From Cut to Cancer | Baby's Bilingual Boost | Quantum Twirls

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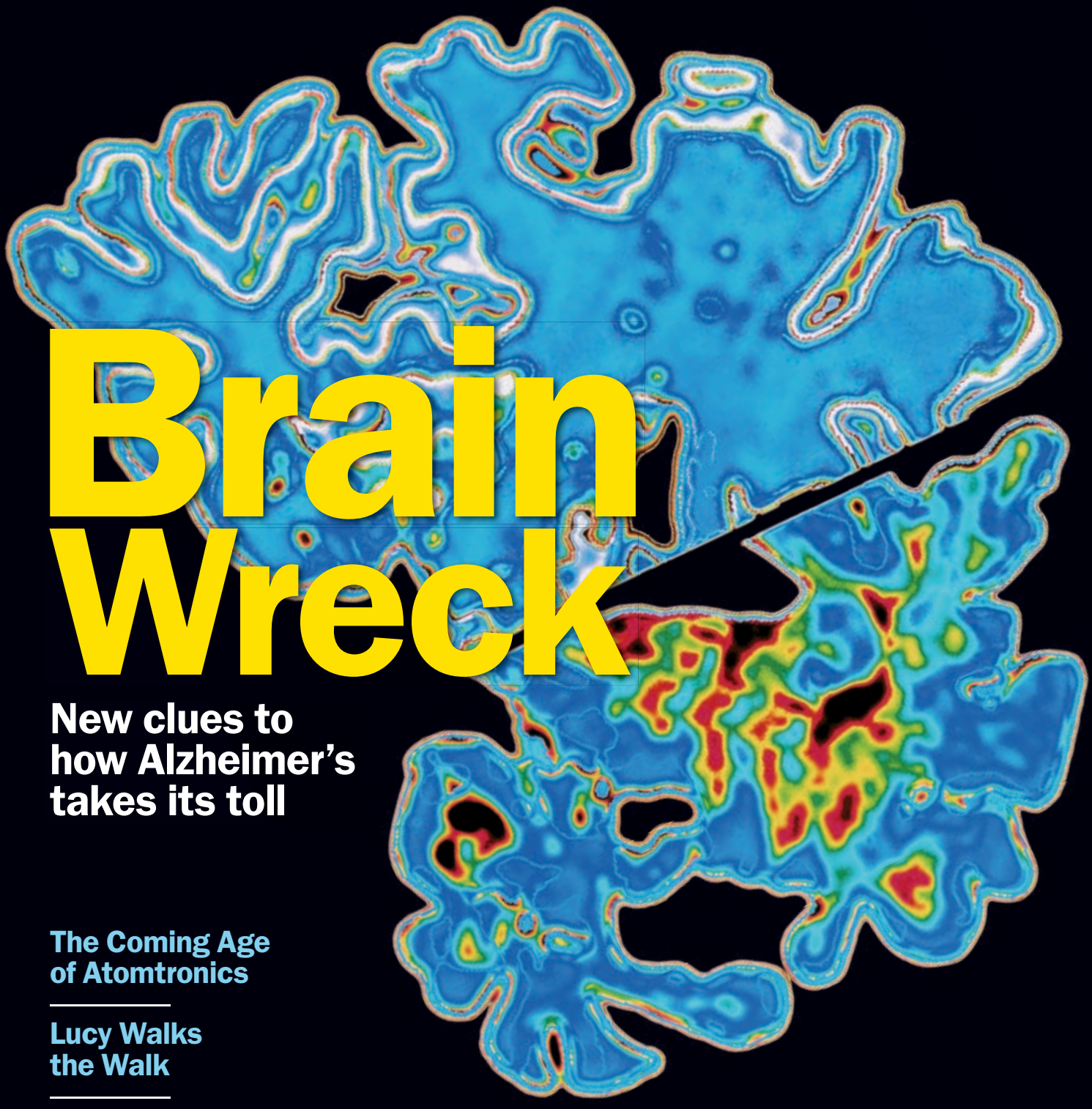
ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ MARCH 12, 2011



Brain Wreck

New clues to how Alzheimer's takes its toll

The Coming Age of Atomtronics

Lucy Walks the Walk

Twilight Triggers Coral Passion

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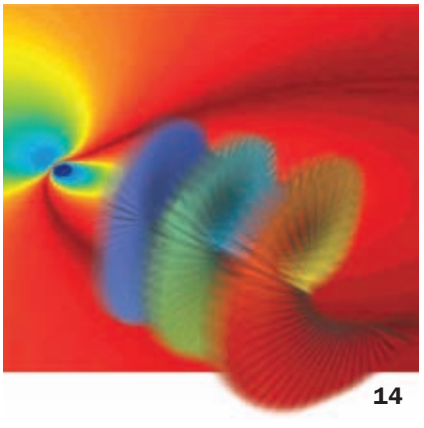
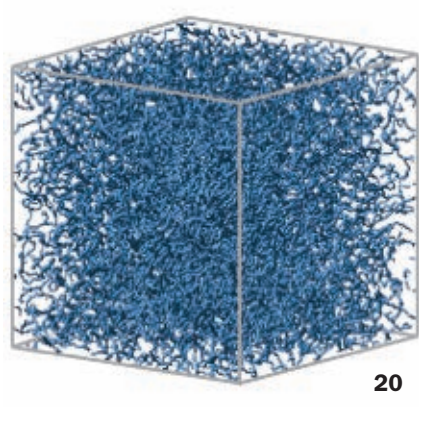




ScienceNews

In The News

5 STORY ONE
- Flowing atoms foreshadow an atomtronic future

8 HUMANS
- Lucy's walking prowess
- Neandertals lost footrace

9 GENES & CELLS
- Wounds trigger tumors in mice
- Gene for boosting blood sugar: good then, bad now

10 LIFE
- Blue cue for coral spawning
- Dissecting the flea's long jump
- Plant traps prey, and quickly

12 BODY & BRAIN
- Allergies may lower cancer risk
- In utero fix for spina bifida

13 MATTER & ENERGY
- Magnetic charges on the move
- Nanowire computer chip
- Imaging hydrogen atoms

14 ATOM & COSMOS
- New spin from black holes
- A comet in pictures

15 SCIENCE & SOCIETY
- R&D dollars in federal budget

16 AAAS MEETING
- Bilingual babies build brains
- Bears' energy-saving sleep
- Microbe-oil mix on Gulf floor
- Misbehavior, no remorse
- Self-healing batteries
- Logistics relief for disasters
- Meeting notes

Features

20 QUANTUM WHIRLS
After decades of waiting, scientists finally get a look at vanishing vortices and other strange behaviors of exotic matter.
By Marissa Cevallos

24 MEMORIES CAN'T WAIT
COVER STORY: New findings challenge the conventional wisdom about amyloid's role in Alzheimer's disease.
By Laura Sanders

Departments

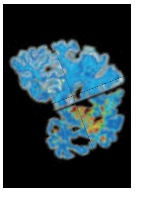
2 FROM THE EDITOR

4 NOTEBOOK

30 BOOKSHELF

30 FEEDBACK

32 COMMENT
Harvard theoretical physicist Lisa Randall discusses what the world's largest particle accelerator may reveal about how the universe is put together.



COVER Damage caused by Alzheimer's disease leaves a brain shrunken and lesion-filled (bottom) compared with a healthy brain (top).
Alfred Pasieka/Photo Researchers, Inc.

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FROM THE EDITOR

Nothing beats science for building your vocabulary

One of science's most entertaining features is its capacity for linguistic gymnastics.

Just imagine what it would be like if scientific advances had to confine themselves to descriptions using preexisting words. "Quarks" would have been called "little things inside atomic nuclei." "Lasers" would have been "emitters of really tightly focused beams of light produced by stimulating coherent radiation." "Antimatter" would have been "stuff to be really careful with."

Apart from being hard to fit in headlines in magazines, such terms would fail to capture the imaginative nuances of new discoveries, the leaps in knowledge that demand comparable lexicographical innovation. New ideas and new phenomena need new words.

Fortunately, scientists are almost always up to the task. Two recent examples are described in this issue by physical sciences writer Devin Powell.

One is the self-explanatory *atomtronics*, a word still too new to show up in Webster's although it appears occasionally in *Physical Review Letters*. By manipulating atoms supercooled into the weird quantum state known as a Bose-Einstein condensate, physicists have begun to create rudimentary analogs of electronic circuits, with the atoms playing the part of the electrons (see Page 5).

If that coinage isn't poetic enough for you, try *magnetricity*. It sounds a little like the name of a villain from the X-Men movies, but it's actually the magnetic version of electricity, recently demonstrated by a scientist at University College London and his collaborators. Their latest report (Page 13), building on work published in 2009, describes magnetic currents that last for minutes. In this case, the role of electrons in electric current is played by "magnetic monopoles" that move around by virtue of the shifting positions of atomic groupings in a crystalline material called spin ice. Someday, the researchers hope, magnetricity will spawn the related neologism *magnetronics*.

Whether *atomtronics* or *magnetronics* will ever achieve the linguistic notoriety — or economic impact — of *electronics* might not be known for decades. For that matter, some other new word might come along and outdo (or encompass) both of them. For just as science always seems to spawn surprising advances, the language also takes some unforeseen turns. After all, when J.J. Thomson discovered electrons in 1897, he called them corpuscles. — *Tom Siegfried, Editor in Chief*

B.C. ON C.D.

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About Your Professor

Dr. Ernest L. Martin is the author of over 200 special and theological studies, over 400 hours of recorded lectures, and numerous books on biblical, historical and archaeological topics. His wide-ranging research has been incorporated into such standard works as *Handbook of Biblical Chronology* and included in the "Star of Bethlehem" programs at planetariums worldwide. A much-sought-after lecturer, Dr. Martin's fast-paced and layman-oriented presentation style made him a popular speaker in both the US and Great Britain for over three decades.

"Martin's arguments are very persuasive."
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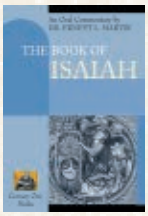
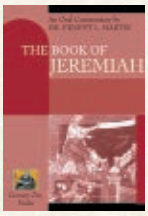
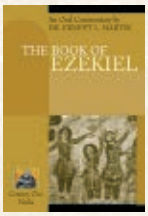


The Book of Isaiah - Set of 7 Audio CDs
Isaiah is the first and most famous of the Old Testament prophets. His long tenure with the kings of Judah foresaw the collapse of the Northern (ten tribes) Kingdom of Israel. This 7-hour presentation gives the listener an overview of the historical Isaiah and his prophetic relevance to modern times.



The Book of Jeremiah - Set of 4 Audio CDs.
Jeremiah lived at the time when many of Isaiah's utterances were coming to pass on the Kingdom of Judah. His narrative and prophecies are thoroughly covered, along with his relevance to us today.



The Book of Ezekiel - Set of 4 Audio CDs
Ezekiel prophesied in the early years of the Babylonian Exile (593 – 570 BC) and foresaw the fall and restoration of Israel. Ezekiel prophesied from Babylon at about the same time his contemporary Jeremiah was in Jerusalem. This 4-hour series gives the listener both historical background and examines in detail Ezekiel's many predictions for the future.

The Minor Prophets and Modern Times - Set of 14 Audio CDs.
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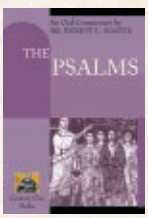

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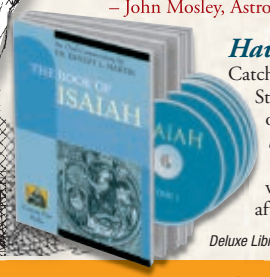

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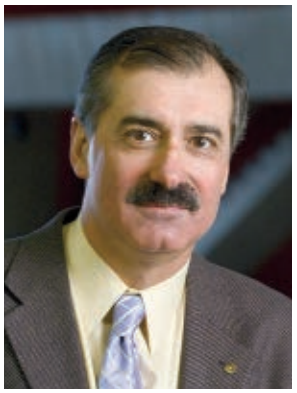

Scientific Observations

"I view the cosmological constant as the energy of the vacuum, or the energy of nothing. And thinking about nothing occupies a lot of people. I try to get my students to think about nothing; some of them are pretty good.... According to the principle of quantum uncertainty, particles and antiparticles can appear from the vacuum out of nothing [and] exist for a brief instant of time before disappearing into the vacuum. So nothing is something. Sort of a Zen-like quality to nothing." **—COSMOLOGIST ROCKY KOLB OF THE UNIVERSITY OF CHICAGO, AT THE AMERICAN ASTRONOMICAL SOCIETY MEETING IN JANUARY**

Science Past | FROM THE ISSUE OF MARCH 11, 1961

CHICKS LIKE BRIGHT COLORS — Chickens tend to like bright colors and dislike dull or drab colors and black, a poultry scientist said. However, chickens, like people, are individuals and also show individual preferences for different colors, Dr. George D. Quigley of the University of Maryland, College Park, Md., told *Science Service*. For instance, yellow is generally "disliked" by the chickens Dr. Quigley is testing for color recognition and preference. Nevertheless, some of the chickens apparently "think" it is prettier than all other colors by the preference they show for yellow. Dr. Quigley said he has had the nests of the chickens he is testing painted pink, red, blue, orange, yellow, tan, brown, black and metallic gray.... When the poultry scientist finds out where a hen lays its eggs the two nest boxes on either side of the one the hen uses are painted in colors different from the dull neutral gray of the unpainted nest. If the hen changes its egglaying to one of the painted nests, it has recognized the color and shown preference for it.

Science Future

March 15
Learn how brain-immune battles may lead to diseases like Alzheimer's. In Portland, Ore. Go to www.omsi.edu/events

March 15–27
The 19th annual Environmental Film Festival screens at venues across Washington, D.C. See www.dcenvironmentalfilmfest.org

March 21
Join science-minded chefs in exploring experimental gastronomy in New York City. Go to www.nyas.org/Events

March 25–July 6
In Los Angeles, view Small World photo-taken-through-a-microscope winners. See www.californiasciencecenter.org

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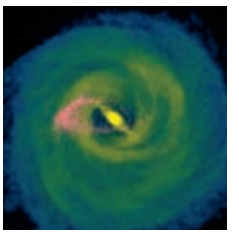
BODY & BRAIN
Neurons in prenatal brains as young as 20 weeks old fire like those in sleeping adults. Read "Brain cells start sending signals early."

ATOM & COSMOS
A frictionless fluid core may explain temperature changes in the youngest known neutron star. See "Supernova to superfluid."

Scientists spot stellar crumbs (pink) from the Milky Way's most recent bout of cosmic cannibalism. Read "Milky Way munched on galactic snack."



SCIENCE & SOCIETY
Video game consoles did 25 percent of the world's computing in 2007, a recent study concludes. See "The numbers prove it: This is a data age."

How Bizarre

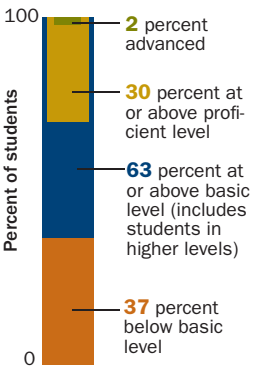
A long-standing perceptual illusion of objects' weights may be related to humankind's rise on Earth. Researchers have known for a while about the size-weight misperception, in which a person holding two objects of equal weight but different sizes thinks the smaller object weighs more. Now, Qin Zhu of the University of Wyoming and Geoffrey Bingham of Indiana University in Bloomington suggest that the illusion might actually be related to humans' unique ability to throw long distances, which many scientists argue helped *Homo sapiens* rise to dominance. The researchers suggest online January 12 in *Evolution and Human Behavior* that the weight illusion, which even toddlers experience, helps people pick good projectiles and marks a readiness for throwing akin to the readiness to learn language.

Science Stats | SCIENCE SCORES

Eighth-grader science proficiency, 2009

Sixty-three percent of eighth-graders in the United States performed at or above "basic level" on a science knowledge and skills test. Basic level required students to recognize the role of decomposers in an ecosystem and identify how some lunar surface features are formed, among other facts.

SOURCE: *NAEP SCIENCE 2009 REPORT CARD* 2011



CLOCKWISE FROM TOP LEFT: FERMILAB VISUAL MEDIA; ARMAN KHALATYAN/AIP; OLARU RADIAN-ALEXANDRU/SHUTTERSTOCK

“This work says that if you have a predisposition to getting cancer, wounding might enhance the chance that it will develop.”
—ANTHONY ORO, PAGE 9

In the News

Humans Bones inform on hominid gaits

Genes & Cells Wounds may spur tumors

Life Twilight hue may be coral spawning cue

Body & Brain More allergies, less cancer

Matter & Energy Promise of magnetricity

Atom & Cosmos Light-bending black holes

Science & Society Federal science wish list

STORY ONE

Ultracold atoms on spin cycle can mimic electricity

‘Atomtronics’ could lead to the creation of new devices

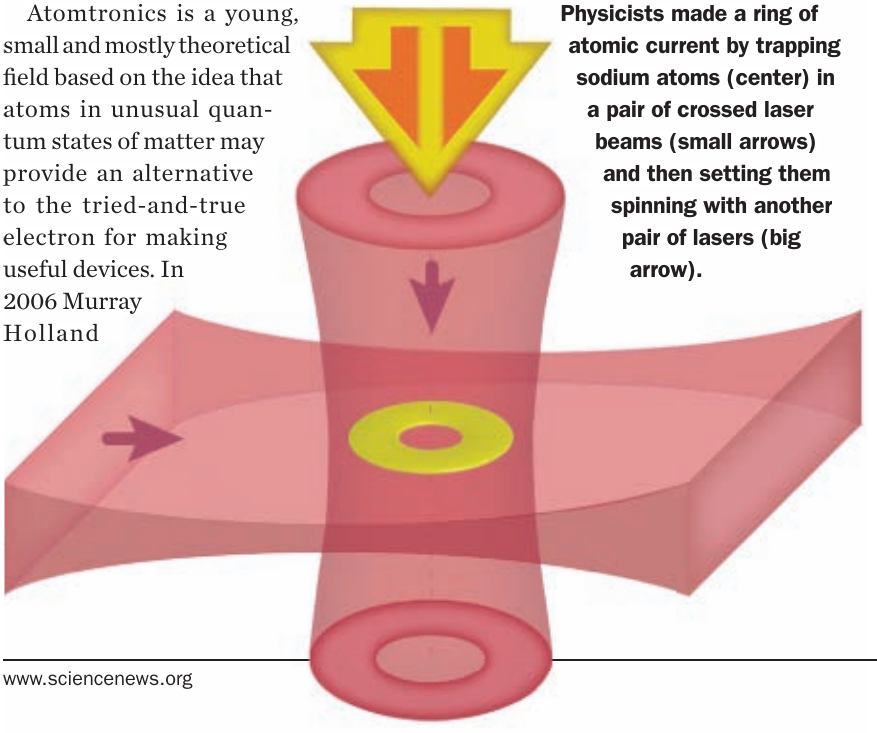
By Devin Powell

Forget about wires, silicon and electricity. Physicists have developed a new type of circuit that is little more than a puff of gas dancing in laser beams. By choreographing the atoms of this ultracold gas to flow as a current that can be controlled and switched on and off, the scientists have taken a step toward building the world’s first atomtronic” device.

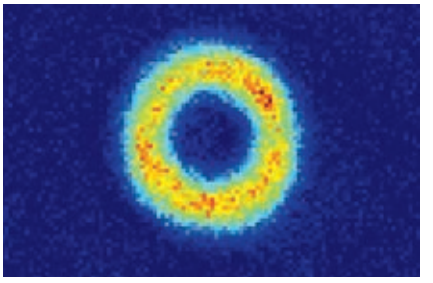
Atomtronics is a young, small and mostly theoretical field based on the idea that atoms in unusual quantum states of matter may provide an alternative to the tried-and-true electron for making useful devices. In 2006 Murray Holland of JILA, a joint institute of the University of Colorado at Boulder and the National Institute of Standards and Technology, developed many of the first blueprints for atomic versions of traditional electronic components. He proposed using optical lattices, egg carton–like structures made of laser light, to trap individual atoms and move them around from pocket to pocket. This approach, he argued, could be used to make atomtronic wires, batteries, transistors and diodes.

“None of these devices have been made yet,” Holland says.

At the Joint Quantum Institute in Gaithersburg, Md., graduate student Anand Ramanathan and his colleagues have been working on a completely different approach. They hope to make atomtronic sensors not by controlling atoms individually, but by manipulating the flow of hundreds of thousands of atoms all moving together in an ultracold state of matter called a Bose-Einstein condensate.



Physicists made a ring of atomic current by trapping sodium atoms (center) in a pair of crossed laser beams (small arrows) and then setting them spinning with another pair of lasers (big arrow).



This doughnut of ultracold gas spins without friction, creating a current of atoms that could be used to develop the first “atomtronic” sensors.

In an upcoming paper in *Physical Review Letters*, the team reports creating this condensate by cooling sodium atoms suspended in magnetic fields. The researchers trapped the sodium atoms in a pair of crossed laser beams and further chilled the atoms to less than 10 billionths of a degree above absolute zero. The two beams shaped the resulting condensate into a flattened doughnut with a radius of about 20 micrometers.

“A lot of care was required in how we created the trap,” Ramanathan says. “We had to make it as smooth as possible to make sure that imperfections played a minimal role.”

A second pair of lasers transferred energy to the doughnut to start it rotating. Because atoms in the condensate behave as a single, coherent quantum “superatom,” such a ring doesn’t speed up or slow down gradually—it jumps between different speeds, much like a blender would if it could change settings instantaneously. The scientists chose

BOTH: JOINT QUANTUM INSTITUTE

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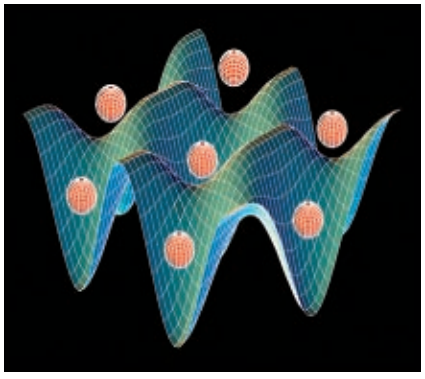


Physicist Murray Holland of JILA has proposed using atomtronics to move individual atoms (red) between locations in an optical lattice (blue).

the lowest setting for their ring, about one revolution every second.

Because the condensate also happens to be frictionless, this ring should, in theory, rotate forever. Limited by technical difficulties, the research team kept it going for about 40 seconds, the lifetime of the condensate.

"This is the first time that someone has actually made a ring-shaped condensate," says team member and physicist Gretchen Campbell. "We're hoping to use this condensate in much the way that superconductors have been used to make improved devices and sensors."

Her first idea for a useful device was inspired by sensors that respond to very weak magnetic fields, called superconducting quantum interference devices, or SQUIDs. These devices, loops of superconductors used as detectors in medical scanners, change current suddenly when a barrier to the flow of electrons through the loop is triggered by a magnetic field.

Using a similar principle, Campbell's team believes that Bose-Einstein condensates could provide an extremely sensitive rotation sensor — similar to sensors based on cryogenically cooled superfluid helium that have already provided precision measurements of the Earth's rotation.

To mimic a SQUID, Campbell added a barrier to the flow of condensate around the loop, a wall created by a blue laser that could speed up or shut down the current depending on its size. A wall such as this moving around the condensate ring could, in theory, trip sudden changes in current that would reveal the speed of rotation.

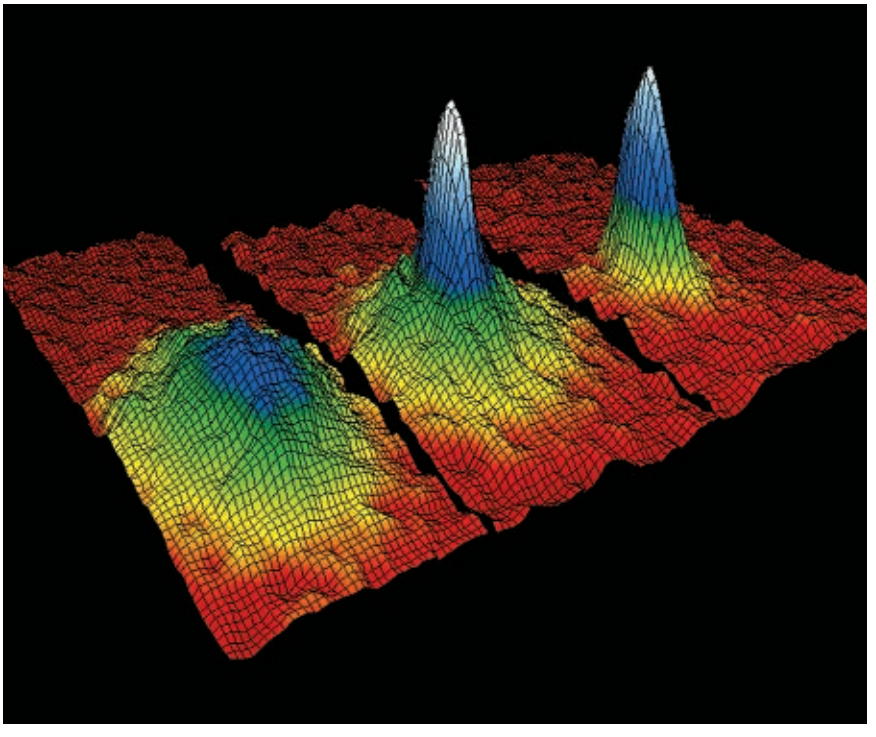
The team's approach to creating an atomtronic device is one of several being pursued in labs around the world. "They've added another tool that we can start to use to build up the atomtronics toolbox," says JILA's Dana Anderson, who is developing a different system based on manipulating atoms with magnetic fields. Other bits and pieces that may one day enable these devices are under development in laboratories in Germany and at Harvard.

The goal of these pioneers isn't to replace electronics with atomtronics; the electron has proven its worth beyond any doubt. But they hope that, for certain applications, atoms will ultimately prove to be more interesting than electrons. ■

Back Story

BIRTH OF THE ULTRACOOL

Physicists Satyendra Nath Bose and Albert Einstein proposed in 1924 that large numbers of atoms could be chilled to the point that they joined together in a single quantum state, bringing subatomic effects to a scale accessible by laboratory experiments. But it wasn't until 1995 that scientists made a Bose-Einstein condensate, using lasers to carefully cool rubidium-87 atoms down to temperatures less than a millionth of a degree above absolute zero. The 2001 Nobel Prize in Physics celebrated this accomplishment, which was also achieved using sodium atoms. This image shows the distribution of atomic velocities in a rubidium gas just before (left) and after (center and right) the formation of a condensate.



BOTH: NIST

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Larger than actual size of 35 mm

"Teddy Roosevelt Silver Dollars" Come Home From Old U.S. Territory

When the Japanese invaded the Philippine Islands during World War II, thousands of U.S. Territorial Silver Dollars were hidden away in a secret cache to prevent them from falling into the hands of the enemy.

Recently, a canvas bag filled with coins from the cache surfaced in Manila. It was immediately offered to our buyer because of our status in the coin industry.

As he opened the bag, one by one, he found 500 U.S. Territorial Silver Dollars—the coins he'd heard stories of! These were "Teddy Roosevelt Silver Dollars," the only Silver Dollar created during Theodore Roosevelt's presidency!

Hard to Hunt Down

This scarcely seen U.S. Territorial Silver Dollar was issued from 1907 to 1912, but is missing from virtually every U.S. Silver Dollar collection. In fact, many collectors don't even know it exists! It was struck at the renowned San Francisco Mint for use only in the Philippines, a U.S. Territory at the time. Sadly, millions of the coins were lost over the years or melted down for their silver content, and very few made their way back to the United States. It's estimated that less than 10 percent of these coins remain!

Silver Legacy of Teddy Roosevelt

In the White House from 1901 to 1909, Roosevelt believed in America's destiny as a world power. His efforts led to building the Panama Canal, eliminating the dreadful yellow fever in the Philippines, Cuba, and Puerto Rico and helping end a war between Russia and Japan, for which he was the first American to be awarded the Nobel Peace Prize.

The San Francisco "S" mintmark

A Big, Beautiful Silver Dollar

The U.S. Territorial Silver Dollar is as rugged as the old Rough Rider himself. It weighs a hefty 20 grams and has a 1.37-inch diameter. The coin has a fineness of .800 silver.

Lady Liberty is featured on the front of the coin, symbolizing the forging of a new territory. The back depicts an eagle standing proudly atop a U.S. shield.

Valuable Coins at a One-Time-Only Price

Only after weeks combing the U.S. coin market did we find even one dealer selling the U.S. Territorial Silver Dollar—for $49.95. But thanks to discovery of this hoard, you can own the U.S. Territorial Silver Dollar for as little as $39.95 each (plus S&H).

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Humans

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Lucy's feet were made for walking

Bone puts a humanlike arch in an ancient hominid's step

By Bruce Bower

A tiny 3.2-million-year-old fossil found in East Africa gives Lucy's kind an unprecedented toehold on humanlike walking.

Australopithecus afarensis, an ancient hominid species best known for a partial female skeleton called Lucy, had stiff foot arches like those of people today, say anthropologist Carol Ward of the University of Missouri in Columbia and her colleagues. A bone from the fourth toe — the first such *A. afarensis* fossil unearthed — provides crucial evidence that bends in this hominid's feet supported and cushioned a two-legged stride, the scientists report in the Feb. 11 *Science*.

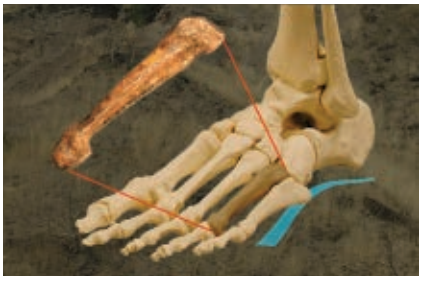
"We now have the evidence we've been lacking that *A. afarensis* had fully developed, permanent arches in its feet," Ward says. Survival for Lucy and her comrades must have hinged on abandoning trees for a ground-based lifestyle, she proposes.

The new fossil confirms that members of Lucy's species could have made 3.6-million-year-old footprints previously found in hardened volcanic ash at Laetoli in Tanzania (*SN Online: 3/22/10*), she says. *A. afarensis* lived from about 4 million to 3 million years ago.

Scientists have argued for more than 30 years about whether Lucy and her kin mainly strode across the landscape or split time between walking and climbing trees.

News of arched feet in these hominids follows a report that a recently discovered *A. afarensis* skeleton dubbed Big Man, though footless, displays long legs, a relatively narrow chest and an inwardly curving back — all signs of a nearly humanlike gait (*SN: 7/17/10, p. 5*).

"There were far too many highly detailed adaptations in every part of the



A 3.2-million-year-old *Australopithecus afarensis* fossil curves like the matching bone in the human foot below it.

A. afarensis skeleton for upright walking and exclusive ground travel not to have emerged," remarks anthropologist Owen Lovejoy of Kent State University in Ohio, who studied Big Man's remains.

In fact, Lovejoy says, a walking-adapted foot much like that attributed to Lucy's kind by Ward's group had already evolved by 4.4 million years ago in the early hominid *Ardipithecus* (*SN: 1/16/10, p. 22*). Though *Ardipithecus* had an opposable big toe incapable of propelling a two-legged gait, he argues that this creature could have walked using its other toes.

Based on the new find, *A. afarensis* does appear to have had arched feet, remarks anthropologist William Jungers of Stony Brook University School of Medicine in New York. But other foot features — including long, curved little toes — indicate that a skeletal system for upright walking had not fully evolved in Lucy's kind, Jungers asserts.

Humans could outrun Neandertals

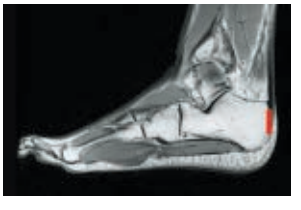
Homo sapiens' heels more suited to long-distance trotting

By Bruce Bower

Stone Age humans, unlike Neandertals, had heel bones spring-loaded for long runs, a new study suggests.

In ancient *Homo sapiens*, as in people today, a short lower heel stretched the Achilles tendon taut, say anthropologist David Raichlen of the University of Arizona in Tucson and his colleagues. That arrangement increased the tendon's springlike action during running and cut energy consumption, the scientists report in a paper published online January 26 in the *Journal of Human Evolution*.

Raichlen's team calculated oxygen consumption for eight experienced distance runners running on a treadmill at 16 kilometers per hour. On a separate day, an MRI scanner took images of each man's heels and Achilles tendons. The runners displayed short lower heel bones, even shorter for those who used oxygen most efficiently.



Heel bone length (red, in modern runner) helped early humans run more efficiently than Neandertals.

Heel-bone measurements of 13 fossil *Homo sapiens* that lived between about 30,000 and 100,000 years ago resemble those of today's runners, the scientists say. On average, the measurements indicate that the ancient humans expended 6.9 percent more energy while running than their counterparts today did — not a substantial difference, the researchers say. Heel bones of seven Neandertals from the same period indicate that these hominids used an average of 11.4 percent more energy while running than the modern athletes did, a statistically notable disparity, Raichlen says.

Raichlen's study "provides a new line of evidence that Neandertals were not as adept at long-distance running as modern humans were," remarks anthropologist Herman Pontzer of Hunter College in New York City.

FROM TOP: KIMBERLY CONGDON, C. WARD, ELIZABETH HARMAN; D. RAICHLEN

Genes & Cells

For more Genes & Cells stories, visit **www.sciencenews.org**

Cuts can induce cancerous tumors

Mutated stem cells flock to wounds in mouse experiments

By Laura Sanders

The slightest cut can cause cancerous cells to crawl to the wound and form tumors in cancer-prone mice. The new finding may explain why certain kinds of cancers seem to cluster around burns, surgical scars and other injuries.

"This work says that if you have a predisposition to getting cancer, wounding might enhance the chance that it will develop," says cell biologist Anthony Oro of the Stanford University School of Medicine.

Epidemiologists have tied a variety of human cancers to wounds, including lung, liver, bone and skin cancers, but the reason for the link has been unclear. In the new study, Sunny Wong and Jeremy Reiter of the University of California, San Francisco introduced a potentially cancer-causing genetic mutation into particular stem cells in mice.

The stem cells live in the part of a hair follicle called the follicular bulge, where they produce new follicles and hair shafts. The researchers expected to see tumors develop around the hair follicles in the mutated mice. But the mice were fine.

If a mouse was wounded, however, tumors developed at the injury site. After the researchers cut a pencil-eraser–sized piece of skin from the backs of the mice, cancerous cells migrated to the wound and formed clusters of tumors. These tumors seemed to be a slow-growing and treatable form of skin cancer called basal cell carcinoma. Small incisions similar to paper cuts also caused these stem cells to form tumors nearby, the team reports in an upcoming *Proceedings of the National Academy of Sciences*.

"It's a very suggestive study that needs to be confirmed on a broader level. But it will certainly stimulate a lot of discussion and interest in this area in the future," Oro says.

Something in the hair follicle environment may keep these mutated stem cells in check. But a wound calls the stem cells out, making them leave their normal location, travel to the injury site and form tumors, the team found. Just how wounding beckons these cells is a mystery, Reiter says.

In the mice, mutated stem cells could still form tumors even if the injury came weeks after the mutation was introduced.

The new research focused on one particular mutation and one particular cell type, so further studies will be needed to test whether the same sort of thing happens in other tissues and for other kinds of cancer.

Gene form raises risk for diabetes

GIP variant may have aided survival during brief famines

By Tina Hesman Saey

A genetic variation that may increase a woman's risk of gestational diabetes is widespread today because it was actually beneficial to early agricultural populations, a new study suggests.

Pregnant women who carry two copies of a low-activity form of the gene *GIP* have higher blood-glucose levels — a marker of gestational diabetes risk — Sheau Yu Teddy Hsu of Stanford University and colleagues report online February 7 in *Diabetes*. But when the gene's low-activity version first arose somewhere in Eurasia an estimated 8,100 years ago, that same glucose-boosting quality may have helped women maintain their pregnancies during lean times.

The work is important for characterizing how one form of a gene can shape physiology and how evolution may act on that gene, says Joshua Akey of the University of Washington in Seattle.

Hsu and his colleagues have previously reported evidence that the low-activity version of the *GIP* gene emerged about 8,100 years ago and rapidly became part of the genetic makeup of Eurasians. Today about half of people of European descent carry this newer form of *GIP*, while 70 percent or more of Asians do. Only about 5 to 10 percent of Africans have the new form, Hsu says. "It arose very fast, so it must have some dramatic effect on human viability," he says.

In the study, the researchers tested whether the low-activity form of the gene had any effect during pregnancy. Study coauthor Chia Lin Chang of Chang Gung University in Taiwan collected blood samples from 123 pregnant women. The team analyzed blood sugar concentrations and found that women with two copies of the new form of the gene had higher levels than did women with the ancestral form.

GIP helps stimulate insulin production after a meal. Insulin, in turn, helps cells more efficiently use sugars from food. Too little insulin can lead to high levels of sugar in the blood, a symptom of diabetes. But higher blood sugar levels may also help fetuses grow. The new form of the gene may have given people an evolutionary advantage to survive famines, the researchers speculate.

At about the same time that the new form of *GIP* appeared, people in Europe and Asia were switching from a hunter-gatherer lifestyle to agriculture. That switch may have exposed people to more frequent famine, such as between harvests or when crops failed. The new version may have kept mothers' blood sugar levels high enough to provide developing fetuses with energy during short famines, the researchers say. ■

Life

"You come out of the water smelling like rotten flower shop." —ALISON SWEENEY

Blue twilight may trigger spawning

Subtle color shifts on nights after full moon could cue corals

By Susan Milius

Sentimental songs aside, maybe it's an absence of moonlight that turns the bounding main into a sea of love.

On nights after the full moon, when the moon lags below the horizon until after sunset, twilight takes on an especially blue cast. That color shift might cue the remarkably synchronized spawning of some marine species, suggests Alison Sweeney of the University of California, Santa Barbara.

Pink bundles of eggs and sperm poke out of coral in Palau waiting for a signal to spawn. A new study proposes blue-tinged twilight as the cue.

Corals may be the most famous of the mass spawners. Sweeney recalls a coordinated spawning along miles of reef in Palau that left a fragrant pink slick still visible the next day: "You come out of the water smelling like rotten flower shop."

Corals don't have central nervous systems or actual eyes. Yet many corals manage to release their eggs and sperm into the water on one or just a few evenings of the year in the same few hours — sometimes just the same 20 minutes — as do neighbors of the same species for miles around. Seasonal cues go into this feat, but what interests Sweeney and her colleagues is how species coordinate the fine-scale timing on a particular evening. "This 20-minute precision is pretty tough to explain," she says.

In a first step to testing the notion of a blue-twilight cue, Sweeney and her colleagues floated sensors and a laptop wedged into an inner tube out to corals in the U.S. Virgin Islands. Measurements showed that the blue shift can be detected underwater, the researchers report in the March *Journal of Experimental Biology*.

Just two light-sensing pigments of the opsin type, one tuned to greenish and the other to a blue wavelength, would be enough to detect such a shift, the researchers calculate. In recent genetic analyses, opsin pigments have shown up in abundance among invertebrates, Sweeney says.

Marine animals often spawn in sync with some phase of the lunar cycle, and twilight's color changes slightly around the time of the full moon, Sweeney says. Moonlight has a slight reddish tinge. So the waxing moon, which appears in the sky before the sun sets, shifts twilight a little toward the red. A full moon, however, just peeps over the horizon as the sun sets. As the moon wanes, it rises after sunset, leaving twilight bluer.

That a light shift could trigger spawning sounds novel to evolutionary biologist Don Levitan of Florida State University in Tallahassee. "This is a correlation that sets up a series of exciting hypotheses that need to be tested," he says.

Fleas leap from feet, not knees

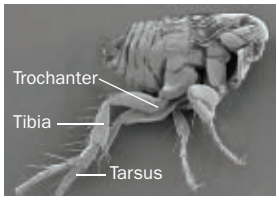
Study settles issue of how impressive jumpers launch

By Daniel Strain

A decades-old debate about how the animal kingdom's most renowned jumper jumps appears to be settled.

Researchers with the University of Cambridge in England have shown that fleas take off from their tibiae and tarsi — the insect equivalent of feet — and not their trochantera, or knees. The researchers report their conclusion in the March *Journal of Experimental Biology*.

Since the late 1960s, researchers have known that fleas launch by storing energy in a naturally springy protein called resilin, then releasing the pent-up energy in one big bound. But where exactly the spring power goes wasn't clear. One camp said the force moves down to the knees; the other said the feet.



Jumping fleas take off from their equivalent of feet (the tibiae and tarsi).

Gregory Sutton and Malcolm Burrows were able to settle the issue by collecting 51 slo-mo video clips of leaping hedgehog fleas. The team also drew up mathematical models to simulate bug leaps and eyed flea anatomy using a scanning electron microscope.

Flea knees never even touched the ground in about 10 percent of jumps, Sutton says. With or without knee contact, the fleas still jumped with the same speed and acceleration. The team also found long spikes on the flea tibiae and tarsi — good for traction, perhaps — but only short hairs on the knees. The jumps Sutton and Burrows watched on film also matched the predictions of feet-jumping but not knee-jumping mathematical models.

FROM TOP: CHARLES A. BOCH; G. SUTTON AND M. BURROWS/*JOURNAL OF EXPERIMENTAL BIOLOGY* 2011

For video of a bladderwort catching a crustacean, visit **www.sciencenews.org/bladderworts**

Exposing secrets of bladderworts

Tiny carnivorous plants trap their prey with super speed

By Daniel Strain

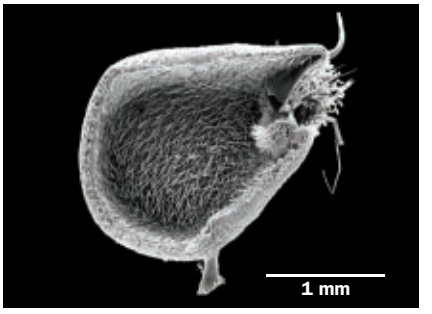
Carnivorous bladderworts trap their prey with speed that would make a Bond villain shudder in gleeful envy.

Using high-speed cameras, researchers have gotten the first good look at how these underwater plants spring their ambushes. Bladderworts sport trapdoors that collapse inward with a tiny nudge, creating a whirlpool that sucks in wee critters — all in about half a millisecond. That's some of the fastest plant action on Earth, a French and German team reports online February 16 in the *Proceedings of the Royal Society B*.

Forget Venus flytraps. Bladderworts, of the genus *Utricularia*, are cunning meat eaters. "*Utricularia* are the smallest of carnivorous plants and also, evidently, the most sophisticated," says Lubomír Adamec, a plant physiologist at the Academy of Sciences of the Czech Republic. Tiny traps, often no wider than an ant is long, dot the surface of bladderworts.

The traps are masterpieces of suction. Pumped nearly dry, the chambers set up a pressure difference between the plant's innards and the water outside. When small crustaceans and other swimmers brush against hairs along the trapdoor, the door bursts open and sucks in water and prey at speeds up to 1.5 meters per second.

The high-speed cameras show that, at least in three bladderwort species, the traps spring using an elastic buckle. At just the right pressure, the domelike trapdoor stays shut. But a tiny touch can collapse the door like a popped bubble-gum bubble, opening a small window to the trap below. Unlike a gum bubble, the doors are bouncy and spring back to their original shape in fractions of a second, says study coauthor Philippe Marmottant, a physicist at Joseph Fourier University in Grenoble, France. Bladderworts move fluid so well, he says, that they could inspire new lab tools.



A cross-section of a bladderwort's trap reveals protruding hairs (right) that trigger a door to pop open, sucking in prey.

CARMEN WEISSKOPF

Body & Brain

35 percent | Fraction of patients with high-grade glioma reporting past allergy diagnosis

46 percent | Fraction of cancer-free patients reporting past allergy diagnosis

Allergies might fight off cancer

Elevated immune response could target some tumors

By Daniel Strain

Hay fever, dog, peanut and other allergies may protect sufferers from certain types of brain tumors, a new study suggests.

In surveys of hospital patients, individuals with glioma — a form of brain and spinal cancer — were less likely than cancer-free individuals to report having allergies, researchers report in the February *Cancer Epidemiology, Biomarkers & Prevention*.

Epidemiologist Bridget McCarthy of the University of Illinois at Chicago and her team quizzed more than 1,000 hospital patients with or without cancer about their allergy histories. Of the 344 patients with high-grade glioma, about 35 percent reported having been diagnosed with one or more allergies in their lifetimes, compared with about 46 percent of the 612 cancer-free respondents. About 10 percent of patients with high-grade tumors had three or more types of allergies, as opposed to 19 percent of the controls. "The more allergies you have, the more protected you were," McCarthy says.

Glioma isn't the first cancer to be negatively correlated with common allergies, says Michael Scheurer, an epidemiologist at Baylor College of Medicine in Houston. Allergy-prone people may fight off colorectal and pancreatic cancer, and even childhood leukemia, better than sniffles-free people, according to some studies.

Just why these links exist isn't clear. Allergy sufferers mount heightened immune responses to certain foreign or dangerous cells and chemicals, says Scheurer. And cancer cells are certainly dangerous — human immune systems naturally seek the cells out. The immune systems in people with allergies may just do it better. "They have an overactive immune system, and maybe that's been protecting them from the development of tumors," he says.

In December, Scheurer and his colleagues reported finding a link between a higher risk for one type of glioma and use of antihistamine drugs such as diphenhydramine, Benadryl's active ingredient. The Illinois team did not find such a link.

Scheurer says Benadryl users shouldn't worry: "Brain tumors are very, very rare tumors, and a lot of people take antihistamines." He suspects that in a small set of individuals with a genetic predisposition to brain cancer, antihistamines may slow down the immune response, giving cancer cells an opening.

Prenatal surgery shows promise

Fetal spina bifida operation increases likelihood of walking

By Nathan Seppa

Fetal surgery performed months before birth can improve the health of children with spina bifida, a neural tube defect caused by an opening in the spine. By comparing children who had gotten surgery before or after birth, researchers found that operating preterm improves the chance that a child with spina bifida will be able to walk and lessens the risk of other neurological complications.

But these potential gains must be weighed against an increased risk of premature birth associated with surgery in the womb. The findings appear online February 9 in the *New England Journal of Medicine*.

The study focused on fetuses and newborns with myelomeningocele, the most common and severe form of spina bifida, in which the spinal cord bulges outside the spinal column. The condition can result in cognitive disabilities, fluid on the brain, bowel problems and paralysis. Usually surgeons operate on such babies a few days after birth by inserting the spinal cord back into its canal and sealing the opening with sutures. If successful, this limits fluid buildup in the brain and spinal cord and lessens the cord's pull on the brain.

Surgery in utero can fix spinal bulges caused by spina bifida, reducing pulling on the brain (arrows).

NIH

In the study, researchers described 158 pregnant women who had a fetus diagnosed with myelomeningocele. Half had been randomly assigned to fetal surgery while the others delayed the procedure until after birth.

The results show that 42 percent of children who had surgery in the womb were able to walk unassisted at 30 months compared with 21 percent of those who received the surgery postnatally. There were no marked differences in mental development between the groups.

Nearly four-fifths of babies who had surgery in utero were premature, with 10 of 78 born before 30 weeks. In the other group, 15 percent were born prematurely.

The study "is a major step in the right direction," say physicians Joe Simpson of Florida International University in Miami and Michael Greene of Massachusetts General Hospital in Boston, writing online the same day in *NEJM*, but "the degree to which intrauterine repair will transform outcomes for fetuses with myelomeningocele remains unclear."

Matter & Energy

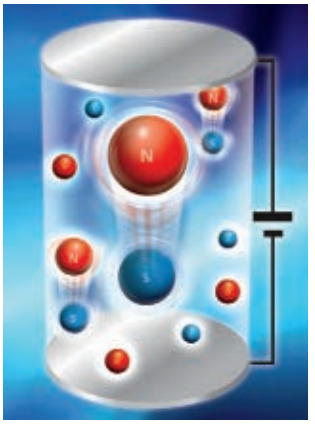
"Eventually they get so far apart that they lose all memory of each other." — **STEVEN BRAMWELL**

'Magnetricity' acts like electricity

Currents of isolated magnetic charges flow through crystals

By Devin Powell

Electricity has a new little sister: magnetricity. A team of physicists in England and France has created magnetic charges — isolated north and south magnetic poles — and induced them to flow in crystals no bigger than a centimeter across. These moving magnetic charges, which behave almost exactly like electrical charges flowing through batteries and biological systems, could one day be useful in developing "magnetronic" devices — though what such devices would do is anybody's guess.



Currents of magnetricity are born when north poles and south poles split up and move around independently.

In magnets, poles always come in pairs. No matter how many times you cut a magnet in half, down to the atoms themselves, each piece will always have a north and a south — a dipole.

But the magnetic molecules that make up a crystalline material called spin ice are arranged in pyramids, so all the poles can't easily line up pointing in the same direction. Instead, each pyramid tends to have two magnets pointing inward and two pointing outward.

In 2009 Steven Bramwell of University College London found that sometimes a molecule in spin ice squirms and flips. Two poles, a north and a south, are born. The molecule itself stays put, but these ghostly poles, which aren't actually attached to a physical object, can move around independently of each other as chain reactions of flipping molecules carry them from pyramid to pyramid.

"Eventually they get so far apart that they lose all memory of each other," says Bramwell. "The dipole splits in half and becomes two monopoles."

Some question using the term monopole for a phenomenon that exists only in spin ice. This term traditionally refers to cosmic monopoles created during the Big Bang. "A real monopole would be a magnetic charge that would exist in a vacuum," says Michael Bonitz of the University of Kiel in Germany. "What they have is a complicated condensed matter system."

Confined in spin ice, though, these wandering poles do behave much like monopoles. The poles have magnetic charge that closely agrees with theoretical predictions, and the charges' interactions follow the same law that governs electric charges, Coulomb's Law.

Using brief magnetic pulses, Bramwell and his team developed a way to trigger currents of magnetic charges — "magnetricity" — that last for minutes.

"We apply a magnetic field to create magnetic charges and get them all going the same direction," says Sean Giblin, a physicist at the Rutherford Appleton Laboratory in England and a coauthor of a paper published online February 13 in *Nature Physics*.

The creation and slow dissipation of new magnetic charges follows the same principles that govern electrical ions in solutions. And spin ice stores magnetic charge the way capacitors store electricity. Thus Bramwell's dream for magnetricity to someday spawn "magnetronics." But it may take a while. The currents appear only in crystals kept close to absolute zero.

FROM LEFT: S. BRAMWELL; RYO ISHIKAWA *ET AL./NATURE MATERIALS*

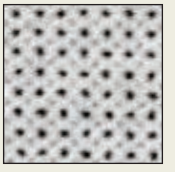
NEWS BRIEFS

Teeny tiny chips

In the onward march of miniaturization, a computer processor that's slightly wider than a pollen grain can perform many of the logic operations larger computer chips do, a team of scientists reports February 10 in *Nature*. The device, developed by researchers from Harvard and the MITRE Corp., contains about 500 transistors made from synthesized nanowires. That's an order of magnitude more complex than any previous nanoprocessor, the scientists say. It's also scalable, allowing individual modules to be connected to each other to potentially develop tiny, low-power nanocontrollers for miniature robots or medical devices. — *Devin Powell*

Hydrogen's head shot

The lightest atoms on Earth have finally come into view. Researchers have directly imaged hydrogen atoms for the first time, two separate teams in Japan report online February 13 in *Nature Materials* and November 5 in *Applied Physics Express*. In the new snapshots, the hydrogen atoms appear as faint spots. The darker blobs are the crystalline solids yttrium dihydride and vanadium dihydride, materials that are being developed as spongelike containers for storing hydrogen. To spot the camera-shy hydrogen atoms, each team developed slightly different ways of detecting how the materials deflected the electrons in the beam of a scanning transmission electron microscope.



— *Devin Powell*

Atom & Cosmos

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Black holes put their spin on light

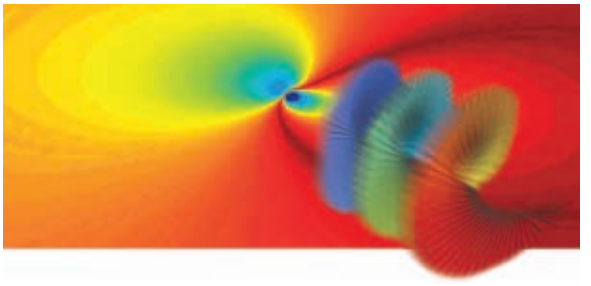
Effect could help studies of Milky Way's own heavyweight

By Ron Cowen

Given how weird black holes are, it's only fitting that researchers have found a screwy way to detect the rotation of these gravitational monsters. Existing telescopes could be equipped with special detectors to record the twist imprinted on light waves that pass near a rapidly spinning black hole, Bo Thidé of the Swedish Institute of Space Physics in Uppsala and his colleagues report online February 13 in *Nature Physics*.

The newly discovered effect that spinning black holes have on light waves is a consequence of Einstein's theory of relativity, shown using numerical simulations performed by the team, Thidé says.

Researchers had already predicted and found some evidence that rotating black holes and neutron stars stir the fabric of surrounding space and time like pancake batter, an effect known as frame dragging (*SN: 9/2/00, p. 150*). But researchers hadn't explored in detail the possibility that rotating black holes could also take light for a spin, imparting angular momentum to the radiation, says Martin Bojowald of Pennsylvania State University in University Park. "The black hole influences spacetime in such a way that light with net orbital angular momentum is automatically produced," he says.



Photons emitted near a rotating black hole get a twist (spiral shape) in the form of orbital angular momentum. Detecting that pattern, researchers say, will allow astronomers to directly measure a black hole's spin.

Light waves are made up of crests and troughs. Those light waves that travel in unison and unimpeded through space have wave fronts — the imaginary surface over which the crest of one wave lines up with the crest of another — that are planes. In contrast, when light passes near a black hole, each photon acquires a twist that alters the wave surface from a plane to a spiral staircase centered around the direction of travel of the light beam.

"What is new and exciting is the proposal that the effect is actually measurable for the black hole at the center of our galaxy," says astrophysicist Saul Teukolsky of Cornell University.

Thidé says his team will review radio telescope observations of the Milky Way's supermassive black hole to see if the twisted-light effect has already shown up. Bojowald says the technique "will not be an immediate tool for actual observations of black holes, but it looks promising enough to suggest upgrading telescopes" so they can search for it.

In the meantime, he says, twisted light "gives us a new means to test general relativity and spacetime." ■

Comet Tempel 1, take two

New portraits of Comet Tempel 1 recorded during a Valentine's Day encounter with NASA's Stardust spacecraft reveal pitting, erosion and other surface features that weren't there in July 2005, the only other time the object was photographed at close range. Tempel 1 (seen from four different angles, at left) has completed a full passage around the sun since a visit by Deep Impact, another NASA craft. The Stardust portraits show for the first time the crater that was gouged when Deep Impact shot a 372-kilogram copper slug into the comet six years ago (*SN: 7/9/05, p. 22*). The crater is about 150 meters wide and has softened features with a central mound on the crater floor. While passing Tempel 1 at a distance of 178 kilometers, Stardust also viewed parts of the comet never before seen up close, including extensive areas of layered deposits and a heavily pitted area. The craft previously flew past the comet Wild 2 and returned samples of that comet's dusty shroud to Earth (*SN: 1/10/04, p. 19*). —*Ron Cowen*

Science & Society

0.3 percent Federal R&D share of U.S. GDP in 1949

2.2 percent Federal R&D share of U.S. GDP in 1964

0.9 percent Proposed federal R&D share of U.S. GDP in 2012

2012 budget offers pain and gain

Amid belt-tightening, clean energy, education, high tech grow

By Janet Raloff

President Obama sent the research community a valentine of sorts in his proposed 2012 federal budget. Sent to Congress on February 14, the budget was a pledge to fight for increased investment in research and education even as the president committed to belt-tightening for most discretionary federal spending.

The $3.7 trillion proposal allocates $147.9 billion to research and development in the coming fiscal year, which begins on October 1. That amounts to a small decrease from the 2011 fiscal year, after accounting for projected inflation of 1.3 percent.

Many R&D programs would see expanded or new funding to meet a number of the administration's goals, says presidential science adviser John Holdren. Those include boosting the budgets for the National Science Foundation, the Energy Department's Office of Science and the National Institute of Standards and Technology; training more science, technology, engineering and mathematics teachers; and advancing clean energy.

To pay for those priorities, Holdren says, agencies were asked to make the painful determination of which programs were underperforming or of lower importance to the president's national objective "to out-innovate, out-educate and outbuild the rest of the world."

"I think it is especially encouraging to have a president who really supports R&D and education," says Albert Teich, who directs science and policy programs at the American Association for the Advancement of Science in Washington, D.C. "You wish every president saw things this way. What's discouraging, of course, is that we face this huge deficit. And not everybody in Congress is going to agree with the president's priorities. So there's bound to be fights over it."

Battles over the 2011 budget led the government to adopt a continuing resolution for the first part of the fiscal year that largely held spending to 2010 levels.

Who would feel the pain — or gain — if the administration's proposals were adopted varies considerably.

For instance, the Department of Education has been slated for a whopping 33.5 percent increase. But owing to its relatively small R&D component, this boost would amount to a rather paltry $124 million. Some $80 million of that boost would pay for research into developing better science, engineering and math teachers. The president has stated a goal of increasing their numbers by 100,000 within a decade.

R&D funding within the National Science Foundation would grow 16 percent under the proposed budget. "In these challenging fiscal times, when difficult financial choices have to be made to return our nation to solid financial footing, this budget request reflects the confidence that the president is placing in NSF as an agency," says director Subra Suresh.

Among agencies slated for a big dip in R&D funding, none stands to lose more than the Department of Defense. The administration has targeted its programs for a nearly $5 billion drop. Part of the cutbacks would be made by terminating several major weapons systems that the administration claims "are experiencing significant development problems, unsustainable cost growth, or are not suited for today's security challenges."

The U.S. Department of Agriculture, slated for a 19 percent R&D decrease, would kill all spending on research grants that Congress had initially earmarked for funding and would cancel $224 million in construction funds. These adjustments would not only allow for some overall savings, but also free up a little money to boost spending for research on human nutrition, obesity reduction, food safety, climate change and crops that could be used to produce biofuels. — *With additional reporting by the* Science News *staff*

Proposed FY 2012 federal R&D budget spending

(dollar values in millions with percent changes from FY 2011 adjusted for projected 1.3 percent inflation)

U.S. agency or department	FY 2010 actual	FY 2011 continuing resolution	FY 2012 proposed	Percent change
Defense	80,602	81,442	76,633	–7.1
NIH (and other HHS R&D)	31,424	31,948	32,343	–0.06
Energy	10,836	10,783	12,989	18.9
NASA	9,262	9,911	9,821	–2.2
NSF	5,445	5,374	6,320	16.1
USDA	2,611	2,619	2,150	–19
Commerce	1,344	1,331	1,720	27.6
Interior	776	776	727	–7.5
EPA	590	590	579	–3.1
Education	353	356	480	33.1
All others†	3,896	3,904	4,149	4.9
Total	**147,139***	**149,034***	**147,911***	**–2.0***

*Figures reflect rounding; †Includes Departments of Transportation, Homeland Security, Veterans Affairs, the Smithsonian Institution and others.

☐ Increase ☐ Decrease

SOURCE: TABLE 22–1, P. 367, *ANALYTICAL PERSPECTIVES: BUDGET OF THE U.S. GOVERNMENT FISCAL YEAR 2012*, FEBRUARY 14, 2011

T. DUBÉ

AAAS Meeting

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Bilingual babies discern languages

Early challenge of learning two tongues may hone thinking

By Bruce Bower

Babies living in bilingual homes get a perceptual boost by 8 months of age that may set the stage for more resilient thinking later on, scientists reported February 18.

Infants raised bilingual from birth can distinguish not only between their native tongues but between languages they've never encountered, even when they see adults speak without hearing what they say, said psychologist Janet Werker of the University of British Columbia in Vancouver. Babies in monolingual households lack these discrimination skills, Werker and her colleagues have found.

Given exposure to two tongues, infants develop an ability to track closely what they hear and see to decode languages, Werker proposed. In the visual realm, such information may include lip movements, the rhythm of the jaw opening and closing, and other facial movements.

Early perceptual strides by infants in bilingual homes may mark the beginnings of an increased ability to focus attention and think in complex ways later in life, suggested psychologist Ellen Bialystok of York University in Toronto. Bialystok's group has found that among more than 400 older adults with Alzheimer's disease, those who speak two languages fluently are, on average, four to five years older when diagnosed than those who speak one language.

Werker's team studied 48 babies, all 8 months old, from families that spoke Spanish only, Catalan only or both languages. The infants sat on their mothers' laps and watched silent videos of three women reading sentences in English and French.

Once babies got bored with clips in one language and began to look away and fidget, they were shown new clips of a woman reciting sentences either in the same language or in a different tongue.

Babies from bilingual homes focused on faces speaking a different language and largely kept ignoring a language that they had just heard, even though both English and French were new to them. Babies from monolingual families paid little attention to switches between French and English.

Bears slow way down in winter

Ursine hibernation turns out to be deeper than expected

By Susan Milius

There's something as yet unknown going on with black bear hibernation that slows metabolic rates more than lower body temperatures alone can explain.

In the depths of Alaskan winters, closely monitored black bears dropped their temperatures only a modest 5.5 degrees Celsius on average. A standard physiological calculation predicts that such a chill would slow metabolism to 65 percent of nonhibernating resting rates. But the bears' metabolisms plunged down to even more energy-saving zones, averaging only 25 percent of the basic summer rate, ecological physiologist Øivind Tøien of the University of Alaska Fairbanks and colleagues reported February 17 and in the Feb. 18 *Science*.

Modest temperature drops in hibernating bears belie a major metabolic slowdown.

Ø. TØIEN/UNIV. OF ALASKA FAIRBANKS

Such a major disconnect hasn't shown up in research on any other hibernating mammal, said study coauthor Brian M. Barnes, also of UA Fairbanks.

The study is the first to manage continuous monitoring of metabolic rate and body temperature throughout bear hibernation with little disturbance of the animals, Tøien said. Other studies based on intermittent sampling with older instruments, indirect evidence or studying bears with lots of people nearby have left the matter "uncertain," as he put it.

The researchers monitored five bears, setting the animals up in wooden den boxes in an enclosure deep in the woods. The boxes were rigged to allow a bear to break out anytime it wanted. While the bears were inside, researchers measured metabolic rate, muscle movement and heart function.

Reports of large drops in bear metabolic rates during hibernation cheer Eric Hellgren of Southern Illinois University Carbondale, who admits to "a biased viewpoint as a bear biologist." He said the Alaska study may lay to rest some of the long-running discussions from physiologists who treat bear hibernation as "a different and 'lesser' form" compared with the big metabolic shifts seen in small animals such as ground squirrels.

Heart rate tracking for three of the Alaska bears showed a drop from 55 steady beats per minute on average before hibernation to 14 erratic beats per minute in winter. Physiological ecologist Hank Harlow of the University of Wyoming in Laramie said that he too has listened to hibernating bear hearts going still for a stretch and then kerthumping arrhythmically. Maybe it saves energy, he said.

The Alaska team also found that when bears got moving again in spring, their metabolisms took several weeks to creep back to normal. Monitoring data showed that bears with half-speed metabolic rates still display normal bearish behavior, however.

5.2 million Total barrels of oil released in Gulf spill

4.4 million Barrels of oil not recovered at source of spill

Gulf floor tainted by oily deposits

Patches are the remnants of an oil-eating bacterial bloom

By Janet Raloff

Huge quantities of oil that gushed from BP's well blowout last spring and summer now taint the Gulf of Mexico's seafloor, newly released video and chemical sampling data show. Within 40 miles of the damaged wellhead, the oil deposits appear extensive but patchy, and range from little spots of oil on the seafloor to localized blankets of goopy hydrocarbons several inches thick.

New data suggest that much of this oil may have rained down from the sea surface, fostered by what scientist Samantha Joye calls "microbial spit." Joye, an oceanographer and biogeochemist at the University of Georgia in Athens, described her team's findings on February 19.

Joye shared underwater images depicting eerie strings of bacterial slime — mucus streamers ranging from 1 millimeter to almost 2 meters long. The key ingredient of the slime is a material that, like laundry detergent, helps break apart large oil globules. Such surfactants are secreted by many oil-eating bacteria and render the oil easier to digest. As the sticky slime picks up cells and other debris from the water, the goop becomes heavy and sinks.

Or that's what appeared to be happening, Joye said. To investigate, her team went back to the lab and added a milliliter of oil from the BP well to a liter of surface seawater collected from an oil-free part of the Gulf.

After a day, naturally occurring microbes in the water began growing on the oil. After a week the cells formed blobs that were so heavy they began sinking to the bottom of a jar. Two weeks later, large streamers of microbial slime and cells were evident.

"This is the mechanism that we propose deposited oil to the [Gulf's] bottom," Joye said.

Photos taken in September in areas that had encountered BP oil show streamers of microbial spit "all over the place," she said. "The stuff we're seeing in the lab forming from the addition of oil is very similar looking to what we see on the bottom."

Strands of oil-laden "bacterial spit" floating in the Gulf of Mexico will eventually sink, carrying oil to the seafloor.

S. JOYE/UNIV. OF GEORGIA

When Joye and her colleagues extracted cores of sediment from the Gulf's spill-impacted zones, the top sediment layers often showed signs of what appeared to be the microbial spit. That layer also was devoid of living animals, forming what Joye called an "invertebrate graveyard."

She often saw dead corals, crabs and sea stars in the affected seafloor areas. Absent were sea cucumbers that are normally abundant in parts of the Gulf where natural petroleum seeps occur.

Callous-unemotional traits an omen

Lack of guilt and empathy in bad kids signals trouble to come

By Bruce Bower

When an unrelenting penchant for misbehaving joins forces with lack of emotion, guilt and empathy, 7-year-olds are headed for years of severe conduct problems, a long-term study of British youngsters suggests.

Kids who regularly misbehave and get into trouble at age 7 and also display traits termed "callous-unemotional" frequently stay on a troubled course until at least age 12, according to a new investigation described February 20.

These findings indicate that callous-unemotional traits should factor into the definition of a particularly virulent form of childhood conduct disorder in the next manual of psychiatric disorders, said study leader Nathalie Fontaine of Indiana University in Bloomington. Chronic misbehavior alone defines conduct disorder in the current edition of the book that doctors use to define mental ailments.

Fontaine's team studied 9,578 children born in England and Wales from 1994 to 1996. Teachers and parents evaluated surveys of behavior problems and callous-unemotional traits at ages 7, 9 and 12.

A total of 4.4 percent of these children, mostly boys, showed high levels of both misbehavior and callous-unemotional traits throughout the study. This group displayed many hyperactive symptoms, got along poorly with peers and came from comparatively chaotic families that used harsh forms of punishment.

Fontaine emphasized that kids with high callous-unemotional traits almost always misbehaved regularly. In contrast, only about half of kids who constantly misbehaved also lacked remorse, guilt and empathy, indicating that a variety of influences play into conduct problems.

AAAS Meeting

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New batteries heal themselves

Self-repairing versions last longer, less likely to catch fire

By Devin Powell

A newly created lithium-ion battery that can heal itself may improve the life span and safety of today's energy-storage technologies.

Rechargeable lithium-ion batteries power cell phones, laptops and other portable electronics. But, like any batteries, they tend to break down over time.

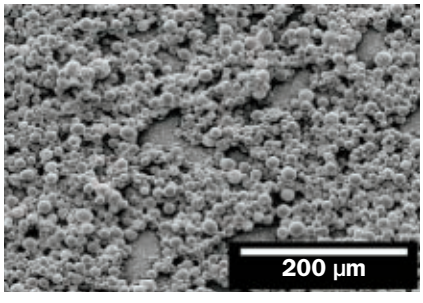
"There are many different types of degradation that happen, and fixing this degradation could help us make longer-lasting batteries," said Scott White, a materials engineer at the University of Illinois at Urbana-Champaign who described the innovation February 20.

One vulnerable site is the anode, a battery's negatively charged terminal. As a battery charges and discharges, the anode swells and shrinks. Over time, this cycling causes damage, creating cracks that can interfere with the flow of current.

To counteract this cracking, White and his colleagues embedded tiny microspheres inside an anode. As cracks formed they tore open the plastic shells, releasing the contents within: a material called gallium indium. This liquid metal alloy seeped out of the spheres and filled the cracks, restoring the flow of electricity.

Damage to a battery or a short circuit between its components can cause problems beyond a shorter life span. Out-of-control currents are known to create hot spots that can grow into raging fires.

"It's not a common occurrence, but when it happens, the consequences are severe," White said. Battery fires have prompted laptop recalls by Dell and Hewlett-Packard; the U.S. Department of Transportation has proposed stricter rules for cargo planes that transport large quantities of lithium-ion batteries.



Minuscule microcapsules like the ones shown here could be used to make safer and longer-lasting lithium-ion batteries.

To safeguard against this type of failure, White developed a second kind of microsphere made of solid polyethylene, an inexpensive plastic. Small spheres embedded in the anode and other battery components can function as a safety cutoff switch. If the temperature inside the battery rises above 105° Celsius, the spheres melt into a thin layer of insulating material that shuts off the flow of electricity, preventing a conflagration.

"We've tested this in real batteries," said White, whose lab is a partner of the U.S. Department of Energy's Center for Electrical Energy Storage. "It works beautifully." This safety feature, he said, could be useful for electric cars emerging on the market.

"Lithium-ion batteries will continue to be the technology used for the next 10 to 15 years in electric cars," said Kristin Persson of Lawrence Berkeley National Laboratory in California, who is looking for new materials that store energy better and avoid some of the pitfalls of existing batteries. ■

Model tackles logistics nightmares

Computer program could help deliver relief after disasters

By Rachel Ehrenberg

Getting blood or other perishable supplies to an area that's been struck by an earthquake or hurricane isn't as simple as asking what brown can do for you. But a new model quickly determines the best routes and means for delivering humanitarian aid, even in situations where bridges are out or airport tarmacs are clogged with planes.

The research, presented February 18, could help get supplies to areas hit by natural disasters or help distribute vaccines when a flu epidemic strikes.

Efficient supply chains have long been a goal of manufacturers, but transport in fragile networks — where supply, demand and delivery routes may be in flux — requires a different approach, said Anna Nagurney of the University of Massachusetts Amherst, who presented the new work. Rather than considering the shortest path from one place to another to maximize profit, her system aims for the cleanest path at minimum cost, while capturing factors such as the perishability of the product and the uncertainty of supply routes. "You don't know where demand is, so it's tricky," said Nagurney. "It's a multicriteria decision-making problem."

By calculating the total cost associated with each link in a network, accounting for congestion and incorporating penalties for time and products that are lost, the computer model calculates the best supply chain in situations where standard routes may be disrupted.

"Mathematical tools are essential to develop formal means to predict, and to respond to, such critical perturbations," said Iain Couzin of Princeton University, who uses similar tools to study collective animal behavior. "This is particularly important where response must be rapid and effective, such as during disaster scenarios ... or during epidemics or breaches of national security."

MARTA BAGINSKA

"Lithium-ion batteries will continue to be the technology used for the next 10 to 15 years in electric cars." —KRISTIN PERSSON

MEETING NOTES

You spin me right round

For the first time in a laboratory setting, physicists have linked the motion of a particle with its spin. Such "spin-orbit coupling" could help researchers build futuristic versions of devices such as transistors. Ian Spielman, of the Joint Quantum Institute in Gaithersburg, Md., cooled rubidium atoms to ultrachilly temperatures until they formed a quantum liquid, then watched as the atoms underwent spin-orbit coupling. Spielman reported the findings on February 18. —*Alexandra Witze*

First foods become favorites

Taste preferences can be set very early in life, new studies reveal. Babies whose mothers fed them salty foods between 2 and 6 months of age had a stronger preference for salt at 6 months than did babies who hadn't eaten salty stuff, Gary Beauchamp of the Monell Chemical Senses Center in Philadelphia reported February 19. —*Tina Hesman Saey*

Electrodes knock out depression

Electrodes implanted deep into the brains of 20 people suffering from severe depression improved symptoms for up to six years, researchers reported February 18. Three to six years after neurosurgeons implanted electrodes in patients' brains, most still showed gains: fewer signs of depression, better physical health and the ability to hold down jobs. No late-developing side effects were evident from the procedure, though two of the subjects committed suicide during depressive episodes, reported neuroscientist Helen Mayberg of Emory University School of Medicine in Atlanta. The implants are used to help people who have not responded to other depression treatments. —*Laura Sanders*

Extending a cosmic yardstick

A longer cosmic yardstick promises to give astronomers a better grasp of how fast the universe is expanding and may offer clues to the nature of dark energy, the mysterious entity that accelerates that cosmic growth. New measurements based on intense radio-wave emissions peg the distance to the galaxy NGC 6264 at 450 million light-years with an accuracy of 9 percent. Previous measurements used a two-step, indirect method that is more error-prone, notes James Braatz of the National Radio Astronomy Observatory in Charlottesville, Va., who reported the finding February 19. —*Ron Cowen*

Guts in knots

The ancient Romans, who thought the future could be read in the complicated shapes of animal entrails, had it all wrong. These twists and kinks aren't nearly so complex, says L. Mahadevan of Harvard University. He can reproduce the gut's loops, which come in regular repeating intervals, with a simple rubber tube stretched and then stitched to a sheet of latex. Unconvinced by a theory that blamed cramped space in the abdominal cavity for these loops, Mahadevan tested the idea that a digestive tube growing faster than the tissue connecting it to the body could create a twisting force. "When the rubber relaxes, we see a periodic structure of loops that arises spontaneously," he said February 18. —*Devin Powell*

Lab jets may tackle cosmic blasts

Lab experiments that collide two jets of positron-electron pairs may help physicists identify the source of gamma-ray bursts in distant galaxies, Hui Chen of the Lawrence Livermore National Laboratory in California proposed February 18. Researchers detect intense flashes of gamma rays about once a day, but no one knows their source. Chen and colleagues reported last year creating and controlling jets of electrons and their antiparticles, positrons, in the lab. Now, she plans to whack them into each other. The collision is expected to create a shock wave that will accelerate particles to high energies and emit radiation. If the signal resembles that seen in space, it may point to a culprit. —*Elizabeth Quill*

Complex causes of cleft palates

A baby's risk of being born with a cleft palate may depend on both the child's genes and whether mom smoked, drank or took vitamins during pregnancy. Researchers examining genetic risk combined with maternal smoking, drinking and vitamin use found that environmental factors can interact with certain genes to raise or lower risk of the malformation, genetic epidemiologist Terri Beaty of Johns Hopkins University in Baltimore reported on February 20. Binge drinking and smoking early in pregnancy interact with some genes to raise the risk of clefts. Multivitamins interact with other genes to protect against clefts. —*Tina Hesman Saey*

Human brain hogs energy

Humans may have evolved to supply the brain with energy at the expense of other body parts. Creatine fuels metabolism by storing energy over the short term and releasing it quickly. Molecular evidence from frozen tissue samples suggests that, compared with chimpanzees and rhesus macaques, humans shuttle more creatine to the brain and less to skeletal muscles. Greg Wray of Duke University in Durham, N.C., reported the findings February 20. They also appear in the February *Journal of Human Evolution*. —*Alexandra Witze*

twists snaps & swirls in Quantum Whirls

How turbulence plays out in exotic materials

By Marissa Cevallos

Grab a mug and slosh the morning coffee around and around and a spinning vortex appears. The swirling rings, with their eddies and choppy waves, obey the laws of classical turbulence, which engineers and applied physicists routinely invoke to study how air flows over an airplane wing or how blood flows through tiny vessels.

Shake up a cup of quantum fluid instead and you still get vortices, but nothing like the tornado in your morning brew.

Quantum vortices can look like tiny rings that shatter into even more minuscule rings and then shrink away altogether. Connected one moment, in the next they appear to flex into curved lines — as if snipped with scissors. Sometimes these lines tangle like a ball of cat hair on a rug. And they can cross over each other into a letter X, swap ends and then shoot away with the gusto of a rubber band flinging from the finger of a mischievous third-grader.

Such scenarios go far beyond breakfast-table turbulence. This is the strange world of quantum turbulence, which pops up not in coffee cups, but in supercold helium, other types of strange cold matter and, some now think, the fabric of the universe.

Physicist Richard Feynman predicted the existence of quantum vortices more than half a century ago. But only in the last few years have physicists actually been able to watch the vortices' behavior with the naked eye. Researchers are now stirring up quantum liquids to see whether Feynman's ideas were correct, and going a step beyond to find out in fuller detail what happens as a sloshing quantum fluid rocks to rest. Understanding turbulence in these fluids may also offer clues to astrophysical mysteries — violent ejections of gas from the sun may obey the same strange dynamics, and thinking of the early universe as a fabric riddled with such vortices might help explain unexpected voids in the cosmos.

Theoretical swirlings

The rules of physics changed dramatically with the arrival of quantum mechanics, which describes how tiny particles such as electrons play. In the quantum world, particles can act like

zipping points one minute and wiggle like waves the next. And particles can't have just any amount of energy; they are confined to particular levels, called quantized states.

Usually quantum weirdness appears only in the microworld (*SN: 11/20/10, p. 15*), but larger systems sometimes display such bizarre behavior too. In 1937 physicists discovered that helium cooled to just above absolute zero flows with almost no viscosity, an exotic property called superfluidity. Russian condensed-matter theorist Lev Landau explained that superfluidity occurs when the atoms join up in a quantum state, which forces them to lose their separate identities and act as one, and he developed a mathematical explanation of that behavior.

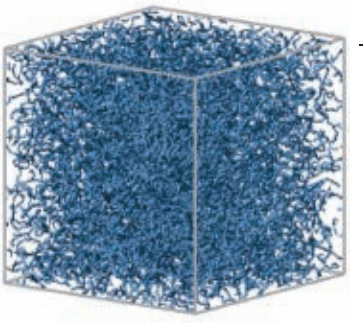
So what exactly would happen to the united particles if someone casually swirled a mug of quantum liquid?

Landau's math suggested that the particles, because they are in a low energy state, would want to remain stationary. So convincing the superfluid to actually rotate like a spinning tornado would require an enormous amount of energy.

Feynman imagined, in a paper published in 1955, that the fluid would ripple in ways unfamiliar to coffee drinkers, cleverly skirting Landau's requirement and still absorbing the energy from the rotating mug. Holes in the liquid, or quantum vortices, would form, but nothing would swirl within them. As long as the mug kept rotating, the vortices would line up into an orderly lattice.

What would happen when the mug stopped rotating, though, would be most fascinating. The holes, which are actually 3-D voids that behave something like strings of spaghetti, would fall against the wall of the mug or tangle in complex ways. Any added energy would have to go somewhere: A quick escape, Feynman speculated, would be for two vortices to collide head-on and snap apart. Sometimes they could loop back on themselves to make SpaghettiOs and shed energy by cascading into smaller rings.

Creating these tubelike vortices wouldn't take much energy, Feynman speculated, and liquid helium would be the best place to see them. But spotting turbulent activity in the superfluid turned out to be a tall order.



A computer simulation shows how quantum vortices might look in a turbulent material.

When turbulence is invisible, like in blustering wind, scientists can plant a sock on a stick to watch how it flaps. When visualizing how fluids rotate, scientists might add food coloring and watch how the colors move. But finding a way to see quantum vortices on the surface of liquid helium was a challenge because helium is so light. Just about any tracer sinks to the bottom.

Scientists tried to visualize the curving lines and circles that Feynman had pictured. Theorists derived equations for such vortices and experimentalists even captured snapshots of the quantum hubbub. But quantum vortices that connect, snap and shrink remained a figment of the imagination for decades.

Of serendipity and snaps

In 2006, a physics graduate student at the University of Maryland unwittingly stirred the dreams into reality. Gregory Bewley, transplanted from a lab at Yale, was finishing his thesis on how fluids such as the ocean, the atmosphere and Earth's molten core experience turbulence while rotating with the Earth. His experiments involved spinning a cylinder the size of a skateboard and watching how the liquid helium sloshed inside.

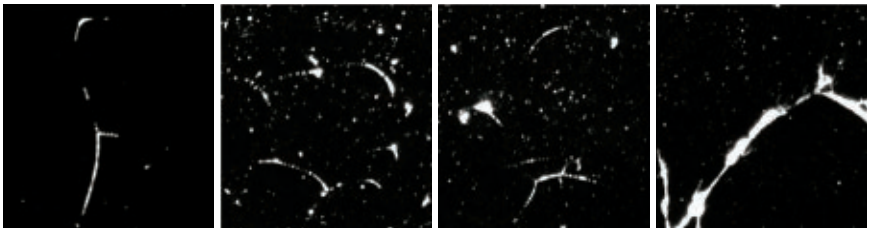
Frustrated that none of the tracer particles he could buy would float, he created a new technique to freeze hydrogen, the only element lighter than helium, into a fog of ice particles. He sprinkled the hydrogen particles like snow onto the helium. They floated.

Two colleagues, physicists who had been thinking about the dynamics of quantum turbulence since Feynman's time, got wind of the new technique. They urged Bewley and his adviser, Maryland's Dan Lathrop, to try the same experiment but with much colder helium, at 2 degrees Celsius above absolute zero.

On a late night in the lab, Bewley shined a laser onto the supercold liquid with the hydrogen snow. He was shocked to see Feynman's vortices pop into existence and bump into each other. A few days later, he and his adviser caught the whole dance on tape, publishing the new techniques and observations in *Nature* in 2006. Physicists rushed back to the problem of quantum vortices when they saw movies from Lathrop's lab. They wanted to see what would happen as the energy dissipated.

On his laptop in his Maryland office, Lathrop plays a movie of a quantum fluid. Energy is steadily added, this time by a heater instead of spinning. White dots and lines sway on a black backdrop as if stars in the night sky were floating down a stream. But then the liquid is abruptly cut off from its heat source. The dance speeds up to a rave: Lines collide. Lines snap away. Then everything calms down again.

But the calming appears to occur too quickly, says physicist Carlo Barenghi



By sprinkling ice particles made of hydrogen (white) into supercooled helium (black), researchers have been able to watch quantum vortices meet up and then fly away from each other in real time (four movie stills shown).

TOP: MAKOTO TSUBOTA; BOTTOM: ENRICO FONDA/UNIV. OF MARYLAND QUANTUM FLUIDS TEAM

of Newcastle University in England; it takes just about 10 seconds for the turbulent fluid to become quiet. A pendulum, released from up high, will move back and forth, back and forth before eventually swinging to rest. It slows because of friction created as it passes by air molecules. But liquid helium is basically frictionless, so any added energy should take quite a while to dissipate.

Computer simulations suggest a solution to the puzzle: Reconnecting vortices could get rid of the energy quickly by adding some wobbling of their own, Barenghi has suggested in several recent papers. Quickly after vortex lines snap away from each other, they could jerk and wiggle and form what are called "Kelvin waves." If these wiggly lines loop up, they can cascade into even tinier rings. Each time the rings get smaller, sound particles called phonons should be emitted, Barenghi says. No one has yet listened for the ping of phonons coming from a quantum liquid, though, so the case hasn't been closed.

Reconnecting vortices could get rid of the energy quickly by adding some wobbling of their own.

Swirling superfluid helium presents other puzzles. In 2008 Lathrop, graduate student Matthew Paoletti and colleagues reported in *Physical Review Letters* that many more quantum vortices sweep around at high speeds than would be expected for classical turbulence, a pace that may be explained by reconnections. Lathrop would also like an explanation for filaments observed in the fluid that look like lines with equally spaced dots on them, an unpredicted quantum pearl necklace of sorts.

By studying turbulence in other quantum fluids, such as an ultracold gaslike state of matter called a Bose-Einstein condensate, scientists might get a more complete picture of quantum turbulence and answer some lingering questions.

Vortices in a Bose-Einstein condensate may be easier to visualize than in helium because the spaghetti strands can be more than a thousand times thicker than those in liquid helium. Plus, the condensate balloons to 40 times its size when allowed to freely expand, magnifying the vortices, Jamil Abo-Shaeer says. Abo-Shaeer, now with the defense research agency DARPA in Arlington, Va., was a member of the MIT team that first spotted vortices in the condensates back in 2001. Another advantage of studying turbulence in this ultracold gas, says Abo-Shaeer, is that it is easy to get nearly all of the atoms acting in unison. In some cases, even in superfluid helium cooled to just above absolute zero, not all the atoms want to participate.

Though quantum vortices had already been spotted in the condensates, a team reported first seeing the vortices tangle in 2009 in *Physical Review Letters*. Vanderlei Bagnato of the University of Sao Paulo in Brazil, a coauthor on the paper, thinks the same turbulent wiggle that appears to dissipate energy in the superfluid helium may be doing so in the Bose-Einstein condensate as well.

Heavenly twists

As Bagnato and colleagues watch turbulence play out in the lab, others are turning to traces of the phenomenon elsewhere in the cosmos.

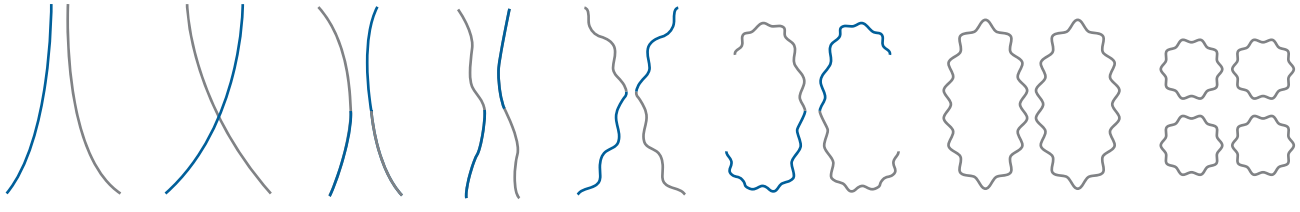
In another University of Maryland building, James Drake tackles the problem of why the sun violently spews particles, an ongoing process that can interfere with satellites. Drake has dedicated much of his career to the idea that hot plasma is ejected from the sun because magnetic field lines cross and twist.

He was working on his laptop in his office in 2006 when Lathrop, a longtime colleague and friend, rushed in. Lathrop, who had just observed the liquid helium turbulence the day before, commandeered the keyboard and typed in a web address. As Drake watched a full-screen movie of lines bumping into each other in liquid helium, he knew in an instant that he was seeing reconnection.

The way that vortices snapped away from each other is similar to how Drake imagined magnetic field lines twisting in the sun. "It was incredible," Drake says. "It's exactly what we've been studying for decades."

Though the processes aren't exactly alike, both quantum vortices and magnetic field lines can be thought of as strings with tension, like a stretched guitar string or rubber band. Lathrop and colleagues had found that, in helium, smaller vortices reconnect faster, and

Getting connected Physicist Richard Feynman predicted that vortices that behave like strings of spaghetti would show up in a quantum fluid as energy is added — say by swirling. Interactions among these vortices may help dissipate energy in such systems.



When the system is cut off from added energy, vortices fight to avoid tangling. Still, some cross over each other to form the letter X.

After forming an X, the vortices can swap ends in what's called a "reconnection event." This meet-up can cause them to fly away from each other.

As the vortices snap away, they can develop ripples called Kelvin waves. In some cases, the new vortices will loop back on themselves to form circles.

Such circles can cascade into even smaller circles, a process that releases particles of sound, or phonons, and may also dissipate energy.

SOURCES: M.S. PAOLETTI *ET AL/PHYSICA D: NONLINEAR PHENOMENA* 2010, M.S. PAOLETTI AND D.P. LATHROP/*ANNU. REV. CONDENS. MATTER PHYS.* 2011

JANEL KILEY

Drake thought the finding might help explain why reconnections happen faster among magnetic field lines in the sun than classical magnetic theory would predict. Drake and colleagues also argued, in a paper published last year in the *Astrophysical Journal,* that similar reconnections may be happening among magnetic field lines at the edge of the solar system.

Real quantum turbulence, not just an analog, may even have occurred at more distant reaches. Kerson Huang, a physicist at MIT, thinks that quantum turbulence could explain a lot about the cosmos. Astronomers studying the heavens have found that there are gaps of relatively empty space billions of light-years across, where few galaxies are found. But space in general looks uniform, so why these gaps exist has remained a mystery.

Huang thinks if the early universe were like a superfluid punctured by quantum vortices, these vortices could have created the gaps. If so, this phenomenon might be seen in a particle accelerator designed to imitate the vacuum of the early universe, such as the Large Hadron Collider outside Geneva. Colliding beams of protons at the LHC generate exotic particles and release a lot of energy.

"It's a fireball that could burn a hole in the vacuum, so to speak," Huang says. Such holes would have been pinpricks in the early universe, but would have bloated as the universe expanded, creating the cosmic voids, wrote Huang and colleagues in a paper posted online in November at arXiv.org.

However, Huang says, people haven't thought deeply enough about how to detect hints of vortices in collider data: "We might create it, but we might not recognize it." He is now doing calculations to figure out whether vortices would grow to a size that matches the size of voids found in the cosmos.

"His ideas are interesting because they connect quantum theory to vortices to the early universe," Lathrop says. If Huang turns out to be right, his work could help rule out some theories for the birth of the universe.

For now, his cosmic void idea is speculative. But sometimes speculation turns out to be true. That was the case with Feynman's predictions about quantum vortices. After suggesting that they would not only pop up, but also reconnect to dissipate energy, Feynman wrote in his 1955 paper: "Having travelled so far making one unverified conjecture upon another we may have strayed very far from the truth." Surely you were joking, Mr. Feynman — your predictions were spot-on. ■

Marissa Cevallos is a former science writer intern at Science News.

Explore more

- For a video of quantum turbulence: http://complex.umd.edu

All shook up

Though you won't spot quantum turbulence in your coffee mug or kitchen sink, you probably experience some form of classical turbulence every day. The phenomenon occurs when fluid attempts to flow past an object or another fluid, bouncing and twisting to create chaotic patterns.

Buckle up Rough air in the form of strong updrafts in storms, downdrafts on the leeward side of a mountain and shifting jet stream boundaries can shake unbuckled airline passengers from their seats. Though bumps caused by air moving against air can injure a person onboard, they rarely damage planes.

Flowing through When doctors bring a stethoscope to your heart, they are listening for the lubb-dupp that comes with a healthy beat. Obstructions resulting from valve malfunctions or clogged arteries can cause a whooshing or blowing sound because they interrupt blood's streamlined flow to create an audible, turbulent one.

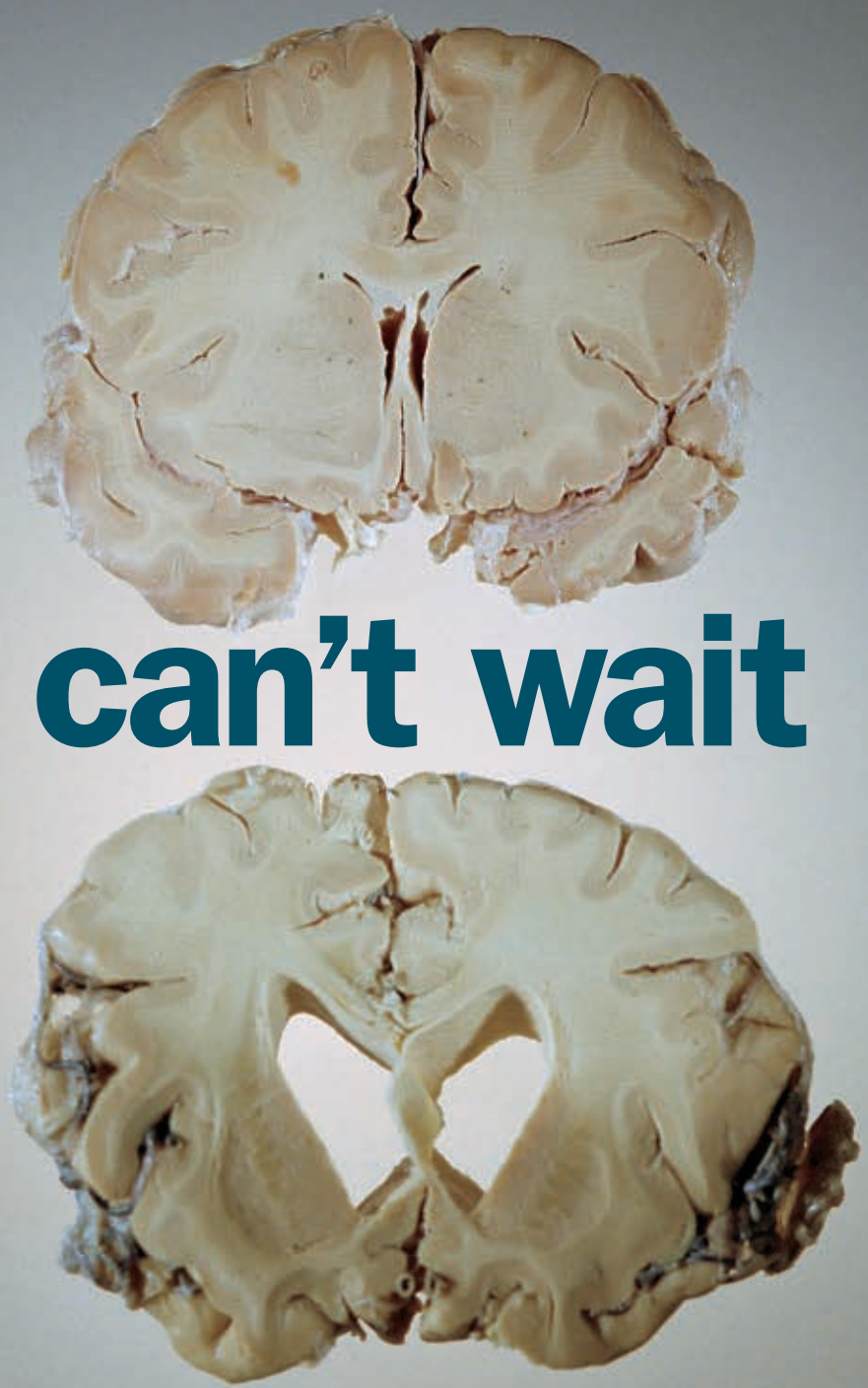
Shine down As the sun's core burns, energy is radiated outward. This results in a constant, turbulent overturning of hot and cold gases in the sun's outer layer, called the convection zone. Computer simulations are helping scientists understand how small-scale turbulence can result in the large-scale order seen in the convection zone.

What a drag The flow of air around a moving car takes on a turbulent quality and increases drag. Though the effect may not matter much at city speeds, Formula 1 race car designers have put a lot of effort into reducing turbulence in air passing *over* their vehicles. At the same time, organizers want turbulence *behind* the car reduced because it makes overtaking another car more difficult.

Seaside surf As a wave approaches the beach, the gradual slope of the ocean bottom causes the wave to steepen until its crest becomes unstable, resulting in white water. Similar disruptions can occur mid-ocean anytime water's flow is interrupted by an obstruction, such as a reef.

CLOCKWISE FROM TOP LEFT: AIRPORTRAIT/ISTOCKPHOTO; MEDICALRF/PHOTORESEARCHERS; GOMEZDAVID/ISTOCKPHOTO; © WEI SENG CHEN/DREAMSTIME

memories can't wait



Researchers rethink the role of amyloid in causing Alzheimer's

By Laura Sanders

The polite term for what Alzheimer's disease does to the brain is "neurodegeneration."

In reality, it's more like violent, indiscriminate devastation. Alzheimer's scrambles communication channels, incites massive inflammation and demolishes entire brain regions as once plump cells shrivel and die, burying memories in the wreckage. As the attack intensifies, Alzheimer's gradually strips away a person's mind, and ultimately the cognitive abilities that permit a conversation with a loved one, a smile or a taste of food.

A couple of decades ago, some researchers thought they knew the root cause of this brain invasion — dangerous buildups of a protein called amyloid-beta. Get rid of these big, sticky globs and cure the disease, the reasoning went. But in recent years, a deeper understanding of the disease, along with a few disappointing clinical trials, has challenged long-held assumptions and forced a reevaluation of this strategy.

Many researchers are convinced that A-beta is still a key target. A litany of damning evidence from genetics, pathology reports and lab experiments makes that case. Yet recent results show that A-beta is not the same foe it was originally thought to be. Smaller pieces of A-beta — not the large plaques that were formerly indicted — are likely to be malicious, capable of destroying nerve cell connections, several new studies show. Other data coming from sophisticated imaging techniques may illuminate how, when and where A-beta accumulates in the brain, and how this buildup might relate to diminished mental powers.

Yet the fact that A-beta can also accumulate in healthy brains, among other findings, has caused some Alzheimer's researchers to shift their sights away from that protein. A new model proposes that inflammation, along with the harm-

Differences in a healthy brain (top) and a diseased one (bottom) clearly show the damage wrought by Alzheimer's.

ful marinade it brings, might be a central cause of the disease. Other studies are turning up links between Alzheimer's and the curious tendency of brain cells under stress to double their genetic material.

While the cause of Alzheimer's remains elusive, the extent of its threat to the brain is becoming increasingly clear. Each week, new studies chronicle the damage in ever more detail: Chemicals that carry messages between nerve cells go MIA, brain cells' birthrates plummet, cells' energy output goes haywire, cell waste begins to pile up and harmful reactive chemicals get produced. Ultimately, brain cells die.

Teasing apart this tangled web — in which it's nearly impossible to distinguish a diabolical mastermind from a lowly hired gun or even an innocent bystander — isn't easy. If it were, the problem would be solved by now. "I think we have to be honest and say this is an incredibly complicated condition, and it's going to be very hard to tackle it," says Alzheimer's researcher Lennart Mucke of the University of California, San Francisco.

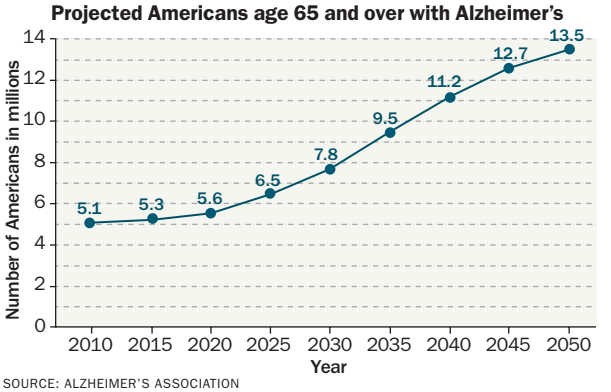
A tangled web

It's no surprise that A-beta has attracted so much attention from those intent on unraveling the mysteries of Alzheimer's. Ominous deposits of the protein (along with tangles of another protein, called tau, that has also garnered a fair share of investigation) were what caught the eye of German physician Alois Alzheimer when he first described the disease a little over a century ago. His postmortem exam of a patient's brain revealed the amyloid plaques that have been associated with Alzheimer's disease ever since.

But much remains unknown about A-beta. While it has been shown that A-beta is a snippet cut from the larger amyloid precursor protein, found in nearly every cell in perfectly healthy brains, A-beta's normal function remains murky. Studies have hinted that the protein might aid nerve cell activity or combat dangerous pathogens. Others suggest A-beta is merely a cellular by-product that adopted a new and damaging role.

In the tangle of Alzheimer's, one thing is clear: Old age is the No. 1 risk factor, a frightening realization as the front edge of the baby boomer tide turns 65 this year. The disease is "obviously an epidemic of staggering proportions, and obviously of great economic impact," says neuroscientist Sam Sisodia of the University of Chicago. Alzheimer's is the fastest growing cause of death from major disorders in the United States, and a recent analysis estimates that the nation's annual cost of Alzheimer's-related care will exceed $1 trillion by 2050.

Alzheimer's boom As the baby boomers age, the number of elderly Americans with Alzheimer's is projected to reach 13.5 million by 2050. Assuming no breakthroughs in treatment, health care costs will continue to increase as well.



SOURCE: ALZHEIMER'S ASSOCIATION

Alzheimer's is unlike anything else clinicians have treated: In most cases, no one knows what causes it. It can't be definitively diagnosed until a pathologist cuts into the dead brain. There is no known cure or therapy for prevention, and even if there were, it wouldn't be clear when to use either one. Many believe the disease causes its irreparable damage years before symptoms appear.

"We have therapies that help with the symptoms, but we don't have disease-modifying treatments," says Paul Aisen of the University of California, San Diego School of Medicine, a neurologist who tests potential Alzheimer's drugs. "And we don't know what the best target is, and we don't know what the best timing is."

But many scientists in the field find hope in the fact that they have sketched out the broad outline of how the disease works, pointing to new targets for therapies. One key to filling in that sketch, scientists now know, is understanding brain cell communication.

Brain chatter, interrupted

A-beta scrambles neural dispatches in an unexpected way, new work from neuroscientist Gabriel Silva of the University of California, San Diego suggests. In a dish of brain cells called astrocytes, a droplet of the A-beta protein sparked a signal that can silence chatter between nerve cells, the brain's main communicators. The signal traveled as a wave of calcium atoms that washed across cells, kicking off a series of damaging events that could end with disrupted nerve cell communication.

"Amyloid-beta is sufficient, completely on its own, to induce these things," Silva says of the finding, which was published last year in *ASN Neuro*. These calcium waves have also been spotted in mice loaded down with the human form of A-beta to mimic the high levels found in some Alzheimer's patients. (A-beta doesn't usually accumulate in the brains of mice.) It's still not clear whether A-beta triggers calcium waves in human brains.

A-beta probably has a more direct path to harming synapses, the junctures where messages, including those that create memories, are transmitted between nerve cells. In mice, an abundance of A-beta can order an assassination of a protein that's important for forming memories, a study by Mucke and colleagues published in the Jan. 6 *Nature* showed.

Normally this protein, called EphB2, oversees the action of a signaling molecule that moves across synapses and helps create new memories. In the experiments, A-beta latched on to EphB2 and helped move it to the cellular dump. Without the right levels of EphB2,

synapse-traveling molecules went haywire. "Nerve circuits couldn't perform properly anymore, and the mouse couldn't learn or remember properly," Mucke says. "The whole information processing pathway comes apart."

Mucke and his colleagues reversed these memory deficits in mice carrying heavy loads of A-beta by boosting levels of the EphB2 protein. Studies show that people with Alzheimer's have less EphB2 in their brain cells, so protecting the protein from A-beta or artificially boosting its levels might be a way to reverse cognitive decline, Mucke says.

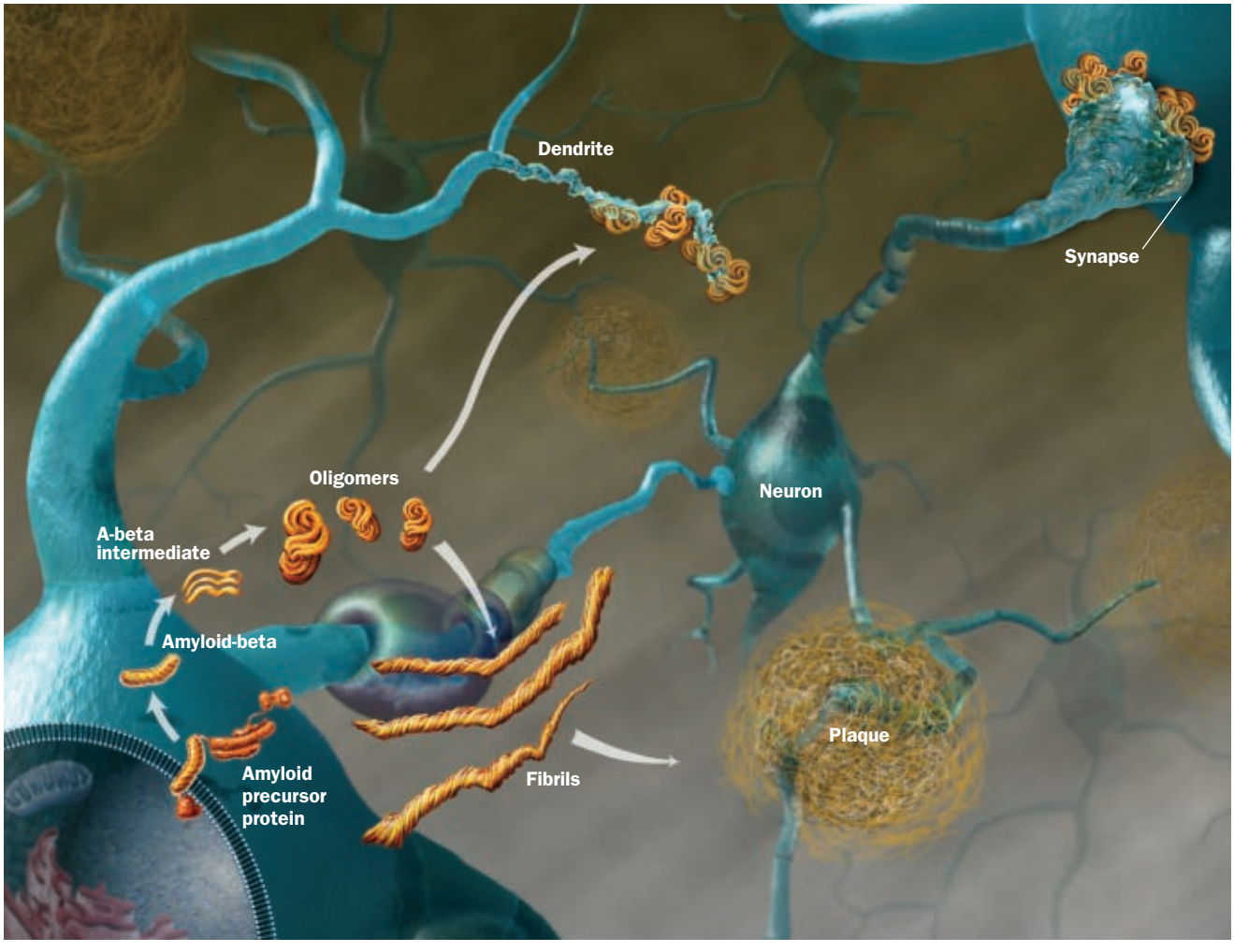
A-beta may also hit another target at the synapse. In mouse brains with high levels of A-beta, a protein called Caspase-3 was busier than normal, a dangerous hyperactivity that led to the disintegration of dendrites, a nerve cell's message-receiving extensions. This A-beta–Caspase-3 combo caused dendrites' demise in the hippocampus, the brain's center for forming memories, researchers reported in the January issue of *Nature Neuroscience*. Dampening Caspase-3's activity protected these dendrites, suggesting that, like EphB2, Caspase-3 might be a good place to intervene to protect nerve cell communication from Alzheimer's disease.

Small but dangerous

These assaults at the synapse were led by diminutive forms of A-beta called oligomers. Small, dissolvable pieces of A-beta, they are the building blocks of the large, insoluble fibrils that form the plaques first spotted by Alois Alzheimer. Oligomers are quickly gaining notoriety as a more probable villain than the well-studied plaques.

Data from neuroscientist Caleb Finch's group at the University of Southern California in Los Angeles, and work by other researchers, have made the case that the oligomers are the most damaging form of A-beta. "We are convinced

Amyloid on the brain Though amyloid-beta has long been implicated in Alzheimer's disease, figuring out just how the protein harms the brain has proved tricky. A-beta appears to cause problems when it aggregates into other forms and accumulates, perhaps because of overproduction or slow clearance. In its small oligomer form, A-beta can damage synapses, message-relaying connections between nerve cells. By setting off cascades of reactions, oligomers can also damage neural extensions called dendrites. Oligomers can clump into fibrils, which then form the large amyloid plaques characteristic of the disease. Many other potential culprits are also being investigated, some of which alter A-beta activity and some of which appear to cause damage in different ways.



NICOLLE RAGER FULLER

that the oligomeric forms, small assemblies of three to 10, are more toxic than the long fibrils," Finch says.

In fact, mice with a form of A-beta that can't accumulate into large fibrils still show memory troubles, Takami Tomiyama of Osaka City University Graduate School of Medicine in Japan and colleagues reported last year in the *Journal of Neuroscience*.

This result "adds powerfully to our theory," Finch says.

Right now, there's no way to visualize these A-beta oligomers in a living human brain. Autopsies and recent developments in brain imaging allow researchers to see larger A-beta plaques, but working backward from the plaque to estimate amounts of the smaller oligomers is tricky. This elusive relationship, says Sam Gandy of Mount Sinai Medical Center in New York City, throws a wrench in studying oligomers in the brain. "It's really hard to get a good accounting of how much is there."

Lots of simulations and test-tube experiments have attempted to demystify the oligomer-plaque relationship — for example, by considering whether there's a critical mass of oligomers required for plaque formation. But the "exploded drugstore" in the brain confounds the math, Finch says. Chemicals and salts floating around in the brain may influence the conversion rate of A-beta oligomers into plaques. "You can do beautiful model assemblies in a test tube ... but how relevant that is to the mess of small molecules in the brain is imponderable," he says.

A-beta logistics

Even though it's not yet clear how to measure oligomer levels from plaque, or vice versa, new brain imaging techniques may help clear up another problem: identifying who's at risk.

In 2002, University of Pittsburgh researchers William Klunk and Chester Mathis tested a compound, Pittsburgh Compound B or PiB, that sticks to plaques of A-beta in the brain and may serve as an Alzheimer's beacon in an imaging scan. Though relatively new, PiB is gaining more and more credence as a reliable measure of A-beta plaques. An autopsy on the first Alzheimer's patient to ever undergo a PiB scan confirmed that the tracker was indeed detecting A-beta plaques, Swedish researchers reported January 1 in *Brain*.

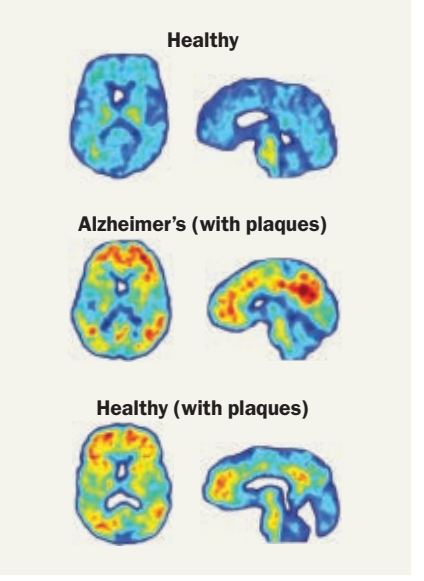
A major question researchers expect PiB to help answer is when A-beta buildup starts. Though PiB hasn't been around long enough for long-term studies, preliminary results suggest that A-beta plaques appear years before brainpower declines. Healthy people with a strong PiB signal in their brains are more likely to exhibit mild dementia within the next few years, a small study published in 2009 in the *Archives of Neurology* found.

This potentially long lag time between the start of the disease and debilitating symptoms fits with clinical observations, says neurologist Randall Bateman of Washington University School of Medicine in St. Louis. "Clinical symptoms are only seen when the neurons are dead," he says. "We know that people aren't symptomatic until they lose 60 to 70 percent of the neurons in key brain regions."

Waiting until a person exhibits severe cognitive problems and then trying to reverse them is like "throwing a rope to a guy that's already jumped off the building," says neuroscientist Charles Glabe of the University of California, Irvine, who is working on a vaccine-based strategy to decrease A-beta in the brain. "He's going to hit."

Modern medicine's approach to treating heart disease isn't to withhold therapies until after the heart fails, Aisen and colleagues pointed out January 18 in *Neurology*. Once treatments are found, figuring out exactly when Alzheimer's sets in will probably help to make them much more effective.

Yet caution is needed when interpreting a PiB-positive or PiB-negative brain scan, especially when considering estimates that 20 to 50 percent of healthy people go about their business with brains chock-full of A-beta plaques. Many of those fully functional brains would easily earn an Alzheimer's diagnosis with PiB scanning. It's not clear whether, if people were to live long enough, anyone walking around with A-beta plaques in the brain would eventually succumb to Alzheimer's.



Plaque marker In a PET scan, labeled PiB protein lights up when bound to amyloid plaques in the brain. A healthy person (top) has little binding compared with the high levels seen in an Alzheimer's patient (middle). But high levels are also found in some healthy people with no cognitive problems (bottom).

"If I'm cognitively normal, do I care if I have amyloid in my brain?" Klunk said at the 2010 Society for Neuroscience meeting in San Diego. "Is it irrelevant, or is it like blood pressure, where you're not sick but you're walking around with 200 over 120? That's not a good thing."

A-beta buildup may be the most obvious, common and even leading cause of Alzheimer's. But for some people, A-beta may indeed be irrelevant.

A new battle plan

Neurobiologist Karl Herrup of Rutgers University says that the idea of Alzheimer's without A-beta must be considered. Herrup points to patients who exhibit all of the cognitive impairments that follow Alzheimer's disease, yet for whom subsequent imaging experiments or postmortem tests find no plaques in the brain. "When I talk to clinicians about it, they all agree that this is a real category, that it's not just the occasional person."

Other pieces of evidence don't add up either, Herrup says. The presence of

G. RABINOVICI/UCSF, W. JAGUST/LBNL

Alzheimer's on trial A small number of Alzheimer's interventions, some highlighted below, are currently in Phase III clinical trials, which are undertaken after preliminary studies show that a drug is safe and may be effective. Right now, more than 800 clinical trials—including those at earlier stages of testing—are searching for potential Alzheimer's therapies. Among those are therapies that examine the effects of exercise, diet and inflammation-reducing drugs.

Potential Alzheimer's therapies in Phase III clinical trials

Alpha-tocopherol (Vitamin E)	Vitamin E may protect brain cells by scooping up toxic free radicals.
Bapineuzumab (AAB-001)	Multiple clinical trials are testing bapineuzumab, a laboratory-designed antibody that binds to and removes A-beta from the brain.
Intravenous immunoglobulin (IVIG, Gammagard)	Harvested from blood donors, these naturally occurring antibodies may reduce A-beta in the brain.
Resveratrol	Found in red wine, this compound may protect brain cells from damage. It is being tested along with glucose and malate, which are thought to prime resveratrol for its beneficial actions.
Solanezumab	This drug is thought to bind to smaller, soluble assemblies of A-beta before they become plaques and remove them from the brain.

SOURCE: WWW.CLINICALTRIALS.GOV/CT2/HOME

A-beta plaques in cognitively healthy people raises doubts about A-beta as the bad actor it was once assumed to be. So does A-beta's failure, in mice, to elicit the kind of massive and widespread neuron death seen in Alzheimer's.

"We've filled mouse heads with plaques, and oligomers for that matter," Herrup says. "And what we've created is, at best, mild cognitive impairment.... If you go to the Alzheimer's ward of any institution, most of the residents there would be ecstatic to be returned to the level of function in our worst mouse model."

Another particularly troubling piece of data is that, so far, lowering A-beta levels in human brains hasn't improved brainpower. A drug called bapineuzumab, thought to shuttle A-beta out of the brain, decreased amyloid plaques in the brain but didn't boost brainpower in patients with mild to moderate disease, a clinical trial published in *Lancet Neurology* last year showed.

"The main issue is that none of these amyloid-lowering therapies have improved cognitive function," Gandy says. "If there had been a benefit to any of the things that lowered amyloid, then that would obviously put all the doubt to rest."

That's not to say A-beta doesn't have a role in the disease. But in some cases A-beta may not be leading the charge.

Instead, Herrup proposes a new model of how Alzheimer's disease sets in and spreads—a model that moves A-beta out of the limelight. First comes an injury, which may be related to some sort of vascular event such as a microstroke or mild head trauma suffered during a fall. This minor event then kicks off an inflammatory response in the brain.

This inflammation, Herrup and others argue, may be at the core of Alzheimer's disease. The "inflammation hypothesis" holds that given enough time, the harmful stew of factors triggered by an injury can cause major, irreversible damage to brain cells.

Herrup's model demotes A-beta but doesn't discharge it entirely. It turns out that A-beta probably worsens inflammation, and inflammation may spur more A-beta formation.

"The major issue is chicken and egg," says Finch. "Right now, I don't think the cause-and-effect aspect of inflammation in Alzheimer's disease can be resolved, but everybody recognizes that it's enmeshed in the process in a fundamental way."

Extended inflammation triggers a permanent change in brain cells, a point of no return, Herrup proposes. "The cells don't care any longer about whether there's amyloid in their environment, or whether there's inflammation in their environment," he says. "They have crossed the Rubicon." After this point, no intervention or therapy could help.

Herrup's hunch is that this switch might be related to a curious fact about neurons: When they're under stress, they duplicate their genetic material. Usually, when most cells in the body do this, it's in preparation for replication of the whole cell, and the new copy of the cell gets the extra set of DNA. But instead of dividing, neurons under duress just chug along with double the amount of DNA. Once the DNA is doubled, there's no way for a brain cell to get rid of it, short of dividing. And neurons don't divide.

"I'm afraid it's been one of those observations that no one can fit anywhere, so they always smile and say, 'Well, that's really interesting,' and go back to what they were doing," Herrup says.

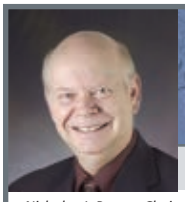
Researchers don't yet know whether this extra DNA is harmful, but it's clear that the stunted duplication occurs more in brain cells battling Alzheimer's. In people with the disease, not only were brain cells more likely to have extra copies of DNA, but those cells were also at a greater risk of death, German researchers suggested in a paper published in July in the *American Journal of Pathology*.

The link between extra DNA and neurons fated for destruction, though intriguing, is preliminary. It may turn out to be another red herring on the quest to find Alzheimer's ultimate cause. Neatly assigning roles to the entire cast of characters at work in Alzheimer's disease, and finding ways to counteract them, remains challenging.

"How close are we to understanding Alzheimer's disease? That's the same question we were asking 10 years ago," Sisodia says. "And we'll be asking that same question 10 years from now." ■

Explore more

■ Alzheimer's Association: www.alz.org



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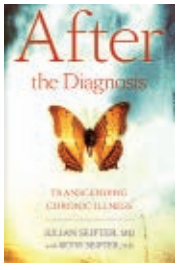
After the Diagnosis: Transcending Chronic Illness

Julian Seifter with Betsy Seifter

Physician and kidney specialist Julian Seifter has written, with his wife's help, a valuable book for people with chronic illnesses and their doctors. The pair address two poorly understood issues in medicine: how people cope with a lengthy, life-threatening ailment and how to provide them with medical care that addresses their psychological needs.



Julian Seifter weaves these themes into the story of his own struggle with diabetes. He knows the loneliness of patients, betrayed by their bodies, facing physicians who see only the disease. He understands the compulsion to deny that an illness exists. He appreciates the irony that chronically ill doctors become better healers.

Seifter encourages patients — and himself — to be "just sick enough" to deal with medical realities while holding on to life's pleasures. Consider Mr. Lee, a former professor of Chinese literature with end-stage renal disease. Unable to imagine feeling good again, he refuses lifesaving dialysis. Seifter asks Mr. Lee to read aloud in English from a book of Chinese poetry, and as the two discuss poems, Mr. Lee warms to the idea of trying dialysis to see how it makes him feel.

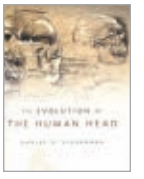
Then there's ex-cop Bill, headed for kidney failure due to diabetes complications. Bill won't give up booze and cigarettes. He turns down dialysis. Some chronically ill people can't make drastic lifestyle changes and would be miserable trying, Seifter says. A growing body of research confirms the physical and emotional benefits of the sense of self-control that this sensitive physician contends that chronically ill patients need. — *Bruce Bower*

Simon & Schuster, 2010, 243 p., $25.

The Making of Modern Medicine

Michael Bliss

A medical historian examines how society came to put faith in science to cure disease. *Univ. of Chicago Press, 2011, 104 p., $18.*



The Evolution of the Human Head

Daniel E. Lieberman

The story of human evolution is encapsulated in the myriad changes to the head's anatomy, traced here throughout the hominid fossil record. *Harvard Univ. Press, 2011, 756 p., $39.95.*

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Lofty argument

I have been a fan of Science Service (now Society for Science & the Public) since I won a subscription to Things of Science [science kit] as a boy in the 1950s, so I feel I must correct a common misunderstanding on how an airplane wing develops lift as stated in your fine publication ("Study finds light can be uplifting," *SN: 1/1/11, p. 9*). Laura Sanders used the analogy of an airplane wing to contrast how optical lift is generated and stated that the airflow above the wing is increased in velocity and thereby creates lower pressure that, in turn, creates lift. But lift is generated by deflecting downward a mass of air equivalent to the mass of the airplane. Though under certain circumstances low pressure can develop above the wing, this does not create the lifting force, nor is there any reason that the air flowing over the wing must stay paired with the air below the wing and thus increase its velocity. This can be shown by holding a stiff, thin board outside the window of a moving vehicle and tilting the upstream end slightly upward. The lift will be immediately felt.

Robert Latham Brown, Woodland Hills, Calif.

Many readers wrote to say that the cause of lift has nothing to do with pressure differences, often ascribed to Bernoulli's principle. Bernoulli discovered that faster-flowing fluid exerts less pressure than slower-flowing fluid. The reasoning goes that faster air on the top of a curved-top wing creates lower pressure than the slower air on the wing's flat bottom, generating lift and sucking the plane upward.

Some readers contended that lift is instead caused by an action-reaction type of force, in which the airfoil pushes approaching air downward; as a result, the plane moves up. This explanation is true. In fact, some jets can fly with completely symmetrical wings, relying mainly on this balancing act of downward-moving air and upward-moving force.

But before the Bernoulli explanation crashes, Jean-Jacques Chattot, an aerospace engineer at the University of California, Davis, points out that it's not so simple. "Actually, both descriptions of lift are correct," he says. Lift can be calculated by summing up all of the various local pressures on the top and bottom of the wing. Lift can also be calculated by analyzing the balance of momentum between the two, and the action-reaction balance. The equations describe different aspects of the same thing.

One explanation for lift doesn't fly: As the reader notes, nothing says two air particles must travel set paths and reunite after flying over the top and bottom of the wing, an assumption known as the "equal transit myth." The reasons for airspeed differences and resulting pressure differences are complicated, but are not because the top particle must fly faster to reach its partner on the bottom. — Laura Sanders

Send communications to: Editor, Science News, 1719 N Street, NW, Washington, D.C. 20036 or **editors@sciencenews.org**. Letters subject to editing.

Lisa Randall

For more Comment, visit Columns at **www.sciencenews.org**

A new era of physics at the Large Hadron Collider

Last month in Washington, D.C., at the annual meeting of the American Association for the Advancement of Science, theoretical physicist Lisa Randall of Harvard University spoke about her hopes for the Large Hadron Collider, the world's most powerful particle accelerator. She sat down with Science News *physical sciences writer Devin Powell after her February 19 talk to discuss what evidence the European collider, which is expected to operate at half power through 2012, might provide for her groundbreaking theories and for the Higgs mechanism, a process that would explain why particles have mass.*

You've said that physics is entering a "new era." What do you mean by that?
At the high energies of the LHC, you're getting very precise, and you're getting to, in some sense, simpler systems where you can see the more basic and more fundamental rules of physics going on.... Studying higher energies is the same as studying smaller scales. We have this target scale, the weak energy scale that the LHC is exploring — that is to say, the scale at which we know particles are somehow acquiring mass associated with the Higgs mechanism.

Explain the theory that you and Raman Sundrum developed to resolve the "hierarchy problem," namely that gravity is much weaker than quantum physics would predict.
The scenario we had in mind is that some stuff is stuck on an object called a brane, which exists in three dimensions, but there can be an extra dimension of space where gravity can be concentrated away from us. That would explain why gravity is so weak for us.... By an extra dimension, I really do mean another dimension beyond the three we're familiar with: left-right, up-down and top-bottom. These extra dimensions are hidden somehow and part of the question is: Why are they hidden? They could be small or very warped.

What would you be most excited to see in the LHC's detectors?
It would be extremely exciting if they saw evidence for our theory, which would consist of a particle that is called the Kaluza-Klein partner of the graviton. You'd see something that looks like a graviton, which communicates gravity, but it would really be from an extra dimension.

It would be extremely exciting if they saw evidence for our theory, which would consist of a particle that is called the Kaluza-Klein partner of the graviton.

If the LHC finds a Kaluza-Klein particle, what does that mean for the Higgs mechanism and string theory?
The Higgs could be there whether or not there are extra dimensions. If we found the Kaluza-Klein particle, it would be a nice target for string theory. When we first wrote down this theory, string theorists told us, "Oh, that's very nice, but it doesn't happen in string theory." Actually they didn't even say it was very nice. But a year later they found it in string theory. The energy of the Kaluza-Klein particle is much too low to prove or disprove string theory, but it gives you different ways to think about what the possibilities are in string theory. If this warped geometry exists, they'd have to say it's part of whatever model comes out of string theory.

Could the LHC find a Kaluza-Klein particle before reaching full power?
We know roughly the energy of this thing. It could be that it's an energy a little higher than the LHC. It could be that it's the energy of the LHC. It probably won't be the energies that they're exploring now, and it probably won't happen — if it happens — until they get to the higher energies.

What would the physics community be most surprised to see in the LHC data?
Something we haven't thought of. If they don't see anything, of course, there's going to be a long period where we have to see: Are they not seeing anything because of experimental deficiencies, or are they not seeing anything because there's really nothing there? We really do expect there to be something there playing the role of the Higgs boson ... but one of the things you find as a theorist when you work out the details is that there could be a lot of stuff there that we just miss.

If you could design a machine to test your ideas, how would it look?
The SSC [the Superconducting Super Collider, an unfinished project in Texas that was canceled by the U.S. Congress in 1993] would have been a great machine. It would have had almost three times the energy of the LHC, and that would really cover a lot of what we're looking for. Obviously, six times the energy would have been great too. The higher the energy, the more chances you have of seeing things at a small scale. I do think that at the SSC energy levels I would have felt much more confident. But the LHC is still a fantastic machine.... It's the highest energy, highest luminosity, highest intensity, biggest machine in the world. ■

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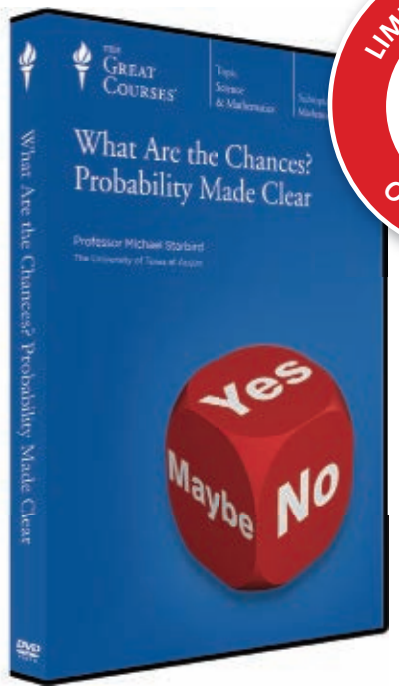

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