SN

SCIENCE NEWS MAGAZINE
SOCIETY FOR SCIENCE & THE PUBLIC
MARCH 2, 2019

Strep Throat on Repeat

Earth's Youngish Inner Core

Neandertal Javelin Throwers

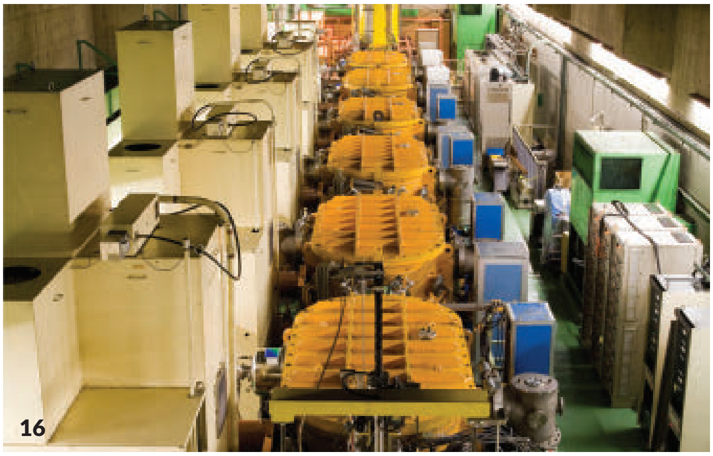
Testing the Limits of the Periodic Table

Burned by Shingles

When varicella zoster virus reawakens, watch out

VOL. 195 | NO. 4

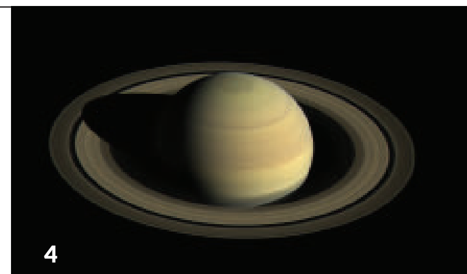
ScienceNews


16

Features

News


10


4

Departments

COVER Shingles, with its burning grip, can hit hard and do lasting damage. *Brian Stauffer*

FROM TOP: RIKEN; SPACE SCIENCE INSTITUTE, JPL-CALTECH/NASA; ALDO MANGANARO/ISTOCK.COM

Scientists set sail for the elusive island of stability

On March 6, 1869, Dmitrii Mendeleev's periodic table was unveiled, and we've launched a yearlong celebration of the 150th anniversary of his iconic work. In this issue, we're looking ahead to imagine the periodic table of the future, as scientists strive to create bizarre new elements. And we also set ourselves a science visualization challenge: charting the half-lives of all the unstable elements on a single page.

In the 20th century, physicists realized that they could create new elements by bombarding or smashing together existing elements. So far, more than two dozen new elements have been created, with atomic numbers ranging up to 118.

Starting on Page 16, our resident physics Ph.D./journalist Emily Conover leads us on an armchair tour of laboratories in Russia, Japan and the United States, where scientists are testing the limits of physics and chemistry to discover new elements, with the goal of finding the heaviest element ever.

These elements decay rapidly, making them devilishly hard to study. For this issue, freelance writer and Ph.D. in chemistry Carmen Drahl, assistant deputy news editor Emily DeMarco and design director Erin Otwell decided that the only way to show the mind-bendingly wide range of life spans among unstable elements was to use a logarithmic scale. The result, on Page 32, plots the half-lives of the longest-lived forms and provides familiar comparisons. Do you know which isotope's half-life nearly matches the run of ancient Rome?

One of the great things about editing a science magazine is that I learn something new every day. This time around I learned about the island of stability, a realm that scientists have not yet explored. This predicted zone is thought to contain isotopes of superheavy elements that would exist for minutes or even a day — making them much easier to study than something like oganesson, which hangs around for less than a millisecond.

Stay tuned for more on the periodic table and the future of physics and chemistry at www.sciencenews.org and here in the pages of the magazine. We hope you'll enjoy this exploration as much as we do. — *Nancy Shute, Editor in Chief*

Subscriber alert

Some *Science News* subscribers have recently received unauthorized "renewal notices." These deceptive notices have been sent by independent solicitation companies without the approval of *Science News* or its publisher, Society for Science & the Public. Their renewal rates are generally higher than our usual rates. Companies operate under numerous names but might include Publishers Partnership Services.

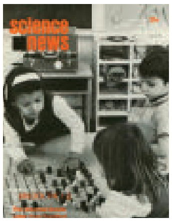
Any notice from *Science News* will always include our logo, refer to your account status and request that payments be made to our processing center in Kettering, Ohio. If you receive a notice that doesn't appear to be from *Science News* or an authorized agent, do not respond to it. If you have questions, call customer service at 800-552-4412 or e-mail subscriptions@sciencenews.org.

Science News
1719 N Street NW, Washington, DC 20036
(202) 785-2255

Subscriber services:
E-mail subscriptions@sciencenews.org
Phone (800) 552-4412 in the U.S. or (937) 610-0240 outside of the U.S.
Web www.sciencenews.org/join
For renewals, www.sciencenews.org/renew
Mail *Science News*, PO Box 292255, Kettering, OH 45429-0255

Editorial/Letters: editors@sciencenews.org
***Science News* in High Schools:** snhs@societyforscience.org
Advertising/Sponsor content: ads@societyforscience.org
Science News (ISSN 0036-8423) is published 22 times a year with double issues in May, July, October and December by the Society for Science and the Public, 1719 N Street, NW, Washington, DC 20036.
Print, online and tablet access: Activate your subscribing member account, including digital access, at www.sciencenews.org/activate
Subscribing memberships include 22 issues of *Science News* and are available for $50 for one year (international rate of $68 includes extra shipping charge). Single copies are $3.99 (plus $1.01 shipping and handling). Preferred periodicals postage paid at Washington, D.C., and an additional mailing office.
Postmaster: Send address changes to *Science News*, PO Box 292255, Kettering, OH 45429-0255. Two to six weeks' notice is required. Old and new addresses, including zip codes, must be provided.

SSP



Excerpt from the March 8, 1969 issue of *Science News*

50 YEARS AGO

Chinese Restaurant syndrome varies

Twenty thousand tons of monosodium L-glutamate are manufactured annually in the United States.... But, according to researchers at the Albert Einstein College of Medicine in the Bronx, "MSG is not a wholly innocuous substance." ... In the Feb. 21 *Science*, [researchers] report "evidence that it (MSG) causes headache, as well as symptoms of acute Chinese Restaurant disease–burning sensations, facial pressure and chest pain."

UPDATE: Studies have consistently failed to validate claims that MSG causes illness. A 1995 report ordered by the U.S. Food and Drug Administration suggested that some people can get symptoms like headaches or drowsiness from eating three grams or more of MSG on an empty stomach. But since the average adult consumes only 0.55 grams of added MSG per day, the FDA deemed it safe. MSG remains popular in Chinese cuisine and in products like potato chips and salad dressing. MSG's flavor, umami, is even a taste category with its own tongue receptors (*SN: 4/6/02, p. 221*).

IT'S ALIVE

Joshua trees exist at the pleasure of fussy desert moths

Joshua trees grow wild in and around the Mojave Desert, where winter snows fall at high altitude.

A year when vandals trashed a Joshua tree during a U.S. government shutdown is a good time to talk about these iconic plants.

Joshua trees belong to the same family as agave and asparagus. The trees' shaggy branches ending in rosettes of pointy leaves add a touch of Dr. Seuss to the Mojave Desert in the U.S. Southwest. The trees bloom in masses of pale flowers that "smell kind of like mushrooms or ripe cantaloupe," says evolutionary ecologist Christopher Irwin Smith of Willamette University in Salem, Ore. His lab even found a form of alcohol in the scent that occurs in mushrooms too.

Headlines over news that a tree was knocked down by visitors to Joshua Tree National Park in California prompted a public outcry. Park vegetation manager Neil Frakes assures there are still about a million trees in the park to see and study.

What biologists get excited about is Joshua tree pollination. Each of the two Joshua tree species (*Yucca brevifolia* and *Y. jaegeriana*) relies on its own species of *Tegeticula* moth. Usually insects pollinate a flower "just by blundering around" as they grope for pollen and nectar, Smith says. But the female moths that service Joshua trees aren't sipping nectar; the trees' glands don't even work. Instead, a moth climbs into a Joshua tree blossom, unfurls semitranslucent tentacles from its mouthparts and collects pollen into a heavy, yellow wad tucked under the moth's head. When the moth reaches a flower that is ready to be fertilized, she spreads some of the pollen and then injects her own eggs. Caterpillars, once hatched, eat the seeds that form inside the pollinated flowers.

Each Joshua tree species is pollinated by a single species of *Tegeticula* moth.

Moths pollinating *Y. brevifolia* trees in the western part of Joshua trees' range are considered a different species from the moths pollinating *Y. jaegeriana* trees in the east.

Smith spent about a decade trying to catch a glimpse of the moths in action. Pollination happens when a flower opens just enough for a moth to slip inside. Smith says a breakthrough came from an "exceptionally patient" undergrad named William Cole, who captured video of an eastern moth inside a flower during a 2015 field trip. The video, showing how the moth fits inside the flower, was the evidence Smith needed for his studies of how the trees and moths evolved codependent lives. "I was rolling around on the ground and cackling and yelling," Smith says. "Finally, finally we had ... video." *— Susan Milius*

TOP AND BOTTOM RIGHT: C.I. SMITH; BOTTOM LEFT: WILLIAM GODSOE

SCIENCE STATS

Saturn's rings reveal a day's length

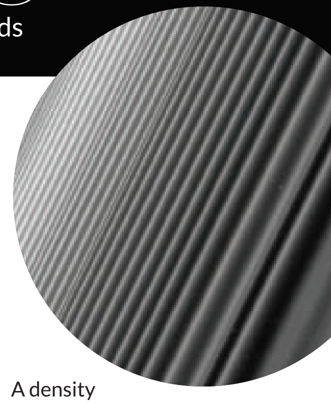
You can't tell how fast Saturn is spinning by watching the clouds swirling at its surface. But ripples in the planet's rings reveal how fast it rotates: A day flies by in just 10 hours, 33 minutes and 38 seconds.

"That's a really fast clip," says astronomer Christopher Mankovich of the University of California, Santa Cruz, who reports the rotation rate in the Jan. 20 *Astrophysical Journal*. Saturn, with a radius of about 58,000 kilometers, is about nine times as wide as Earth, yet its day is less than half as long.

Scientists previously estimated lengths for a Saturnian day using radio measurements. But those estimates varied by about 20 minutes. In 1993, astronomers Mark Marley and Carolyn Porco realized the stirring of Saturn's gases changes the planet's gravity enough to shift the tiny particles in its rings. The frequency of those planetary oscillations could be used to figure out how fast the planet spins.

The 2004 arrival of the Cassini orbiter delivered ring images good enough to test the idea. Using those images, snapped up until the 2017 end of the NASA spacecraft's mission (*SN Online: 9/15/17*), Mankovich and colleagues including Marley, of NASA's Ames Research Center at Moffett Field, Calif., measured waves in the rings responding to Saturn's vibrations. That let the team calculate how fast the planet was rotating beneath the clouds. "The amount we've learned about Saturn's interior from the rings, of all places, is beyond almost anyone's wildest imagination," Mankovich says.

Knowing Saturn's rotation rate can help scientists figure out the gas giant's inner structure. In their work, the researchers assumed Saturn rotates as a rigid ball. But it could instead be layered like an onion, with gases rotating at different speeds. *— Lisa Grossman*



A density wave is seen rippling through Saturn's rings, compressing ring particles like a sound wave compresses air.

Two fossils of the ancient marine reptile *Eretmorhipis carrolldongi* (one shown) are the first to include the animal's skull (top right).

HOW BIZARRE

Early reptile probably felt for prey

My, what tiny eyes you had, *Eretmorhipis carrolldongi*.

Two newly found specimens suggest the ancient reptile had teeny eyes and may have hunted by touch. That would make it the oldest known amniote — a group that includes reptiles and mammals — to hunt using a sense other than sight, scientists report January 24 in *Scientific Reports*.

E. carrolldongi lived about 250 million years ago in a vast lagoon in what's now central China. With fan-shaped flippers it resembled a modern platypus. The fossils, the first of the species to include skulls, show the creature had small eyes, also like a platypus. By elimination, the researchers suggest that *E. carrolldongi* stalked its prey using tactile cues, as with hair cells that detect movement. The small head suggests the animal didn't use hearing to forage, and the absence of telltale holes in the skull rule out chemical sensing. But the animal may have sensed electric fields generated by moving prey, which platypuses can do too. *— Carolyn Gramling*

FOR DAILY USE

Rockabye grown-ups fall asleep faster and slumber more deeply

Babies love to be rocked to sleep. It turns out, so do adults.

Grown-ups tucked into a gently swaying bed fall asleep faster, sleep deeper and have sharper memories the next morning compared with when they sleep on a typical bed, scientists report in the Feb. 4 *Current Biology*. That means sleep rocking might one day be an alternative to sleeping pills, says coauthor Laurence Bayer, a neuroscientist at the University of Geneva.

Bayer and her colleagues invited 18 young adults for laboratory sleepovers, with one night on a rocking bed and one spent on a stationary one. Measurements of brain activity taken by electroencephalogram, or EEG, showed that unrocked participants took an average of 16.7 minutes to reach a light stage of non-REM sleep called N2. When rocked, people hit this sleep stage in 10 minutes on average.

Rocked people also spent more time in a deep non-REM sleep stage called N3 and had fewer wake-ups. And rocking boosted the number of sleep spindles — bursts of brain activity that mark good sleep (*SN Online: 8/10/10*).

Before participants went to bed, they learned pairs of words. Those rocked while asleep better remembered the words the next day — another indicator that they enjoyed higher-quality sleep. *— Laura Sanders*

TOP TWO: SPACE SCIENCE INSTITUTE, JPL-CALTECH/NASA; BOTTOM: L. CHENG *ET AL*/*SCIENTIFIC REPORTS* 2019

News

EARTH & ENVIRONMENT

Ice cliffs may not boost sea level rise

Contribution of collapsing glacial walls was overestimated

Calving of Greenland glaciers (icebergs from Jakobshavn shown) may not be a good proxy for calculating the effects of ice cliff collapse in Antarctica.

BRENDAN DELANY/SHUTTERSTOCK

BY CAROLYN GRAMLING

Sea level rise over the next century won't get a feared boost from Antarctic ice cliffs crumbling into the ocean like dominoes, a new study suggests.

The finding, published in the Feb. 7 *Nature*, is based on a statistical analysis showing that such a rapid collapse of ice cliffs in Antarctica was extremely unlikely to have happened in the past, even during some of Earth's warmest episodes over the last 3 million years.

The study, by climate scientist Tamsin Edwards of King's College London and colleagues, counters a controversial hypothesis that suggests rising greenhouse gas emissions could destabilize those cliffs and help send sea levels surging by over 2.1 meters by 2100. That figure is nearly double some sea level rise projections for the end of the century.

How quickly global warming is causing ice sheets in Greenland and Antarctica to melt is one of the most urgent questions related to future sea level rise.

Some scientists fear that melting could speed up dramatically sometime in the future, thanks to a possible feedback loop known as marine ice cliff instability. The hypothesis was described in 2016 by geoscientist Robert DeConto of the University of Massachusetts Amherst and paleoclimatologist David Pollard of Penn State. Using computer simulations of the mechanical and structural properties of ice, the pair suggested that ice cliffs at the edges of glaciers that jut into the sea are a dramatically underestimated source of future sea level rise (*SN: 4/30/16, p. 13*).

"Ice that flows into the ocean essentially always ends in a cliff," DeConto says. "Basic physics tells us that very tall cliffs, extending 100 meters or more above the water surface, will begin to produce stresses in the ice that can exceed its strength." When that happens, the ice breaks, and giant blocks tumble into the sea. The collapse of such cliffs would create new cliffs behind them that would tumble as well, in a kind of domino effect.

But scientists have questioned the applicability of that hypothesis because there are currently no such giant ice cliffs to observe. Antarctica's glaciers are buttressed from below by floating ice shelves that help support the weight, although that could change as global warming erodes ice shelves. To model ice cliff behavior, DeConto and Pollard used the brittle breaking and speedy retreat of Greenland glaciers that lack ice shelf buttresses, though these ice cliffs aren't as tall as Antarctica's.

One reason the hypothesis was controversial is that there are uncertainties about the progression and effects of such cliff collapse, Edwards says. Would all the blocks end up in the sea? How much surface melting of the ice would there be, and how would that meltwater speed the fractures along? "We would all agree that ice cliffs might have a maximum height and above that they're unstable, that the strength of ice has a limit," Edwards says. But the question is how that translates to sea level rise.

To figure out whether an ice cliff feedback might have happened and contributed to sea level rise in the past, Edwards and colleagues ran a statistical analysis of DeConto and Pollard's simulation. The researchers focused on three time periods: the mid-Pliocene warm period about 3.3 million to 3 million years ago; the last interglacial period 130,000 to 115,000 years ago; and 1992 to 2017, the period for which there are satellite data of the rate of ice mass loss.

The original simulation included only about 64 iterations. Edwards' team, however, mapped out statistically how the simulation would respond in 10,000 different iterations by changing parameters from the estimated rate of atmospheric warming to estimated past sea level rise. The ice cliff collapse hypothesis wasn't needed to reproduce any of the sea level changes during the three time periods.

DeConto says he's happy that researchers are testing the ice cliff instability theory. "The fact that folks are pushing back is a good thing," he says. The new study, he adds, highlights the usefulness of statistically analyzing many possible outcomes for a simulation.

Meanwhile, he, Pollard and colleagues presented an updated version of their simulation in December at the American Geophysical Union annual meeting. Their findings support the new conclusion that ice cliff instability won't double sea levels by 2100 because the instability hasn't really kicked in yet. But if greenhouse gas emissions continue unabated, the researchers said, by 2200 ice cliff collapse could help bump up sea level by up to four meters compared with 2000. ■

BODY & BRAIN

Why some kids often get strep throat

Smaller immune structures in tonsils are tied to repeat infections

BY AIMEE CUNNINGHAM

For kids, getting strep throat again and again is a pain. Now, a study that analyzed kids' tonsils hints at why such repeat infections happen.

Children with recurrent strep infections had smaller immune structures crucial to the development of antibodies in the tonsils than kids who hadn't had repeated infections, researchers found. The frequently sore-of-throat were also more susceptible to a protein, deployed by the bacteria that cause the infection, that disrupts the body's immune response, the team reports in the Feb. 6 *Science Translational Medicine*.

Globally each year, there are an estimated 600 million cases of strep throat. Doctors treat the illness with antibiotics, especially in kids, who are at the highest risk of developing rheumatic fever and heart problems from a strep infection. But even with treatment, some kids repeatedly develop new strep infections.

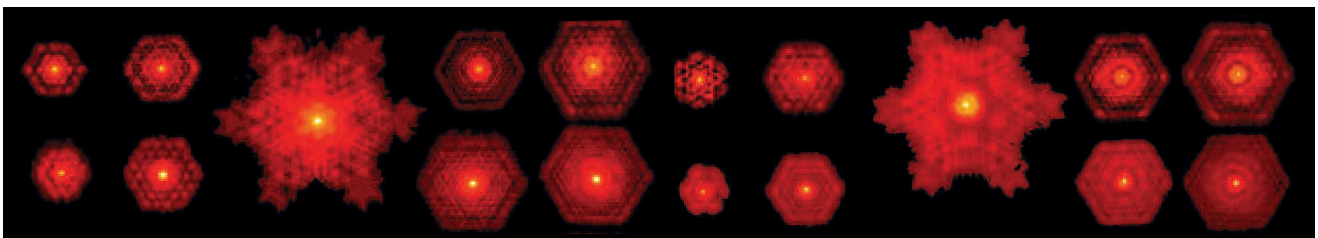
Immunologist Shane Crotty of the La Jolla Institute for Immunology in California and colleagues examined tonsils, the immune tissue found at the back of the throat, that had been removed from 5- to 18-year-olds. Twenty-six of the children had their tonsils taken out because of recurrent strep infections. Thirty-nine had their tonsils removed to resolve sleep apnea caused by enlarged tonsils; this group was a proxy for kids not plagued by repeated bouts of strep.

The team looked at sections of tissue under a microscope and found that kids with recurring strep had smaller immune structures called germinal centers, and the centers had fewer of a particular kind of immune cell, a type of T cell. Those T cells help other immune cells, known as B cells, make antibodies that help the body fight an infection.

In another sample of children whose tonsils were removed, kids with recurring strep had fewer antibodies to a bacterial protein that interferes with the immune response to strep than kids without recurring infections. Fewer antibodies may make kids more susceptible to strep, Crotty says.

The research is elegant and intriguing, says Stanford Shulman, a pediatrician who specializes in infectious disease at the Ann & Robert H. Lurie Children's Hospital of Chicago. But one caveat, he says, is that sometimes kids classified as having recurrent infections are instead carriers of the bacteria that cause strep, group A *Streptococcus*, which means the bacteria are latent in the tonsils but not causing symptoms. In those cases, a sore throat due to a viral infection would still come up as strep in a test. It's estimated that roughly 20 percent of school-aged children are chronic carriers of group A *Streptococcus*.

The seemingly defective immune response toward strep that the study reports might be due to some of those kids being carriers of the bacteria rather than having active strep infections, says Shulman. Future work, he says, should determine which kids have true recurrent infections and which kids are carriers. ■



MATTER & ENERGY

Fractals lurk in laser light

Fractals commonly show up in nature, from spiral-shaped seashells to heads of cauliflower. Now physicists report finding these complex, self-repeating patterns in a very unnatural spot: laser light.

The inside of a typical laser consists of a cavity with mirrors at both ends, in which light bounces back and forth through a crystal that amplifies the light. It's not obvious how something that simple could make something as complex as a fractal. "In lasers, it is really very surprising" to find fractals, says Johannes Courtial of the University of Glasgow in Scotland.

In the laser that Courtial and colleagues studied, a pattern of bright and dark spots of light is imprinted by an aperture, a hole of a particular shape within the mirrored cavity that the light passes through as it bounces back and forth. That dappled pattern gets magnified with each bounce, creating the same shapes on small and large scales — a fractal.

Scientists revealed the pattern by extracting some of the light from the cavity and measuring its brightness in a 2-D slice. The appearance of the fractals, which included hexagon and snowflake shapes (shown above), varied depending on the size and shape of the aperture used, the researchers report online January 25 in *Physical Review A*.

Theoretical calculations hint that laser light should also display 3-D fractals. Finding those patterns will be scientists' next challenge. — *Emily Conover*

WITS UNIV.

MATH & TECHNOLOGY

Machines learn not to be so literal

Artificial intelligence tries to grasp subtext and idioms

BY MARIA TEMMING

Artificial intelligence is starting to learn how to read between the lines.

AI systems are generally good at responding to direct statements, like "Siri, tell me the weather" or "Alexa, play 'Despacito.'" But when it comes to conversational nuances, machines still struggle to understand humans' intent.

To help machines participate in more humanlike conversation, researchers are teaching AI to understand the meanings of words beyond their strict definitions. At the AAAI Conference on Artificial Intelligence, one group unveiled a system that gauges what a person really means when speaking, and another team presented an AI that distinguishes between literal and figurative phrases in writing.

One key conversation skill is picking up subtext. A facial expression or intonation can significantly change the implication of someone's words, says AI researcher Louis-Philippe Morency of Carnegie Mellon University in Pittsburgh. Describing a movie as "sick" with a grimace conveys something different than calling it "sick" with an excited tone and raised eyebrows.

Morency and colleagues designed an AI system that watched YouTube clips to learn how nonverbal cues, such as facial expressions and voice pitch, can affect the meaning of spoken words.

The AI was 78 percent accurate in rating how much negative or positive sentiment a video subject expressed, Morency's team reported January 31. The system also proved adept at distinguishing between expressed emotions. But it recognized some emotions better than others; it identified happiness and sadness with 87.3 and 83.4 percent accuracy but was only 69.7 percent accurate at discerning calm demeanors. Morency next wants to test whether this kind of AI can recognize the facial expressions and tone of voice that signal sarcasm.

Even in written communication, understanding intent is rarely as straightforward as stringing together the meanings of words. Idioms are tricky because they can be interpreted literally or figuratively, depending on context. For example, the same wording can be used in a literal headline — "Kids playing with fire: Experts warn parents to look out for danger signs" — and a figurative one — "Playing with fire in Afghanistan."

Such ambiguity can be a stumbling block for AI systems that analyze sentiments expressed online or translate text into other languages. Computer scientists Changsheng Liu and Rebecca Hwa of the University of Pittsburgh designed a system that decides whether a phrase is literal or figurative based on surrounding words. In the case of "playing with fire," the system might expect to see the words "kids" and "playing" together and deem the first headline as literal, but find "Afghanistan" and "playing" unrelated and judge the second one as figurative.

This AI system learned how to associate different words by reading sentences from Wikipedia. In experiments, the program was 73 to 75 percent accurate in judging whether phrases contained in sentences were literal or figurative, Hwa and Liu reported January 29.

Computers' ability to recognize and interpret nonliteral language is becoming more important as AI becomes more integrated into our lives, says Julia Rayz, a natural language processing researcher at Purdue University in West Lafayette, Ind. Other researchers are tackling similar problems with metaphor and irony.

Understanding linguistic nuance is crucial, says computer scientist Robert West of École Polytechnique Fédérale de Lausanne in Switzerland. If AI can't do that, "we will never have intelligent machines that will be able to survive any conversation." ■

MEETING NOTE

Artificial intelligence recognizes blind spots

A new training scheme could remind artificial intelligence programs that they aren't know-it-alls.

AI programs that run humanoid robots, self-driving cars and other autonomous machines often train in simulated environments. But situations that an AI doesn't encounter in virtual reality can become blind spots in its real-life decision making. For instance, a delivery bot trained in a virtual cityscape with no emergency vehicles may not know that it should pause before entering a crosswalk if it hears sirens.

To create machines that err on the side of caution, MIT computer scientist Ramya Ramakrishnan and colleagues developed a training program in which a human demonstrator helps the AI identify gaps in its education. "This allows the [AI] to safely act in the real world," says Ramakrishnan, who presented the program January 31 at the AAAI Conference on Artificial Intelligence. Engineers could use information on blind spots to improve simulations.

During its probationary period, the AI takes note of environmental factors influencing the human's actions that it does not recognize from its simulation. When the human does something unexpected — like hesitating to enter a crosswalk despite having the right-of-way — the AI scans its surroundings for previously unknown elements, such as sirens. If the AI detects any of these features, it assumes the human is following some safety protocol it didn't learn and that it should defer to the human's judgment.

Ramakrishnan's group has tested this setup by first training AI programs in simplistic simulations and then letting the programs learn their blind spots from human characters in more realistic but still virtual worlds. The researchers now need to test the system in the real world. *— Maria Temming*

LIFE & EVOLUTION

Pandas didn't always stick to bamboo

Specialized diet may have emerged in the last 5,000 years

BY JEREMY REHM

When it comes to deciding what's for breakfast, lunch or dinner, pandas have it easy: Bamboo, bamboo and more bamboo. But that wasn't always the case.

Although giant pandas (*Ailuropoda melanoleuca*) dine almost exclusively on bamboo in the mountain forests of central China, these bears' diet was more varied not so long ago, researchers report online January 31 in *Current Biology*. Chemical analyses of bones and teeth from both ancient and modern pandas indicate the bears' hyperdependence on bamboo could have developed as recently as about 5,000 years ago. That's about 2 million years later than other paleontological and molecular data suggest.

"It has been widely accepted that giant pandas have exclusively fed on bamboo for a long time, but our results show the opposite," says wildlife ecologist Fuwen Wei of the Chinese Academy of Sciences' Institute of Zoology in Beijing. "That made us excited."

Wei and his colleagues compared the relative abundance of isotopes — atoms of the same element but with a different number of neutrons in the nucleus — in modern and fossilized animals, including pandas. Animal diets contain different amounts of naturally occurring "heavy" and "light" isotopes of carbon, oxygen and nitrogen that are then incorporated into bones, hair and teeth.

The ratio in which the isotopes occur in the body depends on the animal's position in the food chain and the climate in which the animal lives. Compared with herbivores, carnivores, for example, have more of the heavy nitrogen-15 isotope because they mostly consume meat, which is made of nitrogen-rich amino acids. And because heavy oxygen-18 doesn't so easily evaporate from cold, dry places, animals in such environments consume more of that isotope than animals in warm, wet conditions.

Giant pandas are well-equipped for chowing down on bamboo, including having a special "thumb" to hold stalks. But these bears may have evolved their specialized diet recently.

Modern pandas have a much lower ratio of heavy-to-light nitrogen isotopes than other herbivores or carnivores that live near the bears, Wei's team found. But isotope ratios in panda bone collagen dated to about 5,000 years ago are indistinguishable from other herbivores of that time, suggesting that the bears' diet wasn't as specialized as it is today.

The team then examined oxygen and carbon isotopes in panda teeth dating as far back as about 2.6 million years ago. In the past, pandas had a much larger

GENES & CELLS

Bacteria fighter also induces sleep

Protein in fruit flies links slumber to the immune system

BY TINA HESMAN SAEY

"Feed a cold, starve a fever," or so the adage goes. But fruit fly experiments suggest that sleep may be a better remedy.

A microbe-fighting protein helps control how much and how deeply fruit flies sleep, which is evidence that sleep speeds recovery from illness, researchers report in the Feb. 1 *Science*.

"We finally have a very clear link between being sleepy and fighting an infection," says Grigorios Oikonomou, a Caltech sleep researcher not involved in the work. Such a link had never formally been demonstrated, says Oikonomou, who coauthored a commentary on the study in the same issue of *Science*.

Amita Sehgal's lab at the University of Pennsylvania's Perelman School of Medicine made the discovery while searching for genes that control sleep. The team looked for proteins that, when overproduced, would cause *Drosophila melanogaster* fruit flies to sleep more. After combing through more than 8,000 overproduced proteins, the researchers found just one that lulled flies to sleep.

Flies with an overabundance of that protein, called Nemuri, took more naps during the day and slept longer and deeper at night. Strong thwacks from a device called "the hammer" roused only about 18 percent of these Nemuri-overproducing flies in the middle of the night but jolted awake more than 94 percent of normal flies, Sehgal's team discovered. Flies that lacked the Nemuri protein were more easily awakened than normal flies when researchers flicked lights on and off or wafted an odor into the tubes where the flies slept.

Sehgal's team found that Nemuri is similar to fish versions of proteins known as antimicrobial peptides, short proteins or pieces of protein that can kill microbes. The protein killed two types of bacteria in lab dishes and, when overproduced, helped bacteria-infected flies survive longer.

A dual role of killing bacteria and triggering sleep is new for antimicrobial peptides, says microbiologist and immunologist Robert Hancock of the University of British Columbia in Vancouver. "But I'm not shocked because peptides do so many things." Yet in actual animal bodies, antimicrobial peptides aren't all that good at killing microbes, he says. Instead,

ALDO MANGANARO/ISTOCK.COM

variation in oxygen isotope abundances than the bears do now. That suggests that ancient pandas may have lived in a variety of environments, not just the cool, moist habitats the bears are restricted to today, the researchers say. Carbon isotope abundances consistent with a strictly plant diet indicate that these ancient pandas may have already transitioned from their ancestors' omnivorous diet to vegetarianism.

Given their bear ancestry, it's not surprising that pandas once had a more varied diet, says Larisa DeSantis, a vertebrate paleontologist at Vanderbilt University in Nashville. "But it is very interesting that these researchers were able to document high levels of diet variability in ancient populations as compared to modern ones."

What factors eventually led pandas to their mostly bamboo diet remain unknown, Wei says. The bears have specialized teeth that make chewing tough bamboo easier and a modified bone in the wrist called a pseudothumb that allows them to grasp bamboo stalks, though it's unclear when these traits evolved. Determining when pandas switched to bamboo is the next goal, Wei says. ■

---

the peptides help regulate the immune system to perform a variety of tasks.

That seems to be the case in fruit flies: Nemuri's lullaby power, not direct antimicrobial activity, appears to be what fights infection. Flies made more Nemuri not just when sick but also when sleep deprived and under other types of stress. "Sleep helps to fight off these challenges," Sehgal says. Nemuri may not be as important for everyday sleep, except for helping flies stay asleep at night

Mammals — including humans, who have more than 100 antimicrobial peptide genes — may also have antimicrobial peptides that induce sleep during illness. "Causing an animal to go to sleep and concentrate all its resources on fighting infection is useful to host defense," Hancock says. Or as one Irish proverb goes, "A good laugh and a long sleep are the best cures in the doctor's book." ■

HUMANS & SOCIETY

Hominids shared cave long ago

Dates show when Denisovans and Neandertals crossed paths

BY BRUCE BOWER

Mysterious ancient hominids known as Denisovans and their evolutionary cousins Neandertals frequented a Siberian cave starting a surprisingly long time ago.

Evidence for visits to Denisova Cave, beginning by about 200,000 years ago for Neandertals and possibly as early as about 300,000 years ago for Denisovans, appears in two studies in the Jan. 31 *Nature*. The studies offer the best look yet at when the two species reached the site and how they may have interacted.

A team led by geoarchaeologist Zenobia Jacobs found that Denisovans occupied the cave as recently as about 55,000 years ago. A second investigation, directed by archaeologist Katerina Douka, places the Denisovans' last stand in the same ballpark. Neandertals last lived in the cave 97,000 years ago, Jacobs' group says.

"It now looks like Denisovans can be placed at the site from close to 300,000 years ago to about 50,000 years ago, with Neandertals there for periods in between," says paleoanthropologist Chris Stringer of the Natural History Museum in London. But it's still uncertain whether the cave's fossils derive from hominids who died during periodic occupations or whose remains were transported there by, say, carnivores, Stringer says.

Two extinct hominid species had a surprisingly ancient timeline at Siberia's Denisova Cave.

RICHARD (BERT) ROBERTS

Jacobs, of the University of Wollongong in Australia, and colleagues generated dates for 103 samples from cave sediment that has yielded stone tools and hominid fossils. Age estimates rested on calculations of when sediment had last been exposed to sunlight.

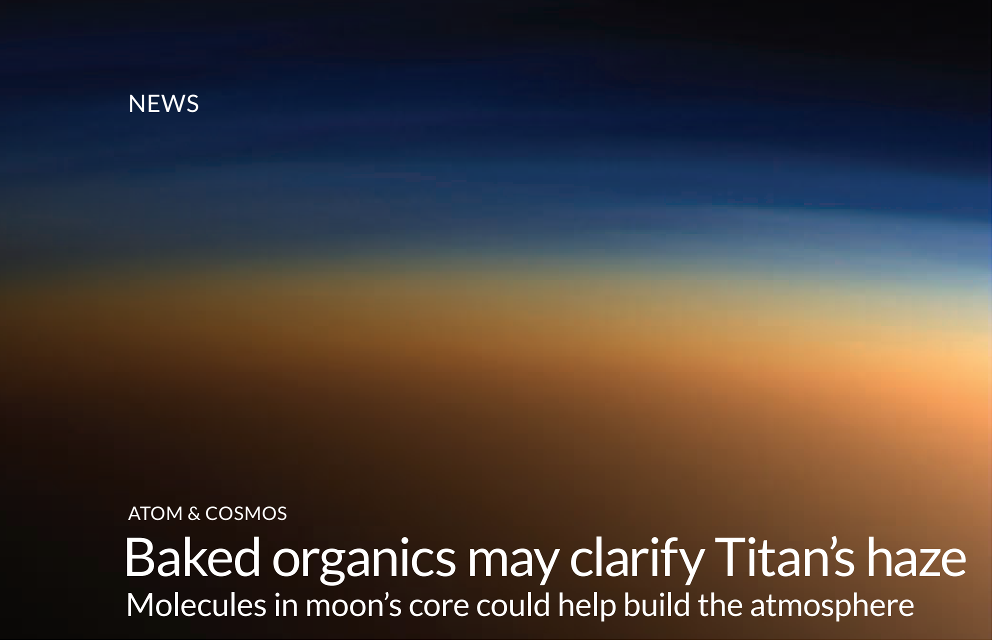
Douka, of the Max Planck Institute for the Science of Human History in Jena, Germany, and colleagues estimated ages for four Denisovans, three Neandertals and three other hominids whose fragmentary remains have been found in Denisova Cave. The team incorporated new and previous age estimates for fossils and sediment, information on original positions of fossils when excavated and comparisons of mitochondrial DNA from fossils.

Until now, Neandertal ages based on fossils in northeastern Asia have been scant and suggestive of a relatively late Stone Age presence. "We did not expect [Denisova Cave] Neandertals to date to before around 120,000 years ago," Douka says. Relatively warm conditions apparently encouraged Neandertals to trek north to Denisova Cave, her team says.

Her team also estimates that animal-tooth pendants and bone points from the cave date from 43,000 to 49,000 years ago. Such artifacts have traditionally been linked to *Homo sapiens*, but Russian archaeologists on Douka's team regard Denisovans as the likely makers. In 40 years of excavations at the cave, none has yielded *H. sapiens* fossils or DNA.

H. sapiens lived elsewhere in Siberia about 45,000 years ago, though. Since Denisovans date no later than 52,000 years ago in the new studies, "my money would be on early modern humans" as the makers of the artifacts, Stringer says.

But it wouldn't be surprising if hybrid offspring of Denisovans and *H. sapiens* fashioned those artifacts, writes archaeologist Robin Dennell of the University of Exeter in England in a commentary in the same issue of *Nature*. Interbreeding among *H. sapiens*, Neandertals and Denisovans may have been more common than scientists realize. ■



An explanation for how Titan's atmosphere formed (layers of haze shown in this composite image) has implications for the search for life.

ATOM & COSMOS

Baked organics may clarify Titan's haze

Molecules in moon's core could help build the atmosphere

BY LISA GROSSMAN

Titan may have a home-baked atmosphere. Saturn's largest moon gets some of its thick haze by cooking organic molecules in a warm core, a study suggests.

Decay of radioactive elements may warm Titan's core from within, splitting nitrogen and carbon off complex organic molecules. Once free, the elements recombine into nitrogen and methane molecules and escape into the atmosphere. That process may account for about half of the atmosphere's observed nitrogen and all its methane, researchers say in the Jan. 20 *Astrophysical Journal*.

Other moons are too small and cold to cloak themselves in gas. "Titan's the only moon that has an atmosphere," says cosmochemist Kelly Miller of the Southwest Research Institute in San Antonio.

Previous studies suggested that Titan's nitrogen was delivered in the ammonia ice of comets. That ammonia could be split apart by sunlight or broken up by the force of a comet strike, creating the nitrogen molecules that fill Titan's skies.

But those studies came before the Rosetta mission, which orbited comet 67P/Churyumov-Gerasimenko. Rosetta showed that the comet is about 25 percent organic matter by weight, much more than scientists had assumed. Comet 67P also has radioactive elements such as potassium, which decays into argon — an element found in Titan's atmosphere.

Ammonia from comets could still donate nitrogen to the atmosphere, Miller says, but she wondered what role the organics might play. Recent theories suggest that comets were the building blocks for Saturn's moons, so Titan's core would have originally been a snowball built from comets. Given the 67P insights, the team calculated what ingredients Titan would have started with and how they could have changed with time.

The idea that Titan bakes organics in its core raises hope for the possibility of life on the moon, says planetary scientist Alexander Hayes of Cornell University. So far, organics have been detected on the surface. But if organics exist in the core, then they may also be at the bottom of Titan's subsurface ocean. Having organics in the core, Hayes says, "makes it one step easier to think about habitable environments at the base of Titan's ocean." ■

MATTER & ENERGY

Lasers dispatch audio messages

New technique can target sound directly at a person

BY EMILY CONOVER

Lasers can send sounds straight to a listener's ear, like whispering a secret from afar.

Using a laser tuned to interact with water vapor in the air, scientists created sounds in a localized spot that were loud enough to be picked up by human hearing if aimed near a listener's ear. It's the first time such a technique can be used safely around humans, scientists from MIT Lincoln Laboratory in Lexington, Mass., report in the Feb. 1 *Optics Letters*. At the wavelengths and intensities used, the laser won't burn the eyes or skin.

The scientists tested the setup on themselves in the lab, putting their ears near the beam. "You move your head around, and there's a couple-inch zone where you go 'Oh, there it is!' " says physicist Charles Wynn. "It's pretty cool." The researchers also used microphones to capture and analyze the sounds.

The work relies on the photoacoustic effect, in which pulses of light are converted into sound when absorbed by a material, in this case, water vapor.

The researchers used two techniques to make the sounds. The first, which involves rapidly ramping the intensity of the laser beam up and down, can transmit voices and songs.

That sound is audible anywhere along the beam, rather than being targeted to just one person. So the team devised a second method: A rotating mirror swept the laser beam in an arc, like swinging a flashlight beam with a flick of the wrist. The farther down the beam, the faster the spot of light swings. The noise occurs only at the distance along the beam where the light zips by at the speed of sound.

This technique can't yet send complex messages; it sounds somewhat like a buzzing insect. And so far, the sounds can be sent only several meters.

For now "it's not as much a practical means of communication, but a very neat demonstration proving the power of photoacoustics," says applied physicist Jacob Khurgin of Johns Hopkins University.

If perfected, such laser messages could be used to communicate in noisy environments or to warn people of danger, for example in an active-shooter scenario. ■

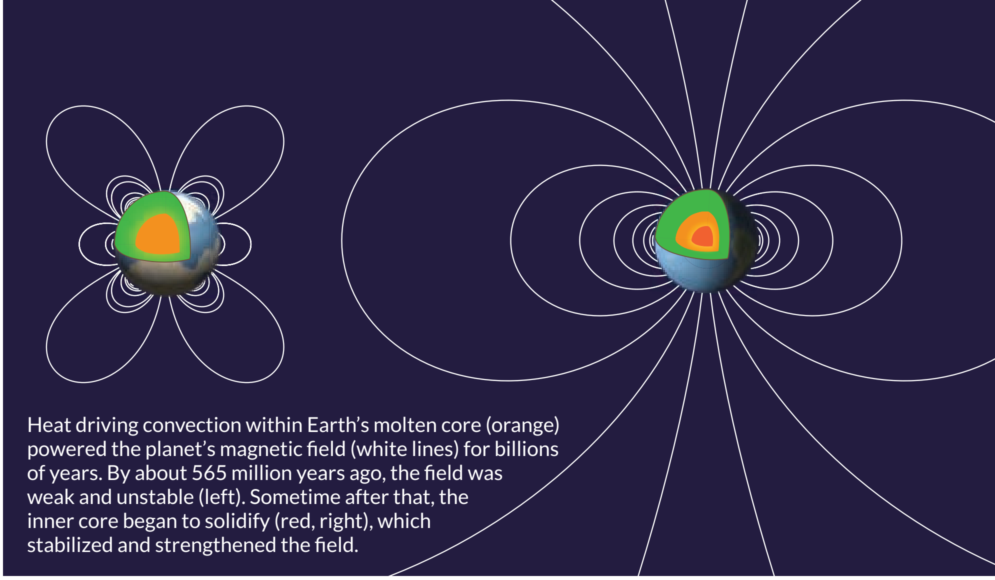
JPL-CALTECH/NASA, SPACE SCIENCE INSTITUTE

EARTH & ENVIRONMENT

Earth's inner core is relatively young

Hardening of planet's interior rescued waning magnetic field

BY CAROLYN GRAMLING



Heat driving convection within Earth's molten core (orange) powered the planet's magnetic field (white lines) for billions of years. By about 565 million years ago, the field was weak and unstable (left). Sometime after that, the inner core began to solidify (red, right), which stabilized and strengthened the field.

Earth's inner core started solidifying sometime after 565 million years ago — just in time to save the planet's protective magnetic field from collapse and kick-start it into its current, powerful phase.

The timing, reported in a paper in the February *Nature Geoscience*, supports a previously proposed idea that Earth's inner core is relatively young. It also provides insight into how, and how quickly, Earth has been losing heat since its formation 4.54 billion years ago, which is key to understanding the generation of the planet's magnetic shield, convection within the mantle and plate tectonics.

"We don't have many real benchmarks for the thermal history of our planet," says Peter Olson, a geophysicist at Johns Hopkins University not involved in the study. "We know the interior was hotter than today, because all planets lose heat. But we don't know what the average temperature was a billion years ago." Pinning down when iron in the inner core began to crystallize could offer a window into how hot the planet's interior was at the time, Olson says.

Earth's iron-nickel core has two layers: a solid inner core and a molten outer core. When the inner core began to form is a long-standing mystery (*SN: 9/19/15, p. 18*). "Proposed ages have been anywhere from 500 million years ago to older than 2.5 billion years," says study coauthor John Tarduno, a geophysicist at the University of Rochester in New York.

The interplay of the two layers drives the geodynamo, the circulation of iron-rich fluid that currently powers the magnetic field. That field, surrounding the planet, protects Earth from the solar wind, a constant flow of charged particles ejected by the sun. As the inner core continues to cool and crystallize, the composition of the remaining fluid in the outer core changes; more buoyant liquid rises like a plume while cooling crystals sink. That self-sustaining, density-driven circulation generates a strong magnetic field with two opposing poles, north and south.

Traces of magnetism in ancient rocks suggest that Earth had a magnetic field as far back as 4.2 billion years ago. That earlier field was probably generated by heat within the planet driving circulation within the molten core. Over time, computer simulations suggest, heat-driven circulation alone wouldn't have been strong enough to power a strong magnetic field. Instead, the field began to shut down, signaled in the rock record by weakening field intensities and relatively rapid pole reversals. Then, at some point, Earth's inner core began to crystallize, jump-starting the geodynamo and generating a new, strong magnetic field.

The new evidence of when that magnetic field breakdown happened comes from Quebec, Canada. Researchers led by geophysicist Richard Bono, now at the University of Liverpool in England, examined magnetic inclusions within rocks dating to about 565 million years ago. Analyses of the inclusions, needle-like iron-rich grains that align themselves with the orientation of the magnetic field that existed when the rocks formed, show that the magnetic field was extremely weak at that time.

"These paleointensity values were 10 times less than the present magnetic field, lower than anything observed previously," Tarduno says.

Combined with other evidence of a rapid pole reversal during that time, the new result indicates the field may have been on the point of collapse about 565 million years ago, which suggests that the inner core hadn't yet solidified.

The rocks bearing the magnetic grains cooled over a long time and represent an average field intensity over about a 100,000-year period. So the scientists haven't just captured a snapshot in time of a fluctuating field, but have found a persistent signal, Olson says. Simulations have suggested that the weak field lasted from about 900 million to 600 million years ago. More paleointensity data from within that time span, plus from other locations, would help confirm that the observed weak phase really signaled the final throes of that original field.

Peter Driscoll, a geophysicist at the Carnegie Institution for Science in Washington, D.C., was one of the theoreticians who estimated how long the weak phase might have lasted. Driscoll, whose commentary accompanies the new study in *Nature Geoscience*, says that a young solid inner core highlights lingering conundrums about how quickly Earth cooled. "If the core is cooling quickly, that means it was very hot in the recent past, and that the lower mantle was very hot in the recent past" — so hot that both were molten just 1 billion to 2 billion years ago. "We absolutely do not see that in the rock record."

Driscoll hopes the study garners attention to the glaring gap in paleomagnetic data from this period. "There's a lot more time here that we could be filling in." ■

ROBERTO MOLAR CANDANOSA, P. DRISCOLL/*NATURE GEOSCIENCE* 2019

HUMANS & SOCIETY

Athletes hurl ancient spears for science

Javelin tests suggest Neandertals could have hunted from afar

BY BRUCE BOWER

Archaeologist Annemieke Milks had convened a sporting event of prehistoric proportions.

The athletes: Six javelin throwers. The weapon: Two replicas of a 300,000-year-old wooden spear, one of nine ancient hunting tools discovered at Germany's Schöningen coal mine. The test: Could Neandertals, the likely makers of the Stone Age weapon, have hurled the spears at prey with any power, accuracy and distance? The answer: Probably.

Data from high-speed video cameras at Milks' throw-off, reported January 25 in *Scientific Reports*, suggest that Neandertals could have used the spears for long-range hunting.

Many researchers have suspected that Neandertals or their ancestors snuck up on and stabbed prey with the pointed wooden rods. That idea aligns with a popular assumption that Stone Age *Homo sapiens* had a monopoly on hurling spears at prey. Yet bodies capable of accurate and powerful throwing may have emerged nearly 2 million years ago in *Homo erectus*. So why not Neandertals?

Athletes threw the two wooden spear replicas a total of 102 times at bales of hay, hitting bales five meters away 58 percent of the time. That figure fell to 25 percent for throws from 10 meters and 15 meters, and 17 percent for 20-meter throws. No one could hit hay bales placed 25 meters away. The results are the first measurements of the Schöningen projectiles' flight characteristics when hurled at a target.

"Being very competitive, [the athletes] were disappointed at their performance," says Milks, of University College London. "But they found it exciting to think that some form of their sport had existed for so long."

Missing the target wasn't so surprising: Those athletes are trained only to heave a javelin as far as possible. But they quickly adapted during the sporting event, starting to throw spears with less power to gain more accuracy, Milks says. More important, Milks' test provided a crucial piece of support for long-range hunting by Neandertals: There was no substantial loss in a spear's speed or physical momentum between its release from an athlete's hand and impact with a target. That is, the spears were built to fly.

The only direct fossil evidence of Neandertal hunting points to closeup attacks on fallow deer. Even so, perhaps "it was not all close encounters with thrusting spears," says biological anthropologist Neil Roach of Harvard University. But the low hit rates of even experienced javelin throwers leave paleontologist Steven Churchill of Duke University doubtful that hurled Schöningen spears could have killed or seriously injured prey.

Milks plans to see if spear-throwing hunters in some modern foraging groups, who have a lot of experience hitting targets, can heave her replica weapons more deftly than javelin athletes did. ■

NEWS IN BRIEF

LIFE & EVOLUTION

Seething mass of fly larvae demolishes a pizza in no time

It all started with a can't-tear-your-eyes-away video of black soldier fly larvae devouring a 16-inch pizza in just two hours. The action of the writhing mass inspired mechanical engineer Olga Shishkov of Georgia Tech in Atlanta to see what makes these insects such champions of collective feeding.

An individual *Hermetia illucens* larva doesn't eat steadily, Shishkov found. One feeds for about five minutes on average and then stops for another five. As a group of thousands, though, they flow continuously like a living fountain rising up against the edge of their food, Shishkov and colleagues report in the Feb. 6 *Journal of the Royal Society Interface.*

Shishkov borrowed methods from the study of fluids, treating larvae as particles moving with a current, for instance, to look for patterns of flow in a mass of insects. She tracked the directions larvae were wriggling around a chunk of food and saw a fountainlike flow develop.

Hungry larvae pushing from behind would force those near food upward. Once at the top, the larvae fall away from the cliff face of food. This up-and-out push lets a larva eager to feed replace one that's taking a break. *— Susan Milius*

BODY & BRAIN

Pills equipped with tiny needles inject a body from the inside

For those who cringe at the sight of needles, there may someday be an alternative to getting a shot: swallowing a pill-sized device that delivers medication by painlessly pricking the inside of the stomach.

A prototype, described in the Feb. 8 *Science*, administers insulin. But similar ingestible capsules could also replace other pharmaceuticals.

Each roughly pea-sized device is shaped like an acorn, with a lightweight polyester "nut" and stainless steel cap. The shape is designed to guide the device to rest, cap down, on the floor of the stomach. There, it sticks a needle tip composed almost entirely of insulin a few millimeters into the mucous membrane lining the stomach. Once the needle tip dissolves, the device passes through the digestive system.

Thanks to the dearth of sharp pain receptors inside the stomach, the injection "is unlikely to cause any discomfort," says study coauthor Giovanni Traverso, a gastroenterologist at Brigham and Women's Hospital in Boston.

In experiments with pigs, the devices delivered a similar amount of insulin to the bloodstream as did skin injections. One week after treatment, there were no signs of tissue damage in the pigs' stomachs. The researchers say future work will help determine if there are any chronic effects. *— Maria Temming*

Watch fly larvae devour a pizza at **bit.ly/SN_Pizza**

Prospecting the periodic table

Weird new elements could reveal nature's extremes

By Emily Conover

At Oak Ridge National Laboratory in Tennessee, researchers create radioactive elements with the High Flux Isotope Reactor (above). Those materials are sent to other labs to search for superheavy elements.

The rare radioactive substance made its way from the United States to Russia on a commercial flight in June 2009. Customs officers balked at accepting the package, which was ensconced in lead shielding and emblazoned with bold-faced warnings and the ominous trefoil symbols for ionizing radiation. Back it went across the Atlantic.

U.S. scientists enclosed additional paper work and the parcel took a second trip, only to be rebuffed again. All the while, the precious cargo, 22 milligrams of an element called berkelium created in a nuclear reactor at Oak Ridge National Laboratory in Tennessee, was deteriorating. Day by day, its atoms were decaying. "We were all a little frantic on our end," says Oak Ridge nuclear engineer Julie Ezold.

On the third try, the shipment cleared customs. At a laboratory in Dubna, north of Moscow, scientists battered the berkelium with calcium ions to try to create an even rarer substance. After 150 days of pummeling, the researchers spotted six atoms of an element that had never been seen on Earth. In 2015, after other experiments confirmed the discovery, element 117, tennessine, earned a spot on the periodic table (*SN: 2/6/16, p. 7*).

Scientists are hoping to stretch the periodic table even further, beyond tennessine and three other recently discovered elements (113, 115 and 118) that completed the table's seventh row. Producing the next elements will require finessing new techniques using ultrapowerful beams of ions, electrically charged atoms. Not to mention the stress of shipping more radioactive material across borders.

But questions circulating around the periodic table's limits are too tantalizing not to make the effort. It's been 150 years since Russian chemist Dmitrii Mendeleev created his periodic table. Yet "we still cannot answer the question: Which is the heaviest element that can exist?" says nuclear chemist Christoph Düllmann of the GSI Helmholtz Center for Heavy Ion Research in Darmstadt, Germany.

At the far edge of the periodic table, elements decay within instants of their formation, offering very little time to study their properties. In fact, scientists still know little about the latest crew of newfound elements. So while some scientists are hunting for never-before-seen elements, others want to learn more about the table's newcomers and the strange behaviors those superheavy elements may exhibit.

For such outsized atoms, chemistry can get weird, as atomic nuclei, the hearts at the center of each atom, bulge with hundreds of protons and neutrons. Around them swirl great flocks of electrons, some moving at close to the speed of light. Such extreme conditions might have big consequences — messing with the periodic table's tidy order, in which elements in each column are close chemical kin that behave in similar ways.

Scientists keep pushing these superheavy elements further as part of the search for what's poetically known as the island of stability. Atoms with certain numbers of protons and neutrons are expected to live longer than their fleeting friends, persisting perhaps for hours rather than fractions of a second. Such an island would give scientists enough time to study those elements more closely and understand their quirks. The first glimpses of that mysterious atoll have been spotted, but it's not clear how to get a firm footing on its shores.

Driving all this effort is a deep curiosity about how elements act at the boundaries of the periodic table. "This might sound corny, but it's really just [about] pure scientific understanding," says nuclear chemist Dawn Shaughnessy of Lawrence Livermore National Laboratory in California. "We have these things that are really at the extremes of matter and we don't understand right now how they behave."

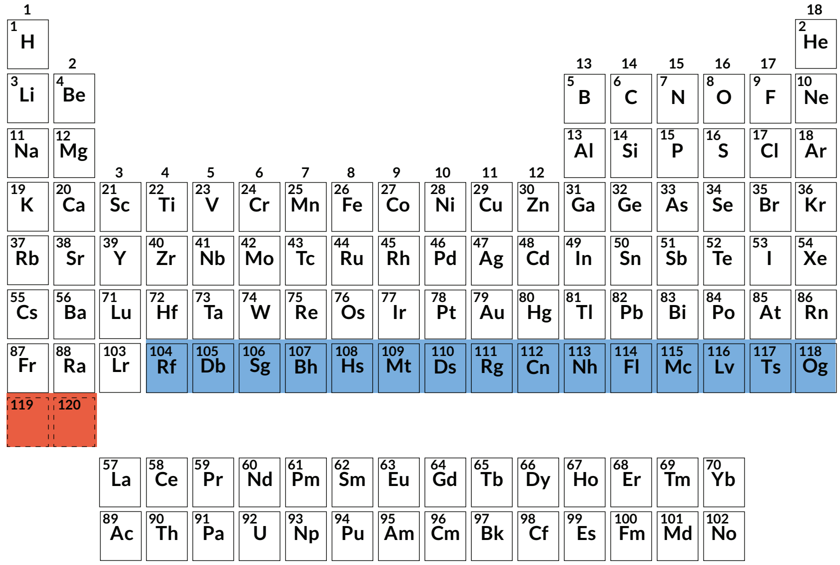
Assembling atoms

An element is defined by the number of protons it contains. Create an atom with more protons than ever before, and you've got yourself a brand new element. Each element comes in a variety of types, known as isotopes, distinguished by the number of neutrons in the nucleus. Changing the number of neutrons in an atom's nucleus alters the delicate balance of forces that makes a nucleus stable or that causes it to decay quickly. Different isotopes of an element might have wildly different half-lives, the period of time it takes for half of the atoms in a sample to decay into smaller elements.

Mendeleev's periodic table, presented to the Russian Chemical Society on March 6, 1869, contained only 63 elements (*SN: 1/19/19, p. 14*). At first, scientists added to the periodic table by isolating elements from naturally occurring materials, for example, by scrutinizing minerals and separating them into their constituent parts. But that could take scientists only so far. All the elements beyond uranium (element 92) must be created artificially; they do not exist in significant quantities in nature. Scientists discovered elements beyond uranium by bombarding atoms with neutrons or small atomic nuclei or by sifting through the debris from thermonuclear weapons tests.

But to make the heaviest elements, researchers adopted a new brute force approach: slamming beams of heavy atoms into a target, a disk that holds atoms of another element. If scientists are lucky, the atoms in the beam and target fuse, creating a new atom with a bigger, bulkier nucleus, perhaps one holding more protons than any other known.

Researchers are using this strategy to go after elements 119 and 120. Scientists want to create such never-before-seen atoms to test how far the periodic table goes, to satisfy curiosity about the forces that hold atoms together and to understand what bizarre chemistry might occur with these extreme atoms.



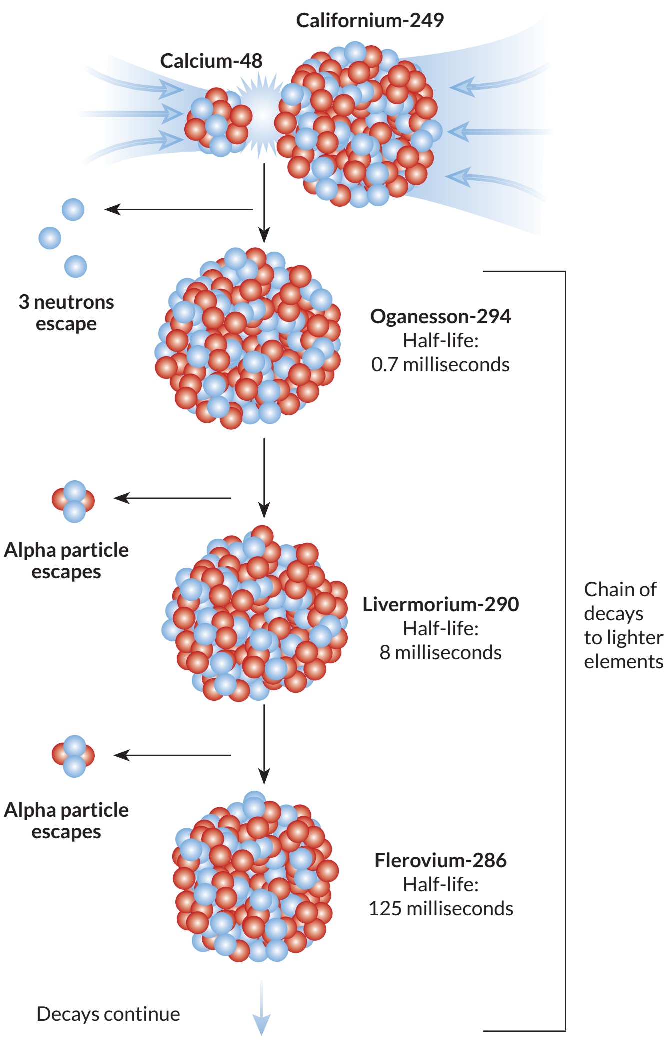
Above: The search is gearing up for the next superheavy elements, 119 and 120 (red boxes in the table above). Meanwhile, scientists are studying the known superheavy elements (blue) to better understand how such large atoms behave.
Left: In Russia, scientist Vladislav Shchegolev inspects a package of berkelium after its overseas flight in 2009. The material was later used to create element 117, tennessine.

FROM TOP: E. OTWELL; COURTESY OF ORNL

Coaxing nuclei to combine into a new element is done only at highly specialized facilities in a few locations across the globe, including labs in Russia and Japan. Researchers carefully choose the makeup of the beam and the target in hopes of producing a designer atom of the element desired. That's how the four newest elements were created: nihonium (element 113), moscovium (115), tennessine (117) and oganesson (118) (*SN Online: 11/30/16*).

To create tennessine, for example, scientists combined beams of calcium with a target made of berkelium — once the berkelium finally made it through customs in Russia. The union makes sense when you consider the number of protons in each nucleus. Calcium has 20 protons and berkelium has 97, making for 117 protons total, the number found in tennessine's nucleus. Combine calcium with the next element down the table, californium, and you get element 118, oganesson.

150 years of the periodic table
Read our ongoing coverage of this iconic table's birthday, its history and its future at bit.ly/SN_PeriodicTable



Decay parade To discover oganesson-294 (with 294 protons and neutrons), scientists slammed calcium ions into a californium target and observed the chain of radioactive decays initiated by the new element.

Using calcium beams — specifically a stable calcium isotope with a combined total of 48 protons and neutrons known as calcium-48 — has been highly successful. But to create bigger nuclei would take increasingly exotic materials. The californium and berkelium used in previous efforts are so rare that the target materials had to be made at Oak Ridge, where researchers stew materials in a nuclear reactor for months and carefully process the highly radioactive product that comes out. All that work might produce just milligrams of the material.

To discover element 119 using a calcium-48 beam, researchers would need a target made of einsteinium (element 99) which is even rarer than californium and berkelium. "We can't make enough einsteinium," says Oak Ridge physicist James Roberto. Scientists need a new approach. They've switched to relatively untested techniques relying on different beams of particles.

But any new approach would have to produce new elements often enough to be worthwhile. It took almost nine years for a Japanese experiment to prove the existence of nihonium. In that time, researchers spotted the element only three times.

To avoid such long waits, scientists are carefully choosing their tactics and revving up improved machines to quicken the search.

A team at the RIKEN Nishina Center for Accelerator-Based Science near Tokyo uses beams of vanadium (element 23), rather than calcium, slamming them into curium (element 96) in the quest to grab elemental glory and find element 119. The group is starting with an existing accelerator and will soon switch to an accelerator upgraded to pump out ion beams that pack more punch. That revamped accelerator could be ready within a year, says RIKEN nuclear chemist Hiromitsu Haba.

Meanwhile, a new laboratory at the Joint Institute for Nuclear Research, or JINR, in Dubna called the Superheavy Element Factory boasts an accelerator that will crank out ion beams that pummel the target at 10 times the rate of its predecessor. In an upcoming experiment, scientists plan to crash beams of titanium (element 22) into berkelium and californium targets to attempt to produce elements 119 and 120.

Once JINR's new experiment is up and running, 119 might be discovered after a couple of years, says JINR nuclear physicist Yuri Oganessian, for whom oganesson, one of several elements discovered there, was named.

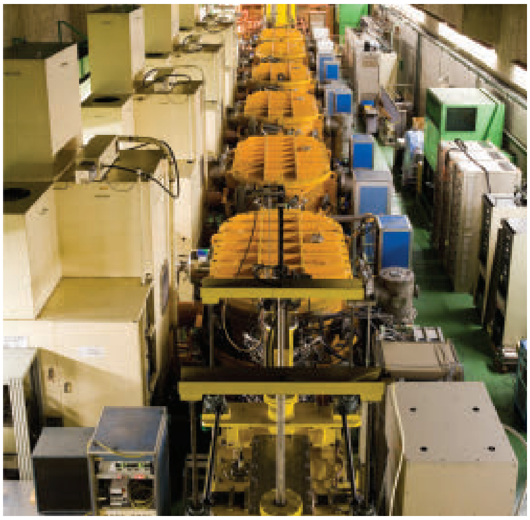
Relativity rules

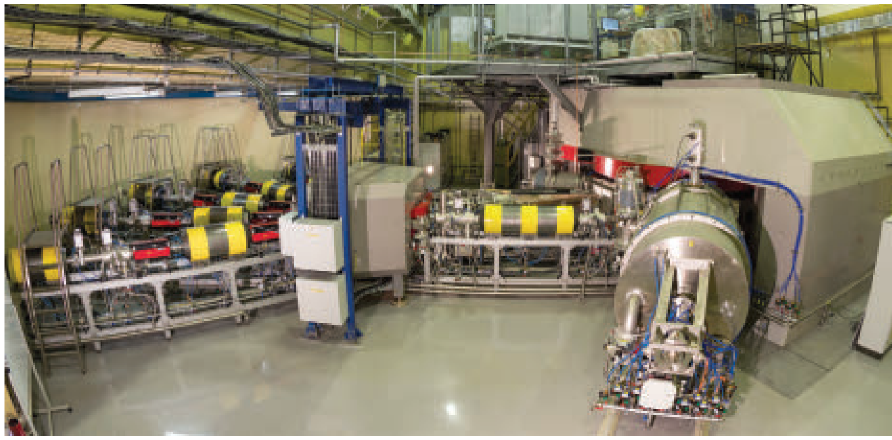
Simply detecting an element, however, doesn't mean scientists know much about it. "How would one kilogram of flerovium behave, if I had it?" Düllmann asks, referring to element 114. "It would be unlike any other material."

The known superheavy elements — those beyond number 103 on the table — are too short-lived to create a chunk big enough to hold in the palm of your hand. So scientists are limited to studying individual atoms, getting to know each new element by analyzing its properties, including how easily it reacts with other substances.

One big question is whether the periodicity the table is named for applies to superheavy elements. In the table, elements are ordered

T. TIBBITTS





The linear accelerator at RIKEN in Japan (left), used to discover element 113, is being refurbished to probe for element 119. Scientists in Russia have built a new accelerator facility, the Superheavy Element Factory (right), to search for elements 119 and 120.

CLOCKWISE FROM TOP LEFT: RIKEN; JINR; T. TIBBITTS

according to their number of protons, arranged so that the elements in each column have similar properties. Lithium, sodium and others in the first column react violently with water, for example. Elements in the last column, known as noble gases, are famously inert (*SN: 1/19/19, p. 18*). But for the newest, heaviest elements at the periodic table's outer reaches, that long-standing rule of chemistry may unravel; some superheavy elements may behave differently from neighbors sitting above them in the table.

For nuclei crammed with 100-plus protons, a special type of physics takes center stage. Electrons zip around these giant nuclei, sometimes surpassing 80 percent the speed of light. According to Einstein's special theory of relativity, when particles move that fast, they seem to gain mass. That property changes how closely the electrons hug the nucleus, and as a result, how easily the atoms share electrons to produce chemical reactions. In such atoms, "relativity rules, and standard common wisdom breaks down," says nuclear physicist Witold Nazarewicz of Michigan State University in East Lansing. "We have to write new textbooks on those atoms."

Some of the periodic table's more familiar elements are already affected by special relativity. The theory explains why gold has a yellowish hue and why mercury is liquid at room temperature (*SN: 2/18/17, p. 11*). "Without relativity, a car would not start," says theoretical chemist Pekka Pyykkö of the University of Helsinki. The reactions that power a car battery depend on special relativity.

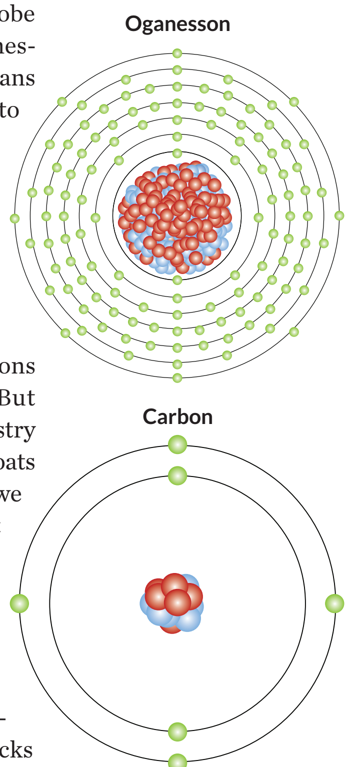
Relativity's influence may surge as scientists progress along the periodic table. In 2018 in *Physical Review Letters*, Nazarewicz and colleagues reported that oganesson could be utterly bizarre (*SN Online: 2/12/18*). The table's heaviest element, oganesson sits among the reclusive noble gases that shun reactions with other elements. But oganesson bucks the trend, theoretical calculations suggest, and may instead be reactive.

Oganesson's chemistry is a hot topic, but scientists haven't yet been able to directly probe its properties with experiments because oganesson is too rare and fleeting. "All the theoreticians are now running around this element trying to make spectacular predictions," says theoretical chemist Valeria Pershina of GSI. Similarly, some calculations suggest that flerovium might lean in the opposite direction, being relatively inert, even though it inhabits the same column as more reactive elements such as lead.

Chemists are striving to test such calculations about how superheavy elements behave. But there is nothing traditional about these chemistry experiments. There are no scientists in white coats wielding flasks and Bunsen burners. "Because we make these things one atom at a time, we can't do what most people think of as chemistry," Lawrence Livermore's Shaughnessy says.

The experiments can run for months with only a few atoms to show for it. Scientists put those atoms in contact with other elements to see if the two react. At GSI, Düllmann and colleagues are looking at whether flerovium sticks to gold surfaces. Likewise, Shaughnessy and colleagues are testing whether flerovium will glom on to ring-shaped molecules, chosen so that the heavy element could fit inside the molecule's ring. These studies will test how easily flerovium bonds with other elements, revealing whether it behaves as expected based on its place on the periodic table.

It's not just chemical reactions that can get wacky for superheavy elements. Atomic nuclei can be warped into various shapes when packed



Getting heavy
The nucleus of superheavy oganesson has 118 protons and many neutrons (blue and red). Its 118 electrons (green) surround the nucleus. Carbon, which is much lighter, contains just six protons and six electrons (not to scale).

with protons. Oganesson may have a "bubble" in its nucleus, with fewer protons in its center than at its edges (*SN: 11/26/16, p. 11*). Still more extreme nuclei may be doughnut-shaped, Nazarewicz says.

Even the most basic properties of these elements, such as their mass, need to be measured. While scientists had estimated the mass of the various isotopes of the latest new elements using indirect measurements, the arguments supporting those mass estimates weren't airtight, says Jacklyn Gates of Lawrence Berkeley National Laboratory in California. "They hinge on physics not throwing you a curveball."

So Gates and colleagues directly measured the masses of isotopes of nihonium and moscovium using an accelerator at Lawrence Berkeley. An apparatus called FIONA helped researchers measure the masses, thanks to electromagnetic fields that steered an ion of each element onto a detector. The location where each ion hit indicated how massive it was.

The nihonium isotope the researchers detected had a mass number of 284, meaning its nucleus had a combined total of 284 protons and neutrons. Moscovium had a mass number of 288. Those masses were as predicted, the scientists reported in November in *Physical Review Letters*. It took about a month just to find one atom of each element.

Island views

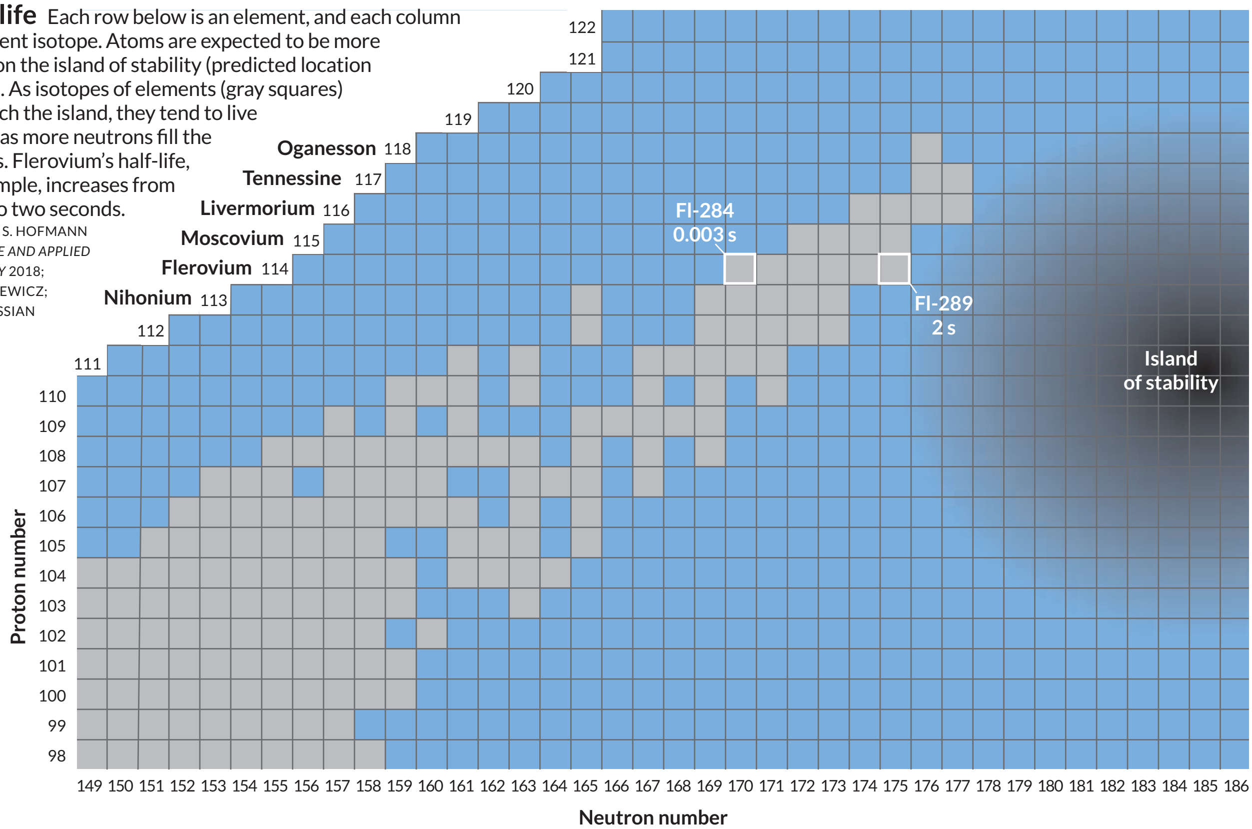
If researchers could coax these fleeting elements to live longer, studying their properties might be easier. Scientists have caught enticing visions of increasing life spans lying just out of reach — the fabled island of stability (*SN: 6/5/10, p. 26*). Scientists hope that the isotopes on that island, which would be packed with lots of neutrons, may live long enough that their chemistry can be studied in detail.

When the idea of an island of stability was proposed in the 1960s, scientists had suggested that the isotopes on its shores might live millions of years. Advances in theoretical physics have since knocked that time frame down, Nazarewicz says. Instead, nuclear physicists now expect the island's inhabitants to stick around for minutes, hours or maybe even a day — a pleasant eternity for superheavy elements.

To reach the island of stability, scientists must create new isotopes of known elements. Researchers already know which direction they need to row: They must cram more neutrons into the nuclei of the superheavy elements that have

Long life Each row below is an element, and each column a different isotope. Atoms are expected to be more stable on the island of stability (predicted location shown). As isotopes of elements (gray squares) approach the island, they tend to live longer, as more neutrons fill the nucleus. Flerovium's half-life, for example, increases from 0.003 to two seconds.

SOURCES: S. HOFMANN *ET AL/PURE AND APPLIED CHEMISTRY* 2018; W. NAZAREWICZ; Y. OGANESSIAN



T. TIBBITTS

already been discovered. Currently, scientists can't make atoms with enough neutrons to reach the island's center, where isotopes are expected to be most stable. But the signs of this island's existence are already clear. The half-lives of superheavy elements tend to shoot up as scientists pack more neutrons into each nucleus, approaching the island. Flerovium's half-life increases by almost a factor of 700 as five more neutrons are added, from three milliseconds to two seconds.

Reaching this island "is our big dream," Haba says. "Unfortunately, we don't have a very good method to reach the island." That island is thought to be centered around isotopes that bulge with around 184 neutrons and something like 110 protons. Making such neutron-rich nuclei would demand new, difficult techniques, such as using beams of radioactive particles instead of stable ones. Although radioactive beams can be produced at RIKEN, Haba says, the beams aren't intense enough to produce new elements at a reasonable rate.

Still, superheavy element sleuths are keeping at it to learn how these weird atoms behave.

End of the line

To fully grasp nature's extremes, scientists want to know where the periodic table ends.

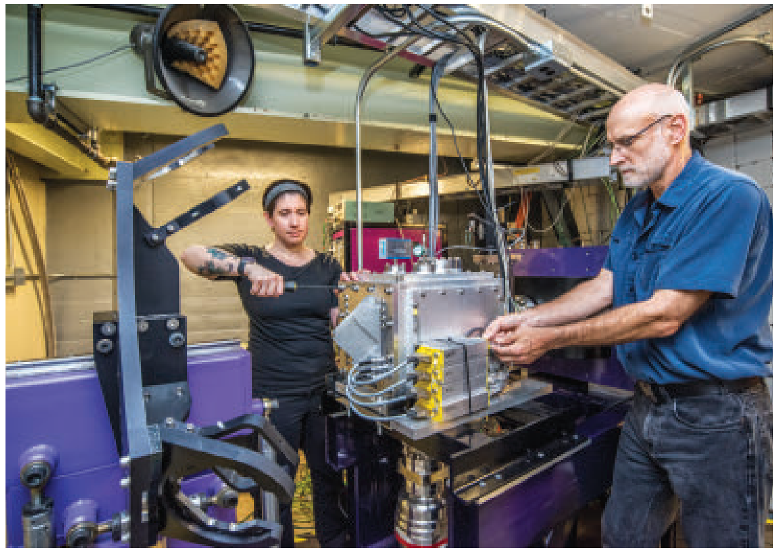
"Everybody knows at some point there will be an end," Düllmann says. "There will be a heaviest element, ultimately." The table will be finished when we've discovered all elements with isotopes that live at least a hundredth of a trillionth of a second. That's the limit for what qualifies as an element, according to the standards set by the International Union of Pure and Applied Chemistry. More ephemeral nuclei wouldn't have enough time to gather a crew of electrons. Since the give-and-take of electrons is the basis of chemical reactions, lone nuclei wouldn't exhibit chemistry at all, and therefore don't deserve a spot on the table.

"Where it will exactly end is difficult to say," Nazarewicz says. Calculations of how quickly a nucleus will decay by fission, or splitting in two, are uncertain, which makes it hard to estimate how long elements might live without actually creating them.

And the final table may contain holes or other odd features. That could happen if, within a row of elements, there's one spot for which no isotope persists long enough to qualify as an element.

Another idiosyncrasy: Elements may not be arranged in sequential order by the number of

MARILYN CHUNG/BERKELEY LAB



Jacklyn Gates and Ken Gregorich of the FIONA experiment at Lawrence Berkeley National Laboratory made the first measurements of the masses of recently discovered elements 113 and 115.

protons they contain, according to calculations in a 2011 paper by Pyykkö in *Physical Chemistry Chemical Physics*. Element 139, for example, might sit to the right of element 164 — if such heavy elements indeed exist. That's because special relativity alters the normal order in which electrons slot themselves into shells, arrangements that define how the electrons swirl about the atom. That pattern of shell filling is what gives the periodic table its shape, and the unusual filling may mean scientists decide to assign elements to spots out of order.

But additions to the table could dry up before that happens if scientists reach the limit of their ability to create heavier elements. When elements live minuscule fractions of a second, even the atom's trip to a detector may take too long; the element would decay before it ever had a chance to be spotted.

In reality, there's no clear idea of how to search for elements beyond 119 and 120. But the picture has seemed bleak before.

"We should not underestimate the next generation. They may have smart ideas. They will have new technologies," Düllmann says. "The next element is always the hardest. But it's probably not the last one." ■

Explore more

- Royal Society of Chemistry's periodic table: www.rsc.org/periodic-table
- Oak Ridge National Laboratory's tennessine resource page: bit.ly/ORNL117

SHINGLES' *SNEAK ATTACK*

After causing chicken pox, varicella zoster virus (shown) waits in the body to launch a different illness, shingles, later. About 1 million people in the United States get shingles each year.

SCIENCE PHOTO LIBRARY/ALAMY STOCK PHOTO

The painful rash is common, but there may be more damage to endure **By Aimee Cunningham**

At age 37, Hope Hartman developed a painful, burning rash in her right ear, in the part "you would clean with a Q-tip," the Denver resident says. The pain got so bad she went to a local emergency room, where the staff was flummoxed. Hartman was admitted to the hospital, where she started to lose sensation on the right side of her face.

During that 2013 health crisis, Hartman's husband, Mike, sent a picture of the ear to his mom, a nurse. She said it looked like zoster, better known as shingles, which is caused by the varicella zoster virus. She "diagnosed it from an iPhone photo," Hartman recalls.

Antiviral treatment didn't fully clear the infection. For about two weeks after her release from the hospital, Hartman coped with severe pain, hearing loss and difficulty eating. Her right eye wouldn't fully open or close. Following an appointment with neurologist Maria Nagel of the University of Colorado School of Medicine in Aurora, Hartman was admitted to the university's hospital to get another antiviral drug intravenously. The pain subsided, and Hartman regained her hearing and the feeling in her face.

To spare others the same trauma of a delayed diagnosis, Hartman arranged for Nagel to give a talk on the virus at the local hospital where staff missed the signs of the illness, known as Ramsay Hunt syndrome. That's the name for a shingles infection that strikes the facial nerve important to facial movement. As Hartman experienced, varicella zoster virus can cause a grab bag of symptoms that go beyond the typical torso rash.

Hartman's young age didn't help with the diagnosis. Shingles is more common in people 50 and older. But no one is risk-free. Varicella zoster virus lives in about 95 percent of the U.S. adult population, thanks to the virus's first line of attack: chicken pox. The body eventually clears the itchy, red pox from the skin, but the virus remains, dormant in nerve cells. The rash kept scores of U.S. children home from school until about 1995 (when a vaccine became available).

Decades after its first assault, varicella zoster virus can mount a second attack from its hiding place within nerve cells, bringing pain, burning, numbness or itchiness to the skin, after which a blistery rash often blooms. The pain and rash are usually confined to the strip of skin connected to the infected nerve cells.

The torso is the most common site of this eruption; the belt of pain and rash wraps from front to back on half of the body. Indeed, the words *zoster* and *shingles*, from Greek and Latin, mean girdle or belt. As to the pain, the Norwegian word for shingles, *helvetesild*, means "hell's fire."

Less common, but just as painful, shingles can originate on one side of the face, in an ear or in and around an eye. And researchers now know that shingles can occur in the gut, which comes with no rash tip-off.

95 percent
Estimated proportion of U.S. adults who carry varicella zoster virus

The list of nasty complications from the infection has also grown beyond the debilitating pain that persists in some people for months or years. Recently, scientists have learned more about the virus's ability to infect arteries, increasing the risk of stroke or causing headaches and vision problems. There are even hints of a connection between shingles in the eye and dementia.

Researchers are fighting back against the virus. In 2017, the U.S. Food and Drug Administration approved Shingrix, a vaccine to prevent shingles in people 50 and older that outperforms an earlier vaccine, Zostavax. (Yet supplies of the new vaccine aren't keeping up with demand.) And in the lab, scientists recently uncovered a genetic message in the virus that may eventually provide a way to lock the virus in a permanent sleep.

A reawakening

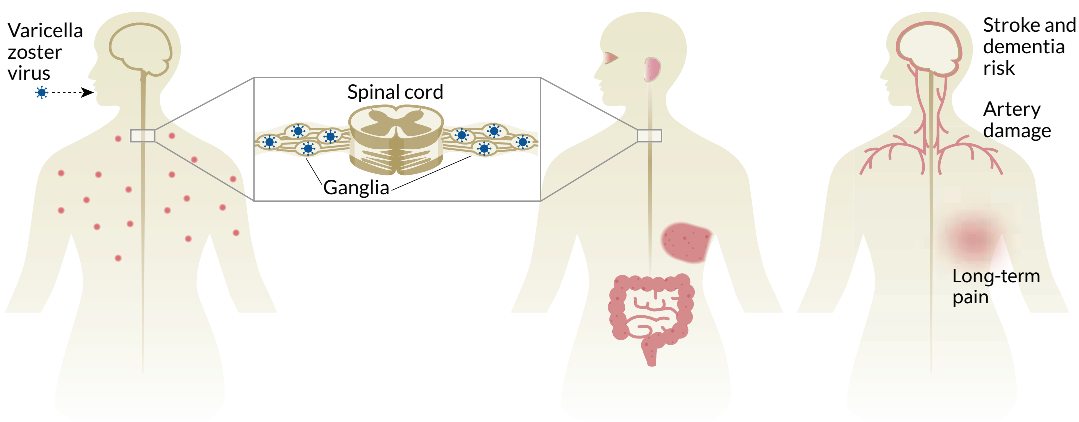
A half century ago, a doctor in Cirencester, England, northwest of London, developed a

Hope Hartman had shingles in her right ear, which stumped the first doctors she saw. She experienced terrible pain, hearing loss and weakened sensation on the right side of her face until the infection subsided.

BOTH: COURTESY OF H. HARTMAN

Double duty

Varicella zoster virus causes chicken pox, a body-wide rash (1), then hides within nerve cell hubs called ganglia (2). Years later, the virus may launch a second infection, shingles (3), in the torso, an eye, ear, or even the gut, depending on the location of the ganglia where the virus awakens. Shingles may lead to complications (4) that boost stroke and dementia risk. SOURCE: LEIGH ZERBONI *ET AL/NATURE REVIEWS MICROBIOLOGY* 2014



hypothesis for how shingles arises, based on observations of 1,270 patients with either chicken pox or shingles in his practice from 1947 to 1962. By tracking those patients, R. Edgar Hope-Simpson demonstrated that shingles was not a new infection from outside of the body but a reawakening of the varicella zoster virus from within. He also noted that the occurrence of shingles rose with age and that patients whose immune systems were suppressed, due to leukemia or radiation therapy, for example, were also at higher risk.

Hope-Simpson shared his hypothesis in a 1964 lecture. He proposed that during chicken pox, the virus travels from the infected skin — along nerves that detect sensation in the skin — to hubs of nerve cell bodies outside of the central nervous system, called ganglia. Within a ganglion, the virus becomes dormant, remaining in the body for life. If the virus awakens and multiplies, copies of the virus travel back along nerves to the skin, and shingles, also called herpes zoster, flares up.

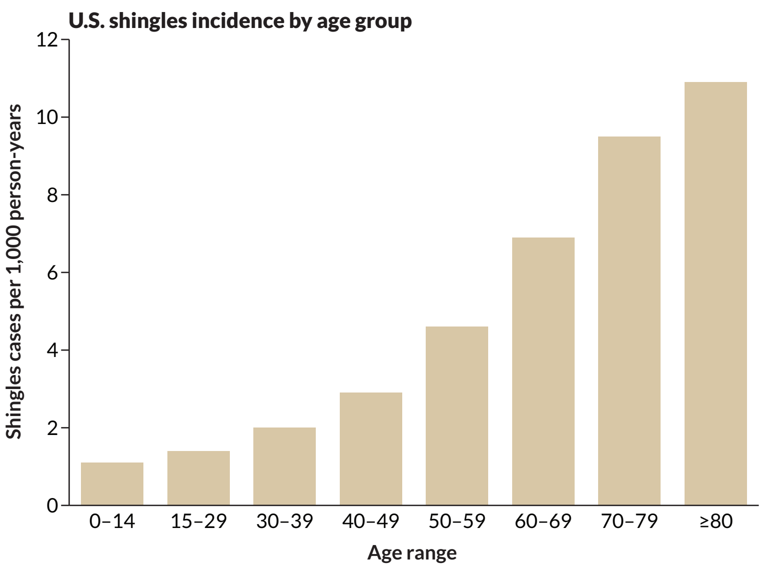
The British doctor's hypothesis was largely on the mark. Today, scientists are expanding the virus's list of effects. Because every organ in the body has a supply of nerves, Nagel says, "there's a direct pathway, when [the] virus reactivates, to hit every single organ system."

One recently discovered viral target is the gut. Anne Gershon, a pediatric virologist at Columbia University Vagelos College of Physicians and Surgeons in New York City, and colleagues found that the virus haunts the digestive organs' local system of nerves, known as the enteric nervous system. In the gut, instead of a rash, the virus can cause abdominal pain, ulcers or other problems.

Gershon and colleagues — including her husband, Michael Gershon, also at Columbia and an expert on the enteric nervous system — detected varicella zoster virus in the saliva of six of 11 patients with unexplained abdominal pain for up to four months. The researchers reported those findings in 2015 in *Clinical Infectious Diseases*.

Age discriminator

Shingles can strike anyone infected with varicella zoster virus, but the risk really begins to climb with each year after age 50. Data here are for the U.S. population, but this trend also holds for populations worldwide.
SOURCE: R.P. INSINGA *ET AL/JOURNAL OF GENERAL INTERNAL MEDICINE* 2005

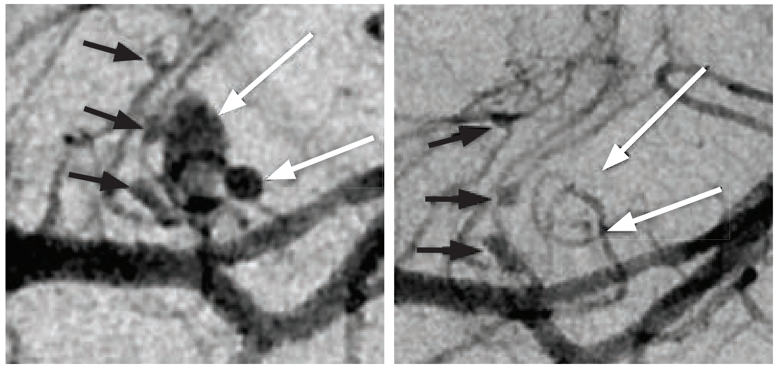


It's complicated

During shingles, the virus can also infect arteries. The immune system's attempt to clear the infection from the vessels sparks inflammation, damaging artery walls. When this post-shingles complication, called varicella zoster virus vasculopathy, hits arteries in the brain, stroke risk goes up.

Numerous studies have shown the heightened stroke risk, to varying degrees and length of time. The first major look was a study of Taiwanese medical records published in 2009, which found

BOTH: E. OTWELL



Shingles can lead to a weakening of the artery wall that causes the vessel to balloon out. These aneurysms boost stroke risk. In a shingles patient, five aneurysms appear in the brain (left, arrows). With antiviral treatment, two of the aneurysms disappeared (right, white arrows).

A.L. LIBERMAN *ET AL*/*NEUROLOGY* 2014

a 31 percent increase in stroke risk for a year after shingles; when shingles had occurred in the eye, stroke risk rose further, roughly four times above normal. More recent studies out of the United Kingdom, Germany and the United States have found similar trends.

Antiviral drugs can reduce pain and itchiness and hasten the rash's departure. The U.K. study, published in 2014 in *Clinical Infectious Diseases*, suggested that those same drugs reduced the risk of a post-shingles stroke. Yet, in cases of shingles that feature pain but no rash, the diagnosis may be missed and the infection left untreated.

The brain vessel damage that can occur with shingles is similar to what is often seen in dementia. So researchers in Taiwan wondered whether having shingles in the eye raises the risk of dementia. The team analyzed health insurance data and found that dementia risk was three times higher for people who'd had shingles in the eye, known as herpes zoster opthalmicus, compared with those who hadn't had an episode. The group with shingles in the eye experienced 10.2 new cases of dementia per 1,000 people per year compared with 3.6 new cases per 1,000 in the group with no shingles, according to a 2017 report in *PLOS ONE*.

The reactivated virus may also be behind some cases of a painful inflammation of the arteries at the temples called giant cell arteritis. More common in older adults, the disorder causes severe headaches, jaw pain and vision problems, and can lead to blindness. Nagel and colleagues found the virus in 61 of 82 artery samples taken from the temples of patients with the disorder, the team reported in 2015 in *Neurology*.

A potential sleeping pill

Varicella zoster virus can stir up a lot of trouble in the body, depending on where it awakens. But surprisingly, the virus appears to hide in very few nerve cells. In autopsy samples of ganglia from 18 people who had had chicken pox, researchers found dormant virus in only 34 of 2,226 nerve cells, or 1.5 percent. The dormant virus in the body "is like a needle [in] a huge haystack," says neurovirologist Randall Cohrs of the University of Colorado School of Medicine in Aurora. "That needle can reactivate and wreak so much havoc."

How this virus does what it does has vexed scientists for a long time. Humans are the only animals that can become infected by this virus, which makes studies in rats and other lab animals challenging. But varicella zoster shares certain features with herpes simplex type 1, a virus that also lies dormant in nerve cells. Herpes simplex causes cold sores and other health problems when it reactivates. Research has revealed a genetic message in the virus, called a latency associated transcript, that appears to keep the herpes simplex virus from becoming active.

Judith Breuer, a clinical virologist at University College London, and colleagues have now found a similar genetic message in varicella zoster virus, which they reported last year in *Nature Communications*. Using recently developed tools that allow researchers to zero in on very small amounts of genetic material, the researchers analyzed ganglia autopsy samples and pulled out a transcript "which had never before been seen," Breuer says.

The transcript, which Breuer's group dubbed the varicella zoster virus latency-associated transcript, or VLT, is a message that appears to stop a gene in the virus from turning on and launching an active infection.

This research offers "a new mechanism for how varicella zoster virus may establish and maintain latency," says Jeffrey Cohen, chief of the Laboratory of Infectious Diseases at the National Institute of Allergy and Infectious Diseases in Bethesda, Md. And because the VLT seems to block a gene that's crucial to an active infection, Cohen says, there may be ways to manipulate the VLT and prevent the virus from reawakening and causing shingles.

Shot to the system

Someday there may be drugs, based on VLT or other new findings, to keep the virus dormant. But for now, vaccines are the best protection.

Approved in 2006, Zostavax was the first vaccine to prevent shingles. Based on the chicken pox vaccine, Zostavax is a high-dose version of live, weakened virus, meant to boost the body's immune response. In a clinical trial of Zostavax in people 60 and older, 315 cases of shingles occurred in a group of about 19,200 people who got the vaccine. In a placebo group of the same size, 642 people got shingles. The vaccine offered less protection for people 70 and older, those at highest risk for the disease.

"The older you get, the more likely you are to get zoster," Anne Gershon says. "And the more likely your zoster is to produce postherpetic neuralgia," the debilitating pain that can persist long after the rash retreats in anywhere from 5 to 30 percent of patients.

A better vaccine that stimulates the immune system with a protein from the virus, rather than with a live, weakened virus, became available in 2017. Called Shingrix, the vaccine was 97 percent effective at preventing shingles in adults 50 and older in a clinical trial that followed participants for an average of about three years, researchers reported in 2015 in the *New England Journal of Medicine*.

Shingrix made a very strong showing in people 70 and older as well; it was about 90 percent effective at stopping shingles and preventing postherpetic neuralgia, scientists reported in the same journal in 2016. So far, the vaccine appears to provide strong immune protection for nine years.

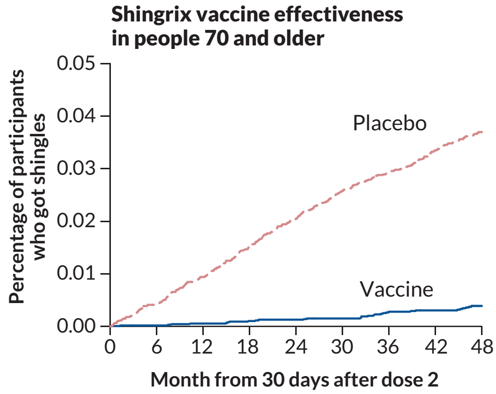
"It feels like the devil.... When the pain gets too bad, it's as though my shirt is on fire."
NORA FOX

The vaccine may also reduce the risk of stroke and other complications of shingles. Shingrix was 94 percent effective at preventing post-shingles complications for those 50 and older (92 percent for those 70 and older) in an analysis of clinical trials, published in 2018 in *Vaccine*.

Unfortunately, a shortage of Shingrix in the United States that began in mid-2018 is expected to continue this year, leaving some adults in limbo as they try to complete the two-shot vaccine regimen. But GlaxoSmithKline, the maker of the vaccine, has pledged to increase the U.S. supply.

Meanwhile, a kind of population-wide experiment is happening, one that might answer this question: Will shingles largely go away? Those vaccinated with Shingrix will be protected against shingles and postherpetic neuralgia — not complete protection but pretty close.

The chicken pox vaccine leaves a live, weakened virus dormant within nerve cells, where it could later cause shingles. But there's early evidence that the vaccine may offer some protection. In a study from 2005 to 2009 in children younger than 18 (who can get shingles, though rarely), researchers recorded 48 cases of shingles per 100,000 vaccinated children per year versus 230 cases per 100,000 per year in kids who did not get the vaccine. The study was reported in



A better option The Shingrix vaccine (blue line) reduced cases of shingles in people 70 and older compared with a placebo (red line). An earlier vaccine, Zostavax, did not work as well in older adults.

2013 in the *Journal of Infectious Diseases*.

The United States is "facing the possibility that [it] will see very, very, very little varicella zoster virus disease," Breuer says. Of course, that requires maintaining high vaccination rates. At the moment, that leaves out people like Hope Hartman, now 43. She had chicken pox before a vaccine was available, and she was (and still is) too young to get the vaccine to prevent shingles. Shingrix was tested only in people 50 and older and therefore approved only for that age group.

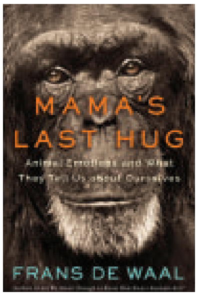
For Nora Fox, who lives in Parker, Colo., the shingles vaccines came too late. Fox's shingles began as she was hanging fall decorations on her porch in September 2005, when she was 67. She felt what she thought was a bug bite under her right arm. That night, her pain grew, and in the following months and years, it did not go away. Now 81, Fox has postherpetic neuralgia. She describes the pain as a branding iron constantly held against her torso. "It feels like the devil."

The pain, for which there is no reliable treatment, shapes Fox's days. She feels best in the mornings, so that's when she plans appointments and does aerobics at the pool. Her pain grows worse in the afternoon and evening. She uses ice packs and creams to try to cool down the skin. "When the pain gets too bad, it's as though my shirt is on fire," she says.

Fox has encouraged her friends to get vaccinated. But they see her in the morning when she feels her best. So she tells them, "You should come see me about 2 o'clock. You'd get it." ■

Explore more

- Kenneth Schmader. "Herpes zoster." *Annals of Internal Medicine*. August 7, 2018.



Mama's Last Hug
Frans de Waal
W.W. NORTON & CO, $27.95

BOOKSHELF

Emotions occur throughout the animal world

During the last few weeks of her life, Mama, an elderly chimpanzee at a zoo in the Netherlands, received a special visitor. As Mama lay curled up on a mound of straw, biologist Jan van Hooff entered her enclosure. Van Hooff, who had known Mama for more than 40 years, knelt down and stroked the arm of the listless chimp. When Mama looked up, her vacant face erupted into a smile. She reached out to van Hooff, calling out as she patted his face and neck.

For primatologist Frans de Waal, this touching scene isn't difficult to interpret: Mama was happy to see her old friend. But such an interpretation has been taboo among many behavioral scientists, who have claimed nonhuman animals are like unthinking, emotionless machines that react to situations with preprogrammed instincts.

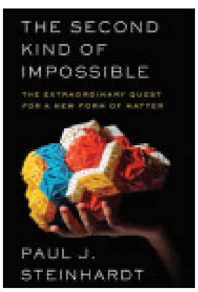
In the thought-provoking *Mama's Last Hug*, de Waal dismantles that view. He presents piles of evidence that animals are emotional beings. The book is a companion to *Are We Smart Enough to Know How Smart Animals Are?*, in which he explored animal intelligence (*SN: 12/24/16 & 1/7/17, p. 40*).

Emotions, de Waal writes, "are bodily and mental states — from anger and fear to sexual desire and affection and seeking the upper hand — that drive behavior." On page after page, he tells of depressed fish, empathetic rats, envious monkeys and other emotional creatures. More than a collection of fascinating anecdotes, *Mama's Last Hug* weaves together formal observations of animals in the wild and in captivity, behavioral experiments and neuroscience research.

That animals have emotions makes sense from an evolutionary perspective, de Waal explains. The basic physiology and brain chemistry that give rise to emotions in humans are present in other members of the animal kingdom. And emotions offer a much more flexible way to evaluate and respond to events in an ever-changing environment than instincts do.

Of course, other animals' emotions are not the same as human emotions, de Waal notes. There are differences "in the details, elaborations, applications and intensity." And whether other animals are aware of their emotions, what de Waal defines as "feelings," is still up for debate, he says.

De Waal's conversational writing is at times moving, often funny and almost always eye-opening. Though some of his claims are more persuasive than others, it's hard to walk away from *Mama's Last Hug* without a deeper understanding of our fellow animals and our own emotions. *— Erin Wayman*



The Second Kind of Impossible
Paul J. Steinhardt
SIMON & SCHUSTER, $27

BOOKSHELF

Quasicrystal quest is a physics adventure tale

When Paul Steinhardt made a discovery that he had been working toward for more than 20 years, he did not cry "Eureka!" On that winter morning in the lab in 2009, he writes, he and a colleague "were dead silent, because no words were necessary."

Steinhardt had just found a natural quasicrystal, a solid whose atoms flout the laws of crystallography by having order that does not repeat. The quasicrystal was in a rock that had been sequestered in a museum in Florence. In *The Second Kind of Impossible*, Steinhardt, a theoretical physicist, chronicles the detective work that led to his no-eureka-necessary moment — and sent him from Princeton University to the wilds of Siberia to find out how that rock had formed.

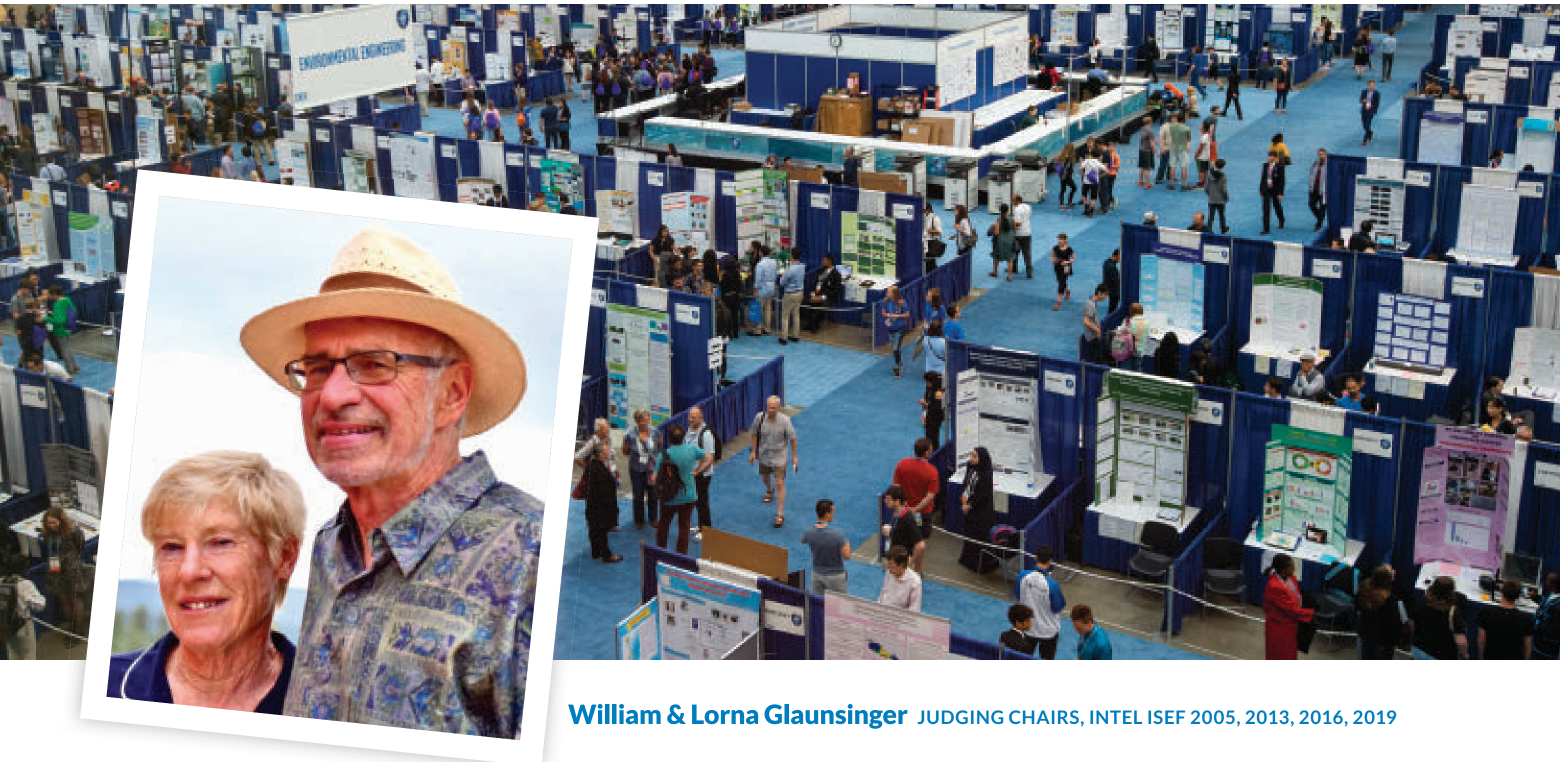
The very idea of quasicrystals was once derided. Chemist Linus Pauling joked, "There is no such thing as quasicrystals. Only quasi-scientists." But in the 1980s, Steinhardt wondered if quasicrystals were truly out of the question, or if they were a "second kind of impossible" — something achievable under conditions that just hadn't been considered yet. By 2009, scientists had synthesized these supposedly impossible materials. Steinhardt wondered if nature could make them too.

His memoir is part physics primer, part fantastic adventure and nearly all delightful. The book is divided into three parts: first, the mathematical work that showed quasicrystals are possible, then the search for a natural quasicrystal and finally the epic trek across the Russian tundra to find additional samples of the rock, a meteorite as it turned out (*SN: 11/3/12, p. 24*).

The account is chock-full of detail, sometimes to the story's detriment. At one point Steinhardt complains of an e-mail written partly in "geochemist-speak." He writes: "I felt like screaming out of sheer frustration." Readers may at times feel similarly, especially in the first third of the book.

But the tempo picks up with the quasicrystal hunt. Starting with an e-mail from the geologist who identified that first special rock, the trail leads from Italy to the Netherlands to Russia. Steinhardt's quest touches on platinum panning in Siberia, secret diaries in Amsterdam, a mysterious Romanian mineral dealer and possible connections to the KGB.

Steinhardt's affection and admiration for the journey's colorful cast of characters infuse every page. Although his excitement is palpable, he is also careful and methodical, often reminding himself that he could be wrong. *The Second Kind of Impossible* shows the benefit of a slow and steady approach to science, where determination and luck are just as important as insight. *— Lisa Grossman*



William & Lorna Glaunsinger JUDGING CHAIRS, INTEL ISEF 2005, 2013, 2016, 2019

Why we volunteer at the Intel International Science and Engineering Fair

After attending our first Intel ISEF experience in 2003, we were hooked!

In 2003, we were recruited to head up judging at Intel ISEF, which was being held in Phoenix two years later. We couldn't say no to the opportunity. We were so impressed with the caliber and passion of the student finalists, and we departed much more optimistic about the future of our society. Since then, we have served in several capacities, including as Grand Awards Judges, Category Co-Chairs, Judging Chairs, members of the Judging Advisory Committee and Science Advisers for the award-winning documentary *Inventing Tomorrow.*

Our favorite Intel ISEF memory

We were on the Judging Advisory Committee in 2017, and Pelagia Majoni from Zimbabwe engineered a high-efficiency potato battery to provide electricity to her remote village. Her project had not received much attention, but it was an excellent example of how students can develop creative solutions to real-world problems. Once the significance of her project was appreciated by other judges, she received a second place category award and a scholarship to the University of Arizona in Tucson.

Why we continue to volunteer and support Intel ISEF more than 15 years later

It's simple: Where else can you encourage such a large cadre of the next generation of science and technology leaders to continue their amazing accomplishments? We desperately need these emerging leaders to stay engaged and help the world address its most pressing problems, ranging from climate change to global health.

We believe that the world's best hope is not to raise an army for combat but instead to develop an army of talented scientists and engineers whose generals will come up through the ranks, inspired by competitions like Intel ISEF.

We also benefit from working with the many outstanding people who share our commitment. We enjoy networking with new and returning academic and corporate judges, as well as interacting with the student finalists.

We encourage you to get involved with Intel ISEF as a judge, an interpreter or in another volunteer capacity.

You just might get hooked like us!

MAIN IMAGE: CHRIS AYERS PHOTOGRAPHY/SOCIETY FOR SCIENCE & THE PUBLIC; INSET: LESTER COAKER

GET INVOLVED WITH INTEL ISEF https://student.societyforscience.org/grand-award-judges

JANUARY 19, 2019

SOCIAL MEDIA

Element name game

In honor of the periodic table's 150th anniversary, *Science News* asked readers to send in their favorite element fact or memory of the periodic table (*SN: 1/19/19, p. 2*). On Twitter, **@msssmhr** shared a tidbit about the noble gases neon, krypton, argon and xenon. "They bear curious Greek names … which mean 'the new,' 'the hidden,' 'the inactive' and 'the alien.' They are so satisfied with their condition that they do not interfere in any chemical reaction."

Join the conversation

E-MAIL editors@sciencenews.org

MAIL Attn: Feedback
1719 N St., NW
Washington, DC 20036

Connect with us

Dad's contribution

*Scientists have long thought that children inherit mitochondria — tiny energy factories found in cells — from only their mothers. But data from three unrelated families suggest that in rare cases children can also inherit mitochondria from their fathers, **Tina Hesman Saey** reported in "Dads can pass on mitochondria too"* (SN: 1/19/19, p. 8*)*. Online reader **John Turner** had a lot of questions about dad-derived mitochondria.

"What factors allow paternal mitochondria to enter the egg?" he asked. "How many human conceptions include paternal mitochondria in the general population? Does the ratio of paternal/maternal mitochondria vary in particular tissues?"

In most cases, paternal mitochondria enter the egg at conception but are usually tagged for destruction and removed, **Saey** says. "As to how many paternal mitochondria escape that death sentence, there's really no way to know without thoroughly examining a large number of people's DNA with a technique called deep sequencing," she says. "The first person discovered to have paternal mitochondria carried them only in his muscle cells. Detecting dad's mitochondria in other tissues may require more than a blood or spit test." The researchers think this phenomenon is probably rare. Mothers are still the parents who pass along the majority of mitochondria.

Online reader **stargene** wondered what implications the finding might have for the human molecular clock, which traces human evolution via changes in mitochondrial DNA.

"This shouldn't radically affect a human's mitochondrial clock," **Saey** says. The clock "is based on rates of mutations in mitochondria rather than on which parent passes along the organelles," she says.

Break it down

*Biochemical changes in rotting meat offer clues about Neandertal diets, **Laurel Hamers** reported in "Neandertal diet may have been rotten,"* (SN: 1/19/19, p. 4*)*.

Reader **Steve Trudell** objected to the article's description of what happens to different forms of nitrogen, called isotopes. In the story, **Hamers** explains that concentrations of nitrogen-15 and nitrogen-14 in meat differ because nitrogen-15 is harder to break down than nitrogen-14.

"Wrong," **Trudell** wrote. "Both [nitrogen-14] and [nitrogen-15] are stable isotopes so they don't 'break down.' "

Hamers acknowledges that the wording is confusing. "Trudell is correct that these nitrogen isotopes don't decay like radioactive isotopes do," she says. It's the compounds that contain isotopes that break down. In decaying meat, bacteria break down molecules rich in nitrogen-14 easier than those rich in nitrogen-15. Microbes take up the lighter nitrogen-14 more readily because it requires less energy to use, says paleobiologist **Kimberly Foecke**. As a result, nitrogen-15 is left behind.

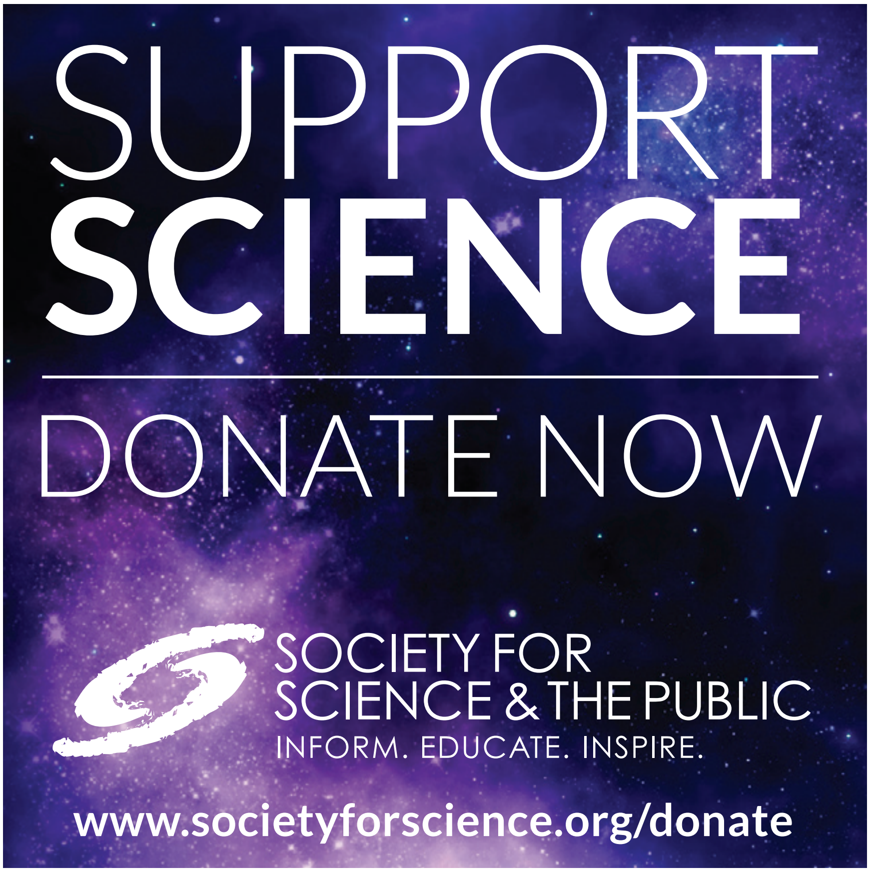
A growing problem

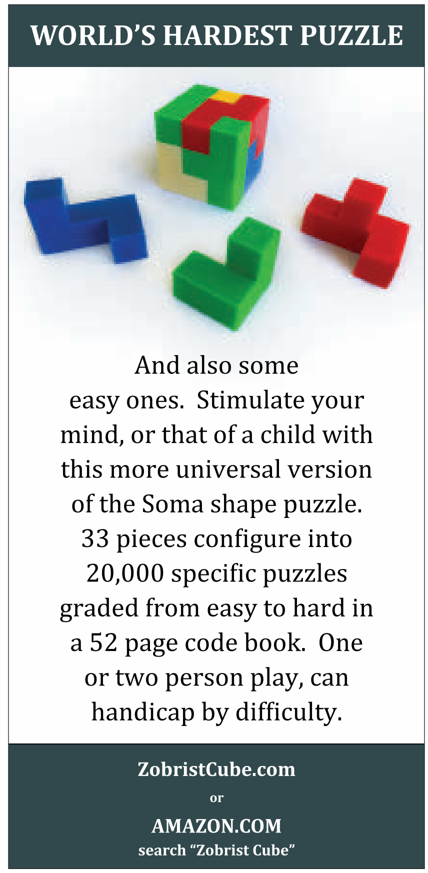
*Many coral species that make up the Great Barrier Reef have been found lurking in the deep ocean, **Cassie Martin** reported in "Corals are abundant in the deep"* (SN: 1/19/19, p. 5*)*. Online reader **John Turner** wondered how deep ocean corals might be affected by microplastics.

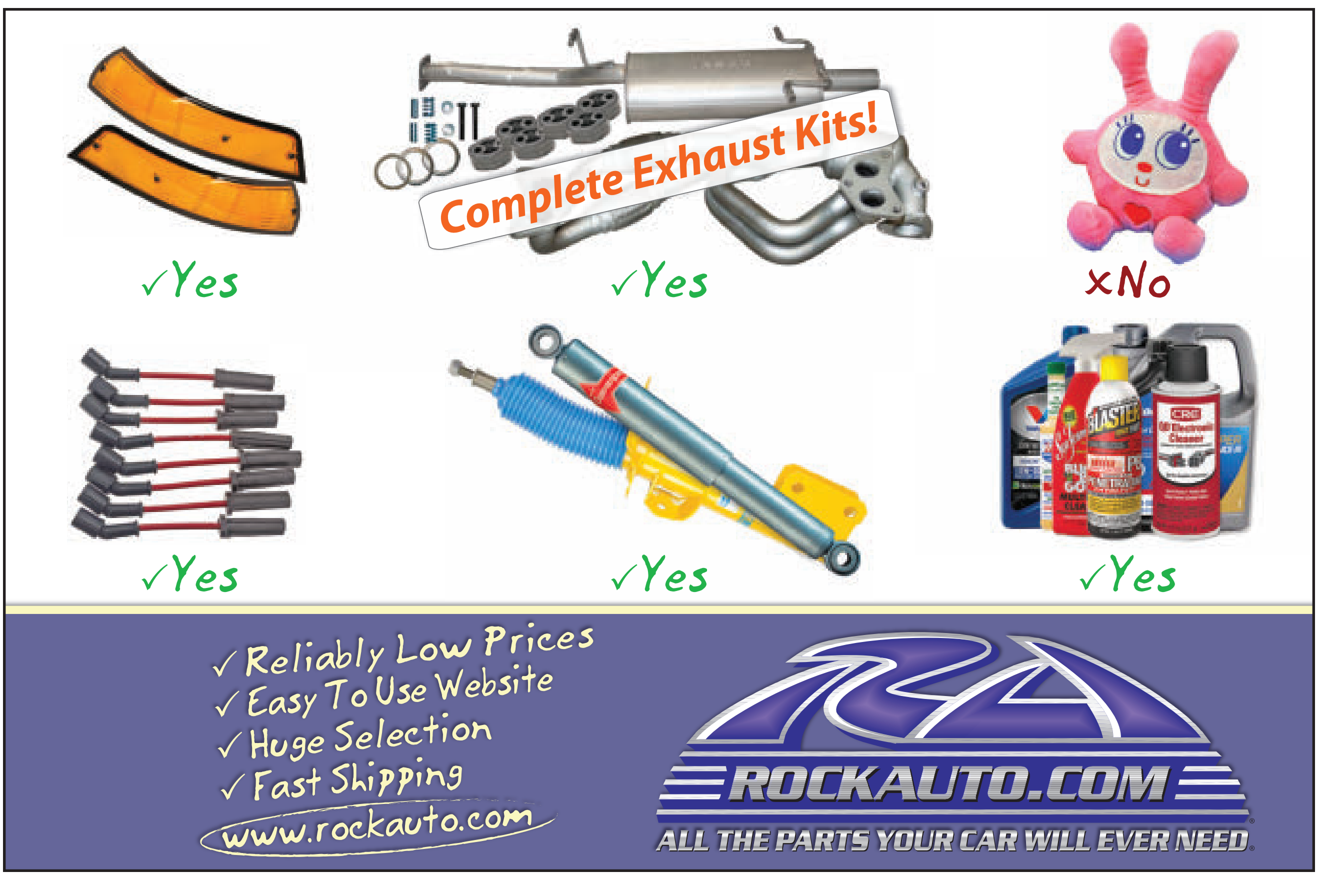
Ocean plastic pollution is a scourge on shallow and deepwater habitats around the world (*SN: 2/20/16, p. 20*). "Scientists are just beginning to understand what tiny plastic debris do to deep ocean corals," **Martin** says. For example, laboratory experiments on one deep ocean coral species suggest that microplastics inhibit coral growth, researchers reported in 2018 in *Scientific Reports*.

Correction

The story "Kilauea curiosities" (*SN: 2/2/19, p. 22*) reported that by the time the months-long eruption of Kilauea ended in August, nearly 300 hectares of seafloor had been added to Hawaii's southeast coast. This is incorrect. The volcanic eruption added almost 300 hectares of land.


SUPPORT
SCIENCE
DONATE NOW
SOCIETY FOR
SCIENCE & THE PUBLIC
INFORM. EDUCATE. INSPIRE.
www.societyforscience.org/donate


WORLD'S HARDEST PUZZLE
And also some easy ones. Stimulate your mind, or that of a child with this more universal version of the Soma shape puzzle. 33 pieces configure into 20,000 specific puzzles graded from easy to hard in a 52 page code book. One or two person play, can handicap by difficulty.
ZobristCube.com
or
AMAZON.COM
search "Zobrist Cube"


✓Yes
Complete Exhaust Kits!
✓Yes
xNo
✓Yes
✓Yes
✓Yes
✓ Reliably Low Prices
✓ Easy To Use Website
✓ Huge Selection
✓ Fast Shipping
www.rockauto.com
ROCKAUTO.COM
ALL THE PARTS YOUR CAR WILL EVER NEED

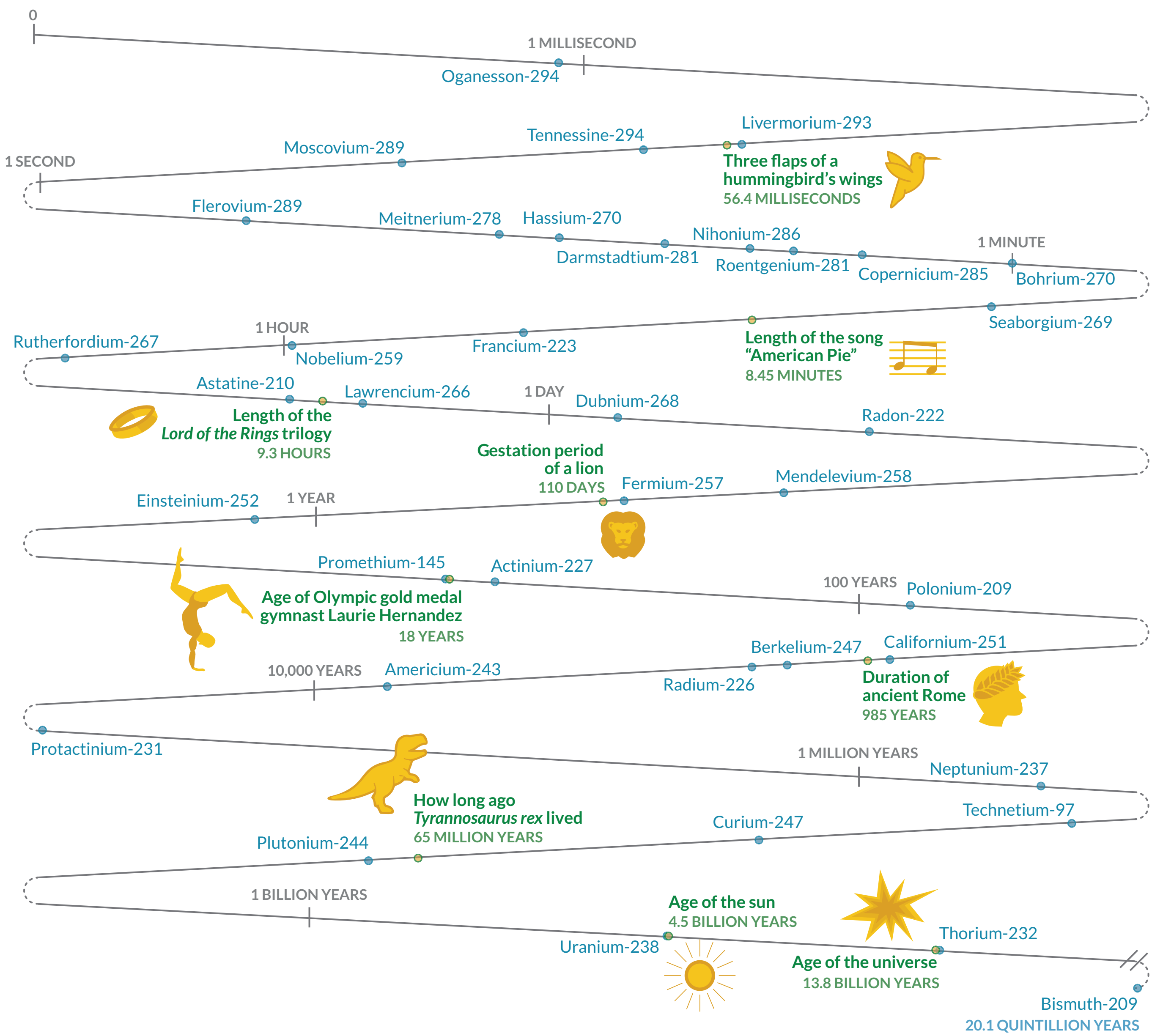
Meet the periodic table's unstable elements

On the periodic table, most elements have at least one stable form. But others have only unstable forms, all of which decay by emitting radiation and transforming into different elements until becoming one that's stable. The timescale of radioactive decay is known as an element's half-life, the time it takes for a sample of an element to be reduced by half.

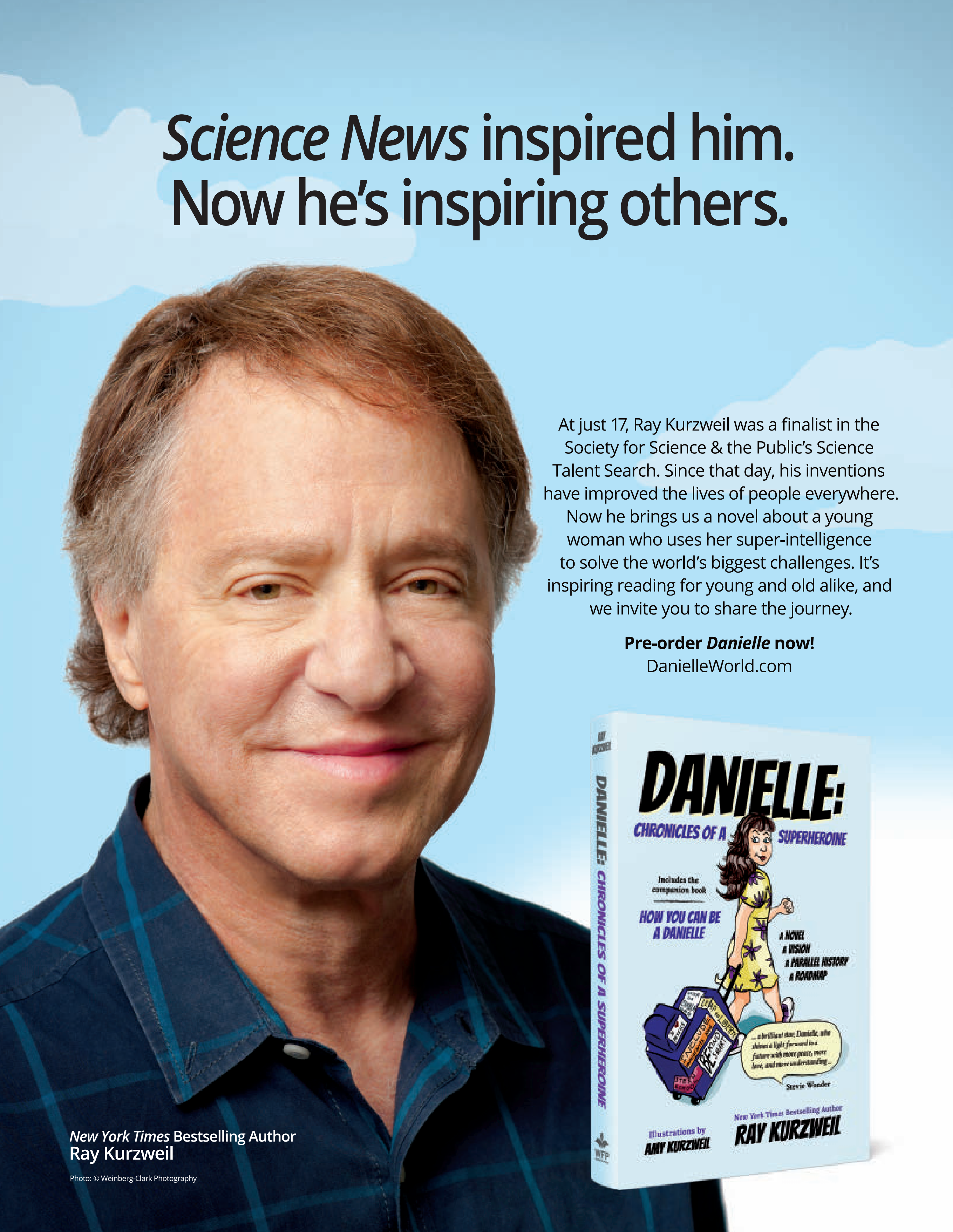
Generally for the elements after uranium, the further along they are on the periodic table — the higher their atomic number — the less time they last. Half-lives of unstable elements vary by nearly 30 orders of magnitude. For comparison, the Milky Way's diameter is about 30 orders of magnitude larger than the width of a DNA helix.

The graphic below charts the time it takes for the longest-lived isotope — a form having the same number of protons but a different number of neutrons — of each of the unstable elements to decay. (These half-lives are not exact numbers; each has an uncertainty associated with it.) Even when plotted on a logarithmic scale, with the distance between points on the graphic representing bigger amounts of time as the half-lives grow, bismuth, the longest-lived unstable element, is off the charts.

Will all future elements discovered have shorter and shorter half-lives? Scientists aren't so sure. They expect to reach a theoretical "island of stability," where half-lives will buck the trend (see Page 16). These elements might last a few seconds, or a day. No one knows what properties they'll have, or if these elements could help scientists learn more about how the atom — and thus all of matter — holds itself together. And so researchers keep smashing atoms together, hoping to paddle closer to the island's fabled shore. — *Carmen Drahl*



GRAPHIC: E. OTWELL; SOURCES: IAEA, BROOKHAVEN NATIONAL LABORATORY, G. AUDI ET AL/*CHINESE PHYSICS C* 2017



Science News inspired him.
Now he's inspiring others.
At just 17, Ray Kurzweil was a finalist in the Society for Science & the Public's Science Talent Search. Since that day, his inventions have improved the lives of people everywhere. Now he brings us a novel about a young woman who uses her super-intelligence to solve the world's biggest challenges. It's inspiring reading for young and old alike, and we invite you to share the journey.
Pre-order *Danielle* now!
DanielleWorld.com
DANIELLE:
CHRONICLES OF A SUPERHEROINE
Includes the companion book
HOW YOU CAN BE A DANIELLE
A NOVEL
A VISION
A PARALLEL HISTORY
A ROADMAP
Stevie Wonder
New York Times Bestselling Author
RAY KURZWEIL
Illustrations by
AMY KURZWEIL
New York Times Bestselling Author
Ray Kurzweil
Photo: © Weinberg-Clark Photography