Itchy & Scratchy | Complications for Complex Life | Memories Begone

ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ NOVEMBER 22, 2008

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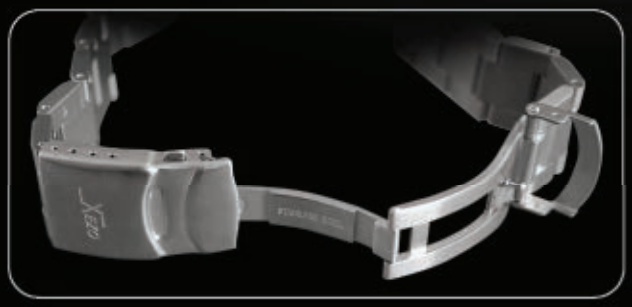

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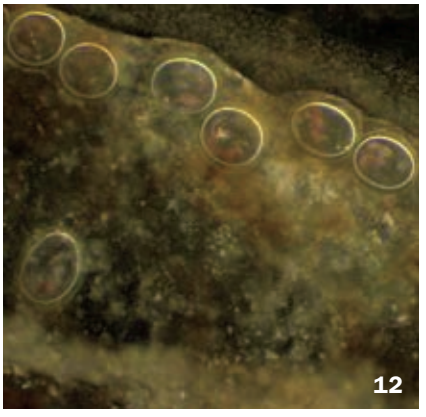

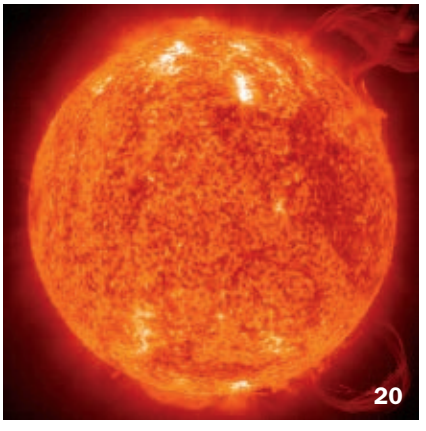

FROM TOP: LEVY; S. SESSIONS, HARTWICK COLLEGE; AMY GUIP; SOHO (ESA & NASA)

ScienceNews

In The News

Features

Departments

COVER Not just for spiders, silk threads could be used to make bulletproof vests and scaffolding for growing cartilage, among other materials. *sot/Getty*

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Maybe radioactivity hasn't revealed all its mysteries

Radioactivity has a long history of confounding conventional scientific wisdom.

By the end of the 19th century, most physicists were convinced by the calculations of Lord Kelvin that the Earth was relatively young — perhaps much less than 100 million years old. But those calculations assumed that a primordial molten Earth had cooled to its current state without any new source of internal heat. After the discovery of radioactive elements in 1896, it soon became clear that the Earth possessed an inner warmth fueled by the elements' energy-releasing decay. So Kelvin's calculations had neglected an important effect, and the age of the Earth turned out to exceed 4 billion years.

Not long after, physicists began to notice a peculiar property of one particular form of radioactivity, beta decay. In beta decay an unstable nucleus emits an electron (labeled a beta particle before anybody knew what it really was). Beta decay was curious enough to begin with, since electrons don't exist within nuclei (and so apparently were created from neutrons). But even worse, the emerging electron flew off at any of a vast variety of speeds — implying that it could possess a wide range of energies. That defied standard physics, because the amount of energy possessed by the nucleus and its ejecta did not appear to be conserved.

For years this observation haunted physicists who revered the law of conservation of energy. Some, including the great Niels Bohr, proposed that the hallowed law might in some ways be violated. But then Wolfgang Pauli proposed that a ghostly new particle, later christened the neutrino, was also emitted in beta decay, carrying precisely enough energy to balance the books and save the energy conservation law.

Now Pauli's neutrino has turned up in another radioactive controversy. Some data analyses seem to suggest that the rate of radioactive decay for certain nuclei is not always the same. In fact, these studies find hints that decay rate depends on time of year, implying that perhaps the Earth's distance from the sun somehow exerts an influence, as Davide Castelvecchi describes in this issue (Page 20). Because the sun emits neutrinos, maybe some neutrino-induced action is messing with the supposed laws governing radioactive decay rates, some scientists speculate.

To be sure, there's no reason yet to throw out the nuclear physics textbooks. More often than not, anomalies of this nature reflect experimental errors or unforeseen factors that could explain away the discrepancies without resorting to breaking or changing any physical laws. But you never know. Radioactivity has a way of revealing some of nature's best-kept secrets. — *Tom Siegfried, Editor in Chief*

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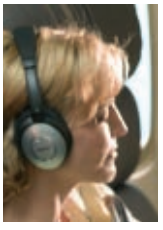

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Scientific Observations

"Carbon is the foundation of life. It exists in every living organism, in every cell. While some is stilled, preserved in fossils over long stretches of time, most is continually recycled.… Humans are mostly water and, after that, mostly carbon—carbon that has been passed down through the ages, from the flesh of a fish, the ear of an elephant, the leaves of a plant. Somewhere in each of us is a cell whose carbon elements may have nourished the planet's nascent life." DEBORAH CRAMER, IN "SMITHSONIAN OCEAN: OUR WATER, OUR WORLD," PUBLISHED IN SEPTEMBER IN CONJUNCTION WITH THE OPENING OF THE SANT OCEAN HALL

Science Past | NOVEMBER 22, 1958

VOLUNTEERS SHOW VACCINE CAN PREVENT COLDS — The common cold can be prevented, a British scientist reported to the sixth annual Symposium on Antibiotics meeting in Washington, D.C. Weekly injections of a vaccine prepared from the volunteer's own nose and throat bacteria significantly reduced the number of colds, Dr. J. Morrison Ritchie, director of the Public Health Laboratory, Birkenhead, England, reported. The number of colds in those not receiving the vaccine was five times that in the vaccinated. Further tests, in which volunteers were given antibiotic tablets of lozenges in order to prevent colds, met with similar success. Only four in 100 of those receiving the antibiotic developed all the manifestations of the complicated cold, Dr. Ritchie said.

Science Future

December 8–10
The National Conference on Science, Policy and the Environment in Washington, D.C. Visit ncseonline.org

December 9–12
Arctic Change 2008 to be held in Quebec City, Canada. Visit www.arctic-change2008.com

December 13
Make body products with natural ingredients taken from cacao at the New York State Museum in Albany. Visit www.nysm.nysed.gov/calendar

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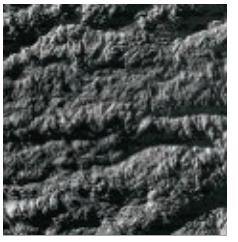
SCIENCE & THE PUBLIC
The users of new buildings on a university campus were surprised to discover lead in the water. The culprit was unexpected: the faucets. Read "Lead-free? Faucets are anything but."

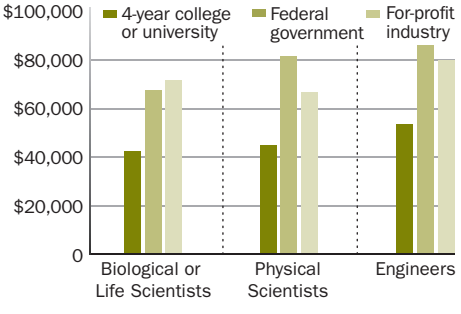


SIGHTS & SOUNDS
On October 31, the Cassini spacecraft captured close-up images (one shown) of one of Saturn's moons in a confluence of circumstances the craft may not experience again. See "Enceladus south pole" and "Tiger stripes up close."

HUMANS
A new genetic study of the Tyrolean Iceman reveals a genetic signature no longer seen in Europe. Read "The Iceman's mysterious genetic past."

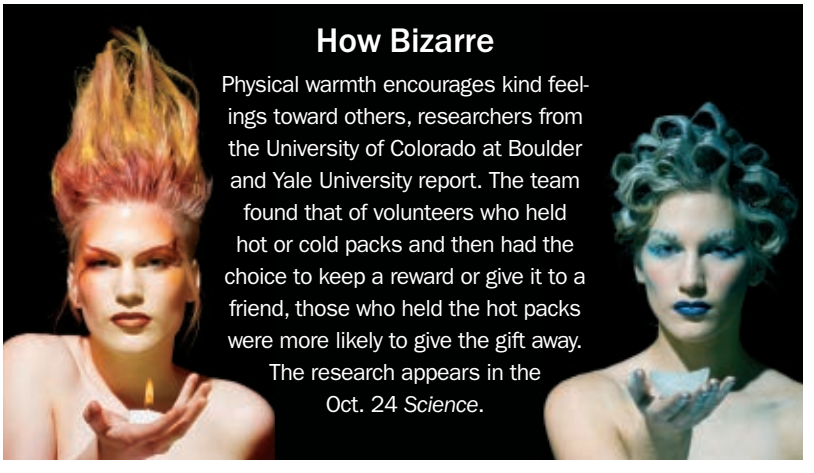
Science Stats | KNOWLEDGE'S WORTH

Median annual salary of employed scientists and engineers by sector in the United States in 2006



SOURCE: NATIONAL SCIENCE FOUNDATION/DIVISION OF SCIENCE RESOURCES STATISTICS, SCIENTISTS AND ENGINEERS STATISTICAL DATA SYSTEM

How Bizarre



Physical warmth encourages kind feelings toward others, researchers from the University of Colorado at Boulder and Yale University report. The team found that of volunteers who held hot or cold packs and then had the choice to keep a reward or give it to a friend, those who held the hot packs were more likely to give the gift away. The research appears in the Oct. 24 *Science*.

CLOCKWISE FROM TOP LEFT: SHAWN G. HENRY; SPACE SCIENCE INSTITUTE, JPL/NASA; HAMMONDOVI/ISTOCKPHOTO

“Lung cancer is many different things all cobbled together.... Now we're able to untangle the different types.”
—RAMASWAMY GOVINDAN, PAGE 15

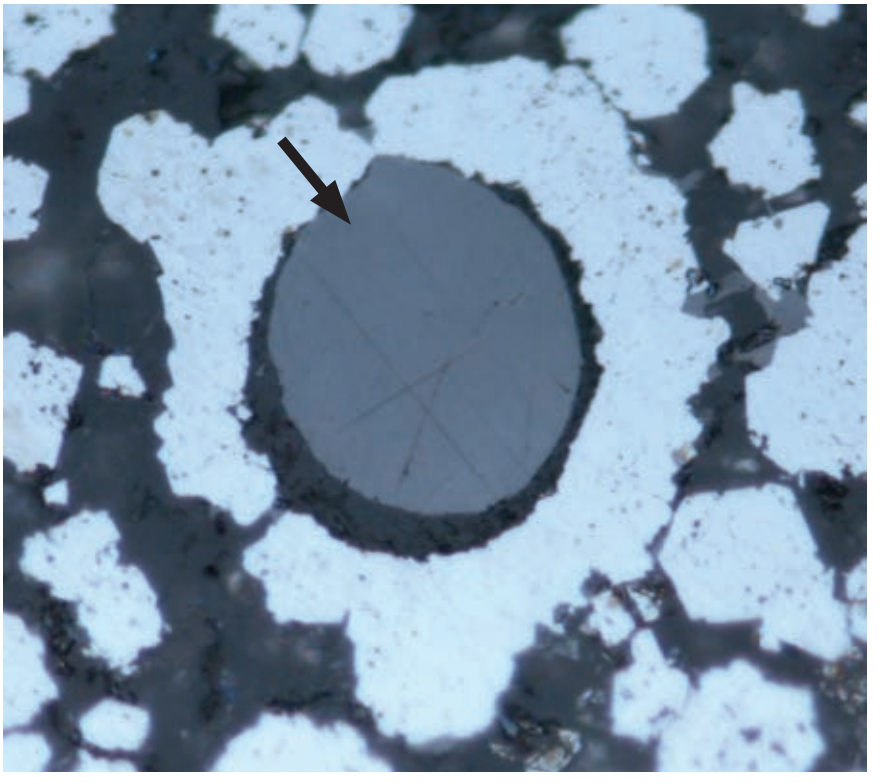
In the News

STORY ONE

Dates in doubt for oldest signs of complex life

New analyses of ancient rocks hint biomarkers came later

By Sid Perkins



B. RASMUSSEN

Carbon isotope ratios in pyrobitumen (arrow) in ancient rocks don't match those of the rocks' biomarkers, a hint that the biomarkers may have a more recent origin.

Chemical biomarkers in ancient Australian rocks, once thought to be the oldest known evidence of complex life on Earth, may have infiltrated the sediments long after they were laid down, new analyses suggest.

The biomarkers in question are distinctive chemical compounds produced by modern-day relatives of cyanobacteria and by other complex life forms. In 1999, a team of researchers contended that the chemical fossils in the 2.7-billion–year-old rocks pushed back the origins of cyanobacteria by at least 550 million years and of the more complex eukaryotes by about a billion years.

Although some scientists interpret the new findings, published in the Oct. 23 *Nature*, as disproving the older dates, others contend that the results still allow for the presence of the organisms or their kin at that earlier time.

Experts believe that the first life on Earth consisted of single-celled organisms, or prokaryotes, such as bacteria. Later came the cyanobacteria, a group of photosynthesizing bacteria that produce oxygen. Before the 1999 work, the oldest known fossils of this group were about 2.15 billion years old. Likewise, the oldest fossils of eukaryotes, the group whose cells contain nuclei, were about 1.7 billion years old. The remains of any of these organisms can be destroyed when intense heat and pressure deep within Earth convert the molecules into petroleum and kerogen, a mixture of long-chain, carbon-rich compounds.

Results of the first analyses of the Australian rocks (*SN: 8/28/99, p. 141*) were controversial, says Birger Rasmussen, a geochemist at Curtin University of Technology's campus in Bentley, Australia. For one thing, the shale—which had been laid down as sediments about 2.7 billion years ago—contained tiny particles of pyrobitumen, coal-like remnants of oil droplets that had solidified as the sediment layers cooked. Pyrobitumen is a sign that the sediments and any organic material they contained experienced temperatures from 200° Celsius to 300°C for an extended time. The rocks also contained significant amounts of kerogen.

Yet the samples also held small quantities of hopanes, a class of organic chemicals produced by cyanobacteria and some other bacteria, as well as steranes, which are produced only by eukaryotes. That the rocks hosted these biomarkers, which should have been destroyed by the heat and pressure required to generate

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the pyrobitumen, "presented a bit of a conundrum," Rasmussen says.

However, because the Australian rocks otherwise showed little evidence of heat-driven degradation, scientists at the time largely dismissed the notion that the hopanes and steranes had migrated into the rocks many years after the sediments had formed. But that interpretation led to yet another conundrum — the inferred presence of oxygen-generating cyanobacteria at least 350 million years before significant amounts of oxygen showed up in the atmosphere (*SN: 1/24/04, p. 61*).

The tests reported in 1999, and others conducted since then, compared the ratios of carbon isotopes in the biomarkers, which could be extracted from the strata, with those of the pyrobitumen and kerogen left trapped in the rocks. Comparing those ratios enables researchers to determine whether the two derived from the same batch of organic material.

Previous isotopic measurements were analyzed in bulk, so they couldn't distinguish isotope ratios in the pyrobitumen from those of the kerogen nearby, says Ian Fletcher, also of the Curtin University of Technology and a coauthor of the new report. In the new analyses, however, he, Rasmussen and their colleagues — including one scientist who was part of the 1999 team — used an instrument with a microprobe that enabled them to measure the carbon-isotope ratios on spots of intact rock as small as 5 micrometers across, about the size of a single bacterium.

Typically, the proportion of the carbon-13 isotope found in kerogen and other hydrocarbons is between 1 and 3 parts per thousand less than the proportion found in the original organic matter from which those substances derived, Fletcher says. But the team's new analyses show that the proportions of carbon-13 isotopes of the kerogen and pyrobitumen in the Australian rocks are between 10 and 20 parts per thousand less than those found in the hopanes and steranes — the presumably unmodified biomarkers for cyanobacteria and eukaryotes — extracted from the same rocks. These differences indicate that the kerogen and the pyrobitumen are probably unrelated to the biomarkers, says Fletcher. It's also a strong sign that the biomarkers migrated into the rocks sometime after 2.2 billion years ago, when the rocks underwent most of the metamorphosis that formed the pyrobitumen. "We can't say where the biomarkers came from, or when," he notes. "We can't pretend to know."

Instruments that can detect substances present in concentrations as small as a few parts per billion pose a challenge because the sensors can also pick up trace contaminants, comments Woodward Fischer, a geobiologist at Caltech in Pasadena. Biomarkers such as hopanes are produced by organisms but also can be found in diesel exhaust, fossil fuel emissions and urban air pollution (*SN: 9/8/07, p. 152*).

The new findings "are interesting observations but Rasmussen and his colleagues pose only one explanation for the results," says Jennifer Eigenbrode, an organic geochemist at NASA Goddard Space Flight Center in Greenbelt, Md.

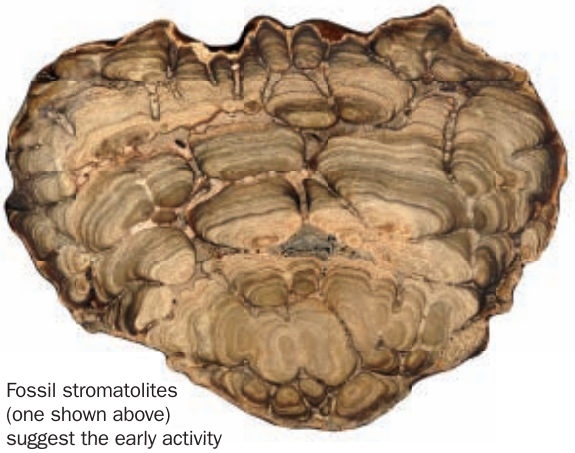
While some of the organisms in microbial communities 2.7 billion years ago got carbon from carbon dioxide, others took it from methane. Both gases were abundant in the oxygen-free atmosphere at that time. "It was a completely different planet then," Eigenbrode says.

Because those microbes recycled carbon among themselves many times, the proportions of carbon-13 in their biomarkers ranged more widely than they do across most microbial communities today, she notes. It's possible that a community of microbes could make hopanes and steranes that, when cooked, would produce the kind of isotopically light pyrobitumen and kerogen seen in the Australian rocks. So the biomarkers could still be legitimate indicators.

Since the 1999 study of the 2.7-billion-year-old Australian rocks, other analyses of rocks of similar age elsewhere in the world, particularly some from South Africa, also have detected biomarkers that bolster the early appearance of cyanobacteria, says Andrew H. Knoll, a biogeochemist at Harvard University. Even if the new results "take some specific evidence off the table, all is not lost," he says. ■

Back Story | SIGNS OF LIFE

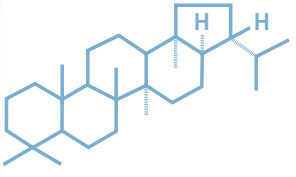
Direct evidence of Earth's earliest life is hard to find. So scientists look to biomarkers, chemicals and structures thought to be produced by living things and then preserved. But evidence from many biomarkers remains contentious.



Fossil stromatolites (one shown above) suggest the early activity of cyanobacteria, but some argue the structures could also have abiotic origins.

$^{13}C:^{12}C$

In nature, carbon-13 is much rarer than carbon-12. Since living things concentrate C-12 during metabolism, the ratio of the isotopes in rocks can be used as evidence of life.



Hopanes are a kind of molecular fossil, formed as part of the cell membranes of living things. But discerning between ancient hopanes and modern contaminants can pose problems.

EDWARD KINSMAN/PHOTO RESEARCHERS

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Body & Brain

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Altering a protein wipes out shocking memory in mouse brain

Erasing effect appears limited to information being recalled

By Tina Hesman Saey

As much as you might want to wipe Uncle Frank's tasteless joke out of your mind but still remember the flavor of Aunt Fran's pie, memory researchers have always said "fuhgedaboudit!" Now, a genetically engineered mouse suggests it may be possible to erase specific unwanted memories.

Scientists from the Medical College of Georgia in Augusta and the East China Normal University in Shanghai selectively removed a shocking memory from a mouse's brain, the team reports in the Oct. 23 *Neuron*.

Insight from such experiments may one day lead to therapies that can erase traumatic memories for people suffering from post-traumatic stress disorder, or wipe clean drug-associated cues that lead addicts to relapse.

"We should never think of memories as being fixed," says Howard Eichenbaum, a neuroscientist at Boston University. "They are constantly being renovated and restructured."

The new research, which he calls "terrific" and "interesting," shows that careful use of molecular tools can manipulate memories.

Joe Tsien, a neuroscientist at the Medical College of Georgia, and his colleagues genetically engineered a mouse to carry an altered version of a protein called alpha-calcium/calmodulin-dependent protein kinase II, or alpha-CaMKII.

A kinase enzyme, alpha-CaMKII is a type of regulatory protein that governs the activity of other proteins. Previous research showed that alpha-CaMKII is involved in learning and memory. Tsien and his colleagues wanted to find out at which stage of memory the kinase enzyme is important. Stages of memory include learning something new and then processing, storing and retrieving the information.

Scientists are beginning to learn more about how memories are made and stored. Memories are probably formed through interactions of brain chemicals and changing connections between neurons. But exactly how that happens and the physical form memory takes remain a mystery.

Researchers can use chemicals to block an enzyme's activity, but the business end of most kinase enzymes look alike, so most inhibitory chemicals tend to block all kinase activity in the brain. Tsien got around that problem by building a hidden cavity into an alpha-CaMKII molecule. A bulky inhibitor fits into the hidden cavity and blocks alpha-CaMKII from doing its job, but doesn't interfere with the action of other kinases. By manipulating activity of the engineered protein, the researchers learned that alpha-CaMKII is important for recalling memories.

A mouse might not be able to recall a memory for two reasons, Tsien says. "Either you can't open the door to get the memory, or you can open the door but there's no memory there."

Altering alpha-CaMKII's activity erases memories as they are being retrieved, the researchers found. And the erasure is specific to the memory being recalled.

The researchers placed mice in a chamber and played a sound, then mildly shocked the mice's feet. The mice learned to associate both the chamber and the sound with a shock and would freeze in anticipation when they entered the chamber or heard the sound.

Once the mouse learned to associate both the chamber and sound with a shock, the researchers replayed one of the conditions while altering activity of alpha-CaMKII. If the researchers placed the mouse in the chamber but didn't play the sound, only the memory of the chamber was erased when alpha-CaMKII's activity was altered. When tested again later, the mouse forgot to freeze when placed in the chamber, but the mouse would still freeze when it heard the sound.

GLOBALP/ISTOCK

And if conditions were reversed and alpha-CaMKII activity was altered when the mouse was recalling that the sound signals a shock, the sound memory was erased. But the mouse still remembered to freeze when entering the chamber. Those results show that the erasure is limited to the portion of the memory being recalled.

Eichenbaum is not convinced that Tsien and his colleagues have erased the mice's memories. Altering a memory so that it can't be recalled under certain circumstances could produce similar results, he says. "We never know for sure that it's really gone," he says.

But if chemicals can help someone specifically forget painful or traumatic memories, it may be irrelevant whether the memories are entirely erased or are just altered beyond recognition, Eichenbaum adds.

Memory-erasing pills are still science fiction, Tsien stresses. This technique will never be used in people as it involves genetically engineering a protein in the brain, he says. But future studies might reveal other ways to selectively forget.

"We've only just put our foot on a very tall mountain," he says. ■

"We should never think of memories as being fixed.... They are constantly being renovated and restructured." — HOWARD EICHENBAUM

Treatment may offer MS turnaround

Leukemia drug improves multiple sclerosis in some people

By Nathan Seppa

A disease thought to be incurable is now a step closer to losing that dispiriting reputation. Multiple sclerosis, the disabling neuromuscular disease that has resisted effective drug therapy, eases off in some people given alemtuzumab, a drug normally prescribed for leukemia, researchers report in the Oct. 23 *New England Journal of Medicine*.

"We think this is something very special," says study coauthor David Margolin of Genzyme Corp. in Cambridge, Mass. Genzyme joined an international team of researchers to conduct the trial.

The optimism, however, is tempered by worrisome side effects that showed up in MS patients on the drug. Two more large-scale trials will address those issues.

In MS, the body's immune cells orchestrate an attack on the fatty sheaths that insulate nerve fibers in the central nervous system. The origins remain a mystery, but the mutiny results in motor control losses and can cause permanent disability.

Alemtuzumab, marketed as Campath, wipes out a huge portion of a person's immune system — a good thing if your immune cells are running amok.

While the drug has helped patients fight chronic lymphocytic leukemia, testing against MS progressed slowly in the 1990s as researchers mainly tested the drug in advanced-stage, mostly middle-aged MS patients, with little success.

That approach changed in 2002 when an international team of researchers began testing the drug on younger, less-advanced-stage MS patients over a three-year trial. The researchers randomly assigned 111 people to get interferon beta-1a, a standard MS drug, and another 223 to get alemtuzumab.

Testing showed that disabilities for people on interferon rose on average during the trial but fell in those getting alemtuzumab, a first for a large trial, the authors note. Over the three years, only 20 percent of the alemtuzumab patients had a relapse, compared with 48 percent of the interferon patients. What's more, MRI scans of the patients' brains showed less inflammation in those getting alemtuzumab. Combined, the findings suggest that the drug is somehow promoting brain repair.

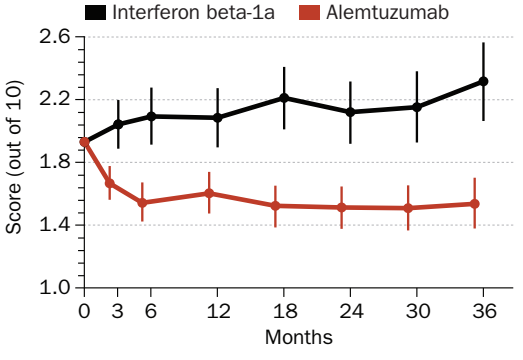
"This is unprecedented," says coauthor Alasdair Coles of the University of Cambridge in England. "Up until now, no one would have thought this would happen."

The most common side effect from alemtuzumab concerns the thyroid gland, and 23 percent of patients getting the drug in this trial developed thyroid problems compared with 3 percent for those on interferon. A dangerous bleeding disorder called ITP also showed up in 3 percent of alemtuzumab patients and 1 percent of interferon patients. One person on alemtuzumab died from the disorder.

Bibiana Bielekova of the National Institute of Neurological Disorders and Stroke in Bethesda, Md., says the drug is "incredibly effective." But he says, "Everybody is scared to death of those side effects."

Disability in MS patients

People taking alemtuzumab showed less disability on the Expanded Disability Status Scale.



NEW ENGLAND JOURNAL OF MEDICINE

Meeting Notes

Interscience Conference on Antimicrobial Agents and Chemotherapy and Infectious Diseases Society of America Oct. 25–28, Washington, D.C.

Halting rotavirus

A vaccine against rotavirus provided potent protection in its first year of widespread use. Scientists offered up several studies demonstrating that the oral vaccine has brought about a sharp decline in rotavirus infections in the United States during 2007–08. "This is a remarkable success," said Jay Lieberman of Quest Diagnostics, leader of one study. — *Nathan Seppa*

Malaria takes on top meds

Like a basketball team that plays best against its toughest opponents, the parasite that causes malaria is showing signs of thwarting the most potent drugs currently used against it. Top-line drugs called artemisinins take nearly twice as long to knock out the parasite in people who contract malaria in western Cambodia as the drugs take to work in neighboring Thailand, Arjen Dondorp of Mahidol University in Bangkok reported. — *Nathan Seppa*

Fungal meningitis spreads

A fungus that causes meningitis has sickened 19 people, four of whom died, in Oregon and Washington over the past four years, Sarah West of the Oregon Health Science University in Portland reported. The new findings indicate that the culprit, a yeastlike fungus called *Cryptococcus gattii*, is spreading gradually down the West Coast. Before 1999, the fungus was rarely encountered in North America. — *Nathan Seppa*

Humans

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David, Solomon may have been kings of copper

Ancient site could unite archaeology, biblical accounts

By Bruce Bower

New finds among the remnants of a settlement in southern Jordan show that a copper-producing society existed there 3,000 years ago, about 300 years earlier than many archaeologists had assumed, according to an international research team. The site's revised age raises the controversial possibility that, in line with Old Testament accounts, Israel's King David and his son Solomon controlled copper production in southern Jordan, says team leader and archaeologist Thomas Levy of the University of California, San Diego.

A long-disputed claim that King Solomon's copper mines were located near the site must now be taken seriously, the investigators report in the Oct. 28 *Proceedings of the National Academy of Sciences*.

"We have conclusively shown that industrial-scale copper production occurred at this site in the 10th and ninth centuries B.C., which resonates with Old Testament descriptions of vibrant, complex societies in the same area at that time," Levy says.

Since 2002, Levy and his colleagues have excavated an ancient copper-producing site called Khirbat en-Nahas, which means "ruins of copper" in Arabic. The site lies in a lowland, arid region south of the Dead Sea. Biblical writings identify this area as Edom, home to a kingdom that barred Moses during the Exodus and warred with King David. David and Solomon may have exerted political control over the area.

In 2006, the researchers excavated down to virgin soil, slicing through more than six meters of smelting debris, or slag. Special software used 20 new radiocarbon dates and other evidence to generate a chronology of the site.

"In calling for a new dialog between scientific dating techniques and historical sources, especially the Bible, these new results support the possibility that Solomon's mines in the region near the Dead Sea may be dated to the 10th or ninth centuries B.C.," says Eric Meyers of Duke University in Durham, N.C.

Israel Finkelstein of Tel Aviv University disagrees. "I see no connection between Nahas and the biblical material on Solomon," he says.

Scholars have long argued about whether Edom was organized early enough to have threatened the Israelites. During the 1930s, archaeologist Nelson Glueck said that he had discovered King Solomon's mines in the northern part of biblical Edom. His claim, and the Bible's assertion that the kingdom of David and Solomon existed 3,000 years ago, came under attack in the 1980s. Excavations of Edom's highlands in the 1970s and 1980s suggested that Iron Age copper production didn't begin there until around 2,700 years ago, fueling skepticism.

Finkelstein and others hold that much of the Old Testament was passed on orally until put in writing between the eighth and fifth centuries B.C., with earlier events being invented or distorted for political purposes by the writers.

Since 2001, many researchers have acknowledged that nomadic groups inhabited the Khirbat en-Nahas area and probably made copper around 3,000 years ago, remarks archaeologist Piotr Bienkowski of the University of Manchester, England. "I still see no evidence for settlement or buildings there prior to the very end of the 10th century B.C. or beginning of the ninth century B.C.," he says.

Bienkowski and Finkelstein assert that the site was reused seasonally, leaving a mix of material that is difficult to separate into distinct layers. But based on buildings and artifacts, Levy regards the site as a key component of a 3,000-year-old society.

Remains of a structure perch on the edge of a copper slag mound that was excavated at Khirbat en-Nahas. Researchers also found Iron Age Egyptian artifacts (below), further evidence of a vibrant society.

FROM TOP: LEVY; LEVY, *PNAS*, CAROLINE HEBRON, UCSD LEVANTINE ARCHAEOLOGY LAB

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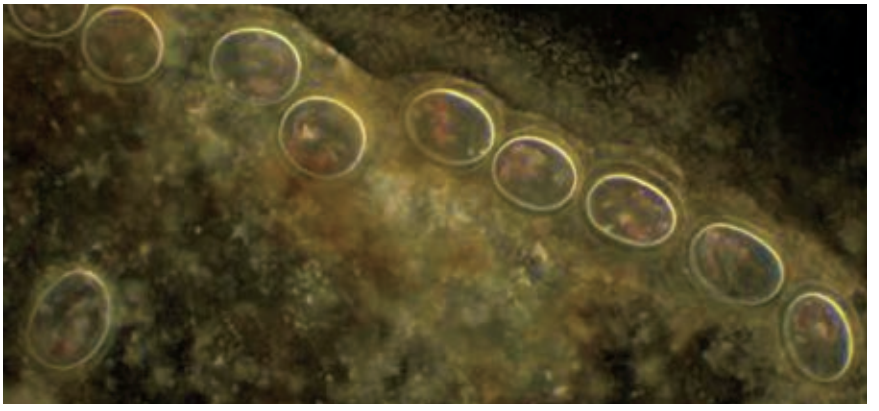
Farm chemicals can hammer frog populations

Study supports link between weed killer and parasites

By Janet Raloff



Larval flatworms (encased in cysts) can infect frog tissue. Researchers found atrazine may increase parasite infection rates in the northern leopard frog (below).

Atrazine, the second-most widely used agricultural pesticide in America, can pose a toxic double whammy to tadpoles. The weed killer not only increases the likelihood that massive concentrations of flatworms will thrive in the amphibians' ponds, a new study reports, but also diminishes the ability of larval frogs to fight infection with these parasites.

Moreover, the new data show, runoff of phosphate fertilizer into pond water can amplify atrazine's toxicity. The fertilizer boosts the production of algae on which snails feed. The snails serve as a primary, if temporary, host for the parasitic flatworms, which can sicken frogs.

Amphibian populations around the world have been declining recently, with many species on the brink of extinction. Infection with trematodes, tiny flatworms, can trigger debilitating limb deformities, and severe infections can kill the amphibians.

Researchers wanted to know why high rates of those deformities began showing up in the mid-1990s. The study suggests that one answer lies in atrazine's quick rise to dominance in U.S. agriculture.

Val R. Beasley of the University of Illinois at Urbana-Champaign and his colleagues quantified more than 240 separate factors in 18 Minnesota wetlands that might affect amphibian trematode infection rates. In the Oct. 30 *Nature*, the team reports that atrazine concentrations stood out as the prime correlate with trematode infection rates in Minnesota's declining northern leopard frog.

The weed killer and its breakdown products accounted for 51 percent of the likelihood these frogs would be sickened by trematode infections. The presence of phosphate fertilizer by itself showed no effect. But when atrazine was present, the pair accounted for 74 percent of the probability that frogs would host infections.

To test whether these chemicals could cause the infections, the researchers raised young tadpoles in tanks designed to imitate woodland ponds. The team added atrazine, phosphate or both — at concentrations that would be present in waters not far from farmland.

Where atrazine was present, four times as many snails developed as did in water free of the weed killer, reports Jason Rohr of the University of South Florida in Tampa, the *Nature* study's lead author. These experiments indicate, he says, that as snail populations climbed so did the number of incubating trematodes.

Because these tank studies were conducted in Pennsylvania, where leopard frogs are in serious decline, the researchers substituted related species — green and pickerel frogs. Among surviving green frogs, trematode infections were significantly higher when atrazine was present. The same was not true for pickerel frogs, but this species did experience a high rate of mortality when trace quantities of atrazine laced the water. Pickerels that died could not be tested for trematodes.

Finally, in the presence of atrazine, the young frogs made one-half to one-seventh as many parasite-clearing immune cells as those in pesticide-free water.

This study "links a couple pieces of the puzzle together," notes Joseph Kiesecker of the Nature Conservancy in Fort Collins, Colo. Other studies had shown that atrazine could impair frog immunity and that trematode infections could cause limb deformity and lethal illness in frogs. The new study, he says, now shows atrazine can play a major role in both problems.

"What really impressed me about the new work," adds Tyrone Hayes of the University of California, Berkeley, "is that it looked at a huge number of factors describing a complex environment and asked which of these 240 things contributes [to the infections]. And the most important one turned out to be atrazine."

Rohr says his team will also look at preserved tadpoles from the tank experiment to see if they exhibit reproductive abnormalities.

Syngenta, which registered atrazine in the United States and remains a leading manufacturer, declined to comment. ■

FROM TOP: S. SESSIONS, HARTWICK COLLEGE; SUZANNE L. AND JOSEPH T. COLLINS/PHOTO RESEARCHERS

Atom & Cosmos

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Double the rubble: Neighboring star system hosts two asteroid belts

Epsilon Eridani may shed light on youthful solar system

By Ron Cowen

In the annals of planethood, astronomers consider the star Epsilon Eridani a member of the fabulous four. Along with Fomalhaut, Beta Pictoris and Vega, Epsilon Eridani is one of the first four stars scientists have found with an icy ring of debris, an indication that a star has begun the planet-forming process.

Epsilon Eridani just got more fabulous: Researchers have discovered that the star, only 10.5 light-years from the sun, sports two inner asteroid belts in addition to the icy ring on the outskirts of the Epsilon Eridani system.

In both location and mass, Epsilon Eridani's innermost asteroid belt is a virtual twin of the solar system's asteroid belt. The star's second asteroid belt is farther out and about 20 times more massive than the solar system's belt. This outer belt circles Epsilon Eridani at roughly the same distance as Uranus orbits the sun.

Perhaps most intriguingly, a previously detected planet orbiting Epsilon Eridani lies just outside the innermost belt, at an average distance of 3.4 astronomical units from the star. (One astronomical unit is the average distance between the Earth and the sun.)

This is the first time that an asteroid belt and a planet orbiting another star have been found in the same arrangement as the solar system's asteroid belt and Jupiter, notes codiscoverer Massimo Marengo of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass. As with Jupiter, the gravity of Epsilon Eridani's planet may have cleared the region beyond the innermost belt, corralling the material in the inner belt.

In addition, the gaps between Epsilon Eridani's dual asteroid belts and the icy ring provide new evidence that the star has at least one other, more distant planet that sculpted the star system's architecture. The 850-million-year-old star, similar in mass to the sun but only one-fifth its age, may be providing a snapshot of what some sunlike systems look like in their youth, notes Marengo.

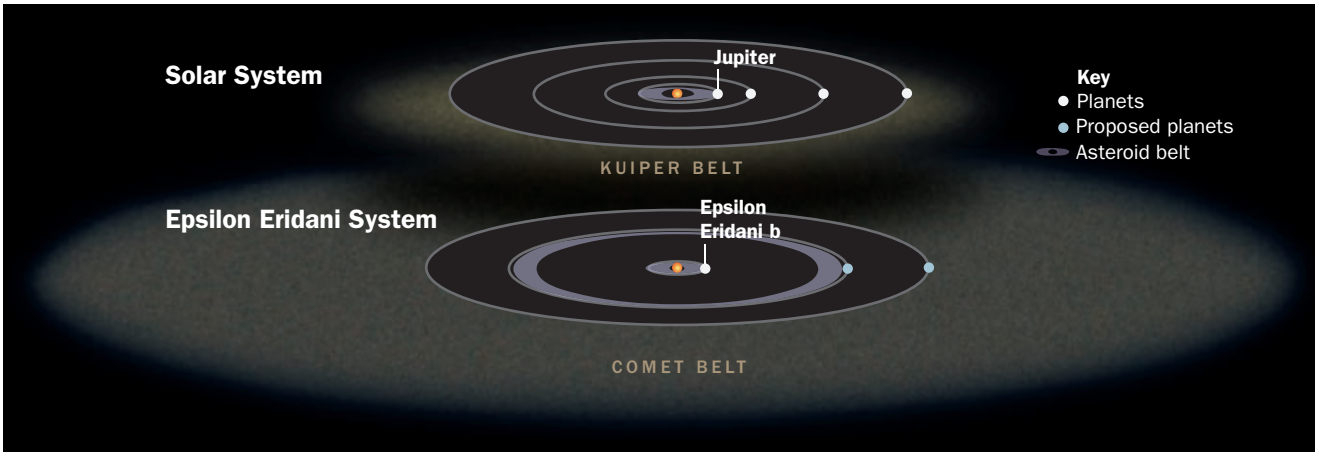
He and study leader Dana Backman of the SETI Institute in Mountain View, Calif., along with their collaborators, are set to report the findings January 10, 2009, in the *Astrophysical Journal*.

The team observed Epsilon Eridani at several infrared wavelengths, using NASA's Spitzer Space Telescope. Spitzer directly imaged the icy outer ring, already known to exist, and the outer of the two asteroid belts. The observatory lacked the resolution to take a picture of the inner belt, but the researchers were able to infer its shape and position from the temperature of infrared emissions.

"Spitzer has given us just a hint into the phenomenon of multiple dust rings," comments Lynne Hillenbrand of Caltech in Pasadena. "In the future, with better technology, we should be able to image more of these young adult planetary systems."

Although Marengo and Backman suggest that the Epsilon Eridani system may be a replica of the youthful solar system, "to me the most interesting thing is that this isn't exactly like the young solar system, because it has three belts of comets and asteroids whereas our system only has two," says Jane Greaves of the University of St. Andrews in Scotland. "This implies that planets can shape systems very differently, and if life emerged in this system in the future, the environment could be very different." Comets and asteroids could pummel a habitable planet, and life would have to evolve quickly to survive, she says.

In 1960, Epsilon Eridani was one of the first stars that radioastronomer Frank Drake searched for signs of an advanced alien civilization. ■



JPL/NASA, BACKMAN *ET AL.*/*ASTROPHYSICAL JOURNAL* 2009

The Epsilon Eridani system shares some features with the solar system, including a Jupiter-like planet (labeled Epsilon Eridani b).

Life

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Cannibals have better babies

Female spiders who dine on guys have more, tough young

By Susan Milius

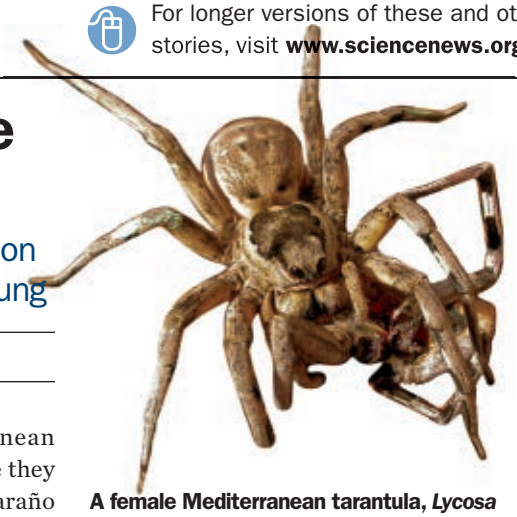
One's company and two's — lunch.

In nature, female Mediterranean tarantulas rarely eat the first male they mate with, reports Jordi Moya-Laraño of the Arid Zone Experimental Station in Almería, Spain. The suitor that shows up next, though, faces triple the risk of becoming a meal instead of a mate.

About a third of female spiders studied in their natural habitats ate at least one suitor, Moya-Laraño and his colleagues report online October 22 in *PLoS ONE*. And dining instead of mating worked out well for the females.

Females that ate a male had more young and had the young earlier than females that experimenters deprived of a male meal, Moya-Laraño says. That head start on laying eggs let the spiderlings hatch earlier and grow bigger and tougher than offspring of noncannibals. When researchers staged fights between the offspring of cannibals and noncannibals, the cannibals' youngsters won.

"This is the first comprehensive study of fitness consequences of sexual cannibalism in nature [under field conditions]," says Mike Maxwell of National University in La Jolla, Calif., a behavioral ecologist who studies sexual cannibalism in praying mantises.



A female Mediterranean tarantula, *Lycosa tarantula*, feeds on a male of her species.

Just how sexual cannibalism has evolved remains a puzzle, says Moya-Laraño, as until now the benefit of eating a potential mate has been hard to pin down.

Many of the experiments have taken place in the lab, but Moya-Laraño and his colleagues spent two field seasons studying spiders in natural habitats as well as in the lab.

Sparse food could favor the evolution of cannibalism in the *Lycosa tarantula* spiders, Moya-Laraño says. They live in arid places, and male spiders amount to what he calls "high-quality prey," a substantial nutritional boost. As it turns out, the female Mediterranean tarantulas do reap the benefit, he notes. Males end up providing prenatal nutrition for some other male's offspring.

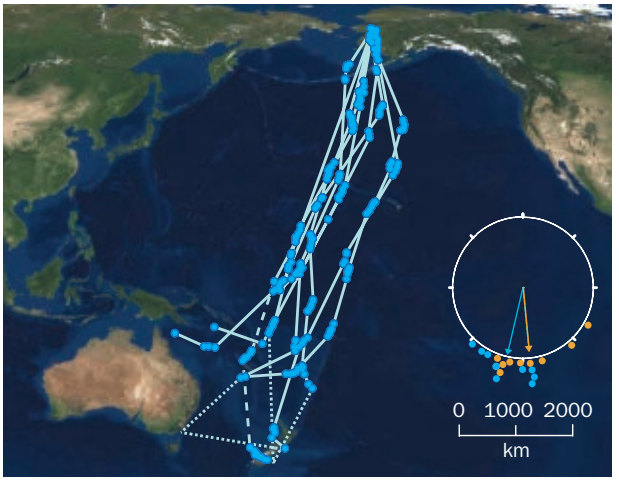
"Good data" on female benefits, says Chad Johnson of Arizona State University in Phoenix. "But it needs to be acknowledged that this is a species with minimal sexual size-dimorphism."

The males typically weigh several grams, about the same size as females, and make a substantial dinner. In some species males are tiny compared with females, and yet the females still eat their suitors.

"It's really the systems with more extreme sex size dimorphism that are difficult to explain," Johnson says.

He and other researchers have suggested that if spiders don't get a good lunch or other benefit from sexual cannibalism, maybe killing suitors is just a spillover of a trait that does have value. Among fishing spiders, Johnson and his colleagues linked a female tendency to cannibalize suitors before mating to extra ferocity in hunting.

Mediterranean tarantulas might have some spillover effect too. The experiments don't rule it out, Moya-Laraño says. What the new study does confirm is that sexual cannibalism, with benefits, isn't some artifact of lab tests in this species.



Nonstop godwit flights

In a flight of epic proportions, a female bar-tailed godwit alighted from her Alaskan breeding ground and flew 11,680 kilometers, nonstop, until she reached her winter home in New Zealand. Called E7, she flew more than eight days without food, water or rest, the longest direct flight by a bird ever documented, researchers report online October 29 in *Proceedings of the Royal Society B*. "It's phenomenal that a bird can go that far," comments Geoffrey Geupel of PRBO Conservation Science in Bolinas, Calif. A research team led by Robert Gill Jr. of the U.S. Geological Survey Alaska Science Center in Anchorage also tracked eight other godwits. Solid lines show estimated paths along data points (blue circles), while dotted lines represent projected routes of birds whose monitors fell silent but who were identified upon reaching their final destination. —*Laura Sanders*

FROM TOP: EVA DE MAS; GILL *ET AL.* "EXTREME ENDURANCE FLIGHTS BY LANDBIRDS CROSSING THE PACIFIC OCEAN: ECOLOGICAL CORRIDOR RATHER THAN BARRIER." *PROCEEDINGS OF THE ROYAL SOCIETY B*, 2008

Genes & Cells

For longer versions of these and other Genes & Cells stories, visit **www.sciencenews.org**

More genes linked to lung cancer

Tumors show more mutations in smokers than in nonsmokers

By Laura Sanders

A new analysis increases from 10 to 26 the number of genes linked to lung cancer, the leading cause of cancer deaths worldwide. The study also identifies new cellular pathways that can trigger these malignancies.

"This study gives us insights that we didn't have before," says Ramaswamy Govindan of Washington University in St. Louis, who was not involved in the study. "Lung cancer is many different things cobbled together," he says. "Now we're able to untangle the different types."

Researchers at Washington University, Baylor College of Medicine in Houston and the Broad Institute of MIT and Harvard analyzed DNA sequences from tumors in 188 people with adenocarcinoma, the most common form of lung cancer. With this sample size, researchers had the statistical power needed not only to find genes that are associated with this cancer, but also to compare the particular groupings of gene mutations present in the tumors. The findings appear in the Oct. 23 *Nature*.

The data offer yet another reason not to smoke: Tumors from nonsmokers exhibited a maximum of four mutations; the max in smokers' tumors was 49.

"This clearly shows that cigarette smoking induces mutations," says Li Ding of Washington University, a coauthor of the new study.

It's well known that cigarettes are the leading cause of lung cancer. Yet about 10 percent of all lung cancers occur in people who have never smoked. By looking at the genes that underwent mutations, the researchers found that some genes were mutated primarily in nonsmokers, while other genes were more likely to be mutated in smokers. What triggers tumors is very different in smokers and nonsmokers, concludes Govindan.

Moreover, not all suspect genes turned out to be big players. Two genes known to affect tumor growth, *KRAS* and *TP53*, did turn out to be instrumental. These genes were mutated in more than 30 percent of the tumors from lung cancer patients. Yet coauthor David Wheeler from Baylor notes that some genes commonly implicated in cancer formation, like *PTEN*, were seldom mutated.

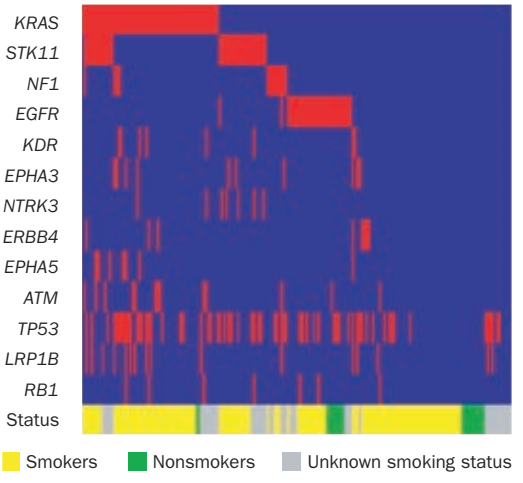
Just because a mutation can cause cancer doesn't mean it actually does, Wheeler points out. Because this study provided a glimpse of actual tumors in a population, it could pinpoint the relative abundance of particular mutations.

The new study also identified genetic networks within cells that are critical to keeping them from turning cancerous. Ding says the team found that "most mutations are clustered in a few key signaling pathways."

Newly identified mutations in both individual genes and genetic pathways are potential drug targets. As a result, Ding predicts, more pathway-based treatments "will emerge quickly" from studies like these.

Mutated genes

The distribution of mutated genes (shown by red lines) was different in smokers than it was in nonsmokers.



DING ET AL., NATURE

Sugar helps *E. coli* go down

Foodstuffs without bacteria may heighten infection risk

By Dina Fine Maron

Some strains of *E. coli* might rely on something sweet to do their harm.

A study published online October 29 in *Nature* presents results from lab work suggesting that foodstuffs such as red meat and dairy products contain sugar molecules not naturally produced in the human body. And toxins from diarrhea-causing strains of *E. coli* bacteria may bind to these molecules, called Neu5Gc, triggering the pathway that causes disease.

The molecules are absorbed by the body and incorporated into intestinal and kidney tissue — later serving as targets for the toxin, says study coauthor Ajit Varki of the University of California, San Diego. He says a typical quarter-pound beef burger would have about 3 milligrams of the sugar.

The team tested human gut and kidney cells steeped in Neu5Gc and found the toxin was about seven times more likely to bind to the cells if the sugar was present. But Varki says it is "not clear how to extrapolate this precisely to the human body."

Andy Benson of the University of Nebraska–Lincoln says these strains are understudied. "Now you've got a scenario where the organism — the toxin — actually needs something from the food it's carried in," he says. "That's truly unique."

How the sugar accumulates or is broken down over time is still unknown, Benson says. It could stay around, heightening the risk the next time around.

By Laura Sanders
Photograph by Amy Guip

Scientists trace a new path behind the maddening, unrelenting, screaming desire to

ITCH

When it comes to sensory information detected by the body, pain is king, and itch is the court jester. But that insistent, tingly feeling — satisfied only by a scratch — is anything but funny to the millions of people who suffer from it chronically.

Garden-variety itches related to histamine, like the kind caused by an angry rash of chicken pox or poison ivy, annoy everyone, but most can be subdued with drugs like Benadryl. But another type of itch is not mollified by these drugs, and therein lies the rub. Pathological itch — called the "itch that laughs at Benadryl" by neuroscientist and itch investigator Glenn Giesler Jr. of the University of Minnesota — is no joke.

Not often pursued by scientists who look at sensation, itch research has lagged far behind investigations of other bodily cues. But in recent years, scientists have begun studying pathological itch seriously. This year researchers found nerve fibers — long, thin strands that carry information from the outer skin to the spinal cord and ultimately, the brain — built to detect this often-devastating type of itch. The new results show that it has its own pathway to the brain.

"That's the hottest topic in the field right now, the idea of different pathways for different itches," says Earl Carstens, a neurobiologist at the University of California, Davis who studies the details of how these itches travel to the brain. The discovery of these fibers has also led some researchers to rethink the relationship between pain and itch.

"In the last two years, there has been an exponential growth of publications in the field, with major findings," says Gil Yosipovitch, a researcher and clinician at Wake Forest University in Winston-Salem, N.C., who founded the International Forum for the Study of Itch in 2005.

Increasing attention to itch is good news for the estimated 17 million Americans with severe, chronic itch from atopic eczema, a skin disease marked by dry, itchy skin, and other itchy conditions. A large study on itch conducted in Oslo in 2004 found that 8 percent of more than 18,000 adult Norwegians surveyed suffered from chronic itch. Itch often afflicts the weakest: It is a well-known but understudied symptom in people with liver failure, multiple sclerosis, HIV and late-stage cancer. Painkillers may help the seriously ill, but often replace pain with severe itchiness. And depression rates soar among people who itch constantly.

It's easy to imagine why. Think of spiny insect legs scurrying up the neck, and of lice, mosquitoes, bedbugs and chiggers crawling on, burrowing in and biting tender parts of the skin. Now magnify those sensations by months, years or even decades.

For patients and doctors, the worst part of this itch is that there is almost no way to treat it. Antihistamines like Benadryl, the tried-and-true way of blocking itch caused by bug bites and hives, have no effect on more serious itch conditions. In many cases, the best (and only) advice has remained unchanged for many years: Moisturize, wear loose clothing and, whatever you do, don't scratch.

"It's maddening," says Susan Lipworth, a board member of the National Eczema Association, based in San Rafael, Calif., who has suffered from severe eczema-related itching for 14 years. The insatiable desire to scratch has left her body scarred with seeping wounds. "I love my doctors, but there is nothing for this," she says.

The original itching

Plants and bugs can make us itch. So can scratchy wool sweaters. It turns out that itch can even be brought on by the power of suggestion.

You feel an itch on the skin. But its roots lie deep in the brain and spinal cord, a finding that emerged from scientists' first modern attempts to understand itch in the 1970s and 1980s. Studying the itches brought on by things like poison ivy, scientists showed that after contact with the plant's toxins, the skin releases a chemical called histamine from specialized cells that cause the skin to swell, redden and itch.

Early work by European researchers showed that histamine causes intense itch when injected directly into human skin. It wasn't until 1997 that a German research group led by Martin Schmelz, now at the University of Heidelberg in Mannheim, discovered the first itch nerve fibers, which responded primarily to histamine and were shown not to be sensitive to pain (*SN:10/18/97, p. 245*).

"The idea was fabulous," says Robert LaMotte, a neurobiologist at Yale University and a leader of studies on the newly discovered chronic itch fibers.

Until the 1997 finding, most researchers thought that itch was a weaker form of pain, and probably sensed by pain-related nerves. Scientists believed that if an itchy stimulus was increased to a high enough level, the itch would turn into an "ouch." Conversely, if a painful poke was lessened enough, the pain would feel itchy. But the discovery of fibers that responded to histamine but not to a painful pinch revealed itch as a sensation unto itself.

"The idea that histamine is the main itch mediator in the skin was prevalent for a long time," Carstens says.

The study of histamine itch led to major gains in understanding a chemical that causes itch and the fibers that detect it, but in a sense, it was a red herring. Even then scientists knew that some itching didn't appear to involve histamine.

Laughing at Benadryl

"It all started with the observations of itch that are resistant to antihistamines. That's why we embarked on this research," says Matthias Ringkamp, a neurobiologist at Johns Hopkins University in Baltimore who has worked with LaMotte on the chronic types of itch.

Another clue also led scientists to look for separate pathways for these types of itch: The nerve endings discovered by Schmelz's group in 1997 cannot detect many types of itch, like the kind caused by unlined prickly wool pants raking against dry winter legs. Researchers thought it might be possible to use temporary non-histamine itches as experimental proxies for chronic, debilitating itches.

To study the itches in the lab, scientists turned to cowhage, a major ingredient in pranksters' itching powder. Back in the 1950s, scientists had described the curiously itchy effects of cowhage, or *Mucuna pruriens*, a tropical plant with white or purple flowers that produces nutritious beans. Its seedpods are coated with tiny lances called spicules. When lodged in the skin, the spicules produce an intense, pure and reproducible itch that lasts for about six minutes. (Probably a very long six minutes for the study participants.)

"You can take Benadryl all day, and if you jump into a cowhage plant, you'll itch like no tomorrow," says Giesler, whose University of Minnesota research group was, in 2004, one of the first since the 1950s to take advantage of cowhage's itchiness. "Right away, we realized that cowhage was a different type of itch."

To draw distinctions between itches, a team of researchers led by Ringkamp conducted experiments using histamine for the usual itch and using cowhage to represent chronic itch. Although the study subjects found both substances to be itchy, the characteristics of the itches were markedly distinct. The itchy area caused by cowhage was restricted to the site of application; the histamine itch spread out from the original site. When an antihistamine was applied to the itches, the cowhage itch persisted.

But when Ringkamp and colleagues treated the itches with the compound that makes chili peppers hot — capsaicin, which triggers a pain response — they blocked the cowhage itch, while leaving the histamine itch unaffected. There was another notable difference. The cowhage itch disappeared in about six minutes, while the histamine itch lasted longer.

These results, published in 2007 in the *Journal of Neuroscience*, showed that while the sensation of the two itches caused by histamine and cowhage felt similar to participants, the mechanisms were undoubtedly different.

Since, like almost all types of chronic, pathological itches, the itch produced by cowhage is impervious to antihistamines, scientists reasoned that if they could figure out exactly which neural fibers were responsible for a cowhage itch, they might understand how pathological itch works. Then, they could figure out how to treat it. The scientists concluded that different itch fibers may carry distinct itch messages to the brain.

Because the histamine-sensing itch fibers could not detect itchy mechanical stimuli, like a scratchy wool sweater, the researchers turned to another likely culprit: pain fibers.

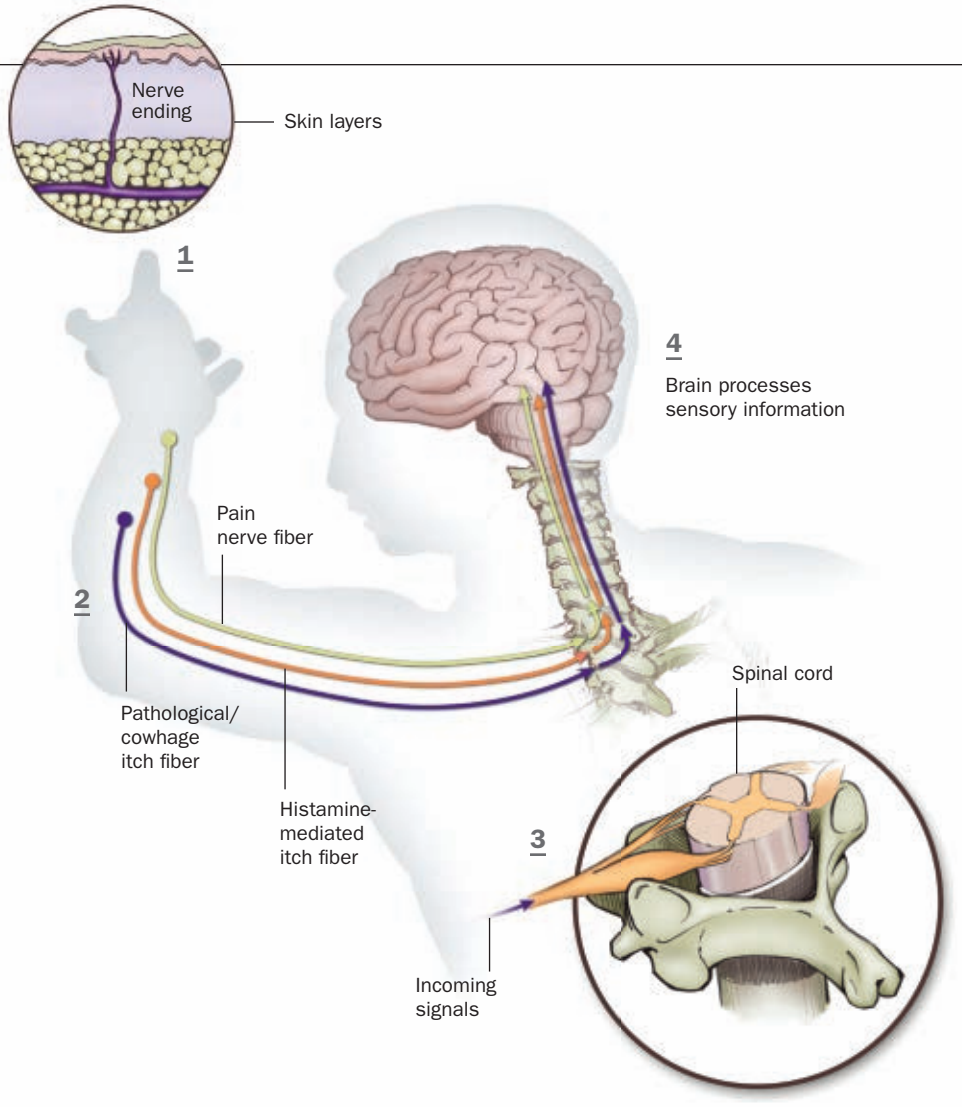
Pain and the itch

Called an "exquisite pleasure" by researcher G.H. Bishop in 1948, scratching an itch is deeply satisfying, probably because the pain caused by scratching overrides itch fiber activity. But the relationship between pain and itch is, to put it mildly, complicated.

After the 1997 discovery of the itch-specific fibers, itch and pain were uncoupled. The new data on cowhage-induced itch suggests that pain and itch, in some cases, do seem to be linked, and perhaps detected by the very same fibers. The finding makes the idea of a clean separation a bit fuzzier.

To see the activity of individual fibers that might respond to pain and itch, LaMotte's team began eavesdropping on the neurons of monkeys. The researchers wanted to know if a type of nerve fiber that detects pain caused by heat and mechanical forces, such as a pinch, could also sense a cowhage-induced itch.

To test this idea, thin, conductive wires were inserted into the skin of a sedated monkey, and different types of stimuli



Itchy pathways

Researchers have identified two distinct types of nerve fibers that respond to itchy sensations, passing signals from the skin to the brain.

1 Itchy stimuli are detected by thin fibers (bundles of nerve cell extensions) ending near the surface of the skin, similar to how pain sensations are detected.

2 When activated, the pathological or cowhage itch fiber (purple) and the histamine-mediated itch fiber (orange) carry the itch signal to the spinal cord. Pain fibers (green) of the same class follow a similar pathway.

3 At the spinal cord, itch signals are transferred to other nerve cells inside the spinal cord, called second order projection neurons.

4 The itch signal is relayed up the spinal cord and into the brain, where it is processed, enabling a response such as scratching. The pathological itch fiber also appears to sense pain sensations such as heat or a pinch.

CHARLES FLOYD

were applied to the arm: Heat and capsaicin to cause pain, and cowhage and histamine to bring on the itch.

The team tapped into individual nerve endings as they responded to pain. A few showed a weak response when histamine was applied. But the majority of the nerve fibers responded strongly to cowhage. The same fibers known to detect painful stimuli like a hard poke or a burn could also detect the cowhage itch. These fibers were pulling double duty.

Vocabulary for itch fibers is lacking, so Ringkamp's group described these new itch fibers, in the July 23 *Journal of Neuroscience,* by their pain fiber names.

Cowhage itch has a private pathway to the brain, independent of the histamine-related pathway, and scientists assume chronic itch conditions do too, Carstens says. "The idea is that there are now at least two separate mechanisms and pathways for itch, one for histamine and another one for cowhage," he says.

Ringkamp explains: "These two kinds of itch induce two different types of neuronal populations."

And then there's the contagious itch, similar to the yawn that can overtake a room. In a 2000 study titled "Observations during an Itch-Inducing Lecture," viewing slide shows starring fleas, mites and allergic rashes led people to scratch themselves.

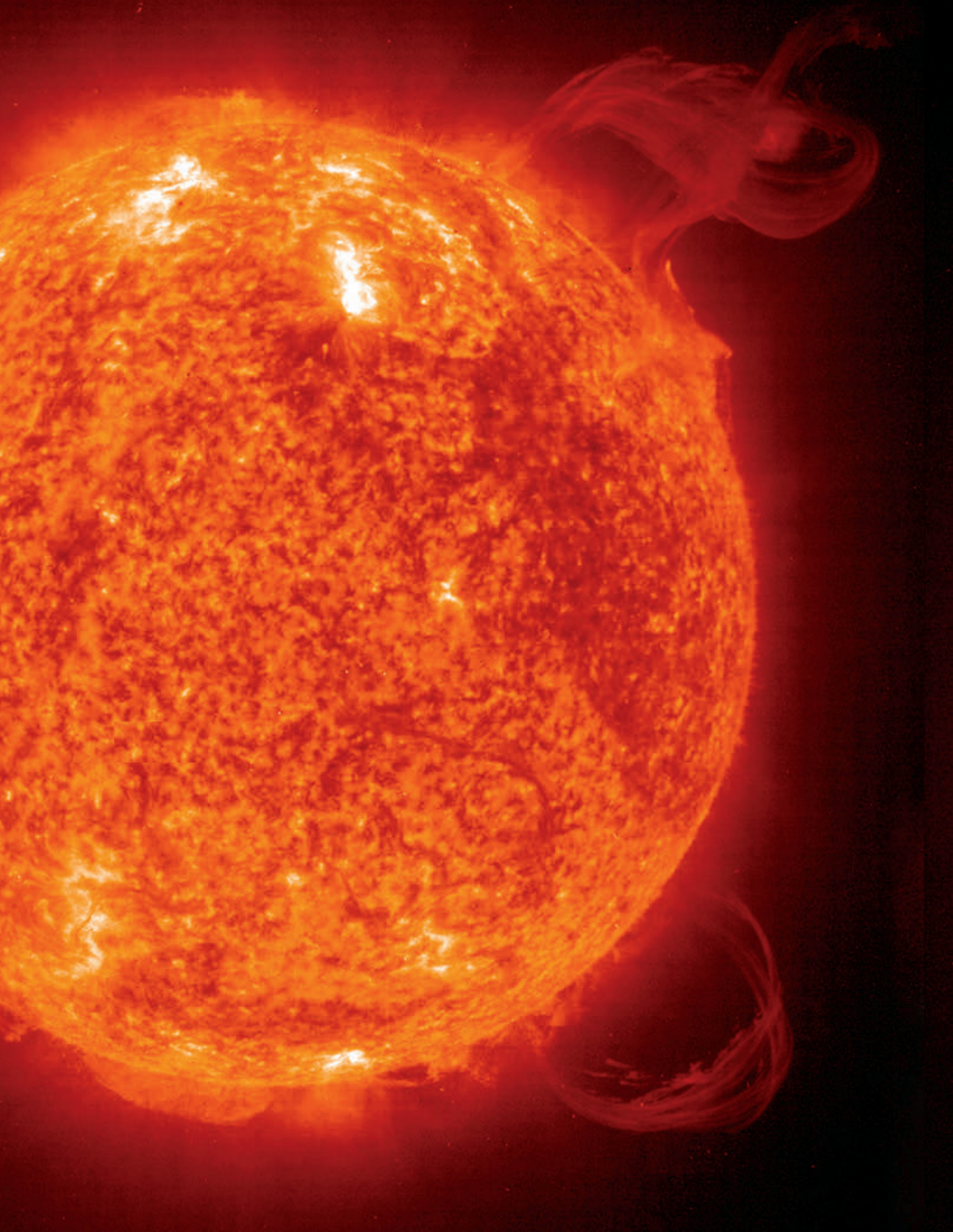
Even reading about itches may be enough to cause the sensation. (Sorry for the scratch marks.)

Understanding the architecture of the types of nerve fibers that detect itch and the complicated brain processing that makes a person want to scratch, scientists say, will lead to a greater understanding of how bodies perceive these sensations. As LaMotte, the neurobiologist from Yale, puts it, "This is a window into how the brain processes stimuli."

Despite all this progress, most researchers in the field agree that the task of classifying and describing all of the different sensory fibers in skin is in its infancy. Scientists, they say, have just scratched the surface. ■

Explore more

- L.M. Johanek, *et al*. "Psychophysical and Physiological Evidence for Parallel Afferent Pathways Mediating the Sensation of Itch." *The Journal of Neuroscience*. July 17, 2007.
- L.M. Johanek, *et al*. "A Role for Polymodal C-Fiber Afferents in Non-histaminergic Itch." *The Journal of Neuroscience*. July 23, 2008.



Physicists are stirred by claims that the sun may change what's unchangeable — the rate of radioactive decay

By Davide Castelvecchi

Half-life (more or less)

It's nuclear physics 101: Radioactivity proceeds at its own pace. Each type of radioactive isotope, be it plutonium-238 or carbon-14, changes into another isotope or element at a specific, universal, immutable rate.

This much has been known for more than a century, since Ernest Rutherford defined the notion of half-life — the time it takes for half of the atoms in a radioactive sample to transmute into something else. So when researchers suggested in August that the sun causes variations in the decay rates of isotopes of silicon, chlorine, radium and manganese, the physics community reacted with curiosity, but mostly with skepticism.

In one experiment, a team at Purdue University in West Lafayette, Ind., was monitoring a chunk of manganese-54 inside a radiation detector box to precisely measure the isotope's half-life. At 9:37 p.m. on December 12, 2006, the instruments recorded a dip in radioactivity. At the same time, satellites on the day side of the Earth detected X-rays coming from the sun, signaling the beginning of a solar flare.

The sun's atmosphere was spewing out matter, some of which would reach Earth the day after. Charged particles would contort the planet's magnetic field, disrupt satellite communications and pose a threat to astronauts on the International Space Station.

But that dip in the manganese-54 radioactivity was not a coincidental experimental fluke, nor was it the solar flare discombobulating the measurements, the Purdue researchers claim in a paper posted online (arxiv.org/abs/0808.3156). In West Lafayette the sun had set while X-rays were hitting the atmosphere on the other side of the globe, and the electrically charged matter that created electromagnetic disturbances worldwide was still in transit. After a solar flare has begun, "the charged particles arrive several hours later," points out theorist Ephraim Fischbach, coauthor of the paper with his Purdue colleague Jere Jenkins.

In a separate paper, also posted online in August, Fischbach, Jenkins and their collaborators compared puzzling and still unexplained results from two separate experiments from the 1980s — one on silicon-32 at the Brookhaven National Laboratory in Upton, N.Y., and the other on radium-226 done at the PTB, an institute that sets measurement standards for the German federal government. Both experiments had lasted several years, and both had seen seasonal variations of a few tenths of a percent in the decay rates of the respective isotopes.

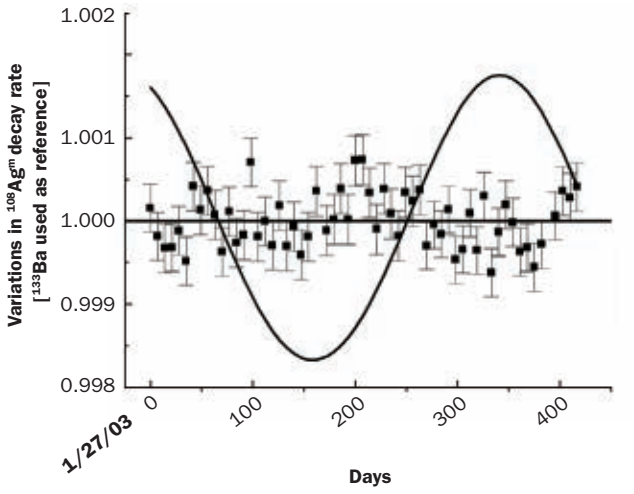
A change of less than a percent may not sound like a lot. But if the change is real, rather than an anomaly in the detector, it would challenge the entire concept of half-life and even force physicists to rewrite their nuclear physics textbooks.

In those experiments, the decay rate changes may have been related to Earth's orbit around the sun, the Purdue team says. In the Northern Hemisphere, Earth is closer to the sun in the winter than in the summer. So the sun may have been affecting the rate of decay, possibly through some physical mechanism that had never before been observed.

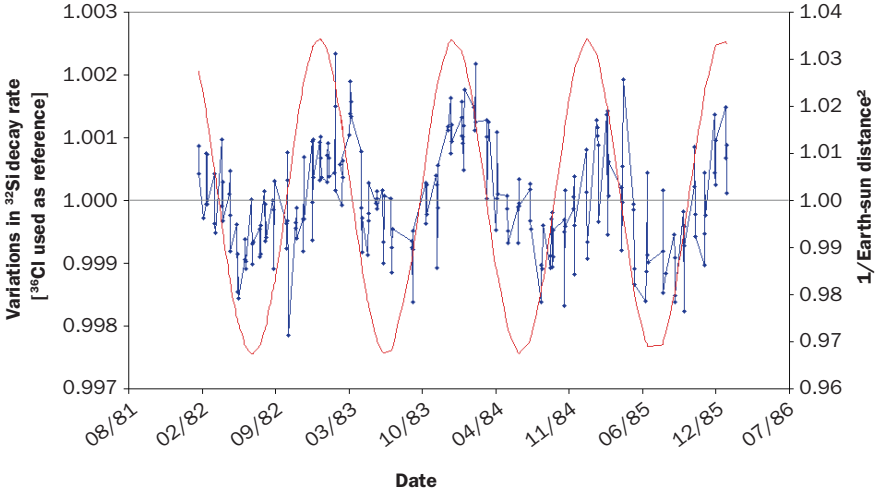
For example, the researchers say, the sun constantly emits neutrinos, sub-

SOHO (ESA & NASA)

1. Radioactivity of silver-108m and Earth-sun distance



2. Brookhaven National Lab data for silicon-32 and Earth-sun distance



atomic particles produced in the nuclear reactions that power the sun. Neutrinos can move through the entire planet without being stopped, so the sun could affect radioactivity day and night. The closer to the sun, the denser the shower of neutrinos. Or the sun may emit fewer neutrinos during a solar flare, which would explain the December 2006 event.

Most physicists are dubious. For one thing, neutrinos interact negligibly with matter, so it's not clear how they would affect radioactivity.

But some physicists take the results seriously and are searching old data for previously unnoticed effects. If the variations turn out to be genuine, theories may need revision, or new theories may be needed. "There's no known theory that will predict something like this," says theoretical physicist Rabindra Mohapatra of the University of Maryland in College Park.

If the results are confirmed, and nuclear decay is not immutable, perhaps physicists could find a way to speed it up to help get rid of waste from nuclear power plants. Such results might revise models of what goes on in the sun or change understanding of phenomena such as supernovas. Since neutrinos travel much faster than dangerous charged particles, using radioactive samples to detect solar flares when they first begin could prevent damage to satellites — and perhaps even save lives of astronauts.

Get a half-life

Some atomic nuclei are unstable, either because they are too big or they don't have the right balance of protons and neutrons. Unstable nuclei decay by releasing different kinds of radiation, including energetic subatomic particles. For example, in beta radiation an excess neutron turns into a proton and spews out an electron — a beta particle — and an antineutrino. With an additional proton, the nucleus transmutes into a different element.

If a nuclide — a particular isotope of a given element — has a half-life of, say, one year, then after one year there will be half of it left. All atoms of a given nuclide are identical, and a one-year half-life means that each nucleus has a 50 percent chance of decaying over one year. If it doesn't decay this year, it won't be any more likely to decay next year — the odds will still be 50-50.

Half-lives are universal constants, as any physics textbook can attest. "Since Rutherford we've taken it as [a given] that decay rates are the way they are and nothing can change them," Jenkins says.

Researchers use radioactive materials in a wide variety of applications where it's useful to know the half-life with decent precision — the classic example being carbon-14, used in carbon dating of fossils. Usually, the half-life of a nuclide is measured in experiments that last just days or weeks. But for certain nuclides longer measurements are needed.

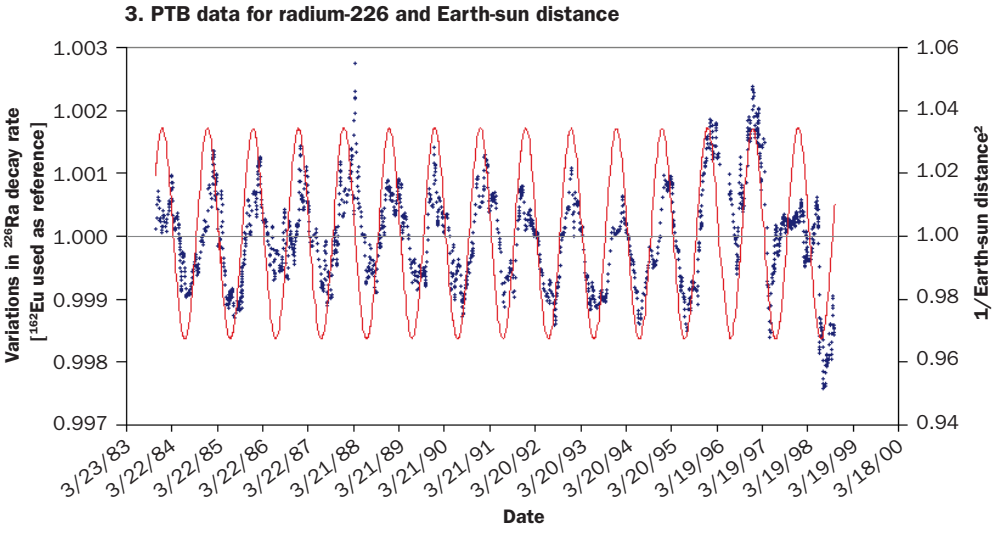
Between 1982 and 1986, a team led by David Alburger of Brookhaven monitored the radioactivity of silicon-32. The isotope's half-life was known to be at least 60 years, so researchers needed a long time to measure it with any precision.

At the same time, the team monitored a chlorine-36 sample. Chlorine-36 has a half-life of more than 300,000 years, so a sample's radioactivity stays virtually unchanged for a long time and can be used to spot any spurious fluctuations. To their surprise, the researchers found that both samples had rates of decay that varied with the seasons, by about 0.3 percent.

The samples were kept at constant temperature and humidity, so the changing seasons should have had no effect on the experiment. The team tried all the fixes it could to get rid of the fluctuations, but, in the end, decided to publish the results. No other lab tried to repeat the experiment, and the anomaly remained unexplained. "People just sort of forgot about it, I guess," says Alburger, who retired shortly after the results came out.

Unbeknownst to Alburger, researchers at PTB in Germany had also found yearly oscillations in a decay rate, in a 15-year experiment on radium-226. (Two of those years overlapped with the Brookhaven experiment.) Now Fischbach and his collaborators' comparison shows that the oscillations are in sync. Well, almost: Mysteriously, the peaks and troughs of the two oscillations seem shifted with

TOP FROM LEFT: SOURCES: NORMAN *ET AL.* "EVIDENCE AGAINST CORRELATIONS BETWEEN NUCLEAR DECAY RATES AND EARTH-SUN DISTANCE." 2008; JENKINS *ET AL.* "EVIDENCE FOR CORRELATIONS BETWEEN NUCLEAR DECAY RATES AND EARTH-SUN DISTANCE." 2008



Radioactive decay and Earth-sun distance

Graph 1: In theory and the vast majority of experiments, the half-life of a radioactive element is constant. This graph shows variations in measurements of the radioactivity of a silver isotope, probably caused by experimental error. These variations do not correlate with Earth-sun distance (curve).

Graphs 2 & 3: But experiments at the Brookhaven National Laboratory (center) and at the PTB in Germany (right) recorded unexpected variations in the radioactive decay rates of silicon-32 and radium-226 (blue dots). Researchers at Purdue University have linked the two observations to the seasonal variations in Earth-sun distance (represented by the red curves) and suggested that there may be a correlation.

respect to each other, by about a month.

Alburger says that the correlation between the patterns seen in his team's data and the PTB's is very convincing. "What causes it is the real question," one that nuclear physicists should now look into, he says.

Mohapatra agrees that the effect looks genuine. But, he warns, genuine-looking effects are often later revealed as statistical flukes or the result of subtle defects in measuring technique. Still, he adds, "it's interesting enough that people in the nuclear field should go back and look at old data."

Take two

Peter Cooper of the Fermi National Accelerator Laboratory in Batavia, Ill., recently did just that. He obtained and analyzed data from the Cassini mission to Saturn. Deep-space probes usually generate power from the heat emitted by a chunk of radioactive material — plutonium-238 for the Cassini spacecraft.

Cassini journeyed as close to the sun as Venus and then far back to Saturn, spanning a much wider range of distances from the sun than Earth does during its yearly orbit. If the sun had an effect on plutonium decay, the fluctuations would have been much more substantial than those seen in Earth-bound experiments. As a result, Cooper reasoned, Cassini should have measured substantial changes in its generator's output. It didn't. (His paper is posted online at arxiv.org/abs/0809.4248.)

Meanwhile, Eric Norman of the Lawrence Berkeley National Laboratory in California reanalyzed data from experiments on radioactive americium, barium, silver, titanium and tin, and found no seasonal variations, he says.

Fischbach is unfazed. Each nuclide, he notes, requires a different amount of energy to be nudged into decaying, and that the type of decay — be it alpha, beta or gamma radiation — may also play a role. "It's possible that plutonium is inherently less sensitive than radium," he says.

More recently, Fischbach found what he says is more evidence for his case. Exhibit A: An experiment on tritium, a radioactive isotope of hydrogen, which his collaborators are running at Purdue, may be measuring a seasonal effect, he says. Exhibit B: A 1990 paper by Kenneth Ellis of Baylor College of Medicine in Houston reported seasonal variations in plutonium-238 radioactivity in a calibration experiment for a radiotherapy machine.

But Fischbach, Jenkins and their colleagues have a lot of convincing to do, says Hamish Robertson of the University of Washington in Seattle. "There's no physical basis for the decay rates to vary with anything, let alone with the Earth-sun distance," he says.

Neutrinos in particular seem a very unlikely explanation to most physicists. Neutrinos only interact via the weak nuclear force, which has very short range, points out Boris Kayser, a neutrino theorist at Fermilab. And ordinary matter is mostly empty space. So detecting neutrinos is notoriously hard, Kayser explains. "Unless the detector is very big, so that it gives the neutrino many chances to come close to one of its particles, the neutrino will just go sailing right through it."

Fischbach, though, says that perhaps neutrinos have a small electromagnetic interaction. While they have no electric charge, neutrinos carry a magnetic field. Instead of one neutrino giving a rare kick to one nucleus, a single neutrino could be giving "a small electromagnetic kick to a lot of nuclei," potentially tipping the unstable ones into decaying. Fischbach admits that he hasn't finished calculations to show that this would be possible.

The Purdue scientists are planning more experiments. In the end, the burden of proof will be on them, Cooper says. "Every experimentalist knows that the apparatus, or at least your understanding of it, is always at fault until demonstrated otherwise," he says. It's likely that seasonal weather caused the anomalies, he says, but admits that future work could prove him wrong. "Nature is really unmoved by what I, or anyone else, believes." ■

Explore more

- J.H. Jenkins *et al.* "Evidence for Correlations Between Nuclear Decay Rates and Earth-Sun Distance." Available at arxiv.org/abs/0808.3283

Mimicking how spiders make their complex array of silks could usher in a tapestry of new materials, and other animals or plants could be designed to be the producers

By Rachel Ehrenberg

SILK

Peter Parker is lucky he was bitten by a spider and not a silkworm. Not only does "Spider-Man" have way more superhero panache than "Silkworm-Man," but of all the silks made by various creatures, spider silk is the standout. Exceedingly strong, yet elastic and lightweight, spider silks are ideal for a range of materials, from bulletproof vests to scaffolding for growing cartilage.

Scientists are coming closer to unraveling spiders' secrets with the hope of producing piles of the fiber to put to good use. While there's progress in understanding spider silk genes and proteins, challenges persist. Silkworms were domesticated centuries ago and are content munching mulberry leaves in close quarters, but most spiders are both predators and loners. When crowded together, they often become cannibalistic, making them difficult to rear en masse. And while a single silkworm cocoon can yield 600 to 900 meters of silk, a spider gives up after spinning out only 130-odd meters or so.

So scientists are trying to coax spider silks from other creatures, experimenting with inserting silk genes into bacteria, tobacco plants and goats. (No pigs yet, but making a silk purse from a sow's ear may not be as crazy as it sounds.) Other researchers are investigating the silken threads made naturally by insects such as bees, wasps and ants.

Once scientists can make mass quantities of silk cheaply — which means perfecting not only the raw material, or silk "dope," but also the best way to spin it — then the threads may find their way into a panoply of products. Part of the allure of mastering natural silks is the potential to make a strong, elastic fiber at room temperature and without harsh chemicals. This promise of green chemistry enthralls scientists, who say silk offers an environmentally friendly alternative to the petroleum-based fibers of today.

"It's really ideal," says Randy Lewis of the University of Wyoming in Laramie. "If you can mimic it, you can eliminate an awful lot of the problems you have with all the man-made fibers that are currently available."

The best understood and most explored silks are those made by silkworms, the caterpillar of the silk moth, *Bombyx mori*. Domesticated some 4,500 years ago, the silkworm can no longer survive — and is no longer found — in the wild. Using a three-step process — make proteins, add glue, spin — the silkworm spins itself a shroud from a single continuous thread that may be more than half a mile long.

The silkworm is easily reared, and its silk has been used for centuries. Today silkworm silk is a more popular surgical suture than collagen. But caterpillar silk has its problems. The silkworm encases its two main silk proteins in a coat of sericin, a gluelike protein that seals the cocoon together. When used as sutures or for other medical applications, this sericin glue can provoke an immune response in people and therefore must be coated over or removed. And silkworms spin just one kind of silk.

"We love the silkworm," says David Kaplan of Tufts University in Medford, Mass. "But spider silk is so diverse — we want to exploit that."

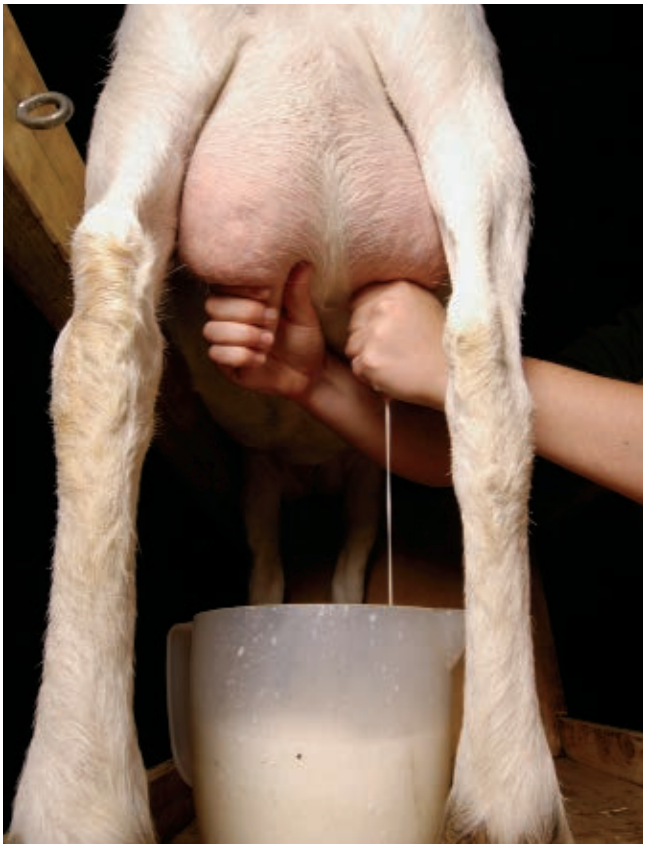
The full orchestra

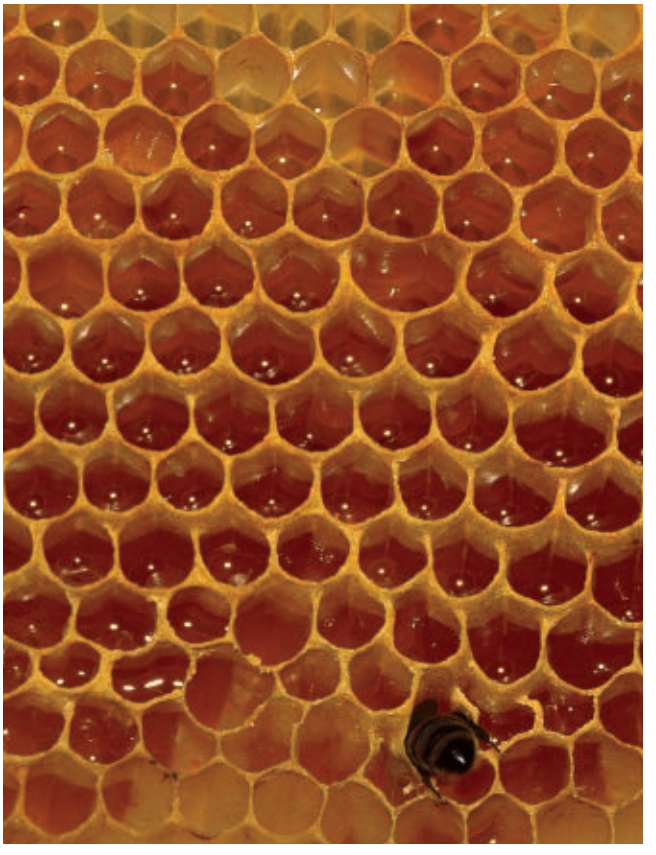
If silkworms are one-note Johnnys, spiders are silk virtuosos. A true spider — a member of the 39,000-species–strong order Araneae — makes up to five kinds of silk fibers. Multiple abdominal glands, the shape and number of which vary across species, allow spiders to produce more than one kind of silk at a time — and mixing threads and proteins from different glands is not uncommon, says Catherine Craig of Harvard University's Museum of Comparative Zoology.

Spiders make egg-case silk, prey-wrapping silk and of course web silk, which comes in several varieties, such as scaffolding, sticky or structural. (The more

Research has hit some snags in the effort to farm mass quantities of silk from spiders (bottom left), so efforts aim to engineer new silk-makers, such as tobacco plants (top left) and goats (top right). Other natural silk-makers, such as bees, could also prove easier to direct (bottom right) than spiders.

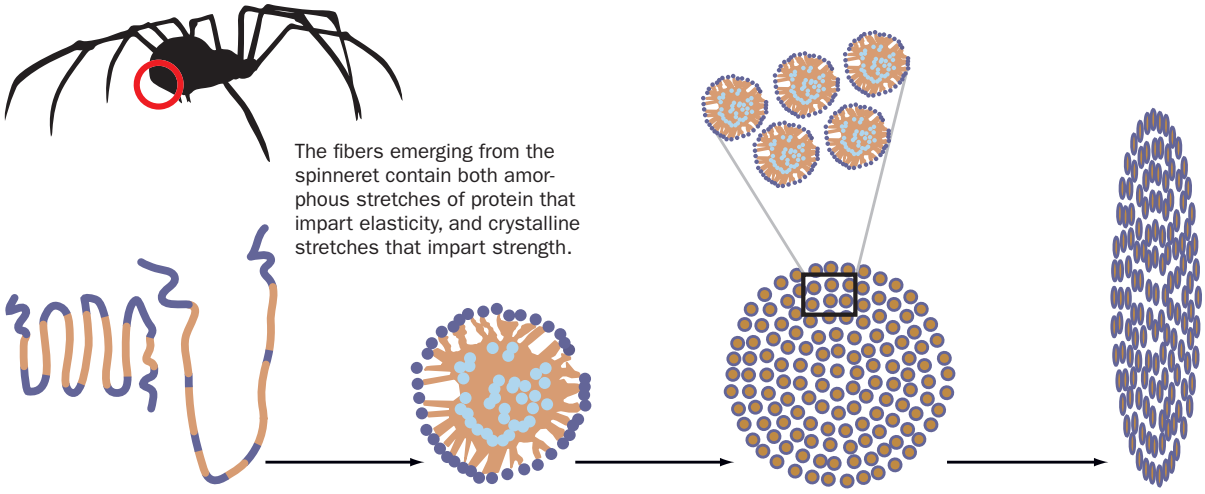
SOT/GETTY; FACING PAGE CLOCKWISE FROM TOP LEFT: ISTOCK/ALEAIMAGE; SIMON CLAY/GETTY; ADRIAN BICKER/SCIENCE PHOTO LIBRARY; GERRY ELLIS/MINDEN PICTURES





Silk from the protein up

Although the web of variations is huge, the basic steps of spider silk-building are:



1. In the spinning duct, silk begins with protein strands that have water-repelling sections (orange) mixed with and flanked by water-loving sections (blue).

2. Within the watery environment, the protein strands gather into orderly clumps called micelles. Water-loving ends face out, and water-repelling sections are sequestered inside.

3. The water-loving faces of individual micelles interact to form aggregates. As more proteins enter the duct, the dope begins to gel and then becomes a crystalline liquid.

4. Triggers such as physical shearing spur the liquid crystals to form ordered sheets, which are connected by amorphous protein regions.

ancient tarantulas, which do not construct elaborate webs but do use silk to wrap their eggs and line their burrows, were recently shown to produce silk from spigots on their feet. This finding raised the possibility that abdominal-gland silk is a more recent evolutionary invention and that feet spigots came first.)

Spiders have been silking it up for more than 350 million years — a skill that was probably instrumental in their diversification, Craig says. Spiders rank seventh among all animal species in global diversity, beat only by certain insect orders and the mites and ticks.

The most studied spider silks come from the golden silk spider, *Nephila clavipes,* and the European garden spider, *Araneus diadematus*. Dragline silk, which these orb-spiders use in the outer rims of their webs and as a safety bungee when dropping or falling from high, has been investigated the most. It is both superstrong — meaning it can support tremendous weight — and supertough — meaning it can absorb a lot of kinetic energy before breaking. An inch-diameter fiber made of dragline spider silk could reel a 747 from the sky, Lewis says. The silk isn't just tougher than Kevlar or as strong as steel; it is also light, and thus an excellent material for things like body armor and parachute cords, or for tethering planes to an aircraft carrier.

Spider silks also seem to be friendly inside the human body. Studies suggest that spider threads don't elicit an angry response from the immune system, says Tuft University's Kaplan, who published a review of spider silk applications in the May *Trends in Biotechnology*. Kaplan cites experiments with ultrathin films made of spider dragline silk, which could be used for wound dressings.

Spider silk is also being used to make porous gels and sponges, which can be seeded with tissue or bone cells that grow around a silk lattice that gradually biodegrades. Researchers have had success growing the nerve cells known as Schwann cells on spider-silk threads, pointing to the possibility of artificial nerve grafts. Scientists have also had recent success engineering tiny capsules with spider silk. The capsules can be broken down by specific enzymes, which would allow doctors to precisely control the release of drugs within the body, the researchers reported last year in *Advanced Materials*.

While spider silks hold promise in numerous applications, scientists are still untangling the intricate set of building blocks and genetic instructions that underlie each thread. Each silk seems to have a corresponding gene, and scientists have deciphered the "letters" of code for 11 silk genes so far, says Lewis. Within each gene the arrangement of code is complex. Repeated stretches of code contain protein-making instructions, but are peppered with introns, or stretches of DNA that don't contain directions. This genetic complexity has probably contributed to the diversity of silks and their stability in the spider lineage, Kaplan says.

Pinch spinners

But this genetic ungainliness has also made it difficult for genetic engineering workhorses, such as the bacterium *E. coli*, to pump out spider silk proteins in the lab. So scientists are now trying to tease silk from a menagerie that includes hamsters, yeast, goats, mice and transgenic silkworms. Plants such as pota-

STEVENFOLEY/ISTOCKPHOTO; GRAPHIC ADAPTED FROM KAPLAN *ET AL. NATURE* 2003, *TRENDS IN BIOTECHNOLOGY* 2008

toes, tobacco and alfalfa have also been recruited.

Lewis has collaborated with scientists at the Canadian firm Nexia Biotechnologies, part of the team that spliced spider silk genes into bovine cells in 2002 and later into goats. Today, transgenic goats roam at the University of Wyoming. While present in every goat cell, the spider silk genes are turned on only in the mammary glands, yielding goat milk laced with silk proteins. While promising, the yield is still low, Lewis says. A gallon of milk may have only 60 grams of silk, which means it would take about 600 gallons of milk to make one bulletproof vest. And there are still problems with purifying the proteins. After a few grams of silk have built up, the milk starts coagulating, perhaps because the silk proteins are binding to proteins in the milk, Lewis says.

Silk proteins come in a rich array of structures, but generally, the molecular structure of silk consists of regions of protein crystals separated by less organized protein chains, Kaplan says. As the spider dumps more and more silk protein into the spinning duct, the protein forms a gel and gradually organizes into a liquid crystalline phase. Then, in a feat that would make Rumpelstiltskin jealous, the spider pulls the fiber from its spinneret. The fiber shears in such a way that crystals form and, in one-tenth of a second, the dope goes from liquid to solid.

"It is truly an amazing process," Kaplan says. "It is fast and efficient, and at once it is insoluble in water, even though it is made in water."

Scientists are making headway in analyzing the ingredients and mechanical properties of various spider silks, but many secrets remain within each gossamer strand. John Gosline of the University of British Columbia in Vancouver, Canada, and his colleague Ken Savage recently compared the dragline silk of the golden silk spider with that of the European garden spider. The silks behaved almost identically when dry, but when wet the golden spider's silk was almost 10 times stiffer, behaving more like a spring than a stretchy rubber band. The difference is probably because of a protein building block, the amino acid proline. Garden spider silk has four times more proline, which may break up the silk's crystalline sheets, giving it more stretch, the researchers report in two papers published in June in the *Journal of Experimental Biology*.

Spiders are particularly adept at spinning silk to suit a specific purpose, says Gosline. The repeated sections of amino acids in dragline silk, for example, differ from the sequence of amino acids in flagelliform silk, the superelastic thread used in the spiral section of the web.

The very same silk, from the very same spider, can have different properties if taken by force — silked or "milked" — than if it is released by choice,

Gosline notes. Spiders can't eject silk, Spidey-style — they must pull it out with their legs or attach it to something and move away. They also seem to have some kind of brake in their spinnerets that allows them to control the silk's flow, like applying a thumb to a water spigot. If researchers anesthetize a spider, they can pull out silk with very little resistance, while a spider that has just begun to be "milked" might resist with a force several times its body weight, resulting in a silk that is much stiffer and stronger, but less extensible, Gosline says.

"Spiders are amazingly adept at using their silk in subtle ways, adjusting it for load size and purpose," he says. "We don't even know the range."

Concocting the right mix of silk proteins is one thing; spinning them into silk is another. Techniques have been developed to purify and spin silk, but none have matched the spider at her loom.

In order to develop better spinning techniques, scientists need silk and lots of it. Since spider farms are out, engineering alfalfa or tobacco plants to make silk holds promise as a relatively cheap means to make lots of it. If goats can make silk proteins only in milk, maybe plants like tobacco could be engineered to make silk proteins in one concentrated and easily harvestable spot.

Many plant seeds have a hefty dose of nutritive tissue, much like the yolk of an egg, which nourishes the young plantlet. Getting plants to replace that tissue with silk proteins may be the best way to mass produce the fiber, says Tara Sutherland, who works in the entomology section of Australia's Commonwealth Scientific and Industrial Research Organisation in Canberra. At the moment though, Sutherland is focused on silks made by insects, which craft many different silks, although only one kind each. Sutherland has zeroed in on the silks of bees, wasps and ants.

Silkier than honey

"Imagine a hive and each new generation of bees being wrapped in a silken cocoon," Sutherland says. "If you remove the wax and look where the bees were raised, there is silk — beautiful sheets of golden silk." In addition to protecting each larval bee in its cell, the silk might add structural support to the hive and prevent the wax from getting so warm that it melts. Sutherland speculates that the buildup of silk in a hive's cells may be what eventually drives the insects to seek a new hive. "Eventually there's just no room."

Sutherland is also investigating weaver ants, which use silk to stitch leaves into nests. It seems that only the baby weaver ants make silk. The adults hold onto and maneuver the little larval silk-makers for desired placement.

The general structure of most silks made by the hymenopteran insects with stingers — the bees, hornets and most wasps — has been known for some time and is very different from other silks. Rather than assembling crystalline sheets, these silk proteins form interlocking helices known as coiled coil silks — like spiraled pasta versus flat sheets of linguine, says Sutherland.

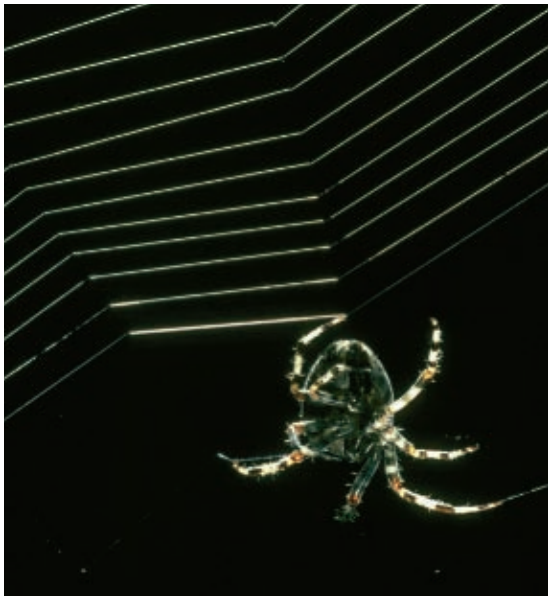
After the sequencing of the honeybee genome, Sutherland's team went hunting for honeybee silk genes and found four, each coding for a different coiled coil protein. Then the team looked for silk genes across a range of hymenopterans: in the bumblebee, weaver ants, bulldog ants and some stinging and non-stinging wasps.

Parasitic wasps and sawflies — the hymenopterans without stingers — also make silk cocoons, but it turns out that they use the flat-sheet format, Sutherland and colleagues reported in *Molecular Biology and Evolution* in November 2007. This difference suggests that the coiled coil silks were invented roughly 155 million years ago, after the split between the stingers and non-stingers, she says. The arrival of coiled coil silks may have even contributed to the social nature of these insects, making hive-living more feasible.

Bee and ant silk is both tougher and more stable than silkworm silk, says Sutherland. But so far, nothing beats spider silk. Nevertheless, the simplicity of the four genes and four proteins that bees use makes their threads an attractive alternative to the more complex silk of spiders.

"It's a wonderful material," Sutherland says of spider silk. "But it is very difficult. The proteins are big and repetitive." And bee silk doesn't seem to make lab bacteria stumble, she says. So watch out villains — Spidey may one day be upstaged by other silk spinners. Here's to Ant-Man, Lacewing and The Bee. ■

"Spiders are amazingly adept at using their silk in subtle ways.... We don't even know the range."
JOHN GOSLINE, UNIVERSITY OF BRITISH COLUMBIA



Orb webs, such as those spun by the European garden spider, can intercept large and fast-flying prey.

OSF/COOKE, J.A.L./ANIMALS ANIMALS

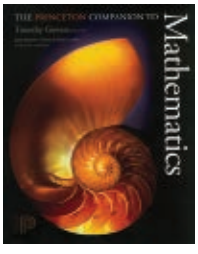
Explore more

- Tree of Life Web Project: Spiders. Visit tolweb.org/Araneae
- J.A. Kluge *et al*. "Spider silks and their applications." *Trends in Biotechnology*. May 2008.

The Princeton Companion to Mathematics

Timothy Gowers, ed.

Math is everywhere, from the gas station and grocery store to the stock market and science magazines. And it shows up, of course, in schools at all levels. But the educational system doesn't provide enough math for most people to appreciate its scope, or understand its intrinsic powers or practical applications.



For those with a deep interest in understanding such things, this book provides a reasonably accessible, technically precise and thorough account of all of math's major aspects — from the basics of algebra, geometry, algorithms and proofs to the essential features of Hilbert spaces and Hamiltonians. Much is understandable to anyone with a good high school math background; sometimes more advanced education is better.

Added attractions include biographical sketches of close to 100 famous mathematicians, a comprehensive chronology of mathematical events throughout history and engaging discussions of math's influence. This book covers such diverse areas as communications, chemistry, biology, economics, image compression, the flow of "traffic" in all sorts of networks (including transportation), music and medical statistics.

Students of math will find this book a helpful reference for understanding their classes; students of everything else will find helpful guides to understanding how math describes it all.

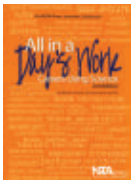
— Tom Siegfried

Princeton Univ. Press, 2008, 1,034 p., $99.

Fixing Climate: What Past Climate Changes Reveal About the Current Threat — And How to Counter It

Wallace S. Broecker and Robert Kunzig

Carbon dioxide recapture is necessary to turn the global warming tide, the authors argue. *Hill and Wang, 2008, 253 p., $25.*



All in a Day's Work: Careers Using Science

Megan Sullivan

A toolkit for those seeking careers in science and science-related fields. *NSTA Press, 2008, 140 p., $15.95.*

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Two crops, only one pops

In "Let's get vertical" (*SN: 10/11/08, p. 16*), writer Rachel Ehrenberg reports that "increased demand for a single crop, such as corn, is felt from movie theaters to hog farms." It is important to note, however, that the corn fed to moviegoers and the corn fed to farm animals aren't the same thing. In fact, they are two distinct and different varieties. Popcorn is *Zea mays averta*, a type of flint corn. The corn used as animal feed, called dent corn or field corn, is *Zea mays indentata*. Try to pop field corn, and you'll just get hard, tough, hot corn.
Jeffry D. Mueller, Eldersburg, Md.

The reader is correct that popping corn and field corn are two different varieties. But the markets for the crops are intertwined. Demand for field corn — which is also used in corn syrups, in products such as paint and, increasingly, in ethanol — has led to price increases, prompting some farmers to switch from popping to field corn. This cuts supply of popping corn and ups its price.
— Rachel Ehrenberg

Shifting paradigms

I wanted to congratulate you on the cogent article by Tom Siegfried on the nature of spacetime ("It's likely that times are changing," *SN: 9/13/08, p. 26*). Since the contributions of Einstein and a few of his contemporaries, physicists have been stuck in the mud as far as new paradigms in physics are concerned. The problem to my mind has been the understanding of time and the entrenched belief that the constants of the universe are the same throughout the universe and throughout time.

If physicists wish to make real progress, they need to open their minds to two fundamental ideas: First, our universe is a bottom-up reality, not top-down, with forces and structure due to emergent properties that evolved from the hierarchical interactions "built" at the most fundamental level from quanta. Second, all constants are relative in space and time. The constants and properties we observe and can so accurately measure and (sometimes) predict are the result of the central tendency of an astronomical number of quanta. In short, the universe is statistical. We are forced to observe and measure nature as a part of it. Time is an illusion based on the changing interaction of nature itself.

Finally, although Darwin may not have realized it himself, he did not only discover and elucidate the way biology changes, but also the way the entire universe evolves as well. The world has yet to completely understand the incredible contribution he has made to science.
Ronald McMurtry, Modesto, Calif.

Cold down there

In the article "Around the ring" (*SN: 10/11/08, p. 8*), Ron Cowen writes that the Large Hadron Collider is closed down for the winter to conserve fuel costs. Since the major portion of the facility is 100 meters below ground, how much colder is it there in the winter than in the summer?
Jesse Stoner, Huber Heights, Ohio

"The LHC tunnel is at a constant temperature year round," says James Gillies, an LHC spokesman. "I don't have a precise figure, but if you're down there for a long time, it's good to take a jacket. The reason we do our maintenance in winter is that energy demand is higher in the winter in this part of the world, so the cost of electricity to us is about 10 times higher in winter than in summer." — Ron Cowen

Drug-focused

Every time there is a new discovery relating to human biochemistry, the knee-jerk reaction of *Science News* has always been: "This may lead to the development of a new drug," as in "Dopamine's role linked to location" (*SN: 8/2/08, p. 8*). However, it has become clear in the past 30 years that new synthetic drugs often cause more harm than good. Why not: "This discovery may lead to a new dietary approach, or a new combination of nutrients and natural phytochemicals to treat such-and-such disease." The degree to which it would be unthinkable for *Science News* to print some version of this statement is exactly the degree to which pharmaceutical thinking (and politics) have taken over the minds of scientists and science writers.
Irv Givot, Sisters, Ore.

Clashing continents

Sid Perkins' article about the effect on CO_2 levels when India and Asia collided was very interesting ("Continental clash cooled climate," *SN: 10/11/08, p. 12*). Mentally following the progress of India from Gondwana to Asia got me thinking that, of course, this continental wandering hasn't stopped. Where do geoscientists predict this ongoing migration is going?
Skip Simonds, Studio City, Calif.

If present-day plate motions continue, in the next 50 million years the Atlantic Ocean will widen, Africa will collide with Europe and parts of California will slide northward to Alaska. About 250 million years from now, most major landmasses will join together to form a supercontinent — just as they have several times in the past billion years, geological evidence suggests. — Sid Perkins

Calming imagery

Regarding the article "Pain relief you can believe in" (*SN: 10/11/08, p. 9*): Surely there must be equivalent calming imagery that would have a similar effect on pain perception and brain activity in those unaffected by the religious imagery. I doubt it's the religious symbols per se that caused the effect. More likely, the Virgin Mary image did not have the same mental or emotional effect on those not predisposed to view a religious icon as an emotionally and spiritually uplifting image.
Wayne Harris-Wyrick, Oklahoma City, Okla.

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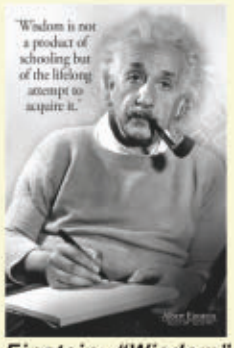

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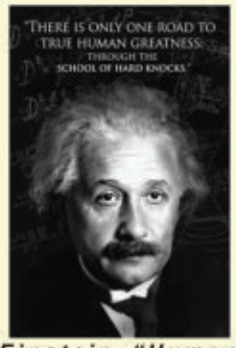

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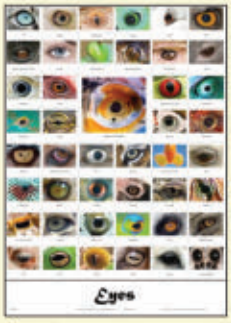

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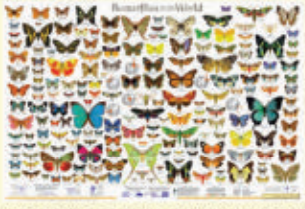

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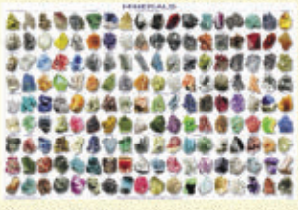

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Gerd Gigerenzer

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Sound reasoning requires statistical understanding

Gerd Gigerenzer is director of the Center for Adaptive Behavior and Cognition at the Max Planck Institute for Human Development in Berlin. He is also director of the Harding Center for Risk Literacy in Berlin. He studies how people can make effective decisions given limited time and information. Gigerenzer also explores ways to improve statistical understanding and communication. He has trained U.S. federal judges and physicians in several countries on how to understand risk and uncertainty. Behavioral sciences writer Bruce Bower asked Gigerenzer about statistical illiteracy and the nature of decision making.

How extensive is statistical illiteracy?

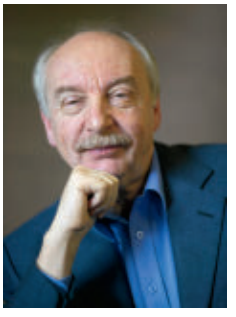
It's a largely unknown problem that applies not only to uneducated people but to the highly educated, including physicians, journalists and politicians. Statistical illiteracy among physicians causes over-treatment, overdiagnosis and increased health care costs. It also affects patients, whose hopes can get unnecessarily raised by the claims that they read in medication advertisements. Statistical literacy should be taught in school beginning in the primary grades.

Can you give an example of statistical illiteracy?

In October 1995, the U.K. Committee on Safety of Medicines issued a warning, widely reported by British newspapers, that third-generation oral contraceptive pills increased the risk of potentially fatal blood clots in the legs or lungs by 100 percent over the same risk from second-generation contraceptives. What the committee and the newspapers failed to report was that the absolute risk of this serious side effect had increased from 1 in 7,000 women who took second-generation pills to 2 in 7,000 women who took third-generation pills. Absolute risks are typically small numbers while corresponding relative changes tend to look big, particularly when the base rate is low.

The pill scare was caused by collective innumeracy. It led to an estimated 13,000 additional abortions in the following year in England and Wales. The cost in increased abortion provision for England's National Health Service reached the equivalent of about $70 million. Teenage pregnancies also increased. Women's confidence in oral contraceptives was undermined and pill sales fell sharply.

Among the few to profit were the journalists who got the story on the front page.



Statistical literacy should be taught in school beginning in the primary grades.

Your research focuses on simple rules of thumb as decision-making aids — fast and frugal heuristics. What are the implications of heuristics for understanding good and bad decisions?

My group has shown that using heuristics based on a few cues in the environment can lead to more accurate decisions than making extensive mental calculations. Many cognitive scientists are scared by this idea that less effort can produce better decisions than more effort does. Fast and frugal heuristics demonstrate that there's a reason for trusting our intuitions.

Weighing and adding up the pros and cons of a tough decision is only possible in limited situations where a person knows all the consequences of his or her potential actions and has lots of time to consider those consequences. In the real world, smart thinking requires finding new alternatives using limited information. We need to trust both our brains and our guts.

Do moral decisions rely on fast and frugal heuristics?

Theories of morality have traditionally assumed that a sense of morality comes from conscious deliberations inside each person. But for many moral decisions, we ask friends for advice, imitate others who have been in similar situations and are otherwise guided by our surroundings. In many situations, people's moral intuitions are based on unconscious rules of thumb ... embedded in their social environments. Deliberate reasoning as a motivation for moral behavior occurs only in unusual contexts, such as in professional debates.

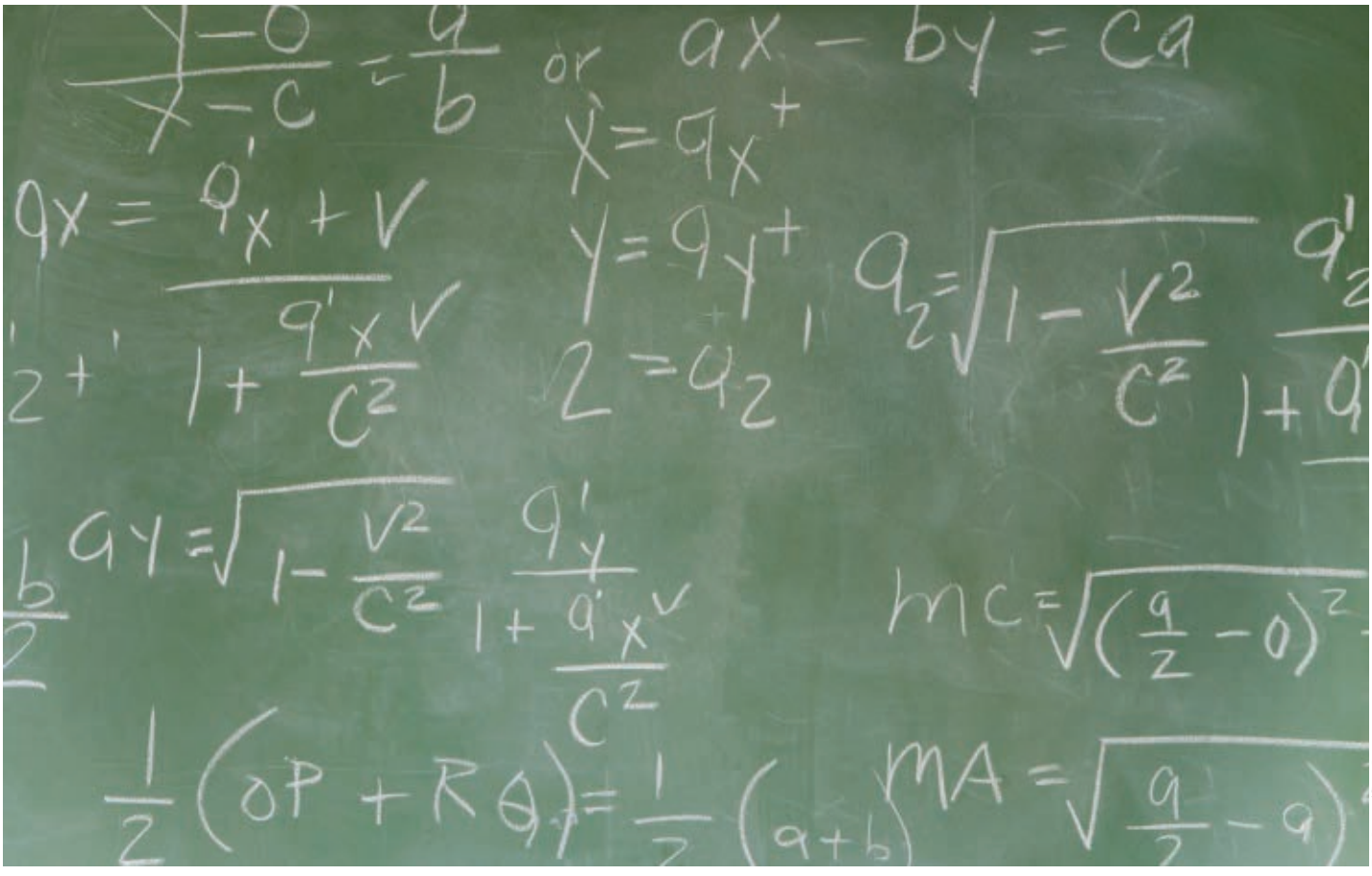
How does heuristics-based morality work in real life?

Take organ donation. Many people die waiting for suitable organs in the United States and Germany, where a minority of citizens sign donor cards. Yet France and Austria have no such problem because 99.9 percent of their citizens are eligible to be organ donors. A powerful heuristic must be at work here that is stronger than deliberate reasoning, national character or individual preferences.

The heuristic goes like this: If there is a legal default, do nothing about it. In countries such as the United States and Germany, the legal default is that nobody is a donor without registering to be one. You need to opt in. In countries such as France and Austria, everyone is a donor unless they opt out.

Collective decisions to follow these default rules have life or death consequences. Knowing the heuristics that guide people's moral actions can be of help in designing change for the better. ■

DIETMAR GUST



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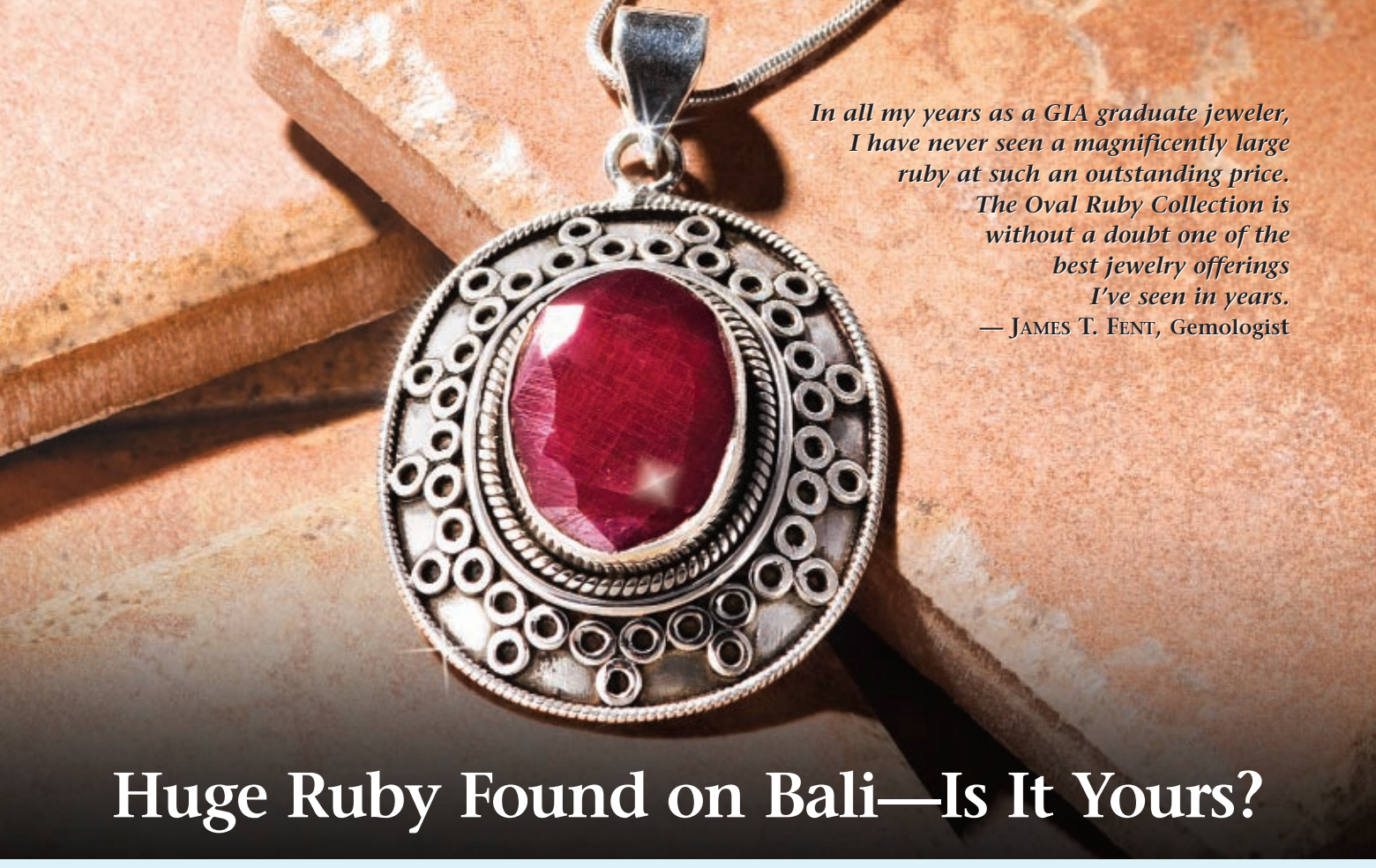

In all my years as a GIA graduate jeweler, I have never seen a magnificently large ruby at such an outstanding price. The Oval Ruby Collection is without a doubt one of the best jewelry offerings I've seen in years.
— James T. Fent, Gemologist

Huge Ruby Found on Bali—Is It Yours?

Paradise is reflected in this magnificent 22 1/2 carat ruby…but the price is the most heavenly.

On the tropical island of Bali, the air is filled with ancient mystery and perpetual festivity. Who would have thought that our deep sea diving trip to this romantic paradise would lead us to a treasure of giant deep red rubies. This beautiful isle is so vivid and untouched it has become the spiritual inspiration for many an artist. Bali has gardens tripping down hillsides like giant steps, volcanoes soaring up through the clouds, long white sandy beaches, and friendly artisans who have a long history of masterful jewelry designs.

We stumbled upon a cache of giant natural rubies at a local artisan's workshop. He brought these exotic Burmese Rubies to Bali and now we have brought them home to you. Our necklace showcases a genuine **22½ carat** facet cut ruby set in a frame of .925 sterling silver in the Balinese style. *That's right—22½ carats!*

The ruby, raised above the handcrafted Balinese silver detailing is surrounded by a bezel of sterling silver and then wrapped with a twisted rope. The Oval Ruby Pendant measures approximately 1¼" by 1½." This exotic pendant suspends from an 18" silver snake chain and secures with a spring ring clasp. Drape this pendant around your neck for a bold luxurious look. And, since rubies are rarer than diamonds, we hope your rings don't get jealous. Most likely, this will be the largest precious gemstone that you will ever own.

Compare the size of a 1 carat ruby to our 22½ carat Oval Ruby.

The real surprise is that you probably expect this stone to sell for 1,000.00s of dollars. But our Stauer adventurers will go to the ends of the earth to find smart luxuries for you at truly surprising prices. And of course, if you are not thrilled with this find, send it back for a full refund of the purchase price within 30 days. As you can understand, this is an extremely limited offer. With rare rubies of this outstanding size and shape, we only currently have less than 490 rubies and may not ever be able to replace them again.

JEWELRY SPECS:
- 22½ ctw oval facet cut ruby
- Pendant is 1 1/2" x 1 1/4" / weight is 1/2 oz.
- 18" sterling silver snake chain
- Stone color enhanced. Individual color may vary.

Sterling Silver Oval Ruby Collection
Pendant Necklace (22½ ctw) MSRP ~~$1,500~~
Your price **$125** +s&h
Bracelet (22 ctw) MSRP ~~$3,000~~
Your price **$295** +s&h
Earrings (11 ctw) MSRP ~~$2,000~~
Your price **$195** +s&h

Call now to take advantage of this limited offer.

1-800-386-5195

Promotional Code ORN253-02
Please mention this code when you call.

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