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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ MAY 10, 2008

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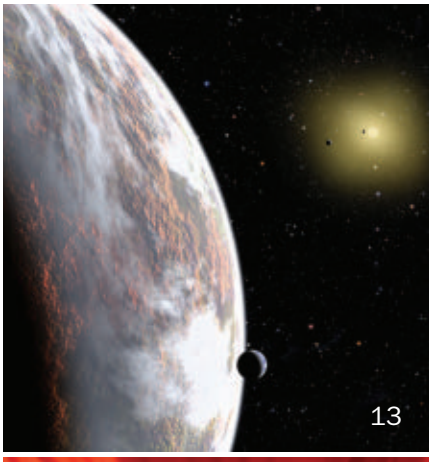

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MAY 10, 2008 • VOL. 173 • NO. 16

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On the cover:
Smoke from burning fossil fuels signifies rising CO_2 levels; scientists hope to capture and store CO_2 to combat global warming.

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FROM THE EDITOR

Welcome to the new *Science News*

WITH THIS ISSUE, *SCIENCE NEWS* opens a new chapter in its tradition of reporting on the world of scientific investigation and discovery.

As I recount in an essay (page 30), the magazine's packaging has evolved since its inception in the 1920s, and even its name has been truncated from the original *Science News-Letter*. But as its look has changed, its purpose has remained steadfast, the substance uncompromised. And so it is with the *Science News* that you now hold.

Henceforth *Science News* is no longer a weekly magazine, but a daily science news provider, offering up-to-the-minute accounts from the frontiers of research on our newly revamped website, www.sciencenews.org. The magazine, now to appear every other week, remains the repository for news highlights, with concise and crisp, authoritative and reliable reports from all realms of scientific research.

The magazine will still include feature articles. Some will provide context and insight on major science-related issues, such as Sid Perkins' report (page 18) on efforts to sequester carbon dioxide from the atmosphere. Other features will explore new developments at the frontiers of current knowledge. And some will just relate what's new in science to what's interesting in life.

Science News will continue its long tradition of calling our readers' attention to worthy new science books. And we are adding some new departments, including space for comment from distinguished scientists on matters where the concerns of science and society converge, such as Nobel laureate Leon Lederman's observations on science education (page 36).

Many of you will miss our weekly arrival in your mailbox. Others, our research suggests, have found the weekly schedule too much to keep up with. Our new approach offers what we believe to be the ideal compromise — daily availability of the news online for those who can't wait, and biweekly delivery in print for those preferring a more leisurely pace of information acquisition.

It is our hope that the magazine's new schedule and remodeled appearance will draw a wider audience to *Science News*, helping to ensure its long-term survival in today's competitive media environment. To longtime loyal readers who may be concerned or dismayed by its new look, I promise that the magazine's mission has not changed and that the quality of its content will not be diminished.

—Tom Siegfried, Editor in Chief

SPENCER NORCROSS

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The Wave® music system shown in Graphite Gray.

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Scientific Observations

"We … draw conceptual categories around entities that we easily perceive, and in so doing we carve out what seems to us to be reality. The 'I' we create for each of us is a quintessential example of such a perceived or invented reality, and it does such a good job of explaining our behavior that it becomes the hub around which the rest of the world seems to rotate."

—DOUGLAS HOFSTADTER, *I AM A STRANGE LOOP*

Science Past: 50 Years Ago

From *Science News Letter*, May 10, 1958

The first reports on findings from the first two U.S. satellites have been announced.... They included: A mysterious radiation ... at heights greater than 600 miles above the earth's surface.... Dr. [James] Van Allen and his colleagues at the State University of Iowa calculate that if the satellite's cosmic ray geiger tube had not been jammed by an intense radiation field, it would have registered at least 35,000 counts per second. They believe this radiation is closely related to the soft radiation previously detected during rocket flights in the auroral zone.... The energy of this radiation, they suggest, may contribute significantly to the heating of the high atmosphere. The particles causing it are believed to be initially associated with huge masses of ionized gas encountered by the earth in its journey through space.

Science Future

May 16

Scheduled launch date for GLAST, NASA's Gamma-ray Large Area Telescope. Visit **glast.gsfc.nasa.gov**.

May 28–June 1

The World Science Festival, an event-filled celebration and exploration of science in modern life, in New York City. See **www.worldsciencefestival.com**.

August 1

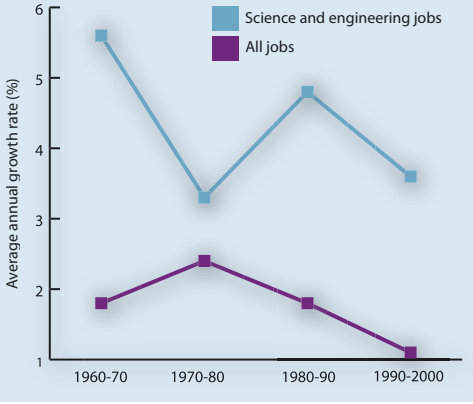
Total solar eclipse, visible in Asia. Visit NASA's site for more at **eclipse.gsfc.nasa.gov**.

The (-est)

The smallest black hole known is as massive as 3.8 suns, two NASA Goddard Space Flight Center researchers reported in March. The black hole's size is a relic of its origin. It likely formed from the collapse of the core of a massive star. The timing of X-ray flashes from the black hole's vicinity provides a measure of its mass that is more precise than earlier calculations.

Science Stats

SCIENCE JOBS GROW FASTER THAN OTHERS



Each decade, the growth rate of the number of people in science and engineering jobs surpassed that of the overall workforce.

SOURCE: NATIONAL SCIENCE BOARD, SCIENCE AND ENGINEERING INDICATORS 2008

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SN TODAY

Your spot for each day's top science stories.

SIGHTS & SOUNDS

Go beyond words. See a lungless frog, starlings flying in formation and much more.

NEW BLOG: SCIENCE & THE PUBLIC

Veteran SN reporter Janet Raloff charts the interface between science and society in her blog. Find out which country recently overtook the United States as the No. 1 emitter of carbon

dioxide, and why grasshoppers, crickets and their six-legged peers may offer a more sustainable source of animal protein than fish and hoofed livestock.

MATHTREK

Columnist Julie J. Rehmeyer breaks down math-e-mat-ics, from primes to stats.

SCIENCE SAFARI

SN highlights science-rich websites geared for students, teachers and the naturally curious.

SN BOOKSHELF

Check out the latest science books.

ROD SEARCEY; AUDUBON NATURE INSTITUTE

"What's exciting is that now we have a biological account of how multitasking affects driving behavior." —MARCEL JUST, PAGE 7

In the News

STORY ONE

Rest in peace nanobacteria, you were not alive after all

Mystery particles made of minerals and proteins may still cause disease

By Tina Hesman Saey

In a solution of blood serum, calcium carbonate can form particles that look like so-called nanobacteria, even appearing to divide like cells.

MARTEL AND YOUNG

Nanobacteria, extremely tiny "microorganisms" that have sparked controversy and may cause disease, have been declared dead. Again.

Some say the nanobacteria were never really alive. Once touted as the world's smallest living organisms, and even an entirely new form of life, the entities are actually nothing more than sub-microscopic balls of minerals and proteins, independent teams of scientists in Taiwan and France report.

Surviving the nanobacteria is their "father," Robert Folk, a geologist from the University of Texas at Austin, who discovered them in deposits from Italian hot springs in the early 1990s. Folk and his colleagues have since found the objects, which are a thousandth the size of common bacteria such as *E. coli*, in sedimentary mineral deposits ranging from limestone to iron oxides to silicates. The microbes may be major players in eroding rocks to make soil, Folk believes.

Initial evidence for nanobacteria sparked excitement among many microbiologists, geologists and other researchers. Some experts were skeptical that the ingredients to make a living cell could be crammed into such a tiny package. DNA is 2 nanometers wide, and some proteins are as large as the proposed size of nanobacteria, 80 to 500 nanometers. But nanobacteria have been cultured in laboratories and seen to grow in number, albeit slowly.

Finnish researchers found nanobacteria in human and cow blood about the time that Folk discovered the organisms in rocks. Since then, nanobacteria have been linked to kidney stone and gallstone formation (*SN: 8/1/98, p. 75*), polycystic kidney diseases, rheumatoid arthritis, some cancers, co-infection with HIV, Alzheimer's disease and chronic prostatitis. They have also been implicated in hardening of the arteries and aging.

The discovery of what appeared to be evidence of nanobacteria in a Martian meteorite (*SN: 8/10/96 p. 84*) sparked extreme reactions from people who were excited about a new form of life (especially one that might have lived on Mars) and people who doubted the existence of nanoscale living organisms.

"It had the optimists turning cartwheels and the naysayers enraged, and it's stayed the same ever since," Folk says.

John Ding-E Young of Chang Gung University in Taiwan believed in nanobacteria so much that he and graduate student Jan Martel embarked on a series of experiments to prove that the microorganisms couldn't be just mineral deposits.

"I really wanted these people to be right," Young says. Instead, the team found just the opposite.

Calcium minerals (found in seashells, eggshells and marble) and calcium phosphate (the stuff that bones are made of) »

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SN Today at **www.sciencenews.org**

» are thought to compose nanobacteria's crusty exterior. When the researchers made calcium carbonate in a solution used to nourish cells, the mineral formed round particles that looked like the nanobacteria found in blood and rocks. Some of the particles even resembled bacteria in the act of reproducing.

Then the researchers made the calcium carbonate particles grow by seeding the solution with human blood serum — a common ingredient in solutions used to grow cells — and incubating the solution with carbon dioxide. More tiny calcium particles formed over the next few days, similar to the slow reproduction time of nanobacteria.

A protein called albumin in the blood serum seems to seed nanoparticles but keeps the calcium carbonate from forming crystals, Young and Martel reported in the April 8 *Proceedings of the National Academy of Sciences*.

Working independently, a group of researchers in France also showed that nanobacteria aren't living organisms.

"These things can be replicated, but we quickly found that they aren't bacteria at all," says Didier Raoult, a microbiologist at the National Center for Scientific Research in Marseille, France.

In a study published February 15 in the online journal *PLoS Pathogens*, Raoult and his colleagues described nanobacteria as complexes of minerals and a protein called fetuin. Fetuin prevents minerals from forming crystals but may aid in clumping calcium molecules into the hollow spheres characteristic of nanobacteria.

But the particles can "infect" other solutions, producing more nanobacteria. "There is something transmissible," Raoult says. "I don't know why, and I don't know what it is. It's not living." He theorizes that nanobacteria, which he dubbed nanons, may work like infectious proteins called prions, which cause mad cow disease, scrapie in sheep and several human brain diseases.

This is not the first time the bell has tolled for nanobacteria. A report in 2000 showed that the entities lack DNA. "In fact, there's no nucleic acid at all," Raoult says.

Folk concedes that the two groups "did a good job" of showing that the particular nanobacteria they studied are nonliving. But the organisms are so diverse that "one explanation is obviously not going to fit all." If the groups had investigated some of the nanobacteria that he has collected, they would find a different story, he says.

"Some are shaped like kidney beans. These are not shapes that minerals take. It's clearly biological," Folk says.

But even researchers who believe nanobacteria may cause disease had already started edging away from the idea that they are minuscule bacteria, even before the latest publications.

"For me it's not important if they are living or not," says Andrei Sommer of the University of Ulm in Germany. "It's more important to focus on their clear link to disease and how to eliminate them." Wrangling over whether nanobacteria are alive or dead is "only blocking the brain and blocking action," Sommer says.

Sommer and his colleague Dan Zhu isolated nanobacteria from fluid found in the joints of people with arthritis. The researchers described their technique in an article that appeared online April 2 in *Environmental Science & Technology*.

"We're just on the brink of understanding how these particles participate in disease."
–VIRGINIA MILLER, MAYO CLINIC

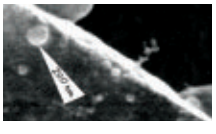
Those who study nanobacteria are used to controversy. "We hear, 'You're studying something that doesn't exist,'" says Virginia Miller, a physiologist at the Mayo Clinic Medical School in Rochester, Minn., who studies "self-replicating calcifying nanoparticles" and their link to disease. Others have called the particles living nanovesicles or nanobiota.

"We're just beginning to understand how particles at the nanoscale interact with cells," Miller says. "It would be a very sad thing if these two papers capped that avenue of research. We're just on the brink of understanding how these particles participate in disease."

Young isn't ready to bury nanobacteria yet, either. "My thinking is that these structures are not only real, but they are important," he says.

But if the particles aren't itty-bitty bacteria, scientists have to decide what to call them. "It's nonsense to use the name nanobacteria," Sommer says. "At the same time, it's unfair not to use it because it would be cutting off a whole history of research." ■

Back Story



1993

Nano-sized calcite structures from hot spring minerals are identified as tiny life-forms.

1996

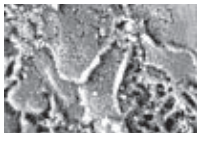
Evidence suggests a Martian meteorite contains tiny life-forms—later shown to be just minerals.

1997

A team identifies nanobacteria in mammalian blood and later suggests a role in kidney stones.

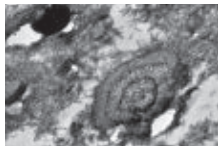
2000

Another team finds that nanobacteria appear similar to mineral crystals and contain no DNA.



2004

Alive again, nanobacteria are discovered in hardened arteries and found to contain DNA.



2008

More evidence bolsters the idea that nanobacteria are not life-forms.

R. FOLK/UNIV. OF TEXAS AT AUSTIN; NASA; PNAS; J. CISAR/NIH; AMERICAN JOURNAL OF PHYSIOLOGY—HEART AND CIRCULATORY PHYSIOLOGY; PLOS PATHOGENS

Humans

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Shifting priorities at the wheel

Multitasking while driving may exceed brain's capacity

By Bruce Bower

A SPECIAL CORNER OF HELL IS RESERVED for drivers who weave from lane to lane at a crawl while blithely chatting on their cell phones. Even a simple form of multitasking — driving while listening to someone else talk — disrupts the ability to navigate a car safely, a new study finds.

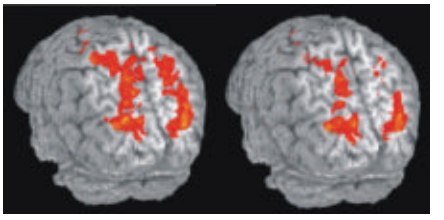
Using functional MRI to watch the brains of people during a driving simulation, researchers find that an intriguing neural response underlies vehicular mishaps associated with such distractions, say neuroscientist Marcel Just of Carnegie Mellon University in Pittsburgh and his colleagues. Attending to what someone is saying galvanizes language-related brain areas while reducing activity in spatial regions that coordinate driving behavior.

People who combine relatively automatic tasks, such as speech comprehension with car driving, exceed a biological limit on the amount of systematic brain activity they can accommodate at one time, the researchers propose in the April 18 *Brain Research*. As a result, the less-ingrained skill — in this case, driving, which is learned long after a person grasps a native language — takes a neural hit.

"What's exciting is that now we have a biological account of how multitasking affects driving behavior," Just says.

Cell phones are particularly problematic, Just notes. So as not to appear rude to an unseen listener, a driver will give the conversation constant attention. Just suggests that other activities may also dent the ability to maneuver a car: listening to a radio, eating, monitoring children and conversing with a passenger.

"Listening to talk radio or to spoken directions from a navigation system while driving probably have similar effects to what we found," Just says. "Multitasking puts high demands on the brain."



Images from fMRI scans show that activity in brain areas involved in driving decreases 37 percent when the driver is listening to someone talk (right) versus not (left).

Psychologist David Strayer of the University of Utah in Salt Lake City agrees, adding that the new results offer a conservative estimate of the neural impact of multitasking on driving. Strayer and his colleagues have documented steep declines in skill during simulated driving, as well as a marked drop in driving speed among volunteers using handheld or hands-free cell phones.

Just's team studied 29 adults, ages 18 to 25. Each participant lay in an fMRI scanner equipped with a screen that displayed a simulated driving exercise. These machines measure blood-flow changes in the brain, signaling rises and falls in neural activity.

Hobbit wars

Small islanders show no signs of growth disorder

By Bruce Bower

COLUMBUS — DEFENDERS OF A SMALL humanlike species that lived on an Indonesian island over 12,000 years ago have new fossil reconstructions and comparisons to bolster their view. Remains of *Homo floresiensis*, also referred to as hobbits, display no signs of growth disorders proposed by researchers who regard the fossils as those of modern humans, says Dean Falk of Florida State University in Tallahassee.

Instead, Falk and Florida State colleague Angela Schauber suspect *H. floresiensis* — especially a partial skeleton fossil called LB1 — adapted to a challenging environment by evolving into a smaller but proportionally equivalent version of an earlier species, possibly *Homo erectus*.

"LB1 didn't have any of the growth pathologies that have been attributed to it," Falk says. She and Schauber presented separate papers in April in Columbus, Ohio, during a meeting of the American Association of Physical Anthropologists.

Work published last year suggested *H. floresiensis* fossils exhibit 33 skeletal symptoms of Laron syndrome, a type of insensitivity to growth hormones. But Falk reported almost no similarities between a skull from LB1 and published data on Laron syndrome, which includes a protrusion of the forehead and a depressed ridge on the nose. LB1 also possesses "whopping long feet," she adds, unlike the small feet observed in the syndrome. Preliminary findings also suggest that LB1 didn't suffer from two other growth disorders.

A separate investigation by Schauber suggests that certain foxes and mice have evolved into "proportional miniatures" of larger counterparts. "The same process could apply to *H. floresiensis*," she says.

Skull reconstructions (bottom) suggest, contrary to corresponding photographs (top), that hobbits belonged to a unique species.

But Robert Eckhardt of Pennsylvania State University in University Park still regards LB1 as a pygmy *Homo sapiens* with an undetermined growth disorder.

KIRK SMITH/MALLINCKRODT INST. OF RADIOLOGY, WASHINGTON UNIV. IN ST. LOUIS SCHOOL OF MEDICINE; E. INDRIATI, D. FRAYER; M. JUST

Life

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Elephant kin liked the water

Isotopes in tooth fossils add new clues to debate

By Sid Perkins

Chemical analyses of fossil teeth suggest that *Moeritherium*, ancient relatives of modern-day elephants, spent much of their time in freshwater habitats.

THE ANCIENT KIN OF MODERN ELEPHANTS may have spent much of their time in lakes, rivers or swamps.

Creatures in the proboscidean genus *Moeritherium* have been known for more than a century, but scientists have never agreed about how the animals lived, says Alexander G.S.C. Liu, a paleontologist at the University of Oxford in England.

Liu and his team analyzed fossils from 37-million-year-old rocks southwest of Cairo. Other fossils from the same sediments include terrestrial animals along with sharks and marine fish. The shapes of *Moeritherium* skulls, placement of their eyes and other features hint that the 300-kilogram animals lived aquatic or semiaquatic lifestyles. However, he notes, the arrangement of bones in their inner ears doesn't suggest that the creatures could have heard well underwater. They likely were not full-time swimmers.

Liu and his colleagues weighed in on the debate by analyzing the ratio of oxygen-16 and oxygen-18 isotopes preserved in the teeth of *Moeritherium* fossils. Most atoms incorporated in tooth enamel when a creature is alive don't readily swap out with those in the environment during fossilization. Therefore, that isotope ratio, among others, can provide clues to various characteristics of a creature's environment, its metabolism or its dietary preferences.

The main clue was that the variation in oxygen isotope ratios among *Moeritherium* samples was extremely low. Creatures that spend much or all of their time on land get their water from a variety of sources, so their populations often have a much broader variation in ratios, Liu notes. The new evidence suggests that *Moeritherium* spent much of its time in or around freshwater habitats, the researchers reported in the April 15 *Proceedings of the National Academy of Sciences*.

"When the morphology, geology and isotope evidence come together and tell the same story, it's really nice," says Bill Sanders, a paleontologist at the University of Michigan in Ann Arbor. ■

China was an ancient-ape paradise

Excavations uncover oldest known ancestral gibbon remains

By Bruce Bower

COLUMBUS — EXCAVATIONS near the steep edge of a plateau in southern China have uncovered a trove of ancient ape fossils, including what are being reported as the oldest known remains of ancestral gibbons.

Fragmentary bones found earlier had been used to suggest that an ape genus known as *Yuanmoupithecus* evolved from East African apes that lived more than 10 million years ago.

But the newly discovered fossil teeth (pictured at left) of *Yuanmoupithecus* dash that hypothesis, says Terry Harrison of New York University. The teeth show clear similarities to those of modern gibbons, small Asian apes that live in rainforests, he reported in April in Columbus, Ohio, at an American Association of Physical Anthropologists meeting.

Analyses of soil layers bracketing the finds indicate the fossils are 9 million years old. DNA studies of living apes suggest that ancestral gibbons first emerged around 10.5 million years ago, not long before the appearance of *Yuanmoupithecus* in southern China.

"This is an important discovery," Harrison says. "I've long hoped to find an early gibbon ancestor."

The southern China and southeastern Asia area was probably a safe haven for small-bodied ancient apes such as *Yuanmoupithecus*, Harrison proposes. Earlier geological data indicated that land movements and the onset of monsoon rains throughout that region by 10 million years ago created the dense forests that such apes favored.

T. HARRISON; L. BETTI-NASH/STONY BROOK UNIVERSITY

Study decodes papaya genome

Tropical fruit tree's DNA has surprisingly few genes

By Rachel Ehrenberg

THE TROPICAL TREE WHOSE FRUIT PACKS a vitamin-rich punch has become the fifth flowering plant to reveal its genome. An international team of researchers has unveiled a draft of the catalog of genetic information needed to make papaya.

It's the first time researchers have compiled the genome of a transgenic fruit crop — the papaya variety had been genetically modified for protection against a virus. The new work will help scientists develop a quick way to determine the sex of a papaya tree. Plants with both male and female flowers are the only ones farmed for fruit, but these plants can't be distinguished from all-male or all-female plants until the trees are 3 to 4 months old. "This will really help the farmers," says Maqsudul Alam, who led the project at the University of Hawaii at Manoa.

The work also illuminates how plant genetic blueprints have changed through evolutionary time and from domestication. "This will help us understand wild genomes as well," says botanist Elena Kramer of Harvard University.

For the size of its genome, about 372 million letters of DNA code, the papaya has surprisingly few genes — under 25,000, the researchers reported in the April 24 *Nature*. Rice, grape and poplar all have genomes similar in size, but have 6,000 to 20,000 more genes than papaya.

The plant might make up for its lack of some genes by making other genes multitask. The researchers found a surprising number of MADS-box genes — 171 compared with 78 in rice — which are management-level genes known for influencing development by turning other genes on and off at just the right times.

Beetles portend crisis in Canada

Outbreak counters forest's ability to capture carbon

By Susan Milius

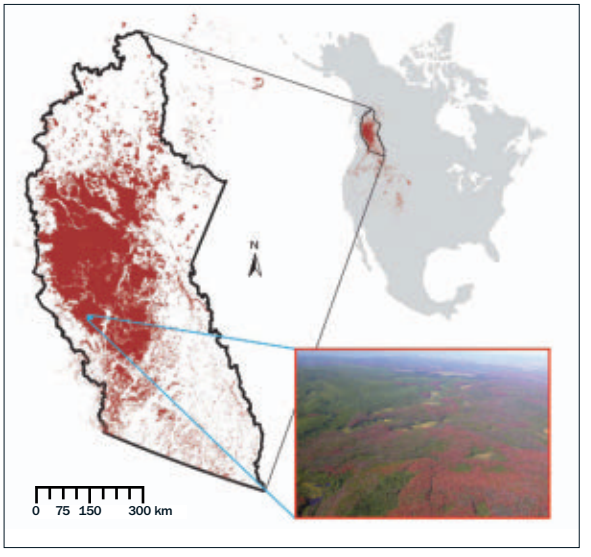
THE LARGEST OUTBREAK OF MOUNTAIN pine beetles on record is turning a forest in British Columbia from part of the solution into part of the problem in the fight against greenhouse gases.

Climate modelers typically count the great boreal forests that stretch across Canada and Russia as friendly assets, helping to take up and store a bit of the excess carbon dioxide that human activity releases into the atmosphere.

Not so anymore for part of Canada's forest, in south-central British Columbia, says forest ecologist Werner Kurz of Natural Resources Canada's Pacific Forestry Centre in Victoria. Records plus a computer model show that beetle damage will probably make the region a net source of carbon at least until 2020, Kurz and his colleagues report in the April 24 *Nature*.

"What is unique and new is that we have been able to improve the model and the data so that we can run the model with, and without, the beetle," Kurz says. It marks the first time greenhouse-gas bookkeeping has weighed the effects of an insect outbreak, he says.

When infested trees die, the forest takes up less carbon dioxide. Also, the wood starts decaying and the dead trees themselves release the carbon they once stored. Carbon pal becomes carbon problem.



In a swath of British Columbia, trees turn red after dying from attack by mountain pine beetles and their hitchhiking fungus.

The computer model finds a big carbon footprint from the beetles, comparable to about a quarter of the emissions from Canada's transportation sector per year. The insect infestation may lead to the release of a total of 270 million metric tons of carbon between 2000 and 2020.

Such upsets in forests need attention as scientists try to understand climate change, says forest ecosystem ecologist Tom Gower of the University of Wisconsin–Madison.

Ironically, the beetle disturbance is itself fueled by climate change. The mountain pine beetle, *Dendroctonus ponderosae*, is native to North America. The beetle larvae spend winters under the bark of mature pines. Every once in a while, beetle populations boom until they "eat themselves out of house and home," Kurz says. Warming temperatures allowed them to expand their range northward, and warm winters failed to blast them with larva-killing cold snaps. Starting in 2000, beetle populations began rising explosively, infesting an area about the size of Alabama. "We've never seen an outbreak like this before," Kurz says.

MAP: NAT. RES. CANADA; PHOTO: J. WESTFALL/ENTOPATH MANAGEMENT

Body & Brain

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

Triggering autoimmune assaults

Mouth bacteria unleash inflammation-inducing protein

By Janet Raloff

SAN DIEGO — OUR BODIES PROVIDE FOOD and shelter for trillions of microbes — bacteria, yeasts and other squatters. Now, researchers report that a few resident species release a substance that can inappropriately rev up the immune system. If this happens at the wrong time, animal tests suggest, the body may launch a dangerous assault against itself.

Once such an autoimmune attack begins, the body finds it hard to shut it down, notes Robert B. Clark. The question has always been what triggers autoimmunity — the condition underlying multiple sclerosis, rheumatoid arthritis, inflammatory bowel disease and a host of other disorders.

Clark's team, at the University of Connecticut Health Center in Farmington, has stumbled onto one new candidate culprit. It's a fatty compound — phosphoethanolamine dihydroceramide, or PEDHC for short — produced by bacteria residing in the human mouth. The researchers learned about it from a dental colleague, Frank Nichols, who noticed that it caused inflammation in test tube studies and showed up in human tissues that experienced inflammation.

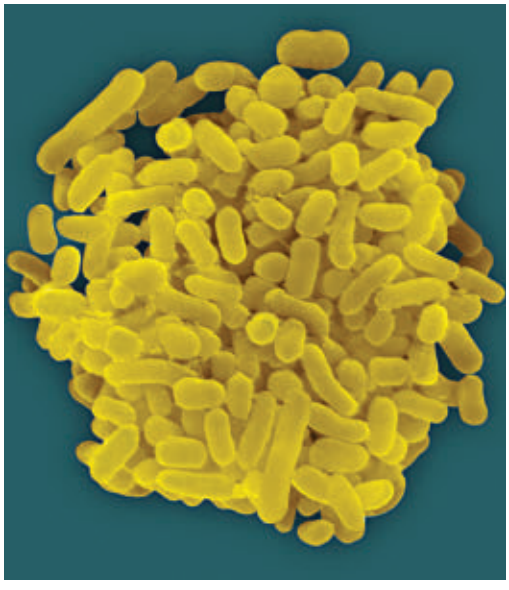
Curious about whether it might affect autoimmunity, Clark's group tested PEDHC in a mouse model for MS known as experimental autoimmune encephalomyelitis.

To bring on the disease, researchers inject rodents with an emulsion containing brain proteins together with a chemical that enhances immunity. Soon, immune machinery in the mice begins mistaking the brain proteins as alien and attacks them. Immune scouts find plenty more of the "alien" proteins in the rodents' actual brains, unleashing autoimmune disease there within 12 to 17 days.

The induced autoimmunity develops two to four days earlier and is far more severe in animals that also receive PEDHC, even in trace amounts, the immunologists reported in April in San Diego at the Experimental Biology meeting.

"We all harbor cells that could cause autoimmune disease," Clark explains, but it develops only when a certain poorly defined cascade of features or events occur, in a particular order.

It's likely that most people develop conditions that might trigger autoimmunity, he says — but never quite get there.



This microbe, *Porphyromonas gingivalis*, has a reputation for fostering gum disease. Now, scientists find hints that it may have a sideline gig: triggering autoimmunity at distant sites in the body.

His group's new data now indicate that exposure to an additional hyperstimulatory agent — like PEDHC — may tip the balance.

Administering PEDHC alone doesn't turn on autoimmunity, Clark says. It appears to be a problem only when the body has first been primed to attack itself by some as yet poorly understood events. Then the fatty compound can trigger a full-scale assault.

The findings support a burgeoning interest in how resident — or commensal — bacteria affect immunity. Some experts suspect the products of these bugs, such as PEDHC, may constitute formerly unsung but important pieces of the puzzle about what influences autoimmunity on the molecular level.

PEDHC's oral source, *Porphyromonas gingivalis*, is not among the body's nobler squatters. This germ can cause inflammation of tissues in the mouth, though good dental care can keep these bugs from harming gums and teeth.

Because PEDHC is not produced by mammalian cells, the body appears to recognize it as foreign.

Indeed, says William Housley, a member of the Connecticut team, when immune system clarions known as dendritic cells encounter this fatty substance, they appear to "misinterpret it as a bacterial infection, even though there may be no bacteria present." If this occurs when the body is already primed to attack itself, the immune reaction may go ballistic.

Brushing teeth may be enough to release some of the fatty substance into the bloodstream, Clark says. From there, it can flow to wherever dendritic cells might be primed to attack.

And it's not just oral bugs that may play such a role. Clark points out that several different bacterial species found in the human gut and vaginal tract also make PEDHC.

The mouse data argue that "a very important trigger that we have been overlooking for years in the development of autoimmune diseases lies within us," Clark says.

The findings are potentially very important, argues Nicholas LaRocca of the National Multiple Sclerosis Society, which funded the work: "It presents a new area to look at in terms of possible therapeutic agents" to prevent autoimmune diseases or diminish their severity. ■

GETTY

Old drug offers new tricks for fighting cancer

DFMO shows promise at extremely low doses

By Nathan Seppa

SAN DIEGO — A DRUG ONCE ENVISIONED AS a treatment for established cancers might instead help prevent the occurrence of colorectal cancer. Other work suggests the uses for this old drug might extend to a deadly childhood brain cancer.

Scientists first synthesized the drug, DFMO, in 1979, but since then it has developed a reputation as a jack of all trades and master of few. In the 1980s, DFMO showed efficacy in treating African sleeping sickness and eventually got regulatory approval for that use. It also gained clearance as a skin cream to fend off sun-related skin cancer. Otherwise, DFMO seemed to have been lost in the shuffle.

"We're looking for commercial partners to try to move this drug forward."
–FRANK MEYSKENS

Part of the problem was a curious side effect of the drug. In some patients, it caused subtle, temporary hearing loss.

Now, oncologist Frank Meyskens Jr. of the University of California, Irvine and his colleagues have completed nearly two decades of testing very low doses of DFMO in people who are at high risk for colorectal cancer. Early on, the work showed that at doses only one-fiftieth the amount used to treat cancers, DFMO was safe and patients tolerated it well — and the hearing side effect didn't show up.

In the recent study, researchers recruited 375 people who had already had precancerous colorectal growths called polyps removed. The scientists randomly assigned some to receive placebo pills and others to get DFMO plus the long-standing anti-inflammatory drug sulindac — both at very low doses. After three years, all participants underwent colonoscopy to determine their polyp status.

The results were so clear that the trial was stopped. About 41 percent of participants receiving placebo pills showed a polyp recurrence, compared with only 12 percent receiving the two-drug treatment. Moreover, 17 people getting placebos had developed more than one polyp while only one receiving the drugs had.

"We're looking for commercial partners to try to move this drug forward," says Meyskens, who presented the findings in April in San Diego at a meeting of the American Association for Cancer Research.

DFMO, or difluoromethylornithine, inhibits the synthesis of polyamines, basic compounds in cells. "Elevation of polyamines leads to increased growth, and almost anything like that leads to cancer opportunities," Meyskens says.

In another study presented at the meeting, researchers in Australia found that DFMO shows promise against neuroblastoma, a brain cancer that preys on children.

Molecular biologist Michelle Haber of Children's Cancer Institute in Randwick, Australia, reported the results of an experiment in which she and her colleagues induced a form of neuroblastoma in mice. All the animals received a standard chemotherapy drug. But mice also getting DFMO stayed tumor-free longer and survived longer than the other mice. "When polyamine levels are low, it reduces the proliferative capacity of cells," Haber says.

Old drugs can have new uses, says Roy Herbst, a medical oncologist at the M.D. Anderson Cancer Center in Houston. "We need to look at all our resources. As we uncover the biology [of cancers] we need to look for our best agents that can target those pathways" essential to tumor growth. ■

MEETING NOTES

American Academy of Neurology
April 12–17, Chicago

Danger from pig brains

Slaughterhouse workers who inhale pig-brain particles risk contracting a nerve-damaging illness. More than 20 people have been diagnosed with the mysterious disease, which causes nondescript pain, weakness, fatigue and possibly paralysis.

The first case appeared in 2004 at a Minnesota slaughterhouse. Since then, at least 18 workers from that plant, Quality Pork Processors in Austin, have been diagnosed. Pork plants in Indiana and Nebraska have had similar problems. Neurologists at the Mayo Clinic in Rochester, Minn., now report new ways to systematically diagnose the unnamed disorder.

Blood test for MS

Doctors and patients have long hoped for an alternative to the spinal tap, a key test for multiple sclerosis. Now a research team funded by the biotech company Gene Logic Inc. reports possible success in developing a test analyzing blood rather than spinal fluid. Using new methods to measure gene activity, the group could distinguish 11 patients with MS from 12 people without the disease. "The idea is to do this blood test and let patients know what their risk of having MS is, up front," says Johns Hopkins neurologist Benjamin M. Greenberg.

A quicker path to Alzheimer's

People with a genetic predisposition for Alzheimer's who smoke and drink raise their risk for an earlier onset of the disease, a new study suggests. When combined, those factors can make a seven-year difference, says Ranjan Duara of the Mount Sinai Medical Center in Miami Beach, Fla.

—Amy Maxmen

Atom & Cosmos

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This X-ray image shows the location of the Milky Way's supermassive black hole, Sagittarius A*. New data indicate that the black hole was much more active about 26,000 years ago.

Black hole once glowed brightly

Fluorescing clouds provide clues to its former glory

By Ron Cowen

JUST OVER 26,000 YEARS AGO, A SLEEPING giant at the center of our galaxy suddenly awoke, spewed several pulses of X-rays and then went back into hibernation.

That's the conclusion of a long-term X-ray study of large gas clouds near the Milky Way's central, supermassive black hole — Sagittarius A*, a monster 4 million times the sun's mass. Data collected by four spacecraft from 1994 to 2005 show that X-ray pulses, apparently shot out by material just before it spiraled into the central black hole, caused the clouds to rapidly fluoresce and dim.

The intensity of the brightening suggests that the black hole, which now appears unusually quiescent, was once active. Material caught in its grip glowed a million times more brightly at X-ray wavelengths and was perhaps one of the brightest X-ray sources in the sky.

It's still a mystery why the Milky Way's central black hole is one of the most quiescent known and why the giant suddenly — but fleetingly — increased its X-ray output in the recent past. One possibility is that it went on a feeding frenzy, gorging on a temporary surplus of gas. This increase in food supply might have been created when a nearby supernova explosion hurled gas toward the black hole, suggests X-ray astronomer Richard Mushotzky of NASA's Goddard Space Flight Center in Greenbelt, Md. He notes that as astronomers attempt to examine X-ray fluorescence from clouds that lie even farther from the supermassive black hole, they may be able to probe the activity of the giant even farther back in time.

Astronomers see the black hole as it appeared 26,000 years ago, since the galaxy's center lies 26,000 light-years from Earth. Because the clouds lie 300 light-years from the black hole, they likely fluoresced 300 years after the black hole emitted the X-ray pulses, Katsuji Koyama of Kyoto University in Japan and colleagues report in an upcoming *Publications of the Astronomical Society of Japan*.

Battle over WIMPs goes another round

Claimed dark matter find remains controversial

By Ron Cowen

OF ALL THE THINGS WORTH ARGUING about in the universe, physicists are once again haggling over a bunch of WIMPs.

At a meeting in Venice in April, Rita Bernabei of the University of Rome announced that her team has found further evidence for an exotic subatomic particle called a WIMP, for weakly interacting massive particle. The new findings, based on years of experiments, are controversial. No other experiment has found evidence for the elusive particle.

Proving the existence of WIMPs could settle a 75-year-old puzzle about the identity of the dark matter in the cosmos and help physicists unify the four fundamental forces of nature.

In the latest version of their experiment, known as DAMA/LIBRA, Bernabei and her colleagues analyzed faint flashes of light from 25 sodium iodide detectors at the Gran Sasso National Laboratory beneath the Apennines east of Rome.

For 11 years, using two different sets of detectors, the team has found an annual rise and fall in the number of flashes that the scientists say is consistent with Earth moving through a vast cloud, or halo, of WIMPs enveloping our galaxy.

"The data show, with very high confidence level, agreement with all the features expected for the presence of dark matter particles in the galactic halo," Bernabei says. No known systematic errors or process related to known elementary particles accounts for the modulation in flashes, she asserts. The team's findings have been posted online.

"On the basis of their plots, there is no doubt that they do observe a modulation,"

F. BAGANOFF/MIT, NASA, CXC

says Bernard Sadoulet of the University of California, Berkeley, who searches for WIMPs in a mine in Minnesota.

Some of the objections physicists have raised in the past about the Italian experiments have been answered, but "the tension is increasing" between Bernabei's results and the lack of signal found by his team and other groups, Sadoulet adds. "I don't see how the two are compatible."

WIMPs have a strong appeal to both astronomers and physicists. For astronomers, WIMPs are one of the leading candidates for the invisible material, known as dark matter, believed to account for some 85 percent of all the mass in the universe. Physicists like WIMPs because they may belong to a family of elementary particles that would help scientists find a theory unifying all the known forces and particles in nature. In a proposed theory known as supersymmetry, every known elementary particle has a heavier, as yet undiscovered counterpart. WIMPs may be neutralinos, the lightest of these supersymmetric partners. The WIMPs that DAMA/LIBRA may have found could have a mass of about 50 times that of the proton.

The experiment relies on assumed distribution and properties of WIMPs. If the universe is indeed chock-a-block with this hypothetical stuff, simulations show that it would clump into vast halos extending hundreds of thousands of light-years beyond the visible outlines of galaxies like the Milky Way. And although the starlit, spiral arms of the galaxy rotate, the dark matter particles, immune to non-gravitational forces, would remain stationary.

"I don't think that ... DAMA/LIBRA on its own will be able to prove the existence of WIMPs."
–JUAN COLLAR

As it rotates, the Milky Way galaxy carries our solar system with it. In the summer, Earth moves around the sun in the same direction as the sun moves with the galaxy. So, during the summer, Earth would travel through the stationary WIMP cloud faster and experience a stronger wind of these subatomic particles. In winter, when Earth moves in the opposite direction, the WIMP detection ought to fall. That's just what Bernabei's team says it has consistently found.

One way to explain the discrepancy between the Italian experiment and other negative results could be that dark matter particles found by DAMA/LIBRA are very light, perhaps only a few times a proton's mass, notes Graciela Gelmini of the University of California, Los Angeles. Lightweight particles seen by DAMA/LIBRA might not produce a signal in the detectors used by other teams, she says.

In the end, says Juan Collar of the University of Chicago, "there's going to have to be information from particle accelerators, satellites and direct detections that all point to the same mass range and coupling. That's when we'll all start believing each other. I don't think that anyone is going to tell you that DAMA/LIBRA on its own will be able to prove the existence of WIMPs, but certainly if they're right, they were the first."

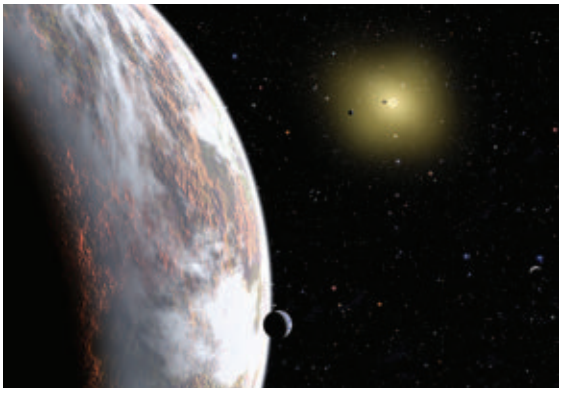
Searching for superEarths

Mass and radius may help identify places like home

By Ron Cowen

ST. LOUIS — IN THE QUEST TO FIND SOME place just like home, astronomers are exploring a new family of planets beyond the solar system — orbs only a few times heavier than Earth. And they're focused on finding rocky ones.

With exoplanet-seeking missions such as the European Space Agency's COROT, launched in 2006, and NASA's Kepler, set for launch this year, astronomers expect to find many superEarths. In the last three years, they have discovered five, ranging from five to 10 times Earth's mass.



D. AGUILAR/HARVARD-SMITHSONIAN

An artist's depiction of a superEarth near its parent star.

But because the bodies are too small and faint for telescopes to image, researchers can, typically, only determine an orb's mass and radius. Reporting in St. Louis at the April American Physical Society meeting, Diana Valencia of Harvard University and her colleagues suggest that this ability to determine a planet's mass and radius could help scientists decide whether a superEarth is, by volume, mostly ocean or ice or mostly rock (like Earth). For a given mass, a completely rocky planet cannot exceed a particular radius.

Theorist Sara Seager of MIT says she admires the model but that it may not distinguish a rocky planet with even a small atmosphere from an oceanic planet.

Rocky superEarths, Valencia's team reported, are more likely to undergo tectonic plate activity. A heavier planet has a larger internal heat source that can move thin plates of material at or near the planet's surface. Plate tectonics is essential for life as we know it because such activity recycles carbon dioxide between rock and the atmosphere, Valencia says. This carbon cycle stabilizes a planet's temperature.

Environment

For longer versions of these and other Environment stories, visit **www.sciencenews.org**

Spiders boost mercury levels

Birds eating arachnids get high dose of toxic metal

By Rachel Ehrenberg

IF YOU KNOW AN OLD LADY WHO SWALLOWED a spider, tell her to cough it up. Spiders and other insects living near a mercury-contaminated river contain unusually high levels of the toxic metal, a new study finds.

"We think of mercury as an aquatic problem," comments wildlife toxicologist Tony Scheuhammer of the National Wildlife Research Centre in Ottawa. "This study shows a particular way that it can become a terrestrial ecosystem problem."

It's known that certain bacteria can convert inorganic mercury to methylmercury, the form that accumulates most easily in the tissues of living things. Then the metal travels up the food chain.

Daniel Cristol of the College of William & Mary in Williamsburg, Va., and collaborators found surprising mercury levels in the blood of 12 insect-eating bird species living along a tributary of the Shenandoah River in Virginia. "The only link we saw was the insects, so we started sampling insects," Cristol says.

Spiders made up 20 to 30 percent of these birds' diets, yet delivered about 75 percent of the mercury, much of it the methylmercury that moves into living tissue, the researchers reported in the April 18 *Science*.

Spiders are predatory, so it makes sense that they have high levels of the toxic metal, comments aquatic ecologist David Schindler of the University of Alberta in Edmonton. "Anything that lengthens the food chain pushes the mercury up, and it is biomagnified by about a factor of 10 with each step," he says. If spiders eat mercury-laden insects, the birds eating those spiders get a heftier dose than birds eating caterpillars, which eat plants.

Honeybees pick up pollen on a visit to a poppy.

STEPHEN L. BUCHMANN/UNIV. OF ARIZONA

Pollution may confuse pollinators

Smog dilutes scents needed to guide floral foragers

By Janet Raloff

OZONE AND OTHER CONSTITUENTS OF smog destroy at least some of the floral perfumes that pollinators rely on to find their meals, scientists report.

Bees might suffer from these smog constituents, which pollute urban and rural areas alike. But the foragers most likely to be confused by air pollution's degradation of floral scents are pollinators that rely less on sight than bees do, such as moths and bats.

Flower scents' vulnerability to ozone and other reactive chemicals is not new. Until now, though, no data existed on how quickly pollution extinguishes these natural perfumes, explains Jose Fuentes of the University of Virginia in Charlottesville.

Fuentes' team recorded meteorological conditions at a snapdragon farm, then used a computer program to calculate chemical reactions between three common floral scent molecules used by pollinators and three fossil fuel combustion products: ozone, nitrate and hydroxyl radicals. Under pristine conditions, scent molecules could drift unchanged over a kilometer or more, the calculations showed. The strength and length of that plume diminished dramatically, however, in the presence of smog constituents.

Within just 200 meters, half of the average intensity of a scent plume was lost, the researchers report in a recent issue of *Atmospheric Environment*. In some cases, the pollutant reactions chemically alter a perfume rather than rendering the air scent-free. Such dramatic scent changes or losses over short distances "was a real surprise," Fuentes says.

The report by Fuentes' group "is certainly intriguing," says Laurie Adams of the Pollinator Partnership, based in San Francisco. Its analyses help identify the potential for "many signals that nature depends on to go askew."

Fuentes points out that field testing will be needed to confirm that the computer results actually occur under real-world conditions. And his team is poised to begin such field testing this summer.

Earth

2.3 million gallons/s — peak flow rate during lake drainage

0.75 million gallons/s — daytime flow rate of Niagara Falls

Melt pond falls through ice in Greenland

Watching flow sharpens picture of moving glaciers

By Sid Perkins

IT TOOK ALMOST A MONTH FOR MELTwater to accumulate atop Greenland's ice sheet in the summer of 2006. It took only 90 minutes for all that water — a lake so large it could fill New Orleans' Superdome more than 12 times over — to pour through a crack in the kilometer-thick ice below it and drain the lake dry.

At its height, the torrent exceeded that of Niagara Falls, and its rumbling triggered seismic instruments nearby. GPS equipment indicated that the westward flow of ice in the region briefly surged, a sign that the water drained down to the bedrock and temporarily lubricated the boundary between ice and rock.

Some scientists have suggested that an increased number of similar events could spur a collapse of much of Greenland's islandwide ice sheet, leading to sudden rises in sea level. But new analyses hint that the overall effects of an increase in such subglacial lubrication, while possibly substantial, would not be catastrophic. All ice on Greenland eventually flows to the sea, with that in glaciers and fast-moving ice streams outpacing the languid flow of most parts of the ice sheet.

The lake that suddenly disappeared in 2006, one of many such melt ponds that form atop Greenland's ice sheet each summer, began accumulating in early July of that year, says Sarah B. Das, a glaciologist at the Woods Hole Oceanographic Institution in Massachusetts. By the morning of July 29, the lake covered 5.6 square kilometers and was in some places more than 12 meters deep.

At that time, instruments show, the lake level began to drop slowly but steadily, about 1.5 centimeters each hour for the next 16 hours. Then, literally, the bottom dropped out: Over about 84 minutes, the lake drained completely, losing on average about 8,700 cubic meters of water each second, she and her colleagues report online and in a paper to be published in *Science*.

That water quickly accumulated at the base of the underlying ice sheet, forming a subglacial lake that drained away during the following 24 hours. During that brief period, the seaward flow rate of the overlying ice sheet approximately tripled, then dropped back to its normal speed of 25 centimeters per day.

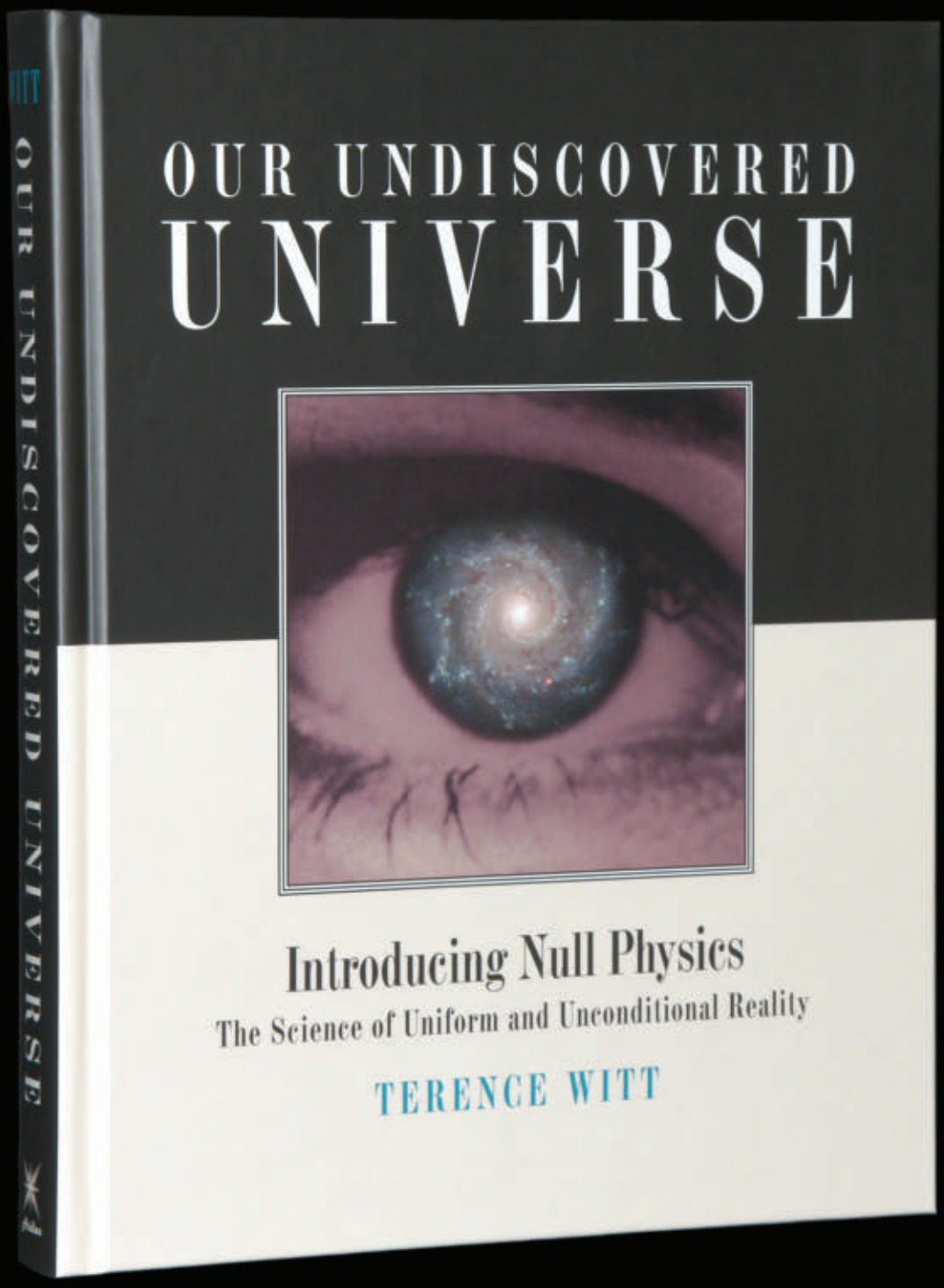
Analyses of space-based radar images of western Greenland suggest that the flow speed of the ice sheet increases, on average, between 50 and 100 percent during the summer — a phenomenon probably linked to increased amounts of meltwater reaching bedrock, says Ian Joughin, a glaciologist at the University of Washington in Seattle. He and Das collaborated on the new report and, along with another group of researchers, also analyzed satellite observations of the region that were gathered from September 2004 to August 2007. That report, too, will appear in an upcoming issue of *Science*.

In regions of Greenland where large glaciers dump ice into the sea, the effect of summer meltwater seems to be less pronounced, says Joughin, perhaps because the flow of subglacial water out of the glaciers is already brisk.

"For huge ice streams, the effect isn't terribly significant," says Waleed Abdalati, a glaciologist at NASA's Goddard Space Flight Center in Greenbelt, Md. Nevertheless, he notes, the new findings have widespread implications for the Greenland ice sheet as a whole and could be important in the long term. ■

DAS/WHOI

A lake of meltwater (like the one seen here) atop Greenland's ice sheet wedged open a crack in the underlying ice that quickly drained the lake dry.


OUR UNDISCOVERED UNIVERSE
Introducing Null Physics
The Science of Uniform and Unconditional Reality
TERENCE WITT
OUR UNDISCOVERED UNIVERSE

Theoretical physics has been hopelessly stalled for over 30 years. Moribund. Ossified. The Standard Model of particle physics uses over 20 ad hoc constants, and no one knows why they are necessary or why they have the values they do. Quantum physics and general relativity remain utterly incompatible. Cosmologists haven't the foggiest idea what could have caused the Big Bang or what, if anything, came before it. And finally, after over 30 years of effort, string theory hasn't even achieved the status of *science*.

There is a very simple reason for this catastrophic, intractable mess. Theorists stopped asking *why* a long time ago. Without the *why*, the search for mathematical symmetries becomes numerology, not science. No telescope or particle accelerator, regardless of its size, is going to tell us *why* the universe is the way it is. When the *why*'s remain unanswered, there is no understanding. When there is no understanding, there is no progress. But this sad situation is about to change forever.

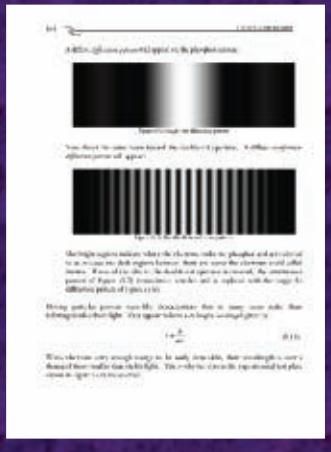
Our Undiscovered Universe is all about the *why*. It's an entirely new paradigm, a premise so powerful that it can finally answer the most important question of all: "*Why does the universe exist?*" This, in turn, reveals many of nature's secrets to a depth and clarity never before imagined.

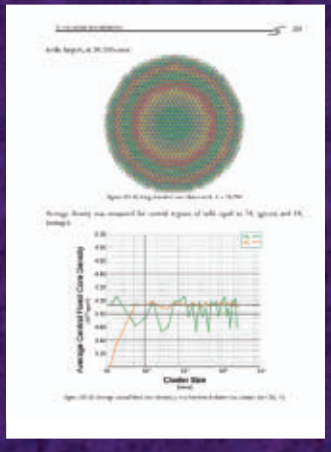
Unified ♦ Rational ♦ Revolutionary ♦ Empirically Validated

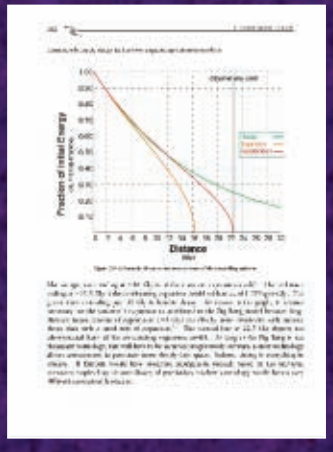
100 years ago, Einstein found a small part of the universe's four-dimensional geometry. Null Physics provides the rest of it. After reading this book, concepts like string theory and the Big Bang will seem positively ludicrous in comparison. Here is a brief glimpse of its sweeping unification:

- Energy is a three-dimensional substance, and its most basic unit is time-distance^2.
- Our universe has only a single fundamental constant: its finite, four-dimensional volume.
- A black hole's peak density is $1.2(10)^{19}$ kg/m^3, about 60 times more dense than atomic nuclei.

Welcome to 21st century physics







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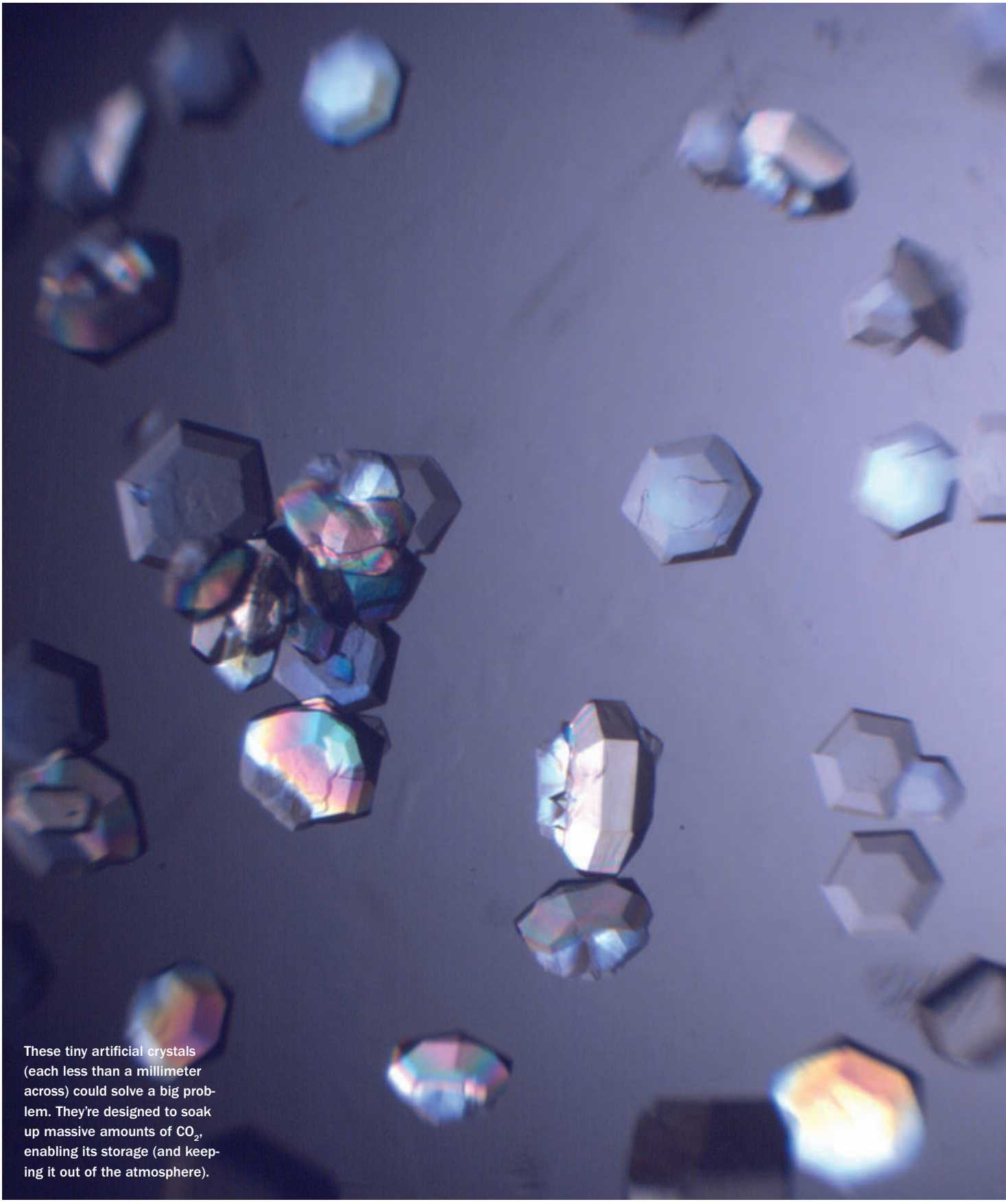
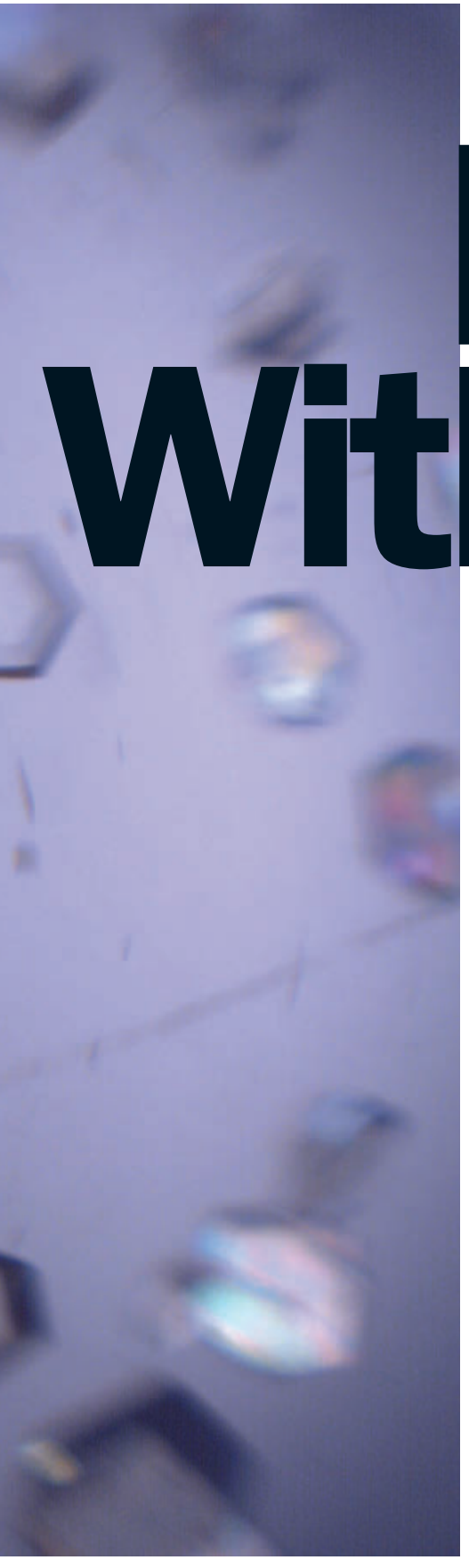


These tiny artificial crystals (each less than a millimeter across) could solve a big problem. They're designed to soak up massive amounts of CO_2, enabling its storage (and keeping it out of the atmosphere).



BANERJEE ET AL.

Down With Carbon

Scientists work to put the greenhouse gas in its place

BY SID PERKINS

One morning each week, a scientist takes a stroll on the barren upper slopes of Hawaii's Mauna Loa volcano, a basketball-sized glass sphere in hand. At some point, the researcher faces the wind, takes a deep breath, holds it and strides forward while twisting open a stopcock. With a whoosh lasting no more than a few seconds, 5 liters of the most pristine air on the planet replaces the vacuum inside the thick-walled orb.

Once every couple of weeks, a parka-clad researcher at the South Pole conducts the same ritual. At these remote sites and dozens of others, instruments also sniff the air, adding measurements of atmospheric chemistry to a dataset that stretches back more than 50 years. The nearly continuous record results from one of the longest-running, most comprehensive earth science experiments in history, says Ralph F. Keeling, a climate scientist at Scripps Institution of Oceanography in La Jolla, Calif. He carries on the effort his father, Charles Keeling, began as a graduate student in the 1950s.

Several trends pop out of the data, says Ralph Keeling. First, in the Northern Hemisphere the atmospheric concentration of carbon dioxide rises and falls about 7 parts per million over the course of a year. The concentration typically reaches a peak each May, then starts to drop as the hemisphere's flush of new plant growth converts the gas into sprouts, vegetation and wood. In October, the decomposition of newly fallen leaves again boosts CO_2 levels. Populations of algae at the base of the ocean's food chain follow the same trend, waxing each spring and waning each autumn.

A second trend is that each year's 7-ppm, saw-tooth variation in CO_2 is superimposed on an average concentration that is steadily rising. Today's average is more than 380 ppm, compared with 315 ppm 50 years ago. And it's still rising, about 2 ppm each year, mainly from burning fossil fuels.

Largely because CO_2 traps heat, Earth's average temperature has climbed about 0.74 degrees Celsius over

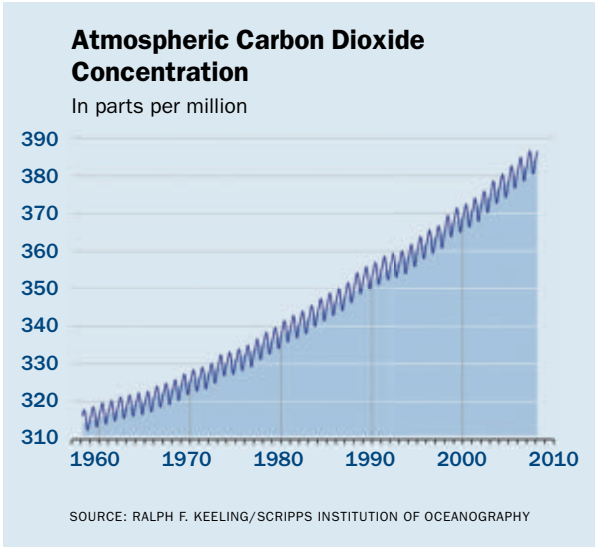
the past century (*SN: 2/10/07, p. 83*), a trend that scientists expect will accelerate. In the next 20 years, the average global temperature is projected to rise another 0.4 degrees C.

Squelching additional temperature increases depends on limiting, if not eliminating, the rise in CO_2 levels, many scientists say. And, Keeling says, "It's clear that if we want to stabilize CO_2 concentrations in the atmosphere, we need to stop the rise in fossil fuel emissions."

But halting the increase in amounts of CO_2 in the air doesn't necessarily mean doing away with fossil fuels. Many experts suggest that capturing CO_2 emissions, rather than only reducing them, could ultimately provide climate relief.

Possible solutions range from boosting natural forms of carbon capture and storage, or sequestration — fertilizing the oceans to enhance algal blooms, say, or somehow augmenting the soil's ability to hold organic matter — to schemes for snatching CO_2 from smokestacks and disposing of it deep underground or in seafloor sediments.

Success in sequestering carbon comes down to meeting two challenges: How to remove CO_2 from the air (or prevent it from getting there in the first place) and what to do with it once it has been collected.



National Oceanic and Atmospheric Administration engineer Paul Fukumura-Sawada samples air atop Hawaii's Mauna Loa.

P. SATO, MAUNA LOA OBSERVATORY, NOAA

Doing it naturally

ORGANISMS THAT dominate the base of the world's food chains soak up quite a bit of CO_2 — currently about 2 percent of the atmosphere's stockpile each growing season. That gas, plus sunlight and other nutrients, is converted into carbon-rich sugars and biological tissues that nourish humans and all other animals. Unfortunately, most of that carbon makes its way back to the atmosphere rather quickly: Animals metabolize their food, breathing out CO_2. Decomposition of dead plants and animals likewise produces the greenhouse gas.

Over the long haul, though, ecosystems can sequester significant amounts of carbon. About 30 percent of the carbon in the world's soil is locked in peat lands of the Northern Hemisphere, for instance, with most of that accumulating since the end of the last ice age about 10,000 years ago (*SN: 2/10/01, p. 95*).

Recent data suggest that North American ecosystems sequester, on average, 505 million metric tons of carbon each year. Some accumulates as organic material in soil, wetlands or the carbon-rich sediments deposited in the continent's rivers and lakes. More is stored in woody plants that have invaded grasslands or trees that have taken over shrublands. Most of the sequestered carbon, about 301 million tons, is locked away in North American forests or in the wood products harvested from them, notes Anthony W. King, an ecosystem scientist at Oak Ridge National Laboratory in Tennessee. He and his colleagues reported their analysis of these carbon sinks last November in an assessment issued by a consortium of ten U.S. government agencies.

Coal-fired power plants generate about **8 billion tons** of carbon dioxide each year.

"New, vigorously growing forests are where most carbon sequestration takes place," King says.

Some researchers, including Ning Zeng, an atmospheric scientist at the University of Maryland, College Park, seek to harness the prodigious carbon-storing power of forests. Right now, forest floors worldwide are lined with coarse wood — everything from twigs and limbs shed during growth to entire fallen trees — containing about 65 billion tons of carbon, says Zeng. Left undisturbed, that material would return its carbon to the atmosphere via decomposition or wildfire. Bury that wood in an oxygen-poor environment, however, and the carbon could be locked away for centuries.

Furthermore, Zeng notes, each year the world's forests naturally produce enough coarse wood to lock away about 10 billion tons of carbon. Burying just half of that amount would significantly counteract the estimated 6.9 billion tons of carbon released into the atmosphere each year via fossil fuel emissions.

While the price tag for this technique would be relatively reasonable — photosynthesis is free, and burying the wood would cost about $14 per ton — the environmental toll could be substantial. Coarse wood collected from the average square kilometer of forest could contain about 500 tons of carbon, Zeng reported in December in San Francisco at a meeting of the American Geophysical Union. That volume of wood would fill a trench 10 meters wide, 10 meters deep and 25 meters long. To sequester 5 billion tons of carbon each year, logging crews would need to dig and fill 10 million such trenches, about one every three seconds.

"This is not an environmentally friendly method" of carbon sequestration, Zeng admits.

Life at sea

In certain parts of the oceans, especially along the western coasts of large continents, nutrient-rich waters fuel the growth of algae and other phytoplankton. Their growth pulls CO_2 from the atmosphere. Many parts of the ocean, however, lack one or more vital nutrients, particularly dissolved iron, and are therefore nearly devoid of life (*SN: 8/4/07, p. 77*).

Adding iron to the surface waters in some seas could help reduce CO_2 buildup in the atmosphere and forestall climate change, some scientists suggest. In the late 1980s, oceanographer John Martin, an early proponent of this idea, boasted: "Give me half a tanker of iron, and I'll give you the next ice age."

Or maybe not. Recent studies in the North Atlantic and North Pacific confirm that natural algal blooms can indeed sequester CO_2, but in many cases the phenomenon may be only temporary, with little if any carbon making its way into deep water or seafloor sediments (*SN: 5/19/07, p. 307*). In late 2004 and early 2005, a similar study near the Crozet Islands southeast of South Africa further demonstrated that natural algal blooms result in only modest carbon sequestration.

Peter Statham, a marine biogeochemist at the National Oceanography Centre in Southampton, England, and his colleagues installed sediment traps at a depth of 2,000 meters at several spots near the islands. South of the islands, particles drifting down through a 1-square-meter area together carry only 0.087 grams of carbon each year, the researchers estimate. North of the islands, where ocean currents have carried dissolved iron and other minerals eroded from the islands, the carbon flux to deep water is almost five times higher, Statham and his colleagues reported in Orlando, Fla., in March at the Ocean Sciences Meeting.

Many uncertainties remain about how effective any artificial attempts to boost algal growth might be, says Statham. First of all, he notes, scientists aren't sure which forms of iron are the ones that marine phytoplankton find most nutritious. And the long-term effects of adding the wrong type of iron — or maybe even the right one, he adds — could damage marine ecosystems for years. "There's a huge gap in our understanding of these phenomena," he says.

Finally, fertilizing the seas to sequester carbon, even with no bad side effects, may have little if any effect on climate. "Even in the most favorable circumstances, oceans would sequester only a small fraction of the carbon dioxide that humans are emitting," Statham argues.

Down and away

Today, coal and petroleum each account for about 40 percent of global CO_2 emissions. Of the two, however, coal poses by far the larger threat to future climate. For one thing, coal produces more CO_2 per unit of energy than any other fossil fuel — about twice that generated by burning natural gas, for example. Also, coal is abundant and therefore relatively cheap: The amount of carbon found in the world's coal reserves is about triple that locked away in petroleum and natural gas deposits.

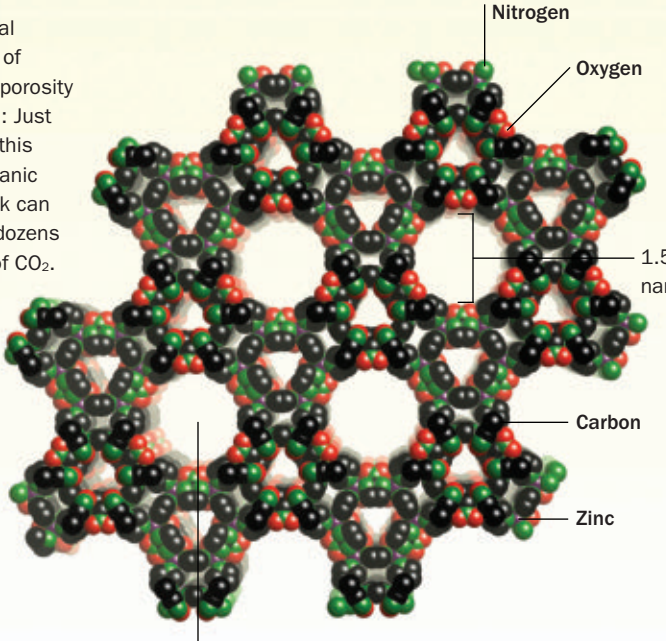
Worldwide, coal-fired power plants each year generate about 8 billion tons of CO_2, an amount that contains about 2.2 billion tons of carbon. And, says Daniel Schrag, a geochemist at Harvard University, emissions are poised to get even worse: About 150 power plants fueled by pulverized coal are now at various stages in the permitting process in the United States, and China reportedly cuts the ribbon on one such plant every week or so.

All told, the coal-fired power plants built in the next 25 years will, during their projected 50- to 60-year lifetimes, generate about 660 billion tons of CO_2, says George Peridas, an analyst with the Natural Resources Defense Council office in San Francisco. That's about 25 percent more than all the CO_2 that humans have produced by burning coal since 1751, a period that encompasses the entire Industrial Revolution.

Because coal-fired power plants are point sources of immense volumes of CO_2, they're tempting targets for sequestration efforts, says Tom Feeley, an environmental scientist at the National Energy Technology Laboratory in Pittsburgh. He and his colleagues are studying ways to capture emissions, ranging from using CO_2-hungry materials to sop

Vacancy Available

The crystal structure of ZIF-70 is porosity perfected: Just 1 liter of this metal-organic framework can soak up dozens of liters of CO_2.



The crystal is riddled with open spaces. One gram offers 1,970 square meters of surface area where CO_2 molecules can park.

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CO_2 from smokestacks to building new types of plants that burn coal altogether differently. The goal is to develop techniques for large-scale field tests by 2012 that can capture at least 90 percent of a power plant's CO_2 emissions but boost the price of its electricity by no more than 20 percent.

In current power plants, CO_2-absorbing materials would be placed in a stream of 200°C emissions, mostly nitrogen with between 3 and 15 percent CO_2. The active materials could either absorb the gas, just as a sponge sops up water, or chemically bind to it.

Materials called metal-organic frameworks (*SN: 1/7/06, p. 4*) fall into the category of CO_2 sponges. In their gaseous state, CO_2 molecules fly about at great speeds and keep a considerable distance from each other, but inside the pores of some of these crystalline sieves, the molecules line up and cram close together, says Rahul Banerjee, a chemist at the University of California, Los Angeles.

Discovering the reactions that produce a substance that effectively captures CO_2 takes time. So, Banerjee and his colleagues recently adopted a technique common in the pharmaceutical industry: They used a computer-controlled device to automatically dispense various combinations and concentrations of reactants into each of 96 tiny wells on a single plate — each well, in essence, its own 300-microliter beaker — which was then heated. The researchers then assessed the CO_2-sopping ability of the resulting crystals.

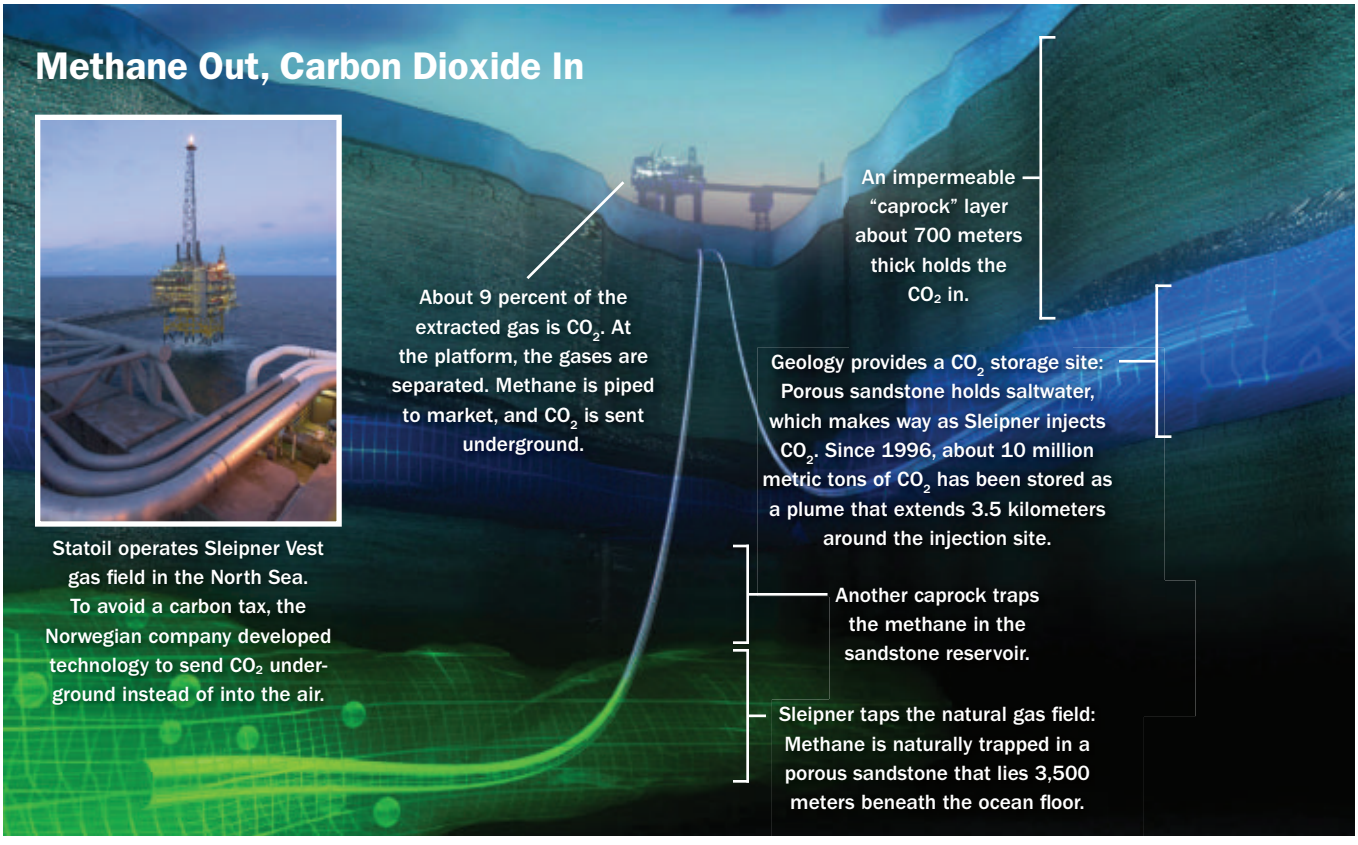
In less than three months, the researchers generated 16 new zeolites, a type of metal-organic framework composed of aluminum silicates, Banerjee and his colleagues reported in the Feb. 15 *Science*. Three of the zeolites are highly porous, with each gram of the material having a large surface area — where CO_2 molecules can attach — of between 1,000 and 2,000 square meters. A 1-liter sample of one of those supersponges, a substance dubbed ZIF-69, could hold up to 83 liters of CO_2 under normal atmospheric pressure.

Another team of scientists has produced a CO_2-absorbing substance — one that binds the gas via a chemical reaction — by painting an organic compound called aziridine on a wafer of silica. Unlike previously developed aminosilica materials, the new substance has a high storage capacity for CO_2, says Christopher W. Jones, a chemical engineer at Georgia Institute of Technology in Atlanta. The chemical reaction can be reversed by heating the CO_2-saturated material, enabling researchers to capture the gas and dispose of it. A series of lab tests indicates that the material, whose amine-rich coating is tightly bound to the silica substrate, retains its capacity to soak up CO_2 after nearly a dozen cycles, the researchers reported in the March 12 *Journal of the American Chemical Society*.

Dump sites

CAPTURING VAST AMOUNTS OF POWER plant emissions is just half the task. The next step is storage. Many scientists propose locking CO_2 underground or in the deep ocean.

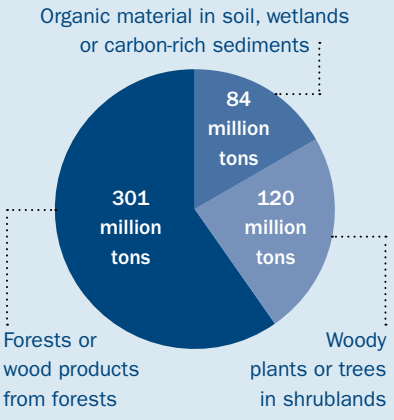
Under high pressure, as in ocean depths below 500 meters, CO_2 is a dense liquid, not a gas, and doesn't mix well with water. Therefore it's possible to deep six CO_2 on the ocean floor, but many research-



GRAPHIC: ALLIGATOR FILM/BUG/STATOILHYDRO; INSET: STATOIL; INFORMATION: A. CHADWICK, BRITISH GEOLOGICAL SURVEY

From Atmosphere to Biosphere

Total carbon sequestered by North American ecosystems: 505 million metric tons of carbon each year, on average.



SOURCE: ANTHONY W. KING, OAK RIDGE NATIONAL LAB

ers have concerns about how large pools of concentrated CO_2 might affect ecosystems there (*SN: 6/19/99, p. 392*). The CO_2 might slowly dissolve into the surrounding water, creating acidic conditions.

A new and relatively simple twist on the deep-ocean technique may address many such concerns. If liquid CO_2 is blended with a mixture of seawater and pulverized limestone, the CO_2 breaks up into globules that are 200 to 500 micrometers in diameter and coated with limestone powder, says Dan Golomb, a physical chemist at the University of Massachusetts, Lowell. The resulting emulsion has a consistency between that of milk and mayonnaise. Injected into the deep sea, the limestone-veneered droplets sink about 200 meters per day, lab tests suggest. As the droplets dissolve into the surrounding water or break up as they jostle about on the seafloor, the limestone's carbonate dissolves too, buffering much of the resulting acidity, like a tiny Tums. Golomb and his colleagues described their carbon-dumping process last July in *Environmental Science & Technology*.

Immense volumes of subterranean strata are a tempting dumping ground, too. Some types of rock formations are naturally impervious to the flow of gases and liquids. In fact, some of these geological reservoirs have already proven themselves by sequestering naturally formed CO_2 for millions of years. Oil companies have been mining that CO_2, transporting it through pipelines and pumping it into the ground to enhance the recovery of petroleum from faltering oil fields for decades — an irony indeed to think that CO_2 is being pumped into the ground so that petroleum, a raw material for even more CO_2, can be extracted.

In many regions of the world, saline aquifers lie deep beneath the ground. Because that salty water isn't suitable for drinking, some of those strata, especially those sandwiched between or capped by impervious rocks, could be used to store CO_2. Scientists estimate that such reservoirs might hold hundreds of years' worth of captured emissions.

Disposal of CO_2 in ancient volcanic rocks may provide an even more secure sequestration technique. A multimillion-dollar field test soon to be under way in southeastern Washington state is designed to find out.

Lab tests suggest that liquid CO_2 will chemically react with basalt to produce various minerals, including calcium carbonate, in a matter of months, says Pete McGrail, an environmental engineer at Pacific Northwest National Laboratory in Richland, Wash. Therefore, concerns about the CO_2 escaping from its underground prison are minimized. Thick layers of basalt, the result of widespread volcanic activity in the region between 6 million and 17 million years ago, underlie the tristate area surrounding McGrail's lab. Although most think of basalt as impervious, many of these deposits are porous because they were frothy when they cooled or they cracked extensively when subsequent flows of lava heated them up or weighed them down.

Later this year, McGrail and his colleagues will inject between 1,000 and 3,000 tons of liquid CO_2 — enough, give or take, to fill an Olympic-sized swimming pool — into the porous rocks at a depth of about 1 kilometer. Then, researchers will assess the effectiveness of their sequestration by occasionally collecting fluid samples at the injection site. Analyses suggest that this volume of CO_2 will react to form carbonate minerals within five years, says McGrail.

If this sequestration technique is deemed suitable, the region's ancient basalts could hold a volume of CO_2 approaching that emitted by every coal-fired power plant in the United States over a 20- to 50-year period, McGrail and his colleagues estimate. Across the nation, deep geologic formations such as saline aquifers and coal layers could sequester 150 years' worth of worldwide power-plant emissions, possibly providing a rock-solid solution to one of the world's most pressing problems.

One region of volcanic rock could hold as much CO_2 as every coal-fired power plant in the United States would emit over **20 to 50 years**.

U.S. saline aquifers and coal layers could hold **150 years' worth** of worldwide power plant emissions.

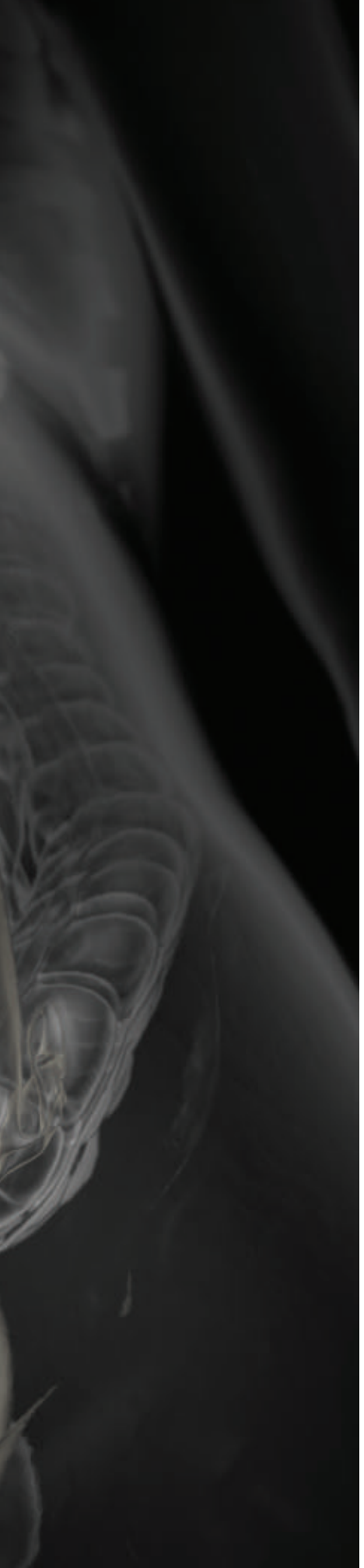
The United States and the world need carbon sequestration—not right now, says Harvard's Schrag, but soon, and on an enormous scale. The challenge, he notes, is to ensure that carbon capture and sequestration technologies are ready when serious political action on climate change is finally taken.

And that time may be coming soon, says Oak Ridge's King. "It's beginning to dawn on people," he says, "that they can change the planet in ways larger than the planet can change itself." ■

Explore more

- "Carbon Dioxide Capture and Storage: Summary for Policymakers," IPCC Special Report, 2005. www.ipcc.ch/pdf/special-reports/srccs/srccs_summaryforpolicymakers.pdf

Provocative evidence about how biology shapes people before birth is emerging from human and animal studies of opposite-sex twins. Females with twin brothers show some traits that are considered more typically masculine than do other females.



Twin Fates

Sharing the womb with a brother may influence a girl's development

Kelly Klump is a curly-haired, compact woman who is fascinated by eating disorders. Her own habits are healthy, but as a high school "peer counselor" she found herself besieged by girls struggling with the addictive starvation of anorexia nervosa and the compulsive binge-and-purge of bulimia. Now a 37-year-old associate professor at Michigan State University in East Lansing, Klump has spent the past 10 years probing the genetic influences in such illnesses and pondering a stubborn question about why biology makes women more likely targets than men for eating disorders.

Lately she has revisited that frustrating question from a new angle. Working with graduate student Kristen Culbert and other colleagues, Klump published a paper in the March *Archives of General Psychiatry* focusing on a very specific group: females from a male-female twin pair.

A few years ago this would have seemed a rather narrow approach to a widespread problem. But several recent studies now suggest that the girl twin in a mixed pair offers provocative evidence concerning the way biology shapes people before birth.

Psychologists in both the United States and Europe have found that females from opposite-sex twin pairs tend to be more aggressive and adventurous, process spatial information more like men, and show more typically masculine left brain dominance

By Deborah Blum ■ Illustration by Bryan Christie

during language tests. Across a range of research, these female co-twins seemed shifted toward the male end of the behavioral spectrum.

Such studies prompted Klump and Culbert to test a specific hypothesis: that girls with boy twins would also behave more like boys when it came to eating disorders. In other words, these girls' risk would drop. Using an eating behavior survey, questioning several hundred twin-pairs from the Michigan twin registry, and looking at opposite-sex and same-sex, both male and female twins, the scientists found their prediction was absolutely on.

Their female co-twins had a lower level of eating disorders, tending toward the male range. By contrast, the same-sex female twins had the highest level of all the twin sets questioned. The Michigan State scientists suspect that the reason can be found in the prenatal environment: Sharing the space with a developing male can apparently alter female development in some small but interesting ways.

"Opposite-sex twins have not historically been a target for biological research," says Dennis McFadden, a psychology professor at the University of Texas at Austin, who has been studying male-pattern hearing in female co-twins. "For a long time, people just thought that all the learning could be done in same-sex twins. So until recently they've been grossly understudied. And now, all at once, there's awareness of this tantalizing potential."

Testosterone tsunami

Developmental biologists have long known that exposure to hormones during gestation has a potent effect on fetal development, especially for males. Near the end of the first trimester of human pregnancy, at about 10 to 12 weeks, male fetuses begin producing a remarkable blast of the steroid hormone testosterone, "something like adult levels," says psychology professor and primate researcher Kim Wallen of Emory University in Atlanta. A similar process exists for most mammals: The timing and the amount of androgens such as testosterone before birth are essential to normal male development.

Human fetuses begin life in a sex-neutral body, whether carrying the XX chromosome match that signals a tiny female or the XY pairing that means a male. But there's another factor in play: Female is considered the "default" state for human development; without that extra testosterone, the body simply continues toward a female design. If XY males don't get enough prenatal androgens, as happens with some genetic defects, those males develop looking like well-formed females.

The female fetuses, on the other hand, don't need to crank up estrogen to turn into a girl. In fact, they tend to produce the hormone at mere trace levels throughout gestation. So, starting in the late 1970s, scientists began to wonder whether exposure to a brother's testosterone before birth might affect the sister's development.

Biologists studying mice turned up the first indications that this was a real possibility. Like humans, male mouse fetuses produce a critical testosterone boost, about midway through gestation. Unlike humans, mice routinely produce large mixed-sex litters. In fact, during their mother's pregnancy, the fetal mice

Psychologist Kelly Klump, left, and graduate student Kristen Culbert, right, found that women with a twin brother face a lower risk than other women of developing an eating disorder.

DERRICK L. TURNER/MSU UNIVERSITY RELATIONS

are packed in place, almost as neatly as a line of peas in a pod. The researchers discovered that for developing females, the sex of their pod-neighbor made a real difference.

Females who were surrounded by other females in utero (sometimes called 0M for their zero-male exposure) developed in the standard way. So mostly did those between a male and another female (1M). But females who were placed between two males (2M) could be identified, after birth, by their more-male body proportions. Further experiments confirmed that the physical difference could be traced to a prenatal diffusion of testosterone (steroid hormones slip fairly easily through cell membranes). In fact, as zoologist John Vandenbergh wrote, "the more males in proximity to a given female, the more masculine characteristics the female displays."

Further studies showed that these changes in the body shape were indicators of other changes. For instance, a region of the brain called the hypothalamus, which is influential in mating behavior, is typically larger in male mice. It turned out that the 2M females also had larger hypothalamuses, had delayed puberty, had more irregular cycles, and were more independent-natured and aggressive. Notably, once the mice all reached mating age, if males were given a choice between a 0M and 2M female, they chose the more "female" mouse.

More like her twin brother

During the 1980s, Vandenbergh — now a professor emeritus of zoology at North Carolina State University — decided to see what this meant in terms of how the mice interacted with others, including all important reproductive behaviors. With his colleagues, he let loose mice populations into the grassy cloverleafs of highways around Raleigh. Within each group, the scientists released about 20 0M and 20 2M females, marking

them all for observation.

Over time, the zoologists discovered that the 2Ms were the most adventurous females; their home ranges were some 40 percent larger than the 0Ms, who tended to be homebodies. But being more assertive and adventurous didn't seem to lend a reproductive advantage. The home-loving 0Ms tended to raise larger litters, although Vandenbergh points out that in a less confined, harsher environment, the exploring tendencies of the 2M mice would offer a greater advantage. In other words, the variety itself offers an advantage in overall species survival.

"It demonstrates the importance of changes during fetal development," Vandenbergh says. "We all try to explain variability, why brains are different, and we're all trying to find explanations for some of that variation. This is at least a reminder that a lot can happen in the fetal environment — that it's a very sensitive time."

Animal researchers can directly experiment with such ideas. Emory's Wallen has demonstrated that by blocking testosterone at different times during gestation, he can alter both the physiology and behavior of monkeys, inducing little males, for instance, to vocalize like females. But as he and McFadden both note, comparable studies cannot be done with human research subjects.

"Animal research offers some really nice opportunities," McFadden says. Human researchers are generally "forced to capitalize on the manipulations of nature," mostly by studying people with genetic defects or variations that cause either an excess of androgens or an inability to absorb them.

> Some question whether it's the prenatal environment or simply growing up with a brother of a similar age that causes differences seen in female co-twins.

Listening for differences

McFadden began his own work on female co-twins in the 1990s while running a series of tests on hearing, comparing different groups to try to sort out genetic influences. In particular, he was looking at a phenomenon called "otoacoustic emissions," in which vibrations within the ear, as it responds to sounds, create faint popping noises that can be registered on scientific instruments. In general, the more sensitive the hearing is, the greater the frequency of such sounds. Overall, women's ears pop more, men's ears less often. But when McFadden tallied up his results across a range of population groups, he discovered that one group of women looked markedly different. Females with a twin brother tended toward the male range of the tests.

The finding has held up, with remarkable consistency, for more than a decade. McFadden, in the meantime, has developed a wide-ranging expertise on the association between prenatal testosterone and physical development in females, such as the heavy masculine bulk of female spotted hyenas, known to experience remarkably high androgen exposure before birth. But neither he, nor anyone else, reports such visible differences in humans. In fact, McFadden's inner-ear finding, some controversial studies on finger length and one report on tooth sizes are the only results so far reported with measurable, physical differences between female co-twins and other women.

"I now argue that thinking about hormonal effects as always global is misleading," McFadden says. "And that brings me back to a caveat about opposite-sex twins. There's a whole array of things that definitely are not affected. It seems more sensible to think instead of relatively localized effects in body and in time. There are probably critical periods of development during which, if androgen levels are high, things end up being masculinized."

Critical nurture

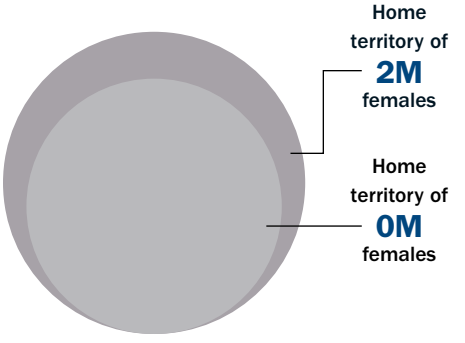
Such caveats, of course, provide an easy opening for critics who say that it would be a mistake to draw too many conclusions from existing opposite-sex twin research. After all, Wallen says, humans have not shown the easily observable effects found in other species. He speculates that human fetuses might be more buffered against each other's hormone production: "The nature of the chorion [the protective membrane around each

Male Influence

In the womb, mice line up like peas in a pod. Scientists compared females that developed next to sisters, brothers or one of each.

F F F	0M	developing female mouse embryo (F) surrounded by two other females
M F F	1M	developing female mouse embryo surrounded by a male (M) and a female
M F M	2M	developing female mouse embryo surrounded by two males

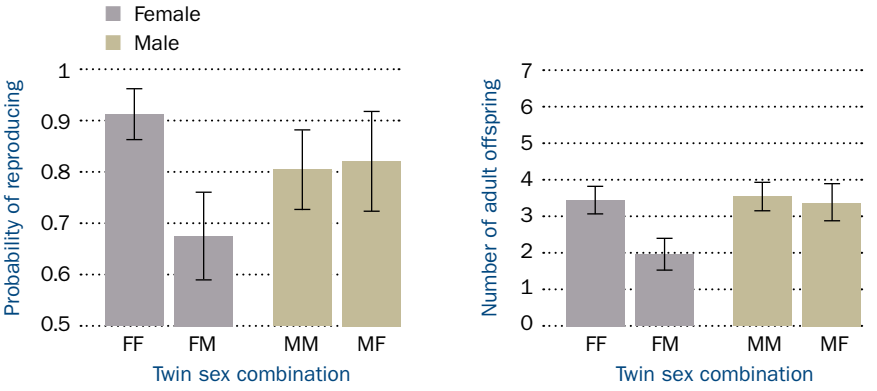
In a field experiment, 2M females ranged farther than 0M mice, claiming territories about 40 percent larger. The 0M females, however, raised larger litters than the 2M mice did.



Fertile Effects

An analysis of centuries-old Finnish church records hints at the possible effects sharing a womb with a twin brother may have on a woman's fertility. Researchers say women with twin brothers (FM) were 25 percent less likely to have children than women with twin sisters (FF). On average, FM twins had fewer children who lived to adulthood than male co-twins (MF) and male-male twins (MM).

SOURCE: VIRPI LUMMAA, JENI E. PETTAY, AND ANDREW F. RUSSELL



fetus] is so different in humans and rodents," he says. "They have a much leakier system than ours. You have to think that would make a difference."

Others complain that opposite-sex twin studies are usually done in relatively small groups, often of a hundred or less, and that few of them have been replicated.

Further, as Cambridge University psychologist Melissa Hines emphasizes, the behavioral differences can also be explained by the simple fact of growing up with a twin brother.

Hines, author of the 2005 book *Brain Gender*, compared play styles across groups of children, including female co-twins. The opposite-sex twins did show a more boyish style of play, but, Hines says, no more so than most girls raised with brothers in the family. She concluded that the socializing effect of a brother was as important, or more, than prenatal exposure to androgens in such cases.

"Obviously, hormones have a prenatal effect," Hines adds. "But we can't say that's the explanation for everything. A lot of these studies don't control for the social effect of having an opposite-sex twin. Look, it could be one or the other and it could be both. So we deliberately set out to see if the effect of the twin was bigger than the effect of the brother. And it wasn't. After that, I went on to other studies. I didn't find that line of inquiry as rewarding."

But Hines says that one study has encouraged her to reconsider. It appeared in the *Proceedings of the National Academy of Sciences* last June.

That research, published by evolutionary biologist Virpi Lummaa of the University of Sheffield in England, reviewed carefully kept Finnish birth, death and marriage records from the 18th and 19th centuries. In those pre-birth control, pro-marriage times, female co-twins were 25 percent less likely to have children than female-female twins, raised smaller families and were, in fact, less likely to marry at all. Further, Lummaa's data showed that the result held steady across social classes and even if the male twin died within three months of birth, leaving the girl to be brought up as an only child.

"I definitely think that this is one of the major strengths of our paper," Lummaa says. Most other studies using modern human data cannot rule out the fact that growing up and playing with a similar-aged brother affects your behavior and attitudes.

"The fact that twin mortality — especially during the few weeks after birth — was so high during our study period makes it possible for us to compare those females who were born with a brother or sister but subsequently raised as singletons. Given that we still see differences between them, this really has to be of prenatal origin," she adds.

Pondering the prenatal

Michigan State's Klump and Culbert also collected data suggesting that growing up with brothers was less influential than a shared womb. Opposite-sex twin girls consistently showed fewer signs of eating disorders than girls raised within a family with brothers. "In none of the groups could the eating patterns be accounted for by levels of anxiety or socialization," Klump and Culbert wrote in the March paper. "Indeed, opposite-sex female twins exhibited lower levels of disordered eating compared to an independent sample of undergraduate women who were raised with one or more brothers."

Culbert said they would still like to find out why prenatal androgens might affect eating disorders, as opposed to other behaviors. Like McFadden, she suggests that the scatter of human results hints at very specific effects of prenatal androgen exposure: "I can speculate that there are areas where this becomes highly concentrated," she says. "But basically we just don't know." Klump adds that the next step is to replicate their finding and use that confirmation to argue for funding to search for the mechanism itself.

As Klump points out, the relevance is not that female opposite-sex twins are somehow different. What makes these studies worthwhile is the way they help reveal some of the fundamental processes involved in early human development. And, of course, Klump hopes that such understanding will also lead to improved options for those battling eating disorders. "The more we understand what factors are important," she says, "the more we can move toward the right ways to treat them." ■

Deborah Blum is a Pulitzer prize–winning science journalist on the faculty of the University of Wisconsin–Madison.

Explore more

- Robert Sapolsky, *The Trouble with Testosterone*, Scribner, 1998
- Melissa Hines, *Brain Gender*, Oxford University Press, 2005

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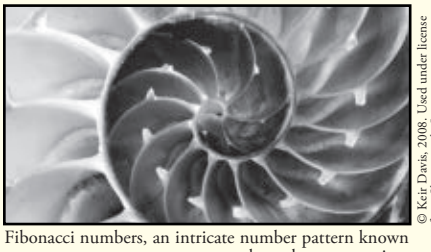

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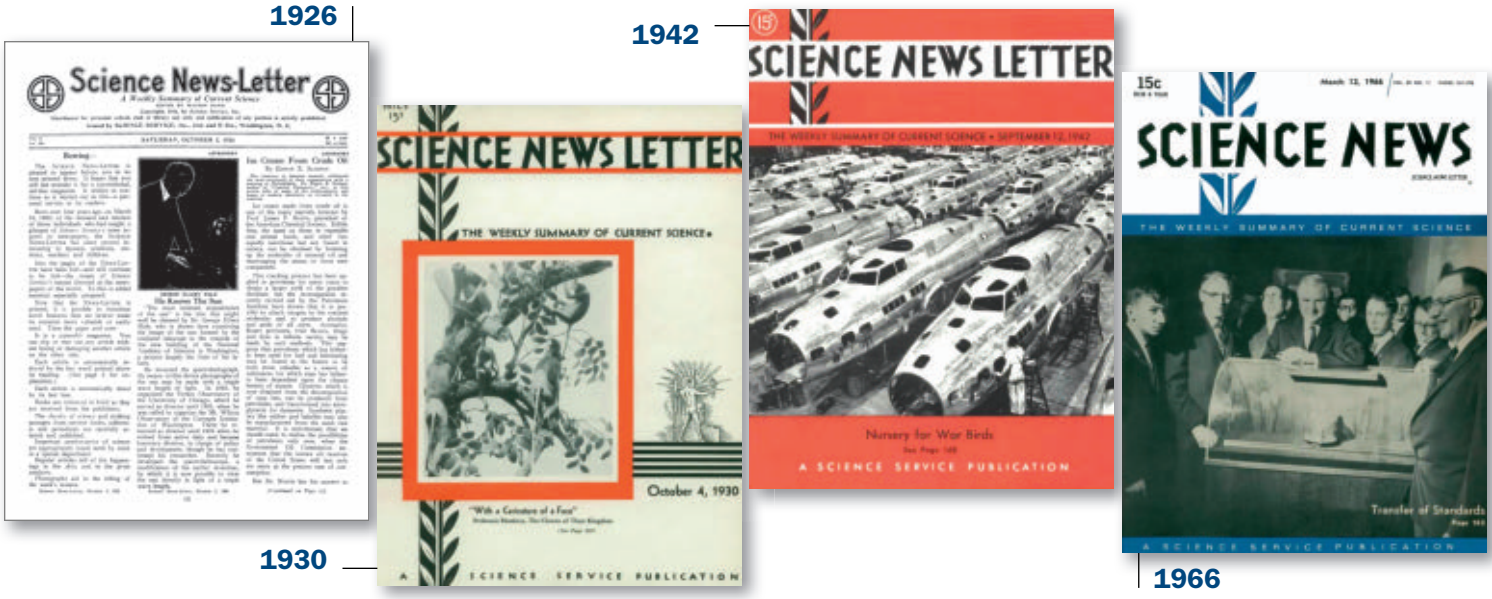

CHANGE WITHOUT CHANGE

New clothes for the modern media climate, but no departure from traditional purpose for *Science News*

By Tom Siegfried

Fourscore and seven years ago, a nonprofit organization called Science Service began providing dispatches to newspapers on news from the world of science. The following year, by popular demand, some of those dispatches were collected and distributed weekly to a wider audience, in the form of typewritten, mimeographed pages carrying the label *Science News-Letter*.

Four years later — on October 2, 1926 — the news-letter announced its transformation into a magazine. "The *Science News-Letter* is pleased to appear before you in its new printed dress," wrote editor Watson Davis. And so its descendant, now *Science News*, is similarly pleased today. Its "new dress" echoes the pattern of its predecessors: new packages appearing from time to time, all preserving the publication's original intent — providing the public with timely and accurate reports from the frontiers of scientific research.

From weekly to daily

In many ways, the current repackaging is the most dramatic in the publication's history, at least since it became a real magazine in 1926. For the first time, *Science News* (the name adopted in 1966) will not be published weekly — it will now appear every other week, at twice its former size. That change in schedule reflects the 21st century reality that weekly is no longer timely. To survive in today's competitive media climate, *Science News* has become a daily science news enterprise, offering each weekday's top stories online, supplemented by a biweekly summary of the best of them delivered the old-fashioned way.

In merging its print tradition with digital modernity, *Science News* retains its original commitment: to serve as a bridge between the world of science and society at large. Shortly after World War I, biologist William Ritter persuaded E.W. Scripps, a newspaper-chain owner, to fund an organization for disseminating news about science to the nation's newspapers. Ritter and Scripps enlisted scientist-journalist Edwin Slosson to manage such a news service, giving birth to the nonprofit institution known as Science Service in 1921.

The mimeographed pages disbursed to newspapers subscribing to the service found their way into other hands, soon leading to a demand for collections of the stories to be made available to libraries, teachers and other interested individuals. From that time on, *Science News* has remained the most constant source of regular science news for the American public (and many foreign subscribers as well).

Readers over the years could find in its pages accounts of all the advances of science, both small steps and grand leaps. From the discovery of vitamin E in 1922 to the cloning of Dolly the Sheep, reported in 1997, *Science News* was on the job, writing the history of science in real time, providing comprehen-

sible synopses encapsulating the complexities of new research across the entire spectrum of scientific disciplines.

As cover styles changed, the content within remained true to that mission, keeping subscribers current on events at the forefront of research. In 1932, *Science News* readers followed reports of a new subatomic particle called the neutron. In 1939, readers learned of the splitting of the atom by Hahn and Strassmann. In 1953, *Science News* described the recent discovery of DNA's double helix structure by Watson and Crick.

"This is something new," the anonymous writer observed. "It may solve a major puzzle."

Get the truth

Such straightforward talk would have pleased Scripps, whose dream for Science Service was to enhance appreciation for science among the public and to disseminate the knowledge acquired by scientists for the benefit of the entire citizenry.

"Get the truth just as far as possible; write the essence of it so simply and clearly that anybody who can read it at all can understand it" — that was Scripps' guiding principle when he started his first newspaper, and it was the philosophical foundation for the news service that spawned *Science News*.

Scripps would no doubt be even happier today to see that his creation, Science Service, has adopted the name of Society for Science & the Public. No label more clearly captures the intimate relationship that Scripps perceived between science and society. And it sums up science journalism's purpose succinctly — to tell the public about science.

As recounted by Ritter (*SN: 12/25/1926, p. 201*), Scripps believed that it was "useless to think of making the world safe for democracy without thinking also of making democracy safe for itself." And the way to make democracy safe, Scripps believed, was by making it more intelligent.

"But since to be intelligent is utterly impossible without having much of the knowledge ... of science, the only way to make democracy safe is to make it more scientific," as Ritter summed up Scripps' philosophy.

Consequently Scripps perceived a substantial overlap between the tasks of newspapers and science. Journalism and science shared a common purpose, he believed: "To discover the truth about all sorts of things of human concern, and to report it truthfully and in language comprehensible to those whose welfare is involved."

And so *Science News* today, in its new dress, rededicates itself to those old principles. New appearance. Same substance. Presented such that all who are interested can partake of science's advances, its successes and even its foibles and faults, for the sake of enabling a saner society.

Magic and change

For his 60th birthday, some decades ago, friends of the late physicist John A. Wheeler prepared a book of essays, titled *Magic Without Magic*. That title alluded to Wheeler's artful way of perceiving nature's secrets, showing how the apparently magical could emerge from the scientifically understandable. The magic wasn't really magic, after all.

Today, *Science News* appears to be changing, but it really isn't change, after all. While the world changes around it, *Science News* merely pretends to change in order to enhance its ability to do what it has done all along — aid the public's understanding of science by reporting on scientists' explorations along the shorelines of the unknown.

It makes no difference that mimeographed sheets have been replaced by electronic messaging and digital printing presses. *Science News* remains devoted to science news. ■

Tom Siegfried is editor in chief of Science News.

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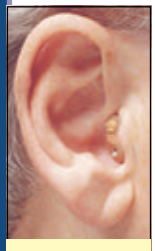

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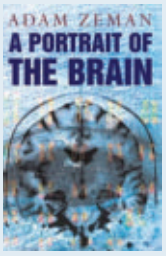
A Portrait of the Brain

Adam Zeman

What you don't know about the brain could fill a book. That's true even if you happen to be a brain surgeon or neuroscientist.

Luckily, Zeman, a British neurologist, has painted *A Portrait of the Brain* in lucid, conversational prose.



Zeman steps us through the brain's inner workings, starting with the most fundamental element—the atom—and, by chapter, guiding us from there to the gene, to the protein, to the organelle, to the neuron … to the psyche and then even to the anatomy of the soul.

Case studies drawn from Zeman's practice illustrate exactly what happens to a person when something in the brain goes wrong. His examples include a case of which few neurologists have firsthand knowledge: the story of a man who contracted a brain-wasting disease from eating beef infected with mad cow disease. Studying such unfortunate disruptions in the brains of people and animals gives doctors and scientists more information on how the brain functions normally.

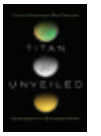
Zeman leads us through the same learning process. He isn't afraid to show his work, even a potentially fatal mistake he made in one diagnosis.

Passages of poetry, along with uncluttered black–and–white illustrations, enhance each chapter. Zeman also provides suggestions for further reading, which is helpful because his easy-reading book will likely serve as an appetizer for learning fully about what goes on inside people's minds. A helpful glossary and index sandwich a one-page appendix, which features an illustration (and scale) for each chapter's subject.

—Tina Hesman Saey

Yale University Press, 2008, 246 p., $27.50.

Titan Unveiled



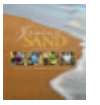
Ralph Lorenz and Jacqueline Mitton

Astronomer Lorenz and science writer Mitton provide the details of what we know so far about Saturn and its moons.

Princeton University Press, 2008, 243 p., $29.95.

A Grain of Sand: Nature's Secret Wonder

Gary Greenberg



Beautiful photos of sand grains up close reveal surprising diversity. Text describes a sand grain's journey from mountain to beach.

Voyageur Press, 2008, 112 p., $20.

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Feedback

"We continue to use some of our most fundamental skills as the world around us changes."

Sports and the brain

The review of *Play Hard, Die Young* (*SN: 3/22/08, p. 191*) discusses gridiron dementia, a real condition of brain damage consistent with repeated blows. Its symptoms are observed in football players. Although the book's subject is football, I wonder if possibly other athletic contact sports could affect the brain. Maybe, to help all participants, brain studies should be considered for athletes in other sports as well, especially in light or research being done on brain functions.

FONTAINE WINNER, ALTA LOMA, CALIF.

Microbe maze

Regarding "Swell, a Pain Lesson" (*SN: 2/16/08, p. 101*), a recent query in the letters section brings up the hygiene hypothesis. Writer Tina Hesman Saey says that "there is little reason to think that people have fewer bacteria in their intestines now than they did in the past." It is not a matter of the number of bacteria in the gut, but rather of their lack of diversity. This lack is clearly and demonstrably affected by our sterile societal policies. This is why we get Montezuma's revenge, while natives do not, and why we get food allergies, as well as problems such as lactose intolerance. Gut bacteria do have a demonstrative effect on immunity.

McCLELLAN G. BLAIR, GREENVILLE, S.C.

The mix of bacteria in the gut has possibly changed over time; but still, we don't know whether the number or the mix has, because we have never taken a thorough survey of the gut community until recently. Even Montezuma's revenge and other diarrheal illnesses don't necessarily change the underlying makeup, or even numbers, of the community of bacteria living in the colon. There are potentially thousands of different species of microbes, including bacteria, archaea, fungi and others, and the mix is probably different for each person. —TINA HESMAN SAEY

Back to which basics?

In "People move like predators" (*SN: 3/22/08, p. 190*), it would be more accurate to describe a person's behavior as that of a hunter-gatherer, which would reflect a searching and foraging nature rather than the stalking and pursuing characteristics of a predator. Either way, it was interesting to see that we continue to use some of our most fundamental skills as the world around us changes. Adapt and survive.

MICHAEL LEFEBVRE, ELLICOTT CITY, MD.

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Science education and the future of humankind

In the 17th and 18th centuries, technology, whose origins go back to pre-history, was largely invention-based. Inventors did not have a basic training in scientific fundamentals. They thrived by gifted intuition, by trial and error, and by a heritage of experience handed down. But beginning in this period, and much more so in the 19th century, the driving force for technology was scientific understanding. Faraday's invention of the electric motor and generator in the 1820s came directly from the drive to understand the physics of electromagnetism. Faraday didn't even take the time to patent his discoveries.

In our own times, new technologies still flow from understanding basic scientific principles, but additionally, some of those new technologies provide a powerful tool for conducting basic research. Thus we have an accelerating pace of change: Science begets technology and technology enables new science, which begets more technology. An example helps: In the 1920s, experimental data from the atom required an entirely new theory, which became known as quantum theory. Applied to electrons in metals and semiconductors, quantum theory led to the invention of the transistor. The transistor revolutionized electronic engineering and gave rise to microelectronics and high-speed digital computers. Modern physical instruments and particle accelerators are based upon these inventions and provide the tools for further advances in all fields of basic research. Out of these came, for example, sophisticated controls, cell phones and MRI.

Now the pace of science-driven change is increasing so fast that what used to evolve over a period of 50 years can take place in 10. Such change has increased longevity (because of improved sanitation and health care) and launched revolutionary improvements in communications, transportation and access to information and entertainment. Of course, not all of these changes are positive, but they are a fact of our times and they influence economics, politics, modes of living and thinking. These changes have entwined continent with continent, region with region, so that the fate of nations is welded together into what is aptly named "the global village."

As a world society, it seems clear that we have arrived at a point in our history when there must be a major increase in the capability of ordinary people to cope with the scientific and technological culture that is shaping their lives and the lives of their children. In a world in which illiteracy is the shame of societies where it is found, *science illiteracy* is increasingly disastrous. And wherever it is measured, this illiteracy rate is 90 to 95 percent.

We face a crucial choice: whether to apply our science for the advancement of humankind or to succumb to the base forces that weave through our history.

Our world is full of brilliant potentialities and menacing threats. For the past 100 years, science and technology have been driven largely by military and economic forces. Today, environmental catastrophe joins the menu of problems to be addressed. We face a crucial choice: whether to apply our science with humanistic wisdom for the advancement of humankind or to succumb to the base forces and epic tragedies that weave through our history. The global village image raises the stakes enormously in this age-old conflict.

Can we modify our educational system so that *all* high school graduates emerge with a *science way of thinking*? Let me try to be more specific. Consider Galileo's great discovery (immortalized as Newton's First Law): "An isolated body will continue its state of motion forever." What could be more counter-intuitive? The creative act was to realize that our experience is irrelevant because in our normal experience, objects are never *isolated*—balls stop rolling, horses must pull carts to continue the motion. However, Galileo's deeper intuition suspected simplicity in the law governing moving bodies, and his insightful surmise was that if one *could* isolate the body, it would indeed continue moving forever. Galileo and his followers for the past 400 years have demonstrated how scientists must construct new intuitions in order to know how the world works.

But let us all realize that to change ways of thinking by students, we must first change the ways of thinking by teachers. Whatever you think about education, bureaucracy, politics, Internet technology, it is fundamentally the teacher in the classroom with students that is the *key priority*. For teachers who love children and who love teaching, it is still a major problem—changing culture is extraordinarily difficult. And teachers who must teach science are too often poorly educated to do this. The role of scientists in this task should be obvious. It is critical that they get involved in many ways: in the curricula of primary and secondary schools, in the training of teachers and in a new and more profound science requirement for the liberal arts students.

Amen! ■

Leon Lederman is a Nobel Prize–winning physicist and director emeritus of the Fermi National Accelerator Laboratory.

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