in an effort to thoroughly explain a few key ideas. But even amid these details, Burdick doesn't lose the overarching truth — that for the most part, scientists simply don't know the answers. That may be because there is no one answer; instead, the brain may create time by stitching together a multitude of neural clocks.

After reading *Why Time Flies*, readers will be convinced that no matter how much time passes, the mystery of time will endure. — *Laura Sanders*



The Perpetual Now
Michael Lemonick
DOUBLEDAY, $27.95

BOOKSHELF

Artist's amnesia could unlock brain mysteries

Generations of gurus have exhorted, "Live in the moment!" For Lonni Sue Johnson, that's all she *can* do. In 2007, viral encephalitis destroyed Johnson's hippocampus. Without that crucial brain structure, Johnson lost most of her memories of the past and can't form new ones. She literally lives in the present.

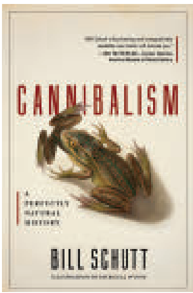
In *The Perpetual Now*, science journalist Michael Lemonick describes Johnson's world and tells the story of her life before her illness, in which she was an illustrator (she produced many *New Yorker* covers), private pilot and accomplished amateur violist. Johnson can't remember biographical details of her own life, recall anything about history or remember anything new. But remarkably, she can converse expertly about making art and she creates elaborately illustrated word-search puzzles. She still plays viola with expertise and expression and, though she will never remember that she has seen it before, she can even learn new music.

Neuroscientists are curious about Johnson's brain in part because her education and expertise before her illness contrast sharply with that of the most famous amnesiac known to science, Henry Molaison. Lemonick interweaves the story of "Patient H.M.," as he was known, with Johnson's biography. Molaison had experienced seizures since childhood and held menial jobs until surgery in his 20s destroyed his hippocampus. At the time, in the 1950s, Molaison's subsequent amnesia came as a surprise, prompting a 50-year study of his brain that provided a fundamental understanding of the central role of the hippocampus in forming conscious memories.

Scientists learned that remembering "what" happened is different from learning and remembering "how" to do things. By studying Johnson, they have found that she gets better at playing music with practice, though the notes never look familiar to her. With tools such as functional MRI, scientists can now ask deeper and more complex questions than in Molaison's time about how different memory systems in the brain work.

Unlike Molaison, whose privacy was protected until his death in 2008, Johnson's sister and mother felt that Johnson's life before her illness was an important part of her story. So they have allowed journalists and the scientists who study her to use her full name. Lemonick interviewed Johnson's family, friends and colleagues to paint a portrait of her upbringing and accomplishments.

If the book lacks answers, it is because Johnson's brain has been studied only since 2010. "Lonni Sue's remarkable brain still has many secrets to reveal about the mysterious thing we call memory," Lemonick writes. — *Diana Steele*



Cannibalism
Bill Schutt
ALGONQUIN BOOKS, $26.95

BOOKSHELF

Grisly dining habit not taboo among animals

Until recently, researchers thought cannibalism took place only among a few species in the animal kingdom and only under extraordinary circumstances. But as zoologist Bill Schutt chronicles in *Cannibalism*, plenty of creatures inhabit their own version of a dog-eat-dog world.

Over the last few decades, scientists have observed cannibalism — defined by Schutt as eating all or part of another individual of the same species — among all major groups of vertebrates. The practice seems to be even more prevalent, and less discriminating, among invertebrates such as mollusks, insects and spiders, whose eggs, larvae and young are often produced in profusion and are therefore readily available, not to mention nutritious.

Cannibalism, Schutt contends, makes perfect evolutionary sense, and not merely as a feeding strategy. When food supplies are low or living conditions are crowded, some mammals and birds may eat some or all of their offspring to terminate an expenditure of effort with poor chances of paying off. For birds, eating a dead or dying hatchling also is a way to get rid of a carcass that could spread infection or whose scent could attract flies or predators to the nest.

Switching to a historical and cultural perspective, Schutt tackles the various forms of human cannibalism, where, he admits, "the ick factor is high." That includes medicinal cannibalism, from 17th and 18th century Europeans' consumption of powdered mummies to modern moms' ingestion of their newborns' placentas to purportedly restore nutrients lost during childbirth. The author also explores survival cannibalism (think famine victims, people under siege, plane-crash survivors and the ill-fated Donner Party) and briefly addresses our natural shock and seemingly unnatural fascination with criminal cannibalism (à la Jeffrey Dahmer).

As Schutt explains, ritual cannibalism — the consumption of a foe or loved one to acquire the decedent's strength, courage or wisdom — is a practice that has apparently taken place in different cultures throughout history. In an interesting aside, Schutt ponders whether people who consume wafers and wine during Communion, especially those who firmly believe these items are literally converted into the body and blood of Christ, are engaging in a form of ritual cannibalism.

Cannibalism is a wide-ranging, engaging and thoroughly fun read. The author's numerous field trips and lab visits with scientists who study the phenomenon heartily enrich this captivating book. — *Sid Perkins*

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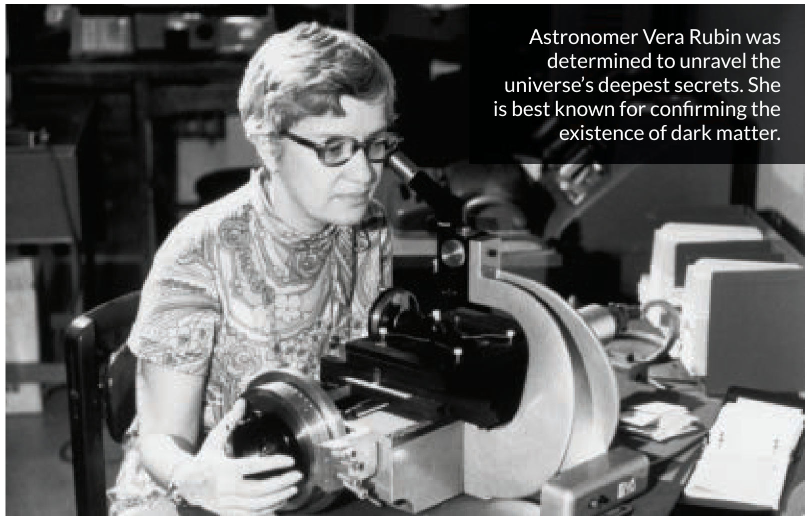

Astronomer Vera Rubin was determined to unravel the universe's deepest secrets. She is best known for confirming the existence of dark matter.

Remembering Vera Rubin, a trailblazer at the telescope and beyond

When we stare up at the night sky, we see shimmering stars, fuzzy galaxies and faint clouds of gas and dust. It is what we cannot see, however, that will forever remind us of astronomer Vera Rubin. Rubin is best known for confirming the existence of dark matter and, along the way, serving as an advocate for women in science and an inspiration to those who wanted to become scientists. She died December 25, 2016. She was 88.

"I hope the day comes when women and minorities in science are so common that Vera's efforts to break down barriers will be hard to appreciate," says Deidre Hunter, an astronomer at the Lowell Observatory in Flagstaff, Ariz. Hunter worked closely with Rubin, often going with her to telescopes around the world to study the stars. Hunter says she hopes Rubin will ultimately be remembered for her scientific achievements, which revolutionized our understanding of the universe. Rubin's passion for astronomy and her humanity should not be forgotten, either, Hunter says.

Rubin respected everyone she worked with, whether astronomers, writers or students, old or young, famous or not. She encouraged everyone to believe they had something to contribute and sought every opportunity to share her passion for science as often as she could, including working with Society for Science & the Public. Rubin served on the Society's Board of Trustees from 2002 to 2008, providing guidance on how the Society could inform, educate and inspire — all actions she strove to achieve in her own life.

"Vera Rubin was truly inspirational," says Neta Bahcall, an astrophysicist at Princeton University. "She was passionate about science, science education, women in science, promoting science literacy, teaching young people. She was amazing."

Rubin was born Vera Cooper on July 23, 1928, in Philadelphia. At age 10, she moved with her family to Washington, D.C. There, she stared out her bedroom window (she said you could still see the stars from the city in the 1930s and 1940s) and traced the paths of stars along with the trails of meteors that flashed across the night sky. She said she knew then that she wanted to become an astronomer. Little did she know that at about the same time, the idea of dark matter was being discussed, very skeptically, in the astronomy community. A few years later, Rubin chose to attend Vassar College in New York, in part because the institution had offered her a scholarship and because she had read that Maria Mitchell, the first American woman to become a professional astronomer, had worked there.

After graduating from Vassar, Vera married Robert Rubin and attended Cornell University, where she studied with physics giants Richard Feynman and Hans Bethe. She also explored the motions of galaxies, and in 1950, rocked the astronomy community with a bold result: The universe appeared to spin around a central axis. Rubin's argument and analysis were met with intense skepticism and ultimately didn't stand the test of time. But the experience taught her to be dogged in her determination to unravel the universe's deepest secrets.

Rubin turned her attention to stars in the 1960s. She wanted to know how fast they circled the center of their galaxy. As she started to measure the speeds of stars farther and farther from a galaxy's center, she saw something unexpected: Stars farther out circled the galactic center at speeds similar to stars closer in. That would be like Pluto circling the sun at the same velocity as Mercury. If that happened, the solar system would be spinning so fast it would fly apart. So should the galaxies. But they didn't. Mysterious matter was keeping them together. Rubin calculated that to stay together, a galaxy had to have at least six times as much of this unknown dark matter than ordinary matter. Her work confirmed that dark matter did, in fact, exist.

Decades later, scientists still aren't sure what dark matter is. The most prominent theories say it is a particle, which has led physicists to build elaborate experiments to detect it. So far, they have been unsuccessful. But these failures never discouraged Rubin. To her, Bahcall says, it just meant that we should keep searching. — *Ashley Yeager*

FROM LEFT: AIP EMILIO SEGRE VISUAL ARCHIVES, RUBIN COLLECTION; PHOTOGRAPH BY MARK GODFREY, COURTESY AIP EMILIO SEGRE VISUAL ARCHIVES, GIFT OF VERA RUBIN

DECEMBER 24, 2016 & JANUARY 7, 2017

Coming attractions

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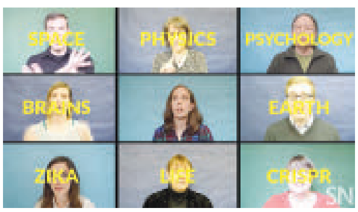

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H. THOMPSON

Power struggle

Ninety percent of people who believe that they are allergic to penicillin are not, ***Emily DeMarco*** *reported in "Most penicillin allergies are off base"* (SN: 12/24/16 & 1/7/17, p. 5)*. A recent study found that testing for penicillin allergies reduced by 34 percent the use of vancomycin, described in the story as "a powerful, last-resort antibiotic."*

Reader **Robin Colgrove**, a physician at Mount Auburn Hospital in Cambridge, Mass., took issue with the description of vancomycin. "The mistaken impression that broad-spectrum antibiotics are more 'powerful' is part of what drives their inappropriate overuse," **Colgrove** wrote. "There is nothing more potent than penicillin against a penicillin-sensitive bacteria. Vancomycin in particular is needed in some cases of antibiotic-resistant infections or for people with true penicillin allergies but is actually less effective, with higher failure rates, when used against bacteria sensitive to penicillin-family antibiotics," he wrote. "This is a case where words have consequences, and ... 'powerful' should be banished from the lexicon of terms used for antibiotics."

Allergist **Allison Ramsey** at Rochester Regional Health in New York refers to vancomycin as a "more powerful, second-line antibiotic" when speaking with patients and the public. The term helps make the distinction that such antibiotics should be reserved for resistant bacteria, she says. But it is true that in most cases, vancomycin is inferior to penicillin-family antibiotics when it comes to eliminating penicillin-sensitive bacteria, **DeMarco** says.

An unlikely bond

Researchers engineered enzymes to bond carbon and silicon — two elements that don't usually link up in nature. The enzymes may eventually allow living organisms to use silicon to build proteins and other molecules, ***Laurel Hamers*** *reported in "Enzyme links up carbon and silicon"* (SN: 12/24/16 & 1/7/17, p. 11)*.*

"While we are a carbon-based species, is there a possibility that species on a distant planet could be silicon-based or silicon/carbon-based?" **David Dixon** asked. "Would that possibility change our view of life in the universe? Change the way we look for things?"

Even though silicon is far more abundant than carbon on Earth, chemical differences between the two elements favor carbon as the basis for life. For instance, carbon bonds to other carbon atoms really well. That lets it form long chains and bigger molecules that build life as we know it. Silicon isn't as strongly attracted to other silicon atoms. And silicon chains, unlike carbon ones, tend to break apart in water. "On a planet with radically different physical conditions than Earth, silicon-based life could theoretically have an edge," **Hamers** says. "Of course, research into the chemistry of life is biased toward what we see on our own planet — so there could be options that we haven't even considered." *Science News*' special report "In search of aliens" takes a closer look at what those options might be (*SN: 4/30/16, p. 28*).

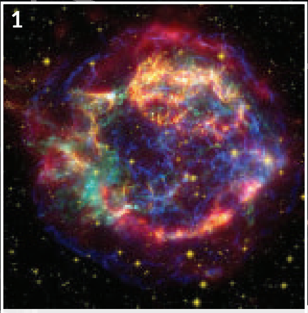
First look

Fetal cells collected from pregnant women during Pap smears may soon be used to test for abnormalities linked to more than 6,000 genetic disorders, ***Meghan Rosen*** *reported in "Pap smear enables fetal genome testing"* (SN: 12/24/16 & 1/7/17, p. 5)*. The new test can be administered weeks earlier than current prenatal tests.*

Online reader **stargene** wondered if fetal cells circulating in a mother's bloodstream could be isolated and tested during early pregnancy.

Prenatal genetic screening from maternal blood is available today. It's called a cell-free DNA test, because scientists don't analyze whole fetal cells — just their DNA. "The earliest this test can be performed is at eight weeks though, compared with five weeks for the Pap smear method," **Rosen** says. "And because there's not a whole lot of fetal DNA floating around in mom's blood (and what's there can be broken into pieces), the test may not be the best bet for quickly detecting a broad range of genetic issues."

1

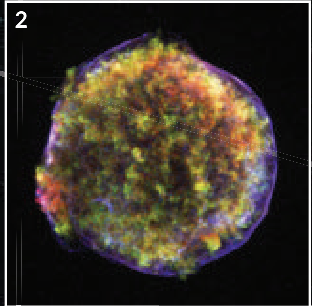


Cassiopeia A

11,000 light-years away

It should have been observed around 1680, but there are no definitive records. Stellar dust clouds might have blocked Earth's view of the explosion.

2



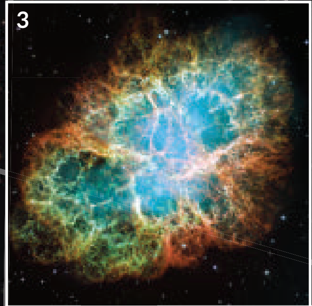
Tycho's supernova

9,000 light-years away

First observed: 1572

This explosion was named after astronomer Tycho Brahe, who studied it extensively.

3



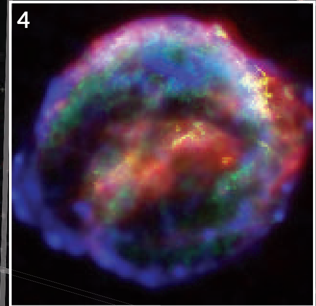
Crab Nebula

6,500 light-years away

First observed: 1054

Stargazers in China, Japan and elsewhere witnessed the supernova. It is home to a powerful pulsar.

4

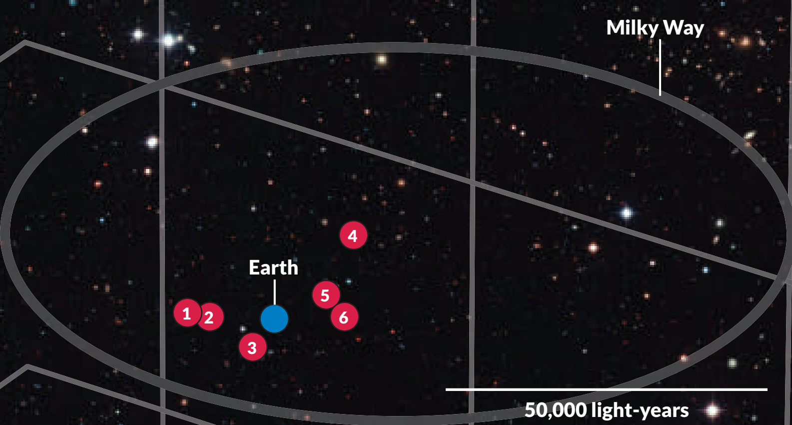


Kepler's supernova

20,000 light-years away

First observed: 1604

Named after astronomer Johannes Kepler, it is the most recent supernova witnessed in the Milky Way.



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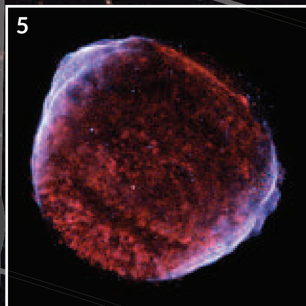


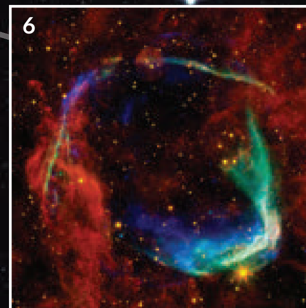
SN 1006

7,200 light-years away

First observed: 1006

It was seen around the world as probably the brightest stellar event on record, about 15 times as bright as Venus.

6



SN 185

9,100 light-years away

First observed: 185

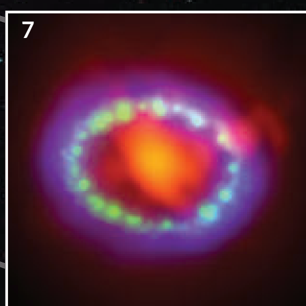
Chinese historians recorded it in the book *Hou Hanshu* as a "guest star" with "scintillating, variegated colors."

The stellar shreds of supernovas

In A.D. 185, Chinese records note the appearance of a "guest star" that then faded away over the span of several months. In 1572, astronomer Tycho Brahe and many others watched as a previously unknown star in the constellation Cassiopeia blasted out gobs of light and then eventually disappeared. And 30 years ago, the world witnessed a similar blaze of light from a small galaxy that orbits the Milky Way (see Page 20). In each case, humankind stood witness to a supernova — an exploding star — within or relatively close to our galaxy (representative border in gray, above).

Here's a map of six supernovas directly seen by human eyes throughout history, and one nearby explosion that went unnoticed. Some were type 1a supernovas, the detonation of a stellar core left behind after a star releases its gas into space. Others were triggered when a star at least eight times as massive as the sun blows itself apart. — *Christopher Crockett*

7



SN 1987A

166,000 light-years away

First observed: 1987

The last supernova bright enough to be directly seen exploded in the Large Magellanic Cloud, a Milky Way satellite.

7


BIG BANG,
BLACK HOLES,
HIDDEN FORCES.
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King Solomon's Secret Treasure: FOUND

Ancient beauty trapped in mines for centuries is finally released and available to the public!

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