Greener Chemistry | Dim Sun | Glacial Slip and Slide

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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ MARCH 26, 2011

Eat thyself

Cellular cannibalism in health and disease

How Not to Dissolve a Corpse

Lizard Physics

Men's HPV Burden

"After reviewing the assembly and precision of the Minuit movement, I'm most impressed."

—George Thomas
Noted Watch Historian

Life Gets Better After Midnight

Make it a night to remember with the spectacular Stauer Minuit Swiss-Made Timepiece–yours for ONLY $199!

This timepiece is a night owl. It ignores curfew and stays up much later than it should. This watch never goes to bed early because it knows that life gets infinitely more interesting after dark. It knows that magical things happen between dusk and dawn. And just like you, the ***Stauer Minuit Timepiece*** doesn't want to miss a moment.

Inspired by the mystery of late nights, the ***Minuit*** is an exceptional Swiss-made timepiece in a category all its own. Even more impressive than its distinctive design is the price. Call today and you can own the stunning ***Swiss-Made Minuit*** for only $199.

What happened when the sun went down. I was wide awake when I dreamed up the design for Stauer ***Minuit***. It was the middle of the night at the top of the world. My wife and I were celebrating in a hotel in the Swiss Alps overlooking Lake Lugano. The world was asleep and the stars seemed low enough to touch. I'll never forget the view that night, an endless blue heaven speckled with stars. You don't get to see that kind of sky in the big city. We stayed up to watch the sun rise through the mountains. Right away I missed the night.

The Stauer *Minuit* is simple, yet striking. It took the designers in Switzerland months to get the look of this timepiece just right. If your favorite color is blue, here's your chance to see it in a whole new way. Inside, the ***Minuit*** is driven by a precision Swiss quartz movement and crafted in Switzerland, home to the world's noblest watchmaking traditions.

In honor of that perfect Alpine sky, we added a touch of sparkle to the shimmering, metallic blue face with a trio of Austrian crystal rounds at the twelve, three and nine o'clock positions. Golden Roman numerals pop against the rich black of the outer dial and an easy-to-read date window sits at the six. The ***Minuit*** secures with a genuine black leather strap and gold-fused buckle.

Your Satisfaction is 100% Guaranteed. Try the Stauer ***Minuit Swiss-Made Timepiece*** for 30 days. We're confident that it will captivate you, but if for any reason it doesn't, send the watch back within 30 days for a prompt and courteous refund. I guess the Swiss have a way with heavenly blue and Stauer has a way of keeping prices down to Earth. Thank your lucky stars.

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- Genuine black leather strap - Fits a 6 3/4"–8 1/2" wrist

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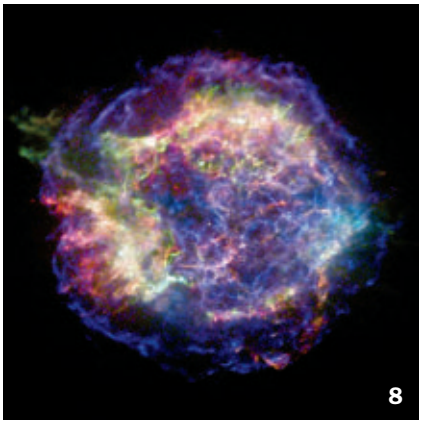

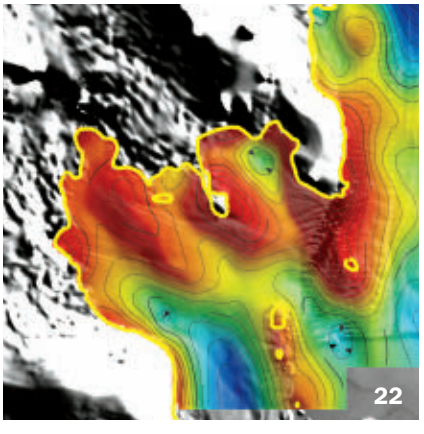

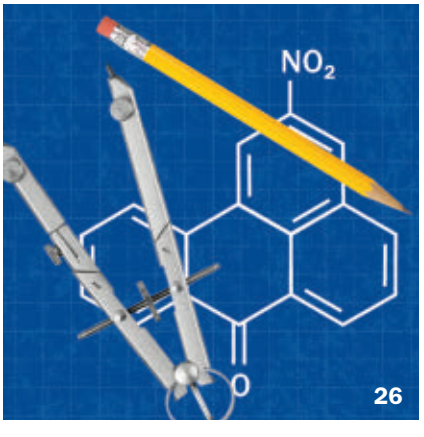

ScienceNews

In The News

Features

Departments

COVER Cells sometimes eat themselves — a process that disposes of bacterial invaders and recycles damaged cellular parts. *Nicolle Rager Fuller*

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FROM THE EDITOR

Scientific guesstimation relies on Bayesian brains

Science and guesswork evolve hand in hand, along with the human brain itself.

Think about it. Brains evolved to make successful guesses about the best survival strategies, helping their bodies live longer and reproduce more successfully than they otherwise might. At the same time brains also evolved the ability to engage in scientific investigation about things pretty far removed from the perils of the savanna.

Turns out, though, that there is a connection between these seemingly discordant abilities. Brace yourself: It has something to do with Bayesian statistics.

In Bayesian statistical analysis, a "prior" probability (an estimate made before data are collected) is factored into calculations of the likelihood that a hypothesis is correct. Bayesian math annoys some traditionalists who cling to good old frequentist statistics, and the proper use of statistics in science is certainly an enormously complicated issue (*SN: 3/27/10, p. 26*). Bayesian math also poses computational challenges; in complex cases it can be more perplexing than calculating an NFL quarterback's efficiency rating.

Nevertheless, neuroscience research suggests that brains are naturally Bayesian: They operate on the basis of past experience but update previous beliefs as new evidence warrants doing so. On Page 13, Laura Sanders discusses one intriguing instance where the brain bases its judgments on prior probabilities (perhaps instilled in early evolutionary times). This example involves the brain's tendency to rate an object's motion as slow. Since most objects don't move very fast, when you have to guess about an object's velocity, it's best to go with what's most probable. If new observations differ from expectations, your brain should compensate by modifying its likelihood guesstimates in the future.

Science as a whole proceeds in that very way: Conclusions based on old evidence are modified as new evidence arrives. In Bayesian terms, science reflects a cognitive strategy of basing degree of belief in a hypothesis not just on data collected in an experiment, but also on the probable truth of the hypothesis as estimated *before* collecting the new data.

If that's confusing, you have discerned why Bayesian methods haven't been universally adopted in science already, even if the brain itself uses them instinctively without doing the math. (Well, the brain does do the math. It just doesn't show its work.) —*Tom Siegfried, Editor in Chief*

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The cell phone that's right for me. Sometimes I think the people who designed this phone and the rate plans had me in mind. The phone fits easily in my pocket, but it flips open and reaches from my mouth to my ear. The display is large and backlit, so I can actually see who is calling. With a push of a button I can amplify the volume, and if I don't know a number, I can simply push one for a friendly, helpful operator that will look it up and even dial it for me. The Jitterbug also reduces background noise, making the sound loud and clear. There's even a dial tone, so I know the phone is ready to use.

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Scientific Observations

"When we mention women in science and engineering, it is often about the diminishing numbers, the lower pay, the many difficulties for women, and the personal sacrifices that women necessarily make. Perhaps, by focusing on the negatives, we are unwittingly persuading young women that science and engineering may not be the right careers for them. Why bother to join this profession? There are many rewards … [such as] the freedom to be curious…. For women who can juggle the demands of a profession and a family, there are special rewards of motherhood. As a young investigator … told me, 'many female colleagues … chose not to have children to be competitive. Having children is the best thing that I have done. I am more effective at work and integrate my skill and knowledge into the society through my involvement in the school.' … There is nothing to lose and everything to gain." **—CALTECH MICROBIOLOGIST AND AAAS PRESIDENT ALICE HUANG, IN HER FEB. 18 EDITORIAL IN *SCIENCE***

Science Past | FROM THE ISSUE OF MARCH 25, 1961

CUT-OFF LIVER KEPT ALIVE — Three surgeons have completely isolated the liver from dogs, and with heart-lung machines have kept the animals and their livers alive for as long as eight hours. They were able to replant the livers in place, rejoin the numerous blood vessel connections and restore the animals to health.... The purpose of the experiments was to determine whether it might be feasible to perform a much simpler operation — perfusion of the liver without removing it — on human beings. Without physically removing the liver, the organ might be cut off from the rest of the body and blood loaded with anticancer drugs could be pumped through the isolated liver without exposing the rest of the system to the toxic effects.

Science Future

March 28
Discuss nanotechnology at a Seattle Science on Tap event. See http://scienceontap.org

April 2–24
In Orange County, Calif., see bouncing bubbles, smoking bubbles and more at Discovery Science Center's Bubblefest. Go to www.discoverycube.org

April 7
Chemists make molecular magic at the Museum of Life and Science in Durham, N.C. See www.ncmls.org/visit/events

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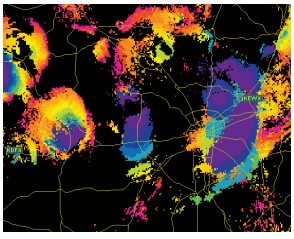
HUMANS
Intoxicated witnesses remember the same number of details as sober ones. Find this story and more in "News in Brief: Humans."

LIFE
Weather radar may help researchers watch creatures' aerial behaviors (bats below). Read "Biologists go bats for storm-watch data."



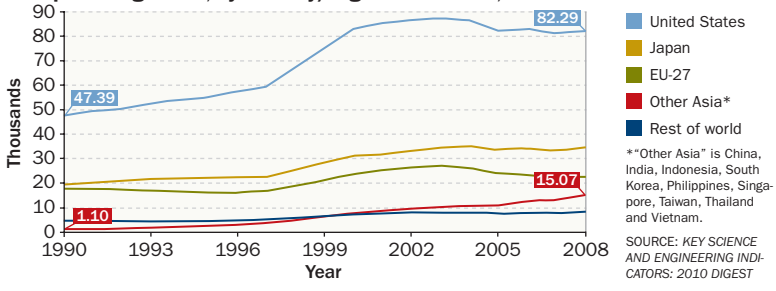
A mosquito-infecting fungus could kill malaria parasites without pesticides. See "Lab-engineered organism fights malaria."

GENES & CELLS
Geneticists find that real estate matters: Location, location, location may encourage DNA variants that are helpful in certain climates. Read "Some genes like it hot."

Science Stats | WHAT'S MINE IS MINE

The number of U.S. patents granted to both domestic and foreign inventors rose from 1990 to 2008, with a 74 percent rise in U.S. inventor patents and a 1,270 percent rise in those from select Asian nations, including China and India. Foreign inventors seek U.S. patent protection because of the large, open nature of the U.S. market.

U.S. patents granted, by country/region of inventor, 1990–2008



**"Other Asia" is China, India, Indonesia, South Korea, Philippines, Singapore, Taiwan, Thailand and Vietnam.

SOURCE: *KEY SCIENCE AND ENGINEERING INDICATORS: 2010 DIGEST*

The (-est)

Researchers have drilled the deepest ice core yet obtained by U.S. teams, reaching a depth of 3,331 meters (about 10,925 feet) on January 28 in West Antarctica. The scientists think that depth is just above the bed material below, but chose not to aim deeper in case the drill hit a water layer. By boring into the region's ice sheet, the researchers hope to tap into a climate record of the planet's last 100,000 years. The project is part of an effort to dig up detailed atmospheric carbon dioxide measurements for the last glacial period, for comparison with cores from Greenland.

CLOCKWISE FROM TOP LEFT: COURTESY OF ALICE HUANG; NMQ

“Ketamine may disrupt patterns of brain activation that coalesce to represent an integrated body and self, leading to out-of-body experiences.” —TODD GIRARD, PAGE 9

In the News

STORY ONE

Spots suggest sun’s doldrums likely to continue

Despite recent flare, weak solar activity still expected

By Ron Cowen

A powerful explosion that erupted on the solar surface on February 14 was the most energetic flare in more than four years, and it heralds an approaching peak in the sun’s 11-year activity cycle. But as the sun pulls out of an exceptionally quiet period of low activity, researchers predict the coming solar maximum won’t be very exciting either.

“This cycle continues to fall below expectations. And those expectations were pretty low two years ago,” says David Hathaway of NASA’s Marshall Space Flight Center in Huntsville, Ala.

The number of sunspots — dark, highly magnetized regions on the solar surface — is one indicator of solar activity, and some scientists now predict this will be the weakest sunspot cycle in 200 years. “We are off to a good start for a below-average cycle peaking in late 2013 or early 2014,” says Dean Pesnell of NASA’s Goddard Space Flight Center in Greenbelt, Md.

Understanding how present activity affects future cycles is important to gauging both the sun’s influence on climate and its likelihood of producing powerful and destructive solar storms.

Solar physicists say they are homing in on the complex internal interactions that could explain why the sun has been hibernating for more than four years now and may not fully awaken for another decade. Hathaway and other researchers say they’re now convinced that a flow of ionized gas, or plasma, known as the meridional flow controls the strength of the solar cycle (*SN: 4/10/10, p. 8*). On either side of the sun’s equator, the flow moves like a conveyor belt that stretches just beneath the solar surface from the equator to the two poles and then dives into the interior, flowing from the poles back to the equator to complete the loop.

The speed of the flow appears to be a crucial parameter. But Hathaway and other researchers disagree on exactly how the meridional flow affects solar activity.

In the March 3 *Nature*, Dibyendu Nandy of the Indian Institute of Science Education and Research in Kolkata and his colleagues report new computer simulations suggesting one way that the flow determines future solar activity. The team’s simulations show that a fast flow during the first half of a solar cycle,

A decade ago, sunspots on the solar surface signaled an activity peak. Scientists have been debating why the following period of low activity was weaker than usual.

SOHO/ESA AND NASA

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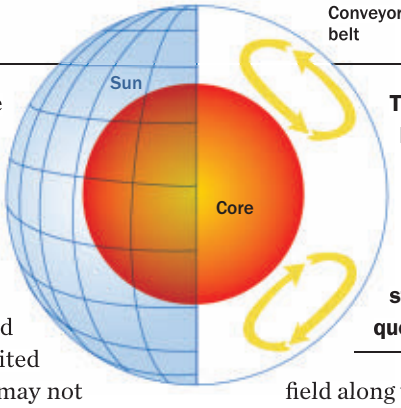
followed by a slower flow during the second half, creates a weak polar magnetic field. This generates an unusually weak and prolonged solar minimum, Nandy says, like the most recent one. From January 2004 until March 2010, there were 780 days with no sunspots. During a similar period in a typical solar minimum, the sun is spot-free for about 300 days.

"The Nandy article is an excellent study of the effect of the meridional flow on what we see at the surface over a solar cycle," says Pesnell.

But Hathaway says that his observations indicate that the speed of the meridional flow was exactly opposite to that required by Nandy and his colleagues. Another solar physicist, Yi-Ming Wang of the Naval Research Laboratory in Washington, D.C., says he is baffled by the apparent contradiction between the model and Hathaway's observations.

Nandy notes that the measurements made by Hathaway and his colleagues are limited to the surface and so may not reflect the true speed of the flow deep in the sun's interior.

Hathaway says that a fast meridional flow is indeed required to explain both the sun's long hibernation and the weakness of the current solar cycle, which began in late 2008. But his observations show that the fast flow occurred during the last half of the last solar cycle, not the first. The flow drags the magnetic field along with it, and a fast flow leads to a weaker field at the poles than a slow flow would. Because the polar fields are thought to be the seeds for the next solar cycle, a weak polar field will cause the next cycle to be weak also.



The speed of conveyor belt–like loops of hot plasma that circulate from the sun's equator to its poles helps determine the strength of the subsequent solar cycle.

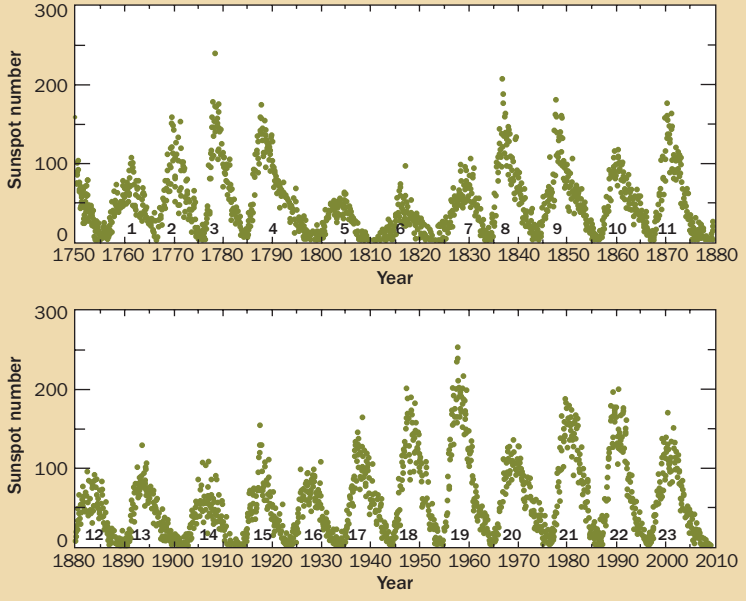
"It is possible that the current sunspot cycle, cycle 24, was seeded with magnetic fields from cycle 23, or even an earlier cycle, cycle 22," says Matt Penn of the National Solar Observatory in Tucson. "This seed field may have been weaker than normal, somehow, and it may be producing a weaker solar activity cycle now."

For now, the exact role that the meridional flow plays in the solar cycle remains a matter of debate. But the new research "demonstrates how the inner working of the sun, and variations in the plasma flow deep within our parent star, can control its magnetic and energetic output, which in turn, determines the environment in space and affects climate on Earth," says Nandy.

A weaker solar cycle is accompanied by a slightly dimmer sun, which reduces the average temperature on Earth, says Judith Lean of the Naval Research Laboratory. She notes, however, that the sun's brightness did not hit an all-time low during the past solar minimum, even though the sun was unusually quiet.

Nonetheless, the decline in solar brightness from 2002 to 2008 as solar activity dwindled probably offset warming on Earth that would otherwise have occurred due to greenhouse gases over that period. "As solar activity now increases," she says, "we can expect this mitigating effect to stop." ■

Back Story | SUNSPOTS, 1750–2010



The sun's activity waxes and wanes on a cycle that averages roughly 11 years, though cycles as short as nine years and as long as 14 years have been observed. Chinese astronomers were already tracking the sun's activity using sunspots more than 2,000 years ago; the modern record of solar output starts in 1755, with cycle 1, and runs through cycle 24, which began in late 2008. Generated by intense magnetic fields, sunspots have proven one reliable indicator of the sun's overall output and its production of solar storms.

FROM TOP: NASA; D.H. HATHAWAY/*LIVING REVIEWS IN SOLAR PHYSICS* 2010

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Atom & Cosmos

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Origin of cosmic rays questioned

PAMELA data suggest that supernovas aren't only source

By Devin Powell

The confirmed origin of ordinary cosmic rays may need to be unconfirmed. New data gathered by an instrument aboard a Russian spacecraft challenge the theory that most cosmic rays are fueled by supernovas, the explosions created by dying stars.

"The mechanism for the acceleration of cosmic rays needs to be completely revised," says Piergiorgio Picozza, a physicist at the University of Rome Tor Vergata in Italy. Picozza is a coauthor of a paper posted online March 3 in *Science* detailing new observations from PAMELA, the Payload for Antimatter Matter Exploration and Light-nuclei Astrophysics.

Cosmic rays aren't actually rays. They're fast-moving particles that carry an extraordinary amount of energy and continuously bombard the Earth from every direction. The most popular explanation for the origin of these particles points to shock waves created by far-off supernovas, one of the few phenomena powerful enough to impart such energy.

According to that explanation, clouds of charged gas rush outward during a supernova and generate strong magnetic fields. These magnetic fields could accelerate charged particles to tremendous speeds and eject them into space.

Orbiting hundreds of kilometers above Earth, PAMELA spent three years collecting cosmic ray particles — mostly hydrogen and helium nuclei with energies ranging from a billion to a trillion electron volts, comparable to the energy of particles collided in the biggest particle accelerator in the United States.

A supernova should accelerate both hydrogen and helium in the same way. But in the PAMELA data, Picozza found differences between measurements of the hydrogen and helium particles that a single shock wave can't explain.

"The two particles seem to be accelerated by different mechanisms," he says.

Scientists should investigate other astronomical objects as possible sources of cosmic rays, Picozza says. One place proposed by Russian physicists is in the novas, or smaller explosions, produced when white dwarf stars belch out energy. Another option could be giant superbubbles of gas blown around the universe by stellar winds, he says.

Exploding stars (one above) have been thought to be the origin of most of the cosmic rays arriving at Earth.

But Mikhail Malkov, a plasma physicist at the University of California, San Diego who studies supernova shock waves, isn't ready to toss out the existing cosmic ray theory. "The data look statistically significant, but it's too early to say that the supernova acceleration model is in trouble. This statement is too strong," he says.

Telescopes peering into supernova remnants have found lots of evidence over the years to support the supernova shock wave theory. Observations of gamma rays reveal the structure of magnetic fields and missing energy that could have been spent making cosmic rays.

Malkov says the difference Picozza observes between hydrogen and helium is small and could be accounted for simply by tweaking the existing supernova model. He suspects that PAMELA may be seeing cosmic rays created by a shock wave that wasn't completely uniform, or a mishmash of particles released by two different supernovas.

Shortcut through a wormhole star

Spacetime tunnels may exist with aid of 'phantom matter'

By Ron Cowen

Some stars may contain wormholes, throatlike tunnels connecting distant points in spacetime, a team of physicists proposes. But other researchers are having a hard time swallowing the idea.

"It's a nice piece of speculative work, but it is speculation," says theoretical physicist Matt Visser of Victoria University of Wellington in New Zealand.

In a paper posted online February 25 at arXiv.org, physicist Vladimir Folomeev of the Institute of Physicotechnical Problems and Material Science of the NAS of the Kyrgyz Republic and his colleagues suggest that pairs of stars could be joined by wormholes built from an exotic material known as "phantom matter."

"I am pretty sure that once you admit exotic matter of some suitable kind, you can mathematically construct a star with a wormhole inside," comments relativity theorist Dieter Brill of the University of Maryland in College Park.

Actually seeing one is another issue. In general, an ordinary star and one containing a wormhole would look the same to a distant observer. But the wormhole might alter properties such as the mass or size of a star in a nonstandard way. And if the wormhole is short, so that the two stars it links don't lie far apart, an observer might see another unusual signpost — two closely spaced objects with nearly identical properties.

For now, says Folomeev, this is just an idea that still must be confirmed by further calculations.

M.D.STAGE *ET AL.*, UMASS AMHERST, MIT, CXC/NASA

Humans

70 percent Fraction of Toronto rave attendees who report using ketamine

1.6 percent Fraction of Canadian high school students who report using ketamine

A man oblivious to music's tempo

Researchers document the first case of 'beat deafness'

By Bruce Bower

The Go-Go's had a 1982 hit record with "We Got the Beat," but a 23-year-old man named Mathieu never got their message. Researchers have identified Mathieu as the first documented case of beat deafness, a condition in which a person can't feel music's beat or move in time to it.

Mathieu flails in a time zone of his own when bouncing up and down to a melody, unlike people who don't dance particularly well but generally move in sync with a musical beat, according to a team led by psychologists Jessica Phillips-Silver and Isabelle Peretz, both of the University of Montreal. What's more, Mathieu usually fails to recognize when someone else dances out of sync to a tune, the researchers report in a paper that will appear in *Neuropsychologia*.

"We suspect that beat deafness is specific to music and is quite rare," Phillips-Silver says.

Mathieu sings in tune and recognizes familiar melodies, so musical pitch doesn't elude him. Hearing and motor areas of Mathieu's brain appear to be healthy, the researchers add.

Language lacks the periodic rhythms found in music, so it's unlikely that Mathieu's problem affects speech perception, remarks cognitive scientist Josh McDermott of New York University.

Mathieu and 33 adults who had no musical timing problems were told to bounce with their knees to a popular merengue song—"Suavemente" by Elvis Crespo. Mathieu and 10 other participants then bounced to eight additional musical excerpts from a variety of genres.

Mathieu consistently bounced out of sync to various musical tempos. He could imitate an experimenter who stood next to him and bounced in time to a merengue tune, but when left to his own devices he lost the beat.

Club drug is out-of-body experience

Ketamine could be used in research on sensory integration

By Bruce Bower

A popular "club drug" promises to open a scientific window on the strange world of out-of-body experiences, researchers say.

Recreational users of a substance called ketamine often report having felt like they left their bodies or underwent other bizarre physical transformations, according to an online survey conducted by psychologist Todd Girard of Ryerson University in Toronto and his colleagues.

Ketamine, an anesthetic known to interfere with memory and cause feelings of detachment from one's self or body, reduces transmission of the brain chemical glutamate through a particular class of molecular gateways. Glutamate generally jacks up brain activity. Ketamine stimulates sensations of illusory movement or leaving one's body by cutting glutamate's ability to energize certain brain areas, the researchers propose online February 15 in *Consciousness and Cognition*.

"Ketamine may disrupt patterns of brain activation that coalesce to represent an integrated body and self, leading to out-of-body experiences," Girard says.

In the new survey, use of marijuana, LSD and MDMA, also known as ecstasy, displayed modest links to volunteers' reports of illusions of walking or moving rapidly up and down while actually remaining still. But only ketamine use exhibited a strong relationship with having had a range of out-of-body experiences, regardless of any other drugs ingested at the time of those sensations, researchers say.

> "Ketamine may disrupt patterns of brain activation that coalesce to represent an integrated body and self."
> TODD GIRARD

Neuroscientist Olaf Blanke of the Swiss Federal Institute of Technology in Lausanne calls ketamine "an interesting candidate to further understand some of the brain mechanisms in out-of-body experiences." Blanke has linked out-of-body experiences to reduced activity in brain areas that integrate diverse sensations into a unified perception of one's body and self.

Girard's team administered online surveys about drug use and drug-related experiences to 192 volunteers, ages 14 to 48. Almost half the people in the sample reported having used marijuana, alcohol, ecstasy, ketamine and amphetamines. Roughly two-thirds had taken ketamine, and nearly everyone had used marijuana and alcohol.

Almost three-quarters of all participants reported having had a feeling of temporarily leaving their bodies, usually on several occasions. About 42 percent had experienced seeing their own bodies from an outside vantage point. Feelings of rapidly moving up and down, falling, flying or spinning had affected more than 60 percent of the volunteers. Another 41 percent reported illusions of sitting up, moving a limb or walking around a room, only to realize that they had not moved.

Of those reporting feelings of leaving their bodies, 58 percent were under the influence of ketamine at the time. Ketamine use also displayed a close association with other unusual bodily sensations.

Matter & Energy

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Diamond may have a softer cousin

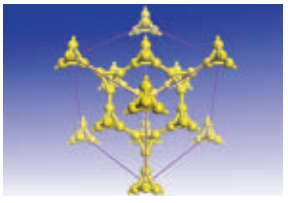
Simulations suggest new member of synthetic carbon family

By Devin Powell

Diamond may have a softer side: T-carbon.

This fluffy form of diamond, simulated in a Chinese supercomputer, could be used for a variety of applications — if someone can make the stuff and prove that it is stable in the real world.

"What is the most surprising to us is that such an elegant structure has never been proposed before," says Gang Su, a materials scientist at the Graduate University of the Chinese Academy of Sciences in Beijing and a coauthor of an upcoming paper describing T-carbon in *Physical Review Letters*.



Replacing diamond's atoms with pyramids of carbon could produce a new form of carbon.

Inspired by a television show about Egypt's pyramids, Su calculated how to revamp the crystal structure of cubic diamond by exchanging each carbon atom with a pyramid of four carbon atoms. This arrangement should be 43 percent as dense and 65 percent as hard as diamond.

"It would be a very light, hard material, so you could imagine a large number of applications," says Wendy Mao, a geophysicist at Stanford University who was not involved with the research.

Su and colleagues hope the material would be valuable for the aerospace industry and for storing hydrogen. Because of the way electrons would flow through T-carbon, it could also be useful as a semiconductor. The researchers speculate that T-carbon may be found in interstellar dust, helping explain distortions of light in the dust noticed by astronomers in 1965.

But other physicists doubt that these carbon pyramids will ever be built. Because of carbon's remarkable ability to form different kinds of molecular bonds, there are countless ways carbon atoms can be rearranged to form new structures, says crystallographer Artem Oganov of Stony Brook University in New York. Most such arrangements, though, are too unstable to exist in an everyday environment. The trick is to find the few that can actually be created and stick around, thus joining the family of carbon "allotropes," which includes graphite and amorphous carbons such as soot (both found in nature) as well as lab-produced substances such as graphene, carbon nanotubes and fullerenes.

"I think there will be problems in synthesizing" T-carbon, says Oganov.

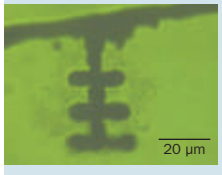
Because of T-carbon's low density, it must be formed at pressures far below atmospheric levels. Other recent efforts to make new forms of carbon have focused on generating high pressures by squeezing materials. To make T-carbon, Su proposes detonating a chunk of diamond or graphite, or creating negative pressures "somehow by stretching diamond with an extremely large strength."

Renata Wentzcovitch, a materials scientist at the University of Minnesota in Minneapolis, says that even if T-carbon was synthesized, "I don't know if it would hold together." Lower-energy structures tend to be more stable. "The energy of this stuff is much, much higher than other forms of carbon," she says, "and little perturbations might cause the structure to collapse." ■

NEWS BRIEFS

Handcrafted nanoart

Beams of light used to "draw" three-dimensional nanostructures could give scientists more flexibility in creating tiny sensors and electronic components.



The new technique, called optically directed assembly, uses a low-power laser to form long filaments from dissolved gold and carbon particles only 40 nanometers in size. A laser process fuses these pieces into structures that remain intact after fluid is drained away, scientists at Argonne National Laboratory report online February 28 in *Physical Review Letters*. To demonstrate, the researchers handcrafted a microscopic glyph—the Chinese character for "king." —*Devin Powell*

Quantum vibes

Pairs of vibrating atoms can be taught to beam energy back and forth like tiny antennas, two studies in the Feb. 24 *Nature* report. This connection, a way to transmit information in quantum computers, caused charged beryllium particles separated by a distance of 40 micrometers to take turns wiggling in a device created by scientists from the National Institute of Standards and Technology in Boulder, Colo. A team from the University of Innsbruck in Austria, working with calcium atoms, found that adding more atoms could boost the strength of the signal. —*Devin Powell*

A new way to disappear

An invisibility potion made of tiny metal rods in a nonconducting liquid could be a new metamaterial, a structure that interacts oddly with light. Scientists at Kent State University in Ohio report online February 14 in *Materials* lining up dissolved gold particles with electric fields to change how light bends. This effect must be improved by a factor of 10 to be useful for optical devices. —*Devin Powell*

FROM TOP: QING-BO YAN; SUBRAMANIAN SANKARANARAYANAN/ARGONNE NATIONAL LAB

Genes & Cells

81 percent Stroke patients with poor outcomes with arginine variant of p53

91.5 percent Hemorrhage patients with poor outcomes with arginine variant

Gene variant ups damage in brain

More cell suicide linked to poorer recovery after stroke

By Tina Hesman Saey

A naturally occurring genetic variant may help predict who will do well after a stroke and who won't. People who have two copies of a particular version of the *Tp53* gene have a poor prognosis after stroke and brain hemorrhages, researchers in Spain report online February 28 in the *Journal of Experimental Medicine*.

The difference between the two versions of the gene amounts to one small change: swapping proline for arginine as the 72nd link in a chain of amino acids that make up a protein called p53.

The arginine-containing variant of p53 had previously been shown to help protect against cancer by increasing apoptosis, a cell suicide program that gets rid of damaged cells. Brain cells can also undergo apoptosis after a stroke, but in the brain it's a bad thing, leading to more widespread damage.

Angeles Almeida of the University Hospital of Salamanca and colleagues tested nerve cells that make either the arginine or the proline version of p53 to see how the variants acted in the brain.

"The difference was huge," Almeida says. Cells with the arginine version had at least two times greater capacity to undergo apoptosis than did cells with the proline variant. And the molecular difference has consequences for the whole brain; when researchers tested the DNA of stroke and brain hemorrhage patients, the team found that a patient's p53 variant correlated with how well the person had recovered after three months.

Of stroke patients with a poor prognosis, about 81 percent carried two copies of the arginine variant. In hemorrhage patients, about 91.5 percent of those with a poor outcome had only the arginine variant. None of the people with two copies of the proline variant had bad outcomes. Those with one copy of each variant tended to have good prognoses. The results, Almeida says, indicate that controlling apoptosis may aid brain recovery.

"Their epidemiological data is really quite convincing," says David Johnson of the University of Texas M.D. Anderson Cancer Center in Smithville.

But Maureen Murphy of the Fox Chase Cancer Center in Philadelphia doubts that the variant will be a useful predictor of stroke outcome for all ethnic groups. African-Americans tend to have the proline version of p53, she notes, but also have high rates of stroke, often with very poor outcomes.

Body & Brain

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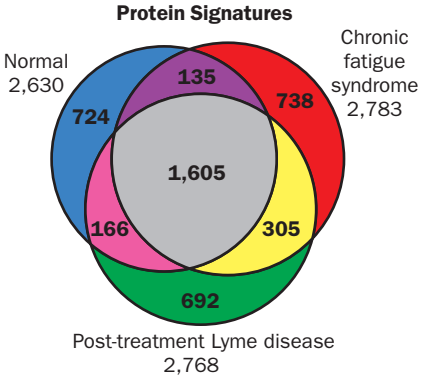
Test for Lyme vs. chronic fatigue

Two conditions show distinct spinal fluid protein signatures

By Nathan Seppa

Proteins found in spinal fluid may serve as biomarkers to help doctors distinguish chronic fatigue syndrome from the lingering effects of Lyme disease. Different sets of proteins discovered in people with the two conditions indicate that the two groups have distinct and distinguishable disorders, researchers report in the February *PLoS One*.

"This provides strong evidence of a biological component" in these conditions, says study coauthor Steven Schutzer, a physician and immunologist at the University of Medicine and Dentistry of New Jersey in Newark. But he cautions that the findings represent a first step in seeking biomarkers for the conditions and don't reveal whether these different protein signatures cause the syndromes or result from them.



Proteins found only in people who have had Lyme disease (green) or only in those with chronic fatigue (red) could help in diagnosing those disorders.

Chronic fatigue is a baffling condition marked by prolonged and severe tiredness that isn't resolved by rest. Its cause is unknown, and it is often difficult to diagnose and treat. Women are most commonly affected.

Lyme disease results from infection by *Borrelia burgdorferi*, a bacterium spread by deer ticks. It is treatable with antibiotics, but infections can go unnoticed, delaying treatment. Also, despite clearing the bacterial infection, some patients continue to have long-term symptoms, including fatigue. Scientists have wondered whether those symptoms are a form of chronic fatigue, but a connection has never been ascertained.

In the new study, Schutzer and his colleagues analyzed spinal fluid from 11 healthy people, 43 with chronic fatigue syndrome and 25 previously treated for Lyme disease but still experiencing cognitive problems and fatigue.

Analysis of the fluid detected more than 2,600 proteins in each group. Many of the proteins appeared in all three groups. But 692 proteins turned up only in the Lyme patients and 738 others showed up only in the chronic fatigue group.

Identifying 20 or 30 proteins that show up consistently in a condition — but not in healthy people — could form the basis of a diagnostic test, Schutzer says.

"I think this a great first step," says Joseph Breen, a biochemist at the National Institute of Allergy and Infectious Diseases in Bethesda, Md. The finding will need to be validated in more spinal fluid samples from greater numbers of people who have these conditions, he says. ■

Half of adult males may carry HPV

Sexually transmitted virus can linger for months, study finds

By Nathan Seppa

The virus notorious for causing cervical cancer in women also turns up frequently in men and can hang on unnoticed for months or even years, researchers report online March 1 in *Lancet*. The study solidifies earlier research indicating that human papillomavirus is highly prevalent in men and strengthens the case for vaccinating men and boys against it, the report's authors say.

Two vaccines, Merck's Gardasil and GlaxoSmithKline's Cervarix, protect against two types of cancer-causing HPV. Both vaccines are approved and recommended for girls and young women. Gardasil is approved for use in males age 9 to 26, and its protection extends to two additional types of HPV that cause genital warts in both sexes.

Starting in 2005, a team led by Anna Giuliano of the H. Lee Moffitt Cancer Center & Research Institute in Tampa, Fla., recruited more than 4,000 men living in Brazil, Mexico and Florida for a study of HPV. The new study reports on the first 1,159 of these volunteers. Their average age was 32; none had been vaccinated against HPV. Swabs of the penis and genital area of each man revealed that 50 percent were infected with at least one HPV type upon enrollment.

The new study results "are of substantial interest," says Joseph Monsonego of the Institute of the Cervix in Paris, writing in the *Lancet*.

Over a median of 28 months, the group acquired 1,572 new HPV infections.

The human immune system can clear HPV from the body, and the men wiped out most of their new infections in a median of 7.5 months. Clearance times didn't vary substantially among the countries but did vary between HPV types. Some cases lingered as long as 20 months.

Male circumcision and the use of condoms have shown little protection against HPV infection, Monsonego says. "HPV vaccination in men will protect not only them but will also have implications for their sexual partners," he says.

SCHUTZER *ET AL*/*PLOS ONE*

"This is the first paper that really shows there are changes in the brain." —HENRY LAI

Brains go low guesstimating speed

Vision centers relying on past experience expect slow moves

By Laura Sanders

SALT LAKE CITY — When the brain can't nail an answer, it falls back on reasonable guesses. Now scientists have evidence that this strategy comes early in processing sensory inputs, a study presented February 26 at the Computational and Systems Neuroscience meeting suggests.

The research took advantage of a common misperception of the human brain: It often seems that hazy, ill-defined objects are moving more slowly than they really are. The brain's rationale for this error: "Things in the world don't tend to move very quickly," said neuroscientist Ed Vul of the University of California, San Diego, who was not involved in the new study. "They're not running past you at 60 miles per hour. For the most part, when things are moving, they're moving slowly."

Researchers already knew that the brain relies on assumptions when it has trouble figuring something out, but it wasn't clear where in the brain — and when — these assumptions get used.

In the new study, Brett Vintch of New York University and Justin Gardner of the Riken Brain Science Institute in Japan scanned people's brains using functional MRI while the volunteers judged how fast black-and-white lines moved on a computer screen. At first, the researchers made the task relatively easy, to see how participants would handle it under normal conditions. The team found that some of the most important vision areas in the brain were used to gauge the speed of the object.

To find out which parts of the brain were active when more guesswork was involved, the researchers made the test harder by making the lines hazier. As participants had less information to rely on, the activity shifted within vision centers, including in parts of the brain that receive input directly from the eyes. This change went along with the slower movement estimates.

The results suggest that the brain falls back on its default "most things are slow" reasoning very early in the brain's vision pathway, Vintch said.

Vul said that the results are interesting, but more studies will be needed to sort out exactly how the brain uses information it already knew. "From this I wouldn't be entirely convinced" that the brain is incorporating assumptions this early in the vision process, he said. ■

Cell phones turn up brain activity

Effects of higher metabolism near active ear are unknown

By Laura Sanders

Power-talkers with cell phones glued to their ears may be getting more than conversation. A 50-minute call boosts activity in brain regions near the ear where a phone is located, a brain-scanning study in the Feb. 23 *Journal of the American Medical Association* shows.

"This is the first paper that really shows there are changes in the brain," says bioengineer Henry Lai of the University of Washington in Seattle, who coauthored an editorial published in the same issue of *JAMA*. Talking on a cell phone pressed to the ear, he says, "is not really safe."

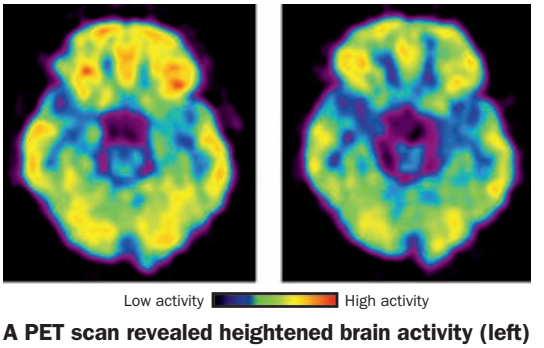
In the study, researchers measured brain activity in 47 participants who had pairs of Samsung cell phones strapped to their heads, one on each side. The phone on the left ear was turned off, while the one on the right received a 50-minute recorded message. This phone was kept muted so the subject didn't know which phone was on, and to prevent stimulation of the brain's hearing center.

A few minutes after the call, a PET scan revealed that brain regions next to the working phone had higher levels of glucose metabolism. The left side of the brain and other areas, even those quite close to the phone, showed no changes. Since active brain cells require glucose, the increase suggests that cell phone radiation is boosting brain activity.

The particular brain regions affected would probably change depending on a phone's design and how a person held it, says study coauthor Nora Volkow of the National Institute on Drug Abuse in Rockville, Md. On the phones used in the study the antennas are near the bottom, so the brain areas involved were the orbitofrontal region, which sits right behind the eyes, and the temporal pole below it.

Glucose metabolism rose in these areas by about 7 percent — a typical increase for active brain regions.

"At this point we do not know what the clinical significance of this particular finding is," Volkow says.



A PET scan revealed heightened brain activity (left) after a 50-minute call on a cell phone, compared with a control where no call was made (right).

Life

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A lizard that can swim on dry land

Study shows how a desert dweller slithers through sand

By Daniel Strain

The sandfish lizard wriggles through desert sands like a sci-fi monster. Now, using computer simulations and bendy robots, researchers at Georgia Tech in Atlanta and Northwestern University in Evanston, Ill., have taken the most complete look yet at the physics of burrowing animals. And, boy, does this reptile wriggle, the team reports online March 4 in the *Journal of the Royal Society Interface*. "This particular behavior is built for speed," says study coauthor Daniel Goldman, a physicist at Georgia Tech.

Like the deadly sandworms in the *Dune* science fiction series, a host of animals from scorpions to snakes burrow in desert sands across the planet. It's not easy to study how these creatures careen through their environments, Goldman says. Scientists have a good idea how water behaves in the wake of an undulating eel or how air flows over a bird wing. But shuffling sand grains ping off each other like billiard balls in a wickedly complicated game of pool.

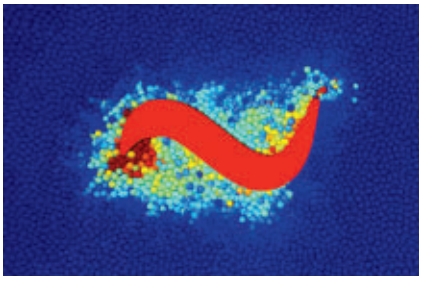
X-ray studies have shown that sandfish lizards (*Scincus scincus*) navigate such chaos with a wormlike wriggle, Goldman says, tucking in their legs and curling from side to side in S-shaped waves. The creatures can grow to 4 inches long, and a fast sandfish lizard dive covers two body lengths per second. But just how the lizards achieve such speed in a complex sandy environment wasn't clear. For that, Goldman's team turned to a new set of tools.

First, researchers simulated sandfish lizards swimming in a sea of 3-millimeter-wide glass beads. The program — which ate up 20 to 30 desktop PCs and still took days to run — illustrated how every bead bumped and thudded as the virtual lizard passed by.

The real fun came next, when the team built a spandex-covered roboreptile that could wriggle much like the real thing. "The beauty of robotics compared to the simulation and theory: It's all in the real world," Goldman says. If the team wanted the robot to bend more or less, the researchers just asked it to bend more or less.

On-screen or clad in spandex, the tests agreed. If virtual lizards curl too much, they don't move far enough forward with each wriggle. If they bend too little, the lizards can't give enough push. Real-life sandfish lizards walk — or rather wriggle — this fine line nearly perfectly.

Such finely tuned diving isn't useful just for lizards, says Robin Murphy, director of the Center for Robot-Assisted Search and Rescue at Texas A&M University in College Station. She designs robots to help in the aftermath of disasters like earthquakes or mudslides. When it comes to machines that can dig like earthworms and slip through rubble, nothing like that exists. "There's a lack of any technology short of a shovel," she says. Burrowing animals could inspire new machines, but so far few studies have been able to capture the constraints robots would face in dirt-filled or muddy environments. "This is the first I've seen that I said, 'OK, we've got it,'" she says.



Computer simulations of lizards negotiating a sea of small glass beads can reveal how single grains respond when a real sandfish swims through sand.

Robots inspired by animals are neat, says Eric Tytell, a researcher at Johns Hopkins University who studies how fish swim in water. But the Georgia team flipped that inspiration around, too. Goldman and his colleagues used robots to get a better grasp of biology. And that's really clever, Tytell says.

Rise of the creepy crawler

Fossils of an ancient "walking cactus" suggest how ancestors of today's lobsters, insects, spiders and related groups went from squishy to spiky. Dating back about 520 million years, the thumb-sized creature probably scuttled along shallow seafloors, says Jianni Liu of Northwest University in Xi'an, China, and the Free University of Berlin. In the Feb. 24 *Nature,* she and her colleagues christen the species *Diania cactiformis*. Discovered in southwestern China, the animal's jointed legs appear to have had a hard covering of armor. An armored outer skeleton and jointed legs are today defining features of arthropods, including crustaceans, insects, spiders and mites. —*Susan Milius*

FROM TOP: YANG DING; J. LIU

U.S. is biggest exporter of fire ants

DNA points to South as source for recent global invasions

By Susan Milius

Genetic evidence now spotlights the United States as the source of recent fire ant invasions in the rest of the world.

The aggressive, stinging fire ants (*Solenopsis invicta*) aren't native to the United States but rather to a broad swath of South America. Yet the southern United States, invaded by fire ants in the 1930s, has sent off at least eight separate waves of fire ant invasions to other countries in recent years, says entomologist Kenneth Ross of the University of Georgia in Athens. A ninth invasion probably hopscotched from the South to California before hitting Taiwan.

Native to South America, fire ants are using the U.S. South as a jumping-off point to invade other shores.

"It's not good news," Ross says. These waves of ants are now colonizing the Caribbean, Australia, New Zealand, Taiwan and China, including Hong Kong and Macau, he and his colleagues report in the Feb. 25 *Science*.

"This study is going to cause quite a stir," says geneticist Michael Goodisman of Georgia Tech in Atlanta, who studies invasive ants. The new fire ant research, he notes, "could have important trade and travel implications."

Regardless of any furor, the study is a valuable step in dealing with the problem, says another invasive-ant biologist, Ben Hoffmann in Darwin, Australia, with the country's CSIRO research service. "We need to know how invasions spread to be able to prevent spread and effectively manage invasions."

Biologists had certainly considered this United States–bridgehead scenario of invasions, Ross says, "but without data, it was anybody's guess." To track the invasions, an international research team analyzed ants from 2,144 colonies in a total of 75 places in 11 countries and looked at several kinds of genetic information, including dozens of DNA markers.

"Most studies don't come close to those numbers," says Goodisman.

Ross explains that looking closely at fire ants in their native range in South America revealed 322 distinct genetic types. Only 11 of those types were found in the southern United States, including three that were very rare in the native range. Yet the populations from newly invaded territories had combinations of the three rare variants found in the United States. Researchers also ran computer models of how gene patterns in populations change as invaders bud off into new territories. The scenarios that fit the data best showed the United States as the source.

This analysis raises the possibility that the rigors of invading the United States and then of moving on toward world domination have winnowed out weaklings among the fire ants. Populations now erupting from the United States could be specially adapted as superinvaders, Ross says.

Even without special adaptations, basic fire ant biology gives the species some tricks for traveling. In the ants' native range, they survive flooding by fleeing their nests with their young and gripping each other to create a living raft of ants that floats until the flood subsides. If they're afloat for longer than they can survive without food, adults eat the young.

SCOTT BAUER/USDA AGRICULTURAL RESEARCH SERVICE, BUGWOOD.ORG

NEWS BRIEFS

Worm history 101

Lazy and busybody worms don't just look and act different; they're evolutionarily distinct. In the March 3 *Nature* a German team presents a DNA analysis showing that annelids, a group including earthworms and leeches, split into two divisions hundreds of millions of years ago—the mobile Errantia and the mostly sedentary Sedentaria. Scientists noticed the different creepy-crawly lifestyles long ago, but whether the changes had sprung from a true evolutionary split wasn't clear. —*Daniel Strain*

Dam cane toads

Keeping cane toads away from human-made water sources in Australia might reduce the amphibians' future spread by about a third under ordinary climate conditions. The invasive toads may be susceptible to a strategy that would essentially close down hubs from which the toads radiate, say Daniel Florance of the University of Sydney and his colleagues. Invasion theorists have floated hub-blocking as a general strategy, but now fencing experiments and data on toad movements suggest a test case, the researchers say in a paper posted online February 23 in the *Proceedings of the Royal Society B*. —*Susan Milius*

Heartless beast

A lump in the chest cavity of a *Thescelosaurus* dinosaur, once proposed to be fossilized heart muscle, is probably just cemented sand grains, a North Carolina team reports in the March *Naturwissenschaften*. The dinosaur gained worldwide headlines in 2000 after a paper in *Science* made the heart claim (*SN: 4/22/00, p. 260*). —*Alexandra Witze*

Science & Society

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Mafia informants flunk acid test

Tales of corpses dissolving in minutes were exaggerated

By Rachel Ehrenberg

Contrary to claims made by informants within the Sicilian Mafia, sulfuric acid will not dissolve a corpse in minutes, a new study finds. The research, reported February 23, was part of a wider effort to test claims about the mafia's "lupara bianca" or "white shotgun" murders, wherein the subject is known to be dead but a body is never found.

Experiments conducted on partial pig carcasses, a widely accepted stand-in for human bodies, showed that it takes days to melt flesh in sulfuric acid. Adding water to the acid speeds up the process, dissolving muscle and cartilage within 12 hours and turning bone to dust within two days, suggesting that the technique could render a corpse completely unrecognizable.

"But it is impossible that they completely destroyed a corpse with acid," at least not in minutes, said study coauthor Massimo Grillo of the University of Palermo in Italy.

Police found tanks of acid in a Palermo hideout known as the "chamber of death," where crime boss Filippo Marchese purportedly dissolved victims after torturing them in the early 1980s, said Filippo Cascino, another study coauthor at the University of Palermo.

Informants had described the disposal method, the researchers said, with statements like, "We put the people in acid. In 15, 20 minutes they were no more. They became a liquid."

> **"We put the people in acid. In 15, 20 minutes they were no more. They became a liquid."**
>
> MAFIA INFORMANT

The research suggests that the members of the crime clan were not as good at telling time as they were at ritual murder.

But "they are smarter than some Georgia criminals," said Michael Heninger, an associate medical examiner in Fulton County, where Atlanta is located. "People think they will destroy a body, but they'll do things that preserve it. These guys are more experienced," Heninger said of the Palermo killings.

It isn't obvious whether the new research will translate into something useful for future investigations. "We constantly see cases that are weird," said Heninger. "I'm never going to see this exact case, but when you do see something weird like this, it gets you thinking about how you would figure it out." ■

Sniffing a rat in a bag of ruined chips

How forensic scientists tell contamination from tampering

By Rachel Ehrenberg

Some crime scenes are exactly the size of a bread box.

Every year forensic scientist Brendan Nytes sees a few cases where a dead rat or mouse is found in a box of cereal, a jug of vinegar or a loaf of marble rye. His job is to collect evidence that can help distinguish genuine contamination from the surprising number of cases involving the intentional introduction of a dead rodent to a perfectly wholesome food product.

While critters do make their way into food accidentally, many arrive with outside help, said Nytes, a microscopist with Microtrace, a private forensic lab based in Elgin, Ill. A careful postmortem may lead investigators to a litigious consumer, vengeful employee or maybe just a kid who is willing to take a prank a little too far.

When a product containing a dead animal arrives at the lab, Nytes reported February 26, he and his colleagues first scrutinize the crime scene. Gnaw marks on the inside or outside of the container may reveal a point of entry or an attempt to escape. Feces or urine within the container can indicate whether the animal arrived in its tomb alive.

But it's a necropsy — the animal version of an autopsy — that can most readily rule out death by food processing.

Ligature marks on the neck? Probably died in a mousetrap. Analyzing stomach contents can reveal the green dye used to mark rat poison or a completely empty belly, both suspicious if the rodent supposedly expired in a box of food.

When faced with mere bones or fur scraps, scientists must first ascertain what animal they are dealing with. Some body parts allow for a much quicker ID than others, said forensic morphologist Bonnie Yates of the U.S. Fish and Wildlife Service Forensics Laboratory in Ashland, Ore.

"Teeth are great because that's how animals make their living," said Yates. "Tail or rib bones, not so much. But if you have a remnant of original form, chances are if you have someone who knows their way around a carcass, they will know what it is."

Occasionally there isn't a carcass at all. Nytes has seen cases where package contents really settled during shipping — so much that a consumer misidentifies a misshapen mass of oats and starch as a body part.

"This is actually a big deal — a consumer often claims it's a rodent, and it isn't," Nytes observed. "It's a rock of product." ■

Pioneering audiologist invents "reading glasses" for your ears.

Neutronic Ear is the easy, virtually invisible and affordable way to turn up the sound on the world around you.

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It's amazing how technology has changed the way we live. Since the end of the Second World War, more products have been invented than in all of recorded history. After WWII came the invention of the microwave oven, the pocket calculator, and the first wearable hearing aid. While the first two have gotten smaller and more affordable, hearing aids haven't changed much. Now there's an alternative… Neutronic Ear.

First of all, Neutronic Ear is not a hearing aid; it is a PSAP, or Personal Sound Amplification Product. Until PSAPs, everyone was required to see the doctor, have hearing tests, have fitting appointments (numerous visits) and then pay for the instruments without any insurance coverage. These devices can cost up to $5000 each! The high cost and inconvenience drove an innovative scientist to develop the Neutronic Ear PSAP.

Neutronic Ear has been designed with the finest micro-digital electronic components available to offer superb performance and years of use. Many years of engineering and development have created a product that's ready to use right out of the box. The patented case design and unique clear tube make it practical and easy to use. The entire unit weighs only 1/10th of an ounce, and it hides comfortably behind either ear. The tube is designed to deliver clear crisp sound while leaving the ear canal open. The electronic components are safe from moisture and wax buildup, and you won't feel like you have a circus peanut jammed in your ear. Thanks to a state-of-the-art manufacturing process and superior design, we can make Neutronic Ear affordable and pass the savings on to you.

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The Ear Horn	17th Century	No	Hardly	Maybe
Wearable Hearing Aid	1935	Weighed 2.5 pounds	No	No
Digital Hearing Aid	1984	No	No	Not for most people
Neutronic Ear	2010	Yes	Yes	Yes

Just think of the places you'll enjoy Neutronic Ear

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Neutronic Ear is not a hearing aid. If you believe you need a hearing aid, please consult a physician.

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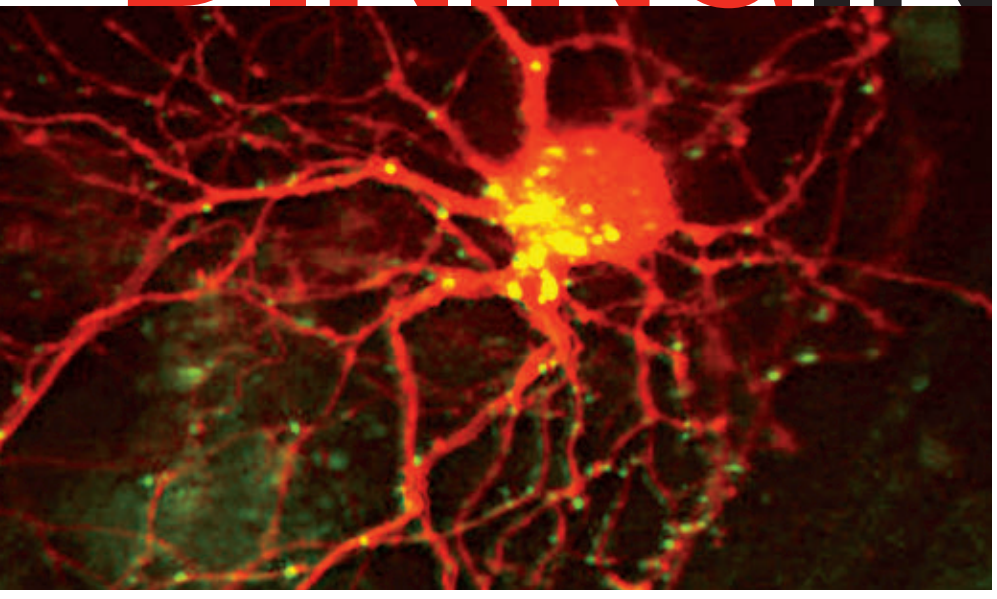


To keep things tidy, nerve cells (red) nibble away at themselves via Pac-Man–like structures (green and yellow).

How the right amount of cellular self-cannibalism can keep you healthy

By Tina Hesman Saey

There's a little Hannibal Lecter in all of us.

But while the famous cannibal dined on chunks of his enemies and friends, most people stick to gnawing on themselves at a microscopic level. In fact, the cells of organisms from yeast to humans regularly engage in self-cannibalism. Cells chew on bits of their cytoplasm — the jellylike substance that fills their bellies — and dine on their own internal organs, although usually without the fava beans and Chianti.

It may sound macabre, but gorging on one's own innards, a process called autophagy, is a means of self-preservation, cleansing and stress management.

"It has become evident that it is really an essential or vital function," says Fulvio Reggiori, a cell biologist at the University Medical Center Utrecht in the Netherlands.

A munch here gets rid of garbage that might otherwise clog the system. A nibble there rids cells of malfunctioning parts. One chomp disposes of invading microbes. In lean times, all that stands between a cell and starvation may be the ability to bite off and recycle bits of itself. And in the last decade or so it has become clear that self-eating can also make the difference between health and disease.

"Too much or too little autophagy is a problem," says Daniel Klionsky, a cell biologist at the University of Michigan in Ann Arbor.

A cell that bites off more than it can chew can kill itself, Klionsky says. A few rare genetic diseases are linked to an excess of unsuccessful autophagy: The muscles of people with Danon disease, Pompe disease and X-linked myopathy can become weak after filling up with Pac-Man–like structures that put the bite on the cell's insides but can't finish digesting.

Not enough autophagy can also lead to disease. Most notably, a cell that can't clean itself up can turn cancerous.

With their sights on fighting disease, scientists are now uncovering the mechanics that keep autophagy in balance. Recent work, for example, shows that faulty versions of a gene that helps spark autophagy can make people more susceptible to tuberculosis. While boosting autophagy can help prevent cancer, researchers have found that once cancerous, cells can hijack the self-eating mechanism, a twist that suggests reining in autophagy may keep tumors at bay.

And for a number of neurodegenerative diseases — including Parkinson's and Alzheimer's — new studies show that cells can't quite get their toxic innards down. In some cases, treating these diseases may be a matter of encouraging autophagy, while others may require a tightening of the self-cannibalizing belt.

Cellular dinnertime

Scientists have known since the early 1960s that autophagy happens. But until a decade ago, when yeast geneticists found genes that control the process, no one could do more than look through a microscope and describe how cells eat themselves. In the first recognizable step of the process, a small, curved, double-membraned structure appears around the parts of the cell that are on the menu. That little bit of membrane grows to encase whatever the cell plans to swallow. "Imagine a teacup expanding and growing and eventually becoming a football" (a soccer ball for Americans), says Sharon Tooze, a cell biologist at Cancer Research UK's London Research Institute.

That soccer ball structure is the Pac-Man, known technically as an autophagosome. It fuses with another intracellular structure called a lysosome, basically a big bag of enzymes that break down proteins and other molecules into their basic building blocks, much the way stomach acid digests food. The building blocks can then be recycled to build more proteins, membranes or other things the cell needs.

Since biologists working with yeast discovered the first genes involved in

ANDREY TSVETKOV, STEVEN FINKBEINER, UCSF

autophagy in the 1990s, more than 20 different genes have been found to play a role in the process in yeast — and many of those genes have counterparts in humans and other animals. But autophagy gets more complex in these other organisms: Several of the genes found in yeast, for example, have multiple copies in human cells. One species of yeast is known to have one *ATG8* gene, while humans have six versions of the gene.

Each of those genes encodes proteins that interact with other proteins, further complicating things. Researchers at Harvard Medical School reported last year in *Nature* that it takes 409 different proteins interacting in 751 different ways to carry out autophagy in human cells. With so many moving parts, perhaps it's no surprise that things sometimes go awry.

Unfortunately, interfering with self-eating can do more than just give a cell indigestion. Messed-up autophagy can ruin a cell's whole life, not to mention the health and life of the organism in which the cell lives. That's because autophagy is one of a cell's best methods of coping with stress.

Though a low level of autophagy is maintained constantly, during times of stress the body ramps it up. This boost helps save cells from starvation. "It's like carrying around your own refrigerator or a cooler with your sandwich," says Vojo Deretic, a cell biologist at the University of New Mexico Health Sciences Center in Albuquerque.

Too much trash, such as broken cell batteries, misfolded or damaged proteins and inoperative organelles can also cause stress, so self-eating serves as an important cellular garbage disposal.

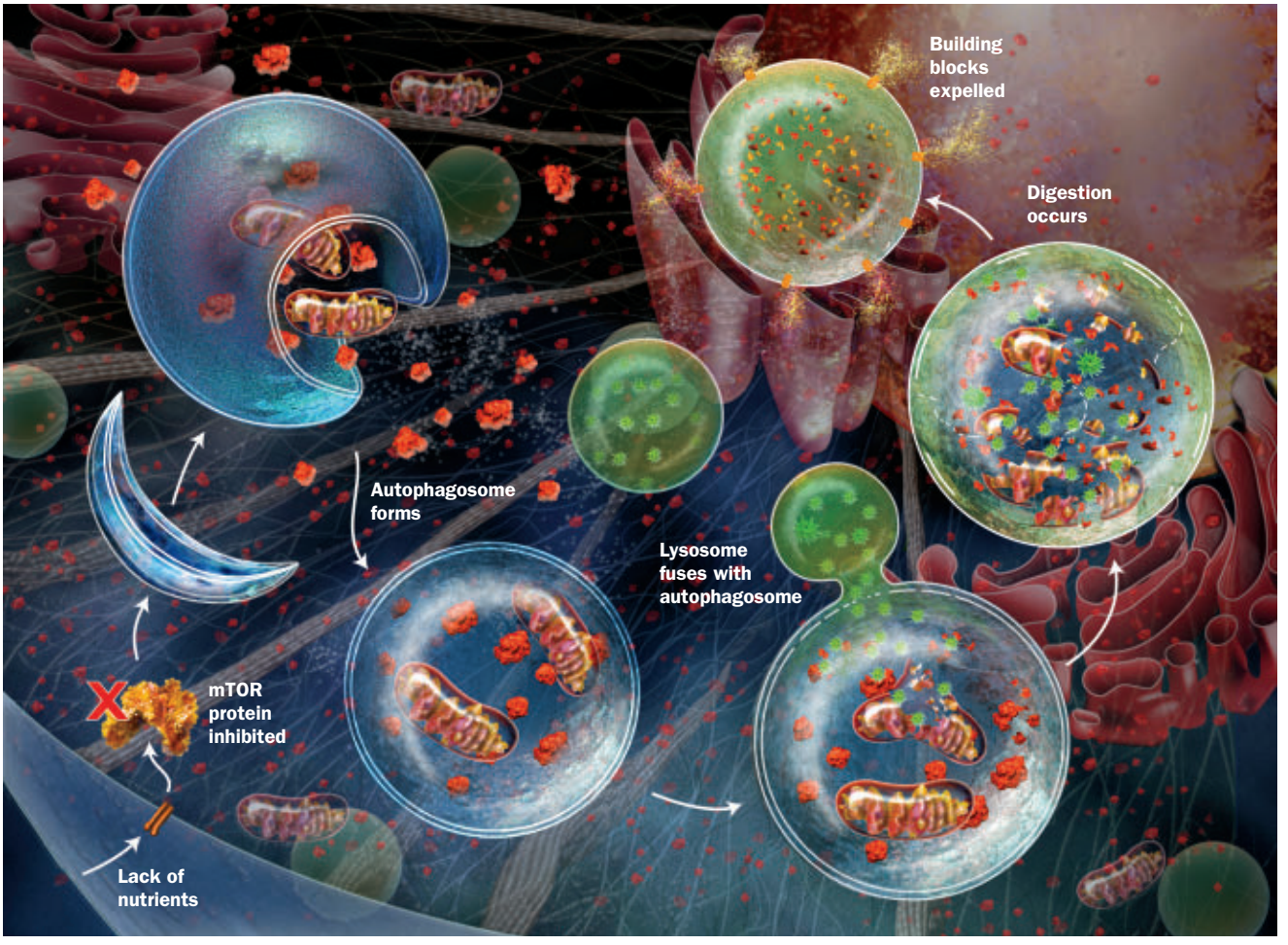
But perhaps the most important stress-reducing function of autophagy is defending against pathogens, Deretic says. He and his colleagues have found that without autophagy to digest invading microbes, a cell is headed for disaster.

Eating invaders

Autophagy probably arose as a pathogen-defense mechanism very early in the evolution of cells that sequester DNA in a compartment called the nucleus. These "eukaryotic" cells differ from bacteria and archaea, the other two major groups of life, which don't have nuclei.

When the first cells were swimming around the primordial soup, bacteria and archaea ruled. "The eukaryotic cell

Hungry, hungry cell A lack of nutrients, among other factors, can trigger cells to dine on themselves. The process begins with inhibition of a key protein. Then a curved double-membraned structure begins to form. It grows into what's called an autophagosome and envelops cell innards in need of digestion. After an autophagosome fuses with a bag of enzymes called a lysosome, the contents get broken down and expelled for future use.



NICOLLE RAGER FULLER

was an intruder in the mix, feeding on bacteria," Deretic says.

But bacteria can be a dangerous food. Once gobbled up by the eukaryotic cell, the microbes could start eating the cell from the inside out, giving the eukaryotes the microscopic equivalent of food poisoning. Autophagy was a eukaryote's recourse, allowing the cell to recognize invading parasites, bacteria and viruses, then engulf and destroy them. "The cell learned how to defend itself," Deretic says.

> "These are what we call the oncology horror movies."
> EILEEN WHITE

Reggiori agrees that autophagy may have been the first immune system, and he and other scientists are interested in studying pathogens that have learned to evade the autophagy system, in hope that the loopholes may point to ways to cure disease.

One microbe that has found such a loophole is the bacterium that causes tuberculosis, which can sometimes hide out in cells without getting digested. Some people are more prone to tuberculosis infections than others, but the reason why hasn't been clear. A version of a gene called *IRGM* may be to blame, Deretic and colleagues reported in the December *Nature Cell Biology*.

His team found that the IRGM protein plays a role in a series of cellular events that trigger autophagy. When tuberculosis or other bacteria invade a cell, the protein helps autophagy go to work to eat the intruders. But in people with a defective version of the gene, cells can't work up enough of an appetite to keep tuberculosis bacteria in check.

Another variant of the same gene may be linked to a seemingly unrelated disorder, the inflammatory bowel condition known as Crohn's disease. This *IRGM* version can't be properly regulated by small RNA molecules known as microRNAs, which help control how much of the protein gets made.

With this version of *IRGM*, there is an overabundance of the protein and an increase in formation of autophagosomes. To figure out the consequences of this overproduction, researchers infected intestinal cells with a pathogenic form of *E. coli*, one possible trigger that could cause a flare-up of Crohn's disease. Autophagosomes swallowed the bacteria but seemed to have a problem breaking down the invading microbes, Patrick Brest of the French National Institute for Health and Medical Research at the University of Nice Sophia Antipolis and collaborators reported online January 30 in *Nature Genetics*. That improper digestion meant more of the bad bacteria stuck around, possibly triggering inflammation and disease.

Hijacked digestion

While microbial invasion is one way to spur a cell to snack on itself, there are other dinner bells. One thing that gives a cell a taste for its own flesh is a reduction in outside nutrients getting to the cell.

Starvation inhibits an important biological signaling system, known as the mTOR pathway — named for a key protein involved in regulating cell growth and survival, cell movement and protein production. The inhibition of mTOR sets off a cascade of reactions inside the cell that end in autophagy and may be crucial to prolonging cell life and ultimately fending off cancer.

A drug that inhibits mTOR, called rapamycin, has been shown to extend life span in mice. It and calorie restriction are the only methods proven to prolong longevity, suggesting both may work through autophagy to make cells live longer.

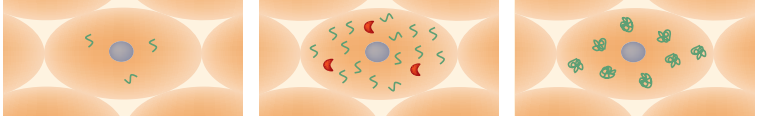
Scientists think self-cannibalism may keep cells healthy by clearing away junk that might otherwise poison or damage the cell and its DNA. Or as Eileen White, a cancer biologist at the Cancer Institute of New Jersey and Rutgers University in New Brunswick, puts it: "The cleaning crew is out full blast mopping up all the garbage and keeping cells pristine."

When the cleaning crew goes on strike or otherwise falls down on the job, a buildup of toxic cellular garbage can either kill cells or damage them in ways that lead to cancer.

But once a person has cancer, starvation and the resulting autophagy can become part of the problem. Cancer cells at the center of a tumor can be constantly hungry if they are cut off from nutrients in the blood. Those starving cancer cells inside tumors use autophagy as a survival mechanism, White says. The cells become very tough to kill when they dine on themselves, and they can start growing like crazy when more food becomes available, such as when tumors grow blood vessels or when

Feast or famine Finding the right balance of autophagy may be crucial for preventing and treating a range of diseases. In some cases, more autophagy is better; in others, less is more.

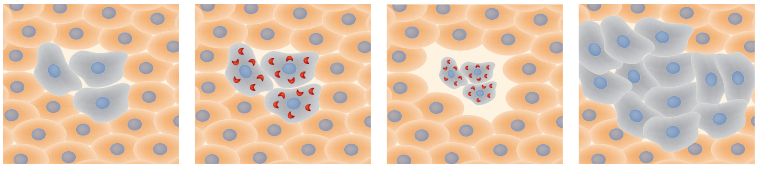
Parkinson's disease



Treatment: Increase autophagy

In people with Parkinson's, a protein called alpha-synuclein (green) builds up in the brain. Without enough autophagosomes (red) to dispose of the protein, it can accumulate to toxic levels and poison the self-eating system. Boosting autophagy might help clear the plaques and reduce damage.

Cancer



Treatment: Decrease autophagy

Autophagy can keep a cell on the straight-and-narrow, but once cells turn cancerous (gray), they can survive by eating themselves. They get smaller and then go dormant, but can rebound quickly when conditions improve. Reducing autophagy may stop cancer cells from hijacking the system.

T. DUBÉ

cancer cells escape from the main tumor.

To get some clues about how tough a hungry cancer call can be, White and her colleagues made cells unable to commit suicide, a hallmark of cancer cells. Then the team starved the cells.

Even cells that can't kill themselves would die eventually if they didn't get enough nutrients, the researchers thought. But in the lab, these cancerlike cells seemed to do just fine without food. "When we looked at them closely, we realized they were eating themselves," White says.

As these starving cells munched away on themselves, becoming smaller and smaller, they eventually went dormant, existing but not doing much else. That dormant state can last a week or a month, depending on the type of cell, White says. But when the cells were no longer under so much stress, they rebounded and began growing again.

Cancer cells in the body may use a similar strategy to hide and ride out tough times, then cause a relapse later. "These are what we call the oncology horror movies," White says.

Although scenes of hungry zombie tumors rising from the dead are terrible, scientists aren't throwing their hands over their faces and cowering. Instead, researchers are experimenting with therapies that may ruin cancer cells' self-eating picnics. Clinical trials are currently under way to determine if drugs that block autophagy, such as hydroxychloroquine, can make cancer cells more vulnerable to chemotherapy.

Balance for the brain

Controlling autophagy may also be the key to quashing neurodegenerative diseases. Though researchers have known that autophagy is messed up in several neuron-killing diseases, only recently have the details come to light.

"In many of these diseases we're getting some quite good clues about what is going wrong when," says David Rubinsztein of the Cambridge Institute for Medical Research and Cambridge University in England.

For instance, in Parkinson's disease globs of a protein called alpha-synuclein build up in the cell and stop autophagosomes from swallowing, Rubinsztein and his colleagues reported last year in the *Journal of Cell Biology*. With the cell's chomping abilities lost, the toxic protein continues to build up, eventually leading to the death of the cell. The same is true of Huntington's disease: Autophagy can't do its part because of toxic levels of the huntingtin protein, Rubinsztein and others have found.

Boosting the amount of autophagy could overcome these defects and possibly prevent or slow the disease. In fact, researchers are beginning clinical trials to see if autophagy boosters, such as a drug for high blood pressure called rilmenidine, can head off Huntington's disease. Last year Rubinsztein and his colleagues reported in *Human Molecular Genetics* that rilmenidine successfully treated Huntington's in mice. If clinical trials in people also work, the drugs may be tested on Parkinson's disease patients too.

Alzheimer's patients might need to do just the opposite — inhibit autophagy. As people age, autophagy in their brain cells slows down, Marta Lipinski of Harvard Medical School and colleagues showed in a study published last year in the *Proceedings of the National Academy of Sciences*. But people with Alzheimer's disease had much more autophagy activity in their brain cells, the team found. The increased activity could be the cells' attempt to dispose of a cell-killing protein that has been linked to the disease, known as amyloid-beta (*SN: 8/16/08, p. 20; SN: 3/12/11, p. 24*).

Although the A-beta protein stimulates cells to make autophagosomes, it also prevents the autophagosomes from properly fusing with lysosomes, the cellular equivalent of choking on food, meaning it never reaches the stomach to get digested. Having too many autophagosomes sitting around may interfere with other important cellular functions.

"We call this the clogged toilet model," Lipinski says. "Flushing a toilet is generally a good thing ... but if the toilet is clogged, flushing is not a good idea anymore."

In her team's study, some Alzheimer's drugs decreased autophagy in the cells. This may have reduced stress by preventing indigestible autophagosomes from building up, Lipinski speculates. The findings are still preliminary, she says, and much more work is needed before scientists can say exactly how A-beta leads to cellular indigestion and whether reducing levels of self-cannibalism might be helpful.

A full understanding of why some cells become overly cannibalistic — and why some don't eat enough of themselves — still requires more research into exactly how autophagy works. Unanswered questions still linger, such as how cells know when it's mealtime and where the membranes that form the autophagosomes come from. Scientists also aren't sure how cells decide when they've eaten enough and the details behind laying down the self-eating fork.

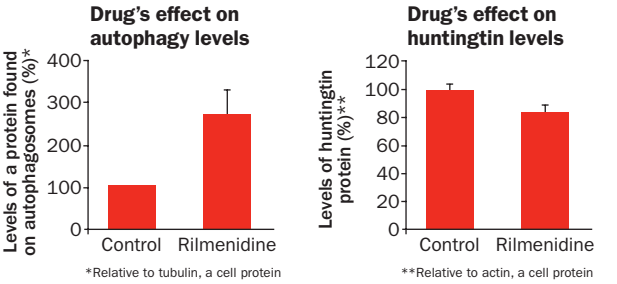
But progress is being made, and soon enough, scientists may have a more complete profile of the inner Hannibal Lecter — and a better idea of when the cannibal should be unleashed. ■

Explore more

- Rebecca Banerjee *et al*. "Autophagy in neurodegenerative disorders." *Trends in Neurosciences*. December 2010.

Dialed up Researchers have found that a drug for high blood pressure boosts autophagy in mice with Huntington's disease, decreasing levels of the toxic huntingtin protein. Scientists aren't sure if the drug works in people.

SOURCE: CLAUDIA ROSE *ET AL*/ *HUMAN MOLECULAR GENETICS* 2010



Ice in Motion

As frozen lands disintegrate, researchers rush to catch the collapse

By Alexandra Witze

Jason Box spent the summer of 2009 waiting for Greenland's Petermann Glacier to break apart. Everything signaled the glacier was ready to go. Melt ponds were pooling on its surface, and massive cracks were opening on the icy tongue that stretched offshore into Baffin Bay. Box, a glaciologist at Ohio State University in Columbus, spent two months on a ship, his cameras trained on the volatile edge where ice meets ocean. He was determined to catch Petermann in the act.

As luck would have it, the glacier held out one more year. When Box wasn't looking, on August 4, 2010, a piece of ice four times the size of Manhattan broke off. It was the largest iceberg to calve in the Arctic since 1962.

The world's frozen places are full of glaciers like Petermann, slow-moving rivers of ice flowing into the ocean and poised on the edge between stability and collapse. In recent years, many of these volatile glaciers have spit out more and more chunks of ice to float away as icebergs and then melt. The more icebergs a glacier discharges, the faster it tends to move, thin and retreat away from the coast.

Scientists say that understanding the processes that control ice's march to the sea, known as "ice dynamics," is crucial for understanding the future of the planet's great ice sheets atop Greenland and Antarctica. Were it all to melt, there's more than enough ice there to raise sea level by 67 meters.

A complete meltdown isn't likely, even centuries from now. But many researchers worry that Greenland and parts of Antarctica could soon contribute more to rising sea level, as temperatures are increasing fastest in those regions. And a small difference — say a foot of sea level rise, versus a meter — could mean the difference between much of Miami staying above water or going under in the next century or two.

As ice melts, water trickling through the remaining ice affects how quickly a glacier moves and breaks apart. To better understand and forecast such effects, researchers are targeting a few key outlet glaciers, which funnel ice from the high frozen interior into the oceans. By peppering these glaciers with instruments to measure their flow, cameras to photograph their every move, and even underwater submersibles to test the surrounding oceans, scientists hope to learn what drives the ice.

"We know that outlet glaciers are complex and dynamic and important," says Leigh Stearns, a glaciologist at the University of Kansas in Lawrence. "We need to pick a few locations and understand them there."

In Greenland, for instance, research is showing how warm ocean waters can affect the terminus, or end, of a glacier at the coastline. In Antarctica, scientists have found that the 2002 breakup of a major floating ice shelf — Petermann, supersized — caused the glaciers flowing into it to speed up. Together, such studies are revealing the mercurial nature of Earth's icy realms.

Slip sliding away

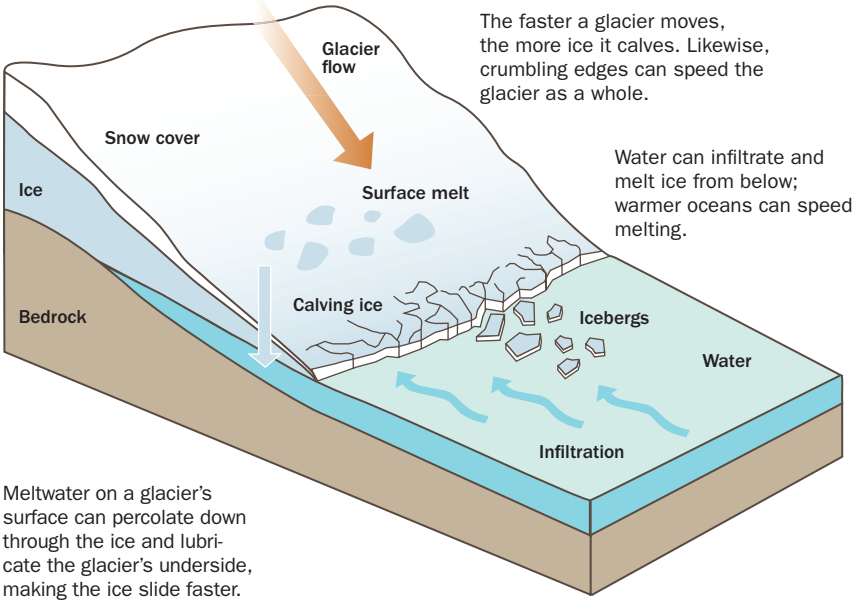
Because of ice dynamics, Greenland loses as much ice each year as is contained in the entire Alps. Within Greenland, perhaps no glacier is more responsible for that ice loss than Jakobshavn Isbrae, on the island's west coast. As glaciers go, it's one of the world's fastest, with ice flowing up to 14 kilometers per year — fast enough that you can see it move.

Jakobshavn is one of Greenland's biggest outlet glaciers and has been spitting ice into the ocean for a long time; scientists consider it the likely source of the iceberg that sank the Titanic in 1912. But after 1997 something funny happened. The glacier began thinning rapidly and accelerating. The faster it moved, the more ice it coughed out, causing its terminus to retreat back farther onto land. "That thing is in a death spiral," says Ian Howat, another glaciologist at Ohio State.

In part, that's because the once-large ice shelf that disintegrated at Jakobshavn's terminus removed the physical support that had held the glacier back like a buttress. But that isn't the whole story, researchers are finding. "You really can't explain all of the speedup by a loss of ice shelf," says Ian Joughin, a remote-sensing expert at the University of Washington in Seattle.

The glacier may also be undergoing changes in internal stress upstream and

How glaciers flow Glaciers are slow-moving rivers of ice, pulled downhill by gravity. If a glacier meets water, some of the ice breaks off as icebergs. In a stable glacier, this calving of icebergs is roughly in balance with snowfall. But there are several ways to speed up a glacier, as shown below.



Meltwater on a glacier's surface can percolate down through the ice and lubricate the glacier's underside, making the ice slide faster.

The biggest Arctic iceberg in five decades (circled) broke off Greenland's Petermann Glacier on August 4, 2010.

FACING PAGE: NASA; THIS PAGE: JANEL KILEY

may be slipping more across the bedrock at its base. Studies in recent summers have shown how meltwater forms ponds on the surfaces of glaciers, then percolates down through cracks to help lubricate the ice's mighty grind toward the ocean. In 2008 Alberto Behar of NASA's Jet Propulsion Laboratory in Pasadena, Calif., even dropped a flock of 90 rubber ducks into watery tunnels atop Jakobshavn to see if the toys would track the flow all the way through the glacier and out into the ocean. (So far, no luck.)

In a step up in instrument sophistication, Joughin and colleagues have been using radar from airplane surveys and satellites to track Jakobshavn's speed. The glacier speeds up and slows down seasonally, but between 2004 and 2010 it accelerated some 2 to 5 percent, Joughin reported in December in San Francisco at a meeting of the American Geophysical Union. At that rate, he said, the glacier should back away from the ocean entirely and end on land in roughly a century.

On the other side of Greenland, its eastern coast, researchers are studding instruments all over another accelerating glacier and the waters into which it flows. Helheim Glacier, also one of Greenland's largest, began speeding up along with others in the southeastern part of the island in the early 2000s. Helheim has since slowed down and, in fact, gained mass over the last decade — about 26 billion metric tons, says Howat, who presented the data in Maryland in January at a planning meeting for Greenland researchers. Compare that with Jakobshavn, which lost nearly 300 billion tons over the same period, and it's clear that Greenland's glaciers can behave in different ways.

Helheim continues to belch ice into a fjord called Sermilik, now the target of a major scientific push. The goal is to understand how Helheim's snout melts when it hits the water. Such ice-ocean interactions are one of the hottest topics in glaciology today. "We'd like to know how much ice is discharging from the glacier high up, versus how much is melting actively at the front," says Stearns.

> "It's like putting an ice cube in a relatively warm bathtub."
> FIAMMETTA STRANEO

For the past three summers, Fiammetta Straneo of the Woods Hole Oceanographic Institution in Massachusetts and her colleagues have been dodging icebergs to drop long instrument-laden cables into Sermilik's waters. The scientists also charter helicopters to fly above the glacier's snout and let instruments fall atop the ever-moving ice. Each year the researchers yank up the cables, pick up any remaining instruments and deploy new ones.

In a surprise, Straneo's team found that warm waters penetrated into the fjord after diverting from their usual path about 150 kilometers offshore. "The waters outside of Sermilik are some of the warmest ocean waters you will find around Greenland," Straneo says.

These waters come all the way from the subtropics, her team reported in 2010 in *Nature Geoscience*, and measure about 4° Celsius. Compared to ice, that's warm. "It's like putting an ice cube in a relatively warm bathtub," says Straneo.

The studies are showing just how important water circulation is to the behavior of glaciers that flow into that water. But many mysteries remain. For instance, warmer temperatures in the fjord occur in the winter, says Stearns, but the glacier still goes faster in the summer.

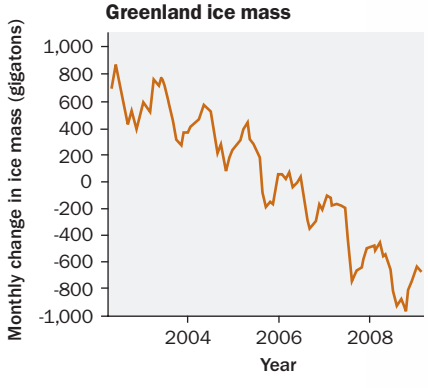
Ice down under

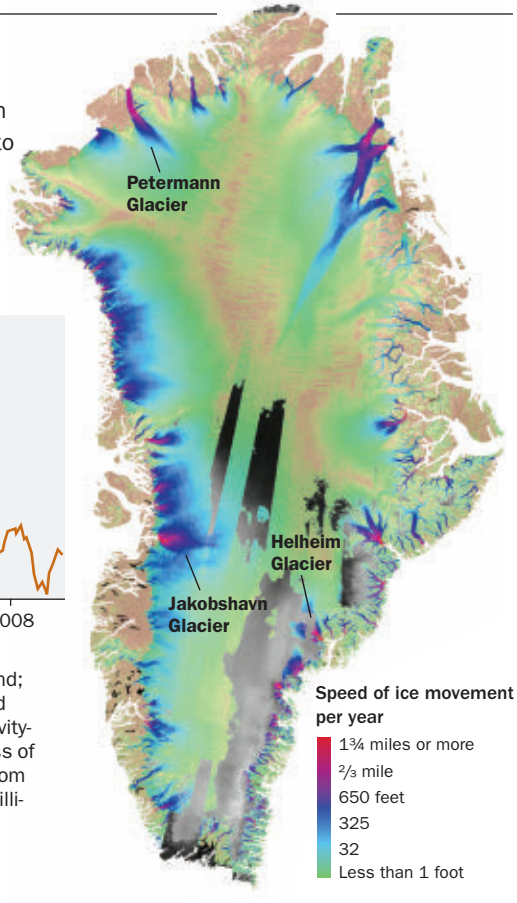
Warm water is also being fingered as a suspect in a case of meltdown much farther south: the Pine Island Glacier, which helps drain Antarctica's frozen interior.

Parts of the Antarctic ice sheet have been gaining mass in recent years, as more snow falls there and compresses down to ice. But the U.S.-German GRACE gravity-measuring satellites, among others, have shown that overall Antarctica is losing mass. And Pine Island is the biggest loser on the continent. Its narrow floating ice shelf has

Glacial speed

Greenland's massive ice sheet is shrinking because of a combination of ice sloughing off more quickly into the ocean (speeds shown at right) and melting from rising Arctic temperatures.





Ice covers about 80 percent of Greenland; were it all to melt, global sea level would rise about seven meters. Data from gravity-measuring satellites (above) show a loss of ice in recent years. Currently, ice loss from Greenland is responsible for nearly 1 millimeter of sea level rise per year.

SOURCE: I. VELICOGNA *ET AL*/ *GEOPHYSICAL RESEARCH LETTERS* 2009

MAP: I. JOUGHIN; CHART: JANEL KILEY

been thinning and retreating rapidly over the last few decades.

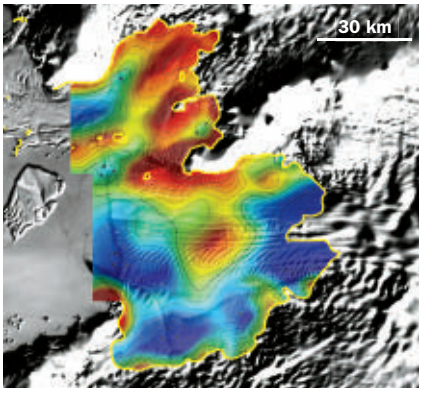
Two years ago, the British Antarctic Survey sent an unmanned submersible called Autosub3 swimming under the Pine Island Glacier's floating tongue. There the robot discovered an underwater ridge running along the seafloor perpendicular to the glacier. Until recently, the glacier was grounded on this ridge, which stabilized it, researchers reported last year in *Nature Geoscience*. But now the glacier has retreated behind the ridge, where the bottom of the ice is exposed to much deeper water circulation that can erode it further.

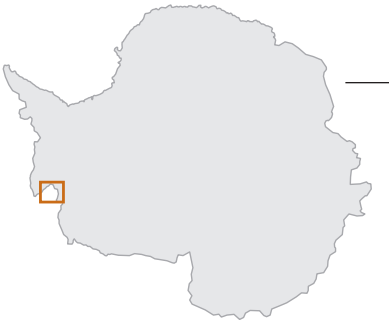
Also last year, scientists flying as part of NASA's IceBridge mission — a series of plane flights over the polar regions to gather data — discovered an underwater channel that diverts water around one end of the same ridge. This channel could allow warm water from offshore, pushed by Antarctica's counterclockwise winds, to flow up under the glacier, the researchers reported at the geophysics meeting in San Francisco. "It really melts the ice at high rates," says glaciologist Robert Bindschadler of the University of Maryland Baltimore County.

Bindschadler and his colleagues have been schlepping research equipment and supplies closer to Pine Island in preparation for a full-out push on the glacier late this year. The scientists plan to take the best measurements yet of the shape of its tongue of floating ice and the water underneath, including by drilling through the ice to get to the water below. If Pine Island were to disintegrate further, it might release pressure holding back much of Antarctica's ice and allow even more to flow out, like popping the cork on a bottle of champagne.

"This is something we are really concerned about," says Michael Studinger, IceBridge's chief scientist and a researcher at Lamont-Doherty Earth Observatory in Palisades, N.Y. "There is tremendous potential for rapid drainage of large parts of the West Antarctic ice sheet."

"Potential" remains a key disclaimer, however. One recent study suggests that despite its recent acceleration, Pine Island may have stabilized its speed for now. "Our model indicates substantial, but not catastrophic, loss from Pine Island over the next century," says Joughin, whose paper appeared in October in *Geophysical Research Letters*.





Antarctica's Pine Island Glacier (location above) drains the continent's frozen interior. A sinuous channel (blue, at left) lets warm ocean water melt the glacier (flowing from the right) from below.

After Pine Island, the next biggest loser in Antarctica is the Antarctic Peninsula, a narrow spit of land that stretches up toward Chile and has warmed 2.5 degrees Celsius in the last half-century. Along the eastern side of the peninsula, a major ice shelf known as Larsen A disintegrated in 1995. An adjacent one to its south, called Larsen B, went in 2002, removing an area of ice the size of Rhode Island in a single summer. Now researchers are closely watching the southern fringe of what's left, the still-standing and largest of all, Larsen C.

Scientists are also watching what the removal of Larsen A and Larsen B did to the glaciers that fed them. New calculations show that between 2001 and 2006 those glaciers were responsible for about one-third of the ice lost from the Antarctic peninsula, says Ted Scambos, a glaciologist at the National Snow and Ice Data Center in Boulder, Colo. "It tells us Antarctica is vulnerable," he says.

Ice shelves disintegrate when crevasses form on their tops and then widen into cracks that are too big to reseal themselves during winter. In summer, as the ice surface melts, water begins ponding and filling these cracks, and the water pressure serves to widen the crack and keep it propagating. "Some shelves go for years with water on the surface, but then in one particular year you get that disintegration," says Scambos.

Hoping to catch one in the act, Scambos and his colleagues have targeted a part of Larsen C known as Scar Inlet. The team put a sophisticated measuring station, bristling with cameras and other instruments, on the floating ice of Scar Inlet itself, as well as another on the glacier feeding it. If the Antarctic peninsula gets a particularly warm summer in the next couple of years, the team expects to be able to watch Scar Inlet disintegrate. If so, the glaciers feeding the Larsen area may speed up even more, thus accelerating the rate at which ice is dumped into the ocean.

One thing is certain about glacier studies in a warming world: There's plenty of job security. "The events in the '90s and this past decade suddenly showed us lots of things to focus on," says Scambos. Events like Greenland glaciers accelerating and the Larsen ice shelves disintegrating "all told us what the important precursors were before you saw a great big change," he says. Now scientists have the data to start understanding how those precursors lead to change.

"We're definitely moving from the realm of observation to the realm of prediction, and that's the goal," says Howat. What matters in the end is not the details of a particular glacier in Antarctica, but what that means for people living along coasts. From a practical perspective, he says, "we don't really care what the ice sheet's doing now. We want to know what it'll be doing in 100 years." ■

Explore more

- State of the Cryosphere website: http://nsidc.org/sotc/

IMAGE: NASA; MAP: GEOATLAS/GRAPH-OGRE, ADAPTED BY JANEL KILEY

Better by Design

Avoiding undesirable traits from the start could help chemists make molecules less meddlesome

By Rachel Ehrenberg

Chemistry is all about sparks — bonds break, beakers bubble, reactions rule. But a growing number of researchers are obsessed with chemistry's quieter side. Rather than vigor and vim, they seek a calm predictability.

These scientists are calling for a new approach to chemical design: They want compounds that do one job well — whether rubber that bounces back or nail polish that shines — but the action needs to end there. No multitasking, thank you very much.

Many of today's chemicals — in packaging, cleaning products, furniture and elsewhere — go where they should not go and do more than they were designed to do. Bisphenol A, a common ingredient in polycarbonate plastics, has made headlines for getting into the body and interfering with tissue development and function (*SN: 7/18/09, p. 5*). Flame retardants new and old persist in the environment, contaminating soil, waterways and wildlife (*SN: 4/24/10, p. 12*). And a new analysis, reported online January 14 in *Environmental Health Perspectives*, finds that the blood and urine of 99 percent of pregnant American women tested contain a laundry list of chemical interlopers, including various PCBs, pesticides, PFCs, PBDEs, phthalates and the rocket-fuel ingredient perchlorate.

Unless there is a fundamental shift in the way that chemicals are created from the outset, the next generation of compounds will probably be just as meddlesome, says Michael Wilson, associate director of the green chemistry center at the University of California, Berkeley. Currently more than 30 million metric tons of chemicals are produced in or imported to the United States each day, a quantity that would fill a line of tanker trucks 10,000 miles long. And industrial chemical production is expected to double in the next quarter century, outpacing population growth.

Ensuring that tomorrow's molecules are more mild-mannered than today's is doable, Adelina Voutchkova of Yale University's green chemistry center and colleagues argued last year in *Chemical Reviews*. (One of the paper's coauthors is Paul Anastas, known widely as the father of green chemistry.) Chemists have long designed compounds to have specific properties, Voutchkova says. The same chemists should be able to design compounds that *lack* unwanted properties.

An analysis published in *Tetrahedron* last year suggests that it is possible to identify the traits that help chemicals get through cell membranes and gum up cellular machinery. Using existing data on the personalities of more than 500 known toxic chemicals and an additional 130,000-plus commercial chemicals, Voutchkova's team came up with a set of parameters for predicting qualities that new compounds would ideally lack.

Some of the toxic compounds, for example, had atoms in tight three- or four-member rings, an awkward conformation that can make the chemicals highly reactive and more likely to inflict cellular damage than those with larger rings.

Of course, lacking small rings doesn't ensure harmlessness. Like setting up a friend on a blind date, fulfilling negative requirements such as "no musicians" or "not an urbanite" doesn't necessarily make for good chemistry. But the assessment suggests that when traits are taken together, there is a relatively well-defined plain-Jane "chemical space" where compounds that tend to behave themselves can be found.

"We are trying to give chemists a tool that says, 'OK, rationally, when I look at this new molecule that I haven't seen before, can I assess how likely is it to be absorbed by the body?'" says Voutchkova. "We hope in five to 10 years that companies will have some rational strategies for finding safe alternatives as opposed to finding them by chance."

A host of everyday products, from plastic bottles to flame retardants applied to fabrics, could be designed to be more safe for people, chemists argue.

TOP, BACKGROUND: DONALD SAWVEL/SHUTTERSTOCK; COMPASS: ANTHIACUMMING/ISTOCKPHOTO; PENCIL: CRACKERCLIPS/ISTOCKPHOTO; BOTTOM, CLOCKWISE FROM TOP LEFT: ANDRE BLAIS/SHUTTERSTOCK; JOHN HURST/SHUTTERSTOCK; DOROO/ISTOCKPHOTO; PALABRA/SHUTTERSTOCK

Do not enter

Little is left to chance in the pharmaceutical industry, in which chemists are adept at creating molecules to push biological buttons. A metric known as "Lipinski's rule of five" is commonly used in drug design to figure out if a compound taken orally is biologically active and therefore a good drug candidate.

"We're basically turning that on its head," says Julie Zimmerman, also of Yale and a coauthor of the paper in *Tetrahedron*. The physical and chemical properties that give molecules access to people's cells can be flipped to prevent access, or to minimize activity if a compound ends up where it shouldn't.

Simple traits such as molecular weight and solubility strongly influence whether a compound will even get into the body — the way height and weight constraints keep adults off of kiddie roller coasters. Inhaled particles larger than 1 micrometer across are less likely to be absorbed into the blood via the lungs. Particles reaching about 5 micrometers or greater will most likely be absorbed by the mucous layer or caught in the throat passage and then swallowed. For particles that make it into the GI tract, having a lot of positive or negative electrical charge can influence absorption.

And shape alone can reveal a lot about how harmful a molecule will be if it does make it into the body, Zimmerman says. If a new compound has a molecular arm that can swat an estrogen receptor, for example, it may meddle with hormonal signaling. The strength of the carbon-hydrogen bonds can help predict whether a compound will interact with enzymes that often kick off the first round of metabolism in humans.

A growing body of data illustrates how tweaking a delinquent compound's shape can rehabilitate it, Voutchkova says. A widely used herbicide known as Paraquat was found to cause serious damage when it accumulated in the lungs. Lung cells are particularly good at transporting certain nitrogen-containing compounds across membranes. A slight tweak brought the chemical's two nitrogens closer together and the altered version, called Diquat, is much less attractive to lung cells.

Switching where the atoms in a chemical link up may also alter behavior. Two molecules that are found in airborne particulates look identical except for which carbon a nitrogen bonds to. Yet the molecules differ vastly in their ability to sabotage DNA, an international team of researchers reported last July in *Chemical Research in Toxicology*.

Made to fade

Whether or not a compound will break down easily and safely in the environment can also be discerned from its molecular structure, says Robert Boethling of the U.S. Environmental Protection Agency's Office of Pollution Prevention and Toxics. Boethling has been reviewing musk compounds as part of a larger effort to identify molecular traits that influence how well a compound biodegrades.

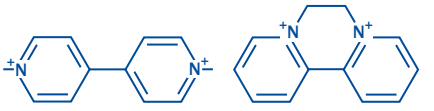
Valued by the perfume industry for its penetrating odor, real musk comes from a sac beneath the abdominal skin of the male musk deer and has an oxygen that helps get the breakdown process going. But cheaper synthetic versions have come into widespread use. Members of one class, the nitro-musks, are ringed structures dotted with nitrogen groups.

"A person wishing to design non-persistent chemicals would have looked at that from the very beginning, from the pencil-and-paper stage, and said, forget it," Boethling says. "It's not going to degrade."

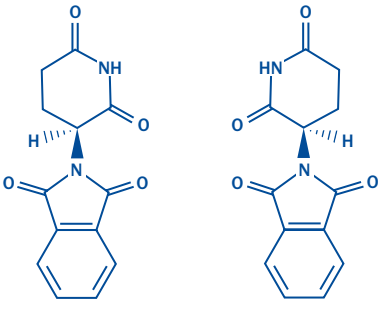
Zimmerman, Voutchkova and others hope that if chemists are made aware of traits such as toxicity and biodegradability, such unfavorable compounds won't make it past the drawing board. "Chemists are actually pretty good at designing for properties — making things that are red, for example, or taste a certain way," says Zimmerman.

Designing a compound with features that make it friendly to the body and the environment needs to become the status quo, Voutchkova says.

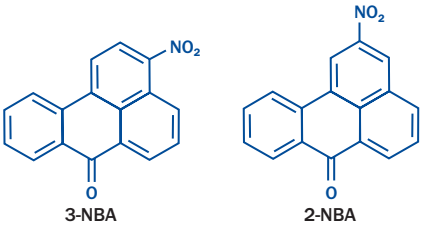
A tweak or two Simple changes to a molecule — shifting one bond or redistributing charges, for example — can affect how the compound interacts with the body.



A change that brings Paraquat's two nitrogens closer makes it less destructive to the lungs.



Changing the handedness of a molecule — turning it into its mirror image — can prevent it from interfering with important proteins.



A compound found in diesel exhaust is much less harmful when its nitrogen dioxide group attaches to a different spot on its carbon ring.

SOURCE: A. VOUTCHKOVA

Scientists outside of chemistry are eager to help. In a letter published March 4 in *Science*, eight scientific societies urge the EPA and the Food and Drug Administration to call on society members in other fields for expertise when assessing chemical risk and setting policy.

"Chemists are never trained to even think about what the consequences of a molecule might be," Voutchkova says. "We aren't trained to understand what the connection between structure, properties and biological effects might be — that's alarming to me." ■

Explore more

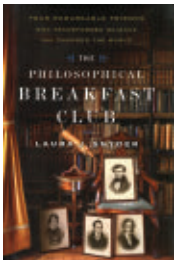
- EPA Design for the Environment program: www.epa.gov/dfe/

The Philosophical Breakfast Club

Laura J. Snyder

Modern science is a strange beast. Lab experiments, calculations and meticulous methods bind to abstract theories and revelations in a single pursuit. The rigorous side of this approach, Snyder argues, comes to today's science largely thanks to four Cambridge friends who in the 19th century faced a British science gone stagnant. In a wonderfully crafted story, she follows how the quartet helped to change the rich man's hobby into a professional field with a public responsibility.

These men — Charles Babbage, John Herschel, William Whewell and Richard Jones — fought to promote Francis Bacon's inductive method, which depended on data to form overarching theories. Trumpeting the call "knowledge is power," the friends sought to unwrap nature's secrets with man's reason. Astronomy, economics, computing and photography (among others) felt their genius. Herschel's chemical dabbling pinpointed a solution that preserved images "painted by the light" on treated paper, while Whewell began the systematic study of the Earth's tides and coined the term *scientist*.



The book is far more than a tale of discoveries. A philosopher of science, Snyder writes with the depth of a scholar and the beauty of a novelist. She connects personal and professional histories into balanced conclusions and poignant scenes, such as Herschel's New Year's Eve farewell to his father's famous telescope, when he and his family gathered in the 4-foot-wide tube to sing a requiem before the instrument was closed up forever.

While the theme-based organization muddles the timeline, it sets the reader firmly in cultural and scientific contexts. The book is a worthwhile read for anyone interested in the history of science. — *Camille M. Carlisle*
Broadway, 2011, 439 p., $27.

Spacesuit: Fashioning Apollo

Nicholas de Monchaux

When Neil Armstrong took his first steps on the moon in July 1969, he wore a spacesuit fashioned by Playtex, the bra and girdle company. Playtex seamstresses assembled all the Apollo suits from 21 layers of flexible fabric, latex and reinforcements — a design that won out over the armorlike suits of interlocking components that military-industrial contractors were offering.

In 21 chapters, one for each layer, de Monchaux, an architecture professor at the University of California, Berkeley, makes the case that spacesuit design reflected changing ideas at the time about architecture, fashion and popular culture.

Many of the chapters meander from the spacesuit's story, but the pace picks up when de Monchaux focuses on Playtex's struggle to convince NASA to accept its softer, nontraditional design. Other companies in the late 1950s had taken a different tack — proposing to modify the human body to allow for space exploration. But "again and again, the human body resisted such encroachments," the author contends.

Each Apollo suit was custom-fitted, so every alteration required a new fitting. When astronauts complained about rough interior surfaces, Playtex added a layer of fuzzy girdle liner. In the end, the comfort and ease of movement provided by the suits won NASA over.

As well as the astronauts. When astronauts come to Washington, D.C., de Monchaux notes, they flock not to the Smithsonian's vast Air and Space Museum, but to a warehouse in suburban Maryland. There they view what was once their second skin: the surviving Apollo spacesuits. — *Ron Cowen*
MIT Press, 2011, 250 p., $34.95.

The Clockwork Universe

Edward Dolnick

This absorbing tale, set in the 17th century, recounts how Isaac Newton and the founders of the Royal Society described the order of the universe. *Harper, 2011, 378 p., $27.99.*

How We Age

Marc E. Agronin

A young doctor reflects on lessons learned about life and medicine as a psychiatrist in a Miami nursing home. *Da Capo, 2011, 320 p., $25.*

Life in a Shell

Donald C. Jackson

A physiologist shows how shells have helped turtles survive virtually unchanged for 220 million years. *Harvard Univ. Press, 2011, 178 p., $29.95.*

What Are Gamma-Ray Bursts?

Joshua S. Bloom

For readers willing to dive into (or skim past) a bit of math, this book surveys the latest research on these mysterious cosmic explosions. *Princeton Univ. Press, 2011, 256 p., $27.95.*

Rabbits: The Animal Answer Guide

Susan Lumpkin and John Seidensticker

Learn little-known facts about the familiar animals, whose 90 species include several of the world's most endangered. *Johns Hopkins Univ. Press, 2011, 235 p., $24.95.*

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The liver's carbon fixation

The possibility that insects can harness solar energy (*SN: 1/15/11, p. 8*) is no less fascinating than the ability of the mammalian liver to do the light-independent part of photosynthesis: carbon fixation. When concentrations of the amino acid methionine rise after a high-protein meal, the liver shifts gears to get rid of the excess via activation of a specific transmethylation pathway requiring the amino acid glycine as a methyl acceptor. This also sets in motion what I call the "glycine generator" — a short cycle involving two reversible folate-requiring enzymes cranking out two moles of glycine for each mole of serine, ammonia and carbon dioxide. Copying this aspect of nature on an industrial scale might enable the recycling of substantial amounts of carbon dioxide.

Joel Brind, New York, N.Y.

Brind is a professor of biology at Baruch College, the City University of New York.

Light on genetic dark matter

"Genetic dark matter" (*SN: 12/18/10, p. 18*) might be hiding in plain sight. For over two decades, abundant variation in the number of tandemly repeated units in microsatellite and minisatellite DNA has been used for genetic fingerprinting. For years, this variation has been widely regarded as functionally meaningless. For much of that time, several biologists (including myself) have hypothesized that such repeat-number variation might help account for heritable variation in certain traits.

Most such repeats are indeed found in genomic regions that lack known function. But among the hundreds of thousands of repeats scattered throughout the human genome are many that are closely associated with genes. Lots of genes, perhaps most, include at least one variable tandem repeat sequence at sites where the number of repeat units can influence gene function. Nevertheless, most attention (and most research investment) remains focused on single nucleotide polymorphisms (SNPs) for the very simple reason that collecting vast data sets on SNPs has become cheap and easy. Although surveying repeat number variation and linking this variation with phenotypic differences are technically challenging, biologists should not lose sight of this very visible source of heritable variation.

Science News has covered some of the relevant studies in past articles (*SN: 12/18/04, p. 387; SN: 1/31/09, p. 26*). The subject of repeat number variation might be suitable for an article that could shed light on many interrelated topics — triplet repeat diseases, evolutionary facilitation, molecular genetics, genomic diversity, etc.

David G. King, Carbondale, Ill.

King is an associate professor of zoology at Southern Illinois University.

Heartburn drugs' pros and cons

Nathan Seppa's article ("It's enough to give you heartburn," *SN: 12/4/10, p. 30*) edges toward tabloid in tone. Proton pump inhibitors and the like have saved many lives and reduced nearly to vanishing the need for peptic-ulcer surgery, and, as Seppa points out, are important in the control of common and dangerous gastroesophageal reflux disease. PPIs have proved remarkably well tolerated in general. Obviously, like all drugs, they should be used prudently.

That said, in addition to the unusual untoward effects of PPIs listed in the article, two more might be mentioned. Because hydrochloric acid is a first-line defender against gastrointestinal infection, the risks of other gastrointestinal infections besides *C. difficile* are likely increased. PPIs may also cause tubulointerstitial nephritis.

Harvey E. Finkel, Brookline, Mass.

Finkel is a physician.

Showing that overuse of drugs can be injurious to your health is not only important from the standpoint of an individual's risk, but also for the overwhelming bill for these drugs, paid sometimes by the individual and at other times by the insurer. There is always a risk-benefit ratio for drugs. Added to the equation should be the cost of profligate use of expensive drugs.

Nelson Marans, Silver Spring, Md.

One cat not lapping

One of my cats does not lap. She puts her paw in the water dish and then licks her paw. I have left your December 4 issue ("Cats lap liquids with a flick of the tongue and fluid dynamics," *SN: 12/4/10, p. 5*) open to the pictures of the cat drinking, so perhaps she will get the idea.

Emily Johnston, Westminster, Md.

Shell-less snails

In "Snails shed shells in one fell swoop" (*SN: 11/6/10, p. 9*), you describe an experiment in which baby snails exposed to the metal platinum develop without external shells. This is hypothesized as a rapid evolutionary mechanism that could explain such events as the transition from snails to slugs.

However, one must inquire whether the creatures' DNA was modified. If these newly shell-less snails were allowed to mature and procreate, would their progeny (in the absence of platinum) still develop shells? If so, then what we are observing is more akin to a birth defect, not evolution.

Irwin F. Kraus, Attleboro, Mass.

The scientists didn't demonstrate that the changes in snail body plan after exposure to platinum were heritable, and we don't know if the next generation would have had shells or not. What the study did show is that a drastic change in body plan doesn't necessarily result from slow, incremental changes — big shifts in development, however induced, can happen quickly. The work suggests that it's possible that some ancient snail could have acquired genetic mutations similar to those induced by the platinum that may have had a large effect on body plan and perhaps on snail and slug evolution. —Rachel Ehrenberg

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Subra Suresh

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Basic research generates jobs and competitiveness

Trained as a mechanical engineer in India, Subra Suresh researched the interfaces between engineering, biology and materials science before becoming dean of engineering at MIT and, as of October, director of the U.S. National Science Foundation. In February in Washington, D.C., at the annual meeting of the American Association for the Advancement of Science, Suresh laid out his vision for the agency he now leads, which has a $7 billion portfolio for funding basic research. Science News *contributing editor Alexandra Witze spoke with Suresh and compiled these comments from the interview and his lecture.*

What is the value of basic research in these tough economic times?

In her memoirs, former British prime minister Maggie Thatcher relates a story about a meeting between the formidable prime minister and statesman William Gladstone and the scientist Michael Faraday. When asked by Gladstone whether his research in electricity had any value, Faraday promptly replied: "Sir, one day you will tax it." How right he was. Our globe is now wired in ways Faraday could not have envisioned, giving us first heat and light, then power to fuel new industries and now the ability to communicate at the speed of light around the globe. The economic benefits flowing from Faraday's early experiments continue to provide returns. We now have an emerging industry based entirely on the smart grid; one estimate projects it will reach $34 billion worldwide by 2020.

Is the United States losing its competitive edge?

Other nations are investing heavily in science and engineering. The U.S. is not the world leader in terms of gross R&D expenditures relative to GDP.... U.S. students are not performing at the top of the charts in international math and science assessments. Foreign students who contribute significantly to the science and research enterprise at American universities and colleges have many more options to study and work in their home countries. These are all troubling signs.

Why should kids be inspired to go into science and technical fields?

Science and engineering are a ticket to prosperity. Look at rapidly growing economies like India and China. The middle class in India, in the last 17 years since India opened up economically, have moved up significantly — that's 350 million people, most through the IT industry. Take a place like MIT; most of the students come from middle-class backgrounds. Those are two powerful examples.

Science and engineering are also a way to address complex societal problems: water, energy, environment, transportation, you name it. The young generation, because of the Internet and other media, are not only interested in producing the next gadget or the next product — they are also very interested in changing the world. Science and engineering are a vehicle to do that.

We can understand the world, ourselves included, and with that knowledge help resolve the major dilemmas facing society today.

How are science and engineering jobs changing?

The number of scientists and engineers working for U.S. small businesses now nearly equals those working for large businesses, including the giants of American industry and technology. In fact, small businesses now employ more scientists and engineers than universities or government.

So what's out there waiting to be discovered?

We can understand the world, ourselves included, and with that knowledge help resolve the major dilemmas facing society today. In fact, the potential for new knowledge has never been greater.

We now ask questions we could not formulate and seek solutions to even a mere five or 10 years ago. We have already crossed a threshold of a new scientific revolution, one initiating a new era of observation. Think of Galileo's telescope or Leeuwenhoek's microscope. They opened vistas which had never before been imagined and profoundly changed how humans viewed the universe and their place within it.

Today telescopes, from the hills of Hawaii to the plains of Chile to the ice fields of Antarctica, give us new visions of the solar system and far beyond, to new planets.... At the scale of geologic time, we can now read millennia of climate data in the Antarctic ice. Observations at the nanoscale advance our capability to design and build materials one atom or molecule at a time.

These are critical times for us to speak with one voice about the significance of our work so that our voice is heard and our contributions to American prosperity, and global prosperity, are fully understood. ■

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If you or someone you love lives in a home with more than one floor, the staircase can be more than an inconvenience, it can be a health threat. Whether it's due to mobility issues or cardiac concerns, why risk your life climbing stairs when an easy solution is only a phone call away? You'll be surprised how easy, simple, and affordable this system is. It features a reliable, aircraft-grade cable drive that's been tested over 30,000 cycles, and comes with an exclusive lifetime warranty* on the drive train. Call our toll-free number now, and a friendly, knowledgeable product expert can answer all of your questions and help you get on the road to independence and safety in the home.

What to look for

Quality Construction and Dependability: Look for a cable drive system that uses high-grade cable. Go for one that has a weight capacity of at least 300 pounds. Has the product been tested over thousands and thousands of cycles?

Safety: Insist on built-in safety sensors to stop the chair upon encountering any obstruction. Make sure there's a swivel safety switch that prevents the lift from operating if you are not in the proper position. Don't forget the seat belt!

Flexibility: Look for a system that can be installed on either side of the staircase, a control that can be put on either side of the chair and has multiple call/send controls. There are systems out there that let you choose either AC or DC operation.

Warranty*: Some systems are backed by limited drive-train and parts warranties—why stop there? Insist on a lifetime warranty on the drive train.❖

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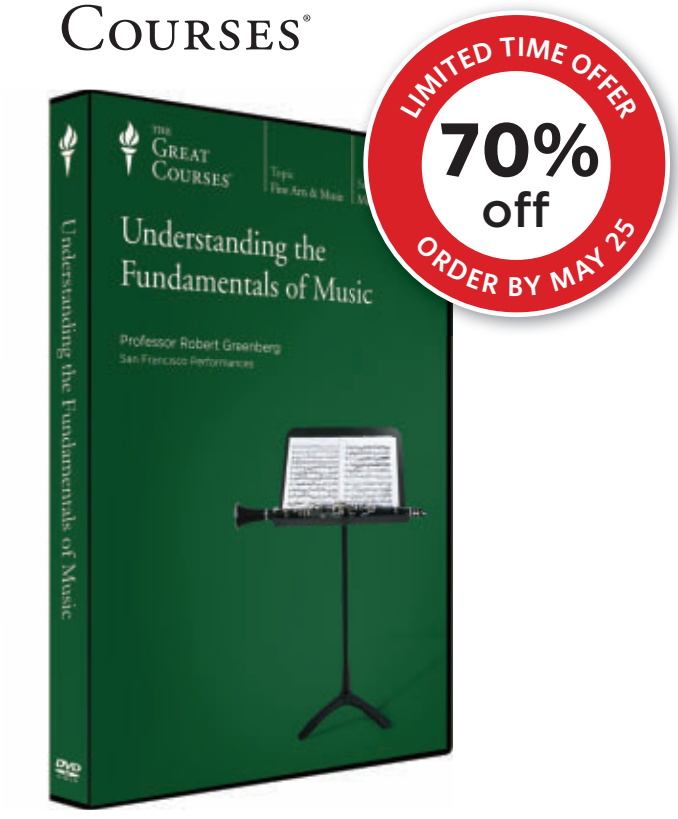

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