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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ SEPTEMBER 11, 2010

Nanobots in Motion

DNA spiders walk the walk

Plume Confusion in the Gulf

Muscles with Memory

First New Chlorophyll in 60 Years

No Contract

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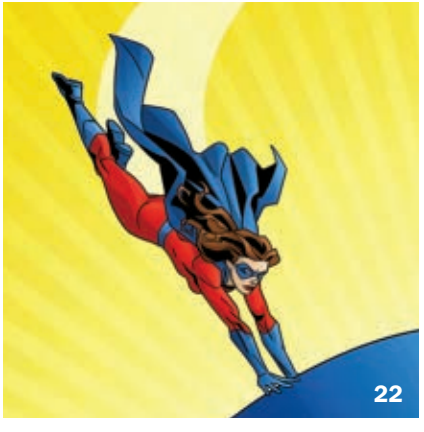

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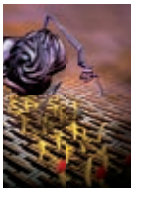

COVER The latest generation of nanosized molecular robots, called DNA spiders, are mobile and can be programmed to complete simple tasks. *Nicolle Rager Fuller*

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FROM THE EDITOR

Fear of spiders shouldn't stop rise of DNA walkers

Among the molecules of life, DNA is the MVP.

It provides the mechanism for heredity, the blueprints for proteins and the recipe for reproduction. It helps explain evolution and illuminates the secrets of many dark diseases. And it gives scientists one of the best tools and toys available for playing around in the nanoworld.

What better way to manipulate molecules on the scale of nanometers than enlisting the aid of the master molecule of life? DNA's chemical components confer on it a powerful versatility, rooted in the forces that bind one strand of the DNA double helix to the other. By exploiting the molecular links that DNA forges naturally, researchers can now make DNA perform unnatural acts, such as walking.

In this issue (Page 18), science writer intern Gwyneth Dickey describes how such nanobotic walkers, or "DNA spiders," have begun to crawl around an artificial landscape (itself constructed of artfully arranged DNA) and how some can even pick up and transport nanoparticle cargo. Someday, optimistic researchers forecast, more sophisticated DNA spiders may be able to crawl around within the body, delivering molecular medicines to diseased cells or assembling nanosized devices for performing cellular surgery. No doubt DNA's nanotechnological abilities will also be applied to making tiny electronic parts for a computer that could fit inside an eyelash.

But all of this won't happen in the blink of an eye. It will take a long time, probably decades, before DNA walkers perform any of the feats that would make them interesting to investors. Right now DNA spiders are still in the baby-steps stage. And they don't even have eight legs yet.

As the researchers point out, though, being far from a goal is no reason not to walk in that direction. Only by starting out small can scientists ever hope to achieve DNA's nanotechnological potential.

Just as the relatively simple DNA molecule is the basis for the complexities of life, primitive DNA walking skills could provide the foundational knowledge needed to create future armies of nanobots. Crews of such tiny devices could be deployed to patrol a realm too small to let human fingers do the walking. You might even say that a small step for DNA really could someday be a giant leap for mankind.

—Tom Siegfried, Editor in Chief

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18. Cauchy's Rigidity and Connelly's Flexibility
19. Mountain Terrains and Surface Reconstruction
20. Voronoi's Regions of Influence
21. Convex Hulls and Computational Complexity
22. Patterns and Colors
23. Orange Stackings and Bubble Partitions
24. The Topology of the Universe
25. Tetrahedra and Mathematical Surgery
26. The Fundamental Group
27. Poincaré's Question and Perelman's Answer
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Science Past | FROM THE ISSUE OF SEPTEMBER 10, 1960

PRIMARY CLUE TO MATTER — The shortest lifetime of an elementary particle — only a quarter of a millionth of a billionth of a second — gives a primary clue to the structure of matter.... [S]cientists have known for about ten years of the neutral pi-meson and have been trying to pin down its lifetime. The new measurement gives theoretical physicists a new universal constant and now they must figure out why it exists or relate it to another constant. When the neutral pi-meson breaks up or decays, two photons of light are produced. These high energy photons, or gamma rays, are purely electromagnetic in character. Thus the new measurement links mesons and the electromagnetic field for the first time.

Science Future

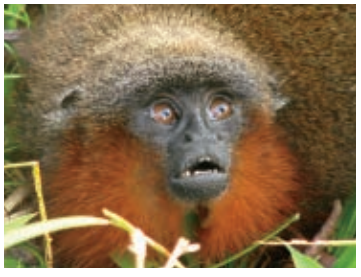
September 16
The North Carolina Museum of Life and Science hosts a Science of Beer event. Go to www.ncmls.org/visit/events/science-beer

September 26
An exhibit on archaeology of the Ottoman Empire comes to Philadelphia. See www.penn.museum/upcoming-exhibits.html

October 15
Entry deadline for National Engineers Week Future City design competition for middle schoolers. See www.futurecity.org

Introducing...

After more than 30 years of speculation among Colombia's biologists, unusual titi monkeys there have been confirmed as a distinct species. The monkeys, which are the size of small cats, have several distinguishing features, including dark hands instead of white. Their description has been delayed by violence in their home region of Caquetá, which has been an insurgent stronghold for decades. During a recent lull in violence, Thomas Defler of the National University of Colombia in Bogotá seized a lucky chance when he learned his new student, Javier García, was a Caquetá native. García returned to the region to observe titis, even bringing two former pets back to the lab. The team describes *Callicebus caquetensis* online August 12 in *Primate Conservation*. The bad news: The species may already qualify as critically endangered.



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ON THE SCENE BLOG
Scientists can sequence ancient DNA, but when it comes to Sitting Bull, experts aren't talking yet. Read "Genome of a chief."

LIFE
Step aside Charlie Chaplin, humans aren't the only ones that can pantomime. See "Orangutans can mime their desires."

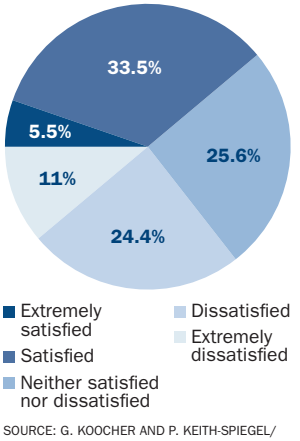
GENES & CELLS
Researchers have succeeded in stealing from their rats, but it's genes they're after, not food. Read "Delivering a knockout."

Science Stats

ARE THESE DATA YOURS?

Scientists who acted on suspicions of colleague misconduct were more often satisfied than dissatisfied with their intervention's outcome.

Feelings after intervening



SOURCE: G. KOOCHER AND P. KEITH-SPIEGEL/ *NATURE* 2010

CLOCKWISE, TOP LEFT: MICHAEL R. DOUGLAS; WIKIMEDIA COMMONS; JAVIER GARCÍA

“This is the best observational evidence so far that the lunar cooling and contraction has persisted over the last billion years.”
—SEAN SOLOMON, PAGE 11

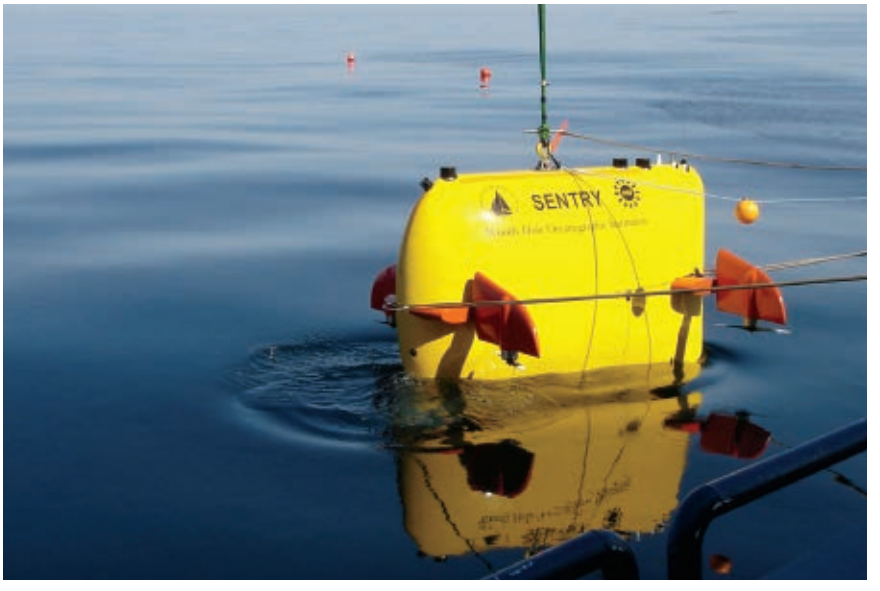
In the News

STORY ONE

Teams disagree over breakdown of BP oil in Gulf

Two studies offer confusing picture of deep-sea plumes

By Janet Raloff



In June, researchers from the Woods Hole Oceanographic Institution probed an oil plume in the Gulf of Mexico using the *Sentry* autonomous underwater vehicle.

CHRIS GERMAN/WOODS HOLE OCEANOGRAPHIC INSTITUTION

A major deep-sea oil-mapping effort reports that as of June an enormous diffuse plume of crude oil generated by the BP spill roamed deep in the Gulf of Mexico and appeared disturbingly stable. Data by a second research consortium also detected a deep dispersed plume in June—but its data indicate that the oil was degrading quickly and may, by now, be completely gone.

Analyses by both groups, published online in August in *Science* just a week apart, point to the difficulty involved in determining the fate of an estimated 4.1 million barrels of oil (172.2 million gallons) that spewed into the Gulf following the *Deepwater Horizon* accident. Because most of this oil has never surfaced, concerns abound over its location and persistence, both of which could influence the pollution’s potential to poison wildlife.

A report online August 19 in *Science* describes a diffuse plume of hydrocarbons more than 35 kilometers long. As this cloud of oil flowed roughly 1,100 meters below the surface, it maintained a configuration roughly 200 meters high, up to 2 kilometers wide and traveling at about 6.7 kilometers per day.

“We’re not sure why this plume set up at this depth,” says lead author Richard Camilli of the Woods Hole Oceanographic Institution in Massachusetts, “but it appears to have persisted for at least several weeks or months. And it appears very stable, but we really don’t know why yet.”

The buildup of stable deep plumes makes sense based on the evolving science of interactions between high-velocity oil and cold, slow-moving waters, comments Roberto Camassa, who directs the Carolina Center for Interdisciplinary Applied Mathematics at the University of North Carolina at Chapel Hill.

“In our lab experiments, things mainly get trapped based on their density,” says Camassa. “So I would expect to find a somewhat sharp transition in density down there, and with such stratification the oil could persist for a long, long time.”

Oil in the plume hasn’t ascended to the surface, he explains, because if droplets are small enough, they become neutrally buoyant and move with the water. Camassa’s lab studies suggest that the high-velocity spray of oil from the BP blowout would essentially have atomized the crude oil into microdroplets.

Analyses by researchers at the National Oceanic and Atmospheric Administration’s Geophysical Fluid Dynamics Laboratory at Princeton University also largely predict what the WHOI team has just reported, notes Robert Hallberg of NOAA.

His group’s findings, to appear in *Geophysical Research Letters*, forecast that much of the oil spewed at great depth will break up into small particles that quickly become neutrally buoyant, and that the microbial breakdown of oil will proceed very slowly. The bugs will eventually eat the hydrocarbons, but temperature can dictate how quickly. “It’s analogous to leaving a sandwich

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on the counter versus putting it in the refrigerator," Hallberg says.

But microbial biologist Terry Hazen of Lawrence Berkeley National Laboratory in California, lead author of a paper published online August 24 in *Science*, says native bacteria in the Gulf have been so voracious that one plume his team had been following "went away approximately two weeks after the well was capped [on July 15]." Its oil is "completely undetectable," he says.

Hazen is part of a team of scientists from two Department of Energy national labs and two universities that has been collecting plume samples continually for months. His team reports that from late May to early June, deep-sea plumes enticed a hitherto unknown cold-water–adapted bacterium to rapidly chow down on the oil. Members of the new species may have accounted for 90 percent of the bacteria in the plume studied, versus only some 5 percent of those outside it.

Also, the oil-digesting bacteria that had inhabited the plume — and that would be expected to stay with it as it moved — remained behind in a microbial cloud. "Doesn't that suggest biodegradation?" he asks.

Images captured by a Woods Hole submersible as it descended near the blowout site in early June show the water turning oily brown at depths around 1,100 meters.

David Valentine, a microbial geochemist at the University of California, Santa Barbara, says he had heard rumors that deep-sea plumes might have gone missing, but currents may have moved them into hiding. "If it sounds too good to be true," he cautions, "it probably is."

Hazen says the plume data his team collected are very similar to data collected by the Woods Hole team — in terms of flow rate, size, path and oil concentrations. But the data diverge over estimated degradation rates. In the field and in lab tanks where plume microbes were housed with crude oil, petroleum appears to have a half-life of just 1.2 to 6.1 days, Hazen's team finds.

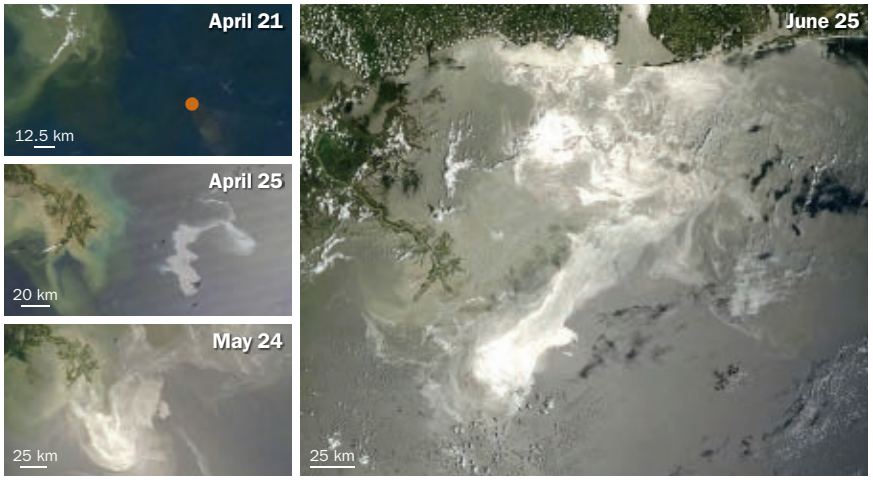
The microbes didn't quickly deplete the water's oxygen, as might have been expected. Evidence of prodigious activity was measured in a depression of nitrates in the water and a continuous loss of straight-chain oil hydrocarbons known as alkanes. Also among the bugs was a floc of wastes from the petroleum dining.

John Kessler, a chemical oceanographer at Texas A&M University in College Station, is skeptical of Hazen's interpretation. Kessler says the team was measuring a component of the entire hydrocarbon mix, which contains thousands of different molecules. Although the molecules studied may well have degraded within weeks, he says, "there are others that have much longer half-lives — on the order of years, sometimes even decades."

Kessler says he has spoken with other researchers in the Gulf who are using other tools and, as of August 22, are still seeing plumes. ■

Back Story | EYES IN THE SKY

Before submersible vehicles could measure the extent of the *Deepwater Horizon* plume beneath the Gulf of Mexico, NASA's Terra and Aqua satellites started tracking the growth and movement of oil slicks on the water surface.



April 21 No oil is visible in this image taken the day after the explosion, but a plume of smoke can be seen spreading southeast from the floating *Deepwater Horizon* rig (orange dot).

April 25 Oil begins spreading north and east of the well site.

May 24 The oil has spread to the outer reaches of the Mississippi Delta, with tendrils swirling north and east from the main slick. Another slick tails off to the southeast. Because of the way the sun glints off the sea's surface, the slick appears white in some locations and dark in others.

June 25 Oil has reached the offshore islands of Alabama and Mississippi, and swirls will eventually be seen throughout the Mississippi Delta region.

TOP: R. CAMILLI/WOODS HOLE OCEANOGRAPHIC INSTITUTION; BACK STORY: ALL IMAGES NASA

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— J. H. from Central Ohio

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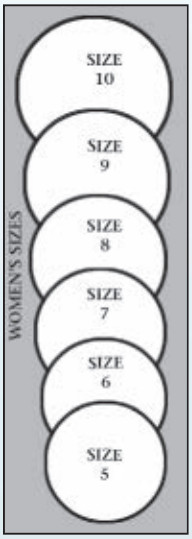

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Butcher may be the world's real oldest profession

3.4-million-year-old bones bear earliest sign of carnivory

By Bruce Bower

For Lucy and her comrades, raw meat sliced off animal carcasses was what's for dinner. That's the implication of a study published in the Aug. 12 *Nature* describing butchery marks on two animal bones from about 3.4 million years ago.

If the new analysis holds up, it provides the oldest evidence so far of stone-tool use and meat eating by members of the human evolutionary family. It's also the first sign of such behavior in hominids preceding the *Homo* lineage, which includes modern humans, say archaeologist Shannon McPherron of the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany.

McPherron and his colleagues discovered the fossils in Ethiopia's Dikika area.

Until now, the oldest animal bones bearing stone-tool butchery marks came from another Ethiopian site, Bouri, and were dated to 2.5 million years ago (*SN: 4/24/99, p. 262*). Researchers found the oldest known stone tools, estimated to be 2.6 million to 2.5 million years old, at nearby Gona, Ethiopia. Those implements were fashioned from select types of rock, suggesting that stone toolmaking began much earlier (*SN: 4/17/04, p. 254*).

A long-standing hypothesis holds that meat eating enabled by stone implements rapidly spurred *Homo* evolution sometime after 2.5 million years ago, especially brain enlargement. "Our finds show that meat eating began much deeper in time and did not lead immediately to the origins of the genus *Homo* and associated biological changes, particularly larger brains," McPherron says.

The fossils place *Australopithecus afarensis*—best known for Lucy, a 3.2-million-year-old partial female skeleton excavated in Ethiopia in 1974—as the oldest known carnivorous wielder of stone tools. Lucy's kind lived in East Africa from about 4 million to 3 million years ago.

No evidence of hunting or fire use exists for Lucy's species. Her kind must have competed with other scavengers to salvage meat from animal carcasses, McPherron proposes.

The new finds add to growing evidence that *A. afarensis* behaved in relatively advanced ways, archaeologist David Braun of the University of Cape Town in South Africa remarks in a comment in the same issue of *Nature*. Lucy's kind had fingers short enough to manipulate stone tools and a humanlike rib cage that would have accommodated a digestive tract capable of processing large amounts of meat (*SN: 7/17/10, p. 5*).

Archaeologist Alison Brooks of George Washington University in Washington, D.C., says the Dikika fossils support her view that ancient primates employed stones as tools even before the origin of hominids around 7 million years ago. Brooks notes that modern chimpanzees and capuchin monkeys use stones to crack nuts (*SN: 11/21/09, p. 24*).

One of the bones described in the new report, a rib fragment, comes from a cow-sized mammal; the other comes from the upper leg of a goat-sized mammal. These fossils were found between volcanic deposits previously dated to 3.24 million and 3.42 million years ago, but were much closer to the older deposit.

Scanning electron microscopy indicated that sharp-edged stones had created incisions on the bones. Chemical analysis showed the incisions had been made before fossilization.

Cutting and scraping of meat yielded distinctive patterns on both bones, McPherron's team asserts. One indentation contained a tiny embedded piece of rock that probably chipped off a tool. Additional damage on the leg fossil came from hammering with a large stone, the researchers say, probably to obtain nutrient-rich marrow inside the bone.

Lucy's relatives would have had to travel six kilometers (nearly four miles) west of Dikika to find rocks suitable for tools, McPherron says. That suggests to Braun that "the meat and marrow of large animals must have been a valued resource."

Two animal bones found in Ethiopia bear damage consistent with the use of stone tools about 3.4 million years ago to remove meat and marrow from the carcasses.

DIKIKA RESEARCH PROJECT

748 per 100,000 | Prison population rate, United States

120 per 100,000 | Prison population rate, China

32 per 100,000 | Prison population rate, India

High imprisonment rates localized

Cynicism, hopelessness common in 'incarceration hot spots'

By Bruce Bower

Crime rates have dropped in the United States over the past 15 years, yet prison populations have soared. The U.S. incarceration rate now exceeds that of other industrialized nations by five times or more, with almost 2.3 million people behind bars and another 5 million on parole or probation.

A major reason for this apparent paradox has gone largely ignored, says Harvard University sociologist Robert Sampson. Certain disadvantaged sections of cities have acted as incarceration hot spots in the midst of a general downturn in crime, he reported August 16.

> "Many kids said they didn't expect to live past age 25 or to avoid ... prison."
> ROBERT SAMPSON

Ballooning incarceration rates in these poor, predominantly black neighborhoods, especially among young men, create a sense of collective cynicism and fatalism that fuels further misconduct and imprisonment, Sampson said. He and graduate student Charles Loeffler of Harvard describe their findings, based on surveys and crime-data analyses of Chicago neighborhoods, in the summer *Daedalus* alongside essays inspired by an American Academy of Arts and Sciences task force on mass incarceration.

"Mass incarceration in the United States has a deep local concentration in relatively few disadvantaged communities," Sampson asserted.

There's an upside to this bleak situation, commented Harvard sociologist Bruce Western. Cash-strapped states are now willing to explore innovative, scientifically tested methods to reduce repeat offending. One such approach in Hawaii targeted men on probation considered likely to commit new offenses. Frequent, random drug tests backed up by swift, short jail stays for infractions substantially deterred these men from using drugs and committing new crimes.

Programs like this cost about $3,000 annually per person, compared with an average of $30,000 to imprison one person for a year, Western said.

Chicago crime data for 1990 to 1995 show that a large majority of prison and jail populations came from two poor, black sections of the city, Sampson and Loeffler found. During that time, crime and violence declined overall in Chicago while incarceration rates rose in those two areas.

Following the city's crime reductions, Chicago officials closed public housing units in the two high-crime, high-incarceration areas because they were considered breeding grounds for drug dealing and violence.

But between 2000 and 2005, the geographic location of each incarceration hot spot in Chicago shifted slightly to the southwest as former public housing residents moved. Incarceration rates in the two new hot spots remained about the same as they had been in the old ones a decade earlier, Sampson said.

Interviews of almost 8,000 Chicago residents between 1995 and 2002 identified intense cynicism about the legal system and hopelessness about future prospects among hot spot residents. Teenagers and children expressed some of the grimmest attitudes. "Many kids said they didn't expect to live past age 25 or to avoid ending up in prison," Sampson said. Researchers need to focus on how the concentration of incarceration within certain poor neighborhoods undermines the quality of life for everyone living there, he added.

Not all poor neighborhoods become incarceration hot spots, Sampson emphasized.

MEETING NOTES

Retiring at 62 boosts well-being

People who retire at or near age 62 receive a surprising benefit—a greater relative increase in physical and emotional well-being than those who retire earlier or later, Esteban Calvo of Boston College reported August 15. Age 62 is when U.S. citizens become eligible to receive partial Social Security benefits. Retiring at culturally and institutionally expected ages yields large dividends in well-being, Calvo suggested. He and his colleagues analyzed data from a national sample of 5,395 people tracked from their 50s into their late 60s. A majority retired during a window around age 62. Members of that group reported substantial improvements in how they felt physically and emotionally after retiring. These signs of general well-being took a progressive turn for the worse in participants who retired at increasingly earlier or later ages. —*Bruce Bower*

Depressed teens not shunned

Depressed teens skirt the social margins of high school mainly because they choose to make friends with peers who have comparably bleak moods, according to a study presented August 15 by David Schaefer of Arizona State University in Tempe. Social withdrawal and avoidance of others by depressed teens prompt their selectivity in choosing friends, he said. Schaefer and colleague Olga Kornienko analyzed previously gathered data on 3,702 teens at 16 public and private schools to assess the likelihood of friendships between individuals with roughly equal mood levels, as determined from interviews of teens, parents and teachers. —*Bruce Bower*

Atom & Cosmos

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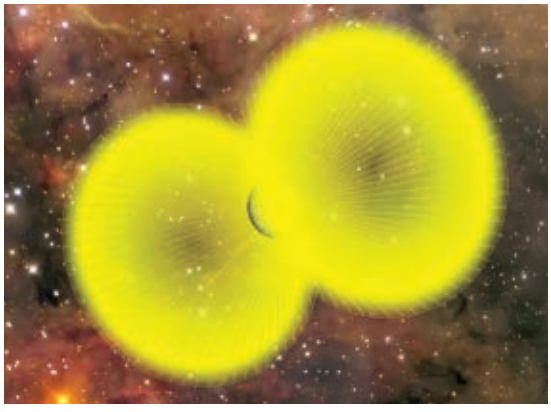
Finding a pulsar in their spare time

Thousands of idle home computers pitch in to detect rare star

By Rachel Ehrenberg



The volunteer computing project Einstein@Home discovered pulsar PSR J2007+2722, depicted here with its radio emission beam illustrated in yellow.

Devil schmevil. Idle computers are doing scientists' work, contributing to advances in fields from epidemiology to nanoscience to mathematics. Now home computers crunching away in Iowa and Germany have helped discover a previously unknown pulsar, a research team reports online August 12 in *Science*.

Enabled by the sophistication of modern web browsers and graphics technologies, plus huge increases in home Internet bandwidth, scientific projects that borrow processing time and wattage from thousands of idle computers can harness power that exceeds a supercomputer's.

The computers that assisted in the pulsar's discovery are involved in the Einstein@Home project, developed at the University of Wisconsin–Milwaukee and the Max Planck Institute for Gravitational Physics in Germany. Begun in 2005, Einstein@Home first searched for gravitational wave signals in data from the LIGO experiment. In March 2009, Einstein@Home also began searching for objects in radio wave data from the Arecibo Observatory in Puerto Rico.

Data from Arecibo are first shipped to Cornell University and Hanover, Germany, where the information is processed into "work units," chunks of about 4 million numbers that are produced in just under five minutes of telescope observing time. These units are sent to volunteer computers — each unit is sent to two machines so the calculations can be validated. After home processing, the data are sent back to Hanover where a human looks at the processed plots and flags anything that looks promising.

The computers that found the pulsar belonged to Chris and Helen Colvin of Ames, Iowa, and Daniel Gebhardt of Mainz University in Germany.

Named PSR J2007+2722, the pulsar rotates a relatively rapid 41 times per second. It is roughly 17,000 light-years from Earth in the Milky Way. While most stars (and pulsars) hang out in pairs, PSR J2007+2722 appears to be alone. But it could have had a companion that blew up, showering it with debris that accelerated its rotation. Or it could just be a very fast young pulsar without a companion.

"Either way, it is unusual," says NASA astrophysicist Alice Harding of Goddard Space Flight Center in Greenbelt, Md.

Similar projects will probably lead to more citizen-assisted discoveries, says François Grey, coordinator of the Citizen Cyberscience Centre, a partnership of CERN, the University of Geneva and the United Nations Institute for Training and Research. Grey recently helped set up the first volunteer scientific computing project in China, CAS@home.

Wishing on stars, hoping for funds

Astronomers prioritize their projects for coming decade

By Ron Cowen

Astronomers tasked with compiling a priority list of U.S. astronomy projects for the next decade are seeing red, and not just because of NASA's meager science budget. An August 13 National Research Council report ranks several telescopes observing the universe at infrared and even longer, redder wavelengths among the highest-priority instruments to be developed between 2012 and 2021. Infrared and longer-wavelength telescopes let astronomers see farther away and thus further back in time, to the first stars, black holes and galaxies, fulfilling one of the overall goals set by the panel.

On the panel's list was the proposed Wide-Field Infrared Survey Telescope, an estimated $1.6-billion orbiting observatory that would examine the nature of dark energy, capture broad views of the infrared sky and look for habitable, Earthlike planets. The panel also recommended that the United States continue plans to develop the Laser Interferometer Space Antenna, an array of satellites that would aim to detect gravitational waves — ripples in spacetime generated by distant black hole mergers and the motions of closely orbiting, dense stars within the Milky Way.

In addition, the panel highly ranked two other proposed space missions — the International X-ray Observatory, which would examine the hot gas around stars and galaxies, and a probe that would further study the universe's early epoch of inflation and the cosmic microwave background, the whisper of radiation left over from the Big Bang.

COURTESY OF F. MOKLER

100 meters — Estimated recent shrinkage of moon's radius

1 kilometer — Estimated recent shrinkage of Mercury's radius

1–5 kilometers — Possible shrinkage of moon's radius since its formation

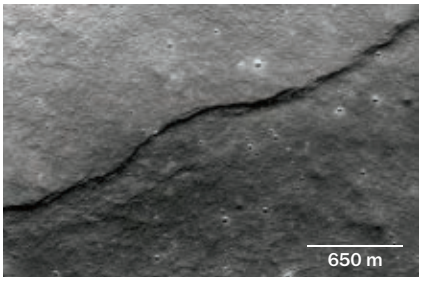
Shrinking moon not so incredible

Widespread cliff formations signal reduced lunar radius

By Gwyneth Dickey

The moon has shrunk in the past billion years, new high-resolution pictures suggest. Evidence comes in the form of cliffs all over the moon that have formed over the last million millennia like wrinkles on a dried-out piece of fruit.

Scientists have studied more than 70 of these cliffs, called lobate scarps, using Apollo mission images from the 1970s. The scarps are generally tens of kilometers long and less than 100 meters high. Researchers had hypothesized that the scarps resulted from shrinkage, but Apollo images did not show whether the scarps spanned the moon's entire surface.



Cliffs called lobate scarps form as the moon's interior cools and shrinks.

Now, images from NASA's Lunar Reconnaissance Orbiter reveal 14 new scarps, providing the first definitive evidence that the scarps occur globally.

"This is the best observational evidence so far that the lunar cooling and contraction has persisted over the last billion years," says planetary scientist Sean Solomon of the Carnegie Institution for Science in Washington, D.C.

Lobate scarps form when a planet or moon cools and contracts. Loss of volume squeezes together parts of the outer crust. Eventually, crust breaks and is pushed up, creating long cliffs that look like wrinkles.

Evidence indicates shrinkage in the last billion years of about 100 meters in lunar radius, says Thomas Watters, a planetary scientist at the National Air and Space Museum in Washington, D.C., who led the study, published in the Aug. 20 *Science*.

Twinkle, twinkle, little fuzzy dot

Astronomers still wonder whether you're a planet or not

By Ron Cowen

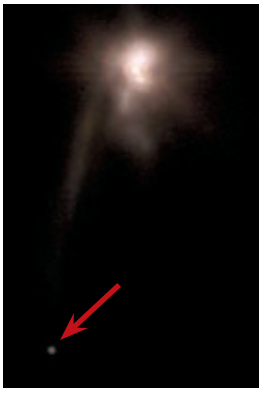
The faint celestial object TMR-1C has had a checkered past — and now it has a checkered present.

In 1998, NASA proclaimed that a picture taken the previous year of TMR-1C — a fuzzy white dot — with the Hubble Space Telescope might go down in history as the first planet beyond the solar system to be photographed (*SN: 6/6/98, p. 357*). Susan Terebey, now at California State University, Los Angeles, led the discovery team, which suggested that the object's location — at the end of a long, luminous filament emanating from two newborn stars — indicated that it was a planet cast off by those incipient suns.

Skeptical researchers noted that the apparent association between the object and the youthful stars might be a chance alignment. Only a year later, Terebey herself declared that the body was too hot to be a planet and could be just an old background star (*SN: 6/26/99, p. 404*).

Now two independent studies, both to appear in an upcoming *Astronomy & Astrophysics*, indicate that Terebey may have written off TMR-1C prematurely. Both reports provide evidence that the object is closely linked to the two youthful stars, probably members of the Taurus star-forming region some 450 light-years from Earth. One of the studies suggests that TMR-1C could indeed be a planet; the other suggests it is just another low-mass star.

"We may have to credit Terebey *et al* with finding a planet after all, but it is perhaps too soon to jump to that conclusion, just as it was too soon to discard the object as a planet 10 years ago," says Eduardo Martín of the Centro de Astrobiología in Madrid, a coauthor of one of the new studies. He and Basmah Riaz of the Instituto de Astrofísica de Canarias in Tenerife, Spain, posted their findings online August 9 at arXiv.org.



This 1997 photograph is possibly the first ever taken of a planet outside the solar system.

Martín and Riaz compared observations they made with the Canada-France-Hawaii Telescope in Hawaii in 2002 and 2009 with those recorded by Terebey and colleagues in 1997 using the Hubble telescope. The object became much bluer between 1997 and 2002 and more than doubled its brightness between 1997 and 2009. That variability suggests that TMR-1C is not an old background star, but a young, nearby object.

Another team, including Monika Petr-Gotzens of the European Southern Observatory in Garching, Germany, took infrared images and spectra of TMR-1C with the Very Large Telescope in Chile. The findings, posted online July 30, also showed that the object can't be a background star. But its temperature is above 3,000 kelvins, indicating that it's not a planet but rather a nearby, low-mass star within a dusty disk, the team says.

FROM TOP: COURTESY OF NASA, GSFC, ARIZONA STATE UNIVERSITY, SMITHSONIAN; NASA

Life

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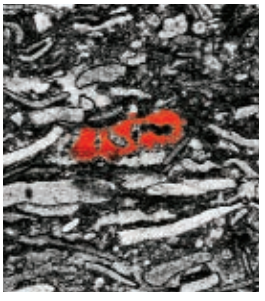
Fossilized blobs may be sponges

Australian rocks contain signs of oldest multicelled animals

By Susan Milius

Little asymmetric whatsits from Australia may be the oldest fossils of full-fledged animal bodies yet discovered, beating the previous contenders by tens of millions of years and pushing body-fossil evidence for animal life to an earlier geologic time.

The newly unveiled fossils, which resemble sponges, come from rocks between 635 million and 659 million years old, Adam Maloof of Princeton University and colleagues report online August 17 in *Nature Geoscience*. That timing sandwiches the fossils between two cold spells that may have iced over most of the planet during a Hollywood-disaster–style geologic period called the Cryogenian.



Shapes like the one marked in red might be the oldest fossils yet found of animal bodies.

The proposed animal fossils do "have all the hallmarks" of being something more than just fragments of microbial mats, says MIT biogeochemist Roger Summons, who was not involved in the study. These mats of single-celled organisms dominated the fossil record for billions of years before true multicelled animals appeared.

Simple forms of life, such as bacteria and even algae with cell nuclei, lived during the Cryogenian. Just before the first of the big snowball ice ages, "we start to get some very cool-looking amoebae," Maloof says. There have been signs that fully multicellular animals probably evolved then too, including chemical traces (*SN: 2/28/09, p. 13*) from rocks and molecular-clock analyses based on how fast DNA changes. Fossils of those animals have been elusive, though.

Work on the newly found fossils started as something different. Maloof and colleagues were exploring the Trezona rock formation in southern Australia to learn about extreme ice ages.

In rock sandwiched between fossilized microbial mats called stromatolites, researchers noticed repeating shapes several millimeters across: anvils, wishbones, rings and belt buckle–like forms that Maloof calls perforated slabs.

Fossils of what might be ancient marine sponges were found between mounds (shown) of fossilized bacterial mats.

The researchers developed software to make a 3-D image based on hundreds of scans of a rock surface as it is ground down about 50 micrometers at a time. Trezona samples showed irregular lumps shot through with a network of fine channels that opened to the outside. "The absence of symmetry and the internal canal system strongly suggests that they are fragments of sponges," Summons says.

Molecular-clock evidence does predict that sponges lived during this period, says molecular paleobiologist Kevin Peterson of Dartmouth College in Hanover, N.H. But he says he is not convinced that the lumps really are sponges.

'Whispering' gives bats advantage

Quieter echolocation allows closer approach to eared moths

By Susan Milius

In a long-running war between bats and moths, at least one bat has gotten the upper wing.

Western barbastelle bats in Europe typically ping out echolocation calls softly enough to locate a moth for dinner before the moth hears the predators coming, says Holger Goerlitz of the University of Bristol in England. It's the first documented case of a bat species outwitting its prey by quiet stealth, he and his colleagues report online August 19 in *Current Biology*. The battle between bats and moths has become a classic system for studying the evolution of predators and their prey.

In searching for moths, barbastelles echolocate at about the 94 decibel level, roughly the equivalent of a busy highway, Goerlitz reports. This bat version of whispering is a tenth to a hundredth the amplitude of typical aerial-hunting bats' echolocation calls. Those rank more in the range of jet engines and the vuvuzelas blaring at the World Cup, Goerlitz says.

Researchers set up a microphone array where bats swooped by at night. Differences in the time it took for calls to reach various microphones let researchers figure out barbastelles' positions for each of nearly 200 calls. This array helped answer whether a barbastelle's echolocation was soft enough for stealth attacks.

The scientists restrained moths along the bat flight alley and recorded activity of their auditory nerves. A European bat with louder echolocation, at 127 dB, triggered the moth's auditory nerves from about 30 meters away. A barbastelle's pings didn't register until it was within 3.5 meters — close enough for the barbastelle to have already detected the moth.

FROM TOP: A. MALOOF; MALOOF LAB, SITU STUDIO

Molecules

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Fifth form of chlorophyll discovered

Photosynthetic pigment's family grows for first time in 60 years

By Rachel Ehrenberg

A new kind of chlorophyll that catches sunlight from just beyond the red end of the visible spectrum has been discovered, extending the known range of light that is usable by most photosynthetic organisms. Harnessing this pigment's power could lead to biofuel-generating algae that are superefficient, using a greater spread of sunlight than thought possible.

The newfound pigment, chlorophyll f, absorbs light most efficiently at a wavelength just beyond the red end of the visible light's slice of the electromagnetic spectrum, researchers report online August 19 in *Science*. This absorbance appears to occur thanks to a chemical decoration known as a formyl group on the chlorophyll's carbon number two. That chemical tweak allows the algaelike organism that makes chlorophyll f to conduct photosynthesis while living beneath other photosynthesizers that capture all the other usable light.

"This is a very important new development and is the first new type of chlorophyll discovered in an oxygenic organism in 60 years," says biological chemist Robert Blankenship of Washington University in St. Louis.

Molecular biologist Min Chen of the University of Sydney in Australia and her colleagues identified the new pigment in extracts from stromatolites, pillars of rock and algae that can form in shallow waters. The samples were collected in the Hamelin pool in Western Australia's Shark Bay.

Previously there were four known chlorophylls made by plants and other photosynthesizing organisms that generate oxygen: a, b, c and d. Chlorophyll a, the standard type, is found in photosynthesizers from algae to higher plants. It absorbs mostly blue light and red light, reflecting green wavelengths to give leaves their hue. Chlorophylls b and c are found in fewer organisms and absorb light in a similar range as chlorophyll a, but shifted a bit. Chlorophyll d, found in a specific group of cyanobacteria, absorbs light most strongly at a slightly shorter wavelength than the new chlorophyll.

The find may enable scientists to engineer algae that are more efficient producers of biofuels, says algae biologist Krishna Niyogi of the University of California, Berkeley. Microbes bearing the new chlorophyll could soak up rays that most microbes can't use.

Body & Brain

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Teens show rise in hearing loss

Surprised researchers had expected some improvement

By Nathan Seppa

The prevalence of hearing loss in teenagers rose by nearly one-third in recent years compared with the rate in the late 1980s and early 1990s, a new study shows. The findings come as a surprise to the study's authors, who had expected overall hearing to improve thanks to publicity about the risks of exposure to loud music and the advent of childhood vaccines against meningitis and pneumonia that can prevent many ear infections.

But in the Aug. 18 *Journal of the American Medical Association*, the scientists report that the portion of U.S. adolescents aged 12 to 19 with any hearing loss rose from 14.9 percent during the 1988 to 1994 period to 19.5 percent in 2005 and 2006.

Researchers based the analysis on information gathered from nearly 3,000 kids in the earlier time frame and more than 1,700 in the later sampling. The findings suggest that as many as 6.5 million teens in the United States now have some hearing loss.

The surveys used largely similar questionnaires and standard hearing tests in which "any hearing loss" was defined as a loss of 15 decibels in at least one ear. That is, a person was determined to have some hearing loss if a tone had to be increased by 15 dB or more beyond the standard detection level to be heard at least half the time.

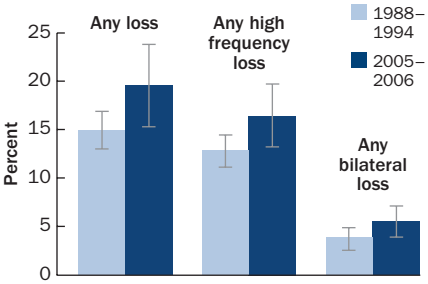
Hearing loss of 25 dB or greater is less common, particularly in children. But it also rose, from 3.5 to 5.3 percent, between the study time frames. The rate of hearing loss increased in high — but not low — frequencies, the researchers found.

This study wasn't designed to find the cause of hearing loss, says study coauthor Sharon Curhan, a physician and researcher at Harvard Medical School and Brigham and Women's Hospital in Boston. While noise exposure is a known culprit, diet, medical care, lack of exercise and obesity might also play a role, she says.

When asked about their exposure to loud music, kids with good hearing didn't give answers substantially different from those offered by kids with poorer hearing. But that may not tell the whole story.

"People underestimate their noise exposure," Curhan says. A single brief noise can compromise hearing levels.

Prevalence of hearing loss among U.S. children ages 12–19



SOURCE: SHARGORODSKY *ET AL*/*JAMA* 2010

The percentage of U.S. adolescents with measurable hearing loss rose by almost a third in just over a decade, a study finds.

Gene activity may predict TB fate

Information could reveal who will go from infection to disease

By Tina Hesman Saey

Thanks to molecular profiling, scientists now have a better idea about how a mass killer selects its victims.

Mycobacterium tuberculosis infects one-third of people worldwide. But only about 10 percent of people infected will actually get sick with the debilitating lung disease tuberculosis. Scientists currently have no way to predict who those people are.

Now, a consortium of researchers has compiled profiles of gene activity in the blood of people with dormant TB infections, people with active infections and healthy people. Such profiles may help predict who will succumb to TB, the researchers report in the Aug. 19 *Nature*.

"This is literally the way to tell who is going to get sick," says Clifton Barry, chief of the tuberculosis research section at the U.S. National Institute of Allergy and Infectious Diseases in Bethesda, Md.

In the new study, researchers drew blood from TB patients and from healthy people in London and analyzed gene activity in the blood cells. People with active TB infections had 393 genes with activity different from that seen in others. The team could classify people into groups — no infection, latent infection or active illness — just by looking at the gene activity profiles in the blood. The findings were replicated in a separate group of patients from Cape Town, South Africa. The TB signature disappeared as people were treated with antibiotics.

About 10 to 25 percent of people with latent infections had signatures similar to those of people with active infections, indicating that people with the active-type profile may go on to develop the disease even if their infection is currently dormant, says study coauthor Matthew Berry of the MRC National Institute for Medical Research in London. The researchers are planning to follow people with latent infections to see if those with the signature really are the same ones who develop active infections later. If the results hold up, the gene profiles could be the first means of predicting who is likely to get sick from TB.

That could spare people from developing a lung-damaging infection, but may also mean that people who aren't likely

18 percent | Hearing loss rate among adults 45–64

30 percent | Hearing loss rate among adults 65–74

47 percent | Hearing loss rate among adults 75 and older

Whether music delivered through headphones or earbuds plays a role in the increased hearing loss remains unknown, but the new findings may trigger research into those devices, she says.

Using family income data, the researchers also found that children living below the poverty line were more likely to have hearing loss than were kids above the line, but only in the 2005–2006 analysis. "One hypothesis is that poor people have more untreated middle ear infections," says Yuri Agrawal, an otolaryngologist at Johns Hopkins University School of Medicine in Baltimore who wasn't involved in the study. Such infections sometimes damage the inner ear and sabotage hearing, she says.

Or, she says, the poverty may *result* from poor hearing, not cause it. Families with mildly poor hearing that is genetically passed on to the children may be impoverished in part because hearing loss can interfere with education and achievement. "This can translate into less opportunity and lower income-earning potential," Agrawal says.

to get sick won't need to take anti-TB drugs that can damage the liver.

TB's molecular signature was distinct from the gene profiles in blood taken from people with other infectious diseases such as *Streptococcus* or *Staphylococcus*, the researchers found. The discovery was unexpected, as most researchers thought that different types of bacteria might change the activity of specific genes at the site of the infection but that those differences would not show up in the blood, says Andrea Cooper, an infectious disease immunologist at the Trudeau Institute in Saranac Lake, N.Y. The variety of signatures indicates that the immune system has developed multiple ways of dealing with infectious organisms.

"It highlights the beauty of the immune response and its finesse in dealing with different pathogens," Cooper says.

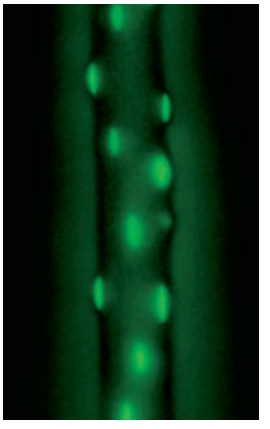
Muscles can remember past glory

Nuclei made in training survive disuse, making regrowth easier

By Tina Hesman Saey

Pumping up is easier for people who have been buff before, and now scientists think they know why — muscles retain a memory of their former fitness even as they wither from lack of use.

That memory is stored as DNA-containing nuclei, which proliferate when a muscle is exercised. Contrary to previous thinking, those nuclei aren't lost when muscles atrophy, researchers report online August 16 in the *Proceedings of the National Academy of Sciences*. The extra nuclei form a type of muscle memory that allows the muscle to bounce back quickly when retrained.



Training produces nuclei (green) in muscle that may help in rebuilding strength after inactivity.

The findings suggest that exercise early in life could help fend off frailness in the elderly, says study leader Kristian Gundersen, a physiologist at the University of Oslo in Norway.

Because muscle cells are huge, more than one nucleus is needed to supply the DNA templates for making large amounts of the proteins that give the tissue its strength. Previous research has demonstrated that with exercise, muscle cells get even bigger by merging with stem cells called satellite cells, which are nestled between muscle fiber cells. Researchers had previously thought that when muscles atrophy, the extra cell nuclei are killed by a cell death program called apoptosis.

In the new study, Gundersen's team simulated the effect of working out by making a muscle that helps lift the toes work harder in mice. As the muscle worked, the number of nuclei increased, starting on day six. Over the course of 21 days, the hard-working muscle increased the number of nuclei in fiber cells by about 54 percent. Starting on day nine, the muscle cells also started to plump up. Those results indicate that the nuclei come first and muscle mass is added later.

In another set of experiments, the researchers worked the mice's muscles for two weeks and then severed nerves so the muscle tissue would atrophy. As it did, the cells deflated to about 40 percent of their bulked-up size, but the number of nuclei in the cells did not change.

These results contradict previous studies that show lots of cell death in muscles during atrophy. Gundersen's team examined individual cells in the wasting muscles and found that apoptosis is going on, but that other cells are dying, not the muscle fibers or their extra nuclei. The extra nuclei stick around for at least three months — a long time for a mouse, which lives a couple of years on average, Gundersen says.

"I don't know if it lasts forever," he says, "but it seems to be a very long-lasting effect." Since the extra nuclei don't die, they could be poised to make muscle proteins again, providing a type of muscle memory, he says.

"That's fascinating thinking, and there's nice proof in this article to support it," says Bengt Saltin, a muscle physiologist at the University of Copenhagen. "It's really novel and helps to explain descriptive findings that muscles are quick to respond upon further training."

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Matter & Energy

To watch videos of icicle formation, visit **www.sciencenews.org/icicles**

Some superconductors go fractal

Oxygen atoms arrange themselves in a self-similar pattern

By Laura Sanders

A new experiment using powerful X-ray beams has found a surprising pattern lurking in a superconductor, a material that conducts electricity without energy-sapping resistance. In a particular kind of superconductor, oxygen atoms are physically arranged as a fractal, showing the same pattern at small and large scales.

Fractals have been spotted in places as diverse as broccoli, coastlines and data from financial markets. Here, the fractal pattern boosts the efficiency of the superconductor, scientists report in the Aug. 12 *Nature*.

The new study is "experimental physics at its best," says physicist Jan Zaanen of Leiden University in the Netherlands, who wrote an accompanying article. A close look at the superconductor "produces a surprise nobody expects."

Though the scientists don't know how the pattern forms or why it enhances superconductivity, they hope the discovery will aid the quest to develop superconductors that work at room temperature, says study coauthor Antonio Bianconi of Sapienza University of Rome. Physicists have pushed superconductivity to higher temperatures, but the top performers are stuck at only about halfway between absolute zero and room temperature.

Bianconi's team bombarded a copper-oxide superconductor that can perform at -233 degrees Celsius with X-rays generated at the European Synchrotron Radiation Facility in Grenoble, France. The resulting diffraction pattern revealed the locations of the material's atoms.

The team knew the material was like a layered cake, with superconducting copper oxide layers alternating with spacer layers. At higher temperatures, oxygen atoms tend to roam around in the spacer layer. But when temperatures drop, they settle down. These oxygen atoms — and the electrons they bring to what would otherwise be vacancies — are thought to contribute to the drop in resistance that accompanies superconductivity. But until now, no one had seen the structure with high resolution.

Bianconi and his team were shocked to find the pattern formed by the once-roaming oxygen atoms was fractal. The pattern looked the same at the 1-micrometer scale and at the 400-micrometer scale.

This self-similarity was completely unexpected, Bianconi says. "We were very astonished. We couldn't believe our eyes," he says. "This is not an area where we expected to see a fractal pattern."

To see whether the fractal pattern was important, the team interfered with it by heating and then quickly cooling the superconductor. Crystals with stronger fractal patterns acted as superconductors at a wider range of temperatures than those with weaker fractal patterns.

The fractal pattern enhanced the superconductor's performance, the team concludes.

Scientists watch as the icicle turns

Drip by drip, simple machine freezes out existing theory

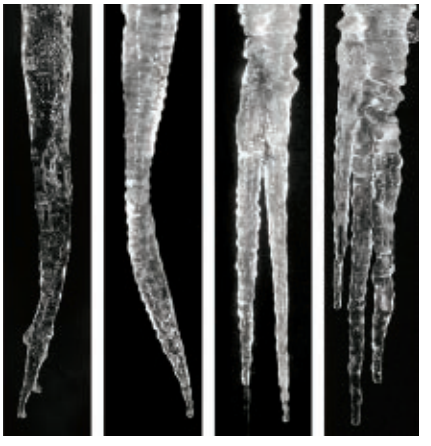
By Laura Sanders

A team of Canadian "iciclologists" has put to rest the notion that one frozen cone of drips is exactly the same as the next. By growing lots of icicles in the lab, the scientists have uncovered evidence that counters an earlier theory that all icicles should, by and large, assume the same uniform, platonic icicle shape. The researchers posted their observations online August 11 at arXiv.org, with a supplementary series of videos on YouTube.

Physicists Stephen Morris and Antony Szu-Han Chen of the University of Toronto tested the existing theory's prediction that most icicles assume a conical shape. Break off one of these perfect icicles anywhere, and the fragment should be the same shape as the whole thing.

"As far as we know, no one has really systematically studied the shape of icicles and how they grow," Morris says. "Nobody has really tried to fill in the physics of how the shape emerges."

Researchers grew the icicles in a frosty contraption made of a refrigerated box with a water drip. Icicles rotated every four minutes, like a rotisserie chicken, so the whole surface got equal treatment.



Researchers have identified reasons why some icicles, such as the ones shown above, don't grow perfectly.

A.S.-H. CHEN, S.W. MORRIS/EXPERIMENTAL NONLINEAR PHYSICS GROUP/UNIV. OF TORONTO

The lab-grown icicles grew to about half a meter long. While some assumed the iconic icicle shape, others came out less than perfect. And while earlier theory posited that growing a perfectly shaped icicle required still air, Morris and Chen found that most of the icicles grown in unmoving air sprouted little legs at their tips. Those grown in the presence of moving air tended to be more ideally shaped.

Also, icicles grown from distilled water were more likely to be perfectly conical than those grown from tap water.

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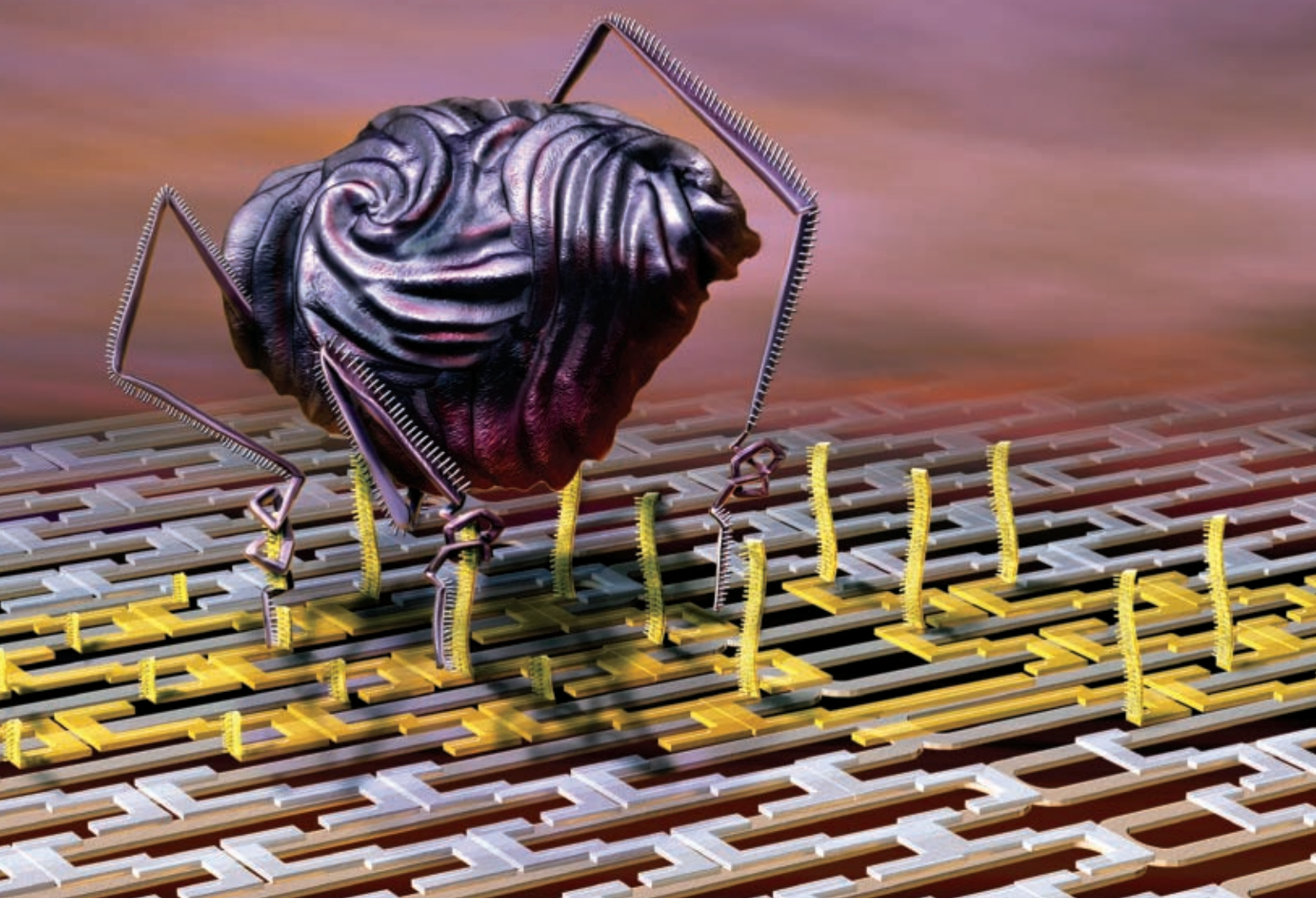


DNA on the Move

Nanobot 'spiders' learn how to walk

By Gwyneth Dickey

Deep inside a beaker in a humming chemistry lab in New York City, a spindly spider crawls over a jumble of origami. It's not the colored-paper kind of origami, but rather is made of precisely designed segments of DNA. For that matter, so is the spider.

This spider wasn't built to spin webs or eat bugs. It's a DNA nanorobot, a primitive version of the machines that may someday perform tasks too small for humans to do.

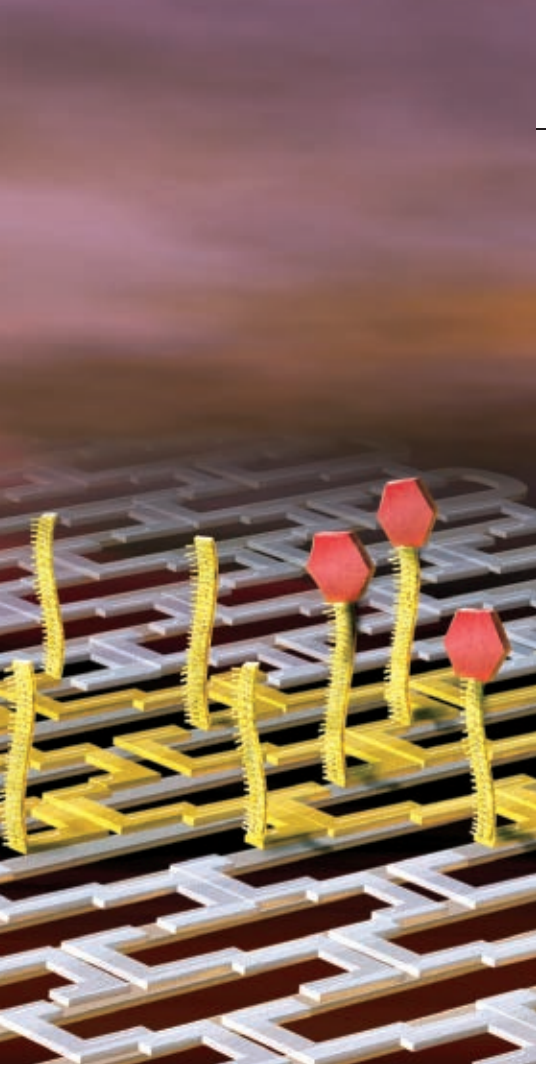
For more than a decade, scientists have been developing DNA nanomachines, from tiny tweezers to two-legged "walkers" that can step to the left or right. Recent molecular robot research has gone a step further, aiming to get DNA molecules to organize themselves and move about, all without batteries or information storage in their nanobodies. These machines harness the power of natural DNA-DNA interactions programmed into the origami foundation.

"Right now there's a molecular explosion going on in programmable behavior of molecules," says biochemist William Shih of Harvard University. "Just like we've seen the evolution in electronics from the calculator to the iPhone 4, we're going to see these things evolve into sophisticated vehicles that can sense their environment and target diseased tissue without harming healthy cells."

The latest arachnoid nanobots have three to four legs and walk across expansive landscapes of exquisitely folded DNA. Some of these molecular machines can take 50 steps all by themselves. Others sport wiggly arms that can pick up and carry around nanoparticles.

DNA spiders aren't going to take over the world anytime soon. They're more like toddlers at this point, tentatively feeling their way across molecular territories as researchers work out the basics of getting the crawlers to move.

NICOLLE RAGER FULLER



LUND ET AL./NATURE 2010

A "spider" with single-stranded DNA legs crawls along a DNA track in this artist's illustration. To move, the nanobot's legs bind to and then cut DNA strands, following the track until hitting stop signals.

But one day nanobot armies may tackle jobs at a scale too small for even the most sophisticated laboratory apparatus. Spiders might be able to seek and destroy cancers in the human body, assemble nanosized medical devices, and build tiny computers vastly smaller than the dot on the iPhone's "i."

"We're pushing the envelope of what's possible with DNA as a working material because we can understand, control and direct DNA more than any other material," says chemist Lloyd Smith of the University of Wisconsin–Madison.

Built-in programming

Getting DNA to move on its own isn't easy. Ordinarily, DNA exists in cells as a twisted double-stranded helix, the blueprint for all life's materials. It's stable and unreactive, untwisting only to be copied for making other molecules like proteins or to replicate itself.

But in recent years, scientists have figured out how to use DNA's own code to set it in motion. DNA strands are made up of four basic chemical building blocks, abbreviated A, T, G and C. In regular DNA, those four letters spell out codes for building proteins. In spiders, those letters are the basis of propulsion.

Each of the spider's legs is made of a single strand of DNA with a specifically engineered sequence of letters. Just as in regular DNA, the A's of one strand are shaped just right to latch onto the T's of another, and the C's match up with G's. By binding to the right partner letters, the legs can stick to single strands of DNA nearby.

That's where the origami surface comes in. DNA origami was invented in 2006 by Caltech synthetic molecular biologist Paul Rothemund. He folded single strands of DNA back and forth until they filled complex two-dimensional shapes: nanosized triangles, stars and smiley faces. Then he designed smaller "staple strands" that matched up with adjacent DNA folds to latch on and hold the shapes in place. Just mixing the single-stranded pieces together in solution allowed the shapes to assemble themselves.

Rothemund's self-assembling DNA origami makes an ideal walking track for DNA spiders, offering a large, 2-D surface into which scientists can program instructions for a spider's movement. That way, the spider doesn't have to carry any information onboard.

In the origami, select staple strands are elongated with extra DNA building blocks to form a crawling trail for the spider. These single strands add a third dimension to the flat surface, sticking upward from the origami like seaweed on the ocean floor. Since their DNA letter sequences match up with those on the spider legs, the staple strands hold the spider to the surface and form a path for walking on.

That part is easy. The tricky part is getting one of the nanobot's legs to pick up and step forward to the next strand.

Forging a path

One solution is to use DNA enzymes in the spider leg to slice through the staple strand. Breaking that strand uproots the leg, allowing it to move on to a nearby strand that is still intact.

Chemist Milan Stojanovic of Columbia University uses this cutting method to get his three-legged DNA spiders to move on their own. They can take upwards of 50 steps without stumbling off the track, he and colleagues reported May 13 in *Nature*.

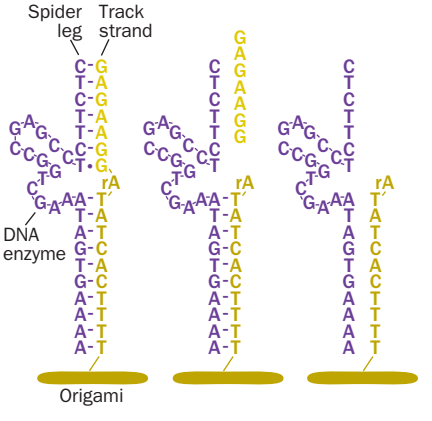
In the past, a problem has been that two-legged walkers sometimes pick up both legs at the same time and float away from the track. With three legs, the spider has a better chance of having at least one leg on the surface at all times.

"The more legs you have, the stickier spiders are and the more steps they can take," says Stojanovic.

His spider has an extra appendage that works like an anchor to bind only to a "start" strand on the origami. When researchers add a piece of DNA that dislodges the spider's anchor, the spider begins to crawl along the other strands of the track.

Since the spider cuts up the strands as it goes, the DNA track gets used up

Making the cut A DNA spider leg links up with a DNA strand on an origami track. The curly-looking DNA enzyme in the leg then cleaves the track strand and a piece of it floats away. No longer bound as strongly to the short strand, the leg lets go and is free to "walk" on and bind to the next intact strand.



behind it. So the spider is most likely to step forward, not back. Following the track laid out on the 65-by-90 nanometer origami field, the spider can walk straight, turn a corner and make its way along the path with no outside help. After about 30 minutes, the spider reaches a "stop" strand that its foot enzymes can't cut. Mission accomplished.

Stojanovic says his next goal with this spider will be to increase the number of steps it can take and program more complex movements into the origami. He also wants to design spiders that can link together and cooperate on a task. Spiders might also read each other's trails, he says, the way ants or other social insects do.

One day in the distant future, these spiders may be able to crawl around on cell membranes, recognizing diseased cells and helping destroy them.

"That's a dream, not something that is around the corner," Stojanovic says.

For that dream to become a reality, the crawlers would need to graduate from their artificial DNA tracks and be able to traverse a more natural landscape, such as the surface of a cell. But since cell membranes aren't covered in DNA, spiders would need to be designed to interact with a different molecule, perhaps an intermediate protein that scientists would insert onto a cell.

"It's a slow process," Stojanovic says. "If you ever want to see something like that happening, you have to go through the stage we are going through."

Burned bridges

One problem with an autonomous spider that cuts up the track behind it is that the origami is used up after only one run.

"If your motors are forever destroying the tracks, you've got to rebuild the tracks, which would cost you a huge amount of energy," says physicist Andrew Turberfield of the University of Oxford in England. "An automobile that chewed up the road behind it would be a bit unpopular."

Turberfield is working on ways for walkers to move by themselves without destroying their tracks. His team has come up with a two-footed walker that walks along a reusable strand of DNA by flipping over itself, like a gymnast doing handsprings across a mat.

A "fuel" strand added to the surrounding solution raises the walker's back foot. The walker then flips over and moves a step forward on the track. It can go backward simply by switching to a fuel strand that reacts with the front foot.

This type of nanobot takes its inspiration from kinesin, a natural molecular motor that carries cargo around the cell, Turberfield says. Kinesin's two feet coordinate so that the back foot is always the one to pick up first and move forward.

"We're looking at what cells do with motors and are trying to emulate the cell," Turberfield says. "If you look at biology as inspiration, then you won't go far wrong."

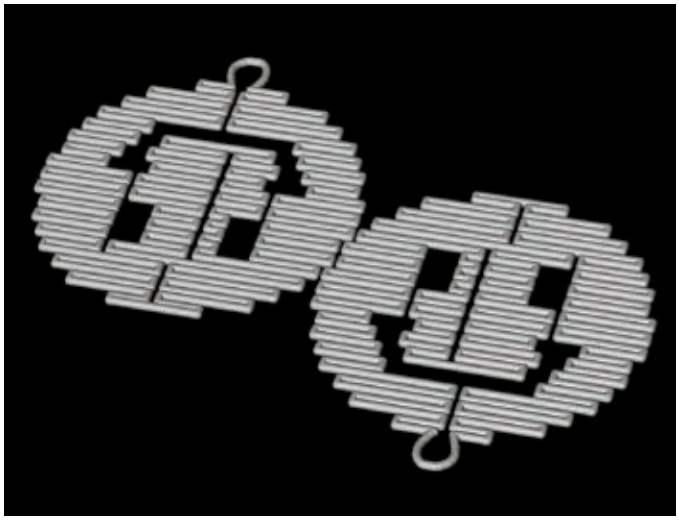
Nano assembly lines

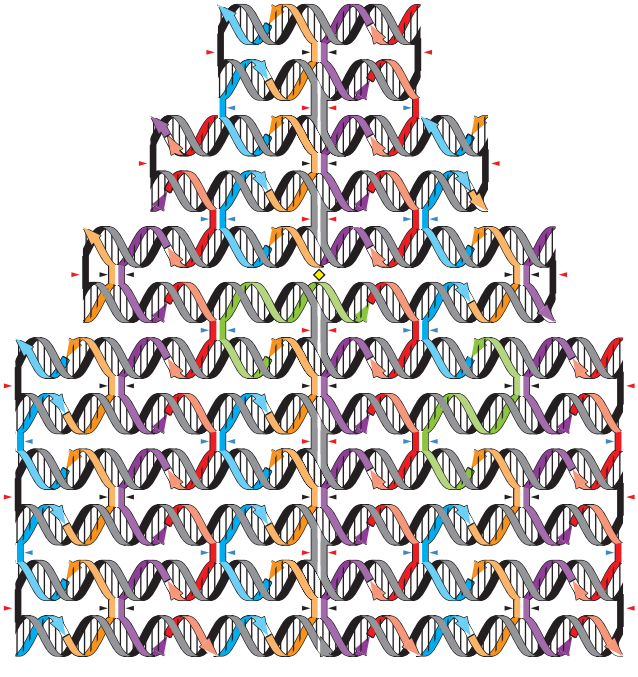
Another breed of DNA spider new to the nanotech world does more than walk. It also picks up cargo with three DNA arms.

A group led by DNA nanotechnology pioneer Ned Seeman of New York University has designed a four-legged, three-armed spider that picks up gold nanoparticles from stations along an origami track. The spider can't walk by itself, but rather requires the scientists to add short, single strands of DNA into the surrounding solution at each step to coax the feet forward.

Researchers embed three stations into the origami. Each station holds a gold nanoparticle wrapped in a single strand of DNA that is complementary to the DNA in the spider's arms. When a spider stops at a station, one of its DNA

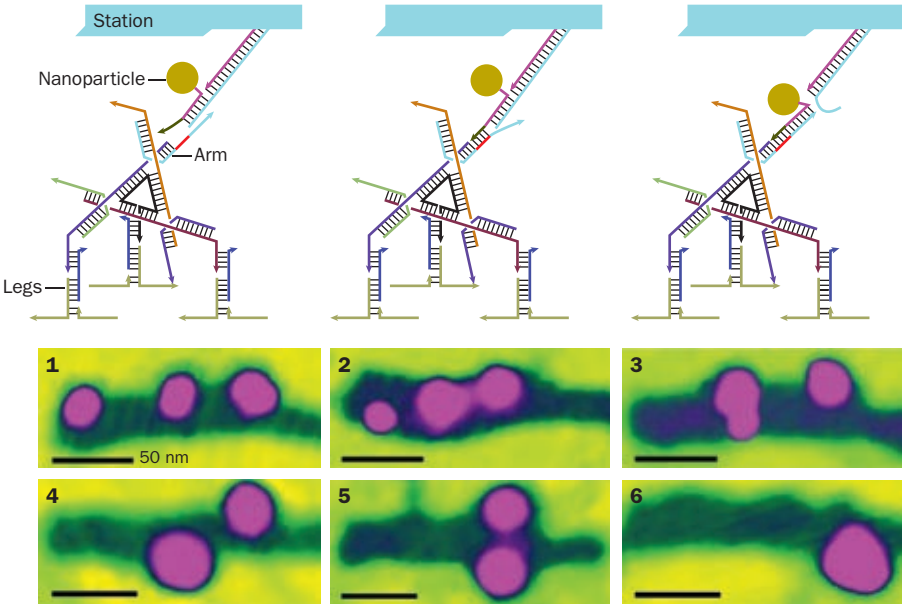
DNA in the fold DNA can be folded into almost any shape, even a smiley face (computer illustration below). A more detailed simulation (right) shows how a single strand of DNA (gray and black) is folded to create a tower shape. Short "staple strands" (colored) bind across the folds, clipping the shape in place. Once the pieces are mixed in solution, the shapes self-assemble.





FROM LEFT: P.W.K. ROTHEMUND; ROTHEMUND/*NATURE* 2006

Going for the gold Researchers have created a DNA spider that can do a simple task—pick up and carry a gold nanoparticle. To do this, the spider's arm binds to a DNA "leash" on a nanoparticle, detaches it from the station and ferries the cargo away (top). Atomic force microscopy (bottom) shows three separate nanoparticles (purple) as they are collected by the spider.



arms binds to this DNA leash, grabbing the nanoparticle and plucking it off the origami. As the spider moves away from that station, it carries the new cargo along to the next stop, where it will pick up another nanoparticle.

Seeman compares the spider to a car chassis moving along an assembly line.

Components are added to the spider "like you would add a door, a steering wheel or an engine to a chassis," says Seeman, whose spider work also appears in the May 13 issue of *Nature*.

After two more stops, the spider might have up to three particles in its arms. But there may also be just one or two. That's because the stations can be programmed to either give up or keep their cargo. Using the same track, the spider may pick up different combinations of nanoparticles.

In the future, Seeman says, a single assembly line may be able to work with many more than three building blocks. Such longer assembly lines could build more complex objects. He also plans to make these spiders autonomous so they can do the work without the scientists having to add new DNA strands for each move.

Finally, he wants to try to assemble molecules that will bind together into complexes, rather than make things that ultimately have to be held together by the DNA. He thinks spiders could pick up individual molecules at each station that would bind to each other. By bringing together molecules one at a time, spiders could fit together molecular puzzle pieces that don't react well together in nature. This could be a help to chemists, he says.

"What we do right now in virtually all chemistry is throw in a bunch of things in the pot, and swirl them around so they collide with one another," Seeman says. "In principle we could do reactions more easily."

Crawling into the future

Researchers concede that DNA spiders can't do anything useful yet, and most scientists are reluctant to project too far into the future about what these nanorobots could eventually do.

"It's very appealing to be able to picture something that's a billion times smaller than a human that can move," says Caltech biological engineer Niles Pierce, who has done work on DNA walkers. "But to take that locomotion and put it to productive use for fabrication of nanoscale components, that's still a futuristic goal."

Yet engineers should continue to experiment with these nanomachines to pave the way for novel discoveries in nanorobotics, Pierce says. "The stuff you would learn along the way pays dividends in other areas."

And the hope remains that decades down the road, swarms of DNA spiders might be deployed in people's bodies searching for telltale signs of cancer or disease. Those spiders would signal to each other where to find the troubled tissue and work together to dive-bomb their targets with sacs of medicine. Such targeted antidisease missiles could avoid the side effects that occur when drugs pervade the body and affect other tissues.

Likewise, DNA crawlers with many arms might skitter across origami assembly line factories, grabbing nanoparticles one by one and assembling them in a precise order. Nanospiders might build nanosized computer chips that cram more memory, power and speed into smaller and smaller spaces. Or perhaps arrange nanoparticles into new configurations and make new metamaterials for cloaking devices.

"One of our goals is to make DNA and protein systems that are as complex as a living cell," says Rothemund. "But to get there, we're going to have to make our DNA nanotechnology systems hundreds of times, thousands of times more complex."

Research labs tinkering with DNA devices increase in number every year as scientists realize how they might harness DNA's potential, he says.

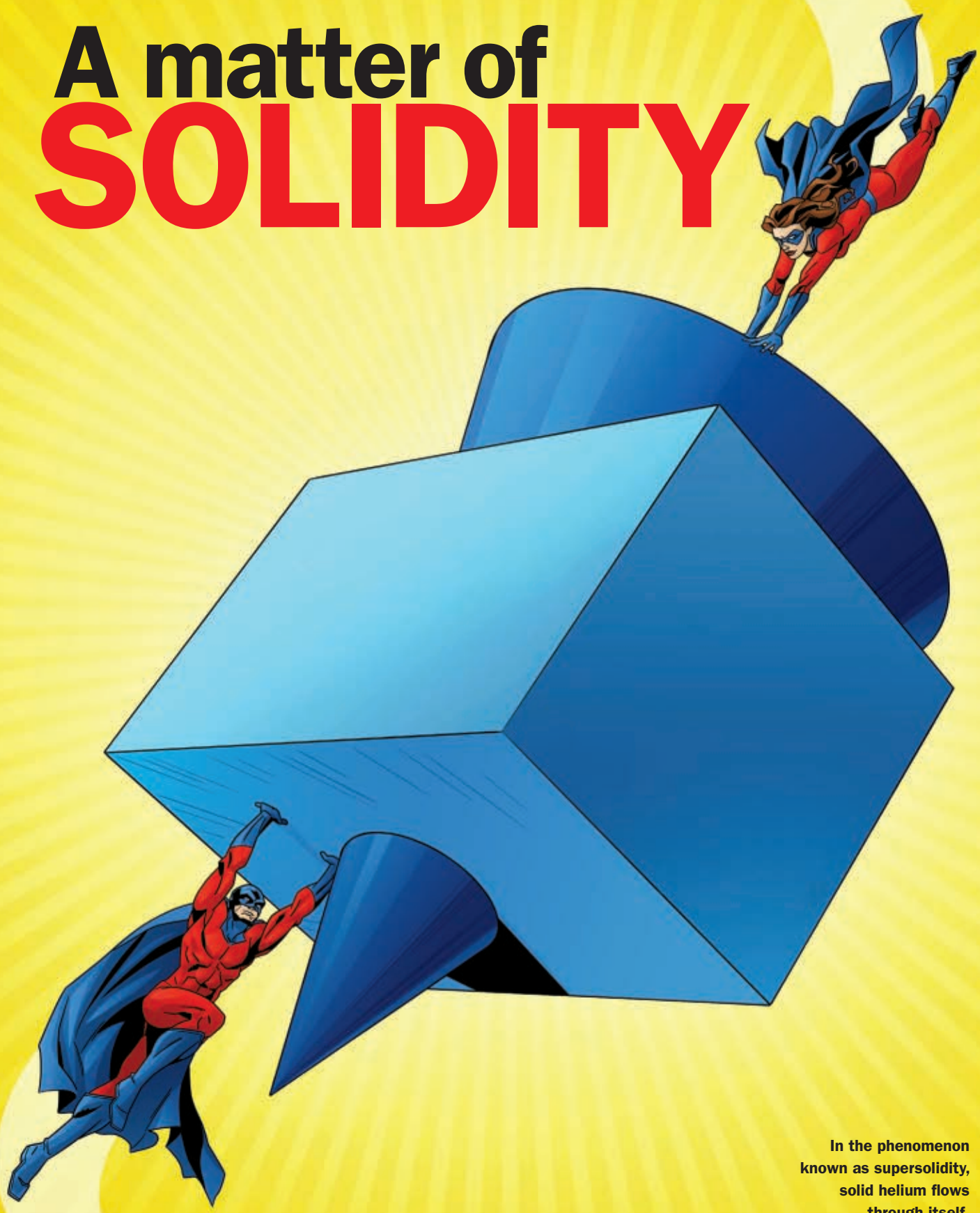
"It's gotten 10 times cooler in the last 10 years, and it got 10 times cooler in the 10 years before that," Rothemund says. "At every stage, I think it will become more and more compelling." ■

Explore more

- Lloyd Smith. "Molecular robots on the move." *Nature*. May 13, 2010.
- For more information, visit the Centre for DNA Nanotechnology website at www.cdna.au.dk

H. GU *ET AL*/*NATURE* 2010

A matter of SOLIDITY



In the phenomenon known as supersolidity, solid helium flows through itself.

SHANE L. JOHNSON

A material that oozes through itself presents a super physics puzzle

By Alexandra Witze

Solids are supposed to be the reliable state of matter.

Gases are flighty and flitting and expand to fill any available space. Liquids will also mold themselves to whatever shape they occupy, from soda bottle to swimming pool. Solids, though, are steadfast and unyielding, stable and dependable, like the rise and fall of tides, the guidance of the North Star or the love of a dog.

But that truism may turn out not to be so true. In the past few years, physicists have learned of a solid that doesn't adhere to fixed rules. Within this solid — helium at very low temperatures — some atoms appear to leave their rigidly defined positions and begin moving through the rest of the material without friction. In essence, the atoms are simultaneously solid and fluid, and the material slides through itself.

Star Trek captains might be familiar with such shape-shifting, but researchers on Earth aren't. Ever since the phenomenon, dubbed "supersolidity," was described, physicists have struggled to explain what might be going on within the mutable material.

"Most people probably thought this would be crystal clear in 18 months," says John Beamish, a physicist at the University of Alberta in Edmonton, Canada. "It's a surprise that five years later we're still not sure — which is telling you it's more complicated than we'd thought."

Some studies suggest that observations once attributed to supersolidity might instead result from materials behaving bizarrely for other reasons. Recent work, however, seems to strengthen the case for supersolidity. While theorists move forward with explanations for how flaws within crystals could give rise to supersolid behavior, experimentalists are building new laboratory devices to try to pin down what is really going on with this superpuzzle.

Excitement in the field runs high because of what's at stake. Not only is supersolidity an entirely new form of material behavior, but it's also Nobel Prize territory. The study of superfluidity, supersolidity's older cousin, has netted a series of Nobels (see Page 25).

From one super state to another

Superfluidity was discovered in 1937, when researchers in England and the Soviet Union independently found that, below temperatures of 2 degrees above absolute zero, liquid helium could flow without any friction. Intrigued, theorists suggested that the atoms had morphed into a new type of quantum state — a "Bose-Einstein condensate," in which atoms lose their individual identities and begin to flow as a collective mass.

Superfluidity has an analog in electricity. A superconducting material is one in which electrons carry electricity without any resistance. Superconductivity also occurs at low temperatures, and also because the electrons stop behaving normally and instead pair up in a Bose-Einstein condensate of their own.

By the middle of the last century, then, scientists knew that both fluids and electrons could flow without resistance thanks to quantum effects. Why not solids, too?

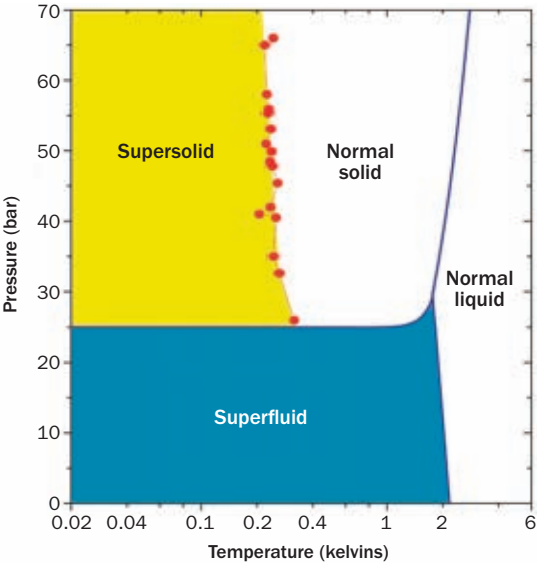
On the face of it, supersolidity seems counterintuitive, since atoms in a solid are arranged in a rigid crystal lattice. But almost all solids have empty spaces — called vacancies — where atoms are missing, like an apartment complex in which some rooms don't have tenants. In 1969, Russian theorists proposed that quantum effects at low temperatures could cause some of these vacancies to hop from one place to another, so that different apartments become empty at different times. The moving vacancies could start to display Bose-Einstein–like behavior, and part of the solid could begin to move without friction.

If supersolidity exists, scientists thought, they should look for it in solid helium. With just two protons in its nucleus, a helium atom is relatively light. It is also not strongly attracted to other helium atoms. So if vacancies could shift around within a crystal lattice, they would do so most easily in helium.

Yet it took more than three decades for experimentalists to discover supersolidity in helium-4, which has two neutrons along with the two protons in its nucleus. The breakthrough came after John Goodkind of the University of California, San Diego reported that sound waves traveled in an unexpected manner through solid helium. Intrigued, Moses Chan of Pennsylvania State University in University Park decided to launch a new study of solid helium using a device called a torsional oscillator. This machine oscillates a sample back and forth around a central axis, like a merry-go-round spinning first one way and then the other at 1,000 times a second.

Such oscillators had been used to

Super helium Under normal conditions, helium-4 is a gas, but at temperatures close to absolute zero it can exist in other phases. A superfluid phase has long been studied; scientists are now exploring its probable supersolid phase.



E. KIM AND M.H.W. CHAN/*SCIENCE* 2004

hunt for superfluidity because quantum materials, when placed in a spinning container, don't spin along. Imagine rotating a bucket of water. If the water were a superfluid, it wouldn't slosh around with the rotation but would instead sit unmoving, decoupled from the bucket's moving sides. Supersolids, if they exist, would do the same thing. Thus, as a solid transitions to a supersolid state at low temperatures, the period of time it takes for the oscillator to rotate back and forth would drop — because less mass would be sloshing around.

Chan and his colleague Eun-Seong Kim didn't think they had much chance of finding supersolidity. "I remember telling Eun-Seong that our chances of seeing something were close to zero — like buying a lottery ticket," Chan says.

Yet when they filled their torsional oscillator with solid helium and spun the machine, they saw its period get shorter — presumably because some of the solid helium was becoming decoupled from the system instead of rotating with it. And when they put solid helium in a spinning device the shape of a doughnut, then blocked a portion of the doughnut before oscillating it, the effect mostly went away — suggesting that flow was indeed occurring within the helium and could be cut off at will.

That discovery, reported in 2004, touched off a rush of excitement among physicists, who thought they had finally seen the long-predicted supersolidity (*SN: 1/17/04, p. 35*). But the observations that followed made it far from crystal clear.

> "The rumor of the demise of the subject of supersolidity is highly exaggerated."
> MOSES CHAN

Super or not so super

For one thing, researchers struggled with understanding what role defects played in supersolidity. In 2007, a team led by physicist John Reppy of Cornell University reported heating helium crystals long enough to heal many of the defects within. These cleaner crystals, when put into a torsional oscillator, changed the rotational period of the device far less than would be expected if supersolidity were happening. Scientists were puzzled.

That same year, doing work that didn't use a torsional oscillator, Beamish's group at Alberta found that at temperatures where supersolidity ought to be starting, the material stiffened up — the opposite of what might be expected for a material that could supposedly flow through itself. And helium stiffening could also explain the periodicity drop in the torsional oscillators.

"The first thing people thought of was, is all the stuff you see in the torsional oscillator just an experimental artifact?" says Beamish. If so, solid helium's odd behavior at low temperatures could be explained by properties less exciting than supersolidity.

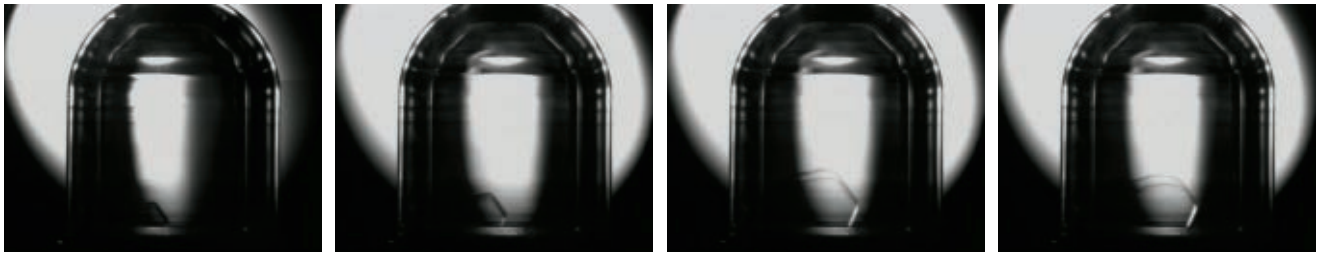
Yet other measurements soon showed that supersolidity and helium stiffening could both contribute to the drop in the oscillator's period. "It seems reasonable to say there are two effects going on," says Chan. And the contribution from supersolidity appeared to be much larger than that from stiffening.

Once again, supersolidity appeared to be on a solid footing. And once again, another challenge arose. This June, Reppy published a paper in *Physical Review Letters* arguing that the changes in rotational periods seen in torsional oscillator experiments are not supersolidity per se, but something else.

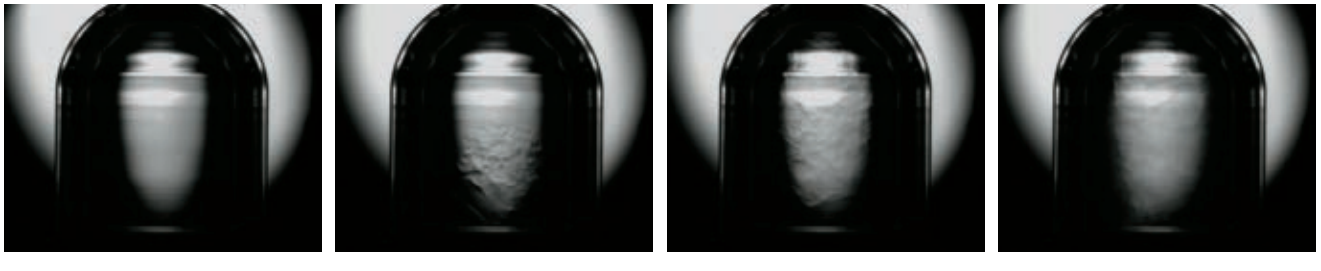
In this work, Reppy has for the first time squished solid helium plastically — that is, squeezed it at high pressure so that its crystal lattice begins to deform

Crystal purity Researchers in Paris have grown solid helium crystals in a transparent torsional oscillator. In the top series, a single pure crystal grows slowly at a temperature of about 25 millikelvins. Below, a highly disordered polycrystal grows quickly, at 600 millikelvins. By watching these crystals develop, scientists hope to tease out whether supersolidity occurs in pure helium or whether defects must be present for the solid to start flowing.

Pure crystal



Polycrystal



X. ROJAS, A. HAZIOT, J. WEST, M. CHAN, S. BALIBAR/ENS PARIS

permanently, like a piece of taffy. Again, the period of the oscillator gets shorter as expected, but only at relatively high temperatures — above 100 millikelvins, or thousandths of a degree above absolute zero. At the lower temperatures at which supersolidity should be occurring, he sees little to no change in the oscillator period.

Instead of displaying supersolidity at low temperatures, Reppy writes, the helium crystals might instead be undergoing some kind of permanent deformation at higher temperatures. Such an explanation would be less sexy than supersolidity, though it would mean scientists had identified a previously unknown way that solid helium can behave.

Many in the field say Reppy's work is provocative but does not disprove supersolidity. "The rumor of the demise of the subject of supersolidity is highly exaggerated," Chan says. In most experiments, he says, the effect of helium decoupling from the oscillator's sides accounts for 80 to 95 percent of the drop in period observed. In Reppy's experiment, though, the permanent-deformation effect seems to dominate, for reasons that remain unclear.

Spotting hopping dislocations

Even as researchers work to explain Reppy's findings in the context of supersolidity, other results are pouring in that may firm up its existence once and for all.

At the University of Massachusetts Amherst, for instance, physicist Robert Hallock has set up one of the few experimental devices that does not rely on torsional oscillators. He injects superfluid helium into a rod made of a porous glasslike substance called Vycor, which enters a cell filled with solid helium that has another Vycor rod on its far end. Hallock then watches to see if the second rod gains mass, possibly because atoms are flowing from one rod to the other. If superfluid helium enters one side and comes out the other, it could indicate that the solid helium in between is behaving as a supersolid.

In a paper under review, Hallock and graduate student Michael Ray report seeing atoms flowing between the rods

Helium's many phases

Aside from a few popular party tricks — making balloons float and voices high-pitched — helium appears to be a rather ordinary gas. But cool the element to just a few degrees above absolute zero, where it changes from a gas into a liquid, and its atoms leave the world of classical physics behind and begin to exhibit quantum behavior. These bizarre properties have led to a number of Nobel prizes for the study of liquid helium.

1. Because it has the lowest boiling point of any element, after its discovery on Earth in the late 1800s helium took center stage in the drive to reach temperatures closer and closer to absolute zero. Liquefying the element would mean hitting 4.2 kelvins, or degrees above absolute zero, in the lab. Dutch physicist Heike Kamerlingh Onnes achieved the feat in 1908, and in 1913 received the Nobel Prize in physics for his efforts. But strange discoveries were still in store.

2. As liquid helium was cooled below 4 kelvins, it boiled like crazy. But below 2.17 kelvins, the boiling suddenly stopped. This meant that helium-4, the most abundant form of the element, had two distinct liquid states, with a transition between them at 2.17 kelvins. Below that temperature, Russian physicist Pyotr Kapitsa found in 1937, liquid helium flowed without friction. This form of liquid, dubbed a superfluid, could flow through tiny holes, creep over the edge of a cup and pull itself up and out of a tube, like a fountain (**pictured**). Kapitsa received a Nobel Prize in 1978 for his studies into low-temperature physics.

3. Superfluidity arises when the atoms in superfluid helium join up in a quantum state called a Bose-Einstein condensate, allowing them to exhibit collective behavior. Russian condensed-matter theorist Lev Landau developed a mathematical explanation for the behavior of helium at low temperatures and was awarded a Nobel in 1962.

4. In the 1970s scientists discovered that helium-3, a rare isotope of the element, also has a superfluid state at temperatures lower than 2 millikelvins. David Lee, Douglas Osheroff and Robert Richardson shared the physics Nobel in 1996 for that find. The behavior of helium-3 appears to be even more complex than that of helium-4, and some scientists have tried to use the vortices that form in superfluid helium-3 to model the development of spacetime defects, called cosmic strings, in the early universe.

5. Helium-3 is much harder to get in a superfluid state than helium-4 because it is made of fermions, particles that cannot occupy the same quantum state. So explaining how helium-3 atoms could begin to move collectively was a theoretical puzzle. British-born physicist Anthony Leggett cracked this problem by proposing that the atoms pair up, analogous to the way electrons pair up in superconductors. Leggett won a 2003 Nobel for his contributions to the understanding of how atoms behave in superfluids.

Today, scientists are finding that the frictionless flow observed in liquid helium may also occur in the solid phase. But the jury is still out on whether supersolidity exists — and whether its discovery will lead to any Nobels. —*Elizabeth Quill*

S. BALIBAR/*NATURE* 2010

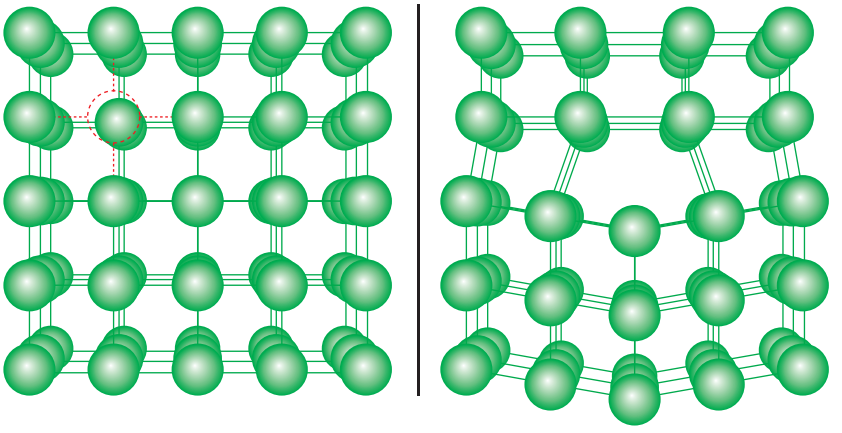
at temperatures where supersolidity could be happening — 80 millikelvins. "You could interpret our experiments as that we are seeing flow associated with what might be expected for supersolid behavior," Hallock says.

Still, he adds, "I'm much more cautious than that." In part that's because of what happens when the researchers lower the temperature below 80 millikelvins: The rate of flow drops dramatically, the opposite of what might be naïvely expected if supersolidity were occurring. And the flow occurs at much higher temperatures as well, up to 600 millikelvins. "Something is necessary to explain the ability of our experiment to pass atoms through the cell," says Hallock. "Is it a supersolid? Could be. Is it for certain? I don't know."

Some theorists think that Hallock's work is the closest to demonstrating true supersolidity. Anatoly Kuklov, a theoretical physicist at the City University of New York's College of Staten Island, says the experiment shows that supersolidity exists, but probably not the kind originally envisioned in 1969. Instead of a simple shifting around of vacancies within a crystal, he says, supersolidity could occur because of atoms moving along a different kind of crystal defect, called a dislocation. Such defects, known for decades, could offer a new explanation for supersolidity's bizarre behavior.

To picture a dislocation, imagine a book in which one page has been ripped in half horizontally. Look at the closed book from the bottom, and all pages might appear to be intact. But look at it from the top, and one page will appear to be missing. The line of that missing page is analogous to a crystal dislocation.

Numerical simulations of a helium crystal with no such dislocations showed no signs of supersolidity, Kuklov says. And experimental results from different laboratories vary widely depending on how the crystals are prepared — again suggesting that the purity of the crystals could be important. "So the effect is most likely produced," Kuklov says, "by a network of defects which can conduct flow," in which atoms move along the defects and allow the solid to flow like a fluid.



SOURCE FROM LEFT: A.R. BARRON AND C. SMITH/*CONNEXIONS* 2010; NDT EDUCATION RESOURCE CENTER

The role of defects Many researchers think that supersolid behavior may arise because of the motion of atomic defects through a solid's crystal lattice. In one common type of defect, called a vacancy, an atom is simply missing in the lattice (left). In another, called a dislocation, an entire atomic row is truncated, causing the rest of the structure to warp accordingly.

To test this idea, experiments are underway to see what happens to a single perfect crystal of helium, free of defects, in a torsional oscillator. Chan and Sébastien Balibar, of the École Normale Supérieure in Paris, have built a contraption where the oscillator's sides are made of transparent sapphire, providing a window to see what's going on inside. (Other torsional oscillators use metallic containers that obscure the view within.) Inside the researchers put the purest crystal they can make. As it oscillates, new dislocations pop into existence.

At a supersolidity workshop in Paris in late July, Balibar and Chan reported seeing single dislocations move "like violin strings" through the solid helium at rates of up to several meters per second. Such speed is impossible with everyday materials and could occur only if quantum phenomena like supersolidity were in play, Balibar says.

In a paper to appear in *Physical Review Letters*, Balibar and colleagues also report that these vibrating dislocations can cause ultrapure crystals of solid helium to soften. Oddly, supersolidity appears only when impurities in the crystal prevent the dislocations from moving.

Additional new evidence supporting supersolidity was reported at the Paris meeting by Kim — now at the South Korean university KAIST — and his colleague Kimitoshi Kono of the RIKEN research institute in Tokyo. They took a torsional oscillator and, as it swung back and forth, also rotated it around its axis like a spinning Earth. "For almost any classical metallurgical explanation, one that doesn't involve superfluidity, it's hard to imagine how rotating it would make any difference," says Beamish. "It's a fundamental property of superfluids that rotation makes a huge difference." And that's exactly what Kim reported at the conference — that mass was flowing through itself not only from the back and forth of the oscillator but also because of the added rotation.

Many say that though supersolidity hasn't been proved beyond a shadow of a doubt, it is looking more and more likely. Clearly, solid helium at low temperatures behaves in a funky way that needs explaining — whether through supersolidity or some other phenomenon. "I think over the next year we're going to see considerable progress," Hallock says.

Whatever transpires in the next round of experiments, it seems certain that the unsolid nature of some solids will continue to confound. "Everyone in the field just wants to know what's going on," says Beamish. "There sure is something interesting, and it will be more exciting if it really is supersomething." ■

Explore more

■ S. Balibar. "The enigma of supersolidity." *Nature*. March 11, 2010.

T. DUBÉ

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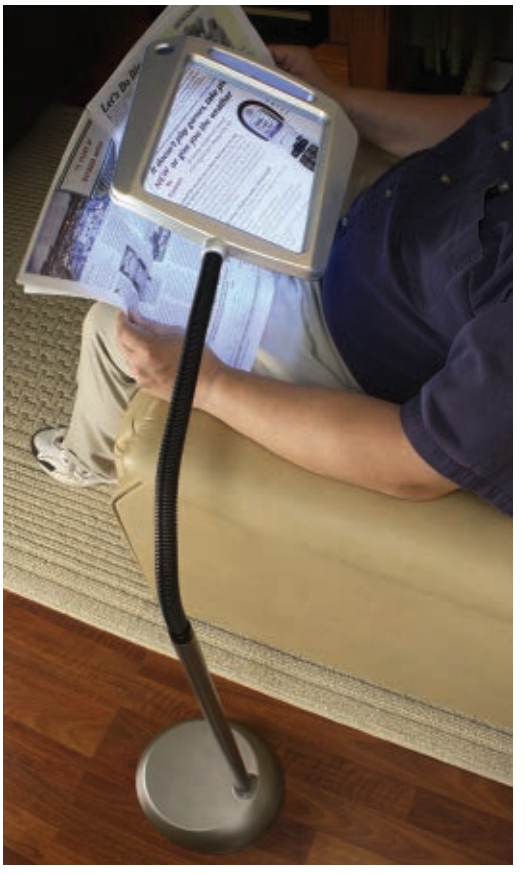

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In field or backyard, frogs face threats

Amphibians and other sensitive groups encounter chemicals across the landscape

By Susan Milius

PROVIDENCE, R.I. — Frogs in the pond have become canaries in the coal mine. As amphibian populations have declined worldwide, concerns have risen about the potential environmental effects of agricultural pesticides and other chemicals. And recent work is challenging existing ideas of what environs and organisms are at risk.

After almost a decade of hot debate over whether atrazine, a common agricultural weed killer (*SN: 2/27/10, p. 18*), is creating frogs with both male and female characteristics, some scientists have taken a step back to survey such intersex frogs in a wide variety of landscapes, including pristine woodlands, urban areas and suburbia. Ecologist David Skelly of Yale University, for example, has found that — counter to usual assumptions — percentages of mixed-sex green frogs may be higher in the suburbs than on agricultural lands.

From 24 wetlands within such various landscapes in the Connecticut River Valley, researchers checked 233 frogs for one telling trait: eggs growing in testes. The researchers did find more of these intersex frogs in agricultural lands than in woodlands: 6 percent versus none. Yet 21 percent of the green frogs tested in suburbia had eggs in their testes too, as did 16 percent of urban frogs.

"That's news because that's not what you would have presumed before hearing this," Skelly says.

At the Joint Meeting of Ichthyologists and Herpetologists, held in Providence in July, Skelly presented a more detailed look at intersex frogs in suburbia. In Avon, Conn., a leafy place of trees and gardens, Skelly and colleagues found that 15 of 16 backyard ponds had at least one intersex green frog. Of the total 188 Avon frogs tested, 18 percent had mixed-up testes.

"We don't know if it's unusual or not because as far as we know we're the first people to look at this," Skelly said.

Earlier outdoor surveys typically focused on farmlands — high-exposure sites for agricultural chemicals — instead of looking at the whole landscape, Skelly said. Though his approach presumes nothing about what might cause intersex frogs, his talk did inspire speculation. A wildlife biologist who has studied snakes, Jennifer Adams of the Federal Energy Regulatory Commission in Washington, D.C., noted that a lot of weed killers such as atrazine end up on suburban lawns and city green spaces.

Another possibility: Wastewater that leaks out of septic systems or sewer pipes almost certainly contains traces of contraceptives or other potent compounds that might disrupt normal hormone function in wildlife, says herpetologist Bob Brodman of Saint Joseph's College in Rensselaer, Ind.

Skelly did find evidence that ponds in Avon were contaminated by wastewater of some sort. Traces of caffeine typically indicate that wastewater is seeping in, and he found caffeine in 14 of 16 ponds.

Contamination wasn't a problem just near houses with septic systems, he says. Homes in Avon that relied on

FROM LEFT: SNEHIT/SHUTTERSTOCK IMAGES; M. LEACH/ANIMALS ANIMALS; PODLESNYAK NINA/SHUTTERSTOCK IMAGES

the municipal sewer system were just as likely to have intersex frogs nearby.

For a next step, Skelly and colleagues are looking for signs that contraceptives or other estrogen-mimicking substances from wastewater are affecting frogs in a typical Avon wetland. If the cause of intersex frogs there turns out to be estrogen mimics in the wastewater, then more than one contaminant may be contributing.

Revelations about intersex frogs in suburbia do not mean scientists have less concern now about amphibians in farmlands.

For example, one of the most widely used fungicides on crops in the United States, chlorothalonil, raises mortality rates among frog tadpoles at low concentrations, Taegan McMahon of the University of South Florida in Tampa reported at the meeting. And by "low," she means one ten-thousandth of the exposure expected after a farmer treats a field near the tadpoles' wetland.

A computer model predicts that waterways near a field will pick up 164 micrograms per liter of the fungicide from runoff, McMahon said. When tadpoles of southern leopard frogs and green tree frogs were put in water tainted with that level of chlorothalonil, all 18 died within 24 hours. (Another species, the Cuban tree frog, proved more resilient.)

When she let testing run for a month, tadpoles exposed to just 0.0164 micrograms per liter also perished in greater numbers than those in clean water. Other research has documented risks to fish and toads, but McMahon said that as far she knows, she and her colleagues are the first to test chlorothalonil's effects on frog tadpoles.

Mixing predatory cues

What happens when tadpoles encounter another pollutant in runoff, the weed killer glyphosate, has proved challenging to analyze in a realistic way.

In a series of lab experiments, Rick Relyea of the University of Pittsburgh had added the scent of predators such as dragonflies to water spiked with glyphosate, familiar in the many formulations of the herbicide Roundup. Death rates of tadpoles were higher in the scented water than in a plain glyphosate bath. That work has raised the concern that earlier findings in lab tests without predators might not have captured the full impact of runoff.

More recently, however, Relyea and colleagues have turned those earlier results topsy-turvy. The team repeated the same basic experiment as part of a series of tests in large outdoor tubs offering more realistic circumstances.

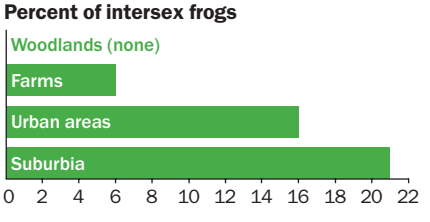
If amphibians are canaries in the coal mine, then reptiles have become ecotoxicology's elephant in the living room.

Addressing whether the results were the same, at the meeting Relyea flashed an image of an outraged baby on the screen with the word "NO" for a caption. In larger tubs, adding a caged predator near the water surface actually increased survival rates rather than reducing them.

What happens in the deeper, more realistic tubs, Relyea said, is that predator cues scare the tadpoles into hiding down deep in the water. And the outdoor tubs have enough sunlight and water to stratify, so the majority of the glyphosate concentrates in the warm upper layer and a substantially lighter dose stays in the cooler bottom layer. In the new study, the scared tadpoles spent most of their time near the bottom with its less dangerous concentration.

The work doesn't mean that glyphosate runoff is safe for amphibians; Relyea has shown that it can kill tadpoles. Yet the experiment shows how difficult it can be to design realistic lab tests for physiological and behavioral responses.

Gender-flipping frogs A study of 233 frogs revealed that the feminizing effects previously seen mostly near farms were even more common in urban and suburban habitats.



E. FELICIANO

Don't forget snakes

If amphibians have become canaries in the coal mine, then reptiles have become ecotoxicology's elephant in the living room, a looming topic that doesn't get a lot of overt attention. Snakes swimming through tainted water have scales to offer some protection, unlike frogs' notoriously permeable skin. Yet water snakes eat mostly fish, and fish can accumulate pollutants in their bodies, says Lorin Neuman-Lee of Eastern Illinois University in Charleston.

Neuman-Lee, along with Stephen Mullin and other Eastern Illinois colleagues, is beginning to look at the possible effects of atrazine on northern water snakes. The researchers did not find evidence of a widely proposed effect of atrazine: revving up an enzyme called aromatase. But in a study of 24 female snakes with developing embryos, "we had some very strange things happen," Neuman-Lee said at the meeting. An unusual proportion of the offspring were stillborn (water snakes don't lay eggs but give birth to fully formed young).

Also, with all the talk about atrazine's possible role in feminizing male amphibians, Neuman-Lee said she would not have been surprised to see a lot of girls in the litters of baby snakes. But only 16 percent of the babies from the atrazine-laden moms turned out to be girls, when normally the ratio would approach 50-50. The skew might be a sign of some kind of disruption, but Neuman-Lee said much more work needs to be done to understand the effect.

Figuring out all that's going on with herps and chemical pollutants is going to take a lot more study. Maybe there will someday be iconically vulnerable snakes in coal mines too. ■

Explore more

- D.W. Sparling *et al*, eds. *Ecotoxicology of Amphibians and Reptiles*, 2nd edition. CRC Press, 2010.

Packing for Mars: The Curious Science of Life in the Void

Mary Roach

Consider everything you do in 24 hours. Now consider doing it without gravity. Roach's new book explores just that, unveiling the "man" in "manned space exploration." She's not interested in heroes, but in humans — the dirty, hungry, sleep- and stimulus-deprived souls shot into the isolation of space, and the scientists who test every contingency to put them there. The resulting tale is a humorous and irreverent look at the innards of space travel.

Take the Apollo 12 astronauts, who were so plagued by sharp, clingy moondust particles that they took off their long johns and flew naked half the way home. Or the volunteers who, in ongoing experiments, are confined to three months of bed rest for studies of their shrinking bone mass. (Don't feel too bad for them: $17,000 goes a long way toward credit card debt.)

Roach makes an art of interweaving details. Her descriptions can make you feel you're floating in a NASA practice flight or tear you apart with shearing forces in a supersonic bailout. She has certainly done her research — perhaps too much. Nearly every page is footnoted with some factoid she couldn't quite fit in. While interesting (who knew guinea pigs can't get car sickness?), only half these asides are pertinent; others feel like desperate interjections.

Roach clearly relishes every gory detail, but some might argue that the nitty-gritty of sexual practices in space would have been better left undescribed. As Roach puts it, manned space travel "forces people to unlace certain notions of what is and isn't acceptable." Just don't read the space sickness chapter while riding the subway. — *Camille M. Carlisle*

W.W. Norton & Co., 2010, 334 p., $25.95.

Here's Looking at Euclid

Alex Bellos

Numberland is a topsy-turvy place. In his new book, Bellos follows math's counterintuitive twists and turns with the surprise and delight of someone rediscovering a long-lost landscape.

After receiving a degree in mathematics and philosophy from Oxford University, Bellos left the world of numbers for the world of words — working as a journalist first in England and later in Brazil. Curiosity brought him back to math, and his return is captured in what could be described as a mathematical travelog. "I realized that I was behaving just like a foreign correspondent on assignment, except that my destination was an abstract one," he writes.

Bellos doesn't cover ground that readers will remember from the classroom. Instead he dabbles in the stories, debates and puzzles that most interest and in some cases confound him. To do so, he travels the globe, visiting India to understand how the concept of zero came to be and to Germany to experience a speed-arithmetic competition. He even stops in to see a fanatical devotee of the slide rule living near London.

When he can't go in person, Bellos takes readers on virtual visits to numerical points of interest. He interviews researchers who study people such as the Munduruku in the Amazon, who have no words for numbers beyond five, and the people of medieval Lincolnshire who used a base-20 counting system. He even ponders checking into the hypothetical Hilbert hotel, a destination with an infinite number of rooms.

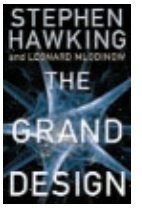
In the end, the spirit of the book is as silly as its title, but with a serious mission — to offer readers a second chance to be surprised and inspired by math. — *Elizabeth Quill*

Free Press, 2010, 319 p., $25.

The Wave: In Pursuit of the Rogues, Freaks, and Giants of the Ocean

Susan Casey

The author interweaves tales of scientists and surfers who, whether for study or an adrenaline rush, seek out monster waves. *Doubleday, 2010, 352 p., $27.95.*



The Grand Design

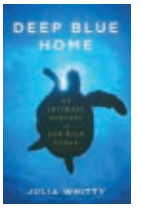
Stephen Hawking and Leonard Mlodinow

In his first major work in nearly a decade, Hawking ponders the origins of the universe and the pursuit of a unified theory. *Bantam Books, 2010, 208 p., $28.*

Asleep

Molly Caldwell Crosby

A historical account of the sleeping sickness pandemic of the 1920s and the science behind it. *Berkley, 2010, 291 p., $24.95.*



Deep Blue Home: An Intimate Ecology of Our Wild Ocean

Julia Whitty

Underwater rivers pulse with life in this lyrical exploration of ocean currents. *Houghton Mifflin Harcourt, 2010, 246 p., $24.*

Physics and Technology for Future Presidents

Richard A. Muller

A Berkeley physics professor puts his popular course for non-scientists into book form. *Princeton Univ. Press, 2010, 517 p., $49.50.*

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Designing for chance

The science in "Life from scratch" (*SN: 7/3/10, p. 22*) is extremely interesting, and I look forward to hearing further results. However, a few comments in the article play into a common Intelligent Design error. The stated aim is "to show how unguided natural events might have led to life..."; the reference to "higgledy-piggledy chance" is in a similar vein. Both the atheistic attempts to infer lack of design from science and the Design advocate's attempts to claim holes in scientific explanation are based on the erroneous assumption that natural causes equal lack of guidance. By this reasoning, if the experiment is successful, we should infer that Szostak's team does not exist. In reality, the experiment is very carefully designed and adjusted, even though it relies on natural processes. Science tells us about natural processes. It cannot tell us whether God (or some functional equivalent) is guiding natural events. Rather, that is a philosophical and religious question. **David Campbell,** Tuscaloosa, Ala.

Jack Szostak's group is indeed carefully setting up the test. The care, however, is to do so with conditions and materials that plausibly could arise by chance on a sterile planet. If successful, nobody could claim that the team's novel, primitive life form arose in the lab by random luck. Researchers are shepherding it into being but leaving its precise form to evolutionary selection. This and follow-up tests should offer insights into how spontaneous, unassisted chemistry could have done so on Earth. And as the reader thoughtfully suggests, evidence of supernatural guidance would be hard to measure, prove or refute. —Charles Petit

Weight loss a psychological issue

As a licensed social worker with 30 years of experience who has written four books on eating and weight, I am disappointed that *Science News* and Robert Russell ("Nutrition society president says eat less, move more," *SN: 7/17/10, p. 32*) have climbed on the tired, old "eat less, move more" bandwagon. Russell is correct in saying that "just getting the word out and providing education" isn't slimming down America and that "awareness has not translated into major behavioral change for the vast majority of the overweight population." However, he fails to include psychotherapists as a catalyst for behavioral change along with communities, families and schools. Sadly, all the education in the world won't change people who need to resolve underlying psychological—not biological—issues before they can succeed at weight loss. **Karen Koenig-Loring,** Sarasota, Fla.

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

Roger Bilham

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Building better can reduce catastrophic quake deaths

Thanks to the planet's exploding population, more than a billion housing units will be built during the next half century. Many of those will be in urban areas that are vulnerable to catastrophic earthquakes such as the magnitude-7 quake that killed more than 200,000 people in Haiti in January. Roger Bilham, a seismologist at the University of Colorado at Boulder who studies the earthquake vulnerability of cities, sat down recently with Science News *contributing editor Alexandra Witze to talk about why builders routinely flout earthquake-engineering regulations, and how urban residents can be kept safe.*

What factors tend to affect whether a government enforces good earthquake-resistant building codes?

It's always difficult to generalize. I just got back from Pakistan, where we have a big project measuring the deformation of the western edge of India. Islamabad is a relatively new city, with earthquake codes; there's really very little that should be wrong with it, particularly because the military have huge control. Not that they are trying to build quake resistance, but they prevent people building anywhere they want. If you go further south, to Karachi, the reverse is true. Corruption is a way of life there. If you want to put up a building without building codes to save money, there are many ways to do it.

How can society reduce the death toll in big earthquakes?

There's a top-down problem — a gap between the important buildings of a city, like the town hall and hospitals and schools; well, it should be schools. Building codes are usually applied for civic structures. But where are most people being killed? In their own dwellings. Governments aren't really interested in that level of construction, but that's where the effort needs to go. U.N. inspections need to get it across, right at the village level, that you don't just start building. You need permission to do it, along with instructions about what to do.

You've proposed creating a special United Nations task force that would enforce local building codes for quakes. How would that work?

I envisage not a U.N. building inspector on every street corner. I envisage a task force where they go to cities and say, how are your inspections done? Let's see what your building code is and what steps you take to have inspections. And we'll explain how we think you should do it to avoid people circumventing the laws that you yourselves want to apply. It's not like a police force where you prevent individual laborers or contractors from assembling buildings. You actually show the government how to implement their own laws seriously.

Everywhere I go there are in fact building codes. Haiti had a building code; it just wasn't implemented ever, except by engineers.

Everywhere I go there are in fact building codes. Haiti had a building code; it just wasn't implemented ever, except by engineers. I saw buildings go up in Haiti that were perfect, the buildings still standing after the quake. But when a developer is involved he's trying to maximize profits. Unfortunately, developers tend to be the bad guy.

What this U.N. task force has to do is be extremely serious about working on showing the world's governments — particularly the ones in the developing nations — how to stop killing their own people. That's unacceptable.

Seismologists knew that Haiti was at risk of a big quake before one struck in January. Why was there still so much devastation?

We got a lesson from the Haiti quake — you can have a tragic disaster from a quake that doesn't break the surface and has little surface effect. There's hope that one might be able to learn about past quakes by looking at submarine slides offshore, by extending geological studies to offshore regions. We could get at the tsunami hazards. The difficulty in improving the seismic risk picture in the Caribbean is the absence of much of a paleoseismic record, and the absence of submarine studies.

The problem with Haiti imposing a building code is that they can't impose anything. The best intentions of engineers and scientists are pointless in the face of human nature.

Is the situation likely to change?

What we have to do is to educate at a very elementary level. When we go to school we're shown how to bake a cake and do wiring and carpentry. Nobody ever shows us how to mix a bag of cement with some sand.

The current building stock will be replaced in 30 years or so, given building lifetimes. The replacement can be done right. We are housing 6 billion people right now. The next 6 billion could be done right, in principle. It requires organized social structures to be implemented in countries that ought to know better. ■

CIRES/UNIV. OF COLORADO AT BOULDER

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