Tsunami Science | How Consciousness Happens | Snakes Gone Wild

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# ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ FEBRUARY 25, 2012

Planets, Planets Everywhere

Psychedelics Turn Your Brain Off

Fish Flip in Acidic Oceans

# Hibernator know-how

## Health hints from winter survivors

# The Mystery of the Gold Angel Hides a Big Secret

During restoration of a 600-year-old monastery in Coventry, England recently, a shocking discovery made headlines. The austere monks who had lived in the monastery were forbidden from owning personal property of any kind. And yet, mysteriously hidden within one of the monk's cells, historians discovered a medieval gold coin.

Why would a poor monk have a gold coin secreted away in his room? The answer to this medieval mystery is revealed in the very name of the coin: The Gold Angel.


*Coin shown larger than actual size of 11 mm.*

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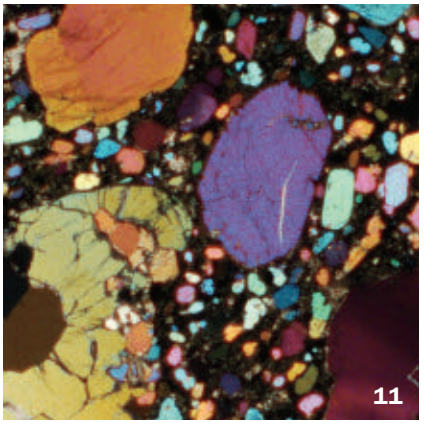
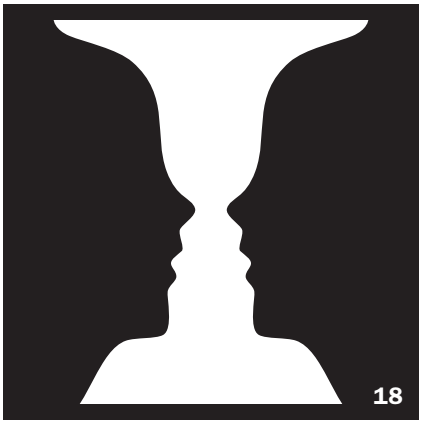
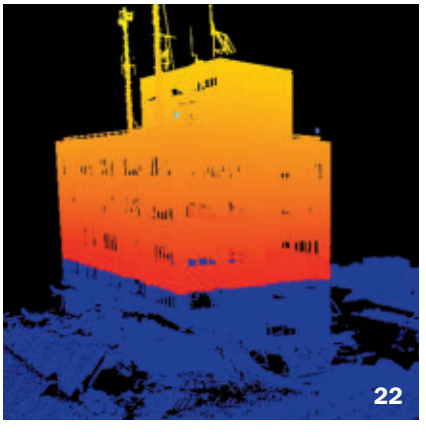







# ScienceNews

## In The News



## Special Report

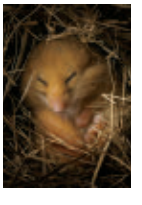


## Features



## Departments





**COVER** A hazel dormouse hibernates in its winter home. Studies of the biology underlying torpor may produce dividends for human medicine. *Bob Elsdale/The Image Bank/Getty Images*

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FROM THE EDITOR

# In the operas of science, the fat lady never sings

In sports, to paraphrase Yogi Berra, it's over when it's over. After a game is in the books, the books don't change (except for all those victories erased from the records of cheating college football teams).

But in science, it's a different story. Even when a scientific finding is enshrined in the pages of *Science News*, it still remains susceptible to further review. In this case it's not instant replay, but distant replay, the process of replicating a result to confirm its validity.

Often such additional studies verify and build on surprising scientific findings, opening up new fields of research. That's how science makes progress. But from time to time, the original findings are overturned, and the record book requires correcting.

Two such examples show up in this issue. As Rachel Ehrenberg reports (Page 10), the 2010 report of a bacterium metabolizing arsenic instead of phosphorus turns out to be contradicted by thorough new research. It seems that this particular microbe doesn't mind having arsenic around the way most living things would. But it apparently doesn't incorporate arsenic into its DNA the way that the original report implied.

In another case of now-you-see-it-now-you-don't, the supposedly first picture of an extrasolar planet, displayed on the cover of the December 6, 2008 *Science News*, turns out to be a picture showing an unidentified dot. A new study concludes that the dot is probably not a planet at all, as Nadia Drake reports (Page 12). Maybe it's a much farther away star, or light bouncing off a cloud of dust. But it's not likely to be a planet, and it's definitely not a microbe munching on arsenic.

Scientists sometimes cringe at such revelations of their fallibility, but there is really no reason to be upset about any of this. It's how science works, and how it works best. Observations and experiments generate results that are supposed to be subjected to further scrutiny. Science's great strength is the willingness to submit to such scrutiny and alter conclusions in the face of new evidence. Nonscientists in any number of other fields of human endeavor might want to ponder whether the world would be better off if they had the same attitude.

*—Tom Siegfried, Editor in Chief*

JIM WEBB

*Technology Simplified*

# WOW…A Computer Designed For YOU, Not Your Grandchildren!

NEW

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

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> I just wanted to tell firstSTREET that I am having a great time on my WOW computer. I am learning something new everyday. I am 79 years old and cannot believe that I am typing and sending e-mails to all my friends now. My daughter and granddaughter are so excited now that I have a computer. They use computers on their jobs everyday, but they cannot believe what you can do on this computer. It is wonderful… Thanks.
>
> – Johnnie E., Ellijay, Ga

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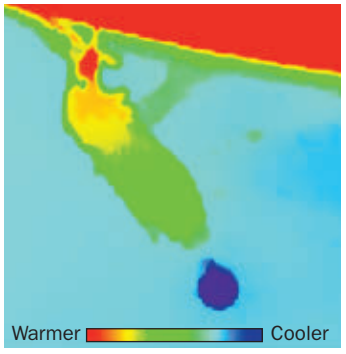



## Say What?

**Hematophagous** ***\hee-muh-TOF-uh-gus\ adj.*** Blood-consuming. Blood is nutrient-rich, but hematophagous animals have to eat and run — or risk being swatted. Blood can also make for an uncomfortably hot meal, reaching up to 104° Fahrenheit. A pair of French researchers used thermal imaging to learn how female mosquitoes keep from overheating while feasting. The images revealed that some species use evaporative cooling, releasing drops of fluid from the ends of their abdomens (shown, drop in purple). It's the same principle as sweating, but mosquitoes release fluid that is composed at least partially of the blood just ingested, the researchers report in the Jan. 10 *Current Biology*. —*Allison Bohac*

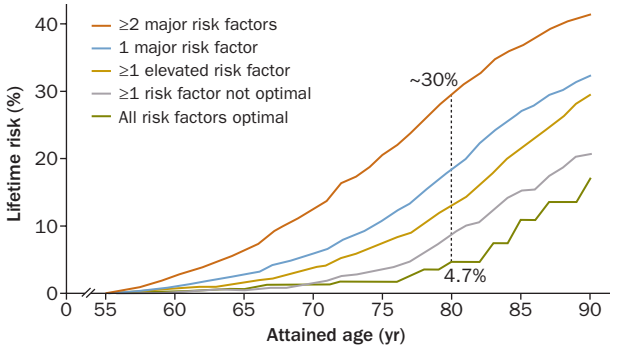
## Science Past | FROM THE ISSUE OF FEBRUARY 24, 1962

BOILING REACTOR WILL MAKE SUPERHEATED STEAM — An Argonne National Laboratory experimental reactor achieved criticality for the first time Feb. 9 at the National Reactor Testing Station near Idaho Falls, Idaho. The plant, known as Borax 5, was built at a cost of nearly two million dollars. It will test the feasibility of making superheated steam by utilizing uranium fuel. The steam, in turn, would be used to drive a turbine to produce power. Borax 5 is designed to produce 20,000 kilowatts of thermal power at its maximum capacity. Nuclear superheated steam as used in the Borax 5 is expected to increase plant efficiency and eventually reduce the cost of nuclear fuel. The nuclear cores of the reactor are shown on the cover.


## Science Stats | HEART RISK HIKE

A 55-year-old man's risk of dying of cardiovascular disease by age 80 skyrockets from 4.7 percent to nearly 30 percent if he has two or more major risk factors such as a smoking habit, diabetes or untreated high blood pressure. SOURCE: J.D. BERRY *ET AL/NEJM* 2012

**Lifetime risk of death from cardiovascular disease**




## Science Future

**March 9–18**
The British Science Association's National Science and Engineering Week explores the theme "Our World in Motion" with events across the United Kingdom. See bit.ly/zqeESh

**March 17–23**
Enjoy science demonstrations and hands-on fun for the whole family at the San Diego Festival of Science and Engineering. Find the schedule of events at www.sdsciencefestival.com

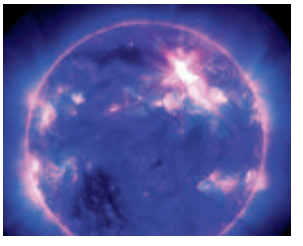
## SN Online

www.sciencenews.org

**LIFE**
Plant species grafted together can swap DNA via energy-catching organelles. See "Plants swap chloroplasts via grafts."

**HUMANS**
Social networks can spread users' emotions. Learn more in "Catching a mood on Facebook."

**ATOM & COSMOS**
A solar flare set off auroras around the Arctic Circle. See "Solar storm."



**BODY & BRAIN**
Protein-based disease agents can jump species. Read "Prions more mobile than thought."

## The (-est)

Scientists have uncovered the biggest flying reptile with teeth found to date. Researchers in the United Kingdom identified an unclassified fossil at the National History Museum in London as the upper jaw of *Coloborhynchus capito*, a pterosaur hailing from the early Cretaceous. First described in 1870, the species' wingspan was believed to top out at about 20 feet. After comparing the fossil with other pterosaurs (some illustrated below), the team estimates in the April *Cretaceous Research* that this *C. capito* individual sported a skull more than 2 feet long and a wingspan up to 23 feet, raising the bar for the potential size of toothy pterosaurs. —*Allison Bohac*

CLOCKWISE FROM TOP LEFT: C. LAHONDÈRE *ET AL/CURR. BIOL.* 2012; NASA, SDO, AIA; COURTESY MARK WITTON/UNIV. OF PORTSMOUTH

“The findings are astounding and are going to completely change how we understand the action of hallucinogens.”
— BRYAN ROTH, PAGE 8

# In the News



MICHAEL R. ROCHFORD, UNIV. OF FLORIDA

**University of Florida scientists show off a 4.5-meter Burmese python, weighing more than 72 kilograms, that was captured in the Everglades. Its stomach contained a 2-meter-long alligator.**

STORY ONE

## Pythons squeeze out local species in South Florida

### Some mammal populations fall by more than 90 percent

**By Janet Raloff**

Giant snakes are eating their way through the Everglades, leaving a drastically changed ecosystem in their wake, a new study shows.

The snakes, many of which measure 3 to 5 meters, are called Burmese pythons. But make no mistake: Virtually all of the estimated 30,000 living in southern Florida were born in the Everglades. Ecologists now report that populations of mammals have begun plummeting throughout the pythons' expanding range. And the timing of these mammal losses matches the geographic spread of the snakes, which federal officials believe were initially released into the wild in Florida by snake fanciers, probably 15 to 30 years ago.

Raccoon, opossums, deer and other mammals, along with birds and alligators, have all turned up in the stomachs of captured pythons, testifying to the snakes' varied appetite, notes ecologist Michael Dorcas of Davidson College in North Carolina. “But until now, there hadn't been any indication that the snakes were altering the ecosystem,” says Dorcas, who led the study.

The new data “make a persuasive case for cause and effect,” says herpetologist J. Whitfield Gibbons of the Savannah River Ecology Lab in Aiken, S.C., who was not affiliated with the new analysis. “The investigators take a convincing position that introduced predatory pythons are responsible for the decline in numbers of large- and medium-size mammals in the Everglades.”

With much of the roughly 6,000-square-kilometer Everglades National Park virtually inaccessible, the team of 11 scientists took an indirect approach to surveying the region's mammal populations. From 2003 to 2011, researchers cruised roads on 313 nights and compared the number of individuals in each species they saw per 100 kilometers traveled with rates witnessed along the same roadways over 51 nights in the 1990s — before pythons had established local breeding populations.

As in the earlier survey, raccoon and Virginia opossums were the most

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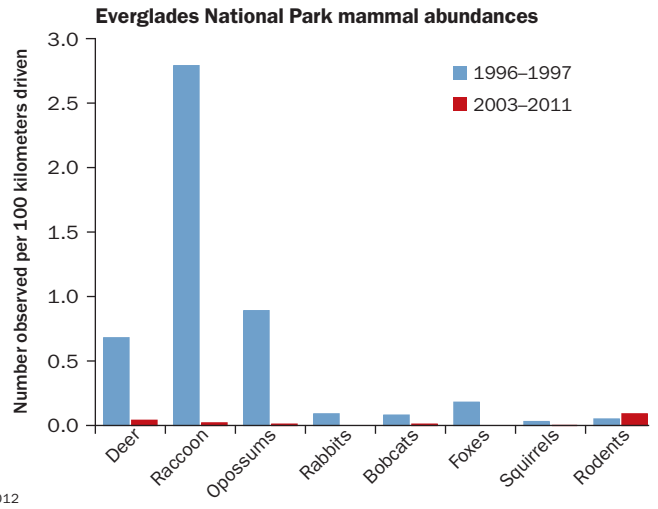
**Pleased to eat you**
Wildlife surveys of the Florida Everglades in the 1990s found abundant deer, raccoon and opossums. But those species, and several others, have plummeted as the population of introduced Burmese pythons has increased in recent years.




SOURCE: DORCAS *ET AL*/*PNAS* 2012

common mammals, although sightings of each were down by more than 98 percent in the most recent survey. Counts were 94 percent lower for white-tailed deer, and bobcat sightings were down by 87 percent. And in contrast to the earlier survey, scientists saw no rabbits or foxes. Rabbits had been among the most common mammals seen in the 1990s.

Roadside sightings of mammal species remained unchanged between the two periods in areas outside the python range. In spots of recent python migration, mammal sightings were also down somewhat from a decade earlier, drops ranging from 20 to 80 percent, Dorcas' team reports online January 30 in the *Proceedings of the National Academy of Sciences*.

The diminished mammal counts in python territory "are pretty similar to what we found," says Joshua Holbrook of Florida Atlantic University in Davie. A more circumscribed road-sampling survey he coauthored in 2010 in *Florida Scientist* turned up nine mammals over four nights: seven deer, an opossum and an unidentified small mammal. On five nights, he and his colleagues saw none. Meanwhile, beyond the pythons' range in the nearby Corbett Wildlife Management Area, he and Thomas Chesnes of Palm Beach Atlantic University sighted 40 mammals over nine nights.

"This study paints a stark picture of the real damage that Burmese pythons are causing to native wildlife and the Florida economy," says U.S. Interior Secretary Ken Salazar. His agency announced new rules on January 17 that will ban the importation and interstate transport of Burmese pythons, yellow anacondas and two other invasive constrictors sold in the pet trade. All have been found in Everglades National Park.

With so many invasive constrictors already breeding in South Florida, research is now focusing on ways to limit their spread and better understand the prey they threaten. Although Burmese pythons need freshwater to survive, a team of biologists with the U.S. Geological Survey led by Kristen Hart in its Davie, Fla., lab showed that the snakes can apparently derive much of their needed moisture from the tissue of prey animals.

The team's experiments suggest that python hatchlings can't survive more than two months with access to only saltwater. But a pair of hatchlings was still alive after 200 days with access to only brackish water. And a yearling snake with access to only saltwater survived seven months—holding open the prospect that these adept swimmers could, if motivated, migrate long distances through seawater, the team reports in the Feb. 10 *Journal of Experimental Marine Biology and Ecology*. In fact, Burmese pythons have already been found eating endangered wood rats on Key Largo, off the mainland coast. ■


# URGENT: Diamond Ring Recall

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# Body & Brain

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## Sleep may consolidate bad feelings

### Negative emotions persist following a night of slumber

**By Laura Sanders**

A night of shut-eye sears bad feelings into the brain, while waking hours take the emotional edge off, a new study finds. Though preliminary and somewhat inconsistent with earlier research, the results suggest that staying awake after something awful happens might be a way to blunt the emotional fallout of trauma, researchers report in the Jan. 18 *Journal of Neuroscience*.

In the study, Rebecca Spencer of the University of Massachusetts Amherst and her colleagues showed pictures of neutral scenes, such as a street, or negative scenes, such as a car wreck, to 106 young adults. Participants then rated the emotion inspired by the image on a one-to-nine scale ranging from sad to happy. Afterward, participants either went to bed for a night's sleep or were asked to stay awake for 12 hours. Then the researchers retested the participants by showing some of the same pictures mixed in with new images.

The people who slept were better at remembering which images they had seen the day before. But the memory wasn't the only thing that stuck around: Sleepers held on tighter to their feelings, while the sadness scores given by people who stayed awake tended to be weaker in the second session.

Cognitive neuroscientist Jessica Payne of the University of Notre Dame in Indiana finds the results "tremendously tantalizing," but cautions that they are too preliminary to be the basis for recommendations about how much to sleep after experiencing trauma.

These new results contrast with a study published in December that found that a night of sleep blunts the emotional impact of unpleasant experiences. That study, led by Matthew Walker of the University of California, Berkeley, used different methods and measurements, which may explain the seemingly opposite findings, says neuroscientist Penny Lewis of the University of Manchester in England.

## Psychedelics chill brain out

### Magic mushrooms subdue areas tied to self-awareness

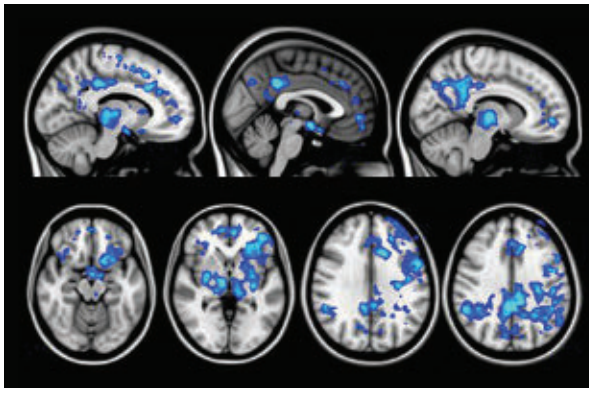
**By Devin Powell**

When Timothy Leary advised his generation to "turn on" by taking psychedelic drugs, he got it all wrong. Turning off parts of the brain may be the real secret to expanding your mind, research reported online January 23 in the *Proceedings of the National Academy of Sciences* concludes.

"The findings are astounding and are going to completely change how we understand the action of hallucinogens," says psychiatrist and pharmacologist Bryan Roth of the University of North Carolina at Chapel Hill.

A team led by psychiatrist and neuropsychopharmacologist David Nutt of Imperial College London recruited 15 people with previous experience taking hallucinogens. Each was injected with a small amount of psilocybin, the ingredient responsible for magic mushrooms' mind-bending properties.

Before and after the volunteers tripped out, their brains were scanned. These measurements revealed decreases in blood flow through parts of the volunteers' brains. Surprised by the result, the researchers repeated the experiment with another group using a different scanning technique. The same pattern emerged, most pronounced in the hubs that connect different parts of the brain — including the thalamus and parts of the cingulate cortex.



**Psilocybin, the active ingredient in psychedelic mushrooms, shuts down hubs linking different parts of the brain, as shown in functional MRI scans (lighter blue indicates less activity after taking psilocybin compared with a placebo).**

ROBIN CARHART-HARRIS, D. NUTT

Studies in mice suggest that hallucinogens stimulate certain neurons in the visual regions of the brain, which would explain the kaleidoscopic hallucinations users often experience.

But suppressing regions that coordinate and control the brain could have deeper consequences.

"Decreasing the activity in certain hubs in the network may allow for a more unconstrained conscious experience," says Matthew Johnson, an experimental psychologist at Johns Hopkins University School of Medicine who studies psilocybin and other hallucinogens. "These drugs may lift the filters that are at play in terms of limiting our perception of reality."

**6.1** percent | Obesity prevalence in U.S. 12- to 19-year-olds, 1971–1974

**10.5** percent | Obesity prevalence in U.S. 12- to 19-year-olds, 1988–1994

**18.1** percent | Obesity prevalence in U.S. 12- to 19-year-olds, 2007–2008

# Bad stress tied to inflammation

## Negative interactions may have biological effects

**By Nathan Seppa**

Competing in vain for the attention of someone special or fretting over a midterm exam may not be healthy. Such stress seems to boost a person's supply of two proteins that cause inflammation, researchers report online January 23 in the *Proceedings of the National Academy of Sciences*.

These inflammatory triggers have been linked to an increased risk of heart disease, high blood pressure, cancer and depression. The new results add to a growing body of research that links social stress with biological risks.

"We wanted to see how mental states such as optimism, or social relationships such as competition, get under the skin," says study coauthor Shelley Taylor, a social neuroscientist at the UCLA School of Medicine. She and her colleagues looked at the relationship between day-to-day stress and two proteins called proinflammatory cytokines that trigger inflammation in the body.

The researchers asked 122 young, healthy adults to keep a diary of all positive and negative social interactions for eight days, as well as descriptions of any incidents that involved competition. "We picked young adults with no history of heart disease or inflammation disorders or depression [because] we wanted to look at the biological processes in a population that was healthy," Taylor says.

Several days later, the scientists collected fluid samples from the volunteers' inner cheeks. Analyses revealed that the people with the most negative social interactions recorded in their diaries, and those who reported stressful competition in work or academic pursuits, had substantially higher levels of one of the inflammatory proteins — TNF receptor 2 — than did those who recorded fewer such incidents. People reporting stressful competition for another's attention had high concentrations of the other inflammatory protein, interleukin-6.

The volunteers then underwent a stressful test in which they did arithmetic calculations in their heads and gave a brief speech in front of strangers. After this test, people who had had the most negative interactions earlier in the week again showed high levels of both inflammatory proteins.

The link between short-term stress and revved-up inflammation could have an evolutionary basis, suggests Nicolas Rohleder, a psychologist at Brandeis University in Waltham, Mass., who wasn't part of the study team. "As early humans, we had to fight for our lives — fight or flight," he says. Inflammation has a useful short-term role in fending off pathogens, so triggering inflammation as a response to stress may have been a way for the body to fend off infections caused by those encounters, which often resulted in some form of injury, he says.

# Obesity not fed by snacks in school

## Sales of junk food not tied to weight gain in national study

**By Bruce Bower**

Sales of candy, soda and other junk food in middle schools don't weigh heavily on students' waistlines. This surprising finding — based on research that followed almost 20,000 kids through middle school — suggests that obesity prevention programs should target children in their homes and communities during the preschool years, when eating habits form, the study's authors say.

Boys and girls, kids from rich families and poor ones, and students of different races displayed no greater tendency to get heavier or to become obese in middle schools stocked with sugary and fatty goodies, as opposed to schools free of junk food, sociologists Jennifer Van Hook and Claire Altman of Pennsylvania State University in University Park report in the January *Sociology of Education*.

The researchers analyzed height and weight data for a nationally representative sample of 19,450 children who were fifth-graders in 2003 and 2004 and eighth-graders in 2006 and 2007, attending both grades in the same county. School principals provided information about foods available for purchase at their schools.

But principals usually don't know what foods are available in their own schools' vending machines and lunch lines, raising doubts about the new study's accuracy, says nutrition scientist Mary Story of the University of Minnesota in Minneapolis. Van Hook and Altman lacked "absolutely essential" data on individual kids' eating habits at school, which would directly show whether junk food availability led to weight gains, Story adds.

A national study conducted in 2004 and 2005 linked junk food sold in vending machines in or near school lunch areas with increased student body weight, Story says. She estimates that 40 percent of elementary and secondary school students in that study obtained enough daily calories, on average, from food other than school lunches to gain weight.

About 59 percent of fifth-graders and 86 percent of eighth-graders in the new analysis attended schools that sold junk food. Yet the percentage of overweight or obese students in the study decreased slightly from fifth to eighth grade, from about 39 percent to 35 percent.

Genes & Cells

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# Arsenic-based life finding fails follow-up tests

## Microbe doesn't use toxic element as a building block

**By Rachel Ehrenberg**

The controversial claim that one microbe can use arsenic in its cellular machinery is mired in scientific quicksand after scientists attempting to duplicate the finding have come up empty-handed. Though the microbe in question clearly thrives in the presence of the usually toxic substance, there is no evidence that the bacterium requires arsenic to live or incorporates the element into its DNA, researchers report online February 1 at arXiv.org.

In the original study, researchers led by Felisa Wolfe-Simon, a NASA astrobiology research fellow, cultured a microbe now known as GFAJ-1 from eastern California's Mono Lake. The lake has an unusual chemistry rich in carbonates, phosphorus, arsenic and sulfur. Wolfe-Simon and her colleagues starved GFAJ-1 of phosphate, a combination of phosphorus and oxygen that's an essential building block of life, and force-fed the critter arsenate, an almost identical arrangement of arsenic and oxygen.

It's the chemical similarity of the two elements that makes arsenic such an effective poison. Cells can be tricked into absorbing arsenate, but the stuff doesn't quite fit into the molecular machinery. That makes it unsuitable as a building block for DNA or cell membranes, jobs taken on by phosphate.

Using arsenate in the place of phosphate is "like putting a round peg in a square hole," says microbiologist Jim Cotner of the University of Minnesota in St. Paul.

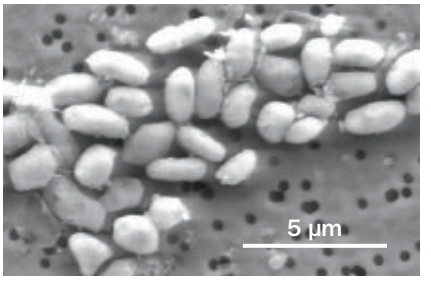
Yet Wolfe-Simon and her colleagues reported that GFAJ-1 thrived when deprived of phosphate and fed only arsenate (*SN: 1/1/11, p. 5*). "We report the discovery of an unusual microbe, strain GFAJ-1, that exceptionally can vary the elemental composition of its basic biomolecules by substituting" arsenic for phosphorus, the team wrote online in December 2010 in *Science*.

The scientific community was astounded and perplexed. The notion that arsenate could do the work of phosphate made no sense chemically, says chemist Steven Benner of the Foundation for Applied Molecular Evolution in Gainesville, Fla. "So much of what we think is true would have to be false," he says. And Wolfe-Simon and her colleagues didn't do some experiments deemed obvious by other researchers, such as attaching a radioactive tag to the arsenate and locating exactly where it turned up in GFAJ-1's DNA.

> **Using arsenate in the place of phosphate is "like putting a round peg in a square hole."**
> JIM COTNER

Now researchers led by microbiologist Rosemary Redfield of the University of British Columbia in Vancouver have tried to replicate the original growth experiments. Redfield, colleague Marshall Reaves of Princeton University and others grew GFAJ-1 in a test tube. After confirming with a genetic test that they had the right microbe, the researchers couldn't get GFAJ-1 to be fruitful and multiply until they added a dash of glutamate, an amino acid that Wolfe-Simon did not use in her experiments.

Then the team tried growing GFAJ-1 with no additional additives. The microbe didn't grow nearly as much as Wolfe-Simon and her colleagues had reported. But Wolfe-Simon's team had noted that the culture might have been contaminated by a little phosphate. So Redfield's team added a sprinkling of phosphate, a comparable amount to what Wolfe-Simon and colleagues thought might have been in their culture anyway.




**New experiments failed to confirm that a microbe called GFAJ-1 (shown) incorporates arsenic into its DNA.**

GFAJ-1 then grew much better. In fact, it grew in densities similar to those Wolfe-Simon and her colleagues had reported for GFAJ-1 when arsenic was added. And adding or removing arsenic from the cultures made no difference in growth, Redfield and her team report.

"At this point the discussion is essentially over," says Benner, who was not involved with the work.

Nonetheless, Redfield then extracted and purified GFAJ-1's DNA. The samples did contain trace amounts of arsenate, but not in the ratios one would expect if the microbe had incorporated arsenate into its cellular machinery. It's more likely, says Redfield, that GFAJ-1 can tolerate a bit of arsenic here or there without any serious effects.

"You can grow a bug in arsenic-rich media and you will see some arsenate," says geobiologist Tanja Bosak of MIT. But that does not mean the arsenate is in the DNA, she says.

Wolfe-Simon, who says she can't comment in detail until Redfield's results appear in a peer-reviewed journal, wrote in an e-mail that her original paper never actually claimed that arsenate was being incorporated in GFAJ-1's DNA, but that others had jumped to that conclusion. "As far as we know, all the data in our paper still stand," she wrote. "Yet, it may take some time to accurately establish where the [arsenic] ends up." ■

COURTESY OF *SCIENCE*/AAAS

# Earth

For more Earth stories, visit **www.sciencenews.org**

## Diamonds belched up by magma

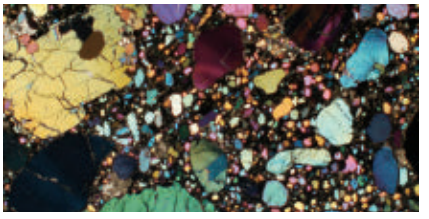
### Chemical reactions fuel gems' journey to Earth's surface

**By Alexandra Witze**

Drop a Mentos candy in a bottle of Diet Coke, and carbon dioxide will bubble violently out of the soda. Similar chemical reactions may send certain kinds of magma frothing up from deep within the Earth, carrying diamonds along the way.

The discovery, reported in the Jan. 19 *Nature*, solves several mysteries about why and how diamond-bearing rocks called kimberlites, which contain many kinds of crystals that formed 150 kilometers or more deep, get to the surface. Since magma ought to get denser the more crystals it picks up, in theory rising kimberlites should run out of steam deep underground.

Kelly Russell, a volcanologist at the University of British Columbia, and his colleagues realized that gas could fuel kimberlites if the magma starts out relatively poor in silicon dioxide (aka silica), a major component of the Earth's crust. As magma rises it begins to dissolve the surrounding rock — especially that containing lots of orthopyroxene, a mineral rich in magnesium, iron and silica. The orthopyroxene releases its silica into the magma, and as the silica content rises, the magma's ability to hold dissolved carbon dioxide drops. The gas bubbles out and pushes the kimberlite to the surface at supersonic speeds.



**A thin slice of kimberlite rock from Canada, seen through a microscope and in polarized light, shows minerals that rose from deep within the Earth.**

Russell confirmed the idea's plausibility with tests in a high-temperature laboratory at the University of Munich.

Lionel Wilson, an earth scientist at Lancaster University in England, says the study fits with other ideas about how kimberlites rise. In 2007, he and James Head of Brown University proposed that diamond-bearing magma moves upward by shattering rocks above it. But their calculations showed it slowing down in shallower depths. The chemistry proposed by Russell's team would give the magma enough oomph to continue all the way to the surface.



LUCY PORRITT

# Atom & Cosmos

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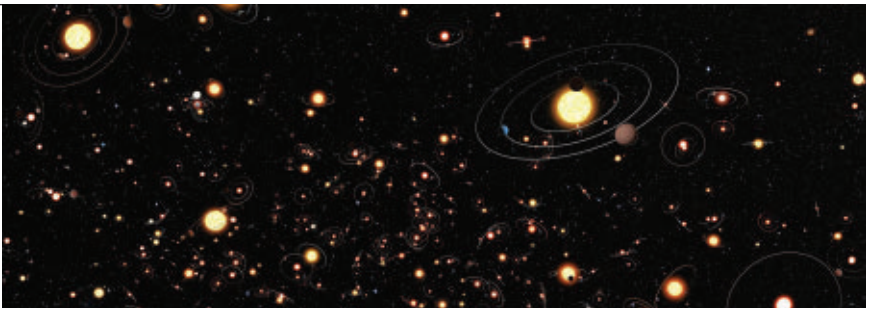
## Planets common as stars in galaxy

### Analysis suggests Milky Way contains 100 billion planets

**By Nadia Drake**



**The Milky Way's stars host, on average, at least one planet, a new analysis suggests. This not-to-scale illustration depicts such stars and accompanying planets.**

When you turn an eye to the evening sky, there's a good chance that many of the stars you see have at least one planet.

Using six years of data from planet-finding surveys, an international team of researchers concludes that, on average, a star in the Milky Way is accompanied by 1.6 planets. That's at least 100 billion planets in all, the scientists report January 12 in *Nature*.

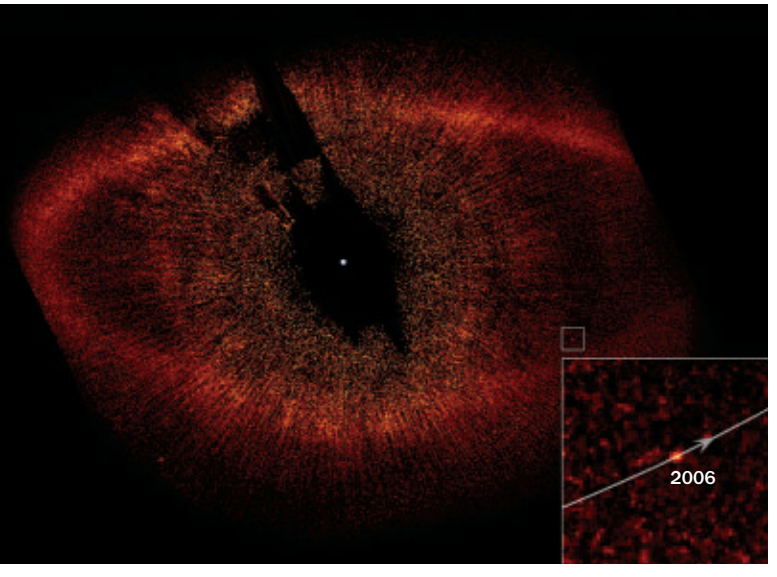
The figure might seem enormous, but it doesn't shock planet hunters. "I'm not surprised by this result," says astrophysicist Wesley Traub of NASA's Jet Propulsion Laboratory in Pasadena, Calif., who was not involved in the study. "This sounds reasonable. This sounds good."

The scientists used data that had been gathered from 2002 to 2007 by surveys looking for temporary brightening in a distant star's light caused by the gravity of a body passing in front of it. If that passing body is a star with one or more planets, the system causes a predictable boost in the distant star's light.

Unlike other types of planet searches, this technique, called gravitational microlensing, works well for stars both near Earth and far away. "If we want to go out of our little box and see into the infinite universe, or in the galactic bulge, or far outside the galaxy — are there planets even there? — then microlensing is the way," says study coauthor Kailash Sahu, an astronomer from the Space Telescope Science Institute in Baltimore. And microlensing can more easily detect small planets in orbits far from their stars — though the new study considered only planets circling from half the distance of Earth to the sun out to the equivalent of Saturn's orbit.

Other methods, such as detecting eclipses of a star by its planet and radial velocity searches that measure stellar wobbles, are more sensitive to planets tucked in close to their hosts and to larger planets. Microlensing is the best way to estimate planet frequencies for planets 10 times the mass of Jupiter to those more like Earth, says astronomer and study coauthor Arnaud Cassan of the Paris Institute of Astrophysics.

Some scientists note that the team based its estimate on a small number of planet detections, but say the small sample size was accurately accounted for. "Non-detections are just as important as detections to constrain the planet frequency," Cassan says.




## More like Faux-malhaut b

In 2008, astronomers claimed that the Hubble Space Telescope had snapped the first actual picture of an exoplanet, a pinpoint of light found within the debris disk of a star called Fomalhaut about 25 light-years from Earth (star at center, proposed planet boxed). Now, a different team of scientists spying on the presumed planet, dubbed Fomalhaut b, with the Spitzer Space Telescope suggests that the dot in the original image isn't a planet at all. Though the team isn't sure what the dot is, the point of light doesn't appear to radiate at the infrared wavelengths where exoplanets should, a team led by Markus Janson of Princeton University reports online January 24 at arXiv.org. This isn't the first time that Fomalhaut b has stumped astronomers. Ground-based infrared telescopes haven't been able to see it, and it's tracing an unexpected path around its star. Theories proposed to explain the imaged "planet" range from a background star to light scattered by a dust cloud. — *Nadia Drake*

FROM TOP: M. KORNMESSER/ESO; NASA, ESA, UC BERKELEY (P. KALAS, J. GRAHAM, E. CHIANG AND E. KITE), M. CLAMPIN/NASA GSFC, M. FITZGERALD/LLNL, K. STAPELFELDT AND J. KRIST/NASA JPL

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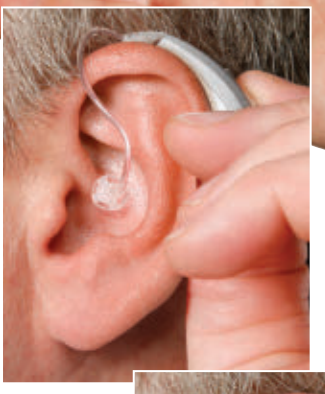

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# Life

For more Life stories, visit **www.sciencenews.org**

## Acidification alters fish behavior

### Higher carbon dioxide in oceans may affect brain chemistry

**By Janet Raloff**

A new study may explain how rising carbon dioxide concentrations — and the ocean acidification they induce — can cause changes in the behavior of fish. Like a flipped switch, the normal response of nerve cells can reverse as acidifying seawater perturbs how a fish regulates acids and bases in its body, including the brain.

The findings, published online January 15 in *Nature Climate Change*, could go a long way toward explaining curious sensory changes observed in fish exposed to acidifying waters, says neurobiologist Andrew Dittman of the National Oceanic and Atmospheric Administration's Northwest Fisheries Science Center in Seattle, who was not affiliated with the study. The scary scent of predators, for example, can suddenly become alluring.

Once excited, nerve cells in the brain need a chemical to calm them down. A compound known as GABA does this by unlocking a "gate" on the cells' outer membrane, allowing ions of chloride and bicarbonate to enter and quiet the cell. Göran Nilsson of the University of Oslo and his colleagues speculated that when a fish's body attempts to maintain chemical balance in the face of changing ocean chemistry, chloride and bicarbonate concentrations could become higher inside nerve cells than outside them.

**Dropping ocean pH levels may change the brain chemistry of reef dwellers such as this Australian damselfish.**

Later, when GABA gates opened, chloride and bicarbonate would then rush out of the cell instead of into it. That would excite the cell instead of calming it, essentially reversing the nerve's response to a stimulus.

To test the idea, Nilsson's group looked at hatchling reef fish. Among clown fish raised in an environment high in carbon dioxide, a predator's scent in the water — normally repellent — proved an attractant. Until, that is, the researchers immersed these fish for 30 minutes in water heavily spiked with gabazine, a chemical that locks the GABA gate closed. When the fish then reentered carbon dioxide–enriched water, a predator's scent proved repellent, the scientists found.

Fish normally show a preference for turning one direction versus another, the piscine equivalent of a human's left- or right-handedness. In a second experiment using Australian damselfish, Nilsson's group showed that fish in a high–carbon dioxide environment exhibited no turning preference. After a brief bout in gabazine-laced water, however, the fish suddenly demonstrated a marked preference for turning in one direction or the other.

"These are really fascinating results," says Dittman. But scientists need to confirm the idea by looking for actual changes in the cells, he says, not just reversals of sensory-based behavioral changes.

## Boas take pulse of prey

A boa constrictor knows to stop squeezing a juicy rat by sensing the heartbeat of its prey, easing up only when the pulse stops, a new study finds. To pinpoint the snake's sensitivity to this particular vital sign, researchers at Dickinson College in Carlisle, Pa., started with rat corpses lacking any signs of life. The scientists then implanted pressure sensors and artificial hearts, small bulbs pumped with fluid that produce the illusion of a regular pulse. Wild boa constrictors attacked the carcasses with or without the simulated heartbeat. But the snakes hugged harder and for about twice as long when their meal had a pulse. Lab-raised snakes never exposed to live prey responded the same way, suggesting the behavior is innate, not learned. Detecting heartbeats may give snakes an edge for hunting large cold-blooded animals that can cling to life for a long time when cut off from oxygen, the researchers report online January 18 in *Biology Letters*. *— Devin Powell*

G. NILSSON; SCOTT BOBACK

# Humans

## Willpower wanes after resisting

### Ability to exert self-control boosted by avoiding temptation

By Bruce Bower

Willpower comes with a wicked kickback. Exerting self-control saps a person's mental energy and makes the next desire that inevitably comes along feel more compelling and harder to resist, a study of people's daily struggles with temptation found.

But the people best able to resist eating sweets, going out with friends before finishing work or other temptations find ways to steer clear of such enticements altogether, so that they rarely have to resort to self-control, psychologist Wilhelm Hofmann of the University of Chicago reported January 28.

"Willpower fluctuates throughout the day, rather than being a constant personality trait," said psychologist and study coauthor Roy Baumeister of Florida State University in Tallahassee, who also summarized at the meeting his recent lab experiments on willpower's mental effects. "Prior resistance makes new desires seem stronger than usual."

Hofmann and his colleagues contacted 205 adults in a German city at various times of day for a week. Using handheld devices provided by the researchers, volunteers furnished 10,558 reports about desires they encountered or thought about.

Most self-reported desires didn't create problems for participants. When desires conflicted with other goals and called for resistance, volunteers' willpower failed 17 percent of the time, on average.

Desires for food, sleep and sex were rated as most intense. On a daily basis, though, participants most often gave in to urges related to media, such as checking their e-mail, and to working on job-related tasks. Surprisingly, Hofmann said, volunteers usually resisted desires to smoke cigarettes or drink alcohol.

> "Willpower fluctuates throughout the day, rather than being a constant personality trait."
> ROY BAUMEISTER

Germans' specific desires may not correspond to those of people in other countries. But the finding that acts of self-control make it harder to resist ensuing desires probably applies to people everywhere, Hofmann proposed.

After having resisted one or more urges, volunteers' average rate of succumbing to new temptations rose from 15 percent early in the day to 37 percent late in the day.

Participants routinely reported no awareness of when their resistance to desires had ebbed. "There appears to be no signature feeling of when willpower is low," Baumeister said. For instance, his work has found that fatigue alone doesn't account for the depletion of resistance.

Scientists have yet to explain precisely how self-control breaks down in the face of urges and desires, remarked psychologist Eli Finkel of Northwestern University in Evanston, Ill. In an analysis of cases of violence committed by one romantic partner against the other, Finkel found that stressful situations triggered physical assaults only among people who were consistently angry to begin with and who lived with emotionally volatile partners.

Specific mixes of personal vulnerabilities with provoking situations prompt individuals to give in to urges ranging from doughnut binges to spouse abuse, Finkel proposed. ■

## NEWS BRIEFS

### Many happy payouts

Money buys happiness when people spend it on others. A survey of more than 200,000 people in 136 countries found that spending on other people produces far more self-reported happiness than spending on oneself, Elizabeth Dunn of the University of British Columbia in Vancouver reported January 27. Testing of more than 900 volunteers in Canada, India and Uganda yielded similar results, as did experiments with 20 Canadian toddlers observed after choosing to give one of their own crackers to a researcher, Dunn said. Stress hormone levels remained stable among college students who shared a financial windfall with others, but those hormone levels rose among volunteers who kept all the loot, as did feelings of shame, she added.
*—Bruce Bower*

### I love you, man

Cupid takes better aim at guys. Contrary to popular opinion about romantic relationships, men confess their love an average of 42 days before women do and feel happier than women upon first hearing those magic words, "I love you," Josh Ackerman of MIT reported January 28. These findings emerged in six studies of romantic couples, individuals questioned about former relationships and randomly surveyed volunteers. Ackerman proposed that, as child bearers, women have evolved to be higher-quality romantic partners than men, who are motivated to confess love earlier for partners viewed as long-term prospects.
*—Bruce Bower*

# Science & Society

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## Data plots reveal election fraud

### Landslides in high-turnout areas suggest ballot stuffing

**By Rachel Ehrenberg**

Election fraud comes in many flavors, but there's a new taste test for one sort of trickery. Scientists analyzing data from recent international contests, including the questionable 2011 parliamentary elections in Russia, have proposed a new mathematical measure to discern fraudulent elections from fair ones.

The researchers examined voter turnout and votes received by the winning party for recent parliamentary elections in Russia, Austria, Finland, Switzerland, Spain and the United Kingdom and for presidential elections in Uganda and the United States. Graphing the relationship between turnout and votes for the winner revealed unusual peaks in the data for the elections in Russia and Uganda — a signature of funny business, the scientists contend.

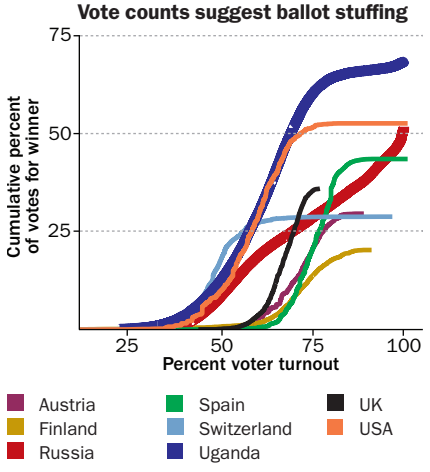
Ballot stuffing best explains the data, says study coauthor Peter Klimek, a complex systems scientist at the Medical University of Vienna.

"Of course, this is a statistical detection technique, not conclusive proof," says Klimek, who, along with Stefan Thurner and other colleagues, report the analysis online January 15 at arXiv.org. But the numbers need explaining, "and nothing explains them as cleanly as the fraud hypothesis," Klimek says.

Thousands of voting regions in Russia and Uganda reported 100 percent voter turnout with 100 percent of those votes for the winning party, the researchers found. Graph these data various ways and the fraud signature pops out, notes Klimek. Plotting votes for the winner cumulatively against voter turnout, for example, reveals a line that slopes off into a plateau for most countries, but for Russia and Uganda those lines keep climbing.

There are possible explanations for the Vienna researchers' results besides fraud, notes Walter Mebane of the University of Michigan in Ann Arbor, a statistician, political scientist and expert on Russian elections. When nearly 100 percent of the voters who turn out vote for the same party or candidate, that doesn't necessarily indicate ballot stuffing, Mebane says. The demographics of each area have to be taken into account; for example, a very militarized area might have very high support for one party.

**Fraud alert** When the percentage of votes for the winner is plotted cumulatively against voter turnout, the resulting curve usually plateaus. But in cases of suspected fraud (Russia and Uganda), the winner keeps gaining.




## The next epidemics will be tweeted

### Twitter posts tracked with official data during cholera outbreak

**By Rachel Ehrenberg**

Twitter, blogs and other social media can be powerful tools for tracking infectious diseases as they spread in poor countries with weak infrastructure, conclude researchers who studied Haiti's post-earthquake cholera outbreak of 2010.

Twitter posts and news about cholera gathered from the Internet in the first 100 days of the outbreak tracked closely with official data reported from hospital and clinics. But the social media data were available almost instantly instead of days to weeks after the fact. Mining such informal news sources could allow for speedier interventions with vaccines or antibiotics, biomedical engineer Rumi Chunara of Harvard Medical School and her colleagues report in the January *American Journal of Tropical Medicine and Hygiene*.

"There's very useful information in some of these nontraditional sources," says Philip Polgreen, an expert in bioinformatics and epidemiology at the University of Iowa. The new work establishes that the approach is useful for tracking a disease that emerges in the unsafe living conditions that often follow a disaster, Polgreen says.

Following the devastating January 2010 earthquake in Haiti, the country experienced a cholera outbreak for the first time in a century. The waterborne disease killed more than 6,500 people and sickened nearly half a million.

While the country's sanitary infrastructure is lacking, an estimated 3.5 million of Haiti's 10 million inhabitants have cell phones, which can be used to send 140-character Twitter posts, known as tweets, out onto the Internet. A team of researchers collected 188,819 tweets that contained or were tagged with the word *cholera* during the first 100 days of the outbreak — from October 20, 2010, the date of the first official cholera hospitalization, to January 28, 2011.

The researchers compared the tweets with data from HealthMap, a disease-tracking tool that mines Internet news stories, blogs and discussion groups and lets the public report illness by cell phone. Both the Twitter and HealthMap data corresponded to official data from the Haitian Ministry of Public Health.

P. KLIMEK *ET AL*/ARXIV.ORG 2012

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# Consciousness Emerges

## Somewhere along a tangled path, sights, sounds and insights pop into awareness

By Laura Sanders

In one of science's most iconic moments, Isaac Newton's eye caught the red glint of an apple as it plunged toward the ground. He heard the leaves rustle in the light breeze and felt the warmth of the tea he was drinking at the time.

These sensory inputs streamed into his brain, where they met his vast stores of knowledge, his internal musings, his peculiar brand of curiosity and perhaps even a fond recollection of escaping the ground's hold while climbing a tree as a boy. All at once, sights, sounds, emotions and memories converged to form a whole, rich experience in the garden that day.

It was this fortuitous experience — perfectly ripe for a big idea — that (legend has it) caused Newton to wonder why the apple fell not sideways or even upward, but straight down. Inspiration struck, ushering in a new understanding of gravity.

Newton gets the glory for figuring out that the same mysterious force pulls planets toward the sun and apples toward Earth, but how he did it hinges on an even deeper mystery: How his brain created a single, seamless experience from a chaotic flux of internal and external messages.

And that mystery isn't confined to brains like Newton's. In all conscious people, the brain somehow gives meaning to the external environment, allowing for thought, self-reflection and discovery. "It's not that conscious experience is one little interesting phenomenon," says neuroscientist Ralph Adolphs of Caltech. "It's literally the whole world."

Understanding how a rich inner experience emerges from fragments

MICHAEL MORGENSTERN

of data is a gargantuan task, akin to understanding the entire U.S. economy by mapping how all of its money flows. But rather than looking at the whole financial picture, insights can be gained from tracking a single dollar by its serial number as it jumps from wallet to cash register to bank.

Similarly, scientists are attempting to clarify the path that leads to consciousness by following a single, bite-sized piece of information — the redness of an apple, for instance — as it moves into a person's inner mind.

Recent research into the visual system suggests that a sight simply passing through the requisite vision channels in the brain isn't enough for an experience to form. Studies that delicately divorce awareness from the related, but distinct, process of attention call into question the role of one of the key stops on the vision pipeline in creating conscious experience.

Other experiments that create the sensation of touch or hearing through sight alone hint at the way in which different kinds of inputs come together. So far, scientists haven't followed enough individual paths to get a full picture. But they are hot on the trail, finding clues to how the brain builds conscious experience.

**Demystifying the Mind**

This feature is the second installment in a three-part series on the scientific struggle to explain consciousness. To read the previous installment and see what's in the next issue, visit sciencenews.org/mind

### The mind's eye

One of the best-understood systems in the brain is the complex network of nerve cells and structures that allow a person to see. Imprints on cells in the eye's retina get shuttled to the thalamus, to the back of the brain and then up the ranks to increasingly specialized cells where color, motion, location and identity of objects are discerned.

After decades of research, today's map of the vision system looks like a bowl of spaghetti thrown on the floor, with long, elegant lines connected by knotty tangles. But there's an underlying method in this ocular madness: Information appears to flow in a prescribed direction.

After planting a vision in a person's retina, scientists can then watch how one image moves through the brain. By asking viewers when they become aware of the vision, researchers may pinpoint where along the pipeline it pops into consciousness.

One of the most fiercely debated stops for visual information is a small patch of wrinkles at the very back of the brain called the primary visual cortex, or V1. By virtue of its prestigious locale on the cortex — the sophisticated outer shell of the brain where thoughts are formed — V1 seems to many like a reasonable place for visual consciousness to arise.

But some researchers argue that V1 is too simple: Instead of the final authority, V1 may be a relay station that conveys the message to higher-ups, more specialized brain regions that have their say in what's conscious and what's not. "V1 is kind of the battlefield," says Masataka Watanabe of the Max Planck Institute for Biological Cybernetics in Tübingen, Germany.

A key way to study V1 is to make an object visible to the retina while keeping it outside the mind's awareness. The eyes may see the object just fine, but the brain will completely miss it.

Scientists can do this by showing one picture to one eye and a different picture to the other. Because it's impossible to integrate the two images into a single vision, people toggle back and forth. Input to each eye's retina holds steady, while perception — whether an image pops into awareness — flips back and forth. Scientists can measure brain activity to track this perceptual switch.

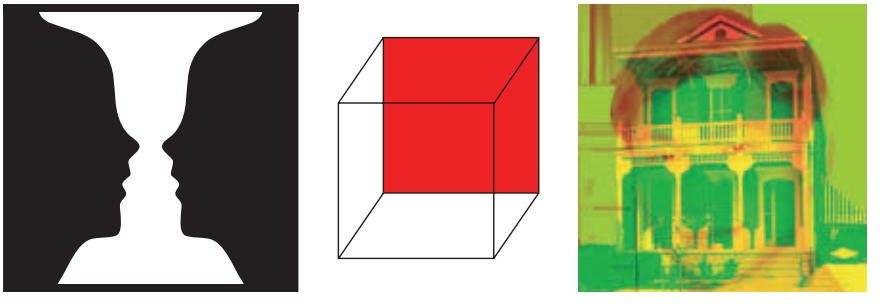
As expected, cells in each retina react to the information the same way, regardless of which image the person perceives. "This eyeball doesn't really care if the brain behind it is conscious or not," says neuroscientist Christof Koch of Caltech and the Allen Institute for Brain Science in Seattle.

After a quick stop-off at the thalamus, the info heads to V1, where the story gets complicated. Functional MRI scans, which measure big changes in blood flow, have found that activity in V1 tracks with toggling perceptions. But other data call V1's gatekeeper role into question. For instance, a technique that uses electrodes to measure the behavior of nerve cells found that V1 behavior did not change as perception switched.

Such conflicting findings stymied scientists until two new studies carefully separated out the confounding effects of a contaminator: attention. Attention is the focusing of the mind on a particular subject, often described as the mind's spotlight.

"If you really want to understand consciousness, then you need to separate the effects of attention," says neuroscientist Naotsugu Tsuchiya of Monash University in Australia.

Separating the two effects wasn't an issue until recently, because people believed them to be the same thing. After



**Flip-flop perception** Visual illusions offer a good way to study awareness. Though input into the retina remains constant, the mind toggles between perceiving a vase versus faces (left) or a box with a red back versus red front (middle). When each eye is shown a different image, a condition called binocular rivalry, the brain perceives one or the other rather than melding the two (right).

C.-Y. KIM AND R. BLAKE/*TRENDS IN COGNITIVE SCIENCES* 2005

all, the two often go together: Focusing on a tart, crunchy bite of a Granny Smith makes the experience more tangible, enhancing your awareness of it. And when attention is diverted, obvious things escape detection — a slip called inattentional blindness. The most famous example comes from a study in which observers are asked to count the number of times a basketball is passed between people. Engrossed in the ball-watching, many viewers are oblivious to a man in a gorilla suit who ambles into the middle of the scene, beats his chest and ambles out.

## Pay attention

But just because consciousness and attention are often linked doesn't mean that they are the same thing. A gripping demonstration comes from a recent experiment's subliminal spiders. Participants who were terrified of spiders watched a screen as pictures of a spider or an outdoor scene flashed for 20 milliseconds — a split second that many scientists think is too fast to detect. None of the subjects could report what was flashed, indicating that the people who saw the spiders were not conscious of them.

Later, the participants were asked to walk into a room and touch a real tarantula. People who were exposed to the spider pictures got closer to the real spider than those who saw the natural scenes. The subliminal spiders desensitized people and reduced their fear, even though the participants were oblivious, psychologist Joel Weinberger of Adelphi University in Garden City, N.Y., and colleagues reported last year in *Consciousness and Cognition*. Though the pictures flashed too quickly to break into consciousness, the mind took note.

Most scientists accept that attention can occur in the absence of awareness. But evidence for the opposite idea, that conscious awareness can exist without attention, has been less clear. Some studies suggest that a person can report the gist of a scene — describing whether it's a library or a garden, for example — even when a huge chunk of attention is siphoned away by a demanding task.

A recent study by neuroscientist Jeroen van Boxtel of UCLA and colleagues set out to cleanly separate consciousness and attention. Van Boxtel and colleagues study afterimages, the phenomenon at work when a person who has stared at a green square for a minute shifts the eyes to a white screen and a ghostly pink square floats where the green square had been. In the study, participants either devoted their full attention to a part of a screen where a half-black, half-white circle would cause an afterimage, or had their attention distracted by a counting job. At the same time, the team manipulated the participants' awareness of the afterimage-inducing circle by showing it to only one eye while flashing a checkerboard pattern to the other eye. When the mind toggles to this dazzling pattern, the circle remains outside of consciousness.

In this way, participants could attend to something they didn't see (attention without consciousness) and see something they didn't attend to (consciousness without attention).

At the end of the experiment, once all the signals on the screen were turned off, the volunteers indicated how long the aftereffect lasted. Surprisingly, attention and awareness had different effects, the team reported in 2010 in the *Proceedings of the National Academy of Sciences*: The more attention a person deployed, the shorter the afterimage lasted. The more conscious a person was of the stimulus, the longer the afterimage lasted.

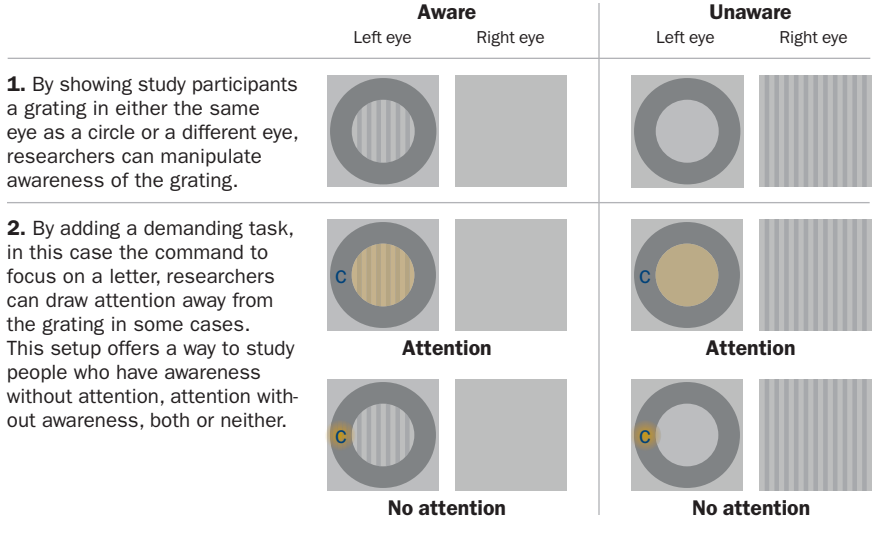
Though some scientists are still skeptical, these results and others like them appear to separate attention and consciousness, meaning each may have its own role in the brain. "The attentional spotlight picks out aspects of the environment and highlights them," says van Boxtel. In contrast, consciousness may be a synthesizer that merges bits of information into a broader picture.

Recent studies designed specifically to clarify V1's job show that when attention is removed from the equation, V1 behavior is no longer tied to consciousness.

In an fMRI study reported in the Nov. 11 *Science*, participants were either made aware of a striped pattern on a screen or not. Then, they either focused attention to the pattern or away from it. Like the study on aftereffects, this setup allowed scientists to separate awareness from attention. The fMRI signal in V1 didn't change as the stripes became visible or invisible if attention held steady. But when attention shifted, so did V1 activity, Watanabe's team reported.

More evidence comes from a recent monkey study, presented by neuroscientist Alexander Maier of Vanderbilt University in Nashville, Tenn., and col-

**Now you see it** Carefully designed experiments (one outlined below) allow scientists to separate the confounding effects of attention from awareness. Such studies have revealed that visual inputs don't reach consciousness as soon as they hit the primary visual cortex, as many researchers had thought. SOURCE: M. WATANABE *ET AL*/*SCIENCE* 2011

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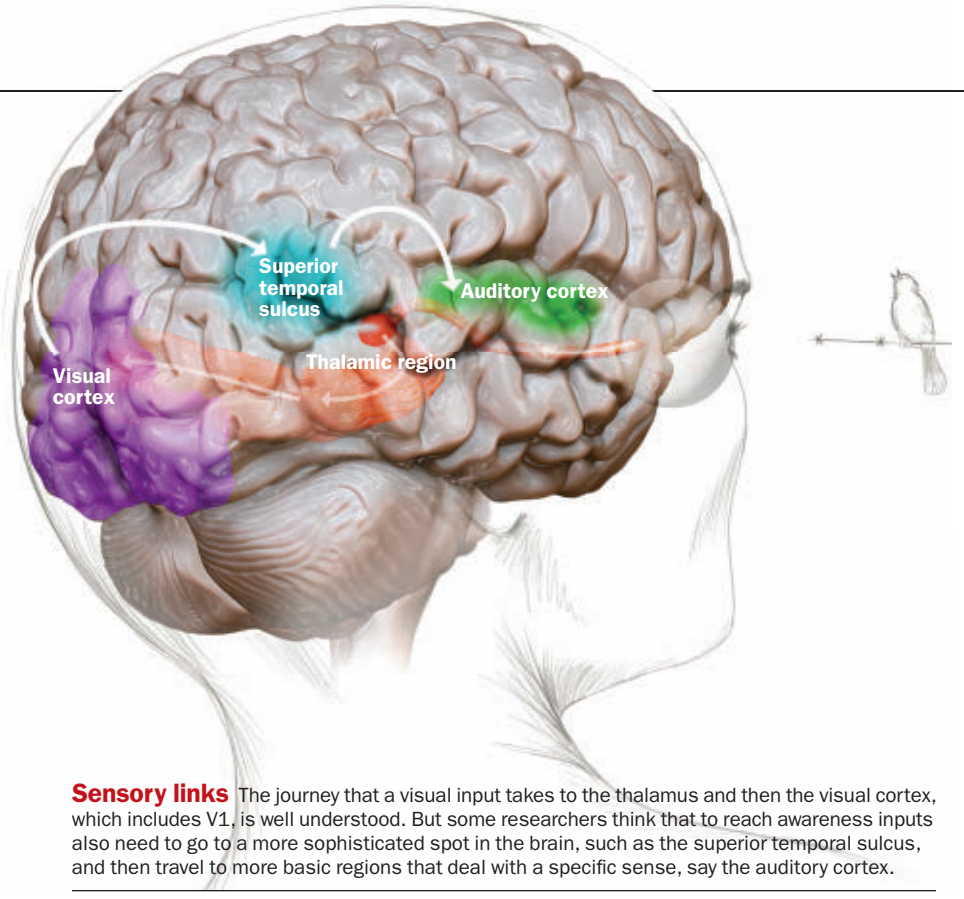



**Sensory links** The journey that a visual input takes to the thalamus and then the visual cortex, which includes V1, is well understood. But some researchers think that to reach awareness inputs also need to go to a more sophisticated spot in the brain, such as the superior temporal sulcus, and then travel to more basic regions that deal with a specific sense, say the auditory cortex.

leagues last year at the annual meeting of the Society for Neuroscience. In this experiment, electrodes measured V1 nerve cell activity as monkeys either perceived or didn't perceive an object, while either paying or not paying attention.

With fMRI studies and electrode studies in agreement, the results suggest that visual signals from the outside world don't break into consciousness as soon as they reach V1. The same may be true for corresponding early cortical stops for auditory, touch and other kinds of sensory input.

"The separation of attention and consciousness is a beautiful example to show that you can make progress on this difficult mind-body problem," Koch says. What's more, the split calls for a careful examination of earlier studies to make sure attention wasn't behind any results that were attributed to consciousness, he and Tsuchiya write in the February *Trends in Cognitive Sciences*.

## Messages from the top

But the new findings don't mean V1 isn't important for consciousness. Signals leaving V1 flow on to increasingly complex areas: places in the cortex where memories, skills and thoughts reside. When these signals then travel back to the simpler cortical regions, conscious experience emerges, proposes cognitive neuroscientist Kaspar Meyer of the University of Southern California in Los Angeles.

Perhaps the best evidence for Meyer's idea comes from his work on how a small bit of information that stimulates one sense can generate a sensation elsewhere. While watching video clips of someone handling a ball of yarn, volunteers' brains filled in a sort of "mind's touch," re-creating the sensation of the soft yarn, Meyer and colleagues reported last year in *Cerebral Cortex*.

A similar effect showed up for vision and hearing. Watching silent movies that are suggestive of a noise — a crowing rooster or a finger hitting a piano key — spurred a person to have the experience of hearing that noise, the team reported in 2010. What's more, videos of sounds that were more evocative to people (such as a howling dog to dog-lovers) had a stronger effect on the brain.

These findings suggest that the path from the outside world to the brain's inner experience is not a straight line. Scientists don't yet know all the stops along that path, or which are most important (although candidates for such stops have been identified, such as a cortical wrinkle called the superior temporal sulcus).

What is now clear is that the brain is not a stimulus-driven robot that directly translates the outer world into a conscious experience. "What we're conscious of is what the brain makes us be conscious of," Meyer says. "While the images we experience may be influenced to a certain degree by information that's incoming, we need to get away from the idea that they reflect exactly what's out there."

In the absence of incoming signals, bits of memories tucked away can be enough for a brain to get started with. That ability is on display every time someone imagines anything or dreams. A person sitting in a silent dark room can vividly picture mom's face, even if she is thousands of miles away. And dreams can be incredibly vivid even when they aren't linked to sensory inputs. "That tells us that your brain, in the absence of any outside input, can generate this movie that appears totally realistic to you," Meyer says.

**A silent video of a finger striking a piano key (still, shown) triggered activity in people's auditory cortex, and the sensation of sound.**

In the Jan. 27 *Science*, Meyer proposed that, more generally, all conscious experiences could be thought of as what Nobel laureate and neuroscientist Gerald Edelman calls a "remembered present." From tiny slivers of sensations, scraps of memories and flashes of emotion, the mind makes something much bigger. In the blink of an eye, the brain creates the entire world. ■

## Explore more


- K. Meyer. "Another remembered present." *Science*. Jan. 27, 2012.


FROM TOP: NICOLLE RAGER FULLER; K. MEYER *ET AL./NATURE NEUROSCIENCE* 2010


# Making waves

## Japanese quake gave scientists an unprecedented look at a big tsunami

By Alexandra Witze

**The map above shows cumulative wave heights predicted following the March 2011 tsunami off Japan's coast. A new forecast system would warn of flooding risk rather than wave height.**

NOAA

By many measures, the magnitude 9.0 earthquake that shook Japan a year ago was a record-breaker. It was the largest quake in the country's written history, the trigger for the worst nuclear accident in 25 years and the costliest natural disaster ever.

Amid such superlatives, it's easy to forget one more: During the Tohoku-oki quake, the seafloor off Japan's coast wrenched itself farther apart than scientists had ever measured along any seafloor. In places, chunks of ground slipped horizontally past their neighbors by more than 50 meters and vertically by 10 meters.

"The earthquake was a scofflaw," says Emile Okal, a geophysicist at Northwestern University in Evanston, Ill. "It violated the scaling laws we're used to."

That deviant behavior is what made the quake so deadly, by producing a monster tsunami. When the seafloor moves by half the length of a football field, it displaces an awful lot of water. Of the approximately 20,000 people who died on March 11, 2011, more than 90 percent drowned, were washed away or were otherwise killed by water. So researchers have been studying what happened off Japan's coast, seeking ways to better detect a lawless quake, track the resulting tsunami and ultimately save lives.

Some of the work, based on survivor videos, reveals how quickly the deadly water surged into and then drained from coastal villages. Other research, looking at ancient sand deposits and boulders tossed like pebbles, suggests that Pacific-wide tsunamis like Tohoku-oki may be more common than once thought.

There's some good news among the bad. The Japan tsunami was the earliest and best-detected monster wave ever, thanks to warning buoys set up globally after the 2004 Indian Ocean tsunami killed a quarter of a million people. With

new findings from the Japan disaster and data from the global buoys, scientists in the United States are working to develop a forecast system that will in principle give people a better warning by predicting areas most likely to flood rather than the heights of incoming waves.

Still, one year after the Tohoku-oki disaster, scientists are far from taming the tsunami hazard. When it comes to translating scientific know-how into reducing death tolls from disasters, says Caltech seismologist Hiroo Kanamori, "we are always one step behind."

## In the wake

Many types of geological disturbances, including underwater landslides and volcanic eruptions, can trigger tsunamis. Most tsunamis, however, are set off by earthquakes, such as those that strike off the east coast of Japan. Here, the western part of the Pacific crustal plate dives beneath a tendril of the North American plate, building up strain that's released occasionally in earthquakes.

Scientists and emergency planners in Japan are well aware of the tsunami threat; in June 1896, the Sanriku earthquake triggered a massive wave that killed more than 27,000 people. But the March 2011 disaster was simply off the scale compared with what most people would have expected.

The Tohoku-oki tsunami got so large not only because of the sheer amount of slip, but also because of the way the ground moved during the earthquake. When the quake hit, part of the seafloor that had been sloping down at a steep angle quickly lurched toward the surface, displacing an unprecedented amount of water, Takeshi Tsuji, a marine geologist at Kyoto University, said in San Francisco in December at a meeting of the American Geophysical Union.

Moments after the rupture came the first sign a tsunami was on its way. One Russian and three U.S. tsunami buoys nearby detected a huge movement of water, up to 1.64 meters high. "We knew immediately, within 30 minutes, that this was gigantic," says Eddie Bernard, former director of the National Oceanic and Atmospheric Administration's Pacific Marine Environmental Laboratory in Seattle.

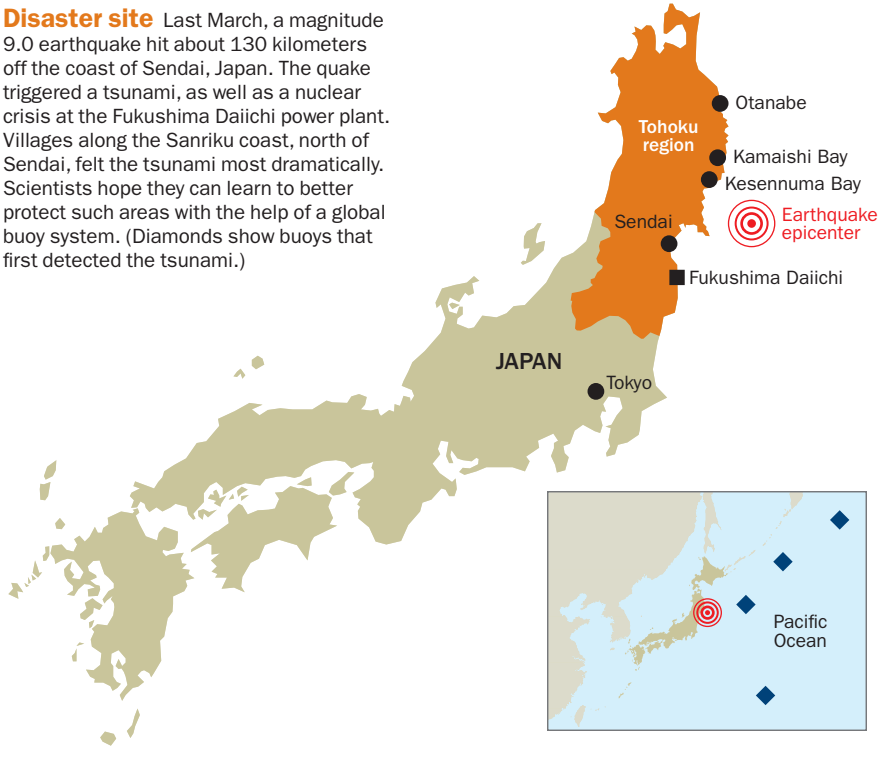
Nowhere was the tsunami felt more dramatically than in the narrow inlets that riddle Japan's Sanriku coast, north of the city of Sendai. Fishing villages nestle within the inlets where they are protected from wind and everyday waves, but such locations are the worst place to be when a tsunami arrives, says Costas Synolakis, a tsunami expert at the University of Southern California in Los Angeles and at the Hellenic Center for Marine Research in Anavyssos, Greece.

In the open ocean, a tsunami typically appears as a few extra centimeters or tens of centimeters moving atop the water column. But once the wave starts to approach land, the energy that had been spread over the entire ocean's depth becomes squeezed into a shallow layer. This compression ramps up the tsunami's amplitude as high as meters or tens of meters, especially in inlets that funnel the water forward. The Japanese waves reached as high as 40 meters.

At the fishing port of Kesennuma Bay, where nearly 1,500 people died, scientists have gone back to the scene of dramatic videos by two survivors to recreate what happened. Aware of the local risks, Kesennuma's emergency manager had sent out a tsunami alarm within two minutes of the earthquake — before either the Japan Meteorological Agency or the Pacific Tsunami Warning Center, the national and international agencies in charge of similar alerts. Within 30 minutes the tsunami arrived at the port, swamping the bay.

In June, a team led by Hermann Fritz of the Georgia Institute of Technology's Savannah campus used lasers to scan the surroundings where many survivors had clustered: a Coast Guard building, a vertical evacuation platform at the local fish market and a hill marked as an evacuation route. From the laser data and photos of the port, Fritz and his colleagues generated a photorealistic three-dimensional rendering of the landscape. The team then calibrated survivor videos against this data, mapping precisely how water inundated the bay and receded — information that's impossible to obtain by surveying after the fact.

By measuring how current flowed on the water's surface, the scientists calcu-




**Disaster site** Last March, a magnitude 9.0 earthquake hit about 130 kilometers off the coast of Sendai, Japan. The quake triggered a tsunami, as well as a nuclear crisis at the Fukushima Daiichi power plant. Villages along the Sanriku coast, north of Sendai, felt the tsunami most dramatically. Scientists hope they can learn to better protect such areas with the help of a global buoy system. (Diamonds show buoys that first detected the tsunami.)

GEOATLAS/GRAPHI-OGRE, ADAPTED BY T. DUBÉ

lated that soon after the tsunami reached its maximum height of 9 meters in the bay, it receded at unsurvivable speeds. The outflow sped up from 3 meters per second to 11 meters per second within just two minutes — something no one caught in the water could navigate through. "These currents are very important because they cause a lot of damage," Fritz says.

When it comes to building concrete breakwaters, seawalls and other coastal defenses, Sanriku is perhaps the best-protected coastline in the world. Stone tablets left by past generations often mark the high-water point of historic floods. In some places, such long memories help plan prevention: The village of Otanabe was devastated by 15-meter-high waves during the 1896 tsunami, so residents rebuilt with a 15.5-meter-high seawall. In March 2011, the barrier kept the sea back. But overall, Sanriku's coastal defenses were built to withstand a tsunami an order of magnitude smaller than the one that arrived. One much-ballyhooed breakwater in Kamaishi Bay, completed three years earlier at a cost of $1.6 billion, mostly crumbled in the face of the Tohoku-oki tsunami.

## Future forecasts

To help coastal residents better prepare, with or without concrete defenses, scientists are promoting new flooding forecasts instead of the usual reports of incoming wave heights. Few people inherently understand the concept of wave height, says Bernard: "They don't know what a 3-meter or 6-meter tsunami means." Another problem with wave-height forecasts is that coastlines are variable. A 1-meter tsunami might cause extensive flooding in one place, whereas a 3-meter tsunami that hits nearby might not lead to flooding at all.

Flooding forecasts could be particularly useful for countries that lie across an ocean basin from a massive quake, and hence have time to prepare for an oncoming wave. "An earthquake shakes for minutes, while a tsunami crashes for hours," Bernard says.

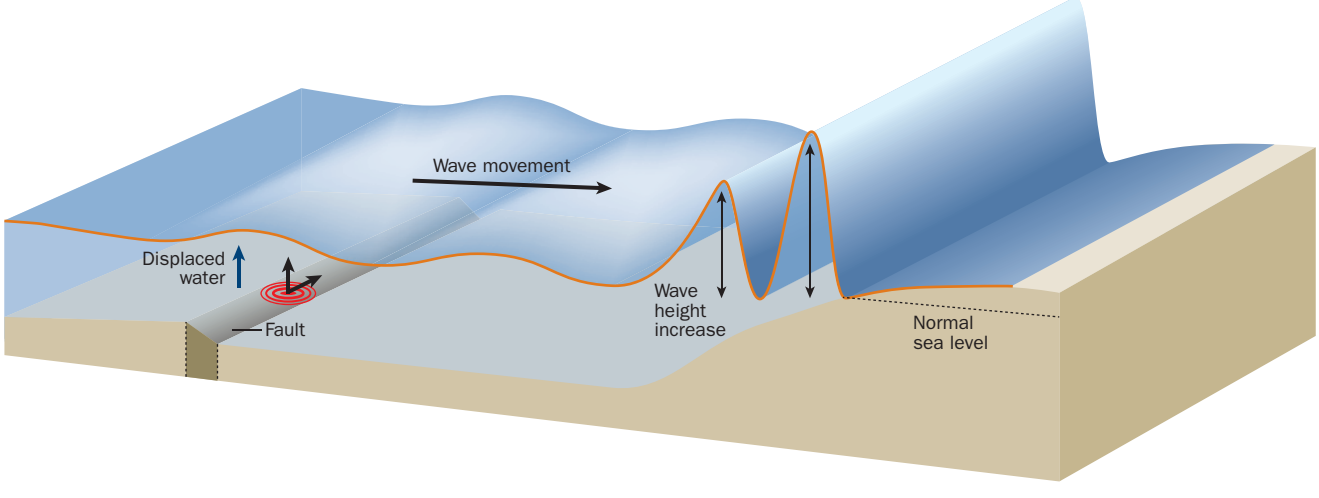
> "An earthquake shakes for minutes, while a tsunami crashes for hours."
> EDDIE BERNARD

In Hawaii, the aftereffects of the Tohoku-oki earthquake continued to arrive throughout the night. Because of the way the Hawaiian Islands are arranged, a tsunami can become trapped "and just keep banging around with no time for the water to drain," Bernard says. The city of Kahului, on the north side of Maui, flooded extensively not just from the initial wave but also from the second and third that arrived soon thereafter. Emergency officials had evacuated much of the coastline, but fine-tuning computer programs used to predict the areas that will flood could mean less overall disruption, Bernard says.

New data to improve such forecasts come thanks to the network of ocean buoys designed for tsunami warnings, called the Deep-ocean Assessment and Reporting of Tsunamis, or DART, array. NOAA started using six of these buoys in 2001, and ramped up its investment after the 2004 Indian Ocean disaster. Today dozens of DART buoys, run by countries from the United States to Russia to Australia, operate constantly. In each, a recorder on the seafloor monitors the pressure of water passing overhead; a buoy tethered on the surface can instantly transmit warnings when a tsunami arrives.

The Tohoku-oki tsunami was the first to be measured by multiple DARTs right near where the quake happened, and was also the first mega-tsunami — with wave heights more than 1 meter in the open ocean — ever detected in real time. Data from the buoys are giving scientists confidence to push their tsunami forecasts into new realms, says Vasily Titov of the NOAA lab, such as cranking out local forecasts within one hour for U.S. coastlines or creating specialized forecasts for crucial facilities such as nuclear power plants, oil and gas

**Building a big one** During an earthquake, the seafloor can shift and lift upward, displacing a lot of water overhead. That water moves outward as a long sea wave. Such a wave may be only centimeters high far out at sea, where the energy is spread through the entire ocean's depth. But the energy becomes compressed into a smaller volume as the waters get shallower, causing wave height to build.

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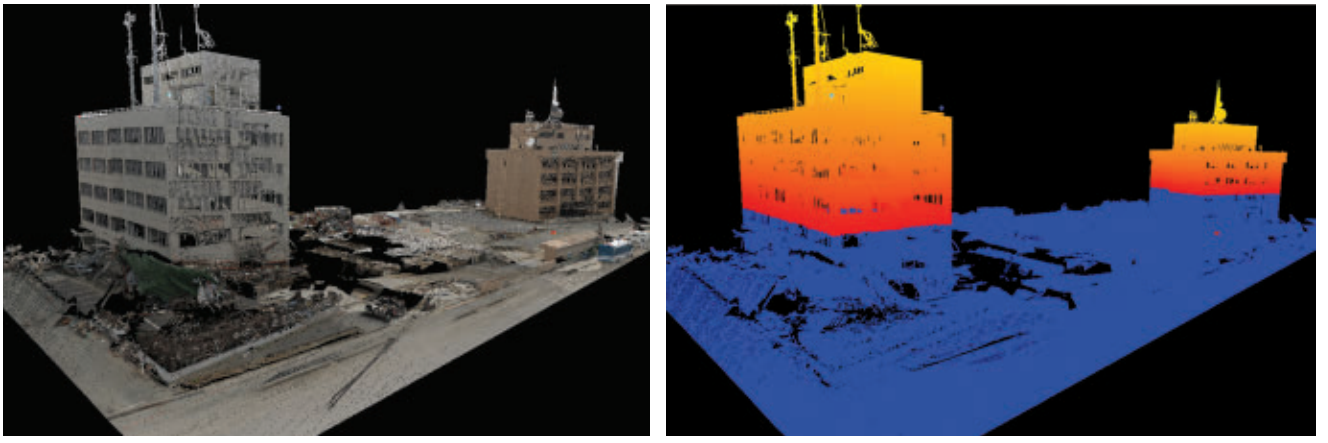


**Detailed mapping is helping scientists understand how floodwaters inundate and then recede. Tsunami waters reached only partway up evacuation buildings at Kesennuma Bay (photorealistic depiction of aftermath at left, flooding in blue at right).**

FROM LEFT: H. FRITZ *ET AL*/ *GEOPHYSICAL RESEARCH LETTERS* 2012; H. FRITZ/GEORGIA TECH AND DAVID PHILLIPS/UNAVCO

infrastructure, and ports and harbors.

Following the Japanese tsunami, NOAA scientists tested their forecasting potential by taking wave-height data from buoys along the Japanese coast and simulating where current programs say the flooding should be expected. The resulting prediction map matched well with flooding actually observed, Titov says.

Titov has produced similar simulations for the U.S. Pacific Northwest coast, which is thought to be at high risk of a large earthquake and tsunami. After a magnitude 9.1 quake, Titov has calculated, wave heights could reach as high as 10 meters at some places along the Oregon and Washington coasts, such as near the mouth of the Columbia River or north of Coos Bay, Ore.

The bottleneck to warnings may not be technology but human organization, or lack thereof. A full-scale test in October of the new Indian Ocean tsunami warning system, set up explicitly to prevent a repeat of the death toll in 2004, went relatively smoothly. But some countries, such as Somalia, have not implemented national plans to respond and pass the message to local residents when an alert from the oceanwide system comes in.

## Ring of Fire risk

Such warning systems may ultimately get more use in the Pacific than previously thought. "Paleotsunami" studies, which look for evidence of waves from centuries past, are beginning to show just how common these disasters are around the Pacific's Ring of Fire.

Over the last decade, for instance, Japanese studies have revealed the scale of a tsunami that struck in July 869. An earthquake, probably around magnitude 8.6, sent sand and other debris flooding across the Sendai plain, Daisuke Sugawara of Tohoku University in Sendai said at the geophysics meeting. Eerily, these deposits match almost exactly the region that was inundated in March 2011.

Farther out in the Pacific, scientists are cobbling together the tsunami history of the small islands that dot the ocean's vast expanses. In the Cook Islands, for instance, shells embedded into the sides of trees speak to the violent wave that swept over after a volcano erupted and collapsed cataclysmically near Vanuatu in the year 1452. Traces of the tsunami linger as high as 30 meters above sea level, yet tsunami assessments for the islands say residents there don't need to worry about anything higher than 2.8 meters. "We are most definitely underestimating the hazard and risk," James Goff, a tsunami expert at the University of New South Wales in Sydney, said at the geophysics meeting.

Other hints come from the traditional environmental knowledge of local residents. In New Zealand, 15th century Maori tales tell of people being thrown into the dunes by a nasty beast attacking from the sea. The tail of the beast broke off and became a small offshore island, a constant reminder of the ocean's threat.

Past tsunamis may even have influenced how people settled islands across the Pacific. Early Polynesians had spread into the Samoan archipelago by 2,800 years ago but then stopped — quite possibly because that's when a big tsunami washed across the Pacific. Similarly, the long-distance Pacific voyaging networks collapsed after the 15th century Vanuatu eruption, Goff said. At least three of four known massive Pacific tsunamis in the last 2,000 years coincided with big changes in human settlement, he said at the meeting.

For now at least, Japan seems to be recovering far more resiliently from its own wave disaster. Parts of the coast around the damaged Fukushima Daiichi nuclear reactors remain off-limits, but people have moved back into other areas to start rebuilding their lives. And government officials are already talking about one way to cope with the threat of future tsunamis.

Figuring the coast has gotten the worst it will get for quite some time, the minister for reconstruction suggested in January that the country should perhaps rebuild its concrete tsunami barriers — to the same height they were before. ■

## Explore more

- NOAA Center for Tsunami Research: nctr.pmel.noaa.gov

# Lessons from the torpid

## Hibernators have some helpful tips for keeping humans healthy

By Tina Hesman Saey

On February 2, groundhog weatherman Punxsutawney Phil roused from hibernation to predict six more weeks of winter. Scientists may snicker at people who think they can learn about the arrival of spring from a furry rodent, but researchers aren't laughing when it comes to learning about human health from animals that check out for the winter.

Understanding how hibernators, including ground squirrels, marmots and bears, survive their long winter's naps may one day offer solutions for problems such as heart disease, osteoporosis and muscular dystrophy.

Despite appearances, hibernation is not the same as going to sleep for a long time. It is extreme living by any measure. For about half the year, hibernating animals stay in their dens or burrows in a state of suspended animation, waking up every now and again to go to the bathroom. Most hibernators eat or drink nothing, living solely off the fat they built up before winter began.

To make fat stores last, animals lower their metabolism and body temperatures. Black bear body temperatures drop to about 33° Celsius (about 91° Fahrenheit), but the bodies of most small mammal hibernators, such as ground squirrels and woodchucks, plunge to nearly freezing. Some Arctic ground squirrels hold steady at subzero temperatures. For all these animals, heartbeats and breathing nearly cease. These are feats of physiological daring that non-hibernators, including humans, could never survive.

Yet sometimes humans do have to deal with more moderate versions of hibernators' challenging circumstances — following periods of weight gain, immobilization or blood loss, for example. So, many scientists think some tricks of the hibernation trade might be a boon to human medicine.

Trying to find ways to treat human diseases with the help of animals is nothing new. Researchers often attempt to solve medical riddles by first creating versions of disorders, such as muscular dystrophy or stroke, in mice or other lab animals and then figuring out what goes wrong. But even when researchers know what's broken, a fix is not always obvious. Hibernators, though, have already found ways to cope with body and lifestyle changes that would lead to disease in humans.

In one effort to tap into hibernators' solutions, Ole Fröbert, a cardiologist at Örebro University Hospital in Sweden, and his colleagues are investigating the body transformations that Scandinavian

brown bears undergo each winter, including how they have such high cholesterol but no increased risk for heart disease. "We see the brown bear as a living library of information," Fröbert says. "It's an animal that has solved a multitude of problems that humans face."

Insights gleaned from bears and ground squirrels may also help researchers prevent or reverse bone and muscle loss in space travelers, elderly people and children with muscular dystrophy. Such lessons could reveal ways to render people confined to bed rest immune to blood clots, bed sores and muscle and bone atrophy. Therapies designed to mimic ground squirrel hibernation strategies could save soldiers and accident victims from bleeding to death. And these critters just might hold secrets for reducing damage from strokes or heart attacks, and even for preserving organs for transplant after they are cut off from a blood supply and put on ice.

## Extra pounds, no problem

Nearly everything about the way an animal's body works changes when it hibernates, and preparations start weeks or months in advance. The first order of business is to fatten up.

"Fat is where it's at for a hibernator," says Matthew Andrews, a molecular biologist at the University of Minnesota Duluth who studies 13-lined ground squirrels. "You bring your own lunch with you." Packing lunch is necessary because the animals go on the world's strictest diet during the winter, surviving entirely off their white fat. "They have their last supper in October; they don't eat again until March," Andrews says.

Bigger fat stores mean a greater chance of surviving until spring. "If they go in really chunky, nice and roly-poly, that's going to be a good hibernator," he says.

Bears also watch their waistlines expand in the months before settling in for the season. The brown bears Fröbert studies pack on the pounds by chowing down on up to 40 kilograms of blueberries a day. Such gluttony among humans could have severe consequences: Obesity is associated with a greater risk of heart disease and diabetes, among other ailments.

To see how fattening up affects Scandinavian brown bears, Fröbert and his colleagues ventured into the wilds of Sweden following signals given off by radio transmitters or GPS devices on tagged bears.

Bears can be dangerous close-up. Even hibernating bears can rouse to action quickly, so scientists tracking down bears in the winter use darts to tranquilize the animals from a distance. Scientists studying the bears in the summer tranquilize them from a helicopter.

Once a bear is under the tranquilizer's influence (which takes about five minutes), the scientists have 60 minutes max to get the animal from its den, weigh and measure it, draw blood samples and do minor surgeries to collect fat and other tissues. The bear is returned to its den by minute 61.

Precious materials collected during this high-pressure encounter need to be analyzed within 24 hours, so the researchers often test for levels of cholesterol or certain proteins in the blood while working in the snow or at a nearby research station. A pilot sometimes flies samples from field sites to a lab in Denmark in order to meet the deadline, Fröbert says. Samples such as bones and arteries that can't be collected from live bears come from bears killed by hunters during the legal hunting season.

Recent analyses revealed that Scandinavian brown bears spend the summer with blood cholesterol levels considered high for humans; those values then increase substantially for hibernation, Fröbert and his colleagues reported online January 10 in *Clinical and Translational Science*. These "very, very fat" bears with high cholesterol also get zero exercise during hibernation. Lolling about in the den pinches off blood vessels, contributing to sluggish circulation. "That cocktail would not be advisable in humans," Fröbert says. It's a recipe for hardened arteries, putting people at risk for heart attacks and strokes.

Even healthy young adult humans can develop fatty streaks in their arteries that make the blood vessels less flexible, but the bears don't build up such artery-hardening streaks. "Our bears, they had nothing," Fröbert says. It's not yet clear how the bears keep their arteries flexible, but Fröbert hopes to find some protective molecule that could stave off hardened arteries in humans as well.

## Sturdy skeletons

The bears' cholesterol-defying arteries are just one of the evolutionary tricks allowing hibernators to spend six months as furry couch potatoes without negative side effects.

Such inactivity wreaks havoc on the human body, which can't maintain strong muscles and skeletons without weight-

**Physiological feats** Hibernators are somehow able to survive six months of stillness, even though a similar lack of movement would threaten human health. Studying the changes that hibernators go through may one day make their skills transferable. SOURCE: O. FRÖBERT

**After six months of bed rest**

| | Human | Hibernator |
|---|---|---|
| **Circulatory system** | ▪ Blood clots<br>▪ Heart failure<br>▪ Oxidative and energetic stress<br>▪ Blood vessel dysfunction | ▪ No blood clots<br>▪ No heart failure<br>▪ Oxidative and energetic stress tolerance<br>▪ No blood vessel dysfunction |
| **Muscle** | 90% reduction in muscle mass | Little or no muscle loss |
| **Bone** | Severe disuse osteoporosis | No osteoporosis |
| **Metabolism** | Carbohydrate, protein and fat breakdown | Primarily fat breakdown |
| **Skin** | Bed sores | No bed sores |

**Researchers race to gather fat samples from a tranquilized hibernating brown bear after tracking it down in a forest in Sweden. The bear has to be back in its den within 60 minutes, when the sedative wears off.**

COURTESY OF O. FRÖBERT

bearing physical activity. People normally lose a little bone as they age; about 1 to 2 percent of the minerals in bone begin to leach out of women's spines and hips each year after menopause. But people on bed rest or in the weightlessness of space may lose 3 to 4 percent of their hip bone minerals each month, says endocrinologist Peter Vestergaard of Aarhus University Hospital in Denmark. Bed sores and blood clots also plague the sedentary human. And yet, come spring, hibernators emerge free of clots and sores and with their skeletons and muscles intact.

Rita Seger ventures into the backwoods of Maine to learn how American black bears keep their bones healthy during hibernation. She and her colleagues from the Maine Department of Inland Fisheries and Wildlife track bears right to their dens, thanks to radio collars fitted on the bears in the spring. The trips usually involve packing a portable centrifuge and an X-ray machine powered by the battery from a cordless drill.

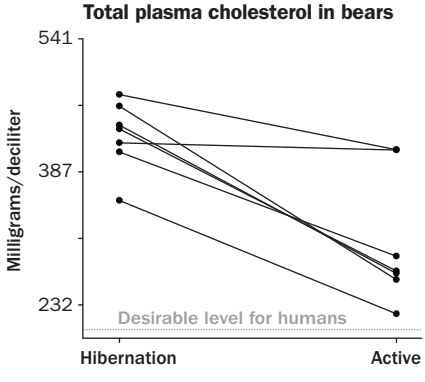
Comparing X-rays of the paws of tranquilized hibernating bears with X-rays taken of paws from bears that had been killed by hunters revealed no differences, suggesting hibernation doesn't melt bone the way bed rest does for humans. Seger and colleagues also compared blood samples from the hibernating bears with blood drawn from bears that were active in the spring, looking for chemical clues to how the skeletons are maintained.

Seger, a general internal medical doctor and physiologist at the University of Maine in Orono, and her team found proteins in the bears' blood indicating that bone-building cells are less active in hibernating animals than in spring bears, reporting the results in the December *Bone*. Humans on bed rest also build less bone than normal, but bone is torn down at a greater rate, making for an overall loss. The black bears balance slower bone building with a reduction in bone loss, the researchers revealed, keeping the skeleton strong.

Some of the bears' balancing skills may be transferable. Already, black bear parathyroid hormone, which helps determine how much bone is built or reabsorbed, is in development as a possible treatment for human osteoporosis, says Seth Donahue, a biomedical engineer at Colorado State University in Ft. Collins. Donahue is working with a biotechnology company to test the hormone's bone-sparing power in rats. When researchers remove the ovaries from female rats to simulate menopause, the rats' bones become spongy. But rats treated with the bear parathyroid hormone retain more bone, preliminary studies show.

Bears may also hold the secret to avoiding blood clots, such as those that develop when people sit still too long on plane trips, Fröbert says. He and his colleagues measured the blood-clotting activity of cells called platelets taken from humans and from brown bears shortly after the bears emerged from their dens in the spring. The bears' platelets were about half as active as the human platelets, the researchers reported in 2010 in *Thrombosis Journal*. Fröbert's team is trying to find out why the bear cells have lower clotting power and how that power changes during hibernation.

**Look ma, no hardening** Clues from the blood of seven brown bears may reveal how they maintain flexible arteries despite levels of cholesterol, especially during hibernation, that are far above those desirable for humans.




## It's in their blood

Bears may have a lot of helpful information to impart, but they are not easy to work with. Some scientists have turned to a smaller hibernating critter that can be studied in the lab, the 13-lined ground squirrel. This rat-sized creature may reveal a strategy to help with another blood problem: massive blood loss.

On a visit to Ronald Cohn's lab at Johns Hopkins University Medical School in early December, most of the 13-lined ground squirrels were curled into drowsy, striped balls, their faces tucked into the cream-colored fur on their bellies. One slumbering squirrel's sides rose and then fell with a single breath. About 20 seconds later, the squirrel breathed again.

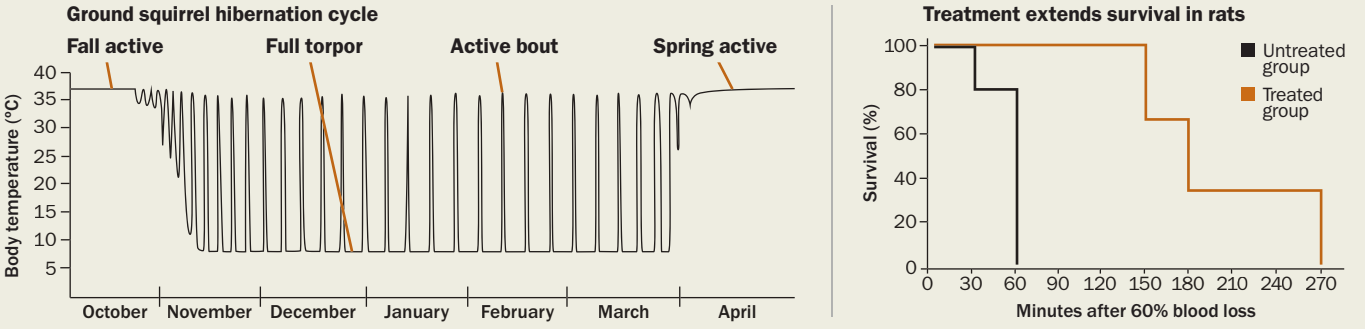
Once these squirrels go into the refrigerator for the winter, they will enter full torpor, as scientists call deep hibernation. The animals will take only two to four breaths and their hearts will beat just two to four times per minute, Cohn says.

"The theory has been that hibernators are exquisitely adapted to function in the cold," says Sandra Martin, an evolutionary geneticist at the University of Colorado School of Medicine in Aurora. "We don't find that. Our results suggest that they're exquisitely adapted to shut everything down in the cold.... It's almost as if the animal is putting itself in an ice bucket, slowing everything down to save energy."

But about every two weeks, the hibernators do something that makes little energetic sense. They warm up and move around, just for a bit.

"It's expensive to be up at high temperatures in the cold," says Hannah Carey, a physiologist at the University of Wisconsin–Madison School of Veterinary Medicine. While the animals are up and about — about 10 to 12 hours for ground squirrels — they may urinate and move around, but generally do not eat or drink. Bears go the entire winter without

FROM TOP: COURTESY OF H. CAREY; ADAPTED FROM K. ARINELL *ET AL*/ *CLINICAL AND TRANSLATIONAL SCIENCE* 2012




**Squirrel cycle** During hibernation, the body temperatures of 13-lined ground squirrels yo-yo, leading to a repeated loss and restoration of blood flow that would be dangerous during the summer. Researchers hope a cocktail of compounds inspired by the squirrels' ability to withstand this cycle could buy time for people experiencing blood loss. When tested in rats with 60 percent blood loss, the treatment extended survival.

SOURCES, FROM LEFT: M.T. ANDREWS/*BIOESSAYS* 2007; A.H. KLEIN *ET AL*/*SHOCK* 2010

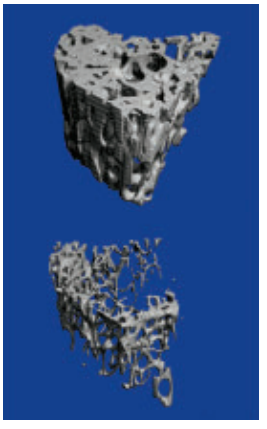
excreting anything at all, though they too stir occasionally.

The 13-lined ground squirrels hibernating in Cohn's refrigerator go from dormant to alert within minutes. "They will all be as active as this guy," Cohn says, tapping a gloved finger on the cage of a bright-eyed ground squirrel, sending it darting for cover. It's soon out front again, whistling curiously at Cohn and his company. After a few hours, the animal will curl into a torpid ball with no regard for Cohn, who is trying to understand how the ground squirrels maintain muscles during torpor.

The ground squirrels' up-and-down cycles cause repeated loss and restoration of blood flow to parts of the animals' bodies, a situation most humans face only when something has gone horribly wrong.

In people, blood clots, heart attacks, strokes, accidents or even sitting or lying too long in one position may shut off blood supply to cells that need it. Oxygen deprivation from reduced blood supply can damage tissues and organs. But restoring blood flow comes with its own problems, Carey says. The influx of oxygen-rich blood causes little power plants called mitochondria to go wild churning out molecular energy for the cell in which they reside. By-products of the energy-producing reactions — molecules called oxidants or oxygen radicals — can damage the proteins, DNA and fats that make up cells. If the damage is bad enough, the cells will die and may contribute to tissue damage or organ failure.

Ground squirrels are susceptible to this type of damage in the summer, but come winter, hibernating squirrels become impervious to the effects of oxygen deprivation and restored blood flow.



**A hormone from black bears maintained bone health in rats at risk of osteoporosis (treated rat tibia at top, untreated tibia at bottom).**

S. DONAHUE

To find out how the squirrels handle the constant near-freezing and thawing, Andrews and his colleagues compared gene activity in summer ground squirrels with activity in hibernating animals, during full torpor and bouts of activity.

The team found that hibernating ground squirrels keep their bodies going during the temperature drop by fueling the organs with breakdown products from fat, rather than glucose as summer ground squirrels do. During brief active bouts, levels of a chemical called melatonin shoot up in the ground squirrels' blood. Melatonin is known mainly as a hormone that helps regulate the body's daily rhythms, but it is also a powerful antioxidant — just what ground squirrels need to fight off damage from oxygen radicals as their blood begins to surge.

A cocktail including fat breakdown products (substances called ketone bodies) and melatonin might help people who have lost a lot of blood, such as soldiers with battlefield injuries or accident victims, hold on until they can get a transfusion, Andrews reasoned. So his team tested concentrated solutions of the cocktail in rats. Untreated, rats that lost 60 percent of their blood died within an hour. But the cocktail extended rats' survival to three hours or more, Andrews and colleagues reported in 2010 in *Shock*. The therapy is now being tested in pigs, and may soon enter human clinical trials.

If the cocktail ends up saving lives, ground squirrels and the power of evolution that has given them extreme survival skills will deserve the glory. "I keep telling people over and over again that the credit goes to the basic hibernator biology," Andrews says. "We never would have come up with that combination on our own."

Further research into how hibernators ride out the winter may yield other therapeutic solutions for humans. Even though people don't go into torpor, they may have the molecular equipment to pull off some milder hibernation-linked feats that could boost health during hard times. "I would argue that the hardware is mostly there," Martin says. "It is just a matter of learning how to use it." ■

## Explore more

- Scandinavian brown bear project: www.bearproject.info

## Concrete Planet

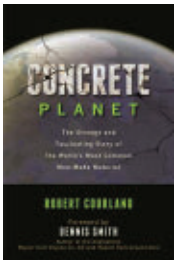
*Robert Courland*

Concrete is everywhere, especially if you live in a city. It's used for buildings, bridges, roads, dams, sidewalks, airport runways, even burial vaults. There are already about 40 tons of concrete on the planet for every person alive, with another ton added each year.

In this wide-reaching book, Courland reviews the saga of what many may view as a mundane material, from its discovery during the Neolithic (the later part of the Stone Age) to its rediscovery in the late 1700s — made necessary after the secrets of its manufacture were largely lost with the fall of the Roman Empire.

A world without concrete simply wouldn't look the same: Skyscrapers wouldn't be as tall and most other buildings would be smaller; all dams would be bulky, earth-filled structures; and roads would certainly have more potholes. In short, Courland suggests, the world would look much as it did in the 1800s.

While iconic Roman-era buildings made of concrete such as the Colosseum and Pantheon have stood for nearly two millennia, Courland notes that few of today's concrete structures will last one-tenth as long, largely because the iron and steel used to reinforce them begins to deteriorate at a rapid rate after just a few decades.




Millions of years in the future, the geologic record of today's era will be an odd layer of rust-tainted sediment — crumbled concrete peppered with flakes of corroded rebar. In the shorter term, the manufacture of concrete is the third-largest source of planet-warming carbon dioxide, right behind fossil fuel–burning power plants and transportation. Whether looking at the past or the future, Courland makes a compelling case for concrete's importance to humankind. — *Sid Perkins*

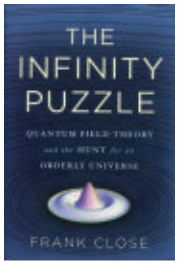
*Prometheus Books, 2011, 396 p., $26*

## The Infinity Puzzle

*Frank Close*

Building the standard model, the flagship theory of modern particle physics, was no mean task. It took decades of painstaking work to bring the forces and elementary particles that make up the universe together in a single framework (which still doesn't include gravity).

Close, a theoretical physicist, chronicles this history from an insider's perspective. He starts just after World War II with the struggle to reconcile the electromagnetic and weak forces. Plagued by infinities that kept popping up in the math, this effort finally succeeded in the early 1970s, thanks to new ideas about symmetries hidden in the universe. Ultimately, physicists would incorporate the strong force as well.




Reconstructed from research papers and the memories of its protagonists, the story doesn't unfold as a simple, clearly developing line of thought. Instead, the reader witnesses scientific progress in all its real-world messiness. It's a comedy of errors at times, full of dead ends, missed opportunities and ideas that lie dormant for years, unproven or unnoticed.

"This history is not a straightforward victory march," writes Close. "We are following people and their mistakes no less than their brilliant insights."

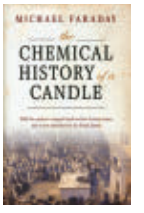
Much of the book consists of "inside baseball," focused on assigning credit for each discovery along the way. And while Close uses analogies that help novices understand complex physics concepts, his detailed text will more likely appeal to the already initiated. For those readers, Close's account of how the Higgs boson was proposed may be particularly interesting. — *Devin Powell*

*Basic Books, 2011, 435 p., $28.99*


**Culinary Reactions**

*Simon Quellen Field*

This clear primer to the chemistry of cooking goes well beyond the basics to teach cooks how to improve their results scientifically. *Chicago Review Press, 2012, 238 p., $16.95*




**The Chemical History of a Candle**

*Michael Faraday*

The physicist's classic lecture is reprinted with an introduction by Faraday expert Frank James as a 150th anniversary edition. *Oxford Univ., 2011, 192 p., $24.95*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*Marc J. Kuchner*

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### Connecting the lincs

As a physician, I was absolutely astounded reading "Missing lincs" (*SN: 12/17/11, p. 22*) and still am. We have been waiting since DNA was discovered to find this 'what makes us human' aspect of our biochemistry. Even in the infancy of this research, we are discovering the chemical reasons for a type of muscular dystrophy and other conditions. What I find especially illuminating is that this may be the etiology of what we call autoimmune diseases, among other problems.

I am sure we will find it is a change in lincRNA balance or function that produces the change in regenerative ability of infants' hearts mentioned in "Reviving a tired heart" (*SN: 10/22/11, p. 26*).
**Linda Mendoza,** Chico, Calif.

We are beginning to unravel the questions of how so few genes and also how so many genes in common across species can lead to the diversity and complexity that we see today. However, the function, if any, of microRNAs is still in question. Can it be that their reason for being is just to gum up the works?
**David Shen,** Reno, Nev.

*Far from just gumming up the works, microRNAs help to precisely tune gene activity in cells, a job that is essential for normal cell function. The importance of RNA in general for human health is becoming more clear as scientists discover new types of noncoding RNAs and what they do. — Tina Hesman Saey*

Tina Hesman Saey is really extraordinary. "Missing lincs" was very well done, just like the rest of her work. Please do not lose her to *Nature*, *Science* or *Scientific American*.
**Peter Nicholls,** Durham, N.C.

### Searching for extinction cycles

"Seeking a friendlier companion" (*SN: 12/3/11, p. 32*) suggests that the idea of periodic mass extinctions is dead, along with the idea of a stellar-mass companion for the sun. However, until NASA's WISE mission, black hole or brown dwarf companions with large orbital radii had not been ruled out. In 2010, we published (*Monthly Notices of the Royal Astronomical Society Letters* 407, L99) new evidence that finds the same significant periodic component in extinction rate in two different fossil datasets.
**Adrian L. Melott,** Lawrence, Kan.

*The writer is correct that, until WISE, black hole or brown dwarf companions had not been found but had not been ruled out. Attention to the periodicity of mass extinctions has waned, but perhaps the new paper will renew interest. — Elizabeth Quill*

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Marketplace

# From the Archive

## Soaring pterosaur!

Next spring, for the first time in more than 65 million years, the flapping shadow of a giant prehistoric flying reptile will be cast on the ground. No, scientists have not cloned the genes of the pterosaur *Quetzalcoatlus northropi*. Instead, the Smithsonian's Air and Space Museum in Washington, D.C., has secured funding to build a full-scale, radio-controlled flying replica of the largest animal ever to fly.

According to the plans, the replica, with about a 36-foot wingspan, will fly realistically, propelling itself by wing flapping. It will be built by AeroVironment, Inc., of Monrovia, Calif., an innovative-aircraft design company. AeroVironment is directed by Paul MacCready, who has developed such human-powered aircraft as the Gossamer Condor and the Gossamer Albatross, which flew across the English Channel, and the solar-powered Gossamer Penguin and Solar Challenger (SN: 6/14/80, p. 373). The major funding for the $400,000 pterosaur project will come from Johnson Wax of Racine, Wis. The museum plans to fly the replica in Washington, beginning in spring 1986, to call attention to a new film about flight. The museum says it "hopes the project will make a significant contribution to the fields of aerodynamics and paleontology."

A *Quetzalcoatlus* model soars above its builder Paul MacCready (left) and Tray MacCready in 1999 at the Museum of Flying in Santa Monica, Calif.

IMAGE: © JONATHAN BLAIR/CORBIS; PAPER: PAPHIA/ISTOCKPHOTO

UPDATE

## Flight lessons from extinct flapper

Think of a great blue heron with a 40-foot wingspan, and you'll get an idea of what *Quetzalcoatlus northropi* was like 65 million years ago, says evolutionary biologist Kevin Padian of the University of California, Berkeley. Now think of the front half of a Cessna 172 trying to stay aloft by flapping its wings, and you'll realize the enormous challenge undertaken by Paul MacCready when he decided to construct a life-size, flying, radio-controlled replica of the pterosaur.

From the beginning, one of the biggest engineering puzzles was how to stabilize the model: *Quetzalcoatlus* lacked the tail and rudder that typical flying machines use to control pitch and yaw. Keeping the version true to life required some extra thought, but it also offered a powerful insight into the evolution of flight.

"Through time, flying things have become less stable and more maneuverable," Padian says. *Quetzalcoatlus* and its peers sacrificed the tails donned by earlier pterosaurs to make way for faster, more flexible flight. This evolutionary change meant the brain had to become more sophisticated to take on the stability task. Likewise, the *Quetzalcoatlus* replica had a special autopilot to serve as a "brain," controlling the head to maintain stability.

"The problems the engineers went through were, I think, simulating the challenges that animals go through when they evolve flight," Padian says.

In the end, MacCready settled on a half-size pterosaur replica. The model successfully flew during filming, but the project ended with a crash at Andrews Air Force Base in May 1986.

—*Elizabeth Quill*

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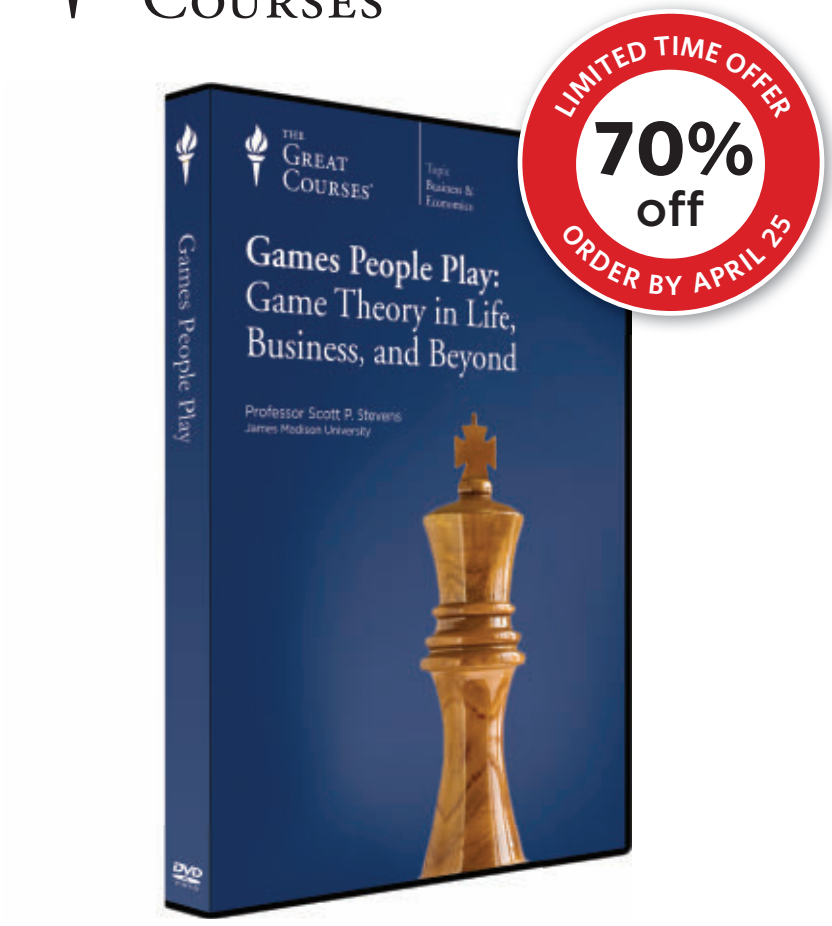


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# Life in the Past Lane

*A watch legend comes back in black! Wear the Midnight Meisterzeit for ONLY $99!*

Turn down the lights. Raise the curtain. Your wait is over. After 89 years, this classic is back on stage. And it's clear that the old black magic is as powerful as ever. This is what happens when "fashionably late" meets "right on time." Inspired by one of the world's first automatic wristwatches, we have painstakingly crafted the ***Stauer Midnight Meisterzeit*** to meet the demanding standards of vintage watch collectors. And for a limited time it's yours for under $100!

**Your new watch is history.** That legendary original was a rare prototype, hand-built by a master of the mechanical arts. The idea that we could recreate it seemed as far-fetched as repainting Picasso. Until we realized it was possible to make our version even better. Its startling good looks get all the attention, but this watch is more than just tall, dark and handsome.

**Why our "new antique" is better than the original.** We found a way to engineer the ***Midnight Meisterzeit*** with a much higher level of precision. The 27-ruby-jewel movement utilizes an automatic self-winding mechanism inspired by the 1923 patent, but built on $31 million in state-of-the-art Swiss machinery. Imagine putting a 21st-century performance engine into the body of a 1920s roadster. The ***Midnight Meisterzeit*** is powered entirely by the movement of your body. It never needs batteries and never needs to be wound. It secures with a genuine black leather strap and is water-resistant to 3 ATMs.

*The balance wheel and escapement can be seen under the Cotswold™ crystal and exhibition back.*

**Your satisfaction is 100% guaranteed.** Order the ***Stauer Midnight Meisterzeit*** and claim a piece of watchmaking history in a rare design priced to wear everyday. If you're not captivated with the ***Midnight Meisterzeit***, simply return it within 30 days for a full refund of your purchase price. But we're convinced that once you experience life after ***Midnight***, you'll find there's no reason to be afraid of the dark!

WATCH SPECS: - 27-jeweled Vertex automatic movement - Exhibition back
- Genuine black leather band fits wrists 7 1/4"–8 1/8"

## Another Stauer Exclusive Not In Stores

**Stauer Midnight Meisterzeit Timepiece—~~$395~~**
***Now $99*** +S&P

*Call now to take advantage of this extremely limited offer.*

**1-800-721-0297**

**Promotional Code MMW141-01**
Please mention this code when you call.

ACCREDITED BUSINESS **Stauer has a Better Business Bureau Rating of A+**

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