SN
SCIENCE NEWS MAGAZINE
SOCIETY FOR SCIENCE & THE PUBLIC
NOVEMBER 15, 2014

DIY Brain Boost

Snake-Bot Shimmy

Speedy Raindrops

Early Cave Art in Asia

SPIRAL INSPIRATION

An age-old shape goes kinetic to help patients walk easier

How You Do That Voodoo That You Do?

Cast your spell with our Flambeaux Necklace, a magical mix of amethyst and peridot for only $59!

New Orleans is like no other place on Earth. Soulful Dixieland jazz and bayou blues combine with a devil-may-care attitude. To honor the jewel of Louisiana we've designed a necklace as bold as the Big Easy. Our ***Flambeaux Necklace*** is 200 carats of genuine gemstones that distills the essence of N'awlins into the cool colors of Mardi Gras. Previously $299, this strand is all yours for an unbelievable **$59!**

Necklace enlarged to show luxurious detail.

Carnival of Carats. The ***Flambeaux*** features 180 carats of genuine amethyst, 20 carats of cool peridot and gold-finished beads that transform any woman into a Bourbon Street beauty queen. Purple, gold and green—representing justice, power and faith—are colors that embody the festive spirit of Mardi Gras. Every year, raucous parades by the Krewes of New Orleans are lit by bright torchlight—*flambeaux*. As their floats roll down Bourbon Street, they toss beaded necklaces to the crowds. But make no mistake: the genuine gemstones in our ***Flambeaux Necklace*** are definitely not for throwing.

Approved by the Roman God of Revelry. Since our ***Flambeaux Necklace*** celebrates one of the biggest parties on the planet, it seemed appropriate to include a gemstone connected with Bacchus, God of Wine and Good Times. According to myth, amethyst was colored purple by the tears of Bacchus after he lost the woman he loved. Peridot, once known as "The Evening Emerald," was also among the ancient world's most powerful precious stones. Mythology made them magical, but only Stauer can make these two legendary gemstones so affordable!

Your Satisfaction is 100% Guaranteed. Try the ***Flambeaux Necklace*** today for only $59. If you're not positively bewitched by its beauty, send it back within 30 days for a full refund of your purchase price. Experience a little bit of Creole flavor spun into a glittering necklace of magic and let the ***Flambeaux*** light your way to the Big Easy!

Flambeaux Necklace ~~$299~~*

Your Cost With Offer Code— **$59** *Save $240!*

You must use the insider offer code to get our special price.

1-800-482-9124

Offer Code FBN175-01
Please use this code when you order to receive your discount.

* *Discount for customers who use the offer code versus the original Stauer.com price.*

200 carats of genuine amethyst and peridot gemstones
• Gold-finished spacers • 18" length (+2" extender) with lobster clasp

TAKE 80% OFF INSTANTLY!
When you use your INSIDER OFFER CODE

Stauer®
14101 Southcross Drive W.,
Dept. FBN175-01,
Burnsville, Minnesota 55337
www.stauer.com

ACCREDITED BUSINESS
Rating of A+

Smart Luxuries—Surprising Prices™

VOL. 186 | NO. 10

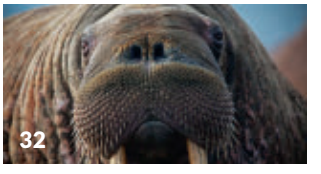
ScienceNews


22

Features

News


6


32

Departments

COVER Spirals have certain mathematical properties that make them a lifesaver for rock climbers and a potential aid for physical rehab. *Casarsa/iStockphoto*

CLOCKWISE FROM TOP: ELI MEIR KAPLAN; RYAN KINGSBERY/USGS; KINEZ RIZA

A species of invention

Roughly 40,000 years ago, early *Homo sapiens* was exploring ways to create images on the rocky walls of caves. Until now, most scientists thought this innovation occurred primarily in Europe, where the oldest examples of cave art have been found. But a recent discovery on the Indonesian island of Sulawesi shows humans there were using pigments to create hand stencils around the same time as their counterparts in Europe. As Bruce Bower reports on Page 6, scientists speculate that this type of artistic representation emerged multiple times, in groups all over the world. A very, very long time ago.

That discovery makes me wonder if the drive to innovate is simply part of who humans are. For more evidence, one need look no further than this issue's cover story. For the team of engineers featured in Dana Mackenzie's story on Page 18, that innovation is inspired by what they call "kinetic shapes" and what the rest of us call spirals. The idea is to use spirals to move better, whether on a shoe that helps people with injuries walk more easily, on a skateboard that rocks and rolls, or on the tip of a crutch designed to give an assist to its user. Whether these devices pan out and become useful products remains to be seen. But the innovation bug is clearly thriving.

Also infected with that bug are the student participants in Broadcom MASTERS, a science competition run by Society for Science & the Public, which publishes *Science News*. Among the 2014 finalists were kids who had developed ways to better predict wildfires and recycle pizza boxes — grease and all. (Read about the winners on Page 26.)

What's behind this invention bug? I'd nominate the human brain, which ceaselessly urges us to fiddle, tweak and improve what we have. As Laura Sanders describes on Page 22, that brain might now have figured out a way to improve itself using tiny electrical shocks. A few pioneers have even started making brain zappers at home. Some are trying to find ways to deal with problems like depression. But many others just want to enhance brain performance — an iffy and possibly risky proposition, Sanders reports. I'd argue our brains already work quite well. But I guess it's hard to stop when you are a species of invention. — *Eva Emerson, Editor in Chief*

EDITORIAL, ADVERTISING AND BUSINESS OFFICES

Audit Bureau of Circulations

1719 N Street NW, Washington, DC 20036
Phone: (202) 785-2255
Customer service: member@societyforscience.org
Editorial/letters: editors@sciencenews.org
Sponsor content: snsales@sciencenews.org

Science News (ISSN 0036-8423) is published biweekly by Society for Science & the Public, 1719 N Street, NW, Washington, DC 20036.

Online and iPad access: Activate your subscribing member account, including digital access and the ability to opt out of print, at sciencenews.org/activate

Subscribe:
Web Visit sciencenews.org/join to become a subscribing member or renew at sciencenews.org/renew
Phone Call (800) 552-4412 in the U.S. or (570) 567-1191 outside of the U.S.
E-mail member@societyforscience.org
Mail *Science News*, PO Box 1205, Williamsport, PA 17703-1205

Subscribing memberships include 26 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 1205, Williamsport, PA 17703-1205. Two to four weeks' notice is required. Old and new addresses, including zip codes, must be provided.

SANDY SCHAFFER

NEW

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

Better Sound and Longer Battery Life

No Contract

FREE Car Charger

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

"Cell phones have gotten so small, I can barely dial mine." Not Jitterbug®, it features a larger keypad for easier dialing. It even has an oversized display so you can actually see it.

"I had to get my son to program it." Your Jitterbug set-up process is simple. We'll even pre-program it with your favorite numbers.

"I tried my sister's cell phone… I couldn't hear it." Jitterbug is designed with an improved speaker. There's an adjustable volume control, and Jitterbug is hearing-aid compatible.

"I don't need stock quotes, Internet sites or games on my phone, I just want to talk with my family and friends." Life is complicated enough… Jitterbug is simple.

"What if I don't remember a number?" Friendly, helpful Jitterbug operators are available 24 hours a day and will even greet you by name when you call.

"I'd like a cell phone to use in an emergency, but I don't want a high monthly bill." Jitterbug has a plan to fit your needs… and your budget.

"My cell phone company wants to lock me in on a two-year contract!" Not Jitterbug, there's no contract to sign and no penalty if you discontinue your service.

Available in Blue, Red (shown) and White.

	Basic 14	Basic 19
Monthly Minutes	50	was ~~100~~ NOW 200
Monthly Rate	$14.99	$19.99
Operator Assistance	24/7	24/7
911 Access	FREE	FREE
Long Distance Calls	No add'l charge	No add'l charge
Voice Dial	FREE	FREE
Nationwide Coverage	YES	YES
Friendly Return Policy[1]	30 days	30 days

More minute plans available. Ask your Jitterbug expert for details.

"I'll be paying for minutes I'll never use!" Not with Jitterbug, unused minutes carry over to the next month, there's no roaming fee and no additional charge for long distance.

"My phone's battery only lasts a couple of days." The Jitterbug's battery lasts for up to 25 days on standby.

Enough talk. Isn't it time you found out more about the cell phone that's changing all the rules? Call now, Jitterbug product experts are standing by.

Order now and receive a **FREE Car Charger** for your Jitterbug – a $24.99 value. Call now!

jitterbug5

firstSTREET for Boomers and Beyond®
1998 Ruffin Mill Road
Colonial Heights, VA 23834

100% U.S. Based Customer Service

NEW Jitterbug5 Cell Phone

Call toll free today to get your own Jitterbug5.

Please mention promotional code 48642.

1-888-666-0354

www.jitterbugdirect.com

We proudly accept the following credit cards.

47618

IMPORTANT CONSUMER INFORMATION: Jitterbug is owned by GreatCall, Inc. Your invoices will come from GreatCall. All rate plans and services require the purchase of a Jitterbug phone and a one-time set up fee of $35. Coverage and service is not available everywhere. Other charges and restrictions may apply. Screen images simulated. There are no additional fees to call Jitterbug's 24-hour U.S. Based Customer Service. However, for calls to an Operator in which a service is completed, minutes will be deducted from your monthly balance equal to the length of the call and any call connected by the Operator, plus an additional 5 minutes. Monthly minutes carry over and are available for 60 days. If you exceed the minute balance on your account, you will be billed at 35¢ for each minute used over the balance. Monthly rate plans do not include government taxes or assessment surcharges. Prices and fees subject to change. [1]We will refund the full price of the GreatCall phone and the activation fee (or set-up fee) if it is returned within 30 days of purchase in like-new condition. We will also refund your first monthly service charge if you have less than 30 minutes of usage. If you have more than 30 minutes of usage, a per minute charge of 35 cents will be deducted from your refund for each minute over 30 minutes. You will be charged a $10 restocking fee. The shipping charges are not refundable. Jitterbug and GreatCall are registered trademarks of GreatCall, Inc. Samsung is a registered trademark of Samsung Electronics Co., Ltd.

Excerpt from the November 7, 1964, issue of *Science News Letter*

50 YEARS AGO

Membrane filters air

A wisp of synthetic membrane, only a thousandth of an inch thick, may hold the answer to a simple system for supplying submarines with air drawn from the water around them.... The "aqua-hamster" penned in a submerged plastic tank, shown on this week's cover, is kept alive by an artificial "gill," a piece of the synthetic membrane stretched across the top, bottom and two sides of its underwater home.... The "gill" extracts air from the surrounding water, while resisting the passage of the liquid.

UPDATE: Membranes are challenging to manufacture on a large scale, so today's submarines use oxygen tanks or generators, which use electricity to extract oxygen from water. Underwater labs like Florida International University's Aquarius are fed oxygen through an umbilical cord. In October, Danish scientists synthesized a crystal that sucks oxygen from air and water and releases it later. A few grains can store enough oxygen for a breath, making it an ideal candidate for underwater breathing.

THE SCIENCE LIFE

Chemist tackles complex problems by keeping things simple

Harvard's George Whitesides holds a handful of simple, paper-based diagnostic devices.

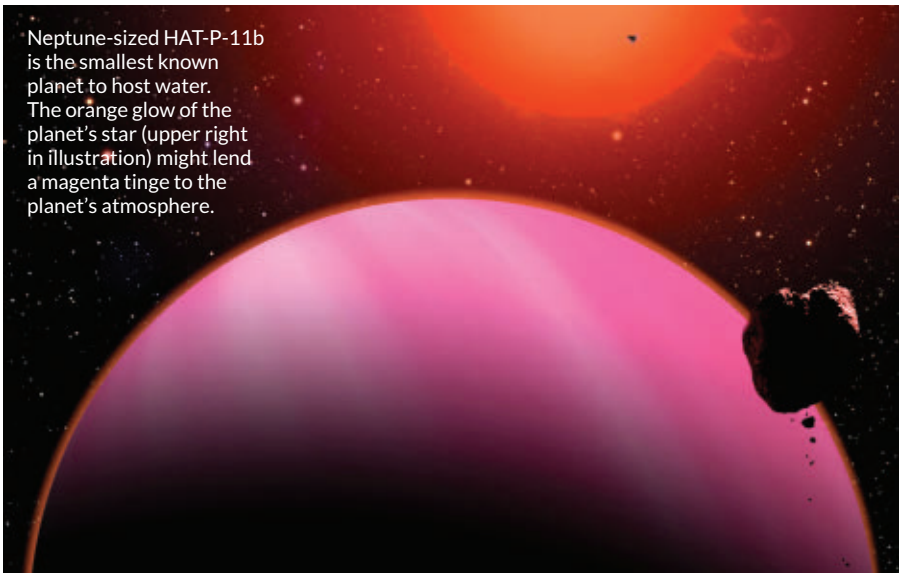
THE –EST

Smallest water-bearing world

The smallest, coolest exoplanet known to host water is roughly the size of Neptune, astronomers report in the Sept. 25 *Nature*. Previously, researchers had found water only on exoplanets about the size of Jupiter. The planet HAT-P-11b is just over four times as wide as Earth.

Gases in a planet's atmosphere leave their mark by absorbing specific frequencies of light. When HAT-P-11b comes between Earth and its star, the planet's atmosphere filters out some of the starlight. The astronomers detected water vapor by observing infrared light that disappeared each time the planet passed between Earth and its host, an orange dwarf about 122 light-years away in the constellation Cygnus.

The data also revealed a relatively clear atmosphere that is rich in hydrogen. The abundance of hydrogen jibes with theories of planet formation, in which gas giants form around a rocky or icy core. The core attracts an atmosphere by pulling hydrogen out of the gaseous disk encircling an infant star. — *Christopher Crockett*

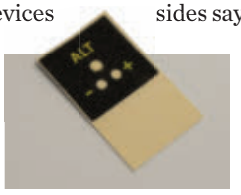


Neptune-sized HAT-P-11b is the smallest known planet to host water. The orange glow of the planet's star (upper right in illustration) might lend a magenta tinge to the planet's atmosphere.

FROM TOP: VOLKER STEGER/SCIENCE SOURCE; DAVID A. AGUILAR/CFA

Early in his career, George M. Whitesides did the kind of chemistry you might call ordinary: making new molecules, figuring out the mechanisms of chemical reactions, tuning instruments to tell one compound from another. But in the last 10 to 15 years, Whitesides has set his sights on bigger problems, like creating cheap, simple and robust devices for diagnosing disease in the developing world.

With his research group at Harvard University, Whitesides has made patterned, postage stamp–sized pieces of paper printed with dyes and proteins. Place a drop of blood, urine or saliva on the strip and the paper's capillary action wicks it along to react with the proteins, producing color changes that give health care workers quick, unambiguous and reliable information about their patients. A company Whitesides helped found, Diagnostics For All, uses one of these devices to test liver function in HIV patients taking concoctions of powerful liver-damaging antiretroviral drugs. The company hopes to start sending the tests to Africa within the next few years.



A drop of blood on this paper strip can reveal high levels of an enzyme that signals liver damage.

"Low-cost diagnostics has the characteristic that it is both a problem that is really important in a very broad sense but also leads to all sorts of interesting new science," says Whitesides.

Simplicity is the key to solving this kind of problem: When these small, adaptable devices go out into the world, Whitesides says, other people can use them as building blocks for systems he might never have imagined.

Whitesides also takes a fundamentally different approach to research than many of his colleagues. "One of the things which I've come to feel very strongly is that we should completely abolish the distinction between science and engineering," he says. "It takes players who are on the same team and pits them against one another." He describes the two as the same activity with different points of view. When looking at ways to lower cost or reduce complexity — problems he says are typically thought of as engineering issues — he often discovers a solution through fundamental science.

With that approach, Whitesides believes that solutions to some big problems may not be so hard to find.

— Sam Lemonick

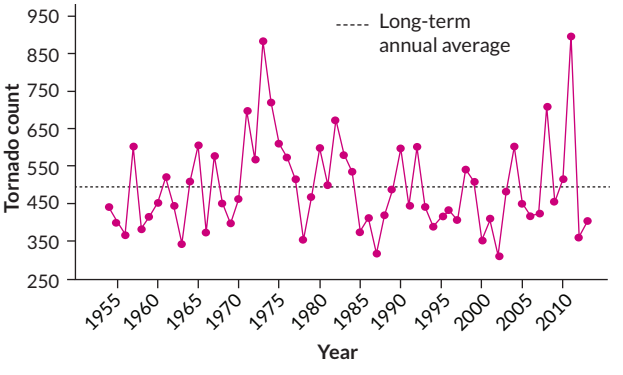
SCIENCE STATS

Timing shift for U.S. twisters

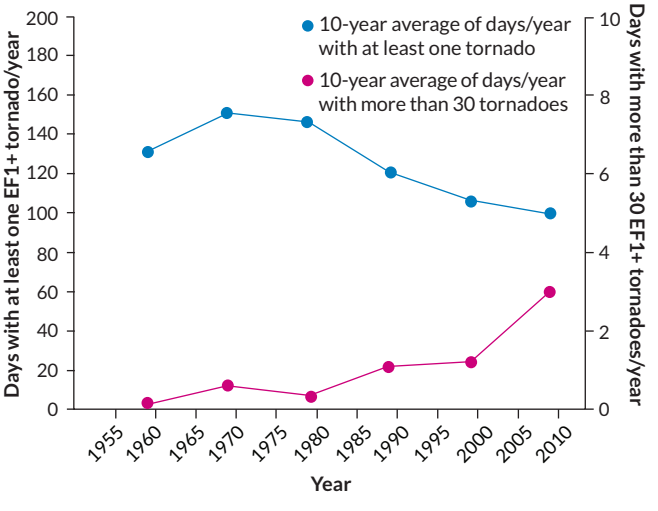
In a good news, bad news situation, the United States now sees fewer days per year with tornadoes than it did decades ago. But the number of days with multiple tornadoes is up.

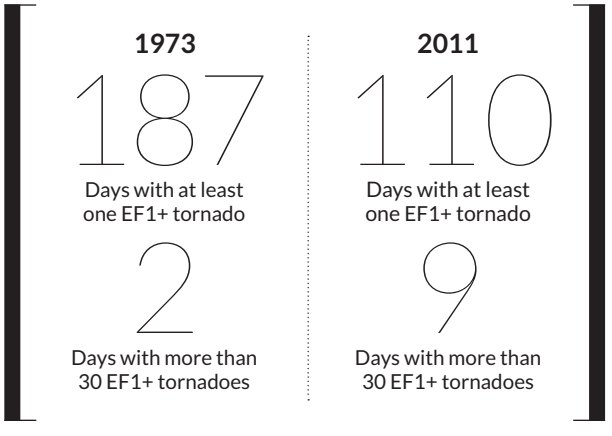
Between 1954 and 2013, the annual number of tornadoes with wind gust speeds greater than 138 kilometers per hour, called EF1+ tornadoes, stayed steady on average (top graph), researchers report in the Oct. 17 *Science*. It's the timing that has changed: Since the 1970s, twisters have clustered in fewer days (bottom graph). Now, a given year will see an average of three days with more than 30 tornadoes, compared with the average of one day or less from a few decades ago. SOURCE: H.E. BROOKS *ET AL*/*SCIENCE* 2014

Reported EF1+ tornadoes in the United States, 1954-2013



Average frequency of U.S. tornadoes by decade





HUMANS & SOCIETY

Stencils rival age of Europe's cave art

Handprints in Indonesia were created nearly 40,000 years ago

Hand stencils, including this one, found in caves on the Indonesian island of Sulawesi date to the Stone Age, a new study finds. Two of the handprints are about as old as the earliest examples of European cave art.

BY BRUCE BOWER

So much for Europe's reputation as the birthplace of cave art.

A couple of hand outlines framed in pigment, discovered decades ago inside caves on the Indonesian island of Sulawesi, were created roughly 40,000 years ago, a new study finds. That date makes them similar in age to Europe's oldest art. Two animal drawings also found inside the Sulawesi caves are almost as old as the handprints.

These Southeast Asian discoveries challenge a long-standing view that a burst of Stone Age creativity, exemplified by cave art, first occurred in Western Europe around 40,000 years ago before appearing in other parts of the world. The oldest Sulawesi hand stencil, formed by blowing, spraying or spitting liquid pigment around an outstretched hand pressed against a cave wall, dates to at least 39,900 years ago. A team led by archaeologists Maxime Aubert and Adam Brumm, both of Griffith University in Southport, Australia, report the findings in the Oct. 9 *Nature*.

A cave drawing of a fruit-eating pig called a pig-deer, or babirusa, dates to a minimum of 35,400 years ago. A portrayal of another large animal, probably a pig, dates to at least 35,700 years ago.

"Our findings show that cave art was made at opposite ends of the [Stone Age] world at about the same time, suggesting these practices have deeper origins, perhaps in Africa before our species spread across the globe," Aubert says.

Aubert and Brumm's team used a relatively new rock-dating technique called uranium-series dating to analyze mineral deposits that had formed over parts of 12 human hand stencils and two animal drawings from nine caves on Sulawesi. Radioactive decay of uranium in mineral deposits proceeds at a known rate, enabling scientists to date the formations and obtain a minimum age estimate for cave art underneath.

A previous uranium-series investigation found that a red disk on the wall of a Spanish cave dates to at least 40,800 years ago, making it the oldest known example of cave art (*SN: 7/28/12, p. 15*). A hand stencil in the same cave was made by 37,300 years ago.

Cave art apparently took similar paths in Europe and Southeast Asia, with hand stencils appearing first and animal drawings soon after, says archaeologist Paul Pettitt of Durham University in England. Hands hold great significance across cultures as bodily tools for acting on the world. Blowing pigment at hands placed on cave walls may have been especially meaningful and a spur to the development of human art, Pettitt suggests.

"It wouldn't take much to observe that if the hand could be depicted in outline, so could other things, like animals," he says. "The Sulawesi discoveries suggest that widely dispersed human groups shared in this immense discovery."

A big challenge now is to track artistic traditions from their African origins to the beginnings of European and Asian cave art, Pettitt adds. By 100,000 years ago, *Homo sapiens* had concocted a red-hued paint and carved geometric designs in chunks of pigment at a cave on South Africa's coast (*SN: 11/19/11, p. 16*).

No single method of dating rock art — whether it's a uranium-series analysis of mineral formations or, as has been previously attempted, a radiocarbon study of bits of paint — is definitive, cautions Robert Bednarik, an independent scholar based in Caufield South, Australia, and self-taught authority on rock art. Results from both techniques need to be checked for consistency, he says. ■

The early history of art

- **By 100,000 years ago**
  Humans are using pigments
- **100,000 to 60,000 years ago**
  Earliest known symbolic engravings, found in South Africa
- **50,000 to 40,000 years ago**
  Crayonlike pigment chunks, found in Australia
- **40,800 years ago**
  Earliest known cave paintings, found in Spain
- **39,900 years ago**
  Handprint in Indonesia
- **35,400 years ago**
  Babirusa painting in Indonesia
- **20,000 years ago**
  Paintings in France's famed Lascaux Cave

KINEZ RIZA

EARTH & ENVIRONMENT

Satellites expose mysteries of the deep ocean

New global seafloor map is most accurate ever created

BY THOMAS SUMNER

A new comprehensive map of Earth's seafloor reveals never-before-seen features hidden deep below the waves, including thousands of uncharted underwater mountains. The map, presented in the Oct. 3 *Science*, is the most accurate global seafloor map ever made and could provide new clues to how Earth's surface got its shape.

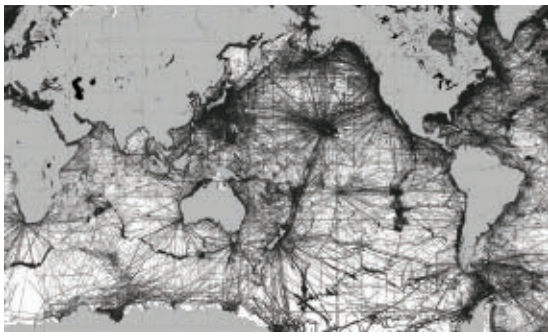
"We know a lot about the continents, but we know almost nothing about what's going on in the oceans," says lead author David Sandwell, an earth scientist at the Scripps Institution of Oceanography in La Jolla, Calif. "It's like being on another planet; the ocean is probably the most unexplored feature in the inner solar system."

Over the last 40 years, hundreds of ships have mapped slices of the seafloor by measuring how long it takes for sound to bounce off the ocean bottom. However, roughly 80 percent of the ocean floor lacks detailed topographic measurements, including much of the region in the Indian Ocean where Malaysia Airlines Flight 370 disappeared earlier this year. Scientists say filling such gaps with ship-based data would require decades of work and billions of dollars.

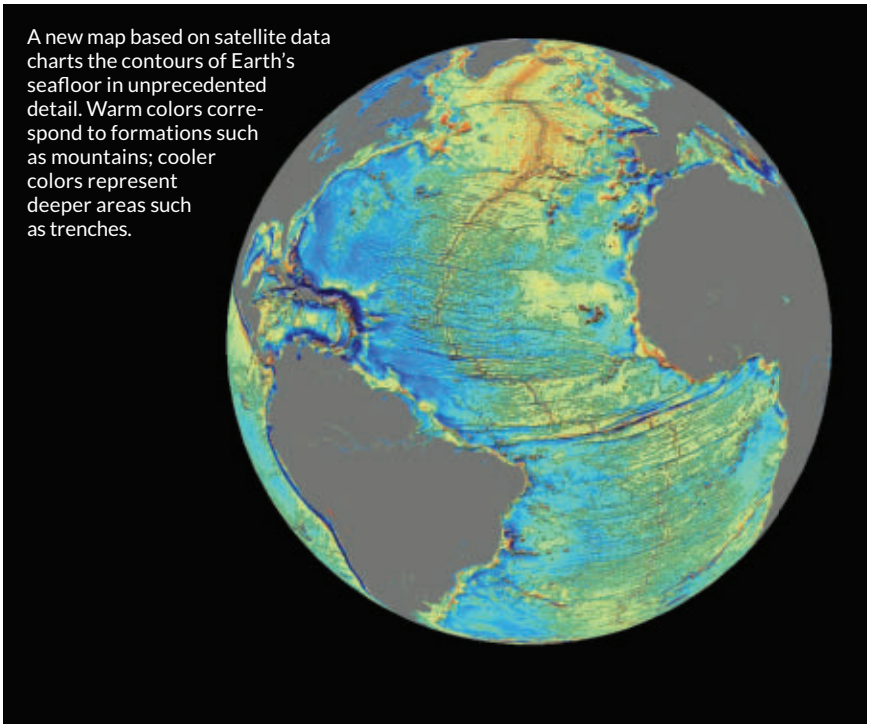
To save money and time, Sandwell and colleagues compiled their map using data collected by satellites such as the European Space Agency's CryoSat-2 and NASA's Jason-1. These satellites can't see below the ocean surface. Instead, they measure the gravitational tug of the seafloor: The satellites send out laser pulses that ricochet off the sea surface similar to the way visible light reflects off a mirror. By timing how long it takes the rebounded pulses to make the round-trip back to the satellite, scientists can calculate the precise sea level height below the spacecraft.

Tiny changes in sea level serve as a fingerprint of what lies below. Massive submerged mountains and ridges that jut out of the seabed attract water toward them with their strong gravitational pull. Because water is hard to compress, the water forms a tiny bump on the ocean surface that mimics the topography of the underlying seafloor.

Observable changes in sea level can be as subtle as a centimeter, so the team combined multiple satellite measurements to correct for temporary changes in sea level from waves and tides. With the combined data, the team discerned the existence of submerged formations measuring about 2 kilometers across or wider. The new measurements are more than twice as accurate as those Sandwell and a colleague used to create a previous seafloor map in 1997, in large part due to new satellite data and refined computer processing.



Ships collect accurate sea-depth measurements using sonar (black lines show charted areas) but many parts of the ocean (white) lack such precise data on seafloor topography.



A new map based on satellite data charts the contours of Earth's seafloor in unprecedented detail. Warm colors correspond to formations such as mountains; cooler colors represent deeper areas such as trenches.

Although the new map's accuracy still pales in comparison with ship-based measurements, which can distinguish features as small as a few meters across, both satellite and ship-based methods are important, says Jim Gardner, a marine geologist at the University of New Hampshire in Durham. "When I go out in a ship, I can see things they can't possibly see using satellites," he says, "but this new map shows us large-scale details of the seafloor and areas of the ocean that haven't been mapped before."

Already Sandwell's team has identified numerous formations hidden beneath Earth's oceans, including about 5,000 underwater mountains taller than New Hampshire's Mount Washington as well as the precise boundary where the South American and African continents ripped apart sometime around 100 million years ago. The researchers also located the rift where the Gulf of Mexico expanded until about 150 million years ago.

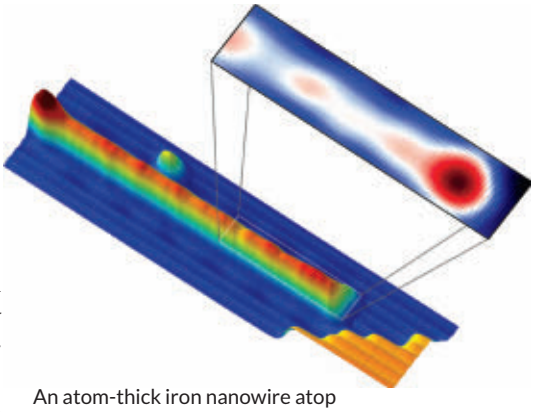
Still, the scientists have only scratched the surface, Sandwell says. "It'll take years to really go through the map in detail and find all the interesting things." ■

FROM TOP: SCRIPPS INST. OF OCEANOGRAPHY; GOOGLE EARTH; D.T. SANDWELL/SCRIPPS INST. OF OCEANOGRAPHY

MATTER & ENERGY

Signal of Majorana particle emerges

Evidence backs existence of entity that is its own antiparticle



An atom-thick iron nanowire atop a lead crystal, illustrated here, may harbor a pair of Majorana particles. The red spot in the top image indicates that one of the particles is confined to the end of the wire, as theory predicts.

BY ANDREW GRANT

A blip of electric current at the end of an atom-thick wire has brought physicists one step closer to confirming the existence of Majorana particles, entities that are their own antiparticles.

The new experiment, described October 2 in *Science*, does not definitively prove that these particles exist. But it provides compelling evidence that complements previous research.

"The level of evidence is enough for an arrest but not for the death penalty," says Leo Kouwenhoven, a physicist at the Delft University of Technology in the Netherlands, whose team has also seen hints of Majorana particles. If confirmed, these exotic particles could help scientists overcome a major barrier toward creating quantum computers.

In 1937, Ettore Majorana proposed the existence of a particle that is also its own antimatter counterpart. (Other subatomic particles have separate antipartners, for instance electrons and positrons.) Neutrinos, wispy particles that barely interact with matter, may qualify as Majorana fermions.

Around 2000, physicists realized that another type of Majorana particle might also exist — one that could emerge on the surfaces of certain materials. Unlike electrons, neutrinos and other particles that can exist in a vacuum, this particle would be a product of its environment, arising from the collective behavior of the electrons around it.

Despite being its own antiparticle, this special particle wouldn't be a fermion. In fact, it wouldn't fit into either category of subatomic particles: fermions (for example, protons, quarks and electrons) or bosons (such as the Higgs). "The Majorana in condensed matter is much more subtle and exotic than a Majorana neutrino," says physicist Joel Moore of the University of California, Berkeley.

In 2012, Kouwenhoven's team reported the first measurement of the predicted signature of a Majorana particle: an electric current that surged within a specially designed nanowire at zero voltage (*SN: 5/19/12, p. 11*). A pair of Majorana particles seemed to form on the wire, one particle on each end. But the team could not show exactly where on the wire the signal was coming from.

The new experiment, led by Princeton physicist Ali Yazdani, used a zigzag-shaped wire of iron atoms placed atop a chilled lead crystal. At temperatures near absolute zero, this setup acts as a superconductor, whisking electrons around with no resistance. The researchers used a powerful microscope to image the electrons in the wire. When there was no voltage between the tip of the microscope and the superconductor, the researchers detected a peak in electric current at one end of the wire, presumably the calling card of one of a pair of Majorana particles.

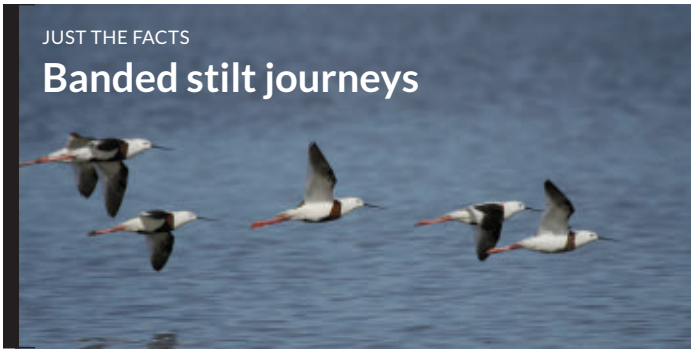
"This is the first time the Majorana particle has been observed," Yazdani says. Moore won't go that far but says the Majorana particle is "a very plausible explanation for what they're seeing. This goes significantly beyond the Delft experiment."

The two studies together are equivalent to taking a nice picture of something that looks like the Majorana particle, Kouwenhoven says. But to prove the particle exists, "you need to take its DNA," he says. "And a DNA test has not been done." That test will require manipulating and moving the particles to demonstrate their particle-antiparticle duality.

Lack of confirmation hasn't stopped Microsoft and funding agencies from supporting Majorana research. The particle may be the ideal qubit, the basic processing unit for quantum computers. The potential of quantum computers to outperform conventional ones depends on qubits' ability to maintain a fragile quantum state in which they hold a 1 and a 0 simultaneously (*SN: 5/31/14, p. 10*). The theorized spacing between Majorana particles should make the particles' quantum states extraordinarily stable. ■

JUST THE FACTS

Banded stilt journeys



2,263

kilometers

The longest recorded distance that a desert-dwelling banded stilt has traveled in search of water; the Australian bird made the trek in less than 2.5 days

SOURCE: R.D. PEDLER *ET AL/BIOLOGY LETTERS* 2014

FROM TOP: YAZDANI LAB/PRINCETON UNIV.; ED DUNENS/FLICKR (CC BY 2.0)

LIFE & EVOLUTION

Baby fish are noisier than expected

Gray snapper larvae may communicate with knocks, growls

BY SUSAN MILIUS

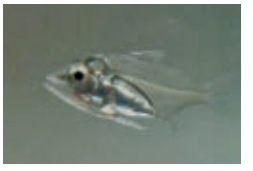
Larval fish can produce some tiny growls and little percussive knocks.

The first published recordings of sounds from larval fish reveal that gray snappers (*Lutjanus griseus*) only about a month old and a centimeter long make noises at night, says Claire Paris of the University of Miami in Florida. The noises may help larvae cluster with their own kind as the fish journey through the ocean in the dark, Paris and colleagues speculate in the October *Biology Letters*.

Biologists have proposed that adult fish's underwater calls help keep schools together, says Dennis Higgs, an ecologist at the University of Windsor in Canada. Yet he doesn't know of any other recordings of such young fish making sounds.

The traditional view of larval fish doesn't give them credit for doing much more than drifting "at the whims of currents," he says. Their parents give them a risky start in life, broadcasting sperm and eggs into the sea. The resulting specks of fertilized tissue spend weeks in the open ocean before arriving at habitats such as coral reefs.

In recent years, the view of haplessly drifting larvae "has broken down to some extent," Higgs says. Some larvae exert control over their journeys, rising, sinking or even moving fast enough to challenge a swim-along scientist (*SN: 1/15/11, p. 18*). Certain fish larvae steer toward clues such as smells that distinguish healthful habitats from harsh ones (*SN: 9/20/14, p. 17*).



Gray snapper larvae make noises at night that may help them stick together.

The discovery that larvae themselves make sounds was an accident, Paris says. She was studying environmental cues under natural conditions and created a floating mesh chamber that held a larval fish under a camera as seawater washed through. To see how sounds entice larvae, she added an underwater microphone.

The microphone picked up fish-like sounds from inside or beside the chamber, which gave the team "an aha moment," says coauthor Erica Staaterman, also at Miami. Fish sounds don't have the wavering melodic intrigue of whale songs. Instead, the noises are "thumpy and knocky and growly, and sound like things banging around," she says.

To see whether the larvae really made the recorded sounds, the team put the little fish in tanks in a sound-proof chamber. The recordings sounded chirpier but still like lower-pitched adult noises.

The discovery "adds a very cool new layer to our understanding of the importance of noise for fish," says Steve Simpson of the University of Exeter in England. The finding, he says, also suggests "that anthropogenic noise from small boats, shipping and construction might interfere at a critical life stage." ■

ATOM & COSMOS

Early universe's overhaul clarified

Leaky galaxy hints at cause of reionization after the Big Bang

BY CHRISTOPHER CROCKETT

A nearby galaxy is leaking clues about one of the biggest makeovers in the history of the universe. New observations show that tiny galaxies in the early universe could have triggered reionization, a time when harsh radiation tore apart hydrogen atoms. Reionization is key to understanding how stars and galaxies arose.

"Reionization is one of the major milestones in the universe's history," says Brant Robertson, an astronomer at the University of Arizona. In the cosmic dark ages, neutral hydrogen gas filled the universe. Then, within a billion years after the Big Bang, ultraviolet radiation filled the universe and ripped electrons from all the hydrogen atoms, leaving them ionized. Astronomers suspect that the radiation came from bursts of star formation in the first generations of galaxies.

But researchers weren't sure if the tiny galaxies that populated the early universe could have produced enough radiation to ionize all of space. Similar galaxies near the Milky Way don't release much ionizing radiation; the ultraviolet light from newborn stars isn't intense enough to puncture the thick hydrogen clouds that swaddle stellar nurseries.

However, Sanchayeeta Borthakur of Johns Hopkins University and colleagues suspected that J0921+4509, a compact galaxy about 3 billion light-years away, might be leaking ultraviolet light. In the galaxy's center, more than a billion stars are crowded into a community nearly 700 light-years across. The mass and size of the galaxy are nearly identical to the most distant, earliest-known galaxies.

Observations from the Hubble Space Telescope show that J0921+4509 floods the surrounding space with ionizing light through holes punched in the enveloping hydrogen clouds, the team reports in the Oct. 10 *Science*.

If you put a lot of stars in a compact region, they can be powerful enough to carve tunnels in the surrounding gas and leak radiation, Borthakur says: "This shows how galaxies which are really tiny can influence the entire universe."

Any ultraviolet photons that escaped from the earliest galaxies would have been absorbed by a neutral hydrogen atom on the journey to Earth. By finding nearby leaky galaxies, Robertson says, astronomers can count how many of those photons escape and use the results to infer what might have happened 13 billion years ago.

The next step is to figure out if there were enough compact galaxies around to ionize the early universe. ■

E. STAATERMAN

Listen to the subtle growls of baby fish at **bit.ly/SN_fishnoise**

LIFE & EVOLUTION

Snakes tutor robot on dune climbing

Sidewinders reveal strategy for traversing a sandy slope

BY SUSAN MILIUS

Sidewinder rattlesnakes wriggling up sand dunes turn out to have a trick of adjusting their curvy moves that's improving robot design and the understanding of legless motion on sand.

In tests on sandy inclines, *Crotalus cerastes* snakes easily outslithered 13 other kinds of pit vipers and a robotic snake, says physicist Daniel Goldman of Georgia Tech in Atlanta.

As a sidewinder slithers upward on increasingly steep slopes, it doesn't press deeper and deeper as might be expected. Instead, sidewinders minimize their risk of slipping by increasing the proportion of their body in contact with the sandy surface on any particular wriggle, Goldman and his colleagues say in the Oct. 10 *Science*. Increasing body contact might take less energy than gouging deeper into the sand, Goldman says.

After researchers adjusted this robot's design based on studies of real snakes, the robot can now writhe up a sandy slope.

The challenge of moving on sand hasn't attracted much scientific attention, says roboticist Auke Ijspeert of the Swiss Federal Institute of Technology in Lausanne. Yet sand, he points out, covers large areas of Earth.

Empowering robots to move up slippery, unstable sand could extend the reach of rescue efforts or just plain exploring, says study coauthor Howie Choset of Carnegie Mellon University in Pittsburgh. In 2011, one of his snake-shaped robots, named Elizabeth, joined an archaeological expedition to caves along Egypt's Red Sea that hold remains of ancient Egyptian ships. Elizabeth wriggled into an unexplored cave but was foiled by a sandy incline.

To see how sidewinders cope with sandy slopes, Goldman turned to Zoo Atlanta. Instead of bringing venomous animals into the lab, coauthor Hamidreza Marvi , then at Georgia Tech, built a sand-locomotion test slope in a shed at the zoo to film snakes climbing at angles. He constructed an air system to gust the particles on the slope back into a smooth-flowing mass after each snake had squiggled around, and he even brought in 200 kilograms of sand from rattlesnake territory in Arizona. On this high-tech dune, coauthor Joseph Mendelson of Georgia Tech and Zoo Atlanta led a team of handlers trying to coax snakes up slopes.

Of the species tested, only sidewinders used a very S-curvy motion to climb, increasing their body contact with the surface to almost half their length when

BODY & BRAIN

Impotence drug can boost insulin

Yohimbine may help diabetics with a certain gene variant

BY KATE BAGGALEY

A drug developed to treat erectile dysfunction helps a subset of people with type 2 diabetes. Called yohimbine, the drug is effective in people with a variant of a gene called *ADRA2A*, researchers report October 8 in *Science Translational Medicine*.

Such a treatment would provide a new therapeutic option to a substantial group of people. Approximately 40 percent of people with type 2 diabetes have a version of the *ADRA2A* gene that makes insulin-releasing cells in the pancreas more sensitive to the stress hormone adrenaline. When adrenaline binds to proteins on the cell surface called receptors, less insulin is secreted. People with the gene variant have more adrenaline receptors.

"It's like driving a car with the brakes constantly on," says study coauthor Anders Rosengren of Lund University in Sweden.

Yohimbine can bind to the same receptors, blocking the effects of adrenaline and allowing more insulin to be released. The treatment "is analogous to releasing the brake and being able to drive with normal speed," Rosengren says.

Stephen Liggett, a geneticist at the University of South Florida Morsani College of Medicine in Tampa, says the approach might benefit patients. Right now, "we really don't have anything that targets that receptor," he says.

In type 2 diabetes, patients have trouble producing and efficiently using insulin, which helps ferry glucose from the blood so that the sugar can be used by cells for energy. In the United States, roughly 27 million adults have type 2 diabetes.

Rosengren and colleagues recruited 49 people with type 2 diabetes, including 28 who have the insulin-reducing version of *ADRA2A*. The team treated patients with yohimbine, which has been available since the 1940s. The chemical is also an ingredient in the herbal supplement yohimbe bark. The researchers knew that yohimbine had been documented to block adrenaline receptors.

Patients took various amounts of yohimbine and drank a high-glucose solution. Researchers then measured patients' insulin levels. Those with the insulin-suppressing version of *ADRA2A* secreted 29 percent more insulin when given the highest dose of yohimbine than when they received a placebo. Yohimbine did not boost insulin secre-

NICO ZEVALLOS AND CHAOHUI GONG

Watch snakes go up sandy slopes at **bit.ly/SN_sidewinder**

slopes reached about 20 degrees. Twelve of the other 13 species failed to climb sandy inclines of even 10 degrees. They "just sort of flail around and do pitifully," Goldman says. One other kind of rattlesnake worked its way awkwardly upward, but it's no sidewinder.

Analyzing video of the snakes inspired Goldman and colleagues to distill the motion to a template, or a simplified concept that captures the essentials. The team proposes that sidewinding arises from the interplay of two wavelike snake motions, just a little out of phase in time, with one wriggling vertically and the other side to side.

"The idea of the template is a really profound way of thinking about all animal movements," says Jake Socha of Virginia Tech in Blacksburg, who studies airborne snake motions. "I think this will be useful for all types of research on locomotion in snakes."

The insights certainly helped the current version of Elizabeth. Researchers tested their ideas about snake motion by adjusting the robot, which now does a passable upslope sidewind. ■

tion in patients without the *ADRA2A* variant.

A side effect of using yohimbine was a minor increase in blood pressure, which worries Jose Florez of Massachusetts General Hospital in Boston. People with diabetes often have coronary artery disease, he says, so yohimbine's beneficial effects might not outweigh its risks.

Another caveat is that the team looked only at the drug's short-term effects that occurred within two hours of treatment.

Rosengren agrees that more work on the drug needs to be done. "We'll try now to modify it to reduce the side effects, and then we will test it in larger patient samples over a longer time," he says.

If yohimbine clears these tests, he says, "it will be a new strategy to personalize drug treatment — to make drug treatment more effective compared to the one-size-fits-all treatments available today." ■

ROBERT LEMASTERS/COLLEGE OF CHARLESTON

EARTH & ENVIRONMENT

Raindrops break terminal velocity

Droplets lack clear explanation, could alter weather forecasts

BY THOMAS SUMNER

Raindrops have been caught breaking the speed limit. Using drizzle detectors, researchers discovered tiny raindrops falling more than 1.3 times as fast as terminal velocity, the speed at which air resistance cancels out gravitational pull.

The cause of the drops' extreme speed remains unknown. But their existence could affect the way scientists estimate average raindrop size, and thereby skew rainfall measurements, says lead author Michael Larsen, an atmospheric physicist at the College of Charleston in South Carolina. Meteorologists often measure rainfall speed to infer the average raindrop size and ultimately the total volume of rainwater.

"If our guesses are wrong as to how fast these drops are falling," Larsen says, "that could ultimately affect a whole bunch of other work."

When a raindrop forms, gravity accelerates its fall. As the descending drop speeds up, the air pushes back harder until the upward and downward forces balance out and the drop falls at a steady speed. Larger raindrops with diameters more than about 0.5 millimeters reach terminal speeds of several meters per second. Smaller drops are limited to velocities under a meter per second.

Until 2009, scientists thought all raindrops hit the ground traveling at terminal velocity. But then researchers spotted tiny drops falling seemingly too fast. Scientists thought the zippy raindrops may have been tiny fragments of fast-moving larger drops, which had broken up after splashing off the instruments used to measure them. The smaller droplets may simply have continued to travel at the parent drop's speed, having not yet slowed down to terminal velocity.

To find out if such dashing drips occur naturally, Larsen and colleagues assembled an assortment of 22 instruments in Hollywood, S.C. At the heart of this array was a rain monitor that every second snaps more than 55,000 images of falling raindrops to determine their size, speed and direction.

Over five months, the team monitored six major rainstorms and detected more than 23 million drops. While all drops wider than a millimeter plunged at expected speeds, more than 30 percent of drops smaller than 0.5 millimeters fell faster than terminal velocity, the team reports October 1 in *Geophysical Research Letters*. Because the researchers also measured horizontal speed, they could disregard drops that had splashed off the edge of an instrument and flown sideways into a detection area.

One explanation for the speedy drops is that larger raindrops shatter during their descent (*SN: 7/15/09, p. 12*) or break up after midair collisions. The newly formed smaller droplets would at first continue moving at the larger drop's higher speed.

Technically, drops smaller than 0.5 millimeters wide are drizzle, not rain, notes Francisco Tapiador, a climate scientist at the University of Castilla-La Mancha in Toledo, Spain. That distinction "is not only a picky, academic, whimsical issue." Because drizzle falls so slowly, the formulas used to calculate terminal velocity may predict incorrect speeds for the tiny drops, he argues.

Even if the expected terminal velocity for the small drops is inaccurate, Larsen says, "they're still hitting the ground at velocities faster than previously assumed." ■

Researchers used an array of 22 sensors, including this one, to clock raindrop speeds.

BODY & BRAIN

Blood sugar's link to spinal injuries

Reducing high glucose levels may improve patient recovery

BY NATHAN SEPPA

Controlling blood sugar in people with spinal cord injuries might aid in recovery and improve their movement and sensory functions. If such trauma patients arrive in emergency rooms with high blood glucose, they fare worse on average than those with normal levels, researchers find. And lab mice with spinal cord damage recover faster if their high blood glucose is regulated with insulin within eight hours of the injury, a team reports in the Oct. 1 *Science Translational Medicine*.

The findings should clear the way for a study in which patients with a spinal cord injury are randomly assigned to standard care or that care plus lowering of blood glucose if needed, says Greet Van den Berghe, a physician and critical care researcher at the University of Leuven in Belgium. "This is very promising and definitely worthwhile."

Physician Kazu Kobayakawa of Kyushu University in Fukuoka, Japan, and colleagues examined health records of 206 people with spinal cord trauma who were admitted to a Japanese hospital from 2005 to 2011 and for whom blood glucose data were available. The researchers divided the patients by glucose level.

> "This inflammation gets resolved quicker and neurons are protected."
>
> GREET VAN DEN BERGHE

Based on standard measures of functional impairment, 45 percent of those with high glucose failed to improve with treatment compared with 31 percent of those with normal glucose.

Patients who were paralyzed upon admission to the hospital were included in the study. Hospitals often treat spinal cord trauma patients who are paralyzed, and some partially recover motor or sensory function, says Van den Berghe. Part of this improvement is due to a reversal in the swelling of nerve tissue, she says. Such improvement in some cases might be traceable to declining blood glucose. "This inflammation gets resolved quicker and neurons are protected," she says.

Lab mice that had spinal cord injuries had worse inflammation and a slower recovery if they had high blood glucose. In a high-glucose environment, Kobayakawa says, immune cells in the central nervous system called microglia become activated and trigger an inflammatory chain reaction that causes neurons and other cells to die.

Controlling blood-sugar levels with insulin is a fast-acting treatment likely to benefit patients, Kobayakawa says, but only a clinical trial can establish its value. ■

MATTER & ENERGY

Alternate way to make oxygen found

Process may alter view of how Earth's atmosphere formed

BY BETH MOLE

With a zap, a beam of ultraviolet light can blast carbon dioxide into oxygen gas, O_2. Because the sun hurls UV radiation, the reaction hints that breathable air could have formed on Earth before the dawn of photosynthetic organisms or even in other CO_2-rich atmospheres like those on Mars and Venus, researchers argue in the Oct. 3 *Science*.

Though scientists had theorized that the detritus of a CO_2 breakup could include O_2, proving it has been extremely difficult. "The authors have made a beautiful set of challenging measurements," says chemist Simon North of Texas A&M University in College Station.

Cheuk-Yiu Ng of the University of California, Davis and colleagues assembled a set of lasers that shoot adjustable wavelengths of UV light in a vacuum. One laser shatters the CO_2 while a second beam identifies the molecular debris.

Normally, CO_2 breaks apart to form a molecule of carbon monoxide and an oxygen atom. This separation requires the least amount of energy because in a molecule of CO_2, the carbon sits between the two oxygens, so only one bond has to break. But if CO_2 is hit with enough energy, chemists theorized, its atoms could become superexcited and form unexpected structures and fragments.

Chemists predicted that energizing CO_2 could cause the two oxygens to link, forming a three-atom ringed structure. Next, one of the two oxygens could break away from the carbon, creating a linear molecule with the oxygens side by side. Finally, O_2 could break free.

The experiment couldn't detect each stage of this atomic scrambling, but the team did identify a lone carbon. The measurement of a single carbon suggests that O_2 formed, though in tiny quantities; only about 5 percent of the CO_2 broke up this way.

Because the wavelengths that destroyed CO_2 are produced by the sun, the finding hints that solar radiation could create O_2 and other unexpected molecular wreckage, Ng says.

This method of creating O_2 might have influenced the development of Earth's atmosphere, says chemist Alexander Mebel of Florida International University in Miami. About 2.4 billion years ago, the planet underwent the Great Oxidation Event after photosynthetic microbes originated.

If O_2 was already present in the atmosphere before then, it could have helped form a livable planet for oxygen-breathers. But how important those pioneering oxygen molecules were is unclear. Mebel says researchers need to include this newfound chemical reaction in simulations of how atmospheres form. ■

GENES & CELLS

Yeast use scents to entice fruit flies

The fungal cells can hitch a ride on the insects to get around

BY TINA HESMAN SAEY

Yeast produce fruity aromas that lure fruit flies to dinner. In return, the flies provide transport for the otherwise sedentary fungi, a new study suggests.

A gene called *ATF1* allows *Saccharomyces cerevisiae*, also known as brewer's yeast, to attract fruit flies, researchers demonstrate in the Oct. 23 *Cell Reports*.

The discovery puts the genetics and molecular biology of two common lab organisms into ecological context, says Matthew Goddard, a biologist at the University of Auckland in New Zealand. Goddard's group previously found that wild fruit flies carry *S. cerevisiae*. The new work helps explain the genetics underlying that interaction, he says.

What was once thought to be a useless gene might be a linchpin of a mutually beneficial relationship between yeast and flies, similar to that of flowers that produce scent to attract pollinator insects, says Bill Hansson, an evolutionary neuroethologist at the Max Planck Institute for Chemical Ecology in Jena, Germany.

Scientists have long known that yeast make aromatic acetate esters, which give beers and wines their distinctive bouquets. What researchers haven't understood is why the fungi bother producing such energetically expensive molecules. Yeast that lack the *ATF1* gene, which encodes an enzyme that produces the fruity aroma chemicals, grow just fine in the lab, says geneticist Kevin Verstrepen of the University of Leuven and VIB, a research institute also in Belgium.

"By studying these things as monocultures in a sterile environment we miss a lot of interesting behaviors," he says.

Verstrepen got his first inkling about what the smelly stuff might be good for about 15 years ago when he left flasks of yeast sitting on his lab bench over a weekend. "It turned out I was doing an experiment without even knowing it," he says.

When he returned to the lab on Monday, Verstrepen found that *Drosophila melanogaster* fruit flies from a neighboring lab had invaded his flasks. A flask containing a normal strain of yeast had attracted two fruit flies. Another flask held mutant yeast that pump out more acetate esters than usual. Fifty fruit flies had flocked to it. The final flask contained a mutant strain of yeast lacking *ATF1*. It lured zero flies. Verstrepen didn't follow up on the observation right away.

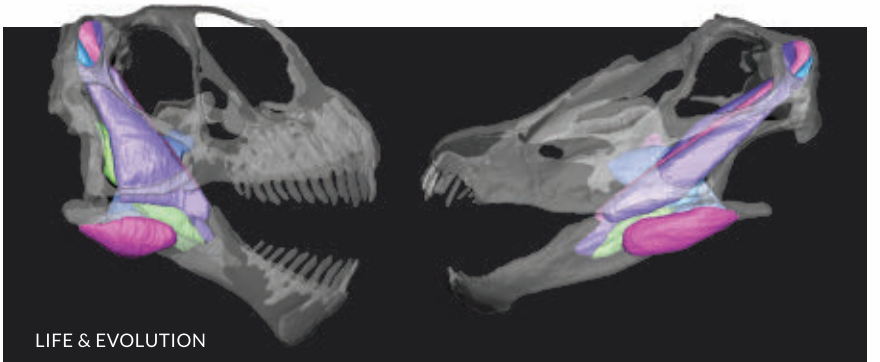
But then a few years ago, he and Emre Yaksi of Neuro-Electronics Research Flanders, a nonprofit in Leuven, talked about the observation over a beer. Yaksi studies chemical senses in fruit flies. The pair teamed up to see if yeast aromas really do attract flies and if so, why.

The researchers streamed air over an aromatic strain of yeast from a vineyard and a mutant strain that can't make the strong-smelling compounds into opposite corners of a plastic box. Fruit flies stampeded toward the fruity-smelling yeast but largely ignored the mutants. When the researchers wafted three acetate esters into the arena in the odorless yeast's corner, more flies than before headed toward the mutants' corner. That finding indicated that the esters are a component that attracts the flies.

It's clear what the fruit flies get from sniffing out yeast: lunch. The yeast provide protein for the flies. Less obvious was why yeast would lure flies to the table. So the researchers tagged aromatic and odorless mutant yeast with different colors of fluorescent proteins, and placed a million cells of each strain on a Petri dish. Fruit flies roamed the plates overnight in complete darkness.

Yeast that made the aromatic compounds were transported around the plate four times as often as the scentless mutants were. The finding indicates yeast trade meals for rides. In the wild, yeast may piggyback aboard flies as they visit ripening and rotting fruit.

Studies like this that consider multiple organisms at a time may help scientists discover the purpose of many genes with no known function, Hansson says. ■



© D. BUTTON

LIFE & EVOLUTION

How plant-eating dinosaurs coexisted

Two kinds of herbivorous dinosaurs that lived side by side had skulls that allowed the dinos to specialize in feeding on different plants, researchers report in the Nov. 22 *Proceedings of the Royal Society B*. Around 150 million years ago, at least 10 genera of large plant-eating dinosaurs called sauropods roamed North America in a semiarid environment offering sparse vegetation. David Button of England's University of Bristol and colleagues took CT scans of the skulls of two sauropods: *Camarasaurus* (left) and *Diplodocus*. By looking at marks on the bones where muscles attached, the team reconstructed musculature (shown in color). With a short, heavy jaw and stronger muscles, *Camarasaurus* had a powerful bite that it probably used to crunch woody conifers. *Diplodocus*, with a long, thin jaw and weaker bite, ate ferns and horsetails, the team suggests. — *Kate Baggaley*

MATTER & ENERGY

Hawking radiation created in the lab

Sonic black hole emits energy as famed physicist predicted

BY ANDREW GRANT

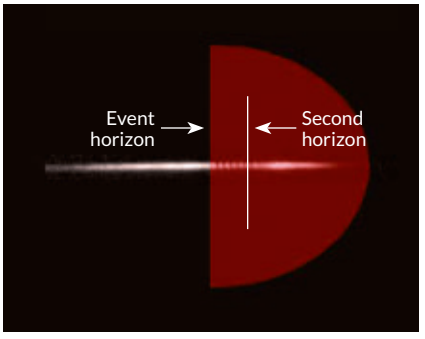
A whisper from a lab-manufactured black hole may confirm the existence of radiation predicted by physicist Stephen Hawking four decades ago. If validated by further research, the finding would offer evidence that particles blinking in and out of existence can rob black holes of mass.

"It's amazing, groundbreaking work," says physicist Daniele Faccio of Heriot-Watt University in Edinburgh. By observing Hawking radiation, the work "demonstrates something that everyone thought was impossible."

Initially, scientists thought of black holes as everlasting objects from which nothing, not even light, could escape. But in the mid-1970s, Hawking proposed an amendment to that rule with huge implications. He noted that quantum mechanics allows pairs of particles to spontaneously pop into existence in the vacuum of space. Usually those particles quickly annihilate each other. But if they formed at the event horizon — the black hole's point of no return — then one particle could get dragged in, while the other could escape as energy called Hawking radiation. The fleeing particle would take a small fraction of the black hole's mass with it, meaning that in the very far future, every black hole in the universe would evaporate.

After initially expressing skepticism, physicists have largely embraced the idea of Hawking radiation, and today it lies at the heart of the quest to unify general relativity, the theory that explains the very large stuff in the universe, and quantum mechanics, which dictates the very small (*SN: 5/31/14, p. 16*). Yet confirming Hawking's prediction is a tremendous challenge: The radiation emitted by black holes light-years away is almost certainly too feeble for detection by telescope.

Instead of looking for Hawking radiation in nature's black holes, physicist Jeff Steinhauer of Technion-Israel Institute of Technology in Haifa conducted the search on a homemade black hole that traps sound rather than light. He used lasers to cool a vat of rubidium atoms to temperatures about a billionth of a degree above absolute zero. Then he set those supercooled atoms, known as a Bose-Einstein condensate, in motion, creating a raging river of rubidium. The event horizon of Steinhauer's hole of silence emerged at the point where the rubidium's flow rate broke the sound barrier: Any sound waves emitted beyond that spot could not escape upstream (*SN: 12/18/10, p. 28*).



Ripples of radiation The pattern in this laser image between the event horizon of a sonic black hole and a second, inner horizon indicates the presence of Hawking radiation.

The success of Steinhauer's experiment hinged on observing pairs of sound waves that emerge from the vacuum at the event horizon. They would form via quantum fluctuations analogous to those predicted by Hawking to produce radiation around a real black hole. To make this acoustic Hawking radiation easier to detect, Steinhauer tried out a previously proposed strategy to make the radiation proliferate. He slowed down the rubidium atoms beyond the event horizon to create a second horizon, one that kept sound waves out rather than dragging them in. Together, the two horizons served as an amplifier: A sound wave that hit the second horizon would bounce back toward the first event horizon, where it would trigger more sound wave pairs that parted ways at the black-hole boundary. "The Hawking radiation amplifies itself," Steinhauer says.

About 120 milliseconds after Steinhauer set the rubidium atoms in motion, a rapidly intensifying cluster of sound waves rippled between the two horizons. At the same time, a corresponding batch of sound waves bolted from the homemade black hole, taking energy with it. In a study published October 12 in *Nature Physics*, Steinhauer reports the finding as the signature of Hawking radiation.

"I find it a very exciting and interesting experiment," says William Unruh, a theoretical physicist at the University of British Columbia in Vancouver. "I would not say that the case is proven," he says, adding that the observed sound waves could have come from an artifact in the Bose-Einstein condensate. "But it is probably the closest anyone has come." In 1981, Unruh proposed creating black holes in the lab but wrote at the time that detecting Hawking radiation "is an extremely slim possibility."

Faccio, who also builds black hole analogs and at one time had claimed to have detected Hawking radiation, says that Steinhauer has made a convincing case. "I think he is showing evidence that the fluctuations are coming from the quantum vacuum," Faccio says. "The experiment works because Hawking's predictions were correct." But he adds that a definitive detection would require taking sensitive measurements of the generated sound waves, including determining whether they share a quantum connection called entanglement.

Even if Steinhauer's findings are confirmed, it's unclear how much a lab-produced sonic black hole mirrors the processes governing a supermassive black hole in space. "Showing that the effect occurs in a Bose-Einstein condensate does not prove it would occur in black holes," Unruh says. "However, it sure increases my confidence that it does. The mathematics and the results are too similar to just be a coincidence." ■

J. STEINHAUER

Foreigner may have ruled Maya city

Tooth chemistry suggests an early Copan king came from afar

BY BRUCE BOWER

Imported royalty may have sparked the rise of an ancient Maya kingdom.

An early Maya king and his retainers grew up hundreds of kilometers away from the seat of power, a new study suggests. The foreigners' remains were found at Copan, an ancient Maya site in what's now western Honduras. These Maya aristocrats may have played central roles in that city's royal dynasty, probably thanks to local connections, proposes a team led by archaeologist T. Douglas Price of the University of Wisconsin–Madison.

The new findings, reported in the December *Journal of Anthropological Archaeology*, are based on chemical analyses of teeth from 32 human skeletons excavated among the remains of a residential compound near Copan's city center between 1999 and 2002. Of those individuals, 14 display signs of having spent their childhoods well outside the Copan vicinity, in the Maya heartland of Guatemala as well as in Belize and Mexico's Yucatán Peninsula.

Tooth enamel contains chemical signatures of the foods and liquids consumed during infancy and childhood. Relative amounts of certain forms of strontium and oxygen in that enamel vary from one region to another, roughly signaling where a person was born and lived early in life.

The body of one of the Copan foreigners was found in a tomb, lying on a stone bench with a jade ruler's scepter, carved jade bars and other items pointing to royal status. The researchers refer to this individual as "ruler X," since his name is unknown. Pottery placed near the body indicates the tomb was built between 400 and 525, during the early stages of Copan's growth.

Carved inscriptions at Copan indicate that the site's founding king, K'inich Yax K'uk' Mo', assumed power in 426 or 427. A sequence of 15 Copan rulers followed him and reigned until about 822. One of those kings could have been ruler X. Price's team reported in 2010 that a chemical analysis of the remains of K'inich Yax K'uk' Mo', found in a tomb in the city center, showed he had grown up northwest of Copan in Guatemala. Ancient Maya inscriptions — which mix historical facts with royal propaganda, leaving room for doubt about their accuracy — say that K'inich Yax K'uk' Mo' came from a distant land.

> Ancient Maya kings and princes may have relocated their seats of power over great distances to start new dynasties and to strengthen preexisting ones.

Evidence that K'inich Yax K'uk' Mo' and ruler X grew up far from where they reigned is consistent with the idea that early states in various parts of the world were able to form because they vested power in prominent foreigners, or "stranger kings," the researchers say. Such foreigners might have had the authority to organize local extended families into political entities of unprecedented size.

The presence of other individuals with foreign roots buried near ruler X, many accompanied by jade items and pottery, "strongly suggests that stranger kings didn't arrive alone but came with others to places where they had local connections via trade, family ties and travel," says anthropologist Charles Golden of Brandeis University in Waltham, Mass.

The Copan finds indicate that ancient Maya kings and princes may have relocated their seats of power over great distances to start new dynasties and to strengthen preexisting ones, says Simon Martin of the University of Pennsylvania Museum of Archaeology and Anthropology.

It's possible, though, that ruler X was driven from another kingdom by war or internal strife and lived in powerless exile at Copan until he died, Martin says.

Maya kings frequently associated themselves with symbols and places of foreign power, notes Andrew Scherer, an anthropologist at Brown University in Providence, R.I. Copan's K'inich Yax K'uk' Mo', for instance, aligned himself with the ancient central Mexican city of Teotihuacan. And homegrown kings typically claimed to be descendants of foreigners as well as liaisons to the gods, essentially making all Maya rulers stranger kings, Scherer says. ■

A jade bar found next to a man's remains in a tomb at the Maya site of Copan bears a mat design, denoting he had governing power. An analysis of the man's teeth suggests he grew up far from Copan.

T.D. PRICE

MATTER & ENERGY

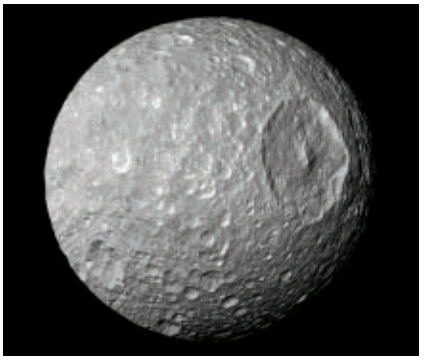
Laser tractor beam tugs on beads

A doughnut-shaped beam of green light can pull glass beads for tens of centimeters, the longest distance ever reported for a tractor beam of light. It's hard to get an object to move in a direction opposite to the light illuminating it because light scattering off an object provides a push. To counter that effect, Australian National University physicist Wieslaw Krolikowski and colleagues used air temperature and pressure. The team illuminated 50-micrometer-wide glass beads with a hollow green laser beam and then adjusted the light's polarization, or orientation of the light's vibration. When the polarization was directed toward the center of the beam, the targeted bead moved forward, away from the light source. But when the polarization was tangential to the beam, the light heated the back of the bead, which lowered the pressure of the surrounding air. Moving from high to low pressure, the bead nudged backward, the team reports October 19 in *Nature Photonics*. — *Andrew Grant*

LIFE & EVOLUTION

Extinct giant kangaroos tiptoed one hind leg at a time

The hulks among extinct kangaroos probably didn't hop: They tiptoed on one rear foot at a time. As recently as 30,000 years ago, the kangaroo genealogical tree had a branch called Sthenurinae. Members of this now-extinct subfamily ranged from small to whopper, with the largest weighing up to 240 kilograms. That's far heavier than today's biggest kangaroos, red males that bulk up to 90 kilograms. An analysis of bones from 78 sthenurines of various sizes suggests the prehistoric big guys were bipedal, says Christine Janis of Brown University. Among the clues: The giant roos' bones suggest a body too heavy for hopping, and their hips flared with room for attaching big gluteal muscles like those that help humans balance on one leg while stepping forward, Janis and colleagues say October 15 in *PLOS ONE*. Modern kangaroos hop on the ends of their feet, and Janis expects the giant roos likewise tiptoed. — *Susan Milius*



JPL-CALTECH/NASA, SPACE SCIENCE INSTITUTE

ATOM & COSMOS

Surprises lurk in a Saturn moon

A subsurface sea or a roughly football-shaped core might lie within Mimas, the smallest of Saturn's major moons. The finding could help researchers understand how Saturn's diverse entourage of icy satellites formed. Like most moons in the solar system, Mimas (above) seesaws around its axis while keeping one side facing its planet. Radwan Tajeddine of Cornell University and colleagues noticed from photos taken by NASA's Cassini spacecraft that the moon twists around farther than expected. The researchers suggest in the Oct. 17 *Science* that the twists are caused by an unusual distribution of mass inside Mimas, which is just under 400 kilometers across. The most likely culprit is an elongated core — a possible remnant from the moon's formation. An underground ocean is also possible, like the one inside another Saturnian moon, Enceladus (*SN: 5/3/14, p. 11*), but Mimas doesn't show any other signs of a subterranean sea. — *Christopher Crockett*

BODY & BRAIN

Pneumococcal vaccine thwarts resistant infections in children

PHILADELPHIA — A vaccine for pneumonia and meningitis given to babies has exceeded expectations. Not only is it effective in preventing pneumococcal infections, it has reduced those illnesses caused by antibiotic-resistant bacteria by nearly two-thirds in the four years since it was approved. The vaccine, called the 13-valent pneumococcal conjugate vaccine, protects against 13 subtypes of *Streptococcus pneumoniae*. This bacterium causes pneumonia, meningitis, blood infections, ear infections and other woes. A 7-valent version introduced in 2000 was similar but covered fewer subtypes. Sara Tomczyk of the Centers for Disease Control and Prevention and colleagues tapped CDC data on millions of infections nationwide and focused on children under age 5. Compared with 2009 when the 7-valent vaccine was in use, in 2013 disease caused by antibiotic-resistant pneumococcal bacteria dropped by 62 percent. Tomczyk reported the findings October 9 at ID Week, a meeting of the Infectious Diseases Society of America and related health care associations. When singling out five subtypes of the microbe covered by the 13-valent vaccine but not by the earlier shots, the team found that antibiotic-resistant infections arising from one of these microbes dropped by 93 percent. — *Nathan Seppa*

Drug appears safe in children with *C. difficile* infections

PHILADELPHIA — The antibiotic fidaxomicin, prescribed to adults for *Clostridium difficile* infections, seems safe for children, a study shows. *C. difficile*, or *C. diff*, is a bacterium that releases a toxin that attacks the lining of the intestines, causing severe diarrhea that can be lethal. Doctors have limited drug options against *C. diff*. When fidaxomicin was approved in 2011, it became the first new drug to tackle *C. diff* in more than two decades. Marketed as Dificid by Cubist Pharmaceuticals in Lexington, Mass., it hadn't been tested in children. Cubist researcher Pamela Sears teamed with hospitals to treat 38 children, age 11 months to 17 years, who had *C. diff*. Nine also had cancer. The patients received the drug for 10 days. By the last day of treatment, 35 of the 38 patients had had no diarrhea for several days. Ten of these patients experienced diarrhea at some point later. The drug caused mild-to-moderate side effects such as fever and vomiting, said Steven Gilman, Cubist's chief scientific officer, on October 11 at ID Week, a meeting of the Infectious Diseases Society of America and related health care associations. — *Nathan Seppa*

HARBOR FREIGHT
QUALITY TOOLS AT RIDICULOUSLY LOW PRICES

FREE
NO PURCHASE REQUIRED
& 20% OFF

How Does Harbor Freight Sell GREAT QUALITY Tools at the LOWEST Prices?

We have invested millions of dollars in our own state-of-the-art quality test labs and millions more in our factories, so our tools will go toe-to-toe with the top professional brands. And we can sell them for a fraction of the price because we cut out the middle man and pass the savings on to you. It's just that simple! Come visit one of our 500+ Stores Nationwide.

SUPER COUPON!

20% OFF
ANY SINGLE ITEM

LIMIT 1 - Save 20% on any one item purchased at our stores, HarborFreight.com or by calling 800-423-2567. *Cannot be used with other discount, coupon, gift cards, Inside Track Club membership, extended service plans or on any of the following: compressors, generators, tool storage or carts, welders, floor jacks, Towable Ride-On Trencher, Saw Mill (Item 61712/62366/67138), Predator Gas Power Items, open box items, in-store event or parking lot sale items. Not valid on prior purchases after 30 days from original purchase date with original receipt. Non-transferable. Original coupon must be presented. Valid through 3/1/15. Limit one coupon per customer per day.

56922043

NO PURCHASE REQUIRED

FREE
ITEM 69052/69111
Item 69111 shown

3-1/2" SUPER BRIGHT NINE LED ALUMINUM FLASHLIGHT

$6.99 VALUE

LIMIT 1 - Cannot be used with other discount coupon. Coupon good at our retail stores only. Offer good while supplies last. Non-transferable. Original coupon must be presented. Valid through 3/1/15. Limit one FREE GIFT coupon per customer per day.

56920409

NO PURCHASE REQUIRED

FREE
ITEM 61428/97825
Item 97825 shown

PITTSBURGH AUTOMOTIVE

6" MAGNETIC PARTS HOLDER

$6.99 VALUE

LIMIT 1 - Cannot be used with other discount coupon. Coupon good at our retail stores only. Offer good while supplies last. Non-transferable. Original coupon must be presented. Valid through 3/1/15. Limit one FREE GIFT coupon per customer per day.

56910065

NO PURCHASE REQUIRED

FREE
ITEM 69080 69030/69031
Item 69080 shown

PITTSBURGH

1" x 25 FT. TAPE MEASURE

$6.99 VALUE

LIMIT 1 - Cannot be used with other discount coupon. Coupon good at our retail stores only. Offer good while supplies last. Non-transferable. Original coupon must be presented. Valid through 3/1/15. Limit one FREE GIFT coupon per customer per day.

56915565

NO PURCHASE REQUIRED

FREE
ITEM 90899 98025/69096
Item 90899 shown

CEN-TECH

7 FUNCTION DIGITAL MULTIMETER

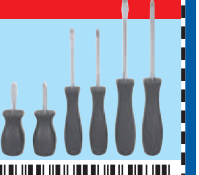
$14.99 VALUE

LIMIT 1 - Cannot be used with other discount coupon. Coupon good at our retail stores only. Offer good while supplies last. Non-transferable. Original coupon must be presented. Valid through 3/1/15. Limit one FREE GIFT coupon per customer per day.

56924187

NO PURCHASE REQUIRED

FREE
ITEM 47770 61313
Item 47770 shown



PITTSBURGH

6 PIECE SCREWDRIVER SET

$4.99 VALUE

LIMIT 1 - Cannot be used with other discount coupon. Coupon good at our retail stores only. Offer good while supplies last. Non-transferable. Original coupon must be presented. Valid through 3/1/15. Limit one FREE GIFT coupon per customer per day.

56911714

SUPER COUPON!

"The Undisputed King of the Garage" – Four Wheeler Magazine

PITTSBURGH AUTOMOTIVE

SAVE $60

LOT NO. 68053/69252 60569/62160

RAPID PUMP® 1.5 TON ALUMINUM RACING JACK

- 3-1/2 Pumps Lifts Most Vehicles
- Weighs 27 lbs.

$59.99 ~~$89.99~~ REG. PRICE $119.99

Item 68053 shown

56931460

LIMIT 3 - Good at our stores or HarborFreight.com or by calling 800-423-2567. Cannot be used with other discount or coupon or prior purchases after 30 days from original purchase with original receipt. Offer good while supplies last. Non-transferable. Original coupon must be presented. Valid through 3/1/15. Limit one coupon per customer per day.

SUPER COUPON!

"We Are Impressed With the Quality... The Price is Incredible" – Car Craft Magazine

SAVE $330

LOT NO. 68784 69387 62270

44", 13 DRAWER INDUSTRIAL QUALITY ROLLER CABINET

Item 68784 shown

NEW

- 2633 lb. Capacity
- Weighs 245 lbs.
- Super High Gloss Finish

US★GENERAL PRO

$369.99 REG. PRICE $699.99

56917105

LIMIT 5 - Good at our stores or HarborFreight.com or by calling 800-423-2567. Cannot be used with other discount or coupon or prior purchases after 30 days from original purchase with original receipt. Offer good while supplies last. Non-transferable. Original coupon must be presented. Valid through 3/1/15. Limit one coupon per customer per day.

SUPER COUPON!

2.4" COLOR LCD DIGITAL INSPECTION CAMERA

CEN-TECH

SAVE $80

LOT NO. 67979 61839/62359

Item 67979 shown

Requires four AA batteries (included).

$69.99 REG. PRICE $149.99

56920784

LIMIT 5 - Good at our stores or HarborFreight.com or by calling 800-423-2567. Cannot be used with other discount or coupon or prior purchases after 30 days from original purchase with original receipt. Offer good while supplies last. Non-transferable. Original coupon must be presented. Valid through 3/1/15. Limit one coupon per customer per day.

SUPER COUPON!

1.5 HP ELECTRIC POLE SAW

SAVE $30

LOT NO. 68862

- Extends from 6 ft. to 8 ft. 10"

CHICAGO ELECTRIC POWER TOOLS OUTDOOR

$69.99 REG. PRICE $99.99

56922617

LIMIT 5 - Good at our stores or HarborFreight.com or by calling 800-423-2567. Cannot be used with other discount or coupon or prior purchases after 30 days from original purchase with original receipt. Offer good while supplies last. Non-transferable. Original coupon must be presented. Valid through 3/1/15. Limit one coupon per customer per day.

SUPER COUPON!

"The Perfect Compressor with Powerful, Quiet and Consistent Airflow... Plus we Love the Low Price" – Street Trucks Magazine

Item 67847 shown

2.5 HP, 21 GALLON 125 PSI VERTICAL AIR COMPRESSOR CENTRALPNEUMATIC

LOT NO. 67847/61454/61693

SAVE $70

$149.99 REG. PRICE $219.99

56907980

LIMIT 3 - Good at our stores or HarborFreight.com or by calling 800-423-2567. Cannot be used with other discount or coupon or prior purchases after 30 days from original purchase with original receipt. Offer good while supplies last. Non-transferable. Original coupon must be presented. Valid through 3/1/15. Limit one coupon per customer per day.

- 100% Satisfaction Guaranteed
- Over 25 Million Satisfied Customers
- No Hassle Return Policy
- Lifetime Warranty On All Hand Tools
- 500+ Stores Nationwide
- HarborFreight.com 800-423-2567

SPIRAL STEPS

The spiral's unique characteristics may help disabled people get where they're going

By Dana Mackenzie

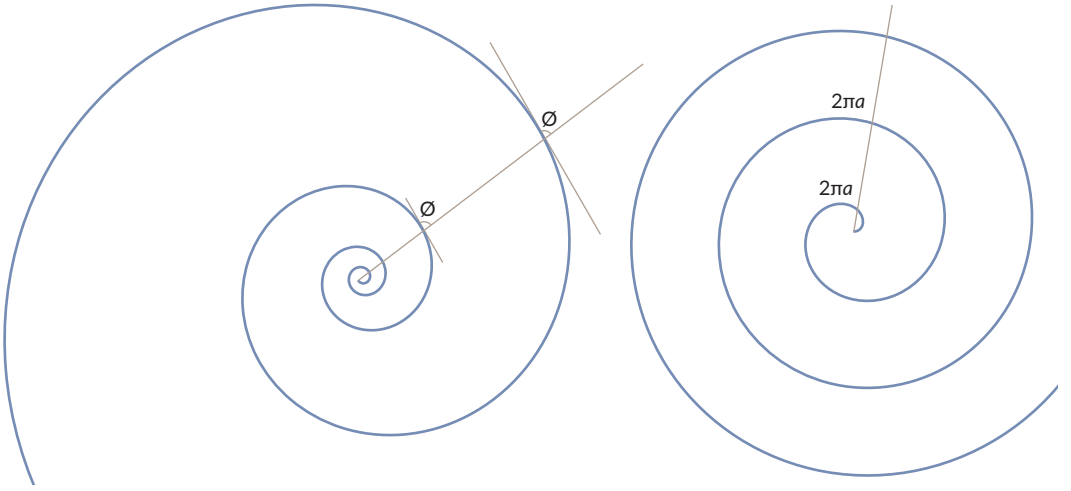
Consider the wheel. Round. Dependable. Boring. Hasn't been redesigned in centuries. Positively Neolithic.

Now consider the spiral. Eccentric. Open-ended. Captivating. Native Americans carved spirals as petroglyphs. The Greek mathematician Archimedes wrote about them around 225 B.C. Jacob Bernoulli, a 17th century mathematician, had a spiral engraved on his tombstone.

As an alternative to the lackluster wheel, the quirky spiral may be the key to forward motion for people who have trouble walking on their own.

Over the last five years, engineers Kyle Reed and Ismet Handžić at the University of South Florida in Tampa have developed a bevy of devices based on spirals. Most of their designs are intended for

NAV/ISTOCKPHOTO



Round and round Logarithmic and Archimedean spirals have very different properties. The logarithmic spiral (far left) maintains a constant angle, the camming angle, between its tangent and its radial line. The Archimedean spiral (right) maintains a constant distance between coils.

people who have difficulty walking, for example, due to a stroke or cerebral palsy. The pair also has one invention that is just meant for fun, a rock-and-roll skateboard.

Bernoulli's epitaph may capture the spiral's essence best: *Eadem mutata resurgo*. "Though changed, I shall arise the same." He meant that the spiral seems to grow and replenish itself endlessly as it spins around. But his motto could just as well describe the way that engineers keep discovering and rediscovering spirals.

Defying gravity

Spirals come in different varieties. The Archimedean spiral looks like a coiled rope or the grooves on a vinyl record. This kind of spiral travels outward (or inward) an equal distance on each turn. Bernoulli was partial to the logarithmic or equiangular spiral, which spreads out as it travels outward, like a nautilus shell. Unfortunately, the stonecutter carving Bernoulli's tombstone made a mistake and engraved an Archimedean spiral instead of the logarithmic one Bernoulli wanted.

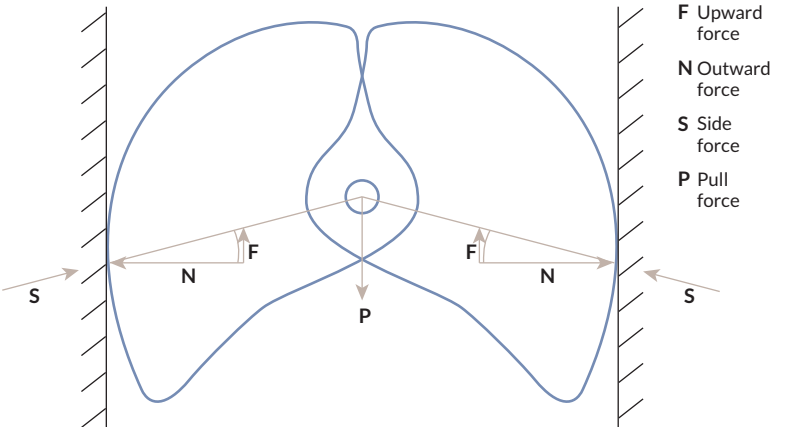
In any spiral, a line drawn from the center of the curve to any given point makes an oblique angle with the tangent to the spiral at that point. In a logarithmic spiral, this angle, the spiral's "camming angle," never varies. In the Archimedean and other types of spirals, the camming angle is not constant.

Spirals had a modern-day rebirth among rock climbers in the 1970s. Former aerospace engineer-turned-rock climber Ray Jardine invented a mechanical device to break a climber's fall. The device used four spring-loaded cams, each shaped like a logarithmic spiral. When placed into a vertical crack in the rock, the cams rest unless the hiker misses a step or slips, causing his or her weight to pull the cams down the crack. The cams grow in width as they rotate. Eventually, they jam tightly against the walls of the crevice, creating a frictional force that stops the climber's fall.

Jardine's device, aptly called the Friend, "changed the game of climbing," says John Middendorf, a climber and engineer from Tasmania who wrote the first published article explaining how it works. "At first there was a huge controversy, because some people thought it made the sport too easy," Middendorf says. Indeed, Jardine was able to climb some routes previously considered impossible. For example, he was first to ascend the sheer vertical Phoenix in Yosemite National Park.

No matter how far the cam rotates before it jams in the crack, the force it exerts on the rock will be the same and it works reliably well within a range of crack widths. The

A climbing buddy A spring-loaded camming device (above right) can save a climber from falling when inserted into a vertical crack in the rock. The climber's weight (P in the illustration below) causes the spiral cams to rotate and expand until they jam against the sides of the rock. The resulting frictional force (F) stops the climber's fall.
SOURCE: J. MIDDENDORF



FROM TOP: E. OTWELL; JOVINO/FLICKR (CC BY-NC 2.0); E. OTWELL

design was supposed to be a trade secret, but Middendorf wrote about it in 1985 because he was concerned that climbers were beginning to use homemade imitations that were not safe. A camming device with the wrong camming angle, or even worse, the wrong kind of spiral, might fail to hold. It's an easy mistake to make: Just ask Bernoulli's stonecutter.

From vertical to horizontal

The spiral cam, for 40 years a friend to climbers, may soon become a friend to stroke victims as well. The principle is the same: to redirect a vertical force into a nearly horizontal one. The vertical force of a person's weight, stepping on a shoe with spiral wheels, causes the shoe to roll either forward or backward, depending on the desired effect, and thereby to even out an asymmetric gait.

People with gait impairments limp in a predictable way. They spend more time on their strong leg, taking longer strides to step onto the weak leg. Amy Bastian, a neuroscientist at Johns Hopkins University, discovered that a specially designed treadmill could help limping patients improve their gaits. The treadmill has two separate belts; the one on the strong side can be programmed to go twice as fast as the one on the weak side.

"You exaggerate the asymmetry, to make them want to lengthen that short step," says South Florida's Reed. When the patients got off the treadmill, they would continue to exaggerate their shorter step, and their limp would be reduced. "After 15 minutes of practice on a treadmill, you can get large changes that you don't see with any other treatment I know of," says neuroscientist Erin Vasudevan, who worked in Bastian's lab from 2007 to 2010 and collaborated with Reed while there.

But split-belt treadmills are expensive and not commonly available. Also, patients do not always retain their gains over the long term. Reed started thinking about a portable device that patients could take with them — a shoe that would offer the therapeutic benefits of a treadmill while allowing them to go about their daily lives.

The challenge was to make a shoe that glides backwards when stepped on, as if the walker were on a treadmill. Reed's first model had ordinary circular wheels and wasn't predictable enough for users to get the hang of. "It felt a little bit as if you were slipping on ice," says Vasudevan, who is now at Stony Brook University in New York. When Handžić joined Reed's lab as a student in 2009, Reed assigned him to improve the design. He suggested that Handžić try spiral wheels.

Handžić started with Archimedean spirals and logarithmic spirals. The Archimedean spirals didn't work well because they didn't generate a constant backward force. The logarithmic ones didn't feel right either. To simulate the steady pace of a treadmill, the body expects the combined force of the foot and the spiral wheels to be constant. In a natural stride, the planted leg does not exert a constant backward force, so the design of the shoe must compensate.

After months of frustration, Handžić finally had a revelation. Instead of prescribing the wheel shape, he could prescribe the forces. He had been stymied by the fact that the force variables (the desired force profile for his user) and the geometric variables (the shape of the wheel) were tangled up together in a complicated equation.

He had been trying to use a computer to find

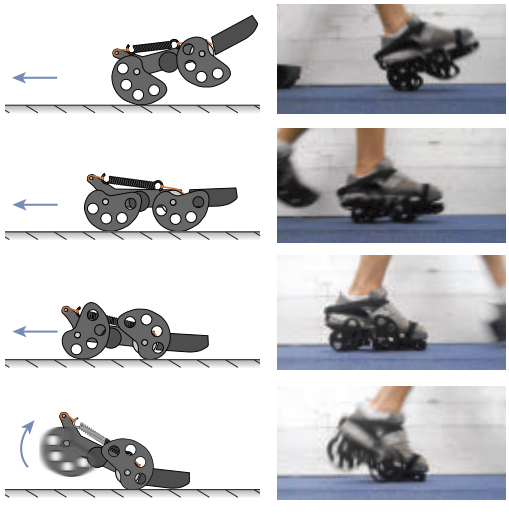
If the shoe fits The Gait-Enhancing Mobile Shoe (prototype below) is equipped with spiral wheels that simulate walking on a treadmill.

Heel strike Rear wheel touches down and begins rotating backward, redirecting the user's weight to a mostly horizontal force.

Mid stance Front wheel touches down so both wheels contact the ground and rotate backward.

Terminal stance A properly designed spiral wheel must compensate for the variations in a human step to produce a steady backward force.

Toe off As the user lifts the foot, the spring-loaded spiral wheels reset themselves.



I. HANDŽIĆ AND K. REED/USF

an approximate solution. But he realized he could use a mathematical method called separation of variables to disentangle the forces and the geometry, and translate perfectly from one to the other. Handžić had recently reviewed this trick while studying for an exam, never suspecting that it would have any use for his research.

There is no record of what the inventor of the wheel did when he saw his creation roll for the first time. But Handžić recorded in his Ph.D. thesis what he did when he discovered the separation of variables idea: "I ecstatically jumped, pumped my fist, [and] jump shot my soft drink can into the trash can, while repeating the words, 'That's it!'" He could finally custom-design a wheel for any application.

Still, spirals have one limitation as a locomotive device: They end. That's why cars don't travel on spiral wheels. For walking, however, spiral wheels can work. As the foot lifts up and the wheel is in the air, the wheel has time to reset itself to its starting position. *Eadem mutata resurgo*, indeed.

Handžić has taken the resetting idea to the extreme with a skateboard he calls the kinetic board. The rider starts leaning back on the rear wheels and rolling forward. (Unlike in the gait-enhancing shoe, where the wheels roll backward to simulate a treadmill, the skateboard's spiral wheels are configured to redirect the rider's weight into a forward force.) Just before reaching the end of the spiral, at which point the rear wheels are unable to roll forward any more, the rider rocks forward onto the front wheels, lifting the rear wheels off the ground so they can reset. Rock back, roll forward. Rock forward, roll forward.

Handžić and Reed have no plans to market their skateboard. However, other self-propelled skateboards, called RipStiks and waveboards, have done well on the toy market, and elementary school students who visit Reed's lab want to give the rock-and-roll skateboard a try. "Their cam-powered scooter looks really fun," says Andy Ruina, an engineer at Cornell University who works on robot and human locomotion. He was not involved in the research. "It's always nice to see new ways to propel things."

The gait-enhancing shoe, on the other hand, has a patent pending and has been licensed by a medical device company called Moterum LLC of Tampa. Reed and Handžić have tested it on healthy volunteers, and the first clinical trial with 12 stroke patients is planned for this fall. The stroke patients will wear the wheeled shoe on their healthy side (simulating the faster treadmill) and a height- and weight-matched shoe with no wheels on the weaker side (simulating the slower treadmill). The inventors hope it will retrain the patients more effectively than regular split-belt treadmill therapy so that the patients eventually won't need the shoe.

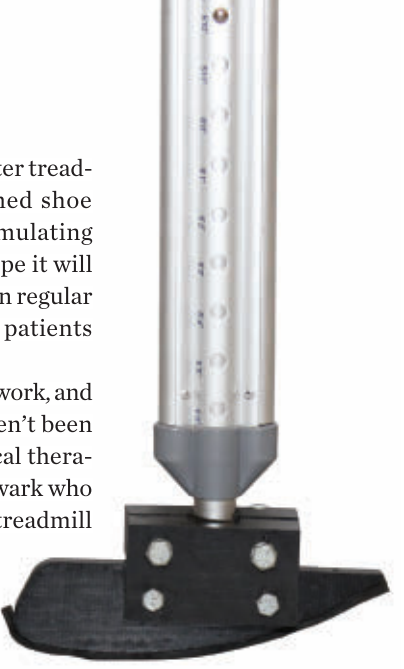
"They've done their engineering homework, and it seems promising, but the studies haven't been done yet," says Darcy Reisman, a physical therapist at the University of Delaware in Newark who has researched the effects of split-belt treadmill therapy. "Patients always surprise us."

A better crutch

Handžić and Reed also hope to reinvent the crutch. Normal crutches have a flat tip, and at the apex of the crutch's motion, the user has to provide all of the propulsive force, as if pushing over a hill on every step. A spiral tip can make the job easier. At the apex, it converts vertical weight into a forward force. Or if the user is going downhill and wants to slow down, the crutch can be turned around to convert vertical weight into a backward force.

In experiments, volunteers said the spiral crutch required less effort than a conventional crutch. Eventually, the researchers envision making a crutch with a tip that could change its shape so the crutch could stand up on its own, freeing the user's hands for other purposes. "Having a crutch or cane be able to stand up independently is a feature that several chronic users of canes are excited about," Reed says.

Meanwhile, at least one person's life has been changed by the research: Handžić himself. Growing up in Bosnia and Herzegovina, he had little idea of what research meant. He entered graduate school, he says, for the sole purpose of earning a higher salary. But the spirals have captured his imagination and showed him that research is about passion, not money. Says Handžić, who hopes to continue research in academia or industry, "It was a cool experience to put the mathematical theory together with practice and have something come out that is so beautiful." ■



I. HANDŽIĆ AND K. REED/USF

An experimental crutch with a spiral tip can redirect the user's weight to give a forward assist at the apex of the crutch's motion.

Explore more

- I. Handžić and K. Reed. "Kinetic shapes: Analysis, verification, and applications." *Journal of Mechanical Design*. June 2014.

Dana Mackenzie is a freelance mathematics and science writer based in Santa Cruz, CA.

See a kinetic board in action at **bit.ly/SN_kineticboard**

Brain Hack

Brain stimulators have escaped the lab — ready or not — and people are juicing their brains from the comfort of home.

ELI MEIR KAPLAN

Consumers take their neurons into their own hands

By Laura Sanders

The first time Nathan Whitmore zapped his brain, he had a college friend standing by, ready to pull the cord in case he had a seizure. That didn't happen. Instead, Whitmore started experimenting with the surges of electricity, and he liked the effects. Since that first cautious attempt, he's become a frequent user of, and advocate for, homemade brain stimulators.

Depending on where he puts the electrodes, Whitmore says, he has expanded his memory, improved his math skills and solved previously intractable problems. The 22-year-old, a researcher in a National Institute on Aging neuroscience lab in Baltimore, writes computer programs in his spare time. When he attaches an electrode to a spot on his forehead, his brain goes into a "flow state," he says, where tricky coding solutions appear effortlessly. "It's like the computer is programming itself."

Whitmore no longer asks a friend to keep him company while he plugs in, but he is far from alone. The movement to use electricity to change the brain, while still relatively fringe, appears to be growing, as evidenced by a steady increase in active participants in an online brain-hacking message board that Whitmore moderates. This do-it-yourself community, some of whom make their own devices, includes people who want to get better test scores or crush the competition in video games as well as people struggling with depression and chronic pain, Whitmore says.

As reckless as it sounds to juice a brain at home with a 9-volt battery and 40 dollars' worth of spare parts, this technology's buzz is based on legit science. Small laboratory studies suggest that carefully controlled brain stimulation can boost a person's memory and math abilities, hone attention and fast-track

learning. The U. S. military is interested and is funding studies to test brain stimulation as a way to boost soldiers' alertness and vigilance. The technique may even be a viable treatment for pernicious mental disorders such as major depression, according to other laboratory-based studies.

Many of the scientists who are leading the charge, however, insist that this simple, relatively safe and cheap technology isn't ready for home use. The research is too preliminary, and such stimulation may prove to be ineffective at best or, at worst, dangerous, some say. Certain kinds of stimulation may cause unintended harm; brain stimulation is not as foolproof as many people would like to believe.

Still, "humans have a long history of playing with their brains," says neuroscientist Vincent Clark of the University of New Mexico and the Mind Research Network, a nonprofit neuroscience research institute in Albuquerque. And it's unlikely that scientists' protests will change that. Right now, scientists, policy makers and DIYers are all wrestling with whether — and how — the technology should be regulated.

Ethical quandaries as well as questions about efficacy and safety call for restraint. But demand, fueled by tantalizing news of promising studies, has largely drowned out those cautionary calls. "We are in such a fog of ignorance," says neuroethicist Hank Greely of Stanford Law School, who studies how brain research intersects with society. "We really need to know more about how this works."

11.5
points
Drop on depression rating scale among people using tDCS plus Zoloft compared with the depression drop for placebos

3
points
The amount of change considered clinically relevant

The promise

The brain traffics in electricity. Minuscule electrical bursts create the signals that allow people to think, remember and feel, so it makes perfect sense that external electricity might influence how the brain operates.

That insight isn't new. A physician to the Roman emperor Claudius eased headaches by placing a live, electric torpedo ray (similar to a stingray) onto the heads of long-suffering patients. In the 11th century, electric catfish were proposed as treatment for epilepsy. In the 1800s, the nephew of Italian bioelectrical pioneer Luigi Galvani, who harnessed lightning to make dead frogs' legs jump, used electrical stimulation to treat people's melancholia.

Neurons working together tDCS can cause changes in blood flow, detected by functional MRI. Here, some brain regions show higher levels of cooperation (red) or lower levels (blue) during tDCS compared with sham stimulation.

MARCUS MEINZER *ET AL./J. VIS. EXP.* 2014

Today's burgeoning field of "electroceuticals" takes advantage of the same principle. Clinicians use various delivery methods — both external and implanted — to transform the brain's electrical activity. For some people, electroconvulsive therapy can ease severe depression or mania that drugs don't touch. This wallop of electricity sparks a short seizure that's thought to reset the brain and lessen symptoms. Some people with Parkinson's disease have also found relief in electricity: Rhythmic zaps from electrodes implanted deep into their brains can reduce tremors and rigidity.

Those methods are different from the one that has captured the attention of the DIY crowd. Transcranial direct current stimulation, known as tDCS, sends small amounts of stable electric current into the scalp. Although the details are still hazy, tDCS is thought to work by coaxing nerve cells to become either more or less active, depending on whether the anode or the cathode of the device is placed over the neurons. The electricity doesn't compel neurons to fire off messages or stay silent; instead, it gently tips the scales toward action or inaction, studies have found.

Depending on which part of the brain gets nudged, tDCS can influence things like attention, working memory, visual abilities and mathematical skills. For instance, stimulation to the top of the brain caused 15 healthy people to learn a made-up number system better than healthy people who received no stimulation, and the benefit lasted months after the stimulation stopped, neuroscientist Roi Cohen Kadosh of the University of Oxford and colleagues reported in *Current Biology* in 2010.

tDCS may also alleviate symptoms of depression, other small studies suggest. In a randomized trial of 120 people with moderate to severe depression, tDCS, with positive stimulation (anode) over the left side of the brain and negative (cathode) over the right, boosted the effects of the drug sertraline, or Zoloft, scientists reported in 2013 in *JAMA Psychiatry*. Over a six-week period, people who received both tDCS and sertraline scored on average 11.5 points better on a depression rating scale than people who received placebos. (A drop of three points was considered clinically relevant.) tDCS alone caused a smaller drop — 5.6 points — versus sham, and sertraline alone caused an even smaller drop: 2.9 points less than placebo.

The technique might influence depression as well as other brain processes by boosting the brain's ability to flexibly respond to new situations or problems — a feature known as plasticity. Electricity can boost plasticity by kicking off a series of events that ultimately change how neurons communicate with one another. Researchers have seen tDCS-induced changes among certain molecules that help send and receive messages between neurons. Those molecules, including NMDA receptors, GABA and glutamate, have been implicated in depression and other brain disorders in numerous studies.

Other more wide-ranging effects of electricity may be involved. tDCS appears to influence the behavior of large cohorts of neurons. Even more generally, electricity can influence blood flow in the brain, inflammation and probably a whole range of other processes.

Despite an incomplete understanding of the technology, clinicians have already taken note of the findings, particularly the antidepressant effects of tDCS. Several clinics offer tDCS therapy to patients, often outside of research studies.

Some people, however, don't want to go to the trouble of visiting a doctor or enrolling in a lab study to experience tDCS. Prefab tDCS machines can be purchased online for a few hundred dollars or less. DIY plans for building a tDCS system are available to anyone with an Internet connection. So people are making their own.

"I have a graduate student whose background is in philosophy, and he was able to build one in an afternoon for less than $50," says neuroscientist and ethicist Peter Reiner of the University of British Columbia in Vancouver. "The device is shockingly simple, and a little scary because of that."

Training sessions coupled with tDCS improved test subjects' ability to tell a harmless scene (top) from one that holds hidden danger (bottom, bomb circled).

Enter the DIYers

No one really knows how many people use this technology at home, Greely says. His Stanford colleague Anita Jwa sent a questionnaire to participants in online tDCS chat groups, and heard back from about 120 respondents. The survey is anything but comprehensive, but it attempts for the first time to study the DIY community, which Jwa found is overwhelmingly male, and not necessarily young. About 23 percent of respondents were 40 or older, the survey revealed. "It's not just the pimply kid in the basement playing a massive online role-playing game," Greely says.

In fact, many of the people who use tDCS have an illness that hasn't been treated successfully and are trying it out of desperation, says Brent Williams, who maintains a tDCS website. With a background in engineering, Williams had no trouble building a unit for himself and his wife. They use it to boost their creativity and memory, among other things.

Williams, who directs an educational outreach program at Kennesaw State University in Georgia, became convinced that the technology can change lives. He began to proselytize about it on his website. "I get e-mails every day from people who are doing tDCS stuff," he says. "A lot of those e-mails come from, frankly, pretty desperate people who live in countries or regions where they don't have access to the doctors that we have access to. They are desperate to do tDCS for depression or chronic pain or whatever the case may be," he says.

That idea — people turning to tDCS instead of working with a doctor or using tDCS regularly to improve performance — worries some scientists and physicians. Notably, most of the scientists who regularly zap subjects' brains in their labs aren't likely to use the technology on their own brains, according to a study published in the July-August *Brain Stimulation*. Of 287 researchers who study noninvasive brain stimulation (including but not limited to tDCS), only 8 percent said they juice themselves. Common reasons for abstaining included believing the benefit was too small and concern about safety.

The perils

And those 8 percent of researchers probably used adequately tested machines to deliver an appropriate dose of electricity. Home use is only as good as the person who builds and operates the system. Just ask the people who have posted online images of scalp burns from improper current.

Burns and even more severe reactions, such as reports of manic episodes and even temporary paralysis caused by brain stimulation, seem to be rare. "It's not like people are dropping dead or having their teeth fall out," Greely says.

Aside from trouble sleeping in the hours after he has used his tDCS system, Whitmore says he has never experienced any negative effects from tDCS. But some effects might be subtle.

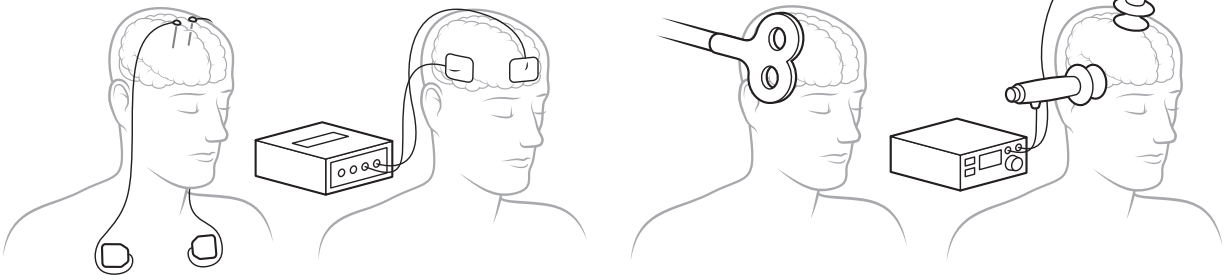
In a 2013 paper in the *Journal of Neuroscience*, Cohen Kadosh and a colleague reported that the math gains people experienced from experimental stimulation weakened a different math skill. "We can improve one function but it comes at the cost of another function," he says. It's entirely possible that other deficits brought about by tDCS have remained hidden because not many people have looked for them.

Assuming safety wasn't an issue, there are plenty of reasons a person at home wouldn't achieve the same results as participants in a carefully done lab study, says Cohen Kadosh. The best brain locale to stimulate is probably different in every person. Depending on culture, expertise and age, people rely on different parts of their brains to do math, for instance. Plus, brain regions can be found at slightly different physical coordinates from person to person.

The question of dose isn't settled, either. Many studies use about 20 minutes of 1 to 2 milliamps of current at a time. But the effect of that dose may vary widely from person to person. Antidepressants can change the brain's baseline excitability, as can other drugs, both legal and illicit. Age, sex and smoking status have all been linked to differences in brain behavior. And the movement of electrical current can be influenced by wrinkles in the brain, the thickness of the skull and the shape of the head. These individual quirks shift the goal line, making it nearly impossible for someone at home to know exactly where and how long stimulation should be applied.

V. P. CLARK *ET AL/NEUROIMAGE* 2012

Electric Avenue Depending on how it's delivered, electricity can have profound effects on the brain. All of the methods below, except for deep brain stimulation, involve external placement of the electrodes or magnet.



Deep brain stimulation
Electrodes surgically implanted into a patient's brain generate pulses that can regulate struggling brain circuits, such as those that go awry in Parkinson's disease. Some clinicians are testing DBS to treat depression, epilepsy and obsessive-compulsive disorder.

Transcranial direct current stimulation
Electrodes are placed on the scalp sending weak electrical current (usually between 1 and 2 milliamps) into the brain. Depending on the placement and type of stimulation, users may alter working memory, attention or math skills. Depression and chronic pain may also be reduced, some studies suggest.

Transcranial magnetic stimulation
A coil of wire held next to the head generates a magnetic field, triggering electric currents in the brain. TMS has shown promise as a way to treat psychiatric disorders and provide cognitive boosts. The Food and Drug Administration has OK'd versions of TMS for depression and migraines.

Electroconvulsive therapy
Once a patient is under anesthesia and given a muscle relaxant to prevent movement, electrodes are placed on the head to send about a 500 to 900 milliamp current through the brain, sparking a brief seizure. ECT is used to treat severe depression, bipolar disorder and schizophrenia.

JAMES PROVOST

For years, Cohen Kadosh has meticulously researched how best to safely and effectively transmit electricity to the brain. But even he has qualms about using tDCS. "People are adults. They're free to do whatever they want," he says. "But I would not do this myself."

To regulate or not?

The fact that the desire for this technology is running ahead of adequate safety and efficacy studies is something that Cohen Kadosh has become acutely aware of during his research with tDCS. "I've been contacted in the past by parents who want to improve their children's performance in order to get into an excellent university or be better in school," he says.

Philosophically, external brain stimulation is no different than making a child take piano lessons, Greely says, so long as the technique is proven safe and effective. And that's a big caveat. "I know enough about brains to know that they're really complicated," he says. Without a firm understanding of how the brain works, Greely is loath to start meddling with his. "At this point, I wouldn't encourage my kids to do it," he says.

Right now, it's perfectly legal to build or buy a tDCS system. The $249 tDCS headset called "foc.us" is advertised as a tool to "excite your prefrontal cortex and get the edge in online gaming." And Thync, a company that's developing a headset to "shift your state of mind," claims it will allow users to tailor their moods, creating energized, relaxed or focused experiences.

The independent, nonprofit Institute of Medicine in Washington, D.C., will hold a workshop early next year to explore the role of external brain stimulation in society. Discussions, sponsored by a collection of federal agencies, patient groups, industry and nonprofits, will include potential benefits and risks of the technology, regulatory quandaries and ethical dilemmas such as whether it's acceptable to use the technology for cognitive enhancement in healthy people and the implications of involuntary or coercive use.

For his part, Williams, the Georgia DIYer, has written about how to safely and ethically use tDCS and has even suggested a code of safety standards for fellow DIY users. His rules include seeking out a medical professional for advice, treatment and follow-up, never using tDCS alone and never using the technology on children or animals.

It's not clear whether tDCS will really take off and become the next killer app, Greely says. But as the science hums along, people will probably keep pushing the technology's boundaries. That means scientists' cautious "Don't try this at home" may continue to fall on deaf ears and tingling scalps. ■

Explore more

- tDCS message board: www.reddit.com/r/tDCS
- Andre Russowsky Brunoni *et al.* "Clinical research with transcranial direct current stimulation (tDCS): Challenges and future directions." *Brain Stimulation*. July 2012.

Holly Jackson (left) and Sahar Khashayar took the top prizes in the Broadcom MASTERS competition.

Sewing study stitches up Broadcom prize

WASHINGTON — A teen who loves to sew zigzagged her way through three days of science, engineering and math challenges to win the top prize at a middle school science competition. At a ceremony October 28, Holly Jackson, 14, of San Jose, Calif., claimed the $25,000 award.

She was one of 30 finalists from 13 states who came to the fourth annual Broadcom Math, Applied Science, Technology and Engineering Rising Stars, or MASTERS, competition. "I was so surprised," Jackson said. "The other finalists had so many great projects." The other top award went to Sahar Khashayar, 14, of Laguna Niguel, Calif.

Eight other finalists took home cash awards or funding to attend a science or engineering camp. The Samueli Foundation, an organization started by Broadcom cofounder Henry Samueli, provided Jackson's funds.

Broadcom MASTERS finalists were selected on the basis of a middle school science fair project. The projects accounted for about one-quarter of each finalist's score. The rest of the score came from performance in science challenges. While in Washington, five-member teams designed, built and tested roller coasters, carbonation-powered rockets and hurricane-proof houses. The finalists also analyzed minerals and scrutinized replicas of fossil skulls.

Jackson's research project analyzed the strength of various types of sewing stitches and the best applications for them. She used thread to sew together 120 samples of cotton, denim and nylon fabric. Then she measured the force needed to break the stitches with a bathroom scale. The results were surprising, she said: "The strongest stitch, on average, was a simple straight stitch." Jackson's findings could be of interest to everyone from fashion designers to parachute manufacturers.

Jackson's project "is a great example of how science is applicable in our everyday lives," said Maya Ajmera, president and chief executive officer of Society for Science & the Public, which runs the Broadcom MASTERS competition and publishes *Science News*.

One of the competition's highlights involved no science: The students met President Barack Obama at the White House.

"Congratulations to Holly, Sahar and the entire Broadcom MASTERS class of 2014 whose STEM skills and collaborative team spirit represent the critical array of diversified talent needed to innovate solutions to the world's grand challenges," said Paula Golden, executive director of the Broadcom Foundation. — *Sid Perkins*

Broadcom MASTERS Winners

The Samueli Foundation Prize: Holly Jackson of San Jose, Calif., won $25,000. She tested the strength of various sewing stitches.

Marconi/Samueli Award for Innovation: Sahar Khashayar of Laguna Niguel, Calif., won $10,000. She created an inexpensive device to provide early warning of wildfires.

STEM Award Winners

The following finalists were selected for demonstrated skills and promise in the disciplines represented by STEM.

Science Awards: First place went to James Roney of Santa Barbara, Calif. He found that ants signal each other about food quality. Second place went to Daniel Bruce of San Diego, who studied people's influence on bird behavior in lagoons.

Technology Awards: First place went to Aditya Jain of Portland, Ore. He created algorithms to better detect lung cancer on CT scans. Second place went to Nikhil Behari of Sewickley, Pa., who developed keystroke-based password security enhancements.

Engineering Awards: First place went to Chythanya Murali of Little Rock, Ark. Her project explored enzymes and bacteria that can clean up oil spills. Second place went to Annika Urban of Pittsburgh, who developed a device to record heartbeats and breath sounds.

Mathematics Awards: First place went to Rajiv Movva of San Jose, Calif., who studied nondrug treatments for type 2 diabetes. Second place went to Jonathan Okasinski of Harleysville, Pa. He developed equipment that can demonstrate quantum entanglement.

Rising Stars Award Winners

Two finalists were selected for scientific promise and spirit of cooperation. Annie Ostojic of Munster, Ind., studied the best ways to microwave foods. Raghav Ganesh of San Jose, Calif., created a "smart" cane for blind people.

P. THORNTON/SSP

Congratulations Broadcom MASTERS!

Broadcom Foundation salutes the 2,054 amazing young scientists and engineers nominated by their science fair judges to compete in the 2014 Broadcom MASTERS®. Congratulations to our 30 finalists!

Muhammad Uğur oğlu Abdulla
Melbourne, Florida

Nikhil Behari
Sewickley, Pennsylvania

Daniel S. Bruce
San Diego, California

Benjamin J. Chrepta
Rochester, Minnesota

Joshua Courtney
Baton Rouge, Louisiana

Arnob Das
Portland, Oregon

Leo Deng
Portland, Oregon

Caroline Edmonds
Fountain Valley, California

Linus Freyer
Pinecrest, Florida

Raghav Ganesh
San Jose, California

Makayla Gates
Peralta, New Mexico

Alden Giedraitis
Byfield, Massachusetts

Floyd S. Greenwood
Andover, Massachusetts

Holly Jackson
San Jose, California

Aditya Jain
Portland, Oregon

Gelsey Jaymes
Mount Pleasant, South Carolina

Sahar Khashayar
Laguna Niguel, California

Rajiv Movva
San Jose, California

Chythanya Murali
Little Rock, Arkansas

Caroline Nolan
Stuart, Florida

Jonathan Okasinski
Harleysville, Pennsylvania

Annie Ostojic
Munster, Indiana

James Peter Roney
Santa Barbara, California

Hafsa Naseem Saeed
Fort Pierce, Florida

Alex Shelby
Fishers, Indiana

Aditya Sivakumar
Beaverton, Oregon

Talar Victoria-Grace Terzian
Gainesville, Florida

Annika Urban
Pittsburgh, Pennsylvania

Katherine Wu
North Potomac, Maryland

Liam Hayden Young
Colorado Springs, Colorado

About Broadcom MASTERS

Broadcom MASTERS, a program of Society for Science & the Public, stands for Math, Applied Science, Technology, and Engineering for Rising Stars. Please visit student.societyforscience.org/broadcom-masters or download the app at broadcomfoundation.org/masters to learn how you can compete in this premier science and engineering competition, created to inspire for 6th, 7th, and 8th grade students to pursue their personal passion for science and math into high school.

student.societyforscience.org/broadcom-masters | facebook.com/broadcommasters

INTERVIEW

Mastering the art of self-control

Psychologist Walter Mischel discusses the science behind willpower

Columbia University psychologist Walter Mischel made his scientific mark by tempting children with marshmallows. For nearly 50 years, Mischel has studied whether kids would eat, say, one marshmallow right away or wait 20 minutes to receive two marshmallows. Kids who waited for double the goodies grew up to do better in school, get better jobs, maintain better physical health and feel better about themselves than their grab-and-go peers (*SN: 10/8/11, p. 12*). *Science News* talked to Mischel about his new book, *The Marshmallow Test*, which describes how self-control can be learned and applied to challenges ranging from losing weight to planning for retirement.

What is the most important lesson of research on self-control?

No matter how bad you are at resisting temptations, there are ways to enhance self-control if you're motivated to use them. Research has shown that self-control involves a set of cognitive skills that are quite teachable, especially early in life. Successful delayers in the marshmallow test use these cognitive skills to think up games and other strategies that help them to cool impulsive urges and reach future goals. We don't have to be victims of our biology, genes or circumstances. People can learn self-control strategies and become active agents in determining how their lives play out.

Willpower is sometimes described as a limited mental resource that can easily be drained, at least temporarily. Do you agree?

I agree that a person's potential for self-control becomes limited as stress levels and fatigue go up. But there are huge differences across individuals in what can be accomplished when stressed and tired. Exhausted people can expend huge amounts of energy if they have strategies they are motivated to use in order to reach a burning goal.

How can people who have lost control of some part of their lives turn things around?

In my book, I use myself as an example of how to reverse destructive behavior. I'm 84 years old, and 50 years ago I was addicted to cigarettes. I also smoked pipes and cigars. I realized I had a problem when I was standing in the shower and noticed a lit pipe in my hand. Shortly after that I saw a hospital patient on a gurney with green X marks on his chest and head. A nurse told me the man had spreading cancer and the marks showed where he was going to receive radiation treatment. I visualized myself as a cancer patient and decided to overcome the conditioned, emotional responses that made me want to smoke. Whenever I felt the urge to light up, I inhaled from a can filled with stale cigarette butts and pipe debris. That's a nauseating smell. I also made a deal with my 3-year-old daughter to stop sucking my pipe if she stopped sucking her thumb. And I publicly promised coworkers and students that I wouldn't mooch cigarettes from them. After a few tough weeks, it worked.

Is it time for a renewed scientific focus on free will?

We need a renewed scientific focus on the nature of human nature. What's become clear in the past 20 years is that the plasticity of brain and behavior is far greater than had been assumed. Researchers need to examine psychological and environmental conditions that enable dramatic behavior changes.
— Bruce Bower

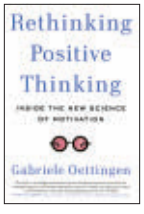
Three secrets to self-control

1. Distract yourself. Kids who wait for two marshmallows often make up stories in their heads, sing songs or invent games to play.

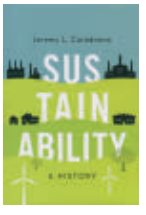
2. Make if-then plans and stick to them. Examples: If there is a dessert menu at the restaurant, I will not order chocolate cake. When the clock hits 5 p.m., I will read my textbook.

3. Shift your time perspective from immediate desires to future negative consequences. A smoker pining for a puff can visualize himself as a cancer patient being wheeled into radiation treatment.

BOOKSHELF



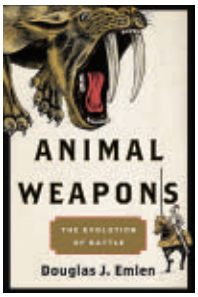
Rethinking Positive Thinking
Gabriele Oettingen
Citing decades of research, a psychologist argues that optimism can be detrimental to success and introduces alternate ways of thinking that can better help people reach their goals. *Current, $27.95*



Sustainability
Jeremy L. Caradonna
Sustainability is not a recent invention. A historian recounts the movement's development, tracing its roots back to early forest management in Europe during the 17th and 18th centuries. *Oxford Univ., $27.95*

The Lagoon
Armand Marie Leroi
Arguing that Aristotle is the true founder of the field of biology, this book takes a detailed look at the philosopher's observations and ideas about the living world and how they compare with current thinking. *Viking, $27.95*

TOP: LITTLE, BROWN AND CO.; OPPOSITE: THAILOEI92/SHUTTERSTOCK



BOOKSHELF

Animal Weapons

The Evolution of Battle

Douglas J. Emlen

The horns of rhinoceros beetles are one example of the elaborate armament found in nature and described in *Animal Weapons*.

The animal world is full of examples of extreme weaponry: the mantis shrimp's supersonic punch, the fiddler crab's giant claw, the African elephant's long tusks. These weapons have evolved as the result of biological arms races lasting millions of years.

In *Animal Weapons*, Emlen, a biologist at the University of Montana in Missoula, explains the science behind those arms races, including how battles for resources and females can influence the evolution of weaponry and how this sort of competition has resulted in some of the craziest looking appendages to ever grace an elk's head or a beetle's back.

Along the way, Emlen peppers the text with his own adventures, such as when he was a graduate student in Belize and sliced his thumb open with a machete. With no hospital nearby, his thumb was sterilized with rum and the cut sutured shut with the bites of trap-jaw ants. In another tale, Emlen describes a mass of 100,000 beetles attacking a pile of elephant dung he had left out near camp: "It was as if somebody was pouring beetles from a bucket."

Emlen's writing is best when he discusses the beetles and other insects that he studies. But there are enough bigger critters in the book, from narwhals to saber-toothed cats, to satisfy the insect-phobic.

Throughout the book, Emlen draws parallels between the evolution of animal weaponry and human weaponry. Battling rhinoceros beetles are more similar to 11th and 12th century European knights than you might expect — in both cases, Emlen argues, males fight for access to reproductive females. But Emlen warns that comparisons between animals and humans can go only so far. Today's nuclear, biological and other extreme weapons have changed the stakes and logic of battle, resulting in an arms race that has no analog in the natural world. — *Sarah Zielinski*

Henry Holt, $32.50

Buy Books Reviews on the *Science News* website include Amazon.com links that generate funds for Society for Science & the Public programs.

OCTOBER 4, 2014

Comparing creepy crawlers

Some readers noticed similarities between an extinct arachnid described by **Alexandra Witze** in "Virtually there" (*SN: 10/4/14, p. 16*) and a vinegaroon, or whip scorpion, found in the southwestern United States. While the two species are related, the vinegaroon (shown) has a size advantage: It can grow to 85 millimeters in length, compared with the ancient arachnid's paltry 4 or 5 millimeters.

Join the conversation

E-MAIL editors@sciencenews.org

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

Connect with us

The war on bacteria

*Changing the way doctors prescribe antibiotics could make a big difference in the ongoing fight against antimicrobial resistance. In "Low-tech bacteria battle" (*SN: 10/4/14, p. 22*), **Nathan Seppa** outlined some of the simple steps physicians are taking to improve their antimicrobial stewardship.*

"It just so happens that I was sitting in my elderly mother's hospital room when I read your article and identified, one day before her doctors, that she had a *Clostridium difficile* infection," wrote **Karen Attaway** in an e-mail. "I pointed out to her nurse that her symptoms were exactly the same as those listed in *Science News*. I also had to ask the nurse if the hospital was giving their patients the quadrivalent or trivalent flu shot," she added (see "High-dose flu shot benefits elderly" *SN: 10/4/14, p. 15*). "Perhaps *Science News* needs to be marketed to more physicians and nurses as well as hospital waiting rooms!"

Many readers pointed out that the biggest antibiotic users aren't human: About 80 percent of antibiotics in the United States are used in agriculture and aquaculture. "I was disappointed that there was no mention of the ongoing dangers of antibiotics in our food sources," wrote **Jacob R. Raitt**. "Should this not be strongly emphasized?"

Seppa acknowledges that overuse of antibiotics in agriculture is a huge problem — one that *Science News* has explored in the past (*SN Online: 3/23/12; SN: 1/1/05, p. 5*). Interested readers can follow *SN*'s coverage on other aspects of the multifaceted resistance problem, such as antimicrobials finding their way into wastewater (*SN: 7/26/14, p. 9*) and antibiotic failure in patients (*SN: 3/24/12, p. 10*), and learn how antibiotics work on the molecular level (*SN: 5/3/14, p. 18*). The recent feature focused on the rise of antimicrobial stewardship to address one key problem: overprescribing.

Forecast fallout

*Around 640,000 years ago, the volcano beneath Yellowstone National Park in Wyoming belched enough ash into the atmosphere to coat North America. A new simulation details the debris dumping the continent would receive from a similar eruption today, as **Thomas Sumner** reported in "Forecast: Cloudy, 100% chance of ash" (*SN: 10/4/14, p. 32*).*

In the article, **Sumner** mentioned that geologists don't think it's likely that Yellowstone's volcano will blow its top again. Lots of readers wanted to know how the researchers arrived at that conclusion. "I'd like to talk with the geologists who say no more eruptions," commented reader **ricwerme**. "No more supervolcano-size eruptions is plausible, as Yellowstone moves off the hot spot. That's just as plausible as a new supervolcano forming next door to Yellowstone."

The magma that fuels Yellowstone today is unlike the molten rock that blasted open the Yellowstone Caldera 640,000 years ago, says **Sumner**. "Studies indicate that the magma is now denser and that the surrounding crust is turning into basalt, which requires lots of energy to melt. While a smaller-scale lava outpouring is much more likely than another supervolcanic blast, the plumbing beneath Yellowstone couldn't even manage that right now. Unless things change, Yellowstone is unlikely to erupt anytime soon, if ever."

Stitches and science

*The Feedback page sidebar "Science-inspired sewing" (*SN: 10/4/14, p. 30*) showcased a* Science News*-based quilt design submitted by a reader who transformed a graph of the microbial communities found on shoes and smartphones into textile art.*

Rosemary Dunn Moeller wrote in to say how much she appreciates art inspired by *SN* stories, including the cross-stitched diagram of twin primes featured on another Feedback page (*SN: 1/11/14, p. 30*). "I love fiber arts and have used quilts, Celtic calligraphy, knitting, string games and magic to teach math to children for years. I enjoy seeing your photos from other science lovers/fiber artists."

Over 100,000 Satisfied Customers

FREE Shipping!

"My Friends all hate their Hearing Aids. I love mine!" Here's why…

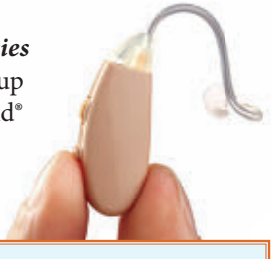
"Hearing aids cost thousands of dollars! That's too expensive!" Not with **MD**HearingAid®. Our FDA Registered hearing aids have the same digital technology and advanced features as the expensive brands to provide clear sound and effortless natural hearing for **a fraction of the cost.**

"A hearing aid will make me look old." 'Old' isn't what you see in the mirror, 'Old' is asking people to "say it again" or cupping hands behind your ears, and always missing the punch line. With the nearly invisible **MD**HearingAid® ***AIR*** you **act and feel years younger.**

"You need to go back to the office so often for adjustments." **MD**HearingAid® hearing aids come shipped to your door pre-programmed for the most common types of hearing loss. You simply choose the volume settings that best suit your needs **in the comfort of your home.**

"My friend had hearing aids that whistled all the time. It was embarrassing!" **MD**HearingAid® ***AIR*** has advanced feedback technology that virtually **eliminates whistling.**

"You have to change the batteries every few days." Batteries last up to 3 weeks in the **MD**HearingAid® ***AIR*** (amongst the longest in the industry).



"I don't want anyone to know I am wearing hearing aids." **MD**HearingAid® ***AIR*** fits discreetly behind your ear. With clear tubing and a small size, **no one will know** you are wearing them.

Nearly Invisible!

"My friend just put her hearing aids in the drawer and never wears them." At **MD**HearingAid®, we want our customers to hear everything they have been missing and love their new hearing aids. Which is why we have doctors, audiologists, and hearing instrument **specialists available 24/7** to help you get the best possible result.

"What if they don't work for me?" With **MD**HearingAid® you have the reassurance of a generous **45-Day return policy**. If you are not fully satisfied with your **MD**HearingAid®, you are eligible for a **100% refund**. Even the shipping is free!

Use offer code AQ32 for FREE Batteries for a Full Year!

Don't miss out any longer!

Try **MD**HearingAid® ***AIR*** RISK-FREE in your own home. **Call Today!**

800-873-0541

Phone Lines Open 24 Hours EVERY DAY

www.MDHearingAid.com/AQ32

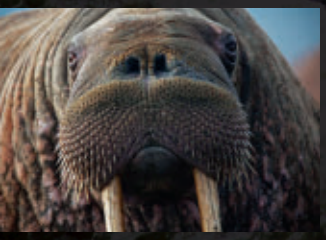
BBB RATING A

MDHearingAid® AIR

THE DOCTOR'S CHOICE FOR AFFORDABLE HEARING AIDS®

100% Money Back Guarantee

Doctor Designed • Audiologist Tested • FDA Registered



Melting ice forces walrus detour

A gigantic group of Pacific walruses, foiled from reaching prime feeding grounds by missing ice, gathered September 23 near Point Lay, Alaska, on the shore of the Chukchi Sea.

The beach's popularity is due to necessity. Typically the walruses scour the seafloor at a popular feeding ground known as the Hanna Shoal, about 240 kilometers from Point Lay, and take breaks between meals on slabs of floating sea ice. But recently, warming temperatures and shrinking summer ice cover have forced the animals to seek solid ground during feeding season. Scientists first observed walruses colonizing Point Lay in 2007.

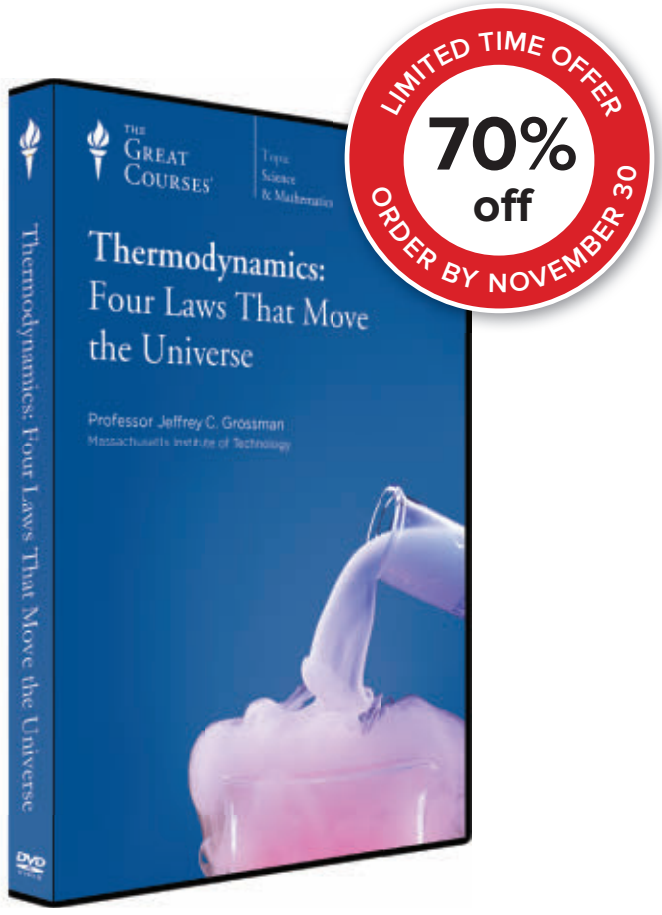
Scientists spotted this year's herd on September 13 and estimated the crowd contained about 10,000 walruses. Since then, the group, known as a haul out, has waxed and waned, with as many as 35,000 animals observed on September 27 (bottom left).

Point Lay is no all-you-can-eat buffet, says Joel Garlich-Miller, a wildlife biologist with the U.S. Fish and Wildlife Service. The sandy beach is low on mussels, oysters and other delicacies, and it exposes the walruses to predators such as polar bears and humans. When spooked, the herd can stampede and may trample and kill calves.

Concerned about the overall health of the herd, scientists recently affixed radio transmitters to 37 walruses. Meanwhile, local residents and the Federal Aviation Administration have worked to reroute planes to reduce potentially panic-inducing noise. — *Bethany Brookshire*

HERDS: COREY ACCARDO, NMML/AFSC/NMFS/NOAA; WALRUS: RYAN KINGSBERY/USGS

THE GREAT COURSES®



Explore the Mind-Blowing Science of Heat

Thermodynamics is the branch of science that deals with the movement of heat. Nothing seems simpler, but nothing is more subtle and wide-ranging in its effects. And nothing has had a more profound impact on the development of modern civilization.

Thermodynamics: Four Laws That Move the Universe gives you an in-depth tour of this vital and fascinating science in 24 enthralling lectures that are suitable for everyone, from science novices to experts who wish to revisit favorite concepts and formulas. Your teacher is Professor Jeffrey C. Grossman of the Massachusetts Institute of Technology. Dr. Grossman, a scientist at the forefront of research on new materials, brings exciting experiments right into your living room.

Offer expires 11/30/14

THEGREATCOURSES.COM/7SN

1-800-832-2412

Thermodynamics: Four Laws That Move the Universe

Taught by Professor Jeffrey C. Grossman
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LECTURE TITLES

1. Thermodynamics—What's under the Hood
2. Variables and the Flow of Energy
3. Temperature—Thermodynamics' First Force
4. Salt, Soup, Energy, and Entropy
5. The Ideal Gas Law and a Piston
6. Energy Transferred and Conserved
7. Work-Heat Equivalence
8. Entropy—The Arrow of Time
9. The Chemical Potential
10. Enthalpy, Free Energy, and Equilibrium
11. Mixing and Osmotic Pressure
12. How Materials Hold Heat
13. How Materials Respond to Heat
14. Phases of Matter—Gas, Liquid, Solid
15. Phase Diagrams—Ultimate Materials Maps
16. Properties of Phases
17. To Mix, or Not to Mix?
18. Melting and Freezing of Mixtures
19. The Carnot Engine and Limits of Efficiency
20. More Engines—Materials at Work
21. The Electrochemical Potential
22. Chemical Reactions—Getting to Equilibrium
23. The Chemical Reaction Quotient
24. The Greatest Processes in the World

Thermodynamics: Four Laws That Move the Universe
Course no. 1291 | 24 lectures (30 minutes/lecture)

SAVE $190

DVD ~~$269.95~~ NOW $79.95
+$10 Shipping, Processing, and Lifetime Satisfaction Guarantee
Priority Code: 95555

For 24 years, The Great Courses has brought the world's foremost educators to millions who want to go deeper into the subjects that matter most. No exams. No homework. Just a world of knowledge available anytime, anywhere. Download or stream to your laptop or PC, or use our free mobile apps for iPad, iPhone, or Android. Over 500 courses available at www.TheGreatCourses.com.

Wrong Turn Leads to $2 Billion in Buried Treasure

Incredibly rare find is now available to the public for ONLY $79!

Tanzania, 1967. A prospector hiking through the sun-baked African hills realizes he is lost. He takes a left instead of a right and finds himself in a Masaai village. Red-robed warriors approach with fists clenched tight. He braces for a fight. But as soon as they open their palms, all is well. Inside are sparkling stones, the likes of which he has never seen. The man smiles and says, "Show me more."

That was how the story of tanzanite began. Today you can continue the remarkable tale with our ***Karatu Tanzanite Ring***. Call today to bring home genuine tanzanite totaling more than 1 carat set in .925 sterling silver (a $399 value*) for **ONLY $79!**

Found in only one place on the planet. The five ovals in our ***Karatu Tanzanite Ring*** are direct relatives of those stunning original gemstones. We know this for a fact because you can't find tanzanite anywhere else on Earth. It only exists within a 960-acre parcel of the Merelani Hills near Mt. Kilimanjaro (an area slightly larger than New York's City's Central Park). This historic exclusivity makes tanzanite at least 1000 times rarer than diamonds!

Tanzanite gets rarer by the minute. In the decades since its discovery, tanzanite has become one of the world's most coveted gemstones. Pieces featured in our own luxury line can sell for $1000 per carat and some retailers charge as much as $2,000 per carat! But while demand is growing, supply is limited. Even though the Tanzanian government strictly controls mining, nobody knows exactly how much tanzanite remains. Most experts predict that the mines will run dry within our lifetime. That's why the time to act is now.

Your satisfaction is 100% guaranteed. Not only have we LOWERED the price on this rare gemstone, but today you can wear the ***Karatu Tanzanite Ring*** for an extended one month trial period. That's right, if you're not captivated by the beauty of tanzanite, send it back within 60 days for a complete refund of your purchase price. Don't miss this chance to claim your own piece of the $2 billion buried treasure!

TAKE 80% OFF INSTANTLY!

When you use your INSIDER OFFER CODE

Karatu Tanzanite Ring — ~~$399~~*

Offer Code Price ***Only*** **$79 + S&P** ***Save $320!***

You must use the insider offer code to get our special price.

1-800-945-7267

Your Offer Code: KTR150-01
Please use this code when you order to receive your discount.

Stauer®

14101 Southcross Drive W., Dept. KTR150-01,
Burnsville, Minnesota 55337 www.stauer.com

BBB ACCREDITED BUSINESS
Rating of A+

**Discount is only for customers who use the offer code versus the original Stauer.com price.*

1 1/5 carats of geniune tanzanite • Lab-created white DiamondAura accents • .925 sterling silver setting • Whole ring sizes 5–10

Smart Luxuries—Surprising Prices™