SN
SCIENCE NEWS MAGAZINE
SOCIETY FOR SCIENCE & THE PUBLIC
JULY 12, 2014

Dinosaurs Reimagined, Again

Rebuilding Old Muscle

The New Essential: Bromine

Mega-Earth Debut

SLACKTIVISTS

'Likes' look good, but don't always translate into genuine activism

Rare African Emerald Find Shocks Colombian Cartel

U.S. jeweler seizes more than 10,000 carats and makes history by releasing the One-Carat Pride of Zambia Emerald Ring for UNDER $100!

LUSAKA, ZAMBIA - A recent find of high quality emeralds in this African republic has thrown the luxury gem world into tumult. For hundreds of years, Colombians have controlled the high-end emerald market and sent prices soaring to over $15,000 per carat for top graded stones. But the history-making discovery of Zambian emeralds has revealed a green gemstone with mesmerizing clarity that simply changes everything.

This important find led Stauer, a major gem dealer and importer, to bid on over 10,000 carats. Stauer designed a classic 1-ctw ring for people who love the gem but don't love outrageously priced luxury. Because of their timely buy, Stauer is releasing this exclusive, natural emerald ring—aka ***"The Pride of Zambia"***—to the public for under $100!

Discover a Different Kind of Emerald

"For the price, these natural gemstones were the most magnificent emeralds that I've seen in 30 years," said Michael Bisceglia at Stauer. "The value of Colombian stones can't compare."

Industry experts back him up. Lab tests prove that Zambian emeralds are less porous and brittle than their Colombian brothers. And gem cutters have found Zambians so brilliant that they lend themselves more to high-luster cuts than traditional emerald designs.

Unfortunately, the window on this exciting emerald opportunity is closing fast. Not long after Stauer acquired their cache, a recent auction saw Zambian emerald prices hit a new record high. The time to act on this great gem value is now, before it's too late. Please call our U.S.-based client service team at 1-888-277-8375 or visit us online at www.stauer.com.

Emerald Is THE Gem of 2014

The rise of emeralds is more than just a passing trend. An article in the *Financial Times of London* from June of this year pointed to the reason. In "Emeralds: Shades of Green Start to Outshine Diamonds," the newspaper reported that emerald demand is soaring worldwide even as diamond demand softens. Rarity is key as fine emeralds are much rarer than diamonds.

"With wealthy Russian and Chinese demand for emeralds way up, we expect prices to continue to rise quickly," Bisceglia said. "That's why we're so happy to have found these beautiful stones at this price."

Your Satisfaction is 100% Guaranteed

Call today and wear the ***Pride of Zambia*** RISK-FREE (less s&p) for 30 days. If you're not dazzled by this precious gemstone, simply send it back for a full refund of your purchase price.

1 ctw genuine Zambian Emerald
Luxurious gold-finish over .925 sterling silver setting
Available in whole sizes 5-10

Pride of Zambia Emerald Ring

(1 ctw) Only $99 + shipping & processing

Call now to take advantage of this fantastic offer.

1-888-277-8375

Promotional Code ZER224-01
Please mention this code when you call.

Independently Appraised at $690*

** For more information concerning the appraisal, visit **http://www.stauer.com/appraisedvalues.asp**.*

Stauer®
14101 Southcross Drive W., Dept. ZER224-01
Burnsville, Minnesota 55337
www.stauer.com

BBB ACCREDITED BUSINESS
Rating of A+

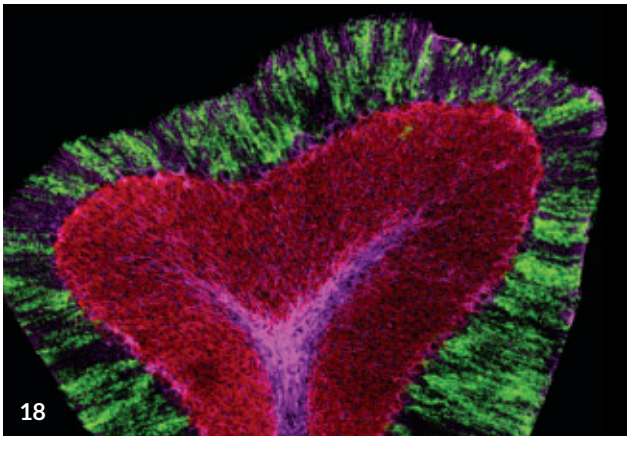
Smart Luxuries—Surprising Prices™

VOL. 186 | NO. 1

ScienceNews

Features

News



Departments

COVER Online awareness campaigns can make people feel they've contributed to a good cause, but social scientists say the tangible benefits of such efforts may be small.

CLOCKWISE FROM TOP LEFT: CHRIS GASH; NASA; AMIT AGARWAL AND DWIGHT BERGLES, COURTESY OF CELL PRESS

A new view of dinosaurs, a clearer view of lunar origins

Dinosaurs have undergone any number of scientific makeovers in the last few decades. When I was young, they were depicted as lumbering, oversized lizards, "cold-blooded" and drab. That simplistic image was eventually replaced with a more vibrant one. The velociraptor à la *Jurassic Park* was agile, quick, birdlike — and quite possibly festooned in feathers. Bright colors (though maybe not Barney purple) and rich social lives have also been proposed.

Scientists' latest look at dinosaurs offers up another revision. As Meghan Rosen describes on Page 6, the new work compares dinosaur growth rates, estimated from fossils, with growth rates from modern animals for insights into dino metabolism. Energetically, dinosaurs were neither fowl nor lizard, but something in between, the researchers conclude. Like today's sea-faring tuna and great white sharks, dinos share some traits with both ectotherms (what people mean when they say "cold-blooded") and endotherms ("warm-blooded").

In science, revisionism can be a good thing. Finding ways to test assumptions and accepted truths can lead to insight and discovery. As Tina Hesman Saey reports on Page 12, for example, the latest DNA studies of chimpanzees are forcing a rethink of just how long ago chimps and humans shared a common ancestor. And despite popular thinking that the Internet can be harnessed to power good causes, one of the first long-term scientific studies of giving in a major online movement reveals far more "slacktivism" than activism, Bruce Bower writes on Page 22. At the same time, other new experiments suggest ways to motivate the public to action.

Of course, science also confirms what we think we know. Take the origin of the moon. The best theory holds it formed after a planet-sized object collided with a young Earth. The resulting explosion created the moon, which would have been chemically distinct from Earth. But chemical analyses of lunar and terrestrial rocks revealed no differences. Now, a more precise comparison of the rocks has found distinctions that support the leading theory, Rosen reports on Page 14.

Testing, revising, substantiating: That's just what science is supposed to do. — *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: mpewett@societyforscience.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

The Neptune® Bath Lift is the affordable way to regain your independence and safely stay in the home you love!

Now you can safely enter and exit your tub!

For many of us, nothing is more relaxing than a long, luxurious bath. Unfortunately, because of safety concerns, many people, particularly older people, have to forego this simple pleasure. Sure, you can spend big bucks to remodel your bathroom to provide a bathtub you can use, but who wants to do that? Now there's a better way, and it lets you use the bath that's in your home today.

If you or a loved one has given up bathing because of age, mobility or safety concerns, the Neptune® Upright Bath Lift is the answer. It is so simple, you'll wonder why no one thought of it earlier. The battery-operated "chair" safely and steadily lowers you to the bottom of the tub, and when you're done bathing, it gently raises you back to the top of the tub, assuring a comfortable and safe exit from the tub. The remote is fully waterproof, so your bath won't be a "shocking" experience.

The New Neptune® Upright Bath Lift was redesigned making it lighter, more affordable, with more room to bathe—also making it easier to move the lift in and out of the tub. The bath lift features an easy-to-use hand control designed for comfort and safety. If there's not enough power stored for a full lower/raise cycle, it will not operate. The bath lift also features a wide seat and high backrest for maximum comfort and support.

Choose the angle of relaxation you prefer!

Lightweight seat folds flat for easy transport.

Waterproof remote included!

Rediscover the simple pleasure of a warm, relaxing bath with our exclusive home trial. Try the New Neptune® Recliner Bath Lift for up to 30 days, and if you are not completely satisfied, simply return it for a refund of the product purchase price.

Neptune® Recliner Bath Lift

Call now for our lowest price!

Please mention promotional code 48185.

For fastest service, call toll-free 24 hours a day.

1-866-565-3490

52492

Excerpt from the July 11, 1964, issue of *Science News Letter*

50 YEARS AGO

Scientists More Admired Now Than 15 Years Ago

Men of science now rank third in the latest admiration poll for the United States. In the esteem of their countrymen, scientists are exceeded only by two other professional groups: the black-robed paragons, the Justices of the Supreme Court, and the guardians of our health, the physicians. Admiration for scientists has increased noticeably over the past 15 years, according to the recent prestige poll analysis made by the National Opinion Research Center, an affiliate of the University of Chicago.

UPDATE: Scientists are still admired, but still not the most. A 1989 survey of occupational prestige by the National Opinion Research Center had physicians and lawyers ahead of "computer systems analyst or scientist," with physicists and astronomers in fifth place and biologists in ninth. In a 2009 survey by Harris Interactive, 62 percent of Americans rated firefighters as having "very great prestige," and 57 percent said the same of scientists.

IT'S ALIVE

Ant lions hunt despite sealed lips

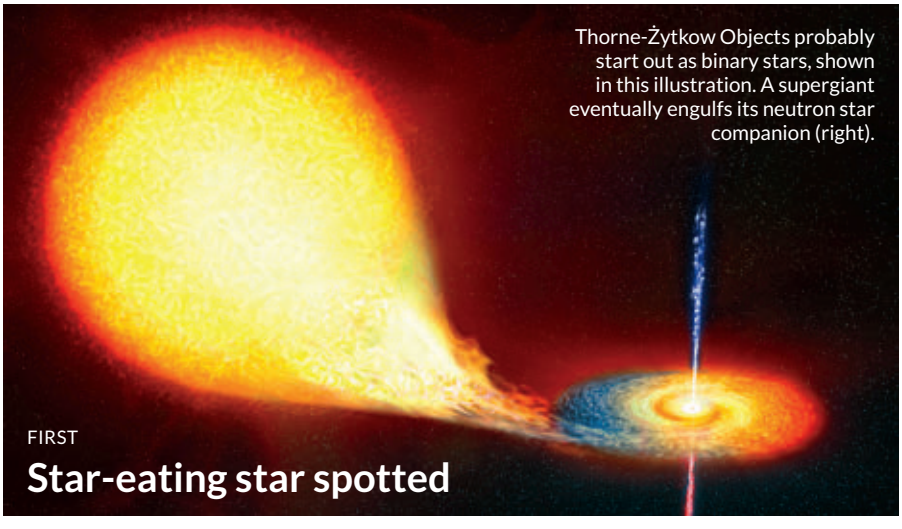
Ant lions are ferocious predators, but some of them don't have a mouth.

At least not in the usual sense. Over evolutionary time, the slit at the front of the mouth cavity has sealed shut in the armored larvae of ant lions that hunt in sand.

Only young sand-dwelling ant lions are mouthless. As adult insects, the 2,000 or so named species in the ant lion family, the Myrmeleontidae, have mouths and often a touch of the nature-calendar prettiness of damselflies, with long, lacy wings. But "they're not the killing machines that the juveniles are," says biologist Sandra Binning of the University of Neuchâtel in Switzerland.

Instead of mouths, the larvae rely on two long, toothed hooks at the front of the head. The youngsters dig pits in sand and bury themselves up to the hooks, ready to grab and stab ants or other insects that tumble in.

Each hook has a covered groove on the underside. When the hook pierces prey, the ant lion injects venom and digestive enzymes via the grooves. Then the same grooves deliver paired streams of liquefied prey back directly into the mouth cavity, says Mervyn Mansell of the University of Pretoria in South Africa. Feeding by grooves is much like "if you drank a cool drink through two straws," he says.



Thorne-Żytkow Objects probably start out as binary stars, shown in this illustration. A supergiant eventually engulfs its neutron star companion (right).

ESA

FIRST

Star-eating star spotted

A star in a neighboring galaxy might have swallowed another star. Sitting about 200,000 light-years away in the constellation Tucana, the star HV 2112 appears to be a red supergiant that has engulfed a neutron star. This strange pair, called a Thorne-Żytkow Object, or TŻO, was largely theoretical until now. Sitting in the Small Magellanic Cloud, a satellite galaxy of the Milky Way, HV 2112 is the first TŻO to be seen. A TŻO starts with two massive stars orbiting one another. When the more massive of the two explodes in a supernova, its core is left behind as a neutron star. One scenario posits that as the other star ages, it swells and swallows the neutron star, which gets dragged down into the heart of its sibling. Alternatively, the neutron star might be shot out of the supernova into its companion. TŻOs are hard to find because they look nearly identical to other red supergiants. Emily Levesque, an astronomer at the University of Colorado, Boulder and colleagues discovered the TŻO by looking for unusual amounts of certain elements in the star's atmosphere. The strange chemistry, the team reported June 1 on arXiv.org, is created when gas inside the supergiant meets the hot surface of its inner neutron star. — *Christopher Crockett*

Ant lion species that hunt in sand traps have evolved extreme eating habits that prevent grit from infiltrating their food.

At least at the front end. The gut of a larval ant lion dead-ends partway through its body. The larva can pee, but solid waste builds up until adulthood when the gut grows an exit.

With no mouth opening and no way to poop, sand-trapper ant lions minimize their intake of anything indigestible. After slurping ant juice, they fling the carcass out of the pit to lie around the rim. The resulting lawn art might scare other ants away, Binning and her colleagues at the Australian National University in Canberra thought, so they tested *Myrmeleon acer* ant lions that they had scooped up with big spoons from under rental trailers near a beach. "The tourists thought we were nuts," she says.

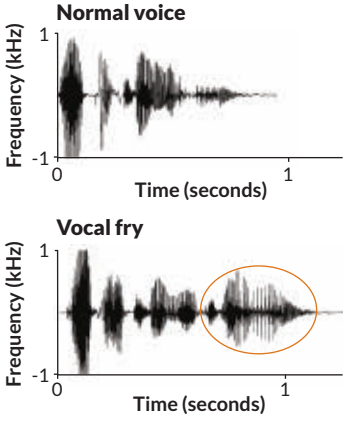
Fresh carcasses lying around reduced a trap's effectiveness, though apparently not as terrifying warnings, the researchers report in an upcoming issue of *Ethology*. Living ants seemed to be drawn to dead ones. Stopping to investigate reduced the chances an ant would blunder over the trap's edge. — *Susan Milius*

SAY WHAT?

Vocal fry
VOH-kuhl freye\ *n.*

A sizzling or rattling sound to speech. Also known as the pulse register phonation or glottal fry, vocal fry is a quality of the lowest registers of the human voice. The effect is produced when the vocal folds in the throat are pressed toward each other and relaxed, creating a popping, creaky sound. The noise can be a result of voice pathology, or simply an affectation. Once you learn to recognize vocal fry, you may start hearing it everywhere. Recent studies have highlighted vocal fry as particularly common among young women in North America. In a study published May 28 in *PLOS ONE*, Rindy Anderson of Duke University and colleagues suggest that most people prefer a voice without vocal fry, rating it more attractive, better educated and more hirable, with women's ratings penalized more for fry than those of men. But the sound has its uses. Vocal fry is found in the bass part of some types of gospel songs, and languages such as Jalapa Mazatec in the Mexican state of Oaxaca use vocal fry to change the meaning of words. — *Bethany Brookshire*

Fingerprint of vocal fry



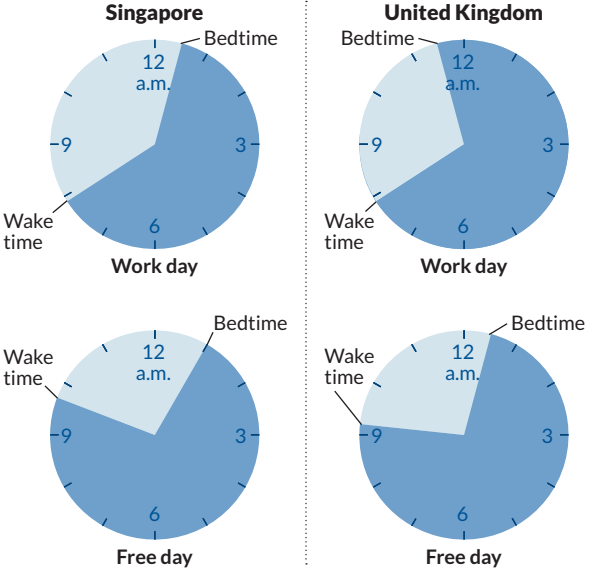
SOURCE: R.C. ANDERSON *ET AL*/*PLOS ONE* 2014

SCIENCE STATS

Sleep around the world

People in Western nations tend to sleep more: seven to eight hours per night on average, compared with less than seven hours in many Eastern nations. A new study suggests that differences in the timing of the natural light-dark cycle are not to blame, but rather differing schedules for work and study. People in Singapore stayed up later on work days (sleep times shown below in darker blue) but rose around the same time as people in the United Kingdom. Schedules were more similar on free days.

Average sleep times by country



CLOCKWISE FROM TOP: LARAH MCELRY/FLICKER (CC BY-NC 2.0); J.C. LO *ET AL*/*FRONTIERS IN NEUROLOGY* 2014, ADAPTED BY S. EGTS

Hear a sample of vocal fry at **bit.ly/SN_vocalfry**

LIFE & EVOLUTION

Dinosaurs had middling metabolisms

T. rex and kin straddled line between cold- and warm-blooded

Dinosaurs' energy needs may have been in between those of slow-growing reptiles and fast-growing birds.

BY MEGHAN ROSEN

Dinosaurs weren't quite like cold-blooded reptiles, but they weren't like warm-blooded birds either. Instead, they fell smack-dab in the middle. Comparisons with modern animals reveal that dinosaurs' metabolisms probably resembled those of great white sharks, researchers report in the June 13 *Science*.

The findings offer new clues into how the animals lived and also rekindle a long-standing debate. "This paper will make us go back to the drawing board," says paleobiologist Martin Sander of the University of Bonn in Germany.

For years, paleontologists assumed that dinosaurs most resembled modern reptiles and other cold-blooded creatures, or ectotherms: slow-growing, low-energy sluggards that bask in sunlight for heat and don't need much food. "When I was a kid, dinosaurs were just scaled-up, tail-dragging reptilian brutes," says Gregory Erickson, a paleobiologist at Florida State University in Tallahassee.

The field took a U-turn in the 1960s, he says, when researchers started to find similarities between dinosaurs and modern birds. Over the next few decades, most paleontologists came to think of dinosaurs as more birdlike: warm-blooded animals, or endotherms, that grew quickly, expended lots of energy and regulated their body heat internally. That thinking inspired popular depictions such as the speedy beasts of *Jurassic Park*.

But trying to shoehorn dinosaurs into one of two camps might be too simplistic, says John Grady, a paleoecologist at the University of New Mexico in Albuquerque.

Previous work had hinted that the animals might not sort so cleanly into either group. So Grady and colleagues designed a massive study to pinpoint dinosaurs' place on the spectrum of cold- and warm-blooded life.

His team tabulated the growth rates and energy use, or metabolism, of 353 modern animal species. The census ran the gamut from slow-growing, low-metabolism crocodiles to fast-growing, high-metabolism ostriches. Then the researchers capitalized on other paleontologists' careful analyses of dinosaur bones to collect the growth rates of 21 dinosaurs, including *Tyrannosaurus* and *Apatosaurus*.

Grady and his team couldn't determine the metabolic rates of creatures that have been extinct for at least 65 million years, but they could make estimates based on data from living animals. When Grady plotted the animals' growth rates against their metabolisms, he found a clear link: Those with high growth rates tended to have high metabolisms and vice versa. This strong correlation allowed him to chart the 21 dinosaurs on the same graph.

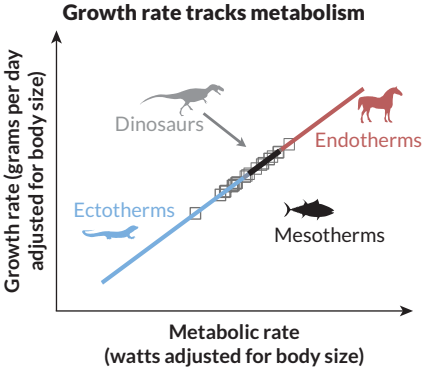
The animals fell right between cold-blooded animals and warm-blooded ones. "I was a little surprised to see dinosaurs in the middle," Grady says. "If they're not like reptiles and they're not like mammals, then what the heck are they?"

Dinosaurs did match up with a few living animals. *T. rex* and other dinos may have had metabolisms similar to those of great white sharks, tuna and leatherback sea turtles, Grady says. These animals, called mesotherms, eat more than cold-blooded fish and reptiles do, but they don't stick tightly to a set body temperature like warm-blooded birds and mammals.

Understanding dinosaurs' metabolic quirks could offer clues into other debated aspects of the animals' lives, such as how they hunted and why they grew so large, Grady says.

The results might be tough for people to digest, says paleontologist Luis Chiappe of the Natural History Museum of Los Angeles County. "Dinosaurs and tuna are so different," he says. "It's hard to envision comparing them." But he agrees with the authors' conclusions that dinosaurs occupied a happy medium between cold- and warm-blooded. "It's going to ignite more research and open people's minds," he says. ■

In between Plotting dinosaur growth rates against growth and metabolic rates for 353 animals places dinosaurs among the mesotherms, a group that falls between mammals and most reptiles in terms of energy use.



FROM TOP: JOELENA/ISTOCKPHOTO; J.M. GRADY *ET AL*/*SCIENCE* 2014, ADAPTED BY E. OTWELL

GENES & CELLS

Oxytocin stimulates repair of old mice's muscles

Hormone known for its role in social bonding could help heal injuries in the elderly

BY TINA HESMAN SAEY

The "love hormone" does more than trigger labor and cement emotional ties between people. Oxytocin also helps repair damaged muscles, at least in mice.

Oxytocin stimulates muscle stem cells to divide when muscle is damaged, researchers report June 10 in *Nature Communications*. Experiments with mice also showed that hormone levels in the animals' blood declines with age. Giving old mice shots of oxytocin restored their muscle-regeneration capabilities to match those of much younger rodents. But extra doses of the hormone did not boost muscle-building in young mice.

"This is not a performance-enhancing drug," says study coauthor Irina Conboy, a stem cell scientist at the University of California, Berkeley.

The findings raise the possibility that oxytocin may stave off muscle atrophy in aging people.

"It is a possible new avenue for therapy," says Kristian Gundersen, a physiologist at the University of Oslo who was not involved in the new work. "But there is still a lot to do before we can recommend this as a drug."

The work grew from studies in which scientists tethered the circulatory systems of young and old mice. Something in the blood of young mice rejuvenated their aging counterparts. Scientists recently described substances in the young mice's blood that benefit old brains (*SN: 5/31/14, p. 8*), but old organs and muscle perked up, too. Conboy and her colleagues went looking for molecules that influence muscle repair.

They knew that muscle stem cells contain oxytocin receptors, proteins on the cell's surface that latch onto the hormone and then send a growth signal into the cell. The number of those receptors declines with age, the researchers found, as do blood levels of oxytocin. Young mice had three times as much oxytocin in their blood as old mice did.

That's a one-two punch that researchers have rarely seen, says Nathan LeBrasseur, a physiologist at the Mayo Clinic in Rochester, Minn. Usually scientists think of aging processes at the cellular level as happening either in a cell or in molecules floating around outside the cell, he says. "Here you see changes in both scenes." So stem cells in older mice don't get oxytocin's message to repair damaged muscle.

> "There are people who will buy oxytocin hoping that they can remain forever young."
>
> **IRINA CONBOY**

When that happens in older people and animals, "Plan B kicks in," Conboy says. Muscle stem cells stay dormant while other cells patch the injury with fat and fibrous, scarlike tissue, she says. The researchers reasoned that giving old mice oxytocin should wake up muscle stem cells and lead to better wound repair.

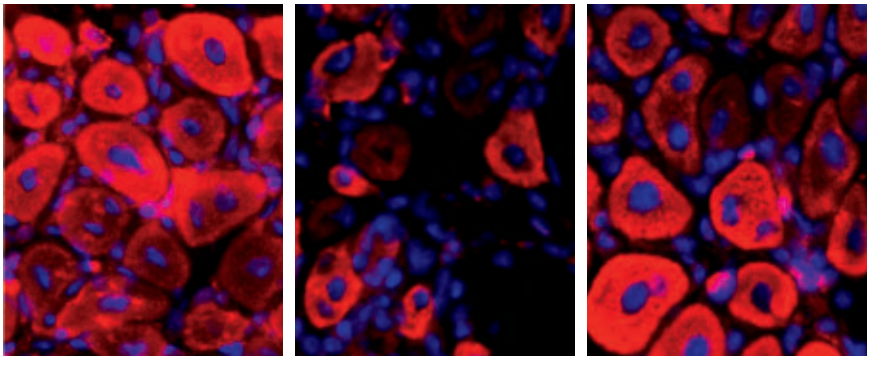
"That's one of the first experiments we tried," says coauthor Wendy Cousin, also a stem cell scientist at UC Berkeley. Sure enough, old mice that got injections of oxytocin repaired injured muscles as well as young mice did.

Mice engineered to lack oxytocin were less able to repair injured muscle compared with normal mice. And that defect got worse with age. Mice lacking oxytocin also had less muscle mass than their normal counterparts. Normal mice, for instance, had a tibialis anterior leg muscle that weighed 32 percent more than the ones from mice without oxytocin. These findings indicate that the hormone may also play a role in muscle atrophy or sarcopenia, the muscle loss that contributes to frailty in old age, the researchers conclude.

The results strongly support the idea that oxytocin stimulates muscle regeneration, Gundersen and LeBrasseur both say. But the two want more data before concluding that declining oxytocin levels cause sarcopenia.

Conboy and colleagues caution that people shouldn't take oxytocin based on this mouse study. "There are people who will buy oxytocin hoping that they can remain forever young," she says. But the team doesn't yet know if oxytocin levels decline as people age, and if they do, what dose would be appropriate, when to give it or what the long-term consequences of such supplementing might be. Without yet knowing the answers to those questions, Conboy's team speculates that the hormone may be of most help to older people who are injured or need surgery. ■

Oxytocin stimulates muscle repair in young mice (left, muscle proteins stained red). Since oxytocin levels decline with age, old mice have trouble regenerating muscle (center, black shows missing muscle cells). Oxytocin injections improved old mice's ability to repair muscle (right).



C. ELABD AND W. COUSIN

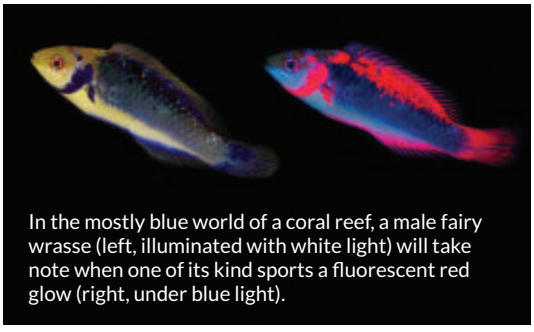
LIFE & EVOLUTION

Reef fish riled by glowing intruders

Male fairy wrasses turn feisty when a rival fluoresces

BY SUSAN MILIUS

Even in the blue underwater realm, fish can see red in more ways than one. Reef fish that see glowing red patches on a rival react with aggressive bites and put on threatening displays, researchers say.



In the mostly blue world of a coral reef, a male fairy wrasse (left, illuminated with white light) will take note when one of its kind sports a fluorescent red glow (right, under blue light).

Red wavelengths from sunshine can't penetrate water much deeper than 10 or 20 meters, failing to reach the zone where more than 40 small *Cirrhilabrus* fish species called fairy wrasses dart along reefs. But shorter, bluer wavelengths can plunge deep, where they are absorbed by the scales and some of the fin rays on both male and female *C. solorensis* fairy wrasses. The fish then fluoresce, emitting their own red light in distinctive his-and-hers swaths across their bodies.

The first behavioral test of whether a red-fluorescing fish cares about the red glow shows that the color sparks aggression among males, says Nico Michiels of the University of Tübingen in Germany. Males seeing the full red glory of a mock intruder responded with attempted bites and menacing displays, Michiels and his colleagues report in the July 22 *Proceedings of the Royal Society B*.

When Michiels and colleagues reported in 2008 that certain reef fish could glow red, some researchers were skeptical that the fluorescence mattered to the fish, he says. Fish vision supposedly excels in the blue and green wavelengths that dominate the animals' habitats, and any reds wouldn't be visible from afar.

For those very reasons, however, Michiels proposed that red fluorescence might offer a discreet channel of communication unlikely to catch the attention of unintended eavesdroppers such as distant rivals or predators. That notion is very difficult to test. "You need to know everything about the bystanders and everybody who is looking at these fish," he laments.

Since then, researchers have described other fish that glow red, and studies of eyes have turned up evidence that certain fish should be able to detect the color.

For a behavioral test of what the fish themselves think of the color, Michiels and his colleagues turned to a fairy wrasse species with strong, deep red fluorescence. Team leader Tobias

BODY & BRAIN

Sleep strengthens brain connections

Mice allowed to snooze show signs of solidified learning

BY LAURA SANDERS

While the body snoozes, the brain is hard at work. Connections between certain nerve cells appear to strengthen during slumber, a study in mice suggests. The results, published in the June 6 *Science*, may help explain how sleep cements new information in the brain.

The new findings emphasize the importance of sleep for learning and memory, says study coauthor Wen-Biao Gan of the New York University School of Medicine. "When you go to sleep, you're not really wasting your time," Gan says. "You're actually making connections better."

Previous studies have found that post-learning snoozes make brains sharper, but just how those improvements happened was unclear.

Gan and his colleagues studied specific nerve cells, or neurons, that help mice perform a newly learned balancing trick. Over an hour, mice learned to run on a rod as it rotated faster and faster. Neurons in the brain's motor cortex helped the mouse stay on the rod as it spun more rapidly.

> "It really provides incontrovertible evidence that sleep can promote the formation of synapses."
> **MARCOS FRANK**

Right after a training session, some mice were allowed to sleep for seven hours. Neurons in these mice's motor cortices sprouted new dendritic spines, docking sites where other neurons can connect, Gan's team found. But mice kept awake after training formed fewer new spines and were worse at balancing on the rod days later than rested mice.

These new docking sites may not all have become working synapses — the communication conduits between neurons. But the presence of the new dendritic spines suggests that overall, connections between the neurons got stronger, the researchers say.

In separate experiments, the researchers found that motor cortex neurons that were active when mice ran on a treadmill were also active later during non-REM sleep, which spans several stages of sleep and accounts for about three-quarters of sleep time in people. This neural rehashing during sleep might be the signal for neurons to form new connections, Gan proposes.

Discovering that these neurons' connections get stronger during slumber is "going to challenge our thinking about what sleep is doing in the brain," says neuroscientist Marcos Frank of the

T. GERLACH *ET AL*/*PROC. ROY. SOC. B*, 2014

Gerlach, also at Tübingen, had to treat the active, rather nervous fish very gently so that he could show males their mirror images. Males responded as if the fish in the mirror were intruders. When a male saw the mirror in full color, he reacted more menacingly, with more display postures and attempted bites, than he did when the researchers used a filter to block the red wavelengths.

Testing fish behavior is important for understanding how fluorescence evolved and how animals use it, says marine biologist David Gruber of the City University of New York and the American Museum of Natural History in New York City. Among more than 180 kinds of fish known to fluoresce, the majority produce red or green light, he and his team reported in January.

These colors could be important in camouflage as well as in signaling, says Gruber. For fish hiding among reef corals and algae, both of which can fluoresce, adding some emitted light of their own could help them blend in. ■

University of Pennsylvania in Philadelphia. "It really provides incontrovertible evidence that sleep can promote the formation of synapses."

And that evidence flies in the face of a popular idea about what sleep does to the brain, Frank says. That idea, called the synaptic homeostasis hypothesis, proposes that synapses weaken during sleep, a cleanup that clears the brain of clutter and prepares it for a new day of learning (*SN Online: 6/23/11*). The ideas aren't necessarily at odds, though: Some synapses — those involved in learning a new trick, for instance — may get strengthened, while others weaken during sleep.

Synaptic strengthening might be specific to neurons involved in movement, says Frank. "This is one kind of neuron in one part of the brain," he says. But similar synapse strengthening during sleep might also happen elsewhere. He and his colleagues have evidence that some neuron connections involved in vision also get stronger during sleep. ■

STEVE JACOBSEN/NORTHWESTERN UNIV.

EARTH & ENVIRONMENT

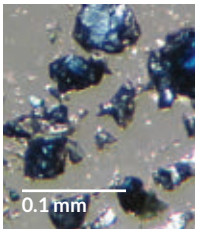
Water permeates Earth's interior

Blue mineral offers peek at conditions inside the mantle

BY RACHEL EHRENBERG

An ocean's worth of water is locked deep within the Earth and may influence all sorts of geological processes, including the grinding of tectonic plates, the formation of volcanoes and the movement of chemical elements.

Researchers examined the rumbling of seismic waves and performed lab experiments that mimicked the crushing pressures and extreme temperatures of Earth's mantle, the thick layer of the planet between the crust and core. The results make a strong case that a huge amount of water resides within the planet, says Yale University geophysicist Jennifer Girard, who was not involved with the study. The findings appear in the June 13 *Science*.



New lab experiments with the blue mineral ringwoodite (shown) suggest that Earth's mantle holds a considerable amount of water.

Some water may have been trapped during the early days of Earth's history, before oceans formed. Water also travels into the mantle during subduction, when tectonic plates collide and ocean-soaked crust dives deep into the mantle. That water probably influences the flow of material in Earth's innards, but exactly where it goes hasn't been clear.

Many geologists think that the water gets trapped about 410 to 660 kilometers beneath Earth's surface, where the upper mantle transitions into the partially molten lower mantle. But evidence has been scant. Holes dug from the surface merely penetrate Earth's crust, so scientists have relied on indirect evidence, including bits of rock ejected by volcanoes, to get a sense of what's happening deeper down.

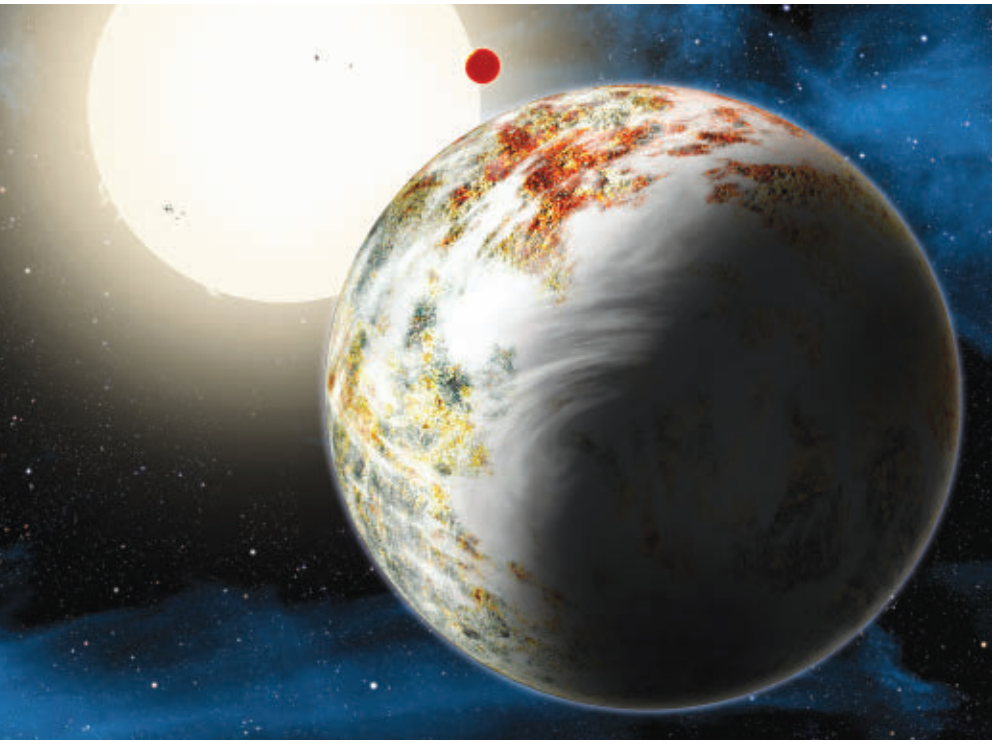
A recent analysis of a battered diamond that made the 400-kilometer trek from mantle to surface in an estimated 10 hours revealed a tiny bit of the sapphire-blue mineral ringwoodite — a mineral that's especially good at holding water in the form of hydroxide ions. Ringwoodite is a form of the mineral olivine, which is common in shallow parts of the mantle. Scientists think ringwoodite predominates in the higher-pressure environment of the mantle's transition zone.

The ringwoodite was about 1.5 percent water by weight, providing tantalizing evidence of a watery reservoir in the mantle. Yet scientists aren't sure whether the diamond came from a particularly water-rich area. The alternative would be that the mantle's water is widespread, says seismologist Brandon Schmandt of the University of New Mexico in Albuquerque.

To investigate, Schmandt and colleagues first figured out what might happen to the water in ringwoodite if the mineral traveled down into the lower mantle, where temperatures begin at 2,000° Celsius. Crushing ringwoodite in the lab with an anvil and blasting it with high-temperature lasers resulted in what scientists call dehydration melting. The ringwoodite shed its water, leaving a thin layer of "melt" around the crystal. That behavior suggested that water can't make the move to the lower mantle and gets trapped in the transition zone.

If water bound in ringwoodite can't travel to the lower mantle, then there should be evidence of this melting in areas of the transition zone where the mantle is flowing downward. So the team compared data from seismic waves traveling deep within Earth with computer simulations of the mantle flowing up or down in the same areas. Sure enough, in spots where the mantle is believed to flow downward, the researchers saw a shift in the type of seismic waves, indicating that the waves were hitting the proposed melting region between the transition zone and the lower mantle.

These data suggest that the mantle contains as much or even more water than all of Earth's oceans, Schmandt says. ■



Kepler-10c, a rocky planet 17 times as massive as Earth, orbits its sun in an artist's illustration. Its sister planet, Kepler-10b (red), sits much closer to the star.

DAVID A. AGUILAR/HARVARD-SMITHSONIAN CFA

ATOM & COSMOS

Overweight planet shakes up theory

Kepler-10c is the most massive rocky world yet discovered

BY CHRISTOPHER CROCKETT

Common wisdom in astronomy says that once a planet has collected about 10 Earths' worth of rock, it draws in gas and becomes a gas giant like Neptune or Saturn. The exoplanet Kepler-10c didn't get that memo. With 17 times the mass of Earth, the distant planet is the heaviest rocky planet known. And astronomers have no idea how it formed.

With the mass of Neptune squeezed into a ball only about 2.4 times as wide as our planet, gravity on Kepler-10c is three times stronger than Earth's, astronomer David Latham reported. "I wouldn't want to be a giraffe on this planet," said Latham, of the Harvard-Smithsonian Center for Astrophysics.

The planet is one of two orbiting Kepler-10, a sunlike star 564 light-years away in the constellation Draco. Both planets are toasty-warm and close to their star: Kepler-10c whips around the star once every 45 days, while 10b's period is even shorter. Both planets were among the first discovered by the Kepler space telescope; 10b was, in fact, Kepler's first confirmed rocky planet.

Astronomers have known of 10c's diameter and short period for three years, but they only recently measured its mass — and thereby calculated its density and realized that the planet is made of rock. Researchers measured Kepler-10c's mass by tracking how much its star gets yanked around by the planet's gravity.

Dimitar Sasselov, a Harvard astronomer, said the research team expected the planet to weigh about the same as two Earths, based on a planet around another star with a similar diameter and period. A mass of 17 Earths was a surprise. The researchers reported the mass June 2 at the astronomy meeting and in a paper posted online May 30 at arXiv.org.

Kepler-10c appears to be the first of a new class of exoplanet: a "mega-Earth." "Every time we get complacent, we find something new," said Sara Seager, an MIT astrophysicist. Astronomers thought that rocky planets maxed out at around 10 Earth masses, she explained. Beyond that mass, growing planet embryos would quickly suck down hydrogen and helium from the disk of raw material encircling their infant sun. These lightweight gases can resist compression from gravity, which results in planets with thick, fluffy atmospheres.

But Kepler-10c breaks those rules. "When one type of planet is found, that's usually the tip of the iceberg," Seager said. "There are probably many, many more of them."

A rocky planet that surpasses 10 Earth masses will most likely keep theorists busy as they figure out how to explain its origin. "I'm more than happy to accept that I was wrong" about the limits of rocky planets, Sasselov said. Theories about planet building are sometimes shots in the dark to help interpret data, he said. But ultimately, observations are the final arbiter. "We're discovering new populations of planets that hadn't been thought of before," he noted.

Kepler-10c is also odd for its age. Its star, and presumably the planet, is about 11 billion years old — almost as old as the Milky Way. (By contrast, the sun is only 4.6 billion years old.) Astronomers had thought that old stars are less likely to host rocky planets. Ancient stars, the theory goes, formed when the heavier elements that make up rocky planets — carbon, oxygen and silicon — were much less prevalent than they are today.

"We don't know how to make this planet," Sasselov said.

He added that Kepler-10c may expand the hunt for alien life. Astrobiologists had mostly ruled out older stars as places to look because rocky planets would be rare. But if an 11-billion-year-old sun can host the most massive rocky planet known, then the number of potentially habitable environments around other stars just got bigger. ■

To find other Earths, block starlight

Proposed telescopes could bring life-bearing planets into view

BY CHRISTOPHER CROCKETT

When Voyager 1 pivoted back toward Earth from beyond Neptune in 1990, it snapped one of the most famous space pictures: the pale blue dot, with Earth appearing as a lonely speck of light. Astronomers are now designing a new generation of telescopes with hopes of taking a photo of another pale blue dot, this one orbiting a distant star.

On June 4, scientists presented ideas for spacecraft that could both get pictures of potentially habitable planets and also measure the chemical makeup of their atmospheres. To do this, scientists would need to block a distant star's light. The proposed designs offer two contrasting ways of accomplishing that: one with a giant shade traveling through space near a telescope and the other with shape-changing mirrors inside a telescope.

NASA's Kepler space telescope has already shown that small rocky planets are common (*SN: 4/5/14, p. 15*). But Kepler's data can't distinguish Earth-like planets from harsh ones more like Venus, Mars or something unimagined. By analyzing exoplanet chemistry, the proposed telescopes would be able to make that distinction. If alien life is anything like life on Earth, it will leave chemical traces — like oxygen and methane — in the atmosphere.

Snapping a picture of an exoplanet is fiendishly difficult. As seen from Earth, a planet hugs its parent star. Adding to the challenge, stars are roughly 1 billion times brighter in visible light than any planet. Anyone who has ever tried to see something while looking toward the sun knows what to do: Block the sun with your hand. It turns out that strategy may work just as well for seeing exoplanets.

Sara Seager, an MIT astrophysicist, presented a telescope design called Exo-S that pairs a simple space telescope with a starshade. The shade is a 34-meter-wide flower-shaped disk floating tens of thousands of kilometers away from the telescope. The starshade's unusual construction — 28 petals, each 7 meters long, that unfurl and snap into place — minimizes how much starlight leaks into the telescope.

The design's big advantage, Seager said, is that it doesn't require a big, complex telescope. Without the starshade, the telescope would need a large mirror to catch dim light from a planet and see objects huddled up close to a star. With a starshade, she said, the telescope could, in principle, be just 1 centimeter in diameter. In practice, Exo-S would need a telescope closer to a meter across, which is still less than half the diameter of the Hubble Space Telescope.

A different proposal named Exo-C calls for putting a small light-blocking disk, called a coronagraph, inside a space telescope. The telescope itself would require a more complicated design than that of Exo-S. To precisely steer the scattered starlight, Exo-C would rely on adaptive optics, mirrors that change shape as needed.

"The amazing thing is that the deformable mirror technology exists to do this," says Karl Stapelfeldt, an astrophysicist at NASA's Goddard Space Flight Center in Greenbelt, Md. The ability to distinguish a point of light from another one that is a billion times brighter has already been demonstrated in the laboratory, he said.

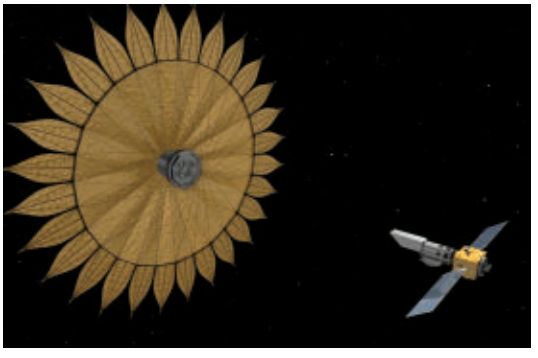
But a simple picture of a dot doesn't help astronomers identify hospitable worlds. To search for a true Earth twin, both designs include a spectrometer, a device that splits light reflecting off an exoplanet into different colors, which will record the chemical mixtures in exoplanet atmospheres.

"Both are really cool concepts," said Nikole Lewis, another MIT astrophysicist, adding that both concepts have pros and cons. Exo-C's coronagraph is similar to what some ground-based planet-hunting telescopes use already. Exo-C could also respond to ground-based discoveries quickly by refocusing on a potential planet-hosting star.

Exo-S, by contrast, would require days or weeks to move its view from one star to another because of the challenges involved with moving the telescope and the starshade in tandem. However, compared with the coronagraph design, Exo-S may be able to see fainter planets that are closer to their stars. While the starshade technology isn't as mature, Lewis said, "it has a better chance of seeing a pale blue dot."

The designs were developed in response to a 2013 request from NASA for innovative exoplanet missions that could be completed for less than $1 billion. Either project would complement a number of early-stage exoplanet missions that NASA already supports that target different types of stars and planets. Over the next decade or so, at least three telescopes will include exoplanets in their missions. Yet only one — the Transiting Exoplanet Survey Satellite — is designed specifically for planet hunting.

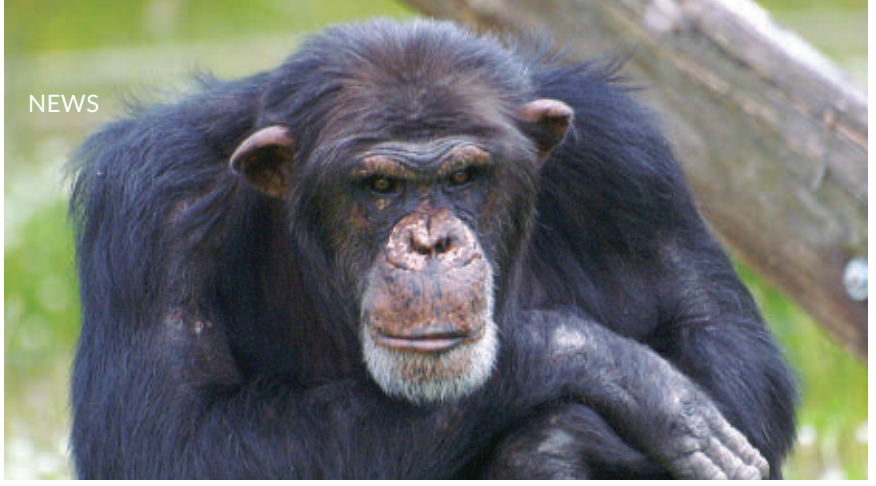
Astronomers are still fleshing out the details for these competing concepts; final reports are due in January 2015. Whichever concept is selected, NASA hopes to start design work in 2017 with a launch date around 2024. If either proposal is successful, humankind may get its first direct glimpse of an Earth twin before the end of the next decade. ■



A starshade accompanying a proposed planet-hunting telescope, shown in an illustration, would block starlight and make it easier for the telescope, shown pointing toward the starshade, to glimpse any planets orbiting distant stars.

NASA

Watch animation of a starshade unfurling at **bit.ly/SN_starshade**



Chimpanzees have a much slower mutation rate than previously estimated. The new rate suggests that humans and chimps last shared a common ancestor 13 million years ago.

GENES & CELLS

Human-ape split gets an earlier date

New study revises DNA mutation rate of chimpanzees

BY TINA HESMAN SAEY

Human and chimpanzee ancestors may have split into different species millions of years earlier than scientists thought, a new study of chimpanzee genetic mutation rates suggests.

In each generation, chimpanzees' average mutation rate is one DNA chemical unit changed out of every 83 million, researchers report in the June 13 *Science*. That mutation rate is nearly identical to the rate previously calculated for humans using similar methods (*SN Online: 6/13/11*). If the human and chimp mutation rates remained constant throughout evolutionary history, the species would have shared their most recent common ancestor about 13 million years ago.

That estimate is dramatically different than the 6 million to 8 million years surmised based on the fossil record. "It's a number that people will be shocked, surprised and upset by," says geneticist Gil McVean of the University of Oxford who led the study.

Most of the mutations arise in male chimps, which contribute seven to eight times as many errors as female chimps do, the researchers found. The discrepancy is explained by the fact that females are born with all of their eggs, while males continually produce sperm from puberty on, providing more chances over time for DNA replication machinery to make mistakes. For each year older a male chimp is when he reproduces, his offspring stand to inherit three more mutations, the researchers report.

In humans, men pass on three to four times as many mutations as women do. For each year of age, men pass on two additional mutations to their children. Some mutations lead to genetic diseases.

"There's a saying that you don't want an old father," McVean says. "But what you really don't want is a father that is an old chimpanzee."

Although humans and chimps appear to have last shared a common genetic ancestor 13 million years ago, McVean says that the figure does not necessarily mean that the human and chimp lineages separated then. It may have taken a million years — or more — for the ancestral populations to accumulate enough changes to actually split into separate species.

The work provides the first reliable measure of mutation rates in a nonhuman primate, says Aylwyn Scally, an evolutionary geneticist at the University of Cambridge. But it also presents a conundrum. "We have to resolve this discrepancy where the genetic date [of the most recent common ancestor] looks so much older than the fossil record suggests," he says.

One possibility: Mutation rates could have been faster in the distant past, says Minyoung Wyman, an evolutionary biologist at Columbia University. If the time between human and chimp generations were shorter in the past, the mutation rate would have been faster, and the most recent common ancestor of humans and chimps may have lived more recently than McVean's group calculates, she says.

To measure the chimpanzee mutation rate, McVean and his colleagues sequenced the genomes of a three-generation family of nine captive Western chimpanzees, *Pan troglodytes verus*. By comparing the DNA of parents and offspring, the researchers identified mutations that arose during the production of eggs or sperm. The team found that each baby chimp inherited around 35 new mutations, 30 of which came from the father.

In the wild, the average parental age of male chimps is 24.3 years. But the captive chimps in the study mated as teenagers. The researchers calculated that wild chimps would bequeath about 69 new mutations to each offspring.

At least one scientist questions whether DNA sequencing really gives an accurate measurement of mutation rates. "It's very, very, very difficult to figure out what are real mutations and what are errors" in sequencing, says Laurence Moran, a biochemist at the University of Toronto. McVean's team may have dismissed real mutations as sequencing errors, leading them to underestimate the number of mutations. The result would be an artificially low mutation rate, inflating the split time between human and chimp ancestors.

But anthropologist John Hawks of the University of Wisconsin–Madison doesn't share that concern. If the researchers had been too conservative in identifying mutations, they probably would not have seen consistent differences between males and females, Hawks says. "I doubt we are missing a large fraction of real mutations in the estimates."

Even with drawbacks, the sequencing method is better than other methods for calculating mutation rates, McVean says. "Direct methods really are the most reliable source of information we have about how the genome changes." ■

COURTESY OF BIOMEDICAL PRIMATE RESEARCH CENTRE

BODY & BRAIN

Skin moles tied to breast cancer

Increased disease risk may reflect higher estrogen levels

BY NATHAN SEPPA

Women who have many moles on their skin are slightly more prone to breast cancer than those without them, two studies find. Skin moles, benign clumps of pigment-producing cells called melanocytes, might arise from high levels of hormones in women's blood, which may facilitate tumor growth, one of the studies suggests.

The presence of moles is influenced by an individual's genetics, but the new studies and earlier work suggest that exposure to estrogen also plays a role, says Barbara Fuhrman, an epidemiologist at the University of Arkansas for Medical Sciences in Little Rock. Like cells in the breast and elsewhere, melanocytes have receptor proteins that estrogen can bind to, triggering cell activities that include growth.

High mole counts have been linked to uterine tissue overgrowth called endometriosis and to a higher risk of the dangerous kind of skin cancer called melanoma. The new studies, appearing June 10 in *PLOS Medicine*, are the first large analyses to show a connection between moles and breast cancer.

In one study, nearly 90,000 women in France did a self-assessment of their skin moles. Those who described themselves as having "very many" moles were 13 percent more likely to develop breast cancer during a median follow-up of 18 years than those reporting no moles.

In the other study, epidemiologist Jiali Han of Indiana University in Indianapolis led a team that analyzed data from nearly 75,000 female nurses. At the study's outset, each nurse counted the moles on her left arm. During 24 years of follow-up, about 8.5 percent of women without moles and 11.4 percent of those with 15 or more developed breast cancer — an increase of roughly one-third. The researchers also found that estrogen levels in women who had six or more arm moles were nearly 46 percent higher than in women with no moles.

Coauthor of the French study Marie-Christine Boutron-Ruault of INSERM, the French National Institute of Health and Medical Research in Paris, allows that the link between moles and breast cancer is "indirect." A woman's breast cancer risk is also affected by family history, age at first menstruation, number of pregnancies, genetics and other factors, she notes. But she says that the potential addition of moles to the list bolsters a hormone connection. In breast cancer and endometriosis, estrogen contributes to unwanted tissue growth, and both are now linked with a high mole count. "All this points to a sort of common background," she says. ■

ATOM & COSMOS

Rocks' chemistry reveals details of moon's origins

New measurements support impact scenario for lunar birth

BY MEGHAN ROSEN

The messy details of the moon's birth just got a bit neater. Earth and its little lunar sister aren't actually twins, a new chemical analysis of Earth and moon rocks reveals.

The findings help iron out a big wrinkle in the giant impact hypothesis, the only idea about the moon's origin that hasn't been shot down yet, says Harvard University planetary scientist Sarah Stewart, who was not involved with the study.

"When everyone saw this work, we all breathed a huge sigh of relief," she says. "In my mind, the giant impact hypothesis is still standing."

This theory suggests that about 4.5 billion years ago a Mars-sized body called Theia bashed into the Earth, spitting out debris that mashed together to form the moon. Computer analyses of the collision suggested that the moon should be made mostly of Theia's remains.

Because objects in the solar system have unique compositions, scientists assumed that the moon and Earth would have distinct chemical fingerprints, says study coauthor Daniel Herwartz, a geochemist at the University of Göttingen in Germany. But until now, studies found the two to be made of exactly the same stuff.

"This was a major problem with the giant impact hypothesis," Herwartz says. "People have been saying maybe the whole thing is wrong. Maybe the moon formed in some other way."

But other ways are hard to find, Stewart says. "There was no second-choice model," she says. "That's why everyone hung on with dear life to the giant impact model."

In 2012, Stewart and others tweaked the theory a bit, varying the size of Theia and Earth's spin to find scenarios that left the moon's composition matching Earth's.

Around the same time, Herwartz and his colleagues revisited the chemical conundrum. They refined a technique to measure oxygen isotopes, versions of the element that vary slightly in mass. Scientists' previous measurements had been within the technique's error range.

Herwartz's team reduced the error by cleaning up the samples — lunar rocks brought back from the Apollo missions and Earth rocks — and then measuring only the rocks' oxygen.

"That was the trick to getting better precision," he says.

According to Herwartz's measurements, the Earth and moon are nearly but not actually identical in chemical makeup, he and colleagues report June 6 in *Science*. Their ratios of oxygen isotopes differ by about 12 parts per million.

"This is the first time people have really picked out a difference," says geochemist Tim Elliott of the University of Bristol in England. "It's an incredibly high-precision piece of work."

Even a slight difference eases the pressure on the giant impact hypothesis, Stewart says.

"We bent over backward with the 2012 impact models to try and make the Earth and the moon as close to each other as possible," she says. "Now we don't have to argue for something extremely special happening."

The findings also hint about the birthplace of the moon's mother, Herwartz says. Since the moon is so similar to Earth, both the planet and Theia may have formed in the same part of the solar system. ■

LIFE & EVOLUTION

Why tree-hugger koalas are cool

Sprawling against the trunk of a tree could provide more than half the cooling a koala needs to survive a typical hot summer day. During a heat wave, panting and licking their fur may bring koalas some relief but also may raise the risk of dehydration. Flopping against bark that's cooler than air is a previously unappreciated part of coping with heat, says ecologist Michael Kearney of the University of Melbourne in Australia. Natalie Briscoe, also of Melbourne, first noticed that at temperatures over 30° Celsius, koalas moved lower in trees, stretched out in dishrag poses and abandoned edible eucalyptus trees for inedible *Acacia mearnsii* trees. Infrared photos (above right) and heat loss calculations revealed that the shifts cooled the koalas. Acacia trunks averaged more than 5 degrees Celsius below air temperature, the researchers report in the June *Biology Letters*. "It gives us a very different perspective" on koala habitat requirements, Kearney says. Koalas need trees good at air conditioning as well as trees good for food. — *Susan Milius*

Bromine found to be essential to animal life

Fruit flies deprived of the element fail to hatch or die as larvae

BY TINA HESMAN SAEY

Bromine is a secret ingredient in the recipe for animal life. The element is necessary for helping cells in multicellular animals stick together, researchers report in the June 5 *Cell*.

Previously, scientists knew that animals had bromine in their bodies, but researchers could find no biological use for it.

"The bottom line is [that] of 92 naturally occurring elements, 27 are essential for the animal kingdom," says Billy Hudson, a biochemist at Vanderbilt University in Nashville who led the work. At least, that was the number before the new study. "Now there are 28."

Hudson's team found that *Drosophila melanogaster* fruit flies need bromine to live. The researchers also help reveal why bromine is essential for all animals, says Kevin Campbell, a membrane biologist at the University of Iowa in Iowa City.

Bromide ions, negatively charged versions of bromine, stabilize cellular support structures called basement membranes, Hudson's team discovered. A connective tissue, basement membranes sit outside cells and are composed of ropes of collagen and other large molecules. The external scaffold helps give cells their shapes.

Bromide facilitates formation of a chemical bond that lashes ropes of one type of collagen together. Hudson's team reported last year that these bonds — sulfur-nitrogen bonds called sulfilimine bonds — are necessities for multicellular animals (*SN Online: 12/17/13*). The researchers had also previously discovered that an enzyme called peroxidasin forges those bonds. In the new study, the researchers found that the enzyme needs bromide ions to function properly.

It seemed possible that other closely related elements, such as chlorine, might be able to substitute for bromine. To determine whether bromine is essential, the researchers eliminated it from the fruit flies' diet. That's no easy task, says coauthor Christopher Cummings, a Vanderbilt biochemist: "It's in the environment everywhere."

Even the tiny amounts of bromine that contaminate laboratory stocks of sodium chloride were enough to throw off experiments, Cummings says. The researchers had to purify their own sodium chloride supply, necessary for growing the yeast that flies eat and making the reagents used to study the peroxidasin's activity, to rid it of bromide.

The team fed female fruit flies a regular or bromine-free diet and tracked what happened to the flies' offspring. More than half of eggs from mothers fed a regular diet hatched, but only about 20 percent of eggs from bromine-free females did. Of the bromine-free larvae that did hatch, almost none survived to adulthood. Closer examination revealed that the basement membranes in bromine-free larvae were abnormal, and the guts of the flies did not develop properly as a result. When the researchers restored bromine to the larvae's diet, the insects grew into normal adults.

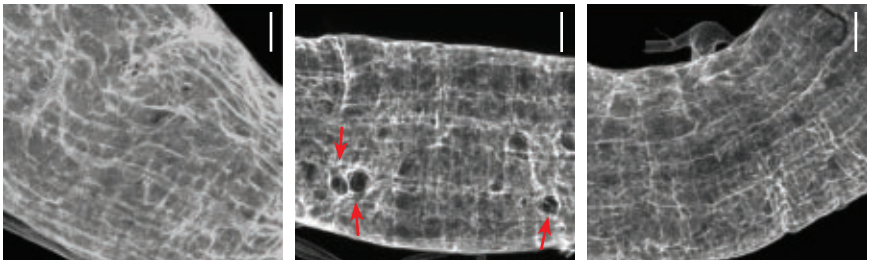
28
Number of elements essential to animal life

The experiments with fruit flies show that sound basement membranes are crucial to animal life, says Kaustabh Ghosh, a vascular biologist at the University of California, Riverside who studies how cells use mechanical forces to communicate with each other. The finding adds to growing evidence that the scaffolding outside cells isn't just a passive support structure; it provides cues to cells about how they should behave. Cells in contact with abnormal basement membranes are more likely to become cancerous, other studies have shown (*SN: 10/5/13, p. 20*).

The researchers' demonstration that bromine's role in forming the basement membrane is necessary for life could be important for human health too, Ghosh says. "The implications are far-reaching," he says, adding that currently, "it doesn't raise much of an alarm if you're low in bromine. This says you should take it seriously."

Although people usually get plenty of bromine in normal diets, those undergoing dialysis or getting their nutrients intravenously sometimes have low levels of the element in their blood, studies have shown. Hudson's team plans to investigate whether that deficiency might cause medical problems and whether bromine supplements could help.

The team also discovered that a chemical in tobacco smoke called thiocyanate inhibits peroxidasin's reaction. That might mimic a bromine deficiency in smokers and help explain why basement membranes in their lungs start to break down. ■



Basement membranes help support cells (fruit fly gut, left) in animals. Fruit flies raised without bromine (middle) develop holes (red arrows) in their basement membranes that can be repaired by adding bromine to the diet (right). Scale bar represents 20 micrometers.

A.S. MCCALL *ET AL*/*CELL* 2014

EARTH & ENVIRONMENT

Bacteria make plants into biofuel

Engineered microbe makes ethanol from switchgrass

BY BETH MOLE

A lone bacterium, genetically tweaked, can demolish switchgrass and ferment the sugary rubble to ethanol in one fell swoop. The microbe's one-step conversion of the crop eliminates the need for expensive plant-digesting treatments, offering the potential for cheaper biofuels.

Plucked from hot springs, the bacterium *Caldicellulosiruptor bescii* grows around 80° Celsius and naturally wrecks tough, complex plant molecules such as cellulose. Breaking down such roughage into fermentable sugars is one of the trickiest feats for converting plants to ethanol fuel, says geneticist Janet Westpheling of the University of Georgia in Athens. Standard methods require extra steps or costly combinations of enzymes.

Given switchgrass (shown), a modified bacterium can break down the plant, ferment sugars and produce ethanol for biofuel in a single step.

For years, researchers have sought a single-step solution, often engineering common microbes that naturally produce ethanol from sugar to become plant destroyers. Westpheling and colleagues tried the reverse: transforming an unusual plant-annihilating microbe into an ethanol factory.

Plants, she says, have evolved for millions of years to thwart microbial attacks. But some rare bacteria, such as *C. bescii*, can tear apart vegetation with enzymatic weaponry. "It already knows how to do the hard part," she says of the bacterium. "It was relatively easy to teach it to make ethanol."

The researchers first deleted the bacteria's gene for making lactate, which the microbe would normally produce from the plant wreckage. Next, the team armed *C. bescii* with genes for fermenting sugars to make ethanol, swiped from another microbe. When the researchers gave their custom-made microbe raw switchgrass, a starter plant for ethanol production (*SN: 8/1/09, p. 24*), the bacteria converted around 60 percent of the sugars into ethanol. The findings appear June 2 in the *Proceedings of the National Academy of Sciences*.

The simple method is "the ideal situation that everyone dreams of," says Alex Berlin of Novozymes in Davis, Calif. But the enhanced microbe is far from ready for an industrial debut, he says. Researchers need to get the bacteria to convert more of the plant material into ethanol, and the process needs to be scaled up to industrial levels, he says. ■

MATTER & ENERGY

New invisibility cloak hides in the fog

Simple scheme uses cloudy environment to mask object

BY ANDREW GRANT

Want to disappear? A new invisibility cloak offers you the chance — provided you carry around a portable fog machine.

The cloak, described June 5 in *Science*, achieves the challenging feat of hiding an object from all angles and all colors of visible light, with the caveat that it works only in hazy environments including clouds, fog and frosted glass. "It's a nice demonstration," says Jason Valentine, a mechanical engineer at Vanderbilt University in Nashville. "It sacrifices functionality in one area to gain functionality in another" — namely, the disappearance of the object to the naked eye.

In 2006, physicists caught invisibility cloak fever after developing intricate synthetic structures called metamaterials, which bend light like no material found in nature. The hope was that these materials could coax light rays to curve around an object rather than strike it, making it imperceptible (*SN: 7/15/06, p. 42*).

But an obstacle arose: To achieve invisibility, light taking a detour around a cloaked object must catch up to light traveling in a straight line. That's challenging because light moves fast through air, reaching nearly the speed of light in a vacuum, the unbreakable speed limit. "Employing a cloak in the Harry Potter–type fashion is not doable now and maybe not doable ever," Valentine says.

So Robert Schittny, a physicist at the Karlsruhe Institute of Technology in Germany, and colleagues designed a cloak that wouldn't have to race against the speed of light. They realized that rendering objects invisible would be a lot easier in a medium such as fog. Instead of zipping through these environments, light bounces off the densely packed particles like a pinball and diffuses gradually.

Taking advantage of this slowdown, the team designed a simple cloak that, as long as it's immersed in a hazy medium, completely hides an object from view. Schittny and his colleagues chose a tank of water mixed with particles of white wall paint to scatter and slow incoming light. The cloak consisted of a stainless steel cylinder or sphere coated with white paint and surrounded by a silicone shell doped with microparticles.

When a computer monitor next to the tank shined white light, the materials steered the light around the cloak and anything inside it, brightening the space behind the cloak that would otherwise appear dark. From the other side of the tank, the cloak was barely perceptible, causing just a subtle lightening of the water's color.

Valentine says the commercial applications are probably limited, but Schittny says the technology could hide metal bars that secure frosted glass windows. ■

H.SCHNEIDER/SHUTTERSTOCK

Road salt reshapes butterfly form

Anti-ice treatments affect monarchs' muscles, brains

BY SUSAN MILIUS

Salting roads in winter can tweak the physiques of the next summer's butterflies.

Milkweeds and oaks, plants that caterpillars graze on, collected from alongside a country road carried higher sodium concentrations than the same species growing at least 100 meters from the splash and drift of deicing salt, says Emilie Snell-Rood of the University of Minnesota in St. Paul.

Monarch caterpillars (*Danaus plexippus*) raised on the sodium-boosted plants grew into males with extra thoracic muscle and females with bigger eyes (probably a sign of bigger brains) than butterflies reared on the more distant foliage, Snell-Rood and her colleagues found. Another butterfly species echoed these his-and-hers effects when reared on a sodium-boosted lab diet, researchers report June 9 in the *Proceedings of the National Academy of Sciences*.

So is road salt good for butterflies? "I do not want that to be the take-home message," Snell-Rood says. Instead, she says, the study demonstrates for the first time that road salt can alter how animals develop. But too little is known to judge whether the effects of those alterations are harmful or beneficial. Her back-roads results, for example, might not apply in the supersalted zones of bigger highways.

"I see this paper as both exciting and worrying," says Nathan Morehouse of the University of Pittsburgh, who has studied diet's effects on butterflies. "This really opens up a broader palette of human influences than we typically consider important, at least for animal nutrition."

People may try to eat less sodium, but for many animals it's in short supply. "It's driven the evolution of really weird foraging behaviors" such as eating dirt, Snell-Rood says. Butterflies crowding to sip from puddles or alighting on another animal's face to drink tears may be feasting on sodium (*SN Online: 5/1/14*).

The idea of studying the effects of road salt on butterflies came to Snell-Rood when she moved to Minnesota in 2011. Earlier work on road salt had focused on different issues, such as behavior. Studies suggested that the roadside sodium bonanza affects ant foraging and draws moose nearer to highways, an unfortunate development if the salty foliage lures more moose to bumble into cars.

How much, if any, sodium from road salt ends up in plant tissues varies massively by species, Snell-Rood found. A kind of panic grass and a wild mustard called hoary alyssum didn't appear to pick up any extra sodium. But roadside Northern pin oaks had about 50 percent more sodium than distant oaks, and milkweeds, the main food for monarch butterfly caterpillars, could carry 30 times as much sodium as their kin that grow far from roads.

The plants' leaves were also dosed and begrimed with other substances that splashed, seeped or blew off the roads. To isolate effects of salt, Snell-Rood and colleagues followed up their monarch study with a test of cabbage white butterflies (*Pieris rapae*), which cooperate in the lab by growing on a highly controllable artificial diet. Changing only the sodium in the diet produced the same kinds of effects that the researchers had seen in the monarchs.

At a sodium dosage of about 3,000 parts per million, higher than average for roadside milkweeds, male cabbage whites matured into butterflies with about 11 percent more thoracic protein (indicating more muscle) than their counterparts raised at the low end of wild sodium concentrations, about 400 ppm. And the female cabbage whites raised on more sodium had about 20 percent bigger brains.

The sex differences surprised Morehouse, who is working with Snell-Rood on another project and was not involved in the new study. The butterfly sex differences may reflect the divergent priorities of the sexes. Male monarchs and cabbage whites both vie for mates in what's called scramble competition, essentially a free-for-all race among males. Stronger thoracic muscles could mean males can outfly the competition.

Females' priority, Snell-Rood says, is finding quality host plants for laying eggs. A butterfly's brain is about 75 percent devoted to vision, so bigger brains may improve butterfly botanizing.

Snell-Rood tried to investigate effects of higher plant sodium concentrations, but not enough of the insects survived. And even for modest levels, the long-term effects are "very poorly understood," says Stuart Findlay of the Cary Institute of Ecosystem Studies in Millbrook, N.Y. Overall, the biggest question about road salt treatments, he says, is their persistence in the environment. ■

MARSHAL HEDIN/WIKIMEDIA COMMONS (CC BY 2.0)

Monarch butterflies showed physiological effects of road salting when caterpillars, like the one shown here on a milkweed, fed on plants that picked up extra sodium.

ATOM & COSMOS

Supercooled water hits record low

Ultrafast laser records liquid droplet at –46° Celsius

BY ANDREW GRANT

Using a miniature water gun and a powerful laser, researchers have probed tiny water droplets at –46° Celsius, the lowest temperature at which ordinary water has ever been detected in the liquid phase.

"It's a world record, and it's hard to imagine it will ever fall," says H. Eugene Stanley, a physicist at Boston University.

Scientists report in the June 19 *Nature* that they have observed liquid water in the low-temperature region where water's already unusual properties are expected to become even weirder (*SN: 1/26/08, p. 58*). By studying such cold conditions, researchers hope to understand water's quirks at all temperatures.

Some of water's odd properties, including its ability to absorb heat and its low compressibility, change suddenly at very low temperatures. Scientists have been eager to explore what triggers these changes in the extreme cold. "If you understand water there, you understand it everywhere," says Anders Nilsson, a physicist at Stanford University and the SLAC National Accelerator Laboratory in Menlo Park, Calif.

Though it usually freezes at 0° C, pure water can remain liquid well below that temperature. This "supercooled" water looks just like water from the tap, but it is far more delicate: It solidifies the moment it encounters a foreign surface, such as a dust grain, ice cube tray or window of a cruising airliner. Past experiments had detected liquid water at –38° C but not colder, despite scientists' suspicion that it could subsist for measurable periods of time at even lower temperatures.

To keep water cold and uncontaminated, Nilsson and colleagues squirted small water droplets about the size of red blood cells into a vacuum chamber. As each droplet traveled, some of its molecules evaporated, releasing heat and causing the droplet's temperature to plummet as much as 10 degrees C per millisecond.

The researchers used SLAC's X-ray laser to serve as a flash camera. The laser zapped ultrashort pulses — each 50 millionths of a billionth of a second in duration — that struck some of the droplets. The laser energy caused each unlucky zapped droplet to explode, but not before X-rays had passed through and delivered the equivalent of a medical scan to a detector on the other side.

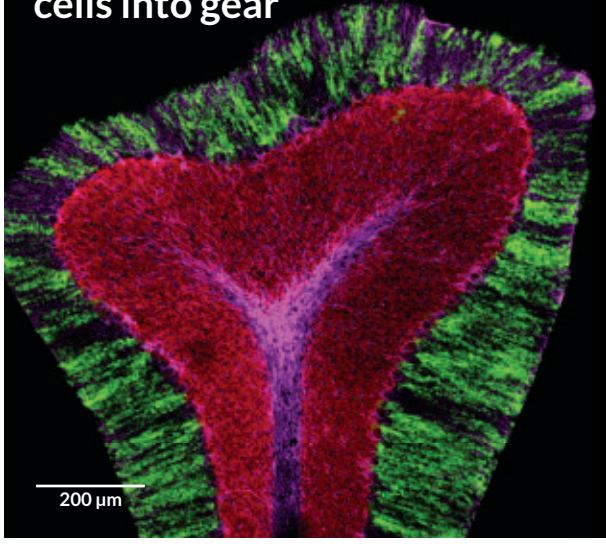
The results revealed that some of the droplets existed in liquid form at temperatures as low as –46° C and lasted about a millisecond before freezing. That's longer than some scientists expected, says Princeton University chemical engineer Pablo Debenedetti. "It's a major experimental accomplishment," he says.

The new work also shows that water's weirdness gets more extreme as the temperature drops, Stanley says. That lends support to the idea, proposed by Stanley and colleagues 22 years ago, that supercooled water undergoes a phase change at around –50° C into two never-before-observed liquid states. One of those novel phases should exist only when water is under pressure. Nilsson plans to subject the droplets to a combination of low temperature and high pressure to try to observe the dual phases.

A new computer simulation, described by Debenedetti and colleagues in the same issue of *Nature*, provides further evidence that water splits into two liquid phases at low temperatures. ■

BODY & BRAIN

Stress hormone kicks brain cells into gear



Some brain cells need a jolt of stress to snap to attention. Cells called astroglia help regulate blood flow, provide energy to nearby cells and even influence message movement between nerve cells. Now, scientists report June 18 in *Neuron* that astroglia can be roused by the stress molecule norepinephrine, an awakening that may help the entire brain jump into action. As mice were forced to walk on a treadmill, an action that makes them alert, astroglia (green) in the cerebellum and elsewhere underwent changes in calcium levels, a sign of activity, neuroscientist Dwight Bergles of Johns Hopkins University School of Medicine and colleagues found. Norepinephrine, which acts as a fight-or-flight hormone in the body and a neural messenger in the brain, seemed to cause the cell-activity boost. When researchers depleted norepinephrine, treadmill walking no longer activated astroglia. It's not clear whether astroglia in all parts of the brain heed this wake-up call, nor is it clear whether this activation influences behavior. Norepinephrine might help shift brain cells, both neurons (red) and astroglia, into a state of heightened vigilance, the authors write. — *Laura Sanders*

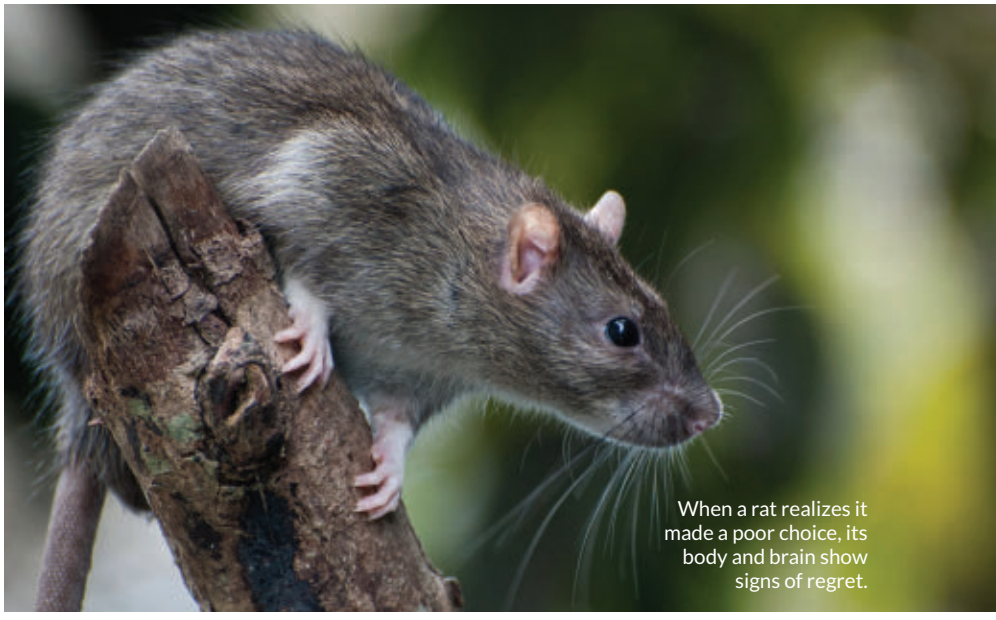
AMIT AGARWAL AND D. BERGLES, COURTESY OF CELL PRESS

BODY & BRAIN

Rats feel regret, experiment finds

Rodents may lament missed opportunities for food

BY LAURA SANDERS



When a rat realizes it made a poor choice, its body and brain show signs of regret.

HEIKO KIERA/SHUTTERSTOCK

With only an hour to eat, a diner hurries into his favorite restaurant. Deterred by a modest wait, he leaves, only to be burned by an even longer wait at the next restaurant. He immediately regrets his decision. This may seem like a typical "woulda, coulda, shoulda" situation — except in this case, the diner is a rat.

In laboratory tests, rodents exhibit regret, scientists report June 8 in *Nature Neuroscience*. After forgoing a good meal for a bad one, rats pause, glance back at what could have been and change their subsequent behavior. Scientists even caught signs of regret in rats' brains: Nerve cells behaved as though the rats were back at the scene of the missed opportunity.

This study and other recent rodent research are turning up signs of seemingly sophisticated behaviors that were thought to be exclusive to people, says neuroscientist Inbal Ben-Ami Bartal of the University of Chicago. Simple analogs of behaviors such as regret and empathy may allow scientists to better understand complex emotions in people. "We can really learn a lot about human brains from rats," Bartal says.

The first hint of rat regret came unexpectedly, says neuroscientist A. David Redish of the University of Minnesota in Minneapolis. While watching rats forage for food, graduate student Adam Steiner noticed that one rat looked as though it lamented a previous bad decision.

That chance sighting led the researchers to build a regret-seeking experiment they called restaurant row. It consisted of a large arena where rats could sample four stations that served up plain food pellets or those flavored with cherry, banana or chocolate. At the entrance to each restaurant, the pitch of a chime indicated how long the rats would have to wait for sustenance.

Each rat had its own flavor preferences, Redish says, allowing the scientists to figure out which restaurants and wait times represented a sweet deal to each animal. For instance, a rat that relished the taste of chocolate would happily wait about 22 seconds for a chocolate meal but would tolerate only about a 16-second wait for a plain one. The rats had only an hour to dine each day, so the pressure was on to find the most satisfying food with the shortest wait.

As four animals ran through multiple scenarios, Steiner and Redish noticed that rats that skipped a good deal and wound up with a bad one exhibited behaviors that looked like regret. The rodents paused and looked back toward a restaurant where they had turned down a good meal. After passing up a favored meal with a short wait, rats were more likely to wait longer for a less desirable meal at the next restaurant. And when food arrived, the rats didn't seem to relish it as much. "Normally they'll take 20 seconds or so to eat the food and get ready to go to the next place," Redish says. "After the regret, they eat in three to five seconds. They just wolf the food down."

Activity in the rats' brains also suggested the rats were ruing missed opportunities. The researchers monitored cells in two brain regions, the orbitofrontal cortex and the striatum, that fired in a distinct pattern when each rat was in a particular restaurant.

When a rat skipped a good meal of banana pellets with a short wait time but then encountered a long wait for a less-than-ideal cherry-flavored meal, for instance, the neurons behaved as though the rat were back in the banana restaurant. Steiner and Redish think that the rat was replaying its bad choice in a moment of regret.

The brain activity wasn't caused by simple disappointment, the team found. When the rat got a bum deal but made a good decision at the previous restaurant, the animal didn't show the same behavioral or brain signs.

"These authors have done really well to take what we think of as a complex concept such as regret and extract all complexity out of it and make it something very simple," says Bartal, whose work has revealed signs of empathy in rats. Of course, she says, regret is a simpler sentiment in rats than it is in humans, who can mentally replay events that took place years ago.

Finding that rats express regret, Redish says, should allow scientists to better understand how the brain learns from its past mistakes. ■

LIFE & EVOLUTION

Preserved pterosaur eggs hint at extinct reptile's social life

A vast graveyard of eggs and bones suggests that a newly discovered pterosaur, *Hamipterus tianshanensis*, probably nested in groups some 145 million to 100 million years ago. In northwestern China, Xiaolin Wang of the Chinese Academy of Sciences in Beijing and colleagues unearthed the fossils of about 40 pterosaurs, narrow-skulled flying reptiles sporting Mohawk-like crests. The researchers also found five complete eggs (one shown, right) that have kept most of their original 3-D shape, the researchers report in the June 16 *Current Biology*. A bit skinnier than chicken eggs, the pterosaur eggs probably had a cushiony membrane covered with a thin shell, like a gummy bear with an M&M coating. Because the eggs were found among the bones of so many pterosaurs, Wang and colleagues think the animals were a social bunch, not loners ranging freely by themselves. — *Meghan Rosen*

MATTER & ENERGY

Energy-efficient laser works at room temperature

An energy-efficient alternative to traditional lasers no longer requires a deep freeze. The first plug-in, room-temperature polariton laser, reported in the June 13 *Physical Review Letters*, could soon find its way into electronics and medical devices. Traditional lasers work by stimulated emission, in which atoms energized by electric current emit light. In polariton lasers, light is emitted by polaritons, particle-like couplings of light and matter. Although not powerful, these lasers require very little electricity. Last year, two research groups reported building polariton lasers that ran on electricity rather than another laser. But both lasers worked only in near absolute-zero temperatures (*SN: 6/29/13, p. 16*). Now one of those groups, led by Pallab Bhattacharya of the University of Michigan in Ann Arbor, has eliminated that restraint. His team uses a thin strip of gallium nitride along with mirrors and electrodes to preserve the short-lived polaritons and emit a weak beam of ultraviolet light. The device uses about 0.4 percent of the electricity of a comparable conventional laser. — *Andrew Grant*

BODY & BRAIN

E-cigarettes may inflame lungs as much as regular cigarettes do

Using electronic cigarettes has the same short-term effects on the lungs as smoking tobacco cigarettes. Both products triggered sharp reductions in exhaled nitric oxide among 25 volunteers. A drop in the gas is a marker of inflammation that signals airway damage. After "vaping," or inhaling e-cigarette vapors, volunteers exhaled 2.2 to 3.2 parts per billion less nitric oxide than when exhaling normally. The bigger drop in exhaled gas occurred in volunteers vaping a nicotine-free fluid. Smoking regular cigarettes dropped nitric oxide values by 2.8 ppb. A previous study found a similar trend but couldn't rule out the role of nicotine. The team also found that e-cigarette vapors contain up to about 65 percent more aerosol particles than does tobacco smoke. Analyses projected that cigarettes would have deposited the fewest aerosols per puff in the lung's tiniest, most critical airways, and nicotine-laced e-cigarettes the most. Sara Marini and her coworkers at the University of Cassino and Southern Lazio in Italy report the findings in the July 1 *Toxicology and Applied Pharmacology*. — *Janet Raloff*

GENES & CELLS

Blind mole-rats are loaded with anticancer genes

Blind mole-rats aren't exactly lookers. But the long-lived subterranean rodents do have other charms, including pronounced abilities to fight cancer (*SN: 12/15/12, p. 12*). Now, an international group of researchers has compiled the animal's genetic instruction book, giving a glimpse into how the rodents evade the disease. The genome of the blind mole-rat, *Spalax galili*, contains more than 22,000 genes, the team reports June 3 in *Nature Communications*. That's about the same number of genes as humans have. The rodents have doubled up on a cancer-fighting gene encoding the immune system chemical beta1-interferon and have more genes involved in regulating cell death and other tumor-killing mechanisms than do their close relatives rats and mice.
— *Tina Hesman Saey*

ATOM & COSMOS

Enormous galactic collision creates monster supercollider

BOSTON — A galactic pileup some 5 billion light-years away is building a powerful particle accelerator, up to a million times stronger than the Large Hadron Collider. New data from the Very Large Array and Chandra X-ray Observatory, presented June 3 at the American Astronomical Society meeting, reveal a colossal collision driving a fountain of charged particles 2.5 million light-years into intergalactic space. Galaxy clusters are the largest gravitationally bound structures in the universe, said Reinout van Weeren of the Harvard-Smithsonian Center for Astrophysics. Astronomers think that large clusters, which house thousands of galaxies, build up over billions of years as smaller clusters collide. The newly imaged particle jet sits at the heart of what van Weeren called "the most complex cluster collision known." Four smaller clusters with a total mass of 3 million billion suns are crashing together. The jet could provide information about how enormous clusters form.
— *Christopher Crockett*

MAURILIO OLIVEIRA

JUST RELEASED:
United States Baseball Legal Tender Coin

Actual size is 30.61 mm

Only $29.95!

Cooperstown, N.Y.

The National Baseball Hall of Fame and the U.S. Mint have just released the FIRST EVER *curved* American coin. This legal tender half dollar has been struck to honor the 75th anniversary of the National Baseball Hall of Fame and Museum.

First Ever Curved American Coin

The coin's curved design is a first in American history. The outward curing 'tails' side of the coin depicts a baseball—complete with intricate stitching. The inward curing 'heads' side of the half dollar reveals a classic leather baseball glove, with the curve perfectly reflecting the natural shape of a weathered and well-loved baseball mitt. Among the celebrity judges who selected this FIRST EVER curved design were Hall of Famers Joe Morgan, Brooks Robinson, Ozzie Smith, Don Sutton, and Dave Winfield. The curved design is like nothing you have ever seen before. You won't believe it when you hold it!

Going...Going...GONE

Public demand for these coins has exploded and a number of versions have already sold out quickly. The 2014 Baseball Hall of Fame Half Dollar will forever go down in history as a runaway best seller. But even though the coins are disappearing at record speed, you don't have to strike out.

If you CALL NOW, you can lock in your very own piece of baseball history—not to mention the *most unusual American coin ever struck*!

Pristine Brilliant Uncirculated Half Dollar

Each 2014 Baseball Hall of Fame Commemorative Half Dollar is minted in Brilliant Uncirculated condition and comes in official U.S. Mint packaging, including the official Mint Certificate of Authenticity. Best of all, you can secure yours today for **only $29.95** (plus s/h). Due to overwhelming demand, orders are limited to a maximum of 5 coins. No dealer orders will be accepted. Lock in yours now for estimated delivery at the end of July. Hurry! A sellout is expected at any time.

When you call, ask about the extremely limited Pete Rose autographed edition.

Call toll-free 24 hours a day

1-800-563-6468

Offer Code HOF173-01
Please mention this code when you call.

GovMint.com®
YOUR ONE BEST SOURCE FOR COINS WORLDWIDE

14101 Southcross Drive W., Dept. HOF173-01
Burnsville, Minnesota 55337

TOKEN Gestures

Online causes may attract many more clicks than commitments

By Bruce Bower

The Save Darfur Cause on Facebook had all the makings of a slam dunk cyber success. More than a million people joined the social media site's digital movement a few years ago to save the people of Sudan's Darfur region from mass slaughter.

There was a hitch in Facebook's humanitarian giddy-up, though: The vast majority of people who enlisted in the Save Darfur Cause recruited no one else to the digital crusade and contributed no money. The sum total of their support amounted to a computer click.

"Facebook conjured an illusion of activism rather than facilitating the real thing," sociologist Kevin Lewis of the University of California, San Diego says about the Save Darfur campaign.

While the effort managed to raise nearly $100,000 after almost three years, the money came from less than 1 percent of the 1.2 million Save Darfur members. Fundraisers and serious activists call the horde of nondonors "slacktivists," people with an activist's righteous intentions but a slacker's lack of follow-through.

> "Facebook conjured an illusion of activism rather than facilitating the real thing."
>
> KEVIN LEWIS

Lewis and his collaborators analyzed records of donations and recruits at the Save Darfur Cause. Their findings, published February 18 in *Sociological Science*, provide the first long-term look at the donation habits among members of a massive online social movement. Lewis conducted the study with psychologist Kurt Gray of the University of North Carolina at Chapel Hill and political scientist Jens Meierhenrich of the London School of Economics and Political Science.

Taken together with other recent experiments, this exposé of slacktivism among digital do-gooders suggests a need to rethink the potency of online awareness campaigns. Whether cruising Facebook or ambling down a crowded street, people gravitate toward slacktivism when others can see their minor act of support for a cause, researchers find. Impressing others with a public but trifling display of civic-minded concern may be all most people are willing to muster, at least those who don't have a burning passion for a cause.

Charitable organizations that encourage people to wear pins, bracelets or other ornaments as a first step toward becoming a donor or volunteer also may need to revise that strategy, researchers say.

Still, some forms of online activism undoubtedly succeed. An online network of protesters played an important role in defeating proposed federal legislation to regulate the Internet in 2012. Facebook and Twitter users also have helped coordinate mass real-world protests against authoritarian regimes, as in the 2011 Egyptian uprisings.

Many social scientists assume that online social networks enhance all types of social and political activism, says Stanford University sociologist Sarah Soule, a deputy editor at *Sociological Science*. But little research has addressed that issue. Some studies of face-to-face encounters have indicated that individuals are more likely to carry out a large request after first consenting to a small request. In contrast, other investigations find that token acts of support provide an excuse for doing nothing more.

Even less is known about whether pop-up Internet humanitarian campaigns, such as this year's #bringbackourgirls movement to rescue more than 200 kidnapped Nigerian girls, kindle successful activism.

"In the case of the Save Darfur Cause on Facebook, Lewis and his colleagues show that the effects of online activism were pretty minimal," Soule says. Whether Save Darfur's disappointing results represent an exception or the rule for digital movements will remain unclear until other online campaigns are evaluated.

Cause without effect

Meierhenrich wasn't sure what to expect to learn about Save Darfur when he began to delve into its members' online activities in 2009.

That investigation grew out of a larger project Meierhenrich had organized to probe the recruiting and money-raising prowess of the Save Darfur Coalition, a worldwide alliance of more than 190 advocacy groups founded in 2004. Shortly after that time, Facebook gained popularity among charitable organizations as a tool for attracting recruits and donations.

Some writers and Internet gurus touted social media as a game changer for activism; others doubted that digital

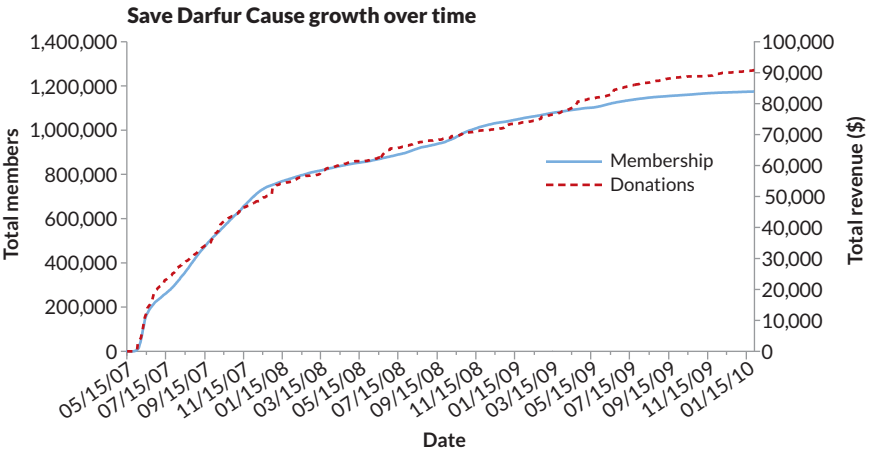
OPPOSITE PAGE: CHRIS GASH

connections made any difference. But their arguments rested on anecdotes, not investigations.

Meierhenrich responded to the debate by calling on Lewis and Gray to help him analyze donation and recruitment records for Facebook's Save Darfur members from May 15, 2007 — the day the online movement was founded — to January 27, 2010.

During those 989 days, nearly 1.2 million people joined the Save Darfur Cause on Facebook. Of that number, about 81 percent were recruited by other members. The rest signed up independently.

Meierhenrich, Lewis and Gray focused on the 1,085,463 members who joined within the first 23 months, so that those who wanted to recruit and give money had enough time to do so. A total of 1,082,858 members — 99.76 percent of the sample — never donated a cent. That left a smidge more than 2,600 members who forked over some dough. Almost 95 percent of that select group gave only once.



Fad of support Membership (solid line) and donations (dashed line) to the Save Darfur Cause on Facebook rose rapidly after May 15, 2007, but began slowing by the end of that year and largely plateaued after mid-2009. SOURCE: K. LEWIS *ET AL*/*SOCIOLOGICAL SCIENCE* 2014

About 72 percent of members recruited no one else into the online movement. Of those who did, nearly half recruited only one other person. Members knew they could recruit as many people to the cause as they wanted, but they weren't prompted to do so on the site. In other words, a tiny number of what the researchers call "hyperactivists" breathed life into the Save Darfur Cause. The most active recruiter corralled 1,196 new members. The top donor gave $2,500 in a series of payments.

Overall, the top 1 percent of hyperactivists were responsible for 47 percent of the funds raised and 63 percent of the movement's members.

By late 2009, donations had fallen to near zero and few new members were being recruited. What had burst on the scene as a viral movement of voluntary recruiters and donors petered out within about two years. "More and more people did less and less," Lewis says. Occasional fund-raising e-mails sent to members had no impact on those overall trends, he adds.

As a result, donations to the online effort fell far short of the more than $1 million raised in 2008 by the Save Darfur Coalition through direct-mail solicitations.

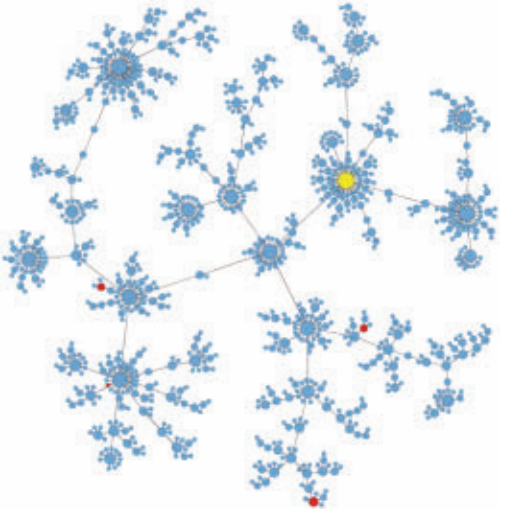
Getting to engagement

Not all online movements trigger a tsunami of slacktivism. Social media can inspire mass activism when lots of people have a direct stake in a cause, as occurred during recent uprisings against authoritarian rule in Arab countries, says sociologist Zeynep Tufekci of the University of North Carolina at Chapel Hill. About half of 1,050 Egyptian protesters surveyed shortly after that nation's president resigned in 2011 said that they used social media to communicate about the demonstrations, especially through Facebook, Tufekci and a colleague reported in the April 2012 *Journal of Communication*.

Social media makes it possible to assemble huge numbers of persecuted people into protest movements with astonishing speed, perhaps explaining why some political rulers have censored or shut down Facebook, YouTube and dissidents' websites. But organizers have yet to figure out how to convert bursts of Internet-fueled activism into sustained movements, Tufekci wrote in a March 20 *New York Times* editorial. Crowds mobilized by the Internet typically hold demonstrations that disperse after a few weeks without changing government policies, she concluded.

Facebook's Save Darfur effort faced participation and fund-raising challenges from the start, says political scientist David Karpf of George Washington University in Washington, D.C. Causes.com, the host site of the Save Darfur Cause, is a for-profit outfit that sells names of those who join its various movements to nonprofit organizations looking for donors. The

Missing links This is a 1,021-member subset of the recruitment network of the Save Darfur Cause. Larger nodes are members who recruited more people to the cause. Lines show recruitment links among members. The initial recruiter is the yellow dot. Only four people (red dots) in this network donated money and 71 percent recruited no one.



K. LEWIS *ET AL*/*SOCIOLOGICAL SCIENCE* 2014

site is set up to encourage people to join causes in a one-time action, Karpf says. An online cause such as Save Darfur that makes it far easier for people to join than to recruit or donate can be its own worst enemy, he suggests.

Karpf adds that many nonprofit organizations now skip Causes.com in favor of mobilizing campaigns on independent Facebook pages, Twitter and other online platforms.

E-mail solicitations currently bring in the most money as well as new members for the Save Darfur Coalition, says Erik Leaver, director of digital strategy for United to End Genocide in Washington, D.C. The Save Darfur Coalition merged with other groups to form Leaver's organization in 2011.

Save Darfur now attracts about 100 new supporters weekly through its own Facebook site, Leaver says.

"I don't think anyone would have predicted the amount of slacktivism we found in the Save Darfur Cause," Lewis responds. "It's time to stop being blindly optimistic about social media activism." For researchers, he adds, that means looking for factors that encourage true online activism once individuals digitally dip their toes in a movement of interest.

Impression managers

A research team at the University of British Columbia in Vancouver and Florida State University recently explored motivators to online and other kinds of activism, even before learning of the slacktivism findings from the Save Darfur Cause.

Kirk Kristofferson, a marketing graduate student, and his colleagues noticed that previous studies made opposing predictions about how people should behave after providing token support to a cause. One line of research suggested that helping others in small ways gives people "moral license" to forgo future support. Yet studies on the "foot-in-the-door" effect indicated that volunteers more often comply with large requests for assistance after agreeing to small requests.

In the April *Journal of Consumer Research*, Kristofferson's group tries to bridge the "moral license" and "foot-in-the door" perspectives. Results of several experiments begin to explain why joining an online activist site might or might not discourage serious involvement in that movement. The researchers also suggest how slacktivism can be deterred.

People are much less willing to go out of their way for a cause after engaging in public token support, versus private token support, the researchers find. An act of trivial backing for a cause that friends and strangers can see (say, clicking "like" on Facebook or donning a colorful wristband) satisfies a need to present oneself to others in a positive light, they propose.

"Token support that's observable by others may not lead to increased support for a cause," Kristofferson says. That's when real-world behavior mirrors results of the moral license studies.

His group ran its first study shortly before a date when Canadians annually show support for veterans by wearing poppy flower pins. Participants consisted of 92 people who walked across a concourse on the University of British Columbia campus that leads to a cafeteria and shops. At the concourse entry, a researcher gave some participants a free poppy and asked them to pin it on their clothing. Others received an envelope containing a poppy inside. A third group got no poppies. At the end of the concourse, another researcher asked all volunteers if they wanted to put donations in a bin on behalf of Canada's war veterans.

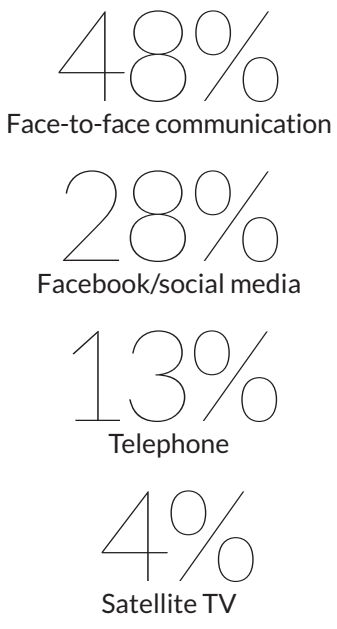
On average, those who received their poppies in envelopes donated more than twice as much as those who were given poppies to display immediately on their coats. Those who got no poppies gave the least. Hidden token support, the exercise suggested, was the best foot in the door to making a substantial contribution.

Comparable findings emerged in a lab investigation. Participants read pamphlets the researchers created for two phony charities, one to combat poverty in developing countries and another to provide international disaster relief. Volunteers who privately signed petitions for either cause later made a verbal commitment to spend an average of 57 minutes stuffing envelopes for their chosen organization, versus an average commitment of 32 minutes by those who signed petitions in front of the other participants. Individuals who weren't asked to sign petitions said they would stuff envelopes for about the same amount of time as those who had publicly inked petitions.

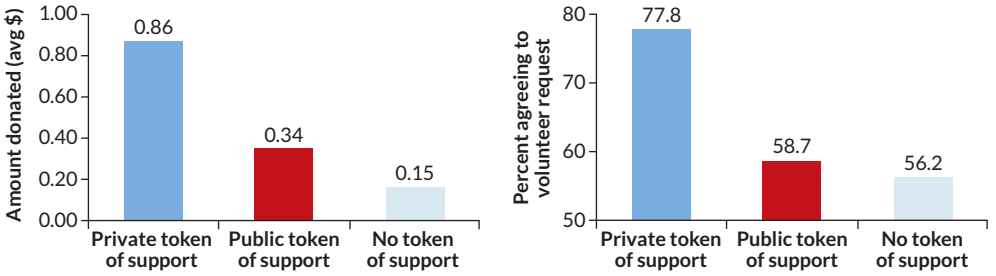
The team's third study suggested that engaging in public token support resolves a popular desire to impress others. In line with that idea, volunteers felt less concerned about how others perceived them after signing petitions in front of peers, relative to just before public signings. In contrast, participants who privately signed petitions reported a greater desire to act consistently with their beliefs and values. People who provide token support without being observed don't worry so much about social status as about contemplating how their personal values align with those of the cause, the researchers suspect.

Based on a fourth study, which focused on online activism, Kristofferson's team thinks it has found a weapon to spur the "one-click-and-done" crowd to further action. In this

Top ways Egyptians first heard about the 2011 Tahrir Square demonstrations:



Facebook became available in Arabic in 2009. Just two years later, it was the second most common way for Egyptians to hear about protests in Tahrir Square. Z. TUFEKCI AND C. WILSON/ *JOURNAL OF COMMUNICATION* 2012



Public displays Those who supported Canadian veterans in private gave more money than people who displayed their support on their lapels and those who did neither (left-hand chart). Private vs. public token support had the same impact on offers to volunteer (right-hand chart). SOURCE: K. KRISTOFFERSON *ET AL*/ *JOURNAL OF CONSUMER RESEARCH* 2014

experiment, 101 college students logged onto their personal Facebook accounts, where they linked to Facebook group pages created by the researchers for the two fake charities used in the petition study. Given the opportunity to join either online group, 74 students did so.

Some participants were told they had joined a public group, making their Facebook friends privy to their membership and future posts. Others were told they had joined a private group, inaccessible to Facebook friends.

One subset was then asked to think about how their personal values differed from those of their charity. In this test, only 32 percent of people who joined a public Facebook activist group volunteered to stuff envelopes for the campaign, versus 71 percent of those who joined a private group. Members of private groups, undistracted by social concerns, took the extra step of considering how their values matched those of a charity, Kristofferson proposes.

Aligning values

When other participants were encouraged to think about how their values aligned with those of the charities, comparably large majorities of both public and private joiners volunteered to stuff envelopes. People in public groups, it seemed, just needed some direction to forget about their public personas and embrace more active roles.

Charities generate a lot of publicity through online campaigns, "but seeking public expressions of token support may not attract new donors," Kristofferson says.

His warning applies not only to online outfits obsessed with collecting "likes" from admirers but to organizations that exhort people, say, to wear ribbons in support of medical research.

The analysis of the Save Darfur Cause indicates that "slacktivism is more common than scholars of online activism have believed," says sociologist Brayden King of Northwestern University in Evanston, Ill. However, he adds, Kristofferson's experiments suggest that getting people to join private online groups may be a way to turn "likes" into meaningful participation.

Online campaigns can achieve success, though, by gathering like-minded, highly motivated groups into an operation that wields political clout without raising a dime.

A diverse network of bloggers, small media outlets, independent groups and private organizations fueled a 17-month online movement that helped to defeat federal legislation aimed at prosecuting copyright violations on the Internet, concludes Harvard law professor Yochai Benkler and his colleagues in a July 2013 report published online by Harvard's Berkman Center for Internet & Society. The activists' aim was to preserve the right of anyone with an online platform to post information from any source without being charged or subjected to copyright-infringement lawsuits.

Benkler's team compiled 9,757 online articles about the proposed law that appeared from its introduction, in September 2010, until revised bills in both houses of Congress got voted down in late January 2012. Using specially designed software, the researchers analyzed the content of each story and the number of links from other sites to each story.

The online protest movement snowballed, drawing in digital contributors from across the political spectrum and eventually triggering critical coverage of the proposed legislation by major television networks and newspapers. Laws that started out with bipartisan congressional support and powerful outside backers buckled under a counterattack launched by small technology media sites that had no political lobbyists or D.C. connections.

The spontaneous, anti–Internet-control movement may have achieved an unlikely political victory because it was managed by a core of highly committed, computer-savvy activists. Or maybe the campaign's success heralds the rise of decentralized, citizen-run political lobbying crusades. Or perhaps the effort was perfectly suited to the medium of the exchange. For now, no one knows.

Lewis suspects that many Internet movements consist of slacktivist multitudes riding the coattails of hyperactivist commanders. "Slacktivism is nothing new, but the threshold for joining causes has now been reduced to a computer click," he says.

In a famous cartoon, one dog is sitting on a chair in front of a computer and another is seated on the floor. The dog in the chair says, "On the Internet, nobody knows you're a dog." Fair enough, Fido. But scientists will increasingly get to know which all-too-human Internet activists are dogging it. ■

Explore more

- K. Lewis *et al*. "The structure of online activism." *Sociological Science*. February 18, 2014.
- K. Kristofferson *et al*. "The nature of slacktivism: How the social observability of an initial act of token support affects subsequent prosocial action." *Journal of Consumer Research*. April 2014.

Technology revolutionizes the most important piece of furniture in your house!

NEW!

"To you, it's the perfect lift chair. To me, it's the best sleep chair I've ever had."

— J. Fitzgerald, VA

Remote Controls for Heat, Massage, Recline and Lift

Separate Heat and Massage Controls!

We've all had nights when we just can't lie down in bed and sleep, whether it's from heartburn, cardiac problems, hip or back aches – could be a variety of reasons. Those are the nights we'd give anything for a comfortable chair to sleep in, one that reclines to exactly the right degree, raises feet and legs to precisely the desired level, supports the head and shoulders properly, operates easily even in the dead of night, and sends a hopeful sleeper right off to dreamland.

Our Perfect Sleep Chair is just the chair to do it all. It's a chair, true – the finest of lift chairs – but this chair is so much more! It's designed to provide total comfort and relaxation not found in other chairs. It can't be beat for comfortable, long-term sitting, TV viewing, relaxed reclining and – yes! – peaceful sleep. Our chair's recline technology allows you to pause the chair in an infinite number of positions, including the Trendelenburg position and the zero gravity position where your body experiences a minimum of internal and external stresses. You'll love the other benefits, too: It helps with correct spinal alignment, promotes back pressure relief, and encourages better posture to prevent back and muscle pain.

And there's more! The overstuffed, oversized biscuit style back and unique seat design will cradle you in comfort. Generously filled, wide armrests provide enhanced arm support when sitting or reclining. The high and low heat settings along with the dozens of massage settings, can provide a soothing relaxation you might get at a spa – just imagine getting all that in a lift chair! Weight capacity 375 lbs. Shipping charge includes white glove delivery. Professionals will deliver the chair to the exact spot in your home where you want it, unpack it, inspect it, test it, position it, and even carry the packaging away! Includes one year service warranty. Your choice of fabrics and colors – ships in approximately three business days.

4 PRODUCTS IN ONE!

1. It's a "Chair"– for crafting, eating, visiting with friends and family

2. It's a "Sit Back Chair"– for reading, watching TV and resting

3. It's a "Sleep Chair"– for a comfortable and relaxing night's sleep

4. It's a "Lift Chair"– that puts your feet safely on the floor – you're ready to go!

Long Lasting DuraLux Leather — Tan, Brown, Burgundy

DuraLux II Microfiber — Burgundy, Cashmere, Fern, Chocolate, Indigo

46358

Call now to find out how you can get your own Perfect Sleep Chair!

Please mention promotional code 48184.

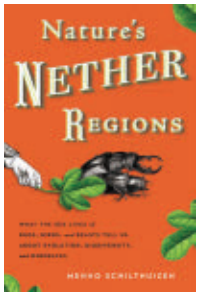
For fastest service, call toll free 24 hours a day. **1-877-666-4530**

The Birdsnap program maps birds' bodies to identify species in photos taken from different angles (bohemian waxwing shown above).

SCREENTIME

To ID birds, try facial recognition

Birding just got easier. No need to page through guidebooks looking for the mystery bird you just spotted — all you need is an iPhone and the new Birdsnap app, or a digital camera and computer. Snap a picture in the app or upload an image to the Birdsnap website, click on the bird's eye and tail, then enter the location and date where the bird was found. Sophisticated algorithms detect parts of the bird, such as the beak and the belly, then maps the bird according to "a common coordinate system from which [Birdsnap] can extract features for the identification system," explains one of Birdsnap's creators, computer scientist Peter Belhumeur of Columbia University. This is similar to how facial recognition systems map features such as the nose and eyebrows to identify people, even when they're not facing a camera head-on. After a few seconds, Birdsnap gives the user its best guess of the bird's species. Birdsnap currently lists only North American species, and it isn't perfect in its identifications — Belhumeur calls it a "work in progress" — but it can help narrow down potential species. Then even an amateur birder can use Birdsnap's descriptions and audio of bird calls to make the ID. Even better, Belhumeur notes, the system teaches you how to recognize birds from key parts so that later, you won't even need your automatic field guide. — *Sarah Zielinski*



BOOKSHELF

Nature's Nether Regions

Menno Schilthuizen

If you want to enjoy eating lightly cooked calamari, skip down two paragraphs. And avoid page 20 of evolutionary biologist Schilthuizen's charming and potentially mind-boggling new book on what he calls the "science of the genitals."

An underappreciated quirk of squid genitals, he explains, provides a bit of truth behind the 2012 tabloid headline "Woman, 63, becomes pregnant in the mouth with baby squid after eating calamari." Male squid encase gobs of sperm in membranes, sometimes covered with spikes, creating "spring-loaded sperm grenades," as Schilthuizen puts it. Even after the squid dies, insufficiently cooked grenades can on occasion burst apart into cephalopod sperm shrapnel inside a diner's mouth.

The book offers more fascinating tidbits on squid mating (males have a penis but don't deliver sperm with it) and plenty of other lively biology. What distinguishes this parade of marvels from other "wow, is nature weird" volumes is that Schilthuizen uses the creatures to offer an appealing introduction to the big themes in current research on how sexual parts, practices and ornaments have become so elaborate and diverse across the domains of life.

Genital evolution goes far beyond the merely postal challenges of delivering and receiving sperm at the right address. Schilthuizen reviews the idea, for instance, that partner persuasion continues even after wooing. This may explain built-in sensory enhancers; male crane flies in action scrape their genitals into humming with a pitch slightly below middle C. And then there are the conflicts of interest between the sexes, which as Schilthuizen explains in a counterintuitive twist may be especially important among hermaphrodites with identical sets of parts.

In spite of the skillfully explained evolutionary concepts, what may be most memorable to readers is the vast oddness of other species' genitals. Hermaphroditic *Deroceras* slugs have female openings, for instance, but partners transfer sperm from penis to penis. Certain female mites lay eggs through a conventional opening located to the rear but take in sperm through their hips. And Schilthuizen compares a chicken flea's elaborate sperm-delivery contraption, complete with combs, plates and springs, with "an exploded grandfather clock." Yet, he shows, the same kinds of evolutionary forces shape humankind's intimate shapes too. — *Susan Milius*

Viking, $28.95

Identify birds using your photos at **birdsnap.com**

BOOKSHELF

Faraday, Maxwell, and the Electromagnetic Field

How Two Men Revolutionized Physics

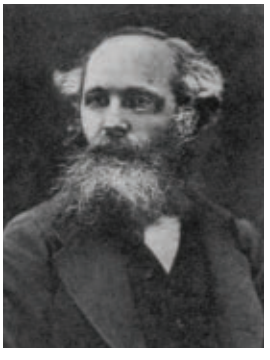
Nancy Forbes and Basil Mahon

On April 3, 1846, Charles Wheatstone was about to present the Friday evening lecture at London's Royal Institution. He had been invited by Michael Faraday, who had long been conducting research there on electrical and magnetic phenomena.

But Wheatstone bolted, struck by an attack of glossophobia (fear of public speaking). Faraday lectured extemporaneously in Wheatstone's place, describing recent electrical inventions. But that didn't consume the hour. So Faraday, off the top of his head, disclosed his speculations on the underlying physics of electromagnetic phenomena. His remarks can even today be recognized as an essentially correct theory of the electromagnetic field. As Forbes and Mahon relate, it was the theory that created the modern world, permeating every aspect of society, from transportation and communication to industry, commerce and domestic life.

But nobody in England understood what Faraday was talking about until James Clerk Maxwell came along. A young Scottish genius, Maxwell possessed a crucial skill that Faraday lacked — mastery of mathematics. By the mid-1860s, Maxwell had mathematized Faraday, figured out that light was electromagnetic radiation, and predicted that other forms of radiation would someday be discovered. Those radiations, in such forms as radio, radar, television signals and X-rays, did indeed transform the modern world beyond the 19th century's imagination.

Of course, virtually nobody understood what Maxwell was talking about, either, and his death in 1879 at age 48 prevented him from reformulating his theory in an accessible way. That task fell to a small group of "Maxwellians," including Oliver Heaviside (who simplified Maxwell's math into the famous "Maxwell's equations") and Heinrich Hertz, who in 1888 demonstrated the existence of Maxwellian radio waves.

After Michael Faraday (left) built the experimental foundations of electromagnetic theory, James Clerk Maxwell (right) devised mathematics for Faraday's ideas, providing the theoretical basis for much of the modern world's technology.

Forbes and Mahon provide an engaging biography of the electromagnetic field in the form of two sub-biographies of Faraday and Maxwell, and a brief chapter on the Maxwellians. It's fine storytelling that doesn't shirk the responsibility of describing some sticky scientific concepts. (If you've ever wondered what "curl" is in the context of electromagnetism, here's your best chance of getting it.)

The backstory of electromagnetism serves as a reminder that brilliant science in progress is not always recognized while it's in progress, and that prejudices ingrained into scientific orthodoxy (in this case, the universal belief that electric and magnetic forces acted at a distance) can blind science to new insights. It might even make you wonder what unconventional but brilliant research under way today is being neglected for similar reasons. — *Tom Siegfried*

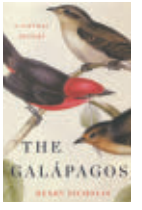
Prometheus Books, $25.95

WIKIMEDIA COMMONS

SUMMER READING

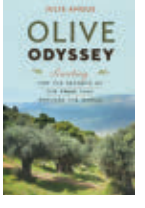
Catch up on science books that evoke the natural world and faraway destinations.

The Reef
Iain McCalman
The history of the Great Barrier Reef is told through the stories of scientists and others who have explored it. *Scientific American/FSG, $27*



The Galápagos
Henry Nicholls
Anyone planning or just dreaming of a trip to the famed islands will get a preview of their natural history in this engaging volume. *Basic, $27.99*

Seven Flowers
Jennifer Potter
A plant writer explores humans' relationship to the floral world through the lotus, lily, rose, opium poppy, sunflower, tulip and orchid. *Overlook, $26*



Olive Odyssey
Julie Angus
A couple sails the Mediterranean and along the way learns the olive's history, genetics, role in medicine and more. *Greystone, $25.95*

The Owl Who Liked Sitting on Caesar
Martin Windrow
The quirky story of a man and his 15-year pet, a tawny owl named Mumble, reveals owl biology along with insights into humankind's relationship with wild animals. *Farrar, Straus & Giroux, $26*

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

MAY 31, 2014

Cosmic rewind

"The video is awe-inspiring, thought-provoking and mind-blowing."

READER RAJ KAMAL, IN RESPONSE TO VIRTUAL UNIVERSE VIDEO

In case you missed it, a favorite from the May 31 issue was Science Visualized, which featured a link to an online video showing a simulation of the universe's early evolution.

Join the conversation

E-MAIL editors@sciencenews.or

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

Connect with

Debates on black hole deaths

Scientists disagree about what would happen to a hypothetical astronaut who floats past a black hole's point of no return — whether the unlucky traveler would be flash-fried or stretched into oblivion. ***Andrew Grant*** *chronicled the event horizon debate in "The mysterious boundary" (*SN: 5/31/14, p. 16*).*

On Facebook, we asked readers to speculate about the astronaut's fate, and most sided with spaghettification. **Charles Reardon** saw a potential silver lining to a horrifying death in deep space: "I'd imagine that, because time outside the black hole would be moving so fast compared to the astronaut, he'd probably be watching all the stars going supernova and being reborn like a fireworks show!" **Mark Cedrick De Vera** jump-started a discussion about whether spaghettification would be painful, and most readers agreed that the poor spaceman would be dead before his brain knew what was happening.

For now, this is all just guesswork. "Falling into a black hole seems like a bit of a stretch!" quipped **Bob Cleland**.

Pterosaur dating

*In "Oldest flying reptile" (*SN: 5/31/14, p. 5*),* ***Meghan Rosen*** *announced the discovery of the pterodactyl* Kryptodrakon progenitor, *an early ancestor to some of the largest reptiles to take to the air.* **Charlie Savoye** said that because pterodactyls weren't the only airborne reptiles, the title of the story was misleading. "The article itself notes that this discovery pushes back the fossil record 'for this type of pterosaur' by more than 5 million years; the pterosaurs as a whole — the order of extinct flying reptiles — go back significantly earlier, to the late Triassic period."

Rosen agrees that the headline incorrectly lumped flying reptiles together. "Though *Kryptodrakon* is the oldest pterodactyloid pterosaur at around 163 million years old, this group of flying reptiles doesn't include all pterosaurs, some of which lived and flew even earlier," she says. Study coauthor **James Clark**, a paleontologist at George Washington University in Washington, D.C., says that the oldest pterosaurs come from the Late Triassic, making them 225 million to 230 million years old.

Noting the difference

Scribbling down notes may help students understand lecture concepts better than typing away at a keyboard. ***Laura Sanders*** *reported that students writing in longhand performed better on postlecture quizzes than their computer-using peers in "Students retain information better with pens than laptops" (*SN: 5/31/14, p. 14*).*

The finding resonated with readers, who ruminated on the benefits of jotting things down. "Typists are famous for automatically putting down what they hear without thinking about it. A good touch-typist can type in their sleep," wrote **John Turner**. "Longhand? You tend to have to engage your brain more. Handwriting takes such complex muscular effort and planning that you're always asking yourself 'why am I writing this and not that?'"

Online commenter **SCstarman** added, "You might appreciate the definition of a lecture given by **Eric Masur** in 'Confessions of a Converted Lecturer': 'The lecture method is a process whereby the lecture notes of the instructor get transferred to the notebooks of the students without passing through the brains of either!'"

Living the slow life

*Big animals enjoy longer lives than smaller ones as a general rule, but taking flight may buy small species some extra years, as described in "Fly more, live longer" (*SN: 5/31/14, p. 4*).*

Readers online brainstormed lots of other possible factors contributing to life span, from brain size to heartbeats. And for bats, "it may be more 'life in the slow lane' that results in the longer life spans," **Anthony Kerwin** wrote. "Not only do they hibernate, but they will use torpor, a semihibernation state, on a daily basis or during cool periods, resulting in a considerable reduction in energetic costs."

ILLUSTRIS COLLABORATION

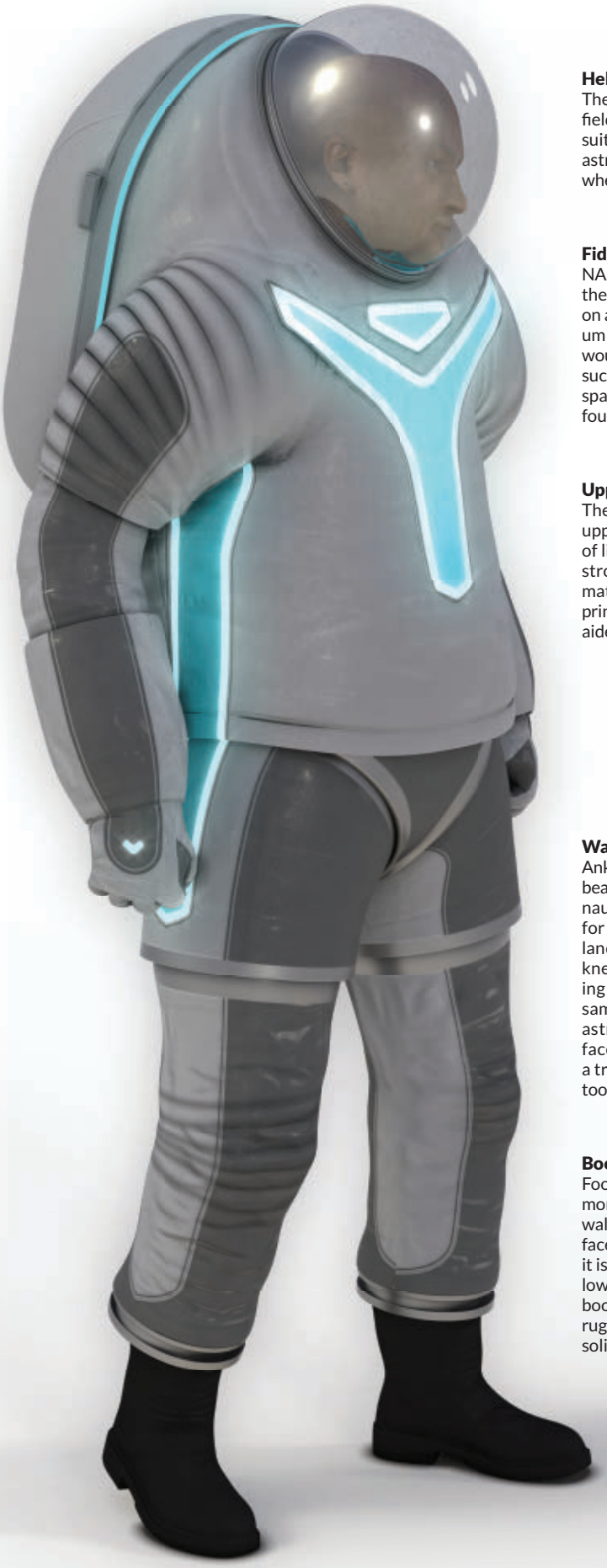
Watch the virtual universe video at **bit.ly/SN_cosmicrewind**

Life support
The suit efficiently disposes of carbon dioxide. A new ventilation system cycles water through the suit in a way that will prevent the kinds of leaks that have endangered astronauts during recent space walks.

Hatchback
Astronauts slide into the estimated 140-pound suit from the back, rather than by putting lower and upper segments on separately. The rear of the suit opens like a refrigerator door.

A suit fit for Mars

Though its styling suggests 1980s sci-fi, NASA's newly revealed Z-2 space suit is the astronaut apparel of the future. It is the second mock-up of a suit that NASA hopes will eventually protect explorers walking on Mars or drilling into an asteroid. "Space suit design is predicated on where you're going and what you're doing," says Amy Ross, a space suit designer at the Johnson Space Center in Houston. As a result, one of the Z-2's most important features is its lower-body flexibility, which allows astronauts to walk, climb and crouch to explore extraterrestrial landscapes. By November, NASA should have a prototype ready for testing, complete with *Tron*-like, blue luminescent patches that were selected by the public in an Internet poll. Unfortunately, those aesthetics won't appear on the final version of the suit, which NASA hopes to have ready for launch by 2018.
— Andrew Grant



Helmet
The visor has a larger field of view than old suits so Mars-roving astronauts can see where they're going.

Fidelity
NASA plans to test the pressurized suit on a person in a vacuum chamber. That would be the first such test of a new space suit design in four decades.

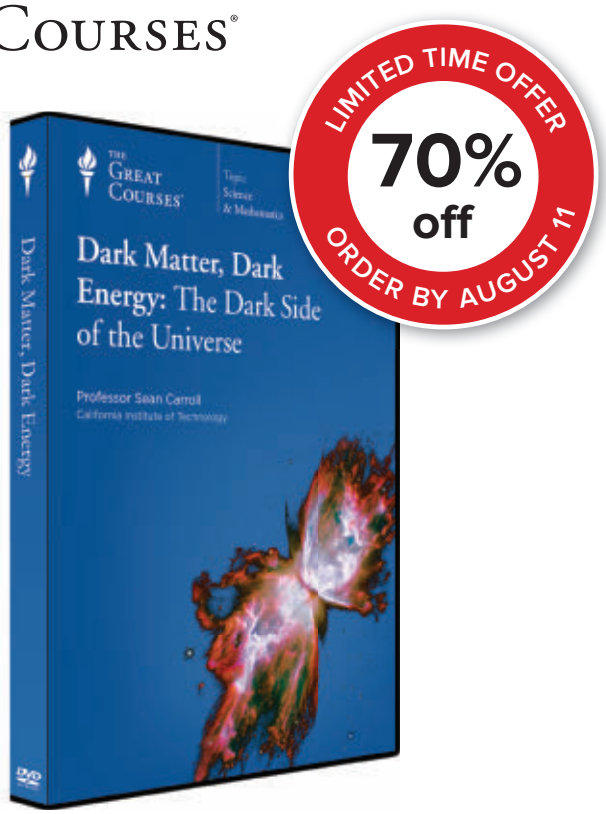
Upper torso
The suit has a solid upper torso made of lightweight yet strong composite materials. 3-D–printed components aided the design.

Waist and legs
Ankle, hip and waist bearings allow astronauts to bend over for studying the landscape and to kneel for collecting and analyzing samples. Apollo astronauts had to face-plant or use a trash picker–like tool to collect rocks.

Boots
Footwear is a lot more important for walking on the surface of a planet than it is for floating in low-Earth orbit. The boots are thick and rugged for traversing solid ground.

NASA

THE GREAT COURSES®



What Is the Universe *Really* Made Of?

In recent years, scientists have discovered that 95 percent of the contents of the cosmos are invisible to all current methods of direct detection. Yet something is definitely there, governing the shape and fate of our universe. These phenomena, called dark matter and dark energy, are the most eagerly studied subjects in astronomy and particle physics today. And for good reason—what could be more exciting than cracking the mystery of the fundamental components and composition of the universe?

Join the search in **Dark Matter, Dark Energy: The Dark Side of the Universe**. This mind-expanding course of 24 lectures, taught by expert theoretical physicist and award-winning professor Sean Carroll, explains the latest complex picture of the universe in easy-to-follow terms. Embark on a fascinating voyage of scientific discovery, from the insights of Albert Einstein to the latest groundbreaking concepts in theoretical physics and astronomy. You'll quickly discover how this "dark side" of the cosmos has brought us, for the first time in history, to the brink of knowing what the universe is made of.

Offer expires 08/11/14

THEGREATCOURSES.COM/4SN

1-800-832-2412

Dark Matter, Dark Energy: The Dark Side of the Universe

Taught by Professor Sean Carroll
CALIFORNIA INSTITUTE OF TECHNOLOGY

LECTURE TITLES

1. Fundamental Building Blocks
2. The Smooth, Expanding Universe
3. Space, Time, and Gravity
4. Cosmology in Einstein's Universe
5. Galaxies and Clusters
6. Gravitational Lensing
7. Atoms and Particles
8. The Standard Model of Particle Physics
9. Relic Particles from the Big Bang
10. Primordial Nucleosynthesis
11. The Cosmic Microwave Background
12. Dark Stars and Black Holes
13. WIMPs and Supersymmetry
14. The Accelerating Universe
15. The Geometry of Space
16. Smooth Tension and Acceleration
17. Vacuum Energy
18. Quintessence
19. Was Einstein Right?
20. Inflation
21. Strings and Extra Dimensions
22. Beyond the Observable Universe
23. Future Experiments
24. The Past and Future of the Dark Side

Dark Matter, Dark Energy:
The Dark Side of the Universe
Course no. 1272 | 24 lectures (30 minutes/lecture)

SAVE $185

DVD ~~$254.95~~ NOW $69.95
+$10 Shipping, Processing, and Lifetime Satisfaction Guarantee
Priority Code: 95537

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.

This Necklace is NOT for Sale…

…It's yours for FREE*

*No kidding. Only Stauer can give you 200 carats of genuine amethyst for **NOTHING**.*

You may think you understood the concept of "priceless" jewelry. For years, "priceless" meant "astronomically expensive." Owning "priceless" treasures was a rare privilege reserved for celebrities, billionaires, and royalty. The best most of us could do was dream. Until now...

Stauer smashes the luxury status quo with the release of our **FREE* 200-Carat *Lusso Amethyst Necklace***. That's right, we said **FREE**... as in "priceless." No charge.* ZERO dollars.* Call now and we'll send you this impressive helping of genuine amethyst (independently appraised at $295) for **FREE**. We cut the price 100% and you pay only $19.95, our charge for shipping, processing and insurance. There are no tricks or gimmicks. You aren't obligated to spend another dime or dollar with us... although we make it VERY hard to resist.

Why give away jewelry? We want your attention. Once you get a closer look at our rare gemstone treasures and vintage-inspired watches, and once you discover the guilt-free fun of getting "Luxury for Less," we're betting that you'll fall in love with Stauer. If not? Keep your **FREE *Lusso Amethyst Necklace*** anyway. No hard feelings.

A collection of purple perfection. Your ***Lusso Amethyst Necklace*** is a 200-carat symphony of smooth purple genuine gemstones. Each gemstone's shape and translucence ignites the velvety, violet hues. The polished amethysts are hand-set on double-knotted jeweler's thread, and the stunning 18" necklace (with 2" extender) secures with a gold-finished lobster clasp. Once you wear it, you'll see that it hangs with the same weight and elegance as similar strands that sell for hundreds more.

One more surprise... If we had our way, we'd send your ***Lusso Amethyst Necklace*** with no shipping charge. Unfortunately, the rising cost of gas and freight makes that impossible. But, to sweeten the deal, we'll include a **$20 Stauer Gift Coupon** with your **FREE** necklace. Amethyst is one of the world's most coveted gemstones and our supply is extremely limited. An offer this good will not last very long. Call to reserve your **FREE *Lusso Amethyst Necklace*** today and treat yourself (or someone you love) to a brilliant new definition of priceless luxury!

Necklace enlarged to show luxurious detail.

Lusso Amethyst Necklace (200 ctw) ~~$199~~**

Your Cost With Offer Code— **FREE***

***pay only shipping & processing of $19.95.**

You must use the offer code below to receive this special free necklace.

1-800-859-1680

BBB ACCREDITED BUSINESS Rating of A+

Offer Code LAN141-01
Please mention this code when you call.

Stauer® 14101 Southcross Drive W., Dept. LAN141-01, Burnsville, Minnesota 55337 www.stauer.com

200 ctw of genuine amethyst • Gold-finished spacers • 18"+2" length necklace

* This offer is valid in the United States (and Puerto Rico) except in TX, FL, CO, OK, RI, NH, WV, OR, SC, VA and ID. These state residents will be charged one cent ($.01) + shipping & processing for the item. Void where prohibited or restricted by law. Offer subject to state and local regulations. Not valid with any other offers and only while supplies last. This offer is limited to one item per shipping address. ** *Free is only for customers who use the offer code versus the original Stauer.com price.* † *For more information concerning the appraisal, visit* ***http://www.stauer.com/appraisedvalues.asp***.

Smart Luxuries—Surprising Prices™