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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ NOVEMBER 6, 2010

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You don't have to pay through the nose to get Personal Sound Amplification Technology.

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

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

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Invention	Date	Easy to Use?	Invisible?	Affordable?
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Wearable Hearing Aid	1935	Weighed 2.5 pounds	No	No
Digital Hearing Aid	1984	No	No	Not for most people
Neutronic Ear	2010	Yes	Yes	Yes

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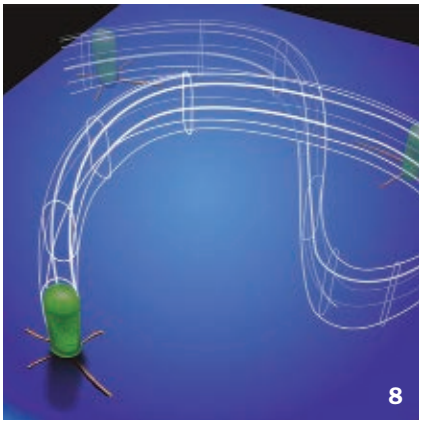

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ScienceNews

In The News

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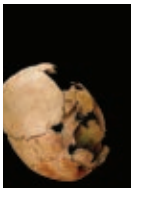

COVER Smashed skulls (one shown) and other broken bones are helping scientists reconstruct an episode of ancient violence in Colorado. *Courtesy of SWCA Environmental Consultants*

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Texterity Digital edition provided by Texterity, www.texterity.com
Science News (ISSN 0036-8423) is published biweekly, for $54.50 for 1 year or $98 for 2 years (international rate $80.50 for 1 year or $161 for 2 years) by Society for Science & the Public, 1719 N Street NW Washington, D.C. 20036. Preferred periodicals postage paid at Washington, D.C., and an additional mailing office.
Subscription Department: PO Box 1205, Williamsport, PA 17703-1205. For new subscriptions and customer service, call 1-800-552-4412.
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FROM THE EDITOR

You can't hold the presses as science sorts itself out

"Journalism is the first draft of history," said the *Washington Post*'s Philip Graham. "Journalism is literature in a hurry," wrote the poet Matthew Arnold. *Science News*, then, must be the first draft of science history, in a hurry.

That "hurry" part is one of the things that makes science journalism different from science. Science does not share journalism's emphasis on speed. It is more like wine, slowly maturing over time as evidence is collected, analyzed, debated and modified by even more evidence that often instigates even more arguments. As the history of science illustrates, it often takes years or decades for new science to establish itself.

Consequently *Science News* should be read as something like a rough draft of the history of science, subject to revision. No single issue delivers the final word on anything. In the October 23 issue, for example, we reported on the discovery of a planet orbiting within the habitable zone around the red dwarf star Gliese 581. Temperatures on that planet would permit water to exist in liquid form. Scientists therefore quickly began debating the likelihood that the planet, Gliese 581g, might harbor living organisms.

Soon thereafter, scientists also began debating whether the planet itself is even there in the first place. After the October 23 issue went to press, another team of planet hunters reported an analysis of the Gliese 581 system that found no sign of the supposedly habitable planet. And researchers have questioned some of the assumptions included in the original team's analysis, as Ron Cowen reports in this issue (Page 14).

This confusion does not necessarily invalidate the first report of a habitable extrasolar planet. Maybe it's more like the premature exaggeration of Mark Twain's death (he did die eventually, after all). Whatever the ultimate outcome, it's all just an illustration of how science works. Planet hunting is hard. Verifying an extrasolar planet's existence from across 20 light-years of space requires lengthy observations and sophisticated mathematical manipulation of the data. Some apparent discoveries inevitably will turn out to be illusions; others eventually will be confirmed beyond doubt.

As science journalists, we cannot, of course, wait to report the apparent discoveries until no doubts remain. In that case we'd have to change our name to *Science History*.

—Tom Siegfried, Editor in Chief

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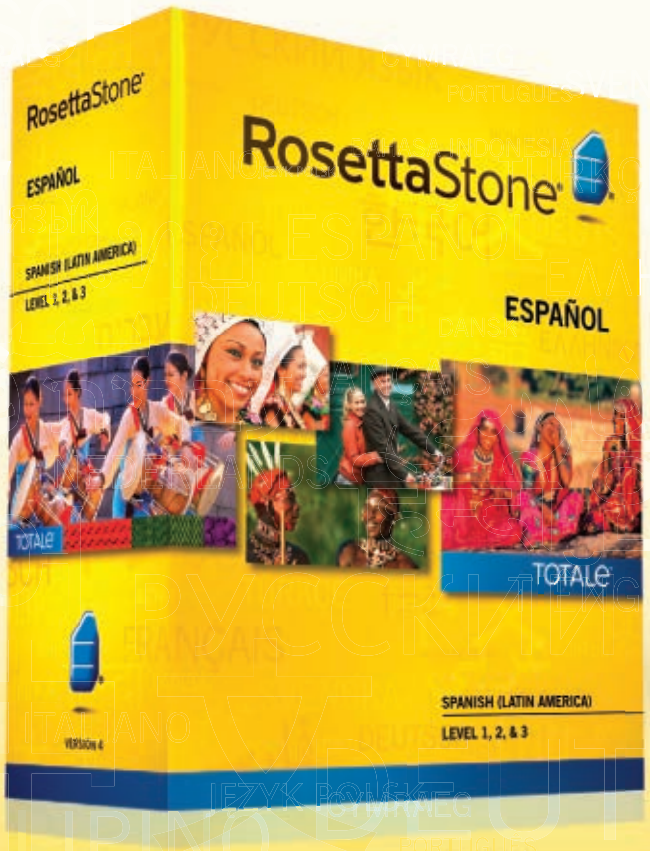

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Scientific Observations

"Even lowly worms do calculus.... [Roundworms] take a derivative to figure out how much a given quantity [such as saltiness, as detected by taste] is changing at a certain point in space and time, and adjust their behavior accordingly. If worms can do calculus, human beings simply have no excuse for avoiding it. I think scientists have a valid point when they bemoan the fact that it's socially acceptable in our culture to be utterly ignorant of math, whereas it is a shameful thing to be illiterate. We could all be just a little bit mathier.... We ought to have some basic understanding of how math in general, and calculus in particular, fits into our cultural framework, and be able to look at a rudimentary equation without breaking into a cold sweat. It is an integral part of our history, after all." —**SCIENCE WRITER JENNIFER OUELLETTE, IN HER 2010 BOOK *THE CALCULUS DIARIES* (PENGUIN BOOKS)**

Science Past | FROM THE ISSUE OF NOVEMBER 5, 1960

"BUMPERS" FOR SPACE SHIPS — Sound-proofed "meteor bumpers" for space ships are needed to provide important psychological and physical protection for astronauts traveling through fast moving concentrations of space dust as they leave the earth, Dr. Fred L. Whipple, director, Smithsonian Astrophysical Observatory and a professor of astronomy at Harvard University, reported. The sound of the tiny "cosmic puff balls" as they hit the space vehicles may give the occupying astronaut "the sense of being under military siege," he warned scientists attending the symposium.... The concentration of space dust close to the earth is 100 to 10,000 times as high as that encountered some 80,000 miles in space.

Science Future

November 6
Tweens can explore science and magic at the Moore Public Library in Tacoma, Wash. Go to www.tacomapubliclibrary.org

November 6
The Orlando Science Center in Florida hosts a "Neanderthal Ball." Cocktail dress with caveman couture. See www.osc.org

November 17
Entry deadline for teen whiz kid competition, the 2010 Intel Science Talent Search. Go to www.societyforscience.org/sts

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ON THE SCENE BLOG
Tornado-chasers detail a funnel's birth and death. Read "Guts of a twister."

LIFE
Scientists find the first new carnivore species in more than 20 years. See "New species a little nipper."

Global warming may bump up cold-blooded creatures' metabolisms. Read "A little climate change goes a long way in the tropics."

ATOM & COSMOS
Two new models compete to explain why the Red Planet is puny. See "Why Mars is a lightweight."

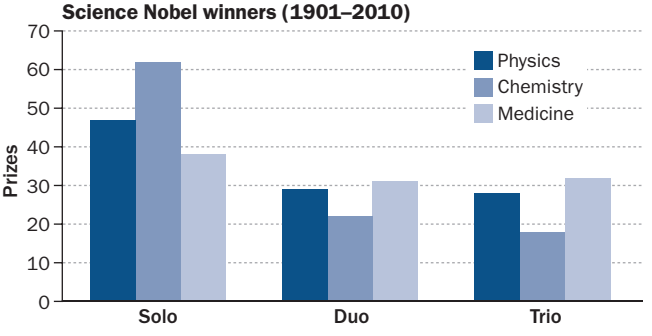
BODY & BRAIN
Researchers pinpoint cells monitoring the brain's door. Read "Guards of the blood-brain barrier identified."

For Daily Use

Breast-feeding may lower women's risk of type 2 diabetes. A study of more than 2,200 women found that mothers who breast-fed their babies for at least one month had noticeably lower rates of type 2 diabetes later in life than mothers who never breast-fed. In the September *American Journal of Medicine*, the researchers reported that 18 percent of moms who breast-fed developed type 2 diabetes, on par with women who had never given birth (17.5 percent). On the other hand, nearly 27 percent of mothers who never breast-fed developed the disease. The difference may arise, the authors suggest, because lactation improves sugar and fat metabolism and helps remove pregnancy-related fat deposits that can lead to a higher risk of diabetes.

Science Stats | NOBEL-ITY

While many Nobels have recognized solo efforts, more than half of science prizes have split the credit, honoring multiple scientists.



SOURCE: NOBELPRIZE.ORG

CLOCKWISE FROM TOP LEFT: KEN WEINGART; TIM VICKERS/WIKIMEDIA COMMONS; T. DUBÉ

“ [Scotch] tape is an even better ... X-ray source than we thought. ” —SETH PUTTERMAN, PAGE 13

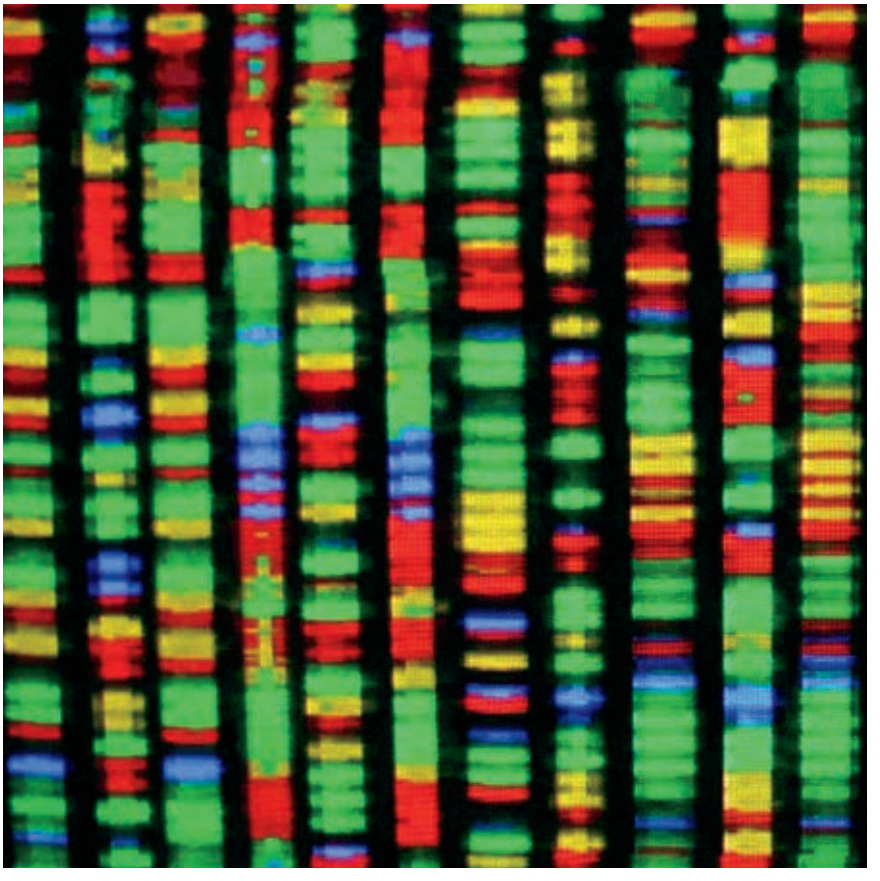
In the News

STORY ONE

Scientists still making entries in human genetic encyclopedia

A precise tally of human genes eludes researchers

By Tina Hesman Saey



Picking out and counting the genes among the billions of DNA letters (shown here as four different colors) that make up the human genome has proved daunting.

M. TAMA/GETTY IMAGES

BOSTON — No one really knows all the genetic parts needed to make a human being.

Exactly how many genes make up the human genome remains a mystery, even though scientists announced the completion of the Human Genome Project a decade ago. That effort was supposed to reveal all of the protein-producing genes needed to build a human body.

“Not only do we not know what all the genes are, we don’t even know how many there are,” Steven Salzberg of the University of Maryland in College Park said October 11 at the Beyond the Genome conference. Most estimates place the number of protein-producing genes in the neighborhood of 22,000. There are also some genes that don’t make proteins, but for the purposes of counting researchers generally concentrate on the ones that do.

Grape plants have 30,434 genes that make proteins, by the latest count. Chickens have 16,736, a number Salzberg said will probably grow as scientists put the finishing touches on the chicken genome. As in the human genome, the gene totals for each species are not as precise as they seem and are subject to revision.

The most accurate estimate of the human gene count is the RefSeq database maintained by the U.S. National Institutes of Health, Salzberg said. He laid out arguments for favoring this estimate, such as its inclusion of all confirmed genes to date, in a paper published in May in *Genome Biology*. By the RefSeq count, humans have 22,333 genes that encode proteins. A different project called Gencode currently recognizes 21,671.

The disparity stems from the fact that genes comprise only about 1 percent of the 3 billion A’s, T’s, G’s and C’s that make up the human genetic instruction book. And the genes aren’t conveniently laid out in single, continuous stretches of genetic code. Instead, genes that make proteins are found in pieces called exons, interspersed with stretches of DNA that don’t code for protein.

To make matters worse, each exon codes for only a portion of a protein. Cells can mix and match different combinations

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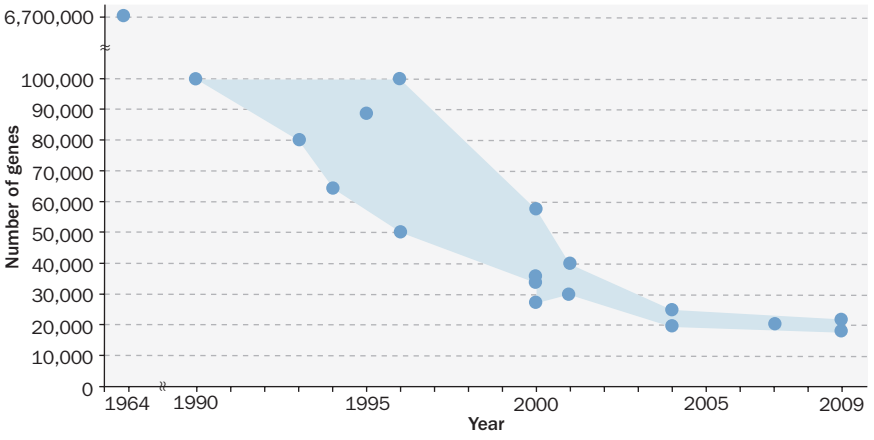
Human gene number estimates over time



Estimates of the number of human genes have fallen and narrowed in range over the years as research has shed more light on how genes are arrayed along DNA.

of exons when they make RNA, the intermediary between genes and proteins.

Worse still, new research suggests that the number of genes differs from person to person. Huge chunks of DNA can be missing from or added to a person's genome, sometimes with no apparent ill effects (*SN: 4/25/09, p. 16*). Even single-letter changes in the DNA sequence may revise the number of working genes in a person, Suganthi Balasubramanian of Yale said at the conference. These one-letter changes, known as SNPs, can cause a gene to produce a severely shortened and often nonfunctional version of a protein. Or the variations can disrupt the ability of the cell to cut away introns and splice exons together. Such a failure can also lead to nonfunctional genes.

Balasubramanian compared the reference sequence for the human genome — a composite of DNA from several different people — with sequences from individual people. She found several genes in which the reference sequence contains shortened or nonfunctional genes or where the reference genome lists a gene that is disabled in some people.

Balasubramanian's research suggests that scientists may never really be able to count the genes needed to make a human, simply because there is no one number.

It's enough to exasperate the most intrepid gene counter. Nevertheless, the Gencode project aims to find all the protein-coding genes and the many permutations of those genes that can produce a dizzying number of proteins. Clues about where genes are located come from computer analyses, studies of RNA produced by genes and comparisons of human DNA with the genomes of other animals. Synthesizing that information allows Gencode to find and mark the locations of genes, a process called annotation.

Gencode's current count of 21,671 genes is bound to rise as the project finds new ways to combine exons, said Gencode researcher Clara Amid of the Wellcome Trust Sanger Institute in Hinxton, England. Already the team has located several new genes on chromosome 4 using RNA data.

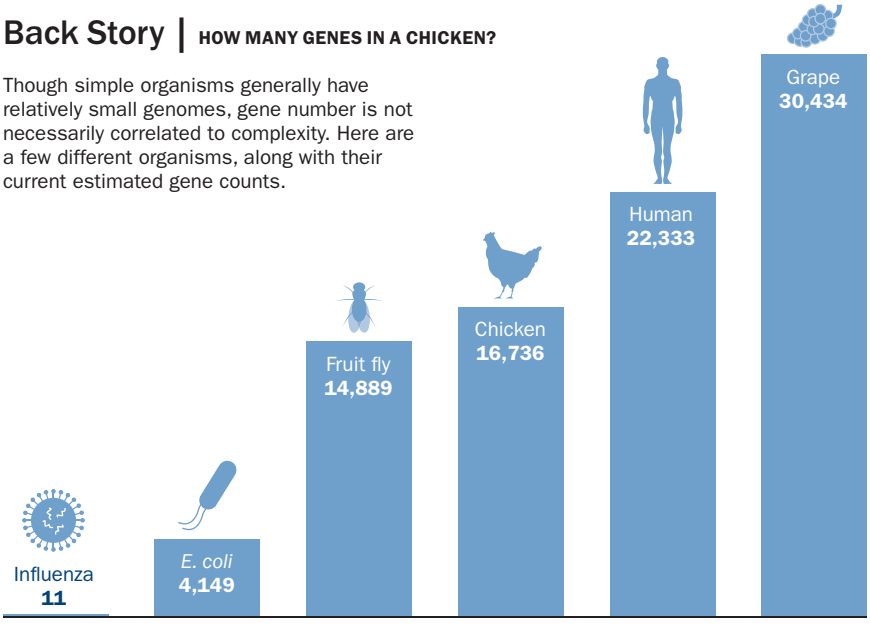
Exactly how many new genes might be found by looking at RNA instead of DNA is anyone's guess. Scientists who searched RNA from fruit flies turned up 1,938 new genes, Brenton Graveley of the University of Connecticut Health Center in Farmington said at the conference.

The Mammalian Gene Collection, one effort to catalog all of the full-length RNA versions of genes, lists 18,877 human genes.

So if new RNA methods detect the same proportion of new genes in people as were found in fruit flies, the human genome could gain about 3,000 more genes in addition to those already confirmed by RefSeq. "That would be an exciting result," Salzberg said. "I'd be surprised, but we like surprises in science."

Back Story | HOW MANY GENES IN A CHICKEN?

Though simple organisms generally have relatively small genomes, gene number is not necessarily correlated to complexity. Here are a few different organisms, along with their current estimated gene counts.



SOURCE: M. PERTEA AND S. SALZBERG/*GENOME BIOLOGY* 2010

TOP: M. PERTEA AND S. SALZBERG/*GENOME BIOLOGY* 2010, ADAPTED BY E. FELICIANO; BACK STORY: T. DUBÉ, CHICKEN ICON: PINARE/SHUTTERSTOCK HUMAN ICON: MYSONTUNA/SHUTTERSTOCK

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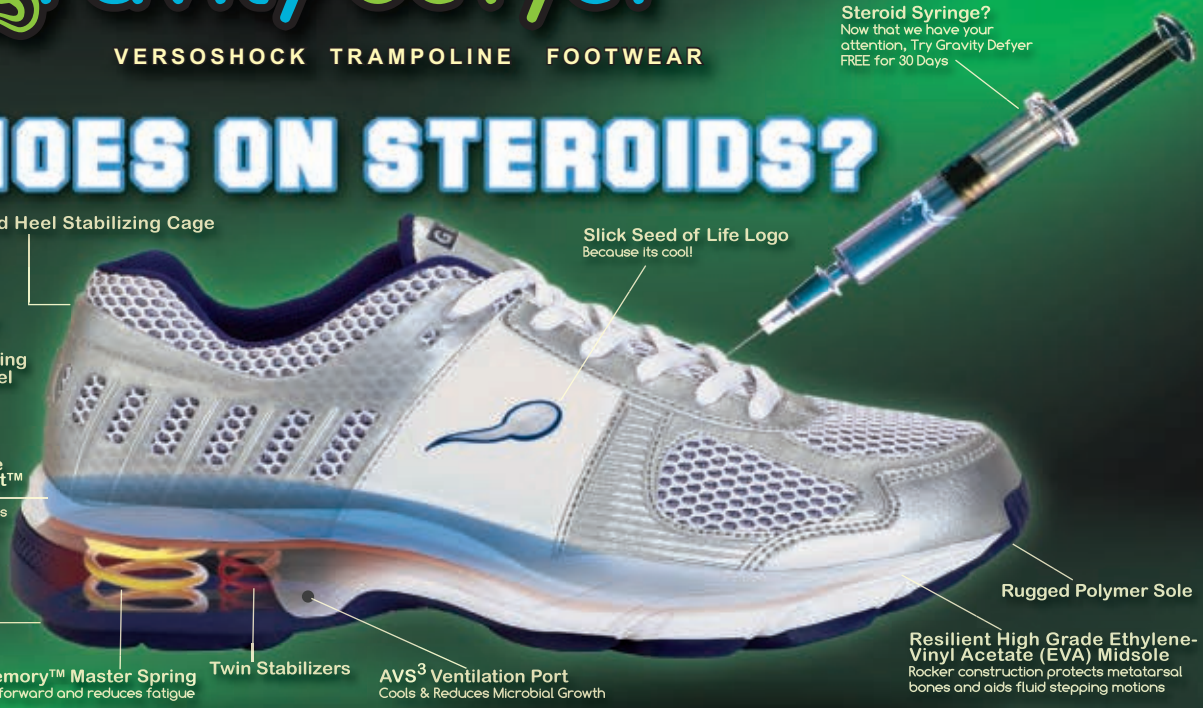

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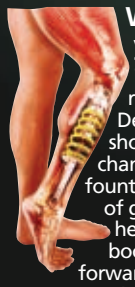
I used to be more active. I used to run, play basketball, tennis, football… I was more than a weekend warrior. I woke up every day filled with life! But now, in my late 30's, I spend most of my day in the office or sacked out in front of the TV. I rarely get to the gym –not that I don't like working out, it's the nagging pain in my knees and ankles. Low energy and laziness has got me down. My energy has fizzled and I'm embarrassed to admit that I've grown a spare tire (I'm sure its hurting my love life). Nowadays I rarely walk. For some reason it's just harder now. Gravity has done a job on me.



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Life

"Sometimes they just pop wheelies and stand up." —GERARD WONG

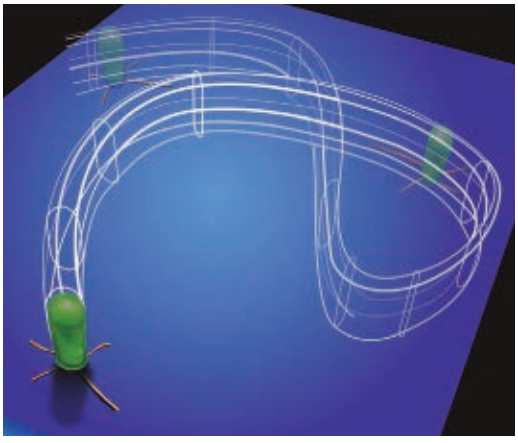
Sure, but can they chew gum too?

Videos catch microbes walking around on tiny hairlike 'legs'

By Tina Hesman Saey

Jokes that open with a bacterium walking into a bar just got a little less farfetched.

Some bacteria can stand up and toddle away on tiny legs, a new study shows. The finding, reported in the Oct. 8 *Science*, could help scientists better understand how some bacteria form dense antibiotic-resistant communities called biofilms and may lead to better ways to combat such microbes.



Some bacteria can stand on end and use thin appendages called pili to stroll across a surface.

Researchers had already documented bacteria swimming through liquids or crawling on their bellies, but no one had ever seen bacteria get up and walk until a group of undergraduate students at the University of Illinois at Urbana-Champaign made videos of *Pseudomonas aeruginosa* bacteria on a microscope slide. Working under the supervision of Gerard Wong, a biophysicist now at UCLA, the students adapted a technique used by physicists to track microscopic particles. Computer programs allowed the researchers to quickly sort through footage of teeming bacteria.

"My students started seeing all this neat stuff," Wong says. "They'd tell me, 'Yeah, sometimes they just pop wheelies and stand up.'"

The bacteria's unsteady walks require the use of hairlike appendages called Type IV pili, the team found. These stringy "legs" were already known to be used for twitching motility, a type of locomotion in which pili at one end of a bacterium pull the cell across a surface. "It's almost like front wheel drive," Wong says. These crawling bacteria move in relatively straight lines over fairly long distances — an average of six micrometers — possibly enabling the microbes to move toward chemical attractants.

In walking mode, a bacterium first stands on splayed pili. Tugging on one of the pili sends the cell lurching in that direction. Bacteria covered more ground and moved faster walking than crawling, the team found, which may help them explore an area more quickly.

When forming biofilms, bacteria need to attach to a surface and then release if conditions are unfavorable. Blocking the ability to stand up may prevent biofilms from forming on medical implants and other surfaces, says microbiologist George O'Toole of Dartmouth Medical School.

Walking is not an uncommon activity for bacteria, the researchers found. After a cell divided in two, about 67 percent of the time one of the newborn cells would move away from its sibling, often by walking.

The bacteria even moved in three dimensions, standing and launching from the surface, says John Kirby of the University of Iowa in Iowa City. "It's like the Earth was flat, but now it's not flat anymore."

Microbes do the electric boogaloo

Bacteria conduct electricity through a network of fibers

By Marissa Cevallos

Just as a household wire carries electrons from wall socket to appliance, bacteria can conduct electricity along tiny wirelike appendages, researchers report online October 11 in the *Proceedings of the National Academy of Sciences*.

A community of bacteria connected by gangly nanowires could act as a slimy fuel cell, digesting organic matter and churning out electricity.

Researchers noticed that deep-sea bacteria grew the curious wires when placed in environments with little oxygen. Rather than suffocate, the microbes grew protein nanowires to hunt for pockets of oxygen or other elements, says microbiologist Yuri Gorby of the J. Craig Venter Institute in San Diego. Then the bacteria appeared to share electrons — their way of breathing — by connecting their wires.

"We've only known about electricity for 200 years, but we're hypothesizing they've been doing it for billions of years," Gorby says. The scientists had suspected that bacterial nanowires carry electrons, but struggled to create instruments that could measure the current without destroying the fragile conduits. Using nanotech tools, researchers led by Mohamed El-Naggar of the University of Southern California in Los Angeles found that wired-up communities of *Shewanella* bacteria can act like circuits.

To capture the electricity for use, an electrode surface would be needed. With the right methods, bacteria in sewage could one day help power treatment facilities, says engineer Bruce Logan of Pennsylvania State University in University Park. "It may not solve all of our energy problems," he says, but waste treatment consumes 5 percent of U.S. electricity.

G. WONG/CNSI/UCLA

11,680 kilometers | Longest recorded nonstop flight by a bird

3.5 meters | Top wingspan of great albatross

10 meters | Estimated wingspan of *Q. northropi*

Snails shed shells in one fell swoop

Common evolutionary step among mollusks likely a leap

By Rachel Ehrenberg

Evolution doesn't have to operate at a snail's pace, even for snails. In recent experiments designed to simulate the evolutionary transition that produced slugs, researchers exposed baby snails to the metal platinum, causing the animals to develop without external shells.

The simple experiments illustrate how a big leap in the history of animal body plans might have occurred. The research also reopens a can of worms concerning the development and evolution of an entire class of shelled creatures.

Scientists reared common aquarium snails in petri dishes containing varying concentrations of platinum. At certain exposures, all of the roughly 80 percent of snails that survived were shell-less, Heinz Köhler of the University of Tübingen in Germany and his colleagues report in the September-October *Evolution & Development*. The researchers posit that the platinum is causing effects similar to the genetic mutation that turned off shell production in some ancient snails, paving the way for their slug descendants.

"This shows that you can get really dramatic changes that could be similar to the genetic mutations that drive evolution, without worrying about doing everything in small incremental steps," says Roger Croll of Dalhousie University in Halifax, Nova Scotia.

Evidence suggests that transitions from having a concrete outer shell to a greatly reduced internal one have happened numerous times in evolution. Such losses or gains occurred repeatedly within the Mollusca, an enormous group that includes clams, oysters, squid, octopuses and of course the gastropods — snails and slugs. The internal bonelike structure in cuttlefish and squid, for example, is thought to be a pared-down version of an ancestral outer molluscan shell.

Though the new study shows that shell loss in gastropods can happen in one fell swoop, it also suggests that another evolutionary transition might have required several steps to complete. Torsion is an anatomical hallmark of the gastropods that makes them look like their bottom halves were rotated 180 degrees relative to their top halves, putting their anuses over their heads. The term torsion also refers to the hypothetical evolutionary process that purportedly led to this awkward anatomy, says evolutionary biologist Louise Page of the University of Victoria in British Columbia, Canada.

The new research suggests that torsion might not have occurred in one grand swivel. In many gastropods the anus, gills and mantle cavity are rotated 180 degrees. But in some there is partial rotation. And in the snails that Köhler's team exposed to platinum there was partial rotation as well: The anus swiveled but the gills and mantle were left in their original positions. This suggests that the gastropod body plan could have arisen through physiological means other than the torsion process, such as asymmetrical growth, where one half of the body atrophies and the other blossoms.

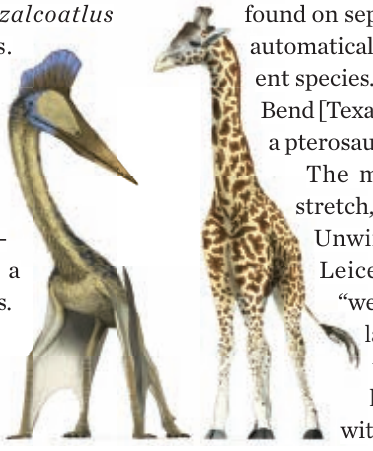
Wide-bodies flew Cretaceous air

Study suggests pterosaurs could soar halfway around globe

By Susan Milius

PITTSBURGH — Predating jet travel by at least 65 million years didn't stop the biggest pterosaurs from racking up miles. These prehistoric creatures may have been able to fly 10,000 miles or more nonstop, according to research presented October 10 at the annual meeting of the Society of Vertebrate Paleontology.

The original elite fliers included four species of what biomechanist Michael Habib of Chatham University in Pittsburgh calls supergiant pterosaurs: flying reptiles such as *Quetzalcoatlus northropi* from Texas. Appearing in the fossil record about 70 million years ago, they stood about as tall as a modern giraffe and soared through the air by spreading membrane wings to a span of roughly 10 meters.



Giraffe-sized pterosaurs could have flown New York to Sydney nonstop.

MARK WITTON

These supergiants "are big by pterosaur standards," Habib said. "They are truly gruesomely huge by bird and bat standards."

If current estimates for pterosaur body masses and wing dimensions are realistic, and if the pterosaurs could catch thermals and glide the way a bird can, "it would make them the longest single-trip–distance fliers in the Earth's history," Habib said. Birds such as Arctic terns can migrate pole to pole, but not nonstop.

Habib's calculations raise the possibility that supergiant pterosaur fossils found on separate continents can't automatically be considered different species. "A pterosaur from Big Bend [Texas] could be mating with a pterosaur from Transylvania."

The mating idea may be a stretch, said researcher David Unwin of the University of Leicester in England, but "we didn't fall on the floor laughing" at the notion that pterosaurs could have flown 10,000 miles without stopping.

Body & Brain

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Mice deprived of darkness get fat

Eating at the wrong time can increase impact of calories

By Janet Raloff

When it comes to weight management, the timing of dining is pivotal, a new study indicates. At least in rodents, food proved especially fattening when consumed at the wrong time of day.

As nocturnal animals, mice normally play and forage at night, often in complete darkness. With even dim illumination of their nighttime environment, however, the animals' hormonal dinner bells ring at the wrong time, researchers report online October 11 in the *Proceedings of the National Academy of Sciences*. Though the animals didn't eat more or exercise less, experiments that shifted when mice ate caused them to fatten up and develop diminished blood sugar control.

"I suspect that what we're doing is demonstrating that a calorie is not always just a calorie," concludes neuroscientist and study coauthor Randy Nelson of Ohio State University in Columbus.

Mice in the new study received 16 hours of bright light each day. But at night, mice were exposed to either darkness or dim light for eight hours. The 5 lux of illumination in the dim-lit night group "is like having a small portable TV in the corner of a 20-by-20-foot room," Nelson says.

Ordinarily, mice eat about two-thirds of their food at night. But those whose nights remained dimly lit consumed more than half of their food during the day. Those animals gained roughly 12 grams during the trial compared with just eight grams in mice getting fully dark nights.

The dim light shouldn't affect wakefulness, Nelson says, since mice usually sleep in bright light. Yet an absence of darkness does seem to subtly reset the rodents' biological clocks — and dinner bells.

Chronically dining at times other than when a species evolved to eat — daytime for humans — may amplify artificial light's disruption of the biological clock, says Gloria Hoffman, a neuroscientist at Morgan State University in Baltimore.

The new study is consistent with others showing that nighttime eating can foster weight gain and prediabetic changes in people, says Satchidananda Panda of the Salk Institute for Biological Sciences in La Jolla, Calif. "Unfortunately there is not even a single study in humans looking at temporal spreading of caloric intake." But, he says, if people respond the way mice do, "the overall take-home message is that when you eat is as important as what you eat."

How deafness can enhance sight

Hearing-specialized brain regions adaptable to visual input

By Laura Sanders

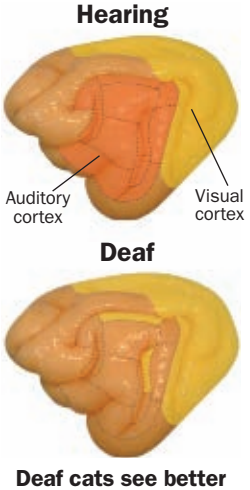
Some deaf people have extraordinarily keen vision, and a new study of cats may explain why. The results, published online October 10 in *Nature Neuroscience*, show how, when one sense is lost, parts of the brain normally dedicated to that sense can pitch in to augment another type of sensory input.

In deaf cats, brain regions typically used for hearing get co-opted to enhance vision, the study finds. Since cat brains are organized much like human brains, the results may mirror what happens in the brain of a deaf person.

Deaf cats don't have better overall vision than their hearing counterparts. Rather, like deaf humans, the cats are better at two particular visual tasks — seeing objects in the far periphery and detecting very slow motion.

After showing that these two visual abilities were enhanced in a group of congenitally deaf cats, Stephen Lomber of the University of Western Ontario in London, Canada, and his team tested whether hearing-related brain areas were responsible for the boost. With the help of a 3-millimeter-wide cooling coil, the researchers inactivated particular regions of the cats' auditory cortices. The coil sits on the outside of the brain and induces a precisely localized hypothermia, causing the region beneath to effectively shut down until the device is turned off.

Deaf cats with chilled hearing-related brain regions lost their visual edge in very specific ways. "What we found was, much to our surprise, that these functions were not distributed randomly over the auditory cortex, but they were specifically localized in particular places," Lomber says. For instance, when a brain region that is normally important for localizing sound signals was shut off, deaf cats lost their superior ability to spot a light that flashed in the far periphery of their visual fields.



Deaf cats see better by tapping brain areas built for hearing.

AMEE J. MCMILLAN

More studies are needed to determine whether this type of sensory mingling applies to other systems in the brain, says neuroscientist Brigitte Röder of the University of Hamburg. "We need to see whether this is a general effect," she says. Specific visual system regions might be lending a hand to boost hearing performance in blind people, for instance.

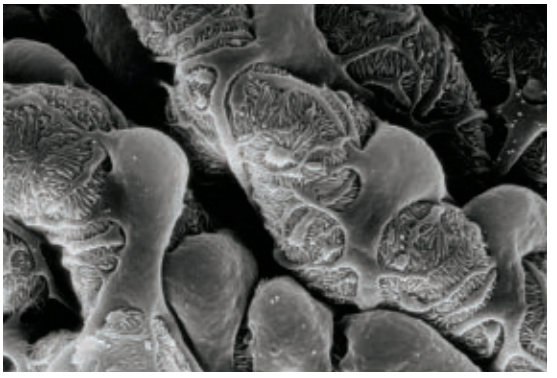
"I suspect that what we're doing is demonstrating that a calorie is not always just a calorie." —RANDY NELSON

Lack of insulin damages kidneys

High blood sugar is not only cause for concern in diabetics

By Nathan Seppa

Diabetic kidney disease may result as much from a failure of certain renal cells to access insulin as it does from runaway blood sugar, a new study shows. The finding suggests that targeting the condition known as insulin resistance might protect the kidneys of people with diabetes, researchers report in the October *Cell Metabolism*.



Kidney cells called podocytes may incur damage due to insulin resistance in diabetics, a new study shows.

Half of all kidney disease that leads to dialysis or a transplant occurs in diabetics, most often people with the type 2 form that typically shows up in adulthood. Type 2 diabetes has clear links to obesity, lack of exercise and insulin resistance, in which cells fail to capture glucose efficiently from the bloodstream after digestion of food. While the precise cause of insulin resistance remains unclear, there's no question it starves cells, forces the pancreas to work overtime making more insulin and leaves a person with high blood sugar.

In the new study, researchers examined cells called podocytes that form part of the blood-cleansing apparatus of the kidneys. The researchers suspected that insulin resistance might damage these filtration cells and therefore underlie the kidney damage common to people with diabetes.

To test that hypothesis, the team genetically engineered mice with podocytes that lacked insulin-receptor proteins. In these mice, podocytes were largely unable to bind to the insulin needed to orchestrate the use of glucose in the cells. Within several weeks the animals showed podocyte damage, allowing leakage of crucial blood proteins called albumins into the urine. Such albumin loss is a telltale sign of kidney problems, says team member Richard Coward of the University of Bristol in England.

This damage showed up, he says, even though the mice didn't have high blood sugar, suggesting that insulin resistance plays a role in kidney disease brought on by diabetes, called diabetic nephropathy.

"This paper turns some of the thinking about diabetic nephropathy on its head," says Sian Griffin, a nephrologist at the University Hospital of Wales in Cardiff. "Previous treatment has focused on optimizing glycemic control, but these experiments suggest a potential novel therapeutic paradigm — that diabetic nephropathy might be prevented or even reversed by targeting the podocyte insulin-signaling pathway in itself."

Implants helpful in quitting heroin

Slow-release drug embedded under skin eases withdrawal

By Nathan Seppa

People addicted to heroin or prescription opiates might have a hands-free device for getting through the rigors of drug withdrawal. The medication buprenorphine implanted under the skin and released over months can ease drug cravings and helps some patients stay clean, researchers report in the Oct. 13 *Journal of the American Medical Association*.

Buprenorphine is a semisynthetic opioid compound used for pain relief and addiction withdrawal. In tablet form, patients sometimes abuse the drug by crushing the pills, liquefying them and injecting them for a stronger effect.

To get around such abuse and ensure that a person is getting a standardized dose of the drug, researchers devised the implants — polymer compounds composed of ethylene vinyl acetate and buprenorphine — that slowly release the drug into the body over 24 weeks. The researchers recruited 163 adults with opioid dependence and randomly assigned 108 to get the implants and 55 to receive placebo implants.

People in either group who felt their treatment was insufficient could request extra doses of buprenorphine as under-the-tongue tablets to control cravings. Nearly 60 percent of those assigned to buprenorphine requested extra tablets during the first 16 weeks, as did more than 90 percent of those who had placebo implants. Even so, 37 percent of urine samples from people with buprenorphine implants tested clean for illicit opioids during the trial, compared with only 22 percent of samples from those with placebo implants.

About two-thirds of people with a buprenorphine implant completed the study, compared with less than one-third of those who had a placebo implant.

"In the addiction field, there's a pretty close relationship between sticking around in treatment — what we call retention — and how well you are doing," says study coauthor Walter Ling, a psychiatrist at the UCLA School of Medicine.

MATTHIAS KRETZLER

Earth

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Seals with tags map the seafloor

Oceanographers with flippers probe depths near Antarctica

By Alexandra Witze

Seals diving for their dinner near Antarctica have surfaced with an extra morsel: data about the shape of the seafloor.

The work has found previously unknown undersea channels through which warm water might flow toward fragile ice shelves. Seals do the job for a fraction of the cost of seafloor mapping from ships.

"It gives you a much denser picture of what the water depth is than anything you can conceivably do with ship tracks," says oceanographer Laurence Padman of Earth & Space Research in Corvallis, Ore., a coauthor of a paper on the technique to appear in *Geophysical Research Letters*.

Seals, walrus, whales and other large marine creatures have moonlighted as oceanographers before. Scientists typically glue sensors to the animals' fur to measure factors like temperature and salinity. The new work is the first to extract bathymetry — information on the seafloor's shape — from the sensors, which also measure pressure and hence depth.

With electronic tags on their heads, seals can help map the seafloor.

"You can actually map the ocean floor," says team member Daniel Costa of the University of California, Santa Cruz.

The data came from 57 elephant seals, tagged at the U.S. Antarctic Marine Living Resources camp in the South Shetland Islands. The tags, which do not harm the seals, record information every few seconds and relay it to scientists via satellite. About 30 percent of the time seals dive all the way to the bottom; with enough dives researchers can deduce where the seafloor lies.

"It's a novel and useful technique for gathering bathymetry data," says Paul Holland, an ocean modeler with the British Antarctic Survey in Cambridge, England.

Ancient mountains entombed in ice

Glaciers may have protected Antarctic range from erosion

By Alexandra Witze

Buried deep beneath East Antarctica's ice sheet, the Gamburtsev Mountains are the world's most invisible range. New research suggests that ice like that hiding them from view today could have preserved their rugged topography for the past 250 million years.

The work bolsters the counterintuitive notion that glaciers, rather than just carving down young peaks into eroded hills like a buzz saw, could sometimes protect high jagged terrain.

"It's feasible for topography to be preserved," says Stephen Cox of Caltech, a coauthor of a paper scheduled to appear in *Geophysical Research Letters*. A supercold cap of ice could have allowed the ancient Gamburtsevs to look like the Alps instead of the highly eroded Appalachians.

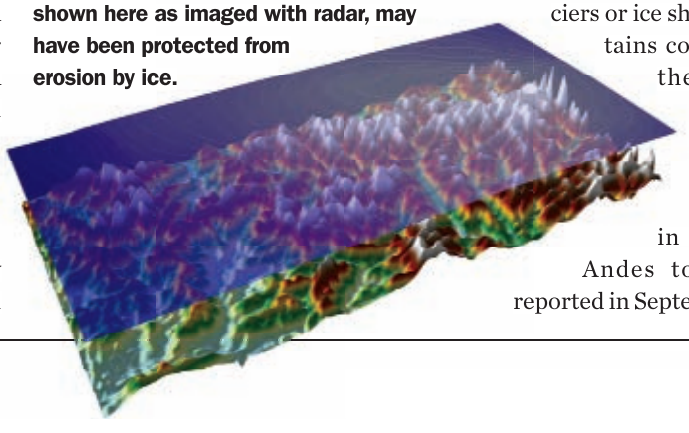
Russian scientists first identified the Gamburtsevs in 1958 as part of a survey during the International Geophysical Year, and geologists have been puzzled ever since about how the range came to be. The mountains are in a stable part of the continent that hasn't seen much tectonic activity — usually the way mountains are born — in more than 500 million years. "The Gamburtsevs are either really old, or some big part of the tectonic puzzle is missing," Cox says.

Because the range is buried, researchers have to study it indirectly — in this case, by probing mineral grains at the bottom of Prydz Bay in East Antarctica, where pieces of rock washing off the Gamburtsevs ended up.

Grains of the mineral apatite preserve a record, known as a cooling age, of how fast the mountains were eroded. Cox's team analyzed the apatite in two ways — the amounts of uranium, thorium and helium it contained, and the number of "fission tracks" left by decaying uranium.

The team concluded that over the past 250 million years, mountains inland of Prydz Bay eroded just 2.5 to five kilometers — an order of magnitude slower than modern erosion in places like the Alps. Earlier studies had suggested slow Antarctic erosion over the past 118 million years, but the new study takes it farther back in time and supports the idea that the Gamburtsevs really are ancient. Cold glaciers or ice sheets atop the mountains could have protected them from wearing down, Cox suggests. Glaciers could similarly be preserving topography in the southernmost Andes today, researchers reported in September in *Nature*.

Antarctica's Gamburtsev Mountains, shown here as imaged with radar, may have been protected from erosion by ice.



FROM TOP: D. COSTA; MICHAEL STUDINGER/LAMONT DOHERTY EARTH OBSERVATORY

Matter & Energy

1930 Year that clear Scotch tape was first marketed

Electrons tell a tale of the tape

Adhesive produces X-rays by mimicking particle accelerator

By Marissa Cevallos

Forget fancy particle accelerators — a cheaper tool for emitting X-rays is right there in the supply cabinet. Peeling back clear sticky tape emits X-rays, the same high-energy light emanating from airport scanners or galaxy clusters, and scientists now have a better understanding why.

Physicists were dumbfounded two years ago when UCLA researchers produced quick flashes of X-rays by pulling back Scotch tape in a vacuum (*SN Online: 10/22/08*). The X-rays pulse at the rate of a billion times a second, radiating from a region only about 100 micrometers wide, says UCLA physicist Seth Putterman. Spotting the X-rays was perplexing because they are 100,000 times more energetic than the chemical bonds holding tape's sticky side down.

Now, two teams of scientists have an explanation: Peeling tape separates positive and negative charges, creating an electric field. The field jump-starts free electrons in the neighborhood, accelerating them enough to emit X-ray photons known as bremsstrahlung radiation. It's just like radiation created in accelerators as they whip charged particles around.

No need to worry about radiation exposure at the office, though. At atmospheric pressure, the electrons run into other particles before having a chance to accelerate and radiate X-rays.

To track the X-rays, Josip Horvat of the Institute for Superconducting and Electronic Materials near Wollongong, Australia, and colleagues rigged up Scotch tape on a spool driven by a motor. The X-rays mostly sprayed at a right angle to the direction the tape was pulled, the researchers report online September 29 in *Applied Physics Letters*. That's convenient, because herding light into a straight line normally absorbs the light's energy, but the tape naturally emits X-rays in a straight line to within 5 degrees.

"Tape is an even better use as an X-ray source than we thought," says Putterman, who in May in *Applied Physics B: Lasers and Optics* identified bremsstrahlung radiation as the X-ray source. He imagines that medical workers in the field could use a hand crank to peel off adhesives and X-ray a finger.

But it's still a mystery, Putterman says, how tape separates enough charge to create a strong electric field, just as physicists don't know how charge separates in clouds to create lightning bolts.

Atom & Cosmos

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Habitable exoplanet find questioned

Swiss team's analysis can't confirm discovery of Gliese 581g

By Ron Cowen

In September, U.S. astronomers made headlines with news of the first extrasolar planet likely to be hospitable to life, orbiting its parent star at a distance where water could be liquid (*SN: 10/23/10, p. 5*).

But a Swiss team has now cast doubt on that finding. On October 11, Francesco Pepe of the Geneva Observatory in Sauverny, Switzerland, announced at a meeting in Turin, Italy, that an analysis of old and new data acquired by his team shows no sign of the planet, Gliese 581g.

"If a signal corresponding to the announced Gliese 581g planet was present in our data," Pepe says, "we should have been able to detect it."

Other astronomers say that only more studies will tell if the first exoplanet in the habitable zone has truly been found. "I don't know if we should be in such a hurry to say one way or the other," says MIT astronomer Sara Seager.

In 2009, the Swiss team reported on 119 measurements over four years of parent star Gliese 581's wobble. Those measurements revealed four planets tugging on the red dwarf star. The latest report includes 60 more measurements made with the HARPS spectrograph on a telescope in Chile, for a total of six and a half years of observations.

"We do not see any evidence for a fifth planet in an orbit of 37 days," says Pepe, referring to the planet that Steven Vogt of the University of California, Santa Cruz and colleagues announced in September.

Pepe says that despite the extreme sensitivity of the instruments used by his team and the U.S. team, the signal of the potentially habitable planet is extraordinarily tiny, about the same level as the noise in the instruments. "Simulations on the real data have shown that the probability that such a signal is just produced 'by chance' ... is several percent," Pepe says. "Under these conditions we cannot confirm the presence of the announced planet Gliese 581g." He adds, though, that his team also can't formally refute it.

Vogt says that he and his colleagues stand by their results, which analyzed a larger set of data and also found evidence for a sixth planet. "I feel confident that we have accurately and honestly reported our uncertainties and done a thorough and responsible job extracting what information this data set has to offer," he says.

Vogt's team combined the Swiss group's 119 measurements with 122 measurements recorded over 11 years using the HIRES spectrograph at the Keck Observatory in Hawaii. Gliese 581g can be detected when the two data sets are combined, Vogt and colleagues write in a paper to appear in *Astrophysical Journal*.

Seager notes that the Swiss analysis doesn't assume that all the planets orbiting Gliese 581 have perfectly circular orbits, as Vogt's team does. That difference could be the crux of the disagreement, says Alan Boss of the Carnegie Institution for Science in Washington, D.C. Assuming Gliese 581's known planets to have elongated orbits could mask the signal from an additional planet, he says. But, Seager adds, allowing only circular orbits could produce false signals of planets.

Comet impostor ID'd as asteroid

Hubble and Rosetta images undo space rock's disguise

By Ron Cowen

A space object spotted in January appears to be an asteroid trailing debris from a collision, not a comet as first thought.

D. JEWITT/UCLA, NASA, ESA

The fuzzy body with the long, bright tail spotted by astronomers in January was a dead ringer for a comet. But the object's location put that notion on the rocks: The body lies in the innermost part of the asteroid belt between Mars and Jupiter, in an orbit that no comet could have.

Instead, researchers have identified the body dubbed P/2010 A2 as a 120-meter-wide asteroid, the remnant of a slightly larger space rock that was recently hit by a much tinier denizen of the asteroid belt. The unseen collision vaporized the smaller body and stripped material from P/2010 A2, creating the debris initially mistaken for a comet's tail.

Astronomers initially thought the suspected collision occurred just weeks before the asteroid was spotted. But new images from the Hubble Space Telescope and the Rosetta spacecraft reveal that the dusty debris from the smashup is expanding sedately rather than flying off like shrapnel, indicating that the collision occurred about a year before P/2010 A2 was sighted, two teams of astronomers report in the Oct. 14 *Nature*.

Although not as recent as astronomers had thought, the smashup is new enough to "open the door to the empirical study of the way asteroids die," says David Jewitt of UCLA, the lead author of the report analyzing Hubble images.

For more coverage of the planetary sciences meeting, visit **www.sciencenews.org/planetary2010**

Life on Earth may have roots in air

Early atmosphere capable of assembling life's ingredients

By Ron Cowen

When it comes to determining exactly where in the solar system life began, things have never been so up in the air. Over the past decade, scientists have suggested deep-sea hydrothermal vents (*SN: 2/2/08, p. 67*), underground aquifers, partially frozen lakes (*SN: 10/23/10, p. 11*) and even comets as locations for the origin of life.

Now an experiment that simulates chemical reactions in the atmosphere of Titan, Saturn's haze-shrouded moon, adds a new location to the list of unexpected places where the chemistry of life could have developed — in the sky.

Using radio waves as an energy source to bombard a mix of gases in a steel reaction chamber, researchers simulated ultraviolet radiation from the sun striking the top of Titan's thick atmosphere and breaking apart gas molecules such as methane and molecular nitrogen. The experiment is the first to produce, without liquid water, the basic chemical ingredients of life — the amino acids found in proteins and the nucleotide bases that make up DNA and RNA.

The results suggest that Titan's upper atmosphere, about 1,000 kilometers above the frigid moon's surface, could produce chemical precursors to life, planetary scientist Sarah Hörst of the University of Arizona in Tucson reported October 7. And because planetary scientists believe that Titan provides a snapshot of the early Earth, the study also indicates that building blocks for terrestrial life might have formed within a primordial haze high above the planet rather than in a primordial soup on the surface, Hörst said.

Planetary scientist Jonathan Lunine, also of the University of Arizona but not part of the study, notes that the compounds found in the experiment "are relatively simple precursor molecules to life, and so there are a lot of additional steps between such molecules and life itself, most of which will likely require a liquid, such as water or methane." However, he adds, everything that forms high in Titan's atmosphere does eventually end up in the moon's lakes and seas of methane.

The study is provocative, Lunine says, because the Saturn-orbiting Cassini spacecraft has detected heavy charged molecules in Titan's atmosphere, but they are too massive for the craft's instruments to identify. Researchers have looked at amino acids as some of the potential candidates for these large compounds.

The atmosphere of Titan, a Saturn moon thought to resemble early Earth, could contain chemical building blocks for life.

To confirm that amino acids and nucleotide bases are actually produced in Titan's atmosphere will require another orbiter that can carry instruments 100 to 200 kilometers deeper than Cassini does into Titan's haze layer, Lunine says. ■

Saturn moon may sport seltzer sea

Fizzy ocean could be source of eruptions on Enceladus

By Ron Cowen

Eau my! Things could be really popping on Saturn's moon Enceladus. A fizzy ocean, similar in carbonation to Perrier, may feed the plumes of water vapor, gas and ice that erupt from the moon, a new model suggests.

Since 2005, when the Cassini spacecraft first observed icy plumes spewing from the south pole of Enceladus (*SN: 5/6/06, p. 282*), researchers have speculated that an ocean may lie buried tens of kilometers beneath the moon's fractured, icy surface. Now Cassini scientist Dennis Matson of NASA's Jet Propulsion Laboratory in Pasadena, Calif., and his colleagues propose adding a bit of effervescence to that watery hypothesis. A bubbly ocean containing 1 or 2 percent dissolved carbon dioxide and other gases could supply water, gas, dust and heat to Enceladus' polar plumes, Matson reported October 5. Carbonation could also explain why some of the ice grains expelled by the plumes carry sodium and potassium salts.

Noncarbonated seawater circulating from the moon's solid core to the surface would stall rather than seep though cracks in the ice because seawater is denser than the icy carapace. If the seawater were fizzy, however, gas bubbles would form in the liquid, reducing the ocean's density. Once the seawater became less dense than the ice, the water could rise to within 10 to 15 meters of the frigid surface. That's close enough to fill chambers in the icy crust with the water that feeds the south polar plumes.

In addition, as the bubbles popped they would spray the plume chambers with tiny droplets containing dissolved salts from the seawater. Those droplets would emerge from the plumes as salty grains like those that have been observed by Cassini (*SN: 8/30/08, p. 10*). The liquid would sink back through the cracks and rejoin the rest of the subsurface ocean.

NASA

Humans

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Testing is an effective memory tool

Quizzes inspire associations that spur information recall

By Marissa Cevallos

Quick — learn these Swahili words: *Wingu* means cloud, a *lulu* is a pearl and *zabibu* means grape.

Covering up the words and quizzing yourself is a better learning strategy than repeatedly reading the words, psychologists report in the Oct. 15 *Science*. Self-testing reinforces the association by creating key words as clues for retrieving the word pairs later on.

> **"If you don't try to retrieve it, you don't know if you know it."**
> MARY PYC

Scholars have long known the value of self-quizzing: Exercise in repeatedly recalling a thing strengthens the memory, Aristotle wrote more than 2,000 years ago. But psychologists aren't sure why.

Mary Pyc and Katherine Rawson of Kent State University in Ohio hypothesized that when studying, say, a foreign language, students invent key words to help trigger the right word. To remember that *wingu* is a cloud, for example, a student might use the word *wing* to think of a bird flying in the clouds.

The researchers asked 118 college students to study 48 pairs of Swahili and English words. Then about half of the students reviewed the words side by side, and half were quizzed by being shown one word and asked to recall its partner. Both groups were asked what mediator — a key word, phrase or concept — they used to link the words.

When students were tested one week later, those who had taken the practice quizzes performed better than those who hadn't. The grades were especially disparate if researchers asked the students to recall their mediators just before the exam. In that case, students who had been quizzed remembered their mediators 51 percent of the time. Students in the unquizzed group remembered their mediators only 34 percent of the time.

"Mediators are playing a role we didn't realize was important before," says Nate Kornell, a psychologist at Williams College in Williamstown, Mass.

Students are often lulled into a false sense of knowledge by staring at information. "The illusion is, you read something and think you'll remember it. But if you don't try to retrieve it, you don't know if you know it," says Pyc, now at Washington University in St. Louis.

Though psychologists recognize the value of self-testing, they say students often neglect it while preparing for exams. Students will underline or highlight facts they think are important, but before test time they only reread the marked information rather than test themselves on it, cognitive psychologist Henry Roediger of Washington University found when he asked undergraduates how they studied.

"They think they know it because they have read it so many times, but they haven't practiced the skill they'll need on the test, which is retrieval," he said.

Roediger says that by connecting a name with an identifying body feature, he uses mediators to learn the names of his students on the first day of school.

Now, exam time: How do you say grape in Swahili? ■

Getting to know you less and less

Long-term couples ignorant of each other's likes, dislikes

By Bruce Bower

BASEL, Switzerland — Long-lasting marriages may thrive on love, compromise and increasing ignorance about one another. Couples married for an average of 40 years know less about one another's food, movie and kitchen-design preferences than do partners who have been married or in committed relationships for a year or two, a new study finds.

Two University of Basel psychologists, Benjamin Scheibehenne and Jutta Mata, working with psychologist Peter Todd of Indiana University in Bloomington, observed this counterintuitive pattern in 38 young couples aged 19 to 32, and 20 older couples aged 62 to 78. The greatest gap in partner knowledge was in food preferences, an area with particular relevance to daily life, the scientists report in a paper to appear in the *Journal of Consumer Psychology*.

On average, members of younger couples accurately predicted a partner's food preference 47 percent of the time, versus 40 percent for members of older couples. A comparable disparity emerged for movies and kitchen designs.

Declines in older couples' knowledge partly reflect a tendency by partners to pay less attention to one another because they view their relationship as firmly committed or assume that they have little left to learn about each other, the researchers propose. Consistent with that hypothesis, long-term partners in the new study expressed more overconfidence in their knowledge about each others' preferences than people in short relationships did.

Longtime partners may also overestimate their similarity to one another, the scientists add. Members of longer relationships often attributed their own food, movie and design preferences to partners who actually had different opinions. Older couples did, however, report more satisfaction with their relationships than did younger couples.

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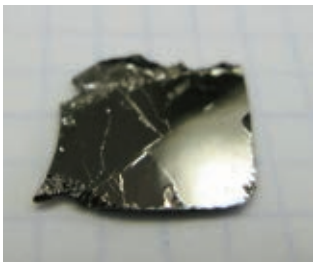
Iron in the mix

Scientists look for the secret behind high-temperature superconductors

By Gwyneth Dickey

Physicist Johnpierre Paglione works in a kitchen of sorts: He precisely blends ingredients, heats his mixtures to just the right temperature and cools them to get the perfect product. But rather than only edible ingredients, his recipes call for toxic chemicals, such as arsenic, and metals — especially iron. His ovens, which line the shelves of his lab at the University of Maryland in College Park, reach 1,700° Celsius before he carefully cools his concoctions over days or weeks. When the timer finally dings, out pops a silvery-black pebble with one flat, shiny surface.



Some iron-based compounds superconduct at relatively high temperatures.

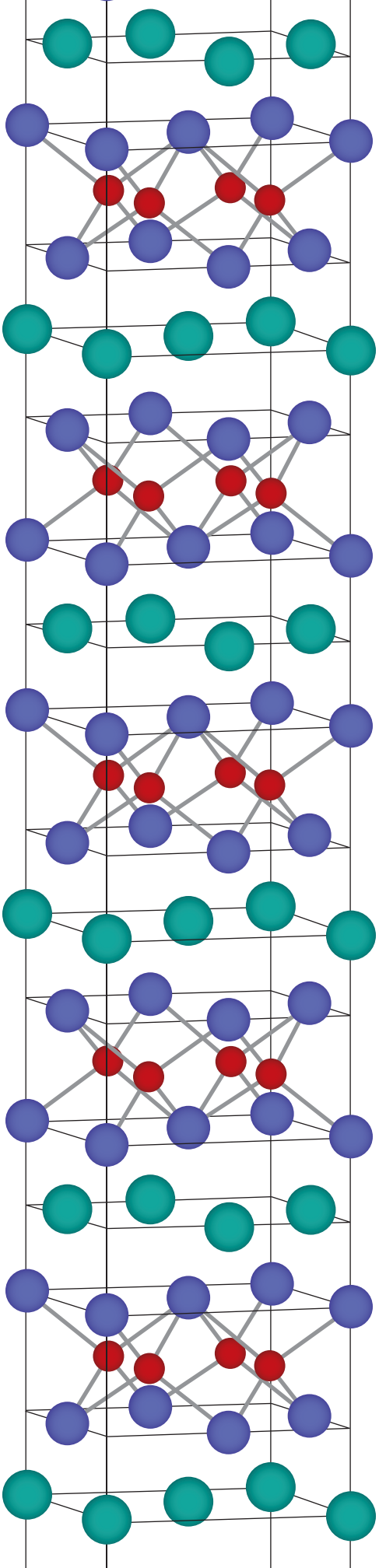
The newly made pebble is a superconductor, a material that shuttles electricity with essentially perfect efficiency, defying the resistance that typically slows electrons down. Because Paglione's pebble incorporates iron into its molecular structure, it's a member of a new class of materials known as iron-based superconductors. These materials, discovered in 2008, work at temperatures as high as −218° Celsius, or 55 kelvins (degrees above absolute zero). Though that sounds pretty cold, conventional superconductors must be cooled to within a few degrees of absolute zero. Only copper-oxide superconductors work at higher temperatures than the iron-based family, and together the two groups make up what are known as the high-temperature superconductors.

Scientists have been trying to figure out how high-temperature superconductivity works since copper oxides, or cuprates, were found to exhibit resistance-free flow in 1986. Right now, even the most promising cuprate must be cooled to about 138 kelvins. Though liquid nitrogen can get materials that cold fairly easily, the cuprates are hard to form into wires.

With the new iron family on the scene, scientists may be able to identify what makes high-temperature superconductors tick, leading to new materials that are easier to work with or that operate at even higher temperatures. And the everyday potential of zero-resistance power lines and levitating magnetic trains may finally be realized.

"The field is feeling very liberated and very excited and very optimistic, because we're not constrained to 'it's just copper oxide, it's just iron arsenide,'" says physicist Paul Canfield of Iowa State University in Ames and the U.S. Department of Energy's Ames Laboratory. "It may be that if we can figure out what's similar between these two very different classes of materials, we may be able to generalize and find other materials that may even have more promising properties."

Thousands of papers have been



Iron-based superconductors are built with layers. The one shown includes iron (red), arsenic (purple) and barium (blue).

MOLECULE: E. FELICIANO; IRON-BASED COMPOUND: J. PAGLIONE

published about iron-based superconductors since their discovery. During 2009 papers came at an average of 2.5 per day. This flood of research has revealed differences in how electrons pair in the cuprates and in the iron-based compounds. But there are also striking similarities in the families' magnetic properties. All together, the findings leave physicists wondering whether they have found a key to high-temperature superconductivity.

A string of super discoveries

The very first superconductor was found in 1911, when Dutch physicist Heike Kamerlingh Onnes discovered that mercury lost its electrical resistance when cooled to 4 kelvins. Over the next 50 years more superconductors were uncovered, but all required temperatures below 25 kelvins.

In these old-school superconductors, electrons travel through the material in what are called Cooper pairs. A negatively charged electron passing through a crystal lattice of positively charged ions pulls nearby ions close, creating a region of positive charge. This region attracts another electron to come through, and it pairs with the first. This pairing prevents the electrons from bouncing around and losing energy. But at "high" temperatures (around 30 kelvins or above), the thinking went, heat energy would overwhelm the Cooper pairs and break them apart.

BRIAN STRAUGHN, COURTESY OF J. PAGLIONE

After making iron-based compounds, Johnpierre Paglione uses a refrigerator of sorts (shown) to cool them down.

Cuprates were the first high-temperature superconductors discovered. Physicists K. Alex Müller and J. Georg Bednorz of the IBM Zürich Research Laboratory in Switzerland found a brittle, ceramic compound made of lanthanum, copper, oxygen and barium that superconducted at 35 kelvins, unprecedented at the time.

"The interesting thing about those materials was that the mechanism of superconductivity seemed new," says David Singh of Oak Ridge National Laboratory in Tennessee.

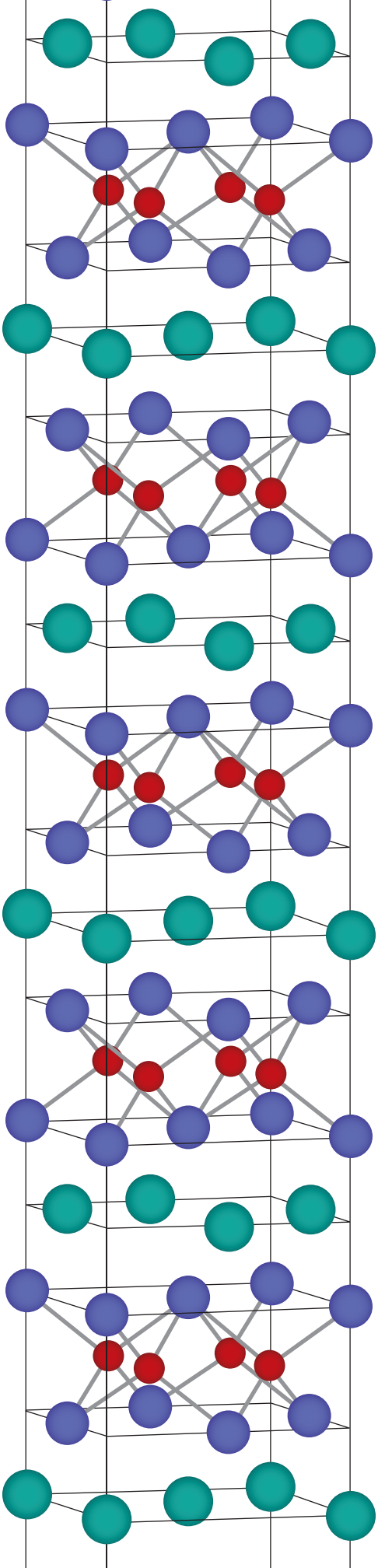
There was a flurry of excitement in the late 1980s about cuprate superconductors. Scientists set about creating more copper-oxide compounds that could superconduct at high temperatures. But after 20 years, scientists still couldn't agree on just how the cuprates worked.

"It was basically an unsolved problem," Singh says. "People had ideas, but there wasn't a general consensus on what were the right ideas."

In the meantime, researchers looked for other types of high-temperature superconductors. A small breakthrough came in 2001, when a well-known compound called magnesium diboride was discovered to superconduct at 40 kelvins. But it appeared to work through traditional Cooper pairing and didn't shed much light on high-temperature superconductivity more generally. After years of little success, scientists began thinking that the cuprates were somehow a warm exception to the cold rule.

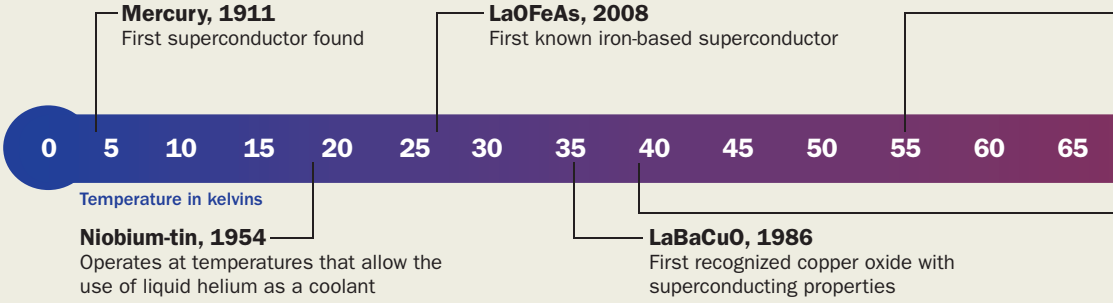
Then in 2008, Japanese scientists led by Hideo Hosono of the Tokyo Institute of Technology reported in the *Journal of the American Chemical Society* that they had found an iron-arsenic mix that superconducted at 26 kelvins. Before long, scientists found related compounds working at temperatures up to 55 kelvins.

The iron-based compounds could help reveal how superconductivity worked at relatively high temperatures, researchers



Superconducting milestones

Finding materials that exhibit resistance-free electric flow at increasingly higher temperatures has been a continuing goal of physicists since superconductivity was discovered in 1911.



thought. They immediately started creating more iron mixes and comparing the cuprates with the iron-based family in search of a common explanation.

Cuprate and contrast

The silvery black pebble that pops from Paglione's oven is a crystal that contains alternating sheets of atoms. Iron-arsenic layers are stacked on top of films of barium the way noodles and tomato sauce are layered in lasagna.

Not all iron-based superconductors combine arsenic with the iron to make the noodle layer. Some use phosphorus, selenium or tellurium instead. And not all have barium; some use other elements such as lithium or mixes of lanthanum and oxygen, for example. And some dispense with the sauce altogether.

But all iron-based superconductors share the layered structure. And it's always the layer with the iron that does the electron shuttling. The other layers provide some structural support and keep unneeded electrons out of the way.

Cuprates are also layered, except that instead of containing iron, the cuprates' superconducting layers are made of copper and oxygen. The copper and oxygen bond so that the layers lie flat, while iron-containing layers, say iron and arsenic, are a bit more three-dimensional, with arsenic atoms embracing iron atoms from above and below.

But a good lasagna requires more than noodles and sauce — it also needs cheese. Superconductors often add another ingredient too. In a process called doping, some atoms are swapped for others — a bit of cobalt replaces some iron in one of the iron-based superconductors, for instance.

The chemical substitution changes the number of electrons in the material, which helps superconductivity happen. Canfield and Iowa State colleague Sergey Bud'ko discussed the intricacies of doping in some iron-based superconductors in August in the *Annual Review of Condensed Matter Physics*.

Though the iron and cuprate families seem to share some structural features, the closer researchers have looked the more dissimilar the materials seem. To probe those differences, scientists have run a battery of tests, such as bombarding a crystal lattice with neutrons, hitting it with X-rays, applying magnetic fields and measuring current flow. And placing different pressures on differently doped crystals helps reveal the boundaries of superconductivity.

Such tests have revealed that electrons in the cuprates and iron-based compounds appear to travel in pairs while superconducting, but not in the way traditional Cooper pairs work.

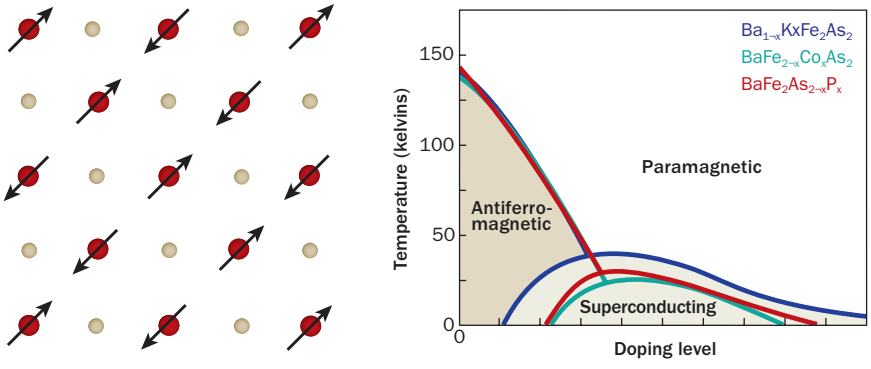
In the high-temperature superconductors, paired electrons seem to repel each other. Like middle school dance partners who are afraid of cooties, the two travel around the gym floor together while still keeping a comfortable distance.

In cuprates, the linkage will break down if the pairs travel in one of four forbidden directions through the lattice.

In a paper published in *Physical Review Letters* in 2008, Singh and three other colleagues, including theorist Igor Mazin of the U.S. Naval Research Laboratory in Washington, D.C., suggested that pairing in iron-based superconductors is closer to pairing in cuprates than to that of traditional superconductors, yet is still different. Electrons maintain their distance, but there are no specific traveling directions that will break pairs apart. Such pairing differences could mean that the mechanism of superconductivity is not the same in the two families.

Papers published since 2008 provide

All about the magnetism Some scientists believe that the breakdown of a property called antiferromagnetism may play a big role in high-temperature superconductivity. In an antiferromagnetic material, the magnetic fields of individual atoms line up in an alternating way (left). Various iron-based compounds transition (right) from an antiferromagnetic to a superconducting state.



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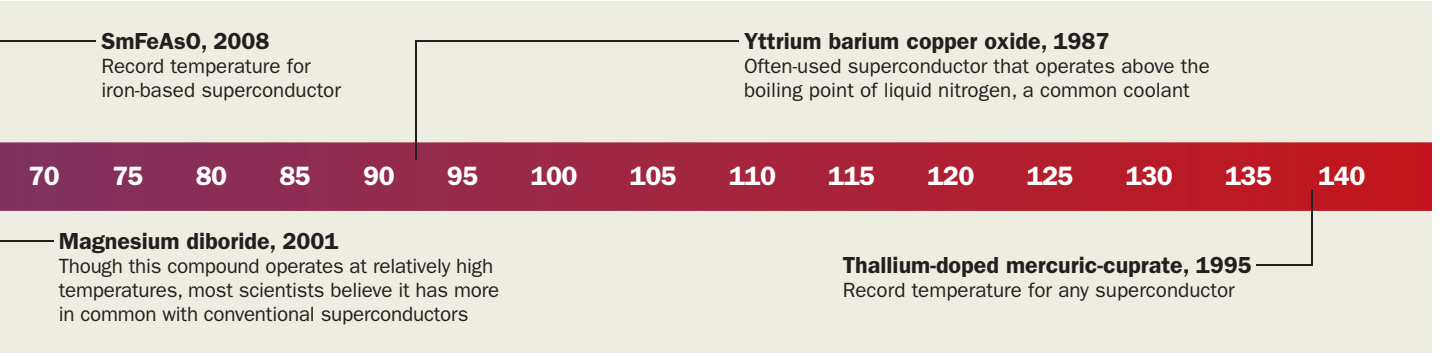


some evidence for the proposal by Mazin, Singh and colleagues, but the idea hasn't been confirmed experimentally yet. In a review published in *Nature* in March, Mazin says such confirmation remains the main experimental challenge and may be just one or two years away.

A magnetic surprise

Iron had always been an elemental ingredient in the kitchen cabinets of scientists. But because of its magnetic properties, no one suspected its usefulness for superconducting recipes.

An atom of iron is its own tiny magnet, with a north and south pole. If the magnetic fields created by individual atoms in a hunk of iron all point in the same direction, the hunk will pick up or repel a paper clip. That's because the many small fields can give the iron a net magnetic field.

But traditional low-temperature superconductors are made of materials whose individual atoms don't create strong magnetic fields. What's more, these materials lose their superconductivity when magnetic impurities enter the compound. Any magnetic field that is introduced can tug on the charged electrons and break the pairs apart.

So it was long thought that magnetism and superconductivity were mutually exclusive.

"Nobody would have dreamed of seeing 55 kelvin superconductivity in an iron-based material," Paglione says.

But in a review paper published in September in *Nature Physics*, Paglione and Richard Greene summarize some of the latest evidence suggesting that magnetism may in fact be important for superconductivity in iron-based materials.

When combined with arsenic, the tiny atomic magnets in the iron line up so that they alternate the direction of their magnetic fields in an orderly fashion — up, down, up, down and so on. This state is called antiferromagnetic. And though an antiferromagnetic material won't pick up a paper clip, it's still a type of magnet.

Cuprates also show antiferromagnetism. And in both groups, superconductivity appears when scientists destabilize the antiferromagnetic order — through doping or by applying pressure — and magnetic orientations within the crystal start to fluctuate, switching from up to down.

> **"There must be more superconductors and some of them might be higher-temperature or better to use."**
> IGOR MAZIN

Most scientists believe that the similarity between the two families suggests that the breakdown of antiferromagnetism plays a role in helping electrons pair, though no one is yet sure exactly how. The magnetic fluctuations may be important for unlocking the mystery. In the review paper in *Nature*, Mazin suggests that magnetism is essential.

Further magnetism studies may help researchers find compounds that work as high as room temperature, doing away with the need for refrigeration that superconductors require today.

"There are many magnetic ions, there are many magnetic systems," Mazin says. "There must be more superconductors and some of them might be higher-temperature or better to use."

Canfield agrees: "One of the ways to look for other superconducting compounds is to try to modify ones that are antiferromagnetic."

Though some scientists are still counting on one common factor underlying high-temperature superconductivity, others believe the differences that have been found between the two families leave open the idea that there may be more than one way to superconduct at high temperature. If that's the case, many more types of high-temperature superconductors may still be found.

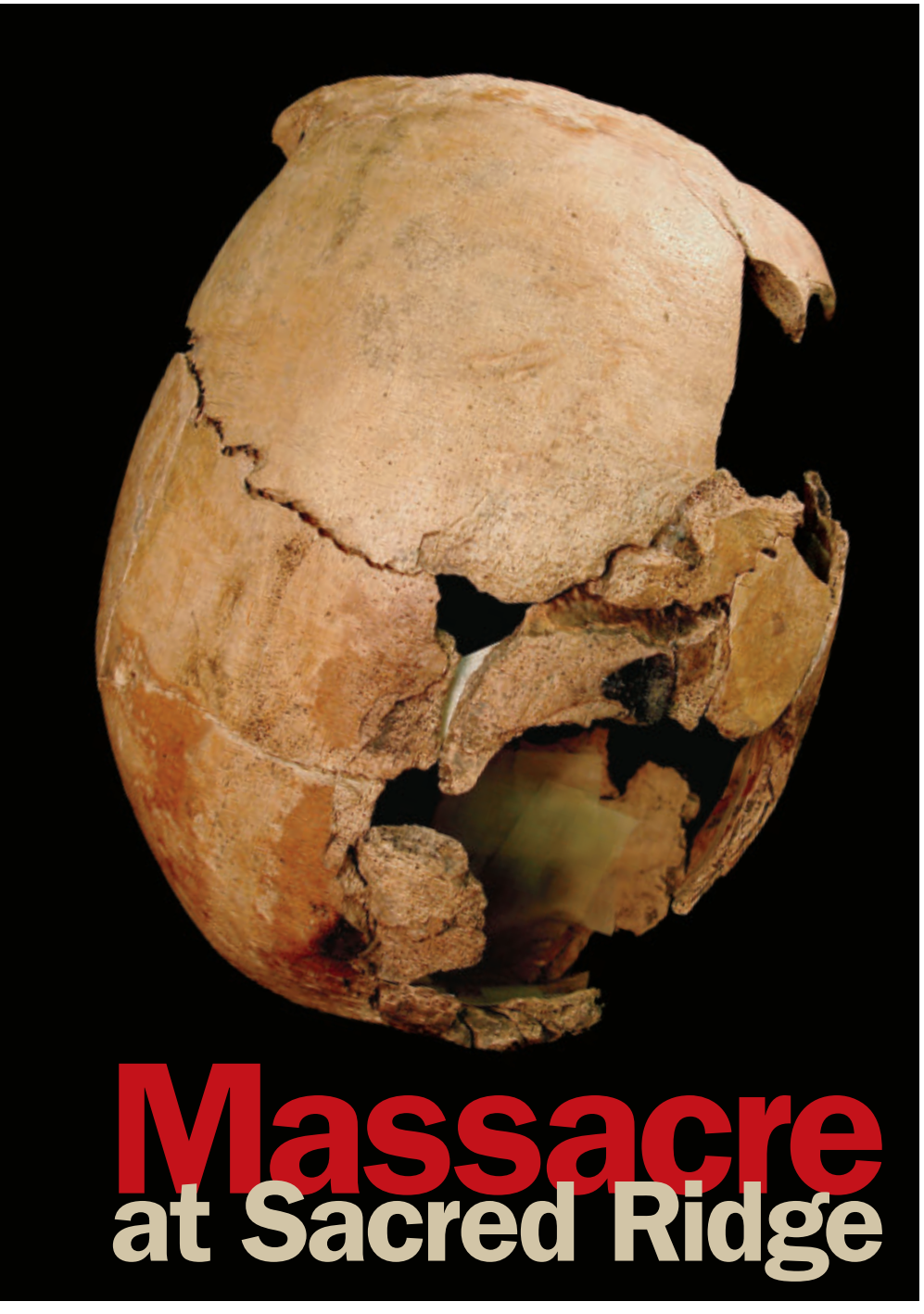
"We already know that there's more than one way to get superconductivity," Singh says. "The other point of view is that ... maybe the cuprates and the iron superconductors take different paths."

Until there's a clear answer, physicists will continue to hunt for new materials and push the boundaries of currently known superconductors, to increase their working temperatures and come up with technologically useful materials.

"The trick is, figuring out what solutions might work," says Canfield, who grows iron-arsenide crystals in his lab. "This is where the basic research and instinct comes in." ■

Explore more

- I. Mazin. "Superconductivity gets an iron boost." *Nature*. March 11, 2010.
- J. Paglione and R. Greene. "High-temperature superconductivity in iron-based materials." *Nature Physics*. September 2010.



Massacre at Sacred Ridge

A violent Pueblo incident sparks debate regarding prehistoric genocide

By Bruce Bower

Excavations at an ancient Pueblo site uncovered crushed skulls (one shown) and other bones from at least 35 victims.

COURTESY OF SWCA ENVIRONMENTAL CONSULTANTS

Attackers with a deadly plan climbed a knoll to a Pueblo village called Sacred Ridge around 1,200 years ago. What happened next was anything but sacred.

At least 35 people, roughly half of those living in the village, were brutalized, killed and sliced into thousands of small pieces. Fellow Pueblo from nearby villages battered victims' feet hard enough to break toes and fracture heels. Blows delivered with blunt weapons crushed the faces and heads of men, women and children. Scalps, and possibly eyes and ears, were removed, perhaps as trophies.

Wielders of sharp stone implements chopped up victims' bodies in at least four Sacred Ridge structures. Attackers removed the roof of a large house and threw in heaps of human body parts, some of which had been fished from burning hearths. Several village dogs met the same fate.

"This extreme level of violence came as a complete surprise," says archaeologist James Potter, who directed the excavations that uncovered this murder at Sacred Ridge. "I was blown away from the start at how many human remains we were finding."

As Potter and his colleagues tried to grasp what they had found, a question struck them: Why did the Pueblo, whose villages dotted southwestern Colorado's 4-kilometer-long Ridges Basin, execute such a brutal, over-the-top massacre?

After leading an analysis of Sacred Ridge's mutilated mass of bones, bioarchaeologist Ann Stodder of the Field Museum in Chicago has a controversial answer: genocide. An ethnically distinct Pueblo clan living at Sacred Ridge maintained tenuous authority over at least two other ethnic groups inhabiting Ridges Basin, Stodder contends. Dire food shortages and anger toward better-provisioned Sacred Ridge elites motivated a raid aimed at destroying an entire lineage and its collective identity, she proposed in April in Albuquerque at a meeting of the American Association of Physical Anthropologists.

Stodder's proposal has raised eyebrows and hackles among some scientists who study ancient Pueblo people and the prehistory of violence. Many regard genocide as a word that implies an effort to exterminate a whole race, religion

or ethnic population. Save the g-word for the Nazi slaughter of Jews and other cases in which mind-numbingly mammoth numbers of people perished, these scientists argue.

Potter, of SWCA Environmental Consultants' branch in Broomfield, Colo., calls what happened at Sacred Ridge a one-off outburst of "ethnocide," not a village-to-village genocidal campaign. Some researchers suspect that attackers attributed misfortunes in home communities to witchcraft practiced at Sacred Ridge; physically obliterating victims would drive evil spirits out and make bodies useless to malevolent forces. Others contend that the intentions of those who attacked Sacred Ridge are difficult to divine from piles of smashed bones.

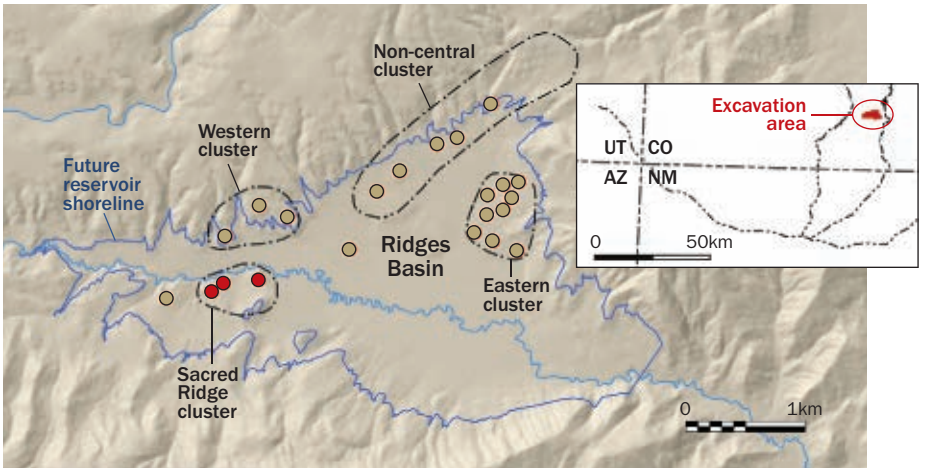
"Archaeologists and anthropologists will be thinking about this site for a long time," says Stodder.

Melting pot meltdown

Potter didn't expect to unearth a slaughter at Sacred Ridge. His effort was part of a federally funded project to document archaeological sites in a larger area of the Four Corners region scheduled to be inundated by a new dam.

Pueblo settlements first appeared in the region around the year 700. Up to that point, mobile hunter-gatherers who are considered to be Pueblo precursors had inhabited the territory for more than 1,700 years. From about 775 to 825, according to radiocarbon and tree-ring dating estimates, Pueblo people resided at Sacred Ridge and more than 30 other Ridges Basin settlements excavated by Potter's team. A few cases of violent deaths have turned up at other basin villages, but nothing that approached a massacre.

Similarly, early Pueblo sites elsewhere in the Four Corners region have revealed a few incidents of killing and possible cannibalism mainly involving just handfuls of people. And a cave in southeastern Utah yielded bones from at least 61 pre-Pueblo individuals who were beaten, mutilated and stabbed around 1,500 years ago, but the predominance of adult males among those victims suggests a warfare-related attack.



During a violent encounter roughly 1,200 years ago, Pueblo people from settlements elsewhere in the Ridges Basin area (brown dots) attacked Sacred Ridge sites (red dots).

Though violent raids on Pueblo sites increased in size and frequency from 900 to 1300 (*SN: 9/9/00, p. 164*), with victims including men, women and children, Sacred Ridge was built during a relatively calm period and therefore seemed an unlikely venue for violence.

Its residents wielded some type of ritual and economic power that, at least for a short time, seemed to result in smooth relations among diverse Ridges Basin villagers. Sacred Ridge encompassed 11.6 acres, considerably more ground than nearby settlements. In addition to 22 underground pit houses, public structures included a domed circular building, a two-story tower and a palisade.

Digs led by Potter in two Sacred Ridge pit houses in 2003 and 2004 uncovered clusters of broken and burned human bones. Chemical analyses identified blood residue on an ax, a jar and other artifacts found near the remains. The next year, thousands more pieces of bone turned up in another pit house that showed signs of having had its roof removed. Potter's team recovered a total of 14,882 human bone fragments from people of all ages.

Scrutiny of strontium isotopes in teeth from 28 individuals at Sacred Ridge suggested that they grew up eating foods from the immediate vicinity and so were not newcomers to the area. Strontium signatures of these villagers matched those previously recorded for plants, animals and rocks in and around the basin.

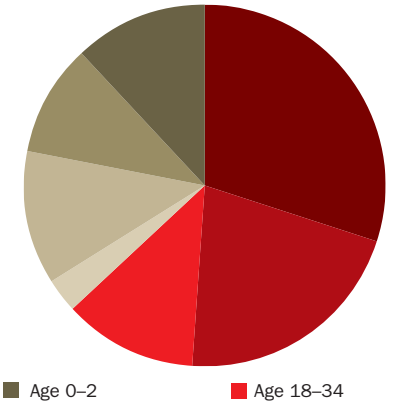
Distinctive house styles, pottery designs, burial practices, tooth shapes and skull features demarcate at least three ethnic groups in the basin at that time, including one at Sacred Ridge, according to Potter.

"Water and other resources attracted growing numbers of people from different ethnic groups to Ridges Basin, where they lived in close proximity for the first time," he speculates.

Increasingly cold and dry weather, dwindling game herds and crop yields,

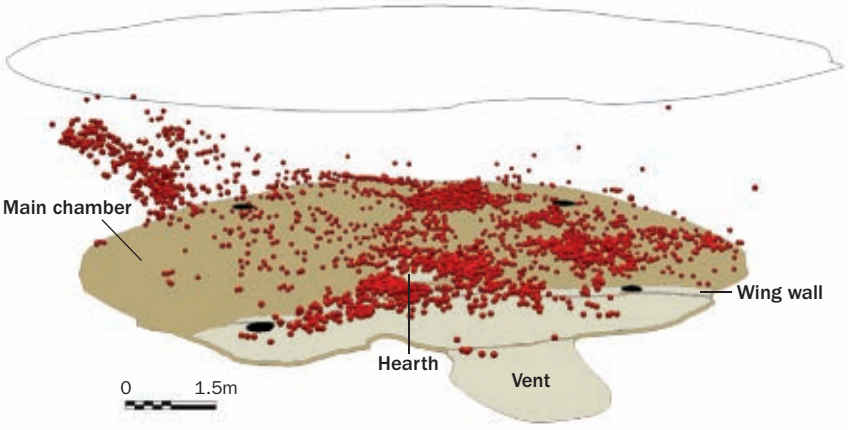
Sparing no one Human remains found during a Sacred Ridge excavation represent more than 30 individuals across all age ranges. Remains of infants and children suggest that the attack wasn't warfare-related.

Age distribution of remains



SOURCE: SWCA ENVIRONMENTAL CONSULTANTS

FROM TOP: COURTESY OF SWCA ENVIRONMENTAL CONSULTANTS; T. DUBÉ



Heaps of evidence Attackers appear to have dumped mutilated and burned body parts into a pit house at Sacred Ridge. The reconstruction at left shows what the structure's interior might have looked like before the attack, and the figure at right shows where bone fragments (red) were found.

and surpluses of stored deer and elk meat confined to Sacred Ridge inflamed ethnic tensions, Potter posits. The regional melting pot boiled over when members of one group eliminated the Sacred Ridge clan in a ferocious attack, he suggests.

Within 15 years of the massacre, Pueblo people abandoned Ridges Basin. Later Pueblo settlements, known for stone and adobe dwellings built along cliff walls, appeared elsewhere in the Four Corners region.

Jigsaw horror

Much of that scenario rings true to Stodder. From her perspective, though, Sacred Ridge offers a chilling example of prehistoric genocide. Although far greater numbers of people died in Nazi death camps and on Cambodia's killing fields, attackers at Sacred Ridge shared much the same devotion to eliminating a population seen as a threat, Stodder proposed at the April meeting.

That argument doesn't sway Potter. One Ridges Basin ethnic group fell on exceedingly hard times and killed culturally different villagers seen as too powerful, he and archaeologist Jason Chuipka of Woods Canyon Archaeological Consultants in Yellow Jacket, Colo., propose in an upcoming *Journal of Anthropological Archaeology*. Ethnic violence at Sacred Ridge was tragic but fell well short of large-scale genocides inflicted by modern societies, in Potter's view.

Other researchers have leveled that same criticism at suggestions that genocide occurred at two European sites, both more than 7,000 years old — one where 67 individuals with violent injuries had been dumped in a trench and another that contained two pits with a total of 38 bodies displaying numerous skull fractures.

For nearly a year after Potter's excavations concluded in 2005, Stodder and colleagues reassembled and analyzed bone fragments from the Pueblo site. Her team managed to put two or more adjoining parts back together for 40 percent of what had been excavated.

> **"It was like doing 15 jigsaw puzzles that could all be part of a larger puzzle."**
> ANN STODDER

"It was like doing 15 jigsaw puzzles that could all be part of a larger puzzle," Stodder recalls.

So many cuts covered bones that researchers counted these tool markings in groups. Knots of marks clustered at joints, a sign that body parts had been systematically detached. In many cases, charring appeared on some parts of reassembled skeletal sections but not others. Attackers may have thrown huge numbers of body parts into hearths, managing to burn a portion of them, Stodder says.

Scrape marks, chop marks, crushed areas and fractures also appeared on many bones. Fractures of the skull base in at least two individuals resembled an execution method used by the Khmer Rouge in Cambodia, an organization that killed roughly 2 million perceived enemies of Communist rulers more than 30 years ago. Kneeling prisoners received deadly blows to the back of the head, close to the brain stem and spinal cord. Extensive damage observed on reassembled foot bones from Sacred Ridge indicated that attackers used clubs of some kind to bash victims' heels and toes. Soles of prostrate villagers' feet were then beaten hard enough to crush and peel underlying bone.

Whatever label one applies to it, the methodical destruction of an extended family with an unsure grip on power "doesn't fit any modern category of social behavior," Stodder says.

Witches of Ridges Basin

Assessing the cavalcade of carnage meted out at Sacred Ridge, anthropologist Debra Martin of the University of Nevada, Las Vegas thinks of witches. Witch accusations and killings have long occurred in societies throughout the world, Martin says. Hopi, Zuni and other Pueblo groups have for centuries killed people regarded as malevolent sorcerers controlled by unseen, wicked forces. Children are viewed as particularly easy prey for evil spirits seeking bodies and souls to commandeer for nefarious purposes.

Procedures for destroying witches include mutilating, cutting up and burning bodies so evil spirits have no human vessels to inhabit. Victims end up looking much like those found by Potter's team.

BOTH: COURTESY OF SWCA ENVIRONMENTAL CONSULTANTS, FIGURE ADAPTED BY T. DUBÉ

"Being from Vegas, I put my money on witch execution at Sacred Ridge," Martin says. Food shortages and other mounting troubles could have sparked witch accusations against an entire extended family or clan, she proposes.

Martin's account sounds plausible to anthropologist Richard Chacon of Winthrop University in Rock Hill, S.C. Chacon has conducted fieldwork among several Native American societies in South America, including Achuar blowgun hunters in Ecuador and Yora bow-and-arrow hunters in Peru. Villagers in these societies often attribute epidemics and other community misfortunes to witchcraft practiced by shamans and others living in neighboring villages, Chacon says. Warriors who kill alleged witches are considered heroes for having performed a vital public service, he notes. That includes the torture and killing of children accused of sorcery.

Bones from Sacred Ridge display many attributes of witch executions, acknowledges Potter. But, he holds, the 35 or more victims at Sacred Ridge "would be an unprecedented number of people found guilty and executed at one time as a result of witchcraft accusations." Historical accounts of Zuni and other Pueblo witch trials typically describe one accused sorcerer, and in rare cases several.

More broadly, Chacon says, research at Sacred Ridge counters claims by some scholars that prehistoric Pueblo people never fought, instead living in harmony with nature and each other. "That stereotype robs Native American peoples of their humanity," he says. "Every group I've worked with has a long history of violent conflicts."

Grave doubts

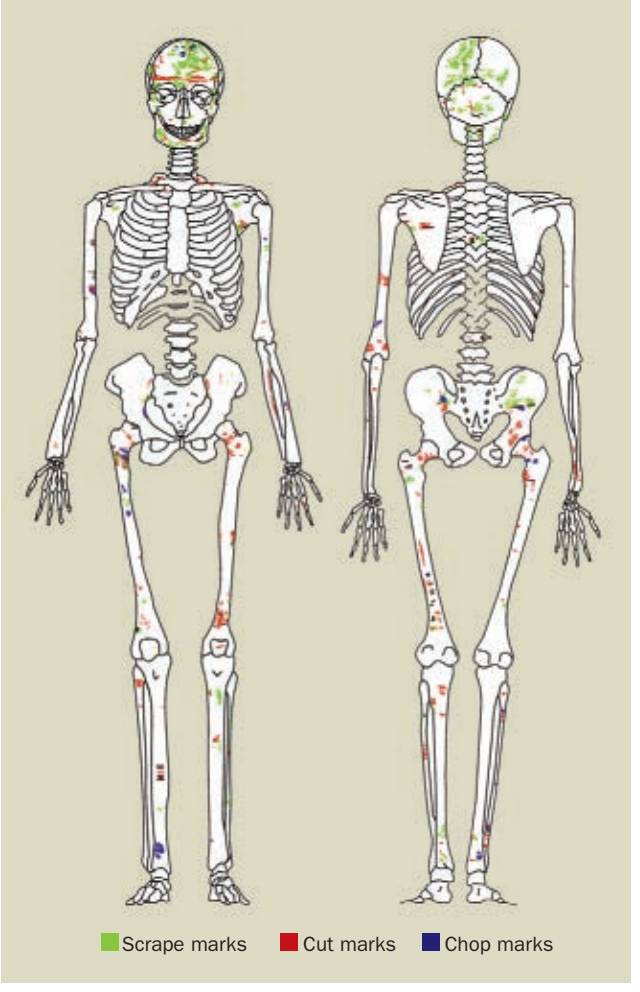
Attacks by one group on a culturally, religiously or ethnically different group undoubtedly occurred in ancient times, in all parts of the world, remarks archaeologist Kristin Kuckelman of Crow Canyon Archaeological Center in Cortez, Colo. Kuckelman's excavations suggest that devastating attacks and possible cannibalism occurred around 1270 at three large Pueblo villages in the Four Corners region. A desire to eliminate and intimidate competitors for scarce food apparently motivated those attacks, she says.

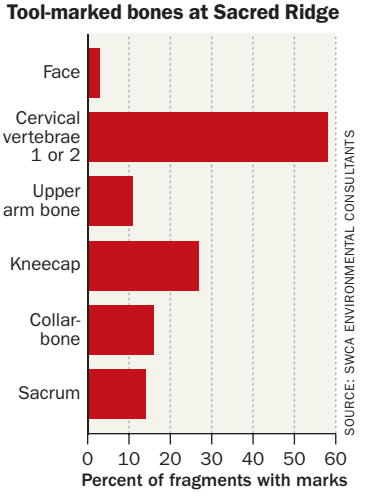
But reasons for the massacre at Sacred Ridge remain puzzling, she cautions. Burned remains of a few people who met violent ends around the same time at three other Ridges Basin villages have been uncovered, so retaliatory raids by members of hostile villages may have culminated in extreme brutality at Sacred Ridge, Kuckelman suggests.

Retribution for alleged witchcraft could explain the literal tearing apart of victims, yet there's no archaeological evidence of pre-Columbian Pueblo sorcery. "It is not at all clear that Pueblo Indian culture included witchcraft belief before European contact," says Kuckelman.

Uncertainty also clouds Stodder's genocide label, comments forensic anthropologist Debra Komar of Liverpool John Moores University in England. A single mass grave, including the one at Sacred Ridge, "could never be

Tallying tool marks Bone fragments recovered from Sacred Ridge (including the hip bone at bottom right) show signs of tool marks, suggesting bodies were mutilated. The skeletons below document where marks were observed on various individuals and the graph shows the percent of selected fragments with marks.





SKELETONS AND BONE: COURTESY OF SWCA ENVIRONMENTAL CONSULTANTS; GRAPH: T. DUBÉ

considered proof of the larger intent of the perpetrators."

In a 2008 paper, Komar cited genocide as one potential explanation of Pueblo violence from 900 to 1300. That period displayed social and behavioral hallmarks of modern genocide documented by Komar a decade ago in Bosnia and six years ago in Iraq: a concentration of previously dispersed groups in a relatively small area, mass graves, mutilation of bodies, killing of women, children and the elderly — and *numerous* large-scale attacks that eradicated villages.

"Times of tremendous conflict occurred throughout the human past," says Richard Wilshusen, an independent archaeologist and Pueblo researcher in Boulder, Colo. "Reasons for those conflicts are so hard to untangle." Attention-grabbing violence at Sacred Ridge shouldn't distract from the vibrant spread of Pueblo villages and cultures soon afterward, he holds. More than 10,000 people inhabited the Four Corners region within a century of the slaughter, heralding a slew of linguistically diverse Pueblo communities by the 16th century.

"Those Pueblo people have much to teach us about how large, sedentary, probably multiethnic communities come together and are held together," Wilshusen emphasizes.

The ancient Pueblo villages at Ridges Basin will soon be inundated together under a slowly rising tide of dam water. In a couple of years, Sacred Ridge will lie in a liquid, man-made grave. Human remains from the site have been ceremonially reburied in a nearby protected area by Pueblo tribal representatives.

Voluminous skeletal data gathered by Stodder's team will go to a federal archive for examination by other interested researchers. In an oddly fitting turn of events, victims of the mysterious massacre at Sacred Ridge will have a long scientific afterlife. ■

Explore more

■ D.L. Nichols and P.L. Crown. *Social Violence in the Prehispanic American Southwest*. University of Arizona Press, 2008.

Violent encounters

Scientists have uncovered evidence of past violent attacks around the world, but deducing motivation is difficult.

At a cave dubbed Ofnet, in Bavaria in 1908, a researcher uncovered two small pits with more than 30 human skulls. Later investigations suggested that someone had intentionally cracked many of the skulls before placing them in the cave (*SN: 4/20/91, p. 254*). The skulls, which date to about 7,200 years ago, belonged to men and women and to adolescents and children. Some say the findings suggest that violence was an integral part of ancient social behavior.

At a settlement in southern Germany, hundreds of people (skullcaps shown at top left) were butchered and eaten over the course of decades some 7,000 years ago, scientists have proposed (*SN: 1/2/10, p. 10*). They argue that skeletal markings indicate human bodies were butchered in the same way as animals. Others argue that the findings are consistent with ceremonial reburial practices.

Investigations in Schletz, Austria, beginning in 1983 have revealed the skeletal remains of 67 individuals with multiple traumas. Studies suggest a settlement's entire population was exterminated about 7,000 years ago. The bodies were left unburied in an oval trench for months.

A fortification ditch at Crow Creek in South Dakota holds the remains of nearly 500 men, women and children. The individuals are believed to represent 60 percent of their village, which dates to 1325. Nearly all of the individuals' remains, uncovered in 1978, showed signs of trauma and mutilation. Most also revealed evidence of scalping, decapitation and dismemberment.

A burial vault uncovered at Teotihuacán, outside Mexico City, contains the remains of a dozen people, all with their hands tied behind their backs. Ten of the people were decapitated. The remains, which date to roughly 2,000 years ago, were found alongside beads, greenstone earspools and animals, suggesting ritual sacrifice.

Pulled from a peat bog in England, the Lindow Man (right) suffered blows to the head, a knee to the back and had his throat slit and a cord tied around his neck sometime during the first century. Probably in his 20s when he died, his body was uncovered in the 1980s. Bogs in northwestern Europe have preserved bodies for as long as 10,000 years.

About 30 kilometers from Cuzco, Peru, a team uncovered the remains of seven children who were apparently killed in a sacrificial rite that honored Inca deities (*SN: 10/23/10, p. 12*). The children were buried beneath a 500- to 600-year-old building. Researchers have not yet determined the cause of death, but accounts written by Spanish conquistadores describe strangulation of sacrificed youngsters.

A 5,500-year-old war zone in Syria was unearthed between 1999 and 2001. Researchers found what looked like bullets numbering to 1,200 and about a tenth as many large clay balls (bottom left). A collapsed mud-brick wall suggests heavy bombardment.

CLOCKWISE FROM TOP LEFT: © CLICHÉ FABIAN HAACK, GDKE RHEINLAND—PFALZ/DIREKTION LANDESARCHÄOLOGIE—SPEYER; COURTESY THE TRUSTEES OF THE BRITISH MUSEUM; UNIV. OF CHICAGO

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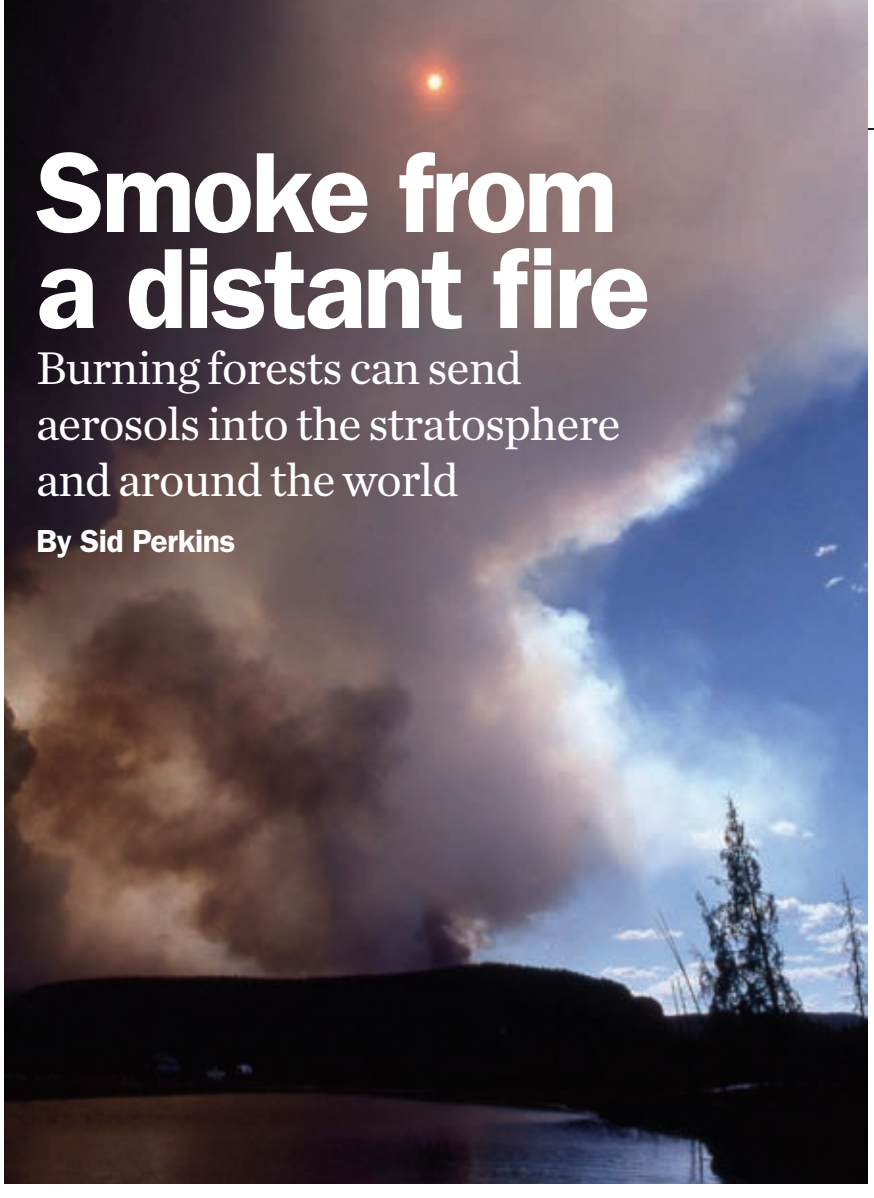
Smoke from a distant fire

Burning forests can send aerosols into the stratosphere and around the world

By Sid Perkins



Smoke from wildfires (Yellowstone National Park shown) can reach the stratosphere via intense storm clouds.

U.S. NATIONAL PARK SERVICE

A dusky shroud hung high over Alaska and western Canada in early August, a plume of smoke, soot and other tiny particles tainting the lower stratosphere and thick enough for satellites to detect. But the particles suspended in the Alaskan and Canadian pall, called aerosols, didn't emanate from one of the wildfires that often strike the region's boreal forests during the long days of summer. Instead, space-based images traced the smoke to massive blazes that erupted in late July in central Russia, more than 9,000 kilometers to the west.

While it has been known for decades that large wildfires can create or enhance thunderstorm clouds, leading to what are called pyrocumulonimbus clouds, only recently have scientists discovered that the clouds can boost smoke into the stratosphere. Once in this layer of the atmosphere — immediately above the troposphere, where most of Earth's weather happens — the smoke can be caught by jet stream winds and carried long distances, says Mike Fromm, a meteorologist at the Naval Research Laboratory in Washington, D.C.

Before the late 1990s, anomalous plumes of stratospheric aerosols were usually blamed on remote and therefore undetected volcanic eruptions, Fromm noted in August at the American Geophysical Union's Meeting of the Americas in Iguaçú Falls, Brazil. But new analyses of satellite data, presented at the meeting and chronicled in the September *Bulletin of the American Meteorological Society*, reveal that pyrocumulonimbus clouds, or pyroCbs, regularly send smoke to the stratosphere. During the 2002 North American fire season alone, pyroCbs lofted aerosols to this layer more than a dozen times.

"In 2000, few scientists believed that these clouds could inject aerosols into the stratosphere," says Pao Wang, an atmospheric scientist at the University of Wisconsin–Madison. "Now it's almost taken for granted that they do."

Along with aerosols, the high-flying plumes carry a heavy load of the chemically active gases that are produced in substantial quantities during a fire, especially in the smoldering phase. While their chemical and climatic effects aren't fully known, the plumes' dark particles tend to absorb sunlight, warming themselves and the atmosphere around them while cooling Earth's surface slightly. A fuller understanding will help scientists fine-tune climate models, adjusting contributions of various aerosol sources.

Fired up

In many ways, says Fromm, pyroCbs are just like other cumulonimbus clouds: They can provide prodigious amounts of precipitation and spawn a lot of lightning. Where pyroCbs differ from standard storm clouds, however, is in their source of convection. While it's the heat produced by condensing water vapor that drives the updrafts in the towering thunderheads of cumulonimbus clouds, those in pyroCbs are largely driven by the intense heat of the wildfire at ground level.

That gives pyroCbs an extra push: The momentum from particularly strong updrafts enables the fire-fueled clouds to routinely make it to the lower reaches of the stratosphere. Even the tops of typical cumulonimbus clouds, in contrast, rarely rise out of the troposphere.

As a column of smoke rises from a wildfire, it pulls in surrounding humid air. The moisture in that air condenses to form the pyroCb cloud as the plume reaches high altitudes.

"Nobody really knows what happens inside these clouds," Fromm says.

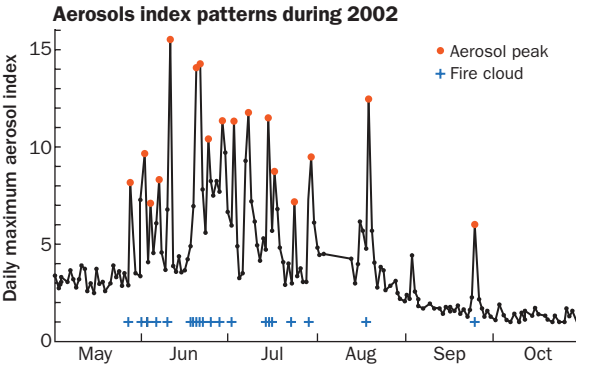
But satellite images clearly show that smoke carried upward inside the clouds emerges from the top as if from a chimney, he notes.

Many high-altitude aerosol plumes detected by satellites in the late 1980s and early 1990s were mistakenly attributed to volcanoes. Take, for instance, a plume that wafted over the central United States in the summer of 1989. Several times during late July and early August, ground-based lasers near Manhattan, Kan., spotted the layer of aerosols in the lower stratosphere. Instruments based near Salt Lake City also recorded the plume. The first analyses of airflow patterns in the lower stratosphere suggested a Central American source. And indeed, Fromm notes, Guatemala's Santiaguito volcano had erupted on July 19 of that year.

But other data didn't support a volcanic origin, Fromm and his colleagues reported at the August meeting. For one thing, witness accounts and satellite images suggested that Santiaguito's plume never rose more than six kilometers into the sky. Also, sensors at the Utah site saw signs that the particles weren't spherical, as typical sulfate droplets from volcanoes would be. New analyses of weather patterns, including the location and speed of the jet stream at the time, track the aerosol plume to large wildfires sparked by lightning in Manitoba and Saskatchewan on July 17 of that year, Fromm said.

Similarly a thick plume of aerosols detected in the stratosphere over the Atlantic Ocean northwest of Spain in late June 1991 was mistakenly linked to eruptions of the Philippines' Mount Pinatubo earlier that month. Fromm's team has traced that plume to wildfires in Quebec.

Satellite images from the 2002 fire season in North America suggest just how often pyroCbs may pollute the stratosphere. That year, 17 different plumes of stratospheric aerosols could be linked to massive wildfires, including Colorado's Hayman Fire and Arizona's Rodeo-Chediski Fire — the largest fires recorded in the histories of those states.



High times for aerosols Clouds generated by wildfires during the 2002 fire season have been linked to peaks in the aerosol index over North America. The index is a measure of the concentration of aerosols in all layers of the atmosphere.

Gas injection

In addition to aerosols such as smoke and soot, fire-fueled clouds inject unusually large quantities of chemically reactive gases such as carbon monoxide, methyl cyanide and hydrogen cyanide into upper layers of the atmosphere, data suggest. Scientists are somewhat concerned about the ultimate effects of these gases on atmospheric chemistry and the planet's climate.

"These clouds are an important route to the stratosphere for smoke, soot and other pollutants," Wang says.

The thickest plume of aerosols lofted from a pyroCb in recent years originated with fires that ravaged southeastern Australia and killed hundreds of people on February 7, 2009 — a day known as Black Saturday. These fires, fueled by high temperatures, low humidity and strong winds, slung an unprecedented amount of pollutants into the stratosphere, says Nathaniel Livesey, an atmospheric scientist at NASA's Jet Propulsion Laboratory in Pasadena, Calif.

Satellite data hint that carbon monoxide concentrations in some parts of the plume in the lower stratosphere reached 800 parts per billion, 10 to 15 times that in normal air, he reported at the August meeting. Preliminary analyses suggest that concentrations of methyl cyanide and hydrogen cyanide were between 2.5 to 7 times normal, says atmospheric physicist Hugh Pumphrey of the University of Edinburgh, who worked with Livesey on the study.

Notes Livesey, "It's still an unanswered question as to what combination of circumstances produced such a strong injection of aerosols from this particular fire." And the ultimate fate of those aerosols isn't clear.

While the plume of aerosols from the Australian fires was unusually thick, those from most other pyroCbs are more modest. "In the broad scheme of things," Pumphrey contends, "pyroCbs may not affect the stratosphere all that much."

Yet Fromm thinks the overall effect of pyroCbs should be detectable. Though individual plumes from pyroCbs aren't nearly as thick as the typical plume of volcanic aerosols, the clouds occur more often than major eruptions do. All together, he suggests, the climatic influence of the fire-triggered plumes may equal a few percent of the global cooling produced by volcanic aerosols.

Determining the precise magnitude of the effect, if any, would be useful, Fromm notes. Once scientists know the cooling power of aerosols from pyroCbs, that result can be incorporated into models of regional and global climate. ■

FROM TOP: ADAPTED FROM M. FROMM *ET AL./BAMS* 2010; NASA GSFC, MODIS RAPID RESPONSE

An aerosol plume (center) generated by fires in central Russia in late July of this year (red denotes fire at ground level) traveled all the way to Alaska.

Explore more

- Mike Fromm explains pyroCbs: http://bit.ly/bri2oX

Sleights of Mind: What the Neuroscience of Magic Reveals About Our Everyday Deceptions

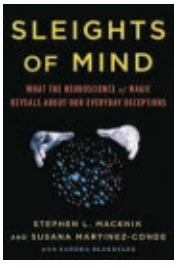
Stephen Macknik and Susana Martinez-Conde, with Sandra Blakeslee

Magic wands, fake drop boxes and invisible thread may be fun gimmicks, but a magician's most valuable tool weighs about three pounds and sits in the skull of the spectator.

In their illuminating book, brain experts Martinez-Conde and Macknik make the case that magicians are some of the most skilled neuroscientists around. No mere hucksters, magicians deftly manipulate brains by sculpting attention, perception and memory so that the outrageous seems possible.

The authors, both researchers at the Barrow Neurological Institute in Phoenix, have a deep appreciation of magic and close ties to the magic community. The duo often draws on the experiences of successful magicians to illustrate the neuroscience behind tricks. The clear, engaging writing is interspersed with bizarre visual illusions, schematics of magical devices and deconstructions of card tricks.

When secrets are revealed, the authors conscientiously mark each one with a "Spoiler Alert" as required by magicians' associations so that readers don't learn any secrets they'd rather not know. Far from spoiling the fun, the book points to an even deeper mystery: how the brain constructs its version of reality.



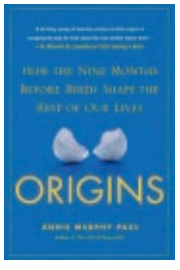
The story culminates at the Magic Castle in the Hollywood Hills, where the authors performed a magician-neuroscientist routine in a bid to win entry into the Academy of Magical Arts. Minds were read, salt was teleported and an entire brain was replicated. (In fact, the authors provide a detailed recipe for a Jell-O brain.) By tricking readers into having fun learning neuroscience, Martinez-Conde and Macknik bring the newly minted field of "neuromagic" to center stage. — *Laura Sanders*

Henry Holt & Co., 2010, 304 p., $26.

Origins: How the Nine Months Before Birth Shape the Rest of Our Lives

Annie Murphy Paul

Gestation isn't destiny, but a person's physical and emotional future do start to form before birth. In her up-close look at the first nine months, Paul deftly intersperses a scientific tour of how fetal environments influence later health and well-being with personal glimpses of her second pregnancy.



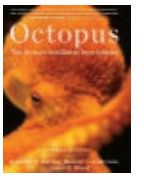
A picture emerges of scientists seeking prenatal insights that have the potential to improve babies' lives — but also to freak out expectant parents. In that vein, Paul, a journalist, candidly describes her own science-fueled fears that eating raw fish and getting too stressed during pregnancy will harm her unborn child.

Early in Paul's pregnancy, she talks to David Barker, a physician who about 20 years ago noted a link between low birth weight and heart disease in adults. Studies now suggest that mothers who eat poorly give birth to small babies with altered energy requirements, setting these infants up for later heart disease.

Other research links malnutrition during pregnancy to a child's increased risk of developing schizophrenia and ties maternal depression to fetal and childhood stress sensitivity.

Paul makes a strong case for the importance of the first nine months, but clearly all is not lost for those who begin life with some gestational disadvantage. Paul wisely cautions that prenatal risks push children in a general direction rather than determining their fates. Stressed, sushi-eating mothers-to-be can still give birth to healthy kids with bright futures. — *Bruce Bower*

Free Press, 2010, 306 p., $26.



Octopus

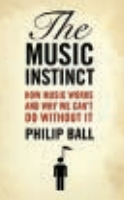
Jennifer A. Mather, Roland C. Anderson and James B. Wood

An in-depth look reveals the uncanny smarts and elegant adaptations of these eight-armed wonders. *Timber Press, 2010, 208 p., $25.95.*

The Dog Who Couldn't Stop Loving

Jeffrey Moussaieff Masson

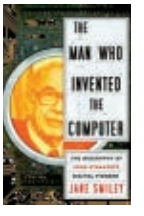
Not just an animal lover's tale, this book looks at recent scientific research on how humans evolved to care for canine companions. *Harper, 2010, 249 p., $25.99.*



The Music Instinct

Philip Ball

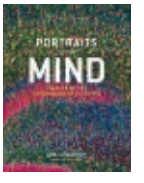
A journalist draws on neuroscience, anthropology and philosophy to explore the universal human experience of music. *Oxford Univ. Press, 2010, 452 p., $29.95.*



The Man Who Invented the Computer

Jane Smiley

The best-selling author tells a quirky tale of John Atanasoff, an Iowa physics professor who in the 1930s pursued the dream of faster calculations. *Doubleday, 2010, 256 p., $25.95.*



Portraits of the Mind

Carl Schoonover

From hand-drawn sketches to high-tech views of single neurons, a neuroscientist unpacks the visual history of brain imaging. *Abrams, 2010, 239 p., $35.*

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Underground particle hunts

The dark matter experiments described in "Mining for missing matter" (*SN: 8/28/10, p. 22*) sound almost identical to those looking for neutrinos. Both are placed deep underground to help screen out background radiation, especially neutrons. How do particle hunters differentiate between neutrino hits and those by the putative dark matter particles? Also, the article makes it sound like investigators think there is only one type of [exotic] dark matter particle. Why is that when there is an entire zoo of normal matter particles and forces?
James Smith, San Jose, Calif.

Neutrinos, for the most part, would deposit much more energy than that expected for dark matter particles, though a few rare types of neutrino interactions could produce signals similar to those of dark matter particles. The sizes of the detectors have been very different, though, with dark matter detectors in the 10 to 100 kilogram range and neutrino detectors upwards of 100,000 kilograms. If much larger detectors have to be built to detect dark matter, then neutrino interactions may well prove to be a limiting background, says Dan Bauer of Fermilab. He adds that, in fact, "most theories do allow for an entire zoo of exotic particles. However, most of these particles will be either charged or decay into other exotic particles. The particle that makes up dark matter has to be neutral and stable to have survived for the entire history of the universe. Typically, this is taken to be the exotic particle with the lowest mass, into which all other exotic particles eventually decay."
—Ron Cowen

Seeking truth with science

Wow! Harold Kroto is a scientist ("Treat science right and it could help save the world," *SN: 8/28/10, p. 32*) who can explain in lay terms what science is and what we need to do to help young people, who will soon be the ones dealing with the catastrophe our planet has become. Thank you. Spoken from a stance of firm, but insightful argument.
Nanci Watkins, Frederick, Colo.

Mr. Kroto's comments highlight a serious problem in today's culture. The loss of civility in our society has made it popular to advance our particular beliefs by attacking the failure of others rather than to focus on how we can cooperate with the larger community to accomplish our goals. We have developed many disciplines to help order our lives. Science is only a recent development. I think it is way too early for science to claim the mantle of The One and Only Ultimate Truth.
L.R. Davis, Margaretville, N.Y.

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

Katherine Wallman

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

Top statistician explains what all those numbers mean

In June, the United Nations passed a resolution designating October 20 as World Statistics Day. The United States planned to mark the occasion with a gathering on Capitol Hill of representatives from number-crunching agencies. Science News *writer Laura Sanders recently spoke with U.S. Chief Statistician Katherine Wallman about why numbers matter.*

What does the United Nations have to do with statistics?

The U.N. has a statistical commission and actually, one of the original functions of the United Nations was to produce comparable statistical information across the countries of the world. This has been an ongoing function since the beginning of the U.N. over 60 years ago. The commission's work has always been probably the most technical work that goes on — the freest, shall we say, from political interests.

What does the chief statistician do?

My office is not a data-producing office, but rather, an office that provides oversight, coordination, priority settings and standard settings for [national statistics].

The systems around the world vary between centralized and decentralized. None of them are totally centralized, but our country is more decentralized than some. That means that we have multiple agencies that actually produce the statistics on which the country relies. If you're talking about our population data, then you're talking about the Census Bureau. If you're talking about our national accounts, then you're talking about the Bureau of Economic Analysis. If you're talking about health statistics, you're talking about the National Center for Health Statistics, and so on. And we can iterate that for criminal justice and education and transportation and so on, which is why I say we have about a dozen agencies in the federal government that produce these statistics, and large [volumes] of them.

In the same way my colleagues worry about priorities for improving health and education or so on, I'm the person who worries the most about improving our statistical programs and how the budget is affected by that.

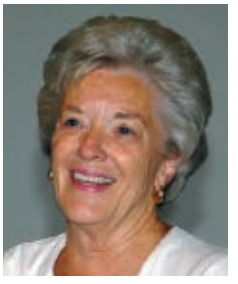
What kinds of statistics are important at the national level?

The most obvious ones are probably on the demographic side, especially since we've just had a census. Everyone is very attuned to the population counts that come from the census and the fact that those are used for reapportionment and redistricting of the U.S. Congress. At more local levels, those numbers are also used in drawing local election districts.

I should also point out that those census counts and other data we produce are used to allocate hundreds of millions of dollars every year....

The second thing that probably should be obvious to people, but perhaps they've forgotten about it, is the use of our economic statistics — our numbers on employment, our numbers on changing prices, our numbers on gross domestic product. Those are used in all kinds of both public and private decisions, about monetary policy, about business policy. You see the attention that's given to the employment numbers roughly the first Friday of every month. There's always great anticipation about what the employment numbers are going to be. The stock market rises and falls on those numbers, literally....

The awareness of the nation's obesity epidemic comes from the statistics that we gather on a routine basis in the National Center for Health Statistics. We have a rather unique program called the National Health and Nutrition Examination Survey that actually goes out and measures people and takes blood samples. It's by following information like that that we can tell with data and not just with anecdotes the increasing tendency towards overweight and obesity in the population.



People have a lot more numbers readily at their disposal.... But they don't necessarily have the statistical literacy to go with it.

It's energy, it's environment. If we look at transportation statistics, we learn everything from usage of the roads and where we may need new roads to on time airplane arrivals. All those things, at the heart, are the result of statistics that are being produced by the federal government, and some of those may be less obvious to people.

How good are people at understanding what numbers mean?

I personally believe that with the advent of computer technology, people have a lot more numbers readily at their disposal. They have a lot of computer literacy, but they don't necessarily have statistical literacy to go with it. So they can manipulate lots of numbers but they may not be doing it in the best advised fashion. I do have a concern personally about the gap between the availability of information and the computer literacy of our population and the statistical literacy they should have if they're going to use these numbers most intelligently. ■

ERIC SAMPSON/AMERICAN STATISTICAL ASSOCIATION

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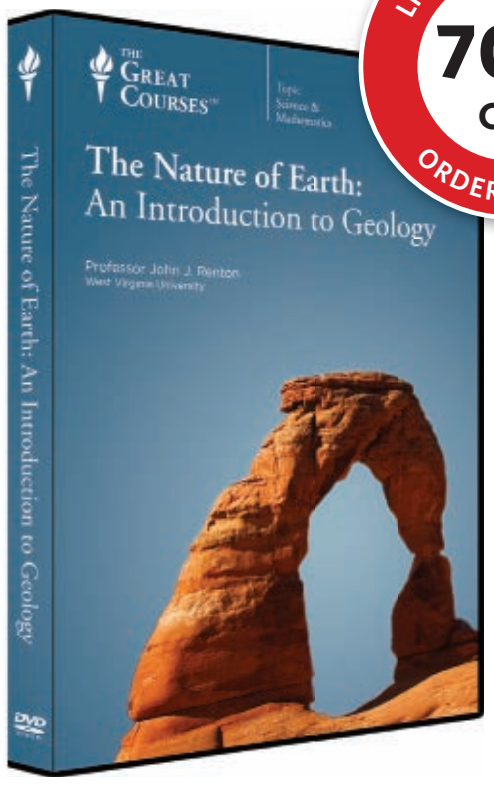

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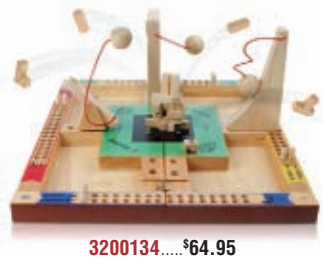

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