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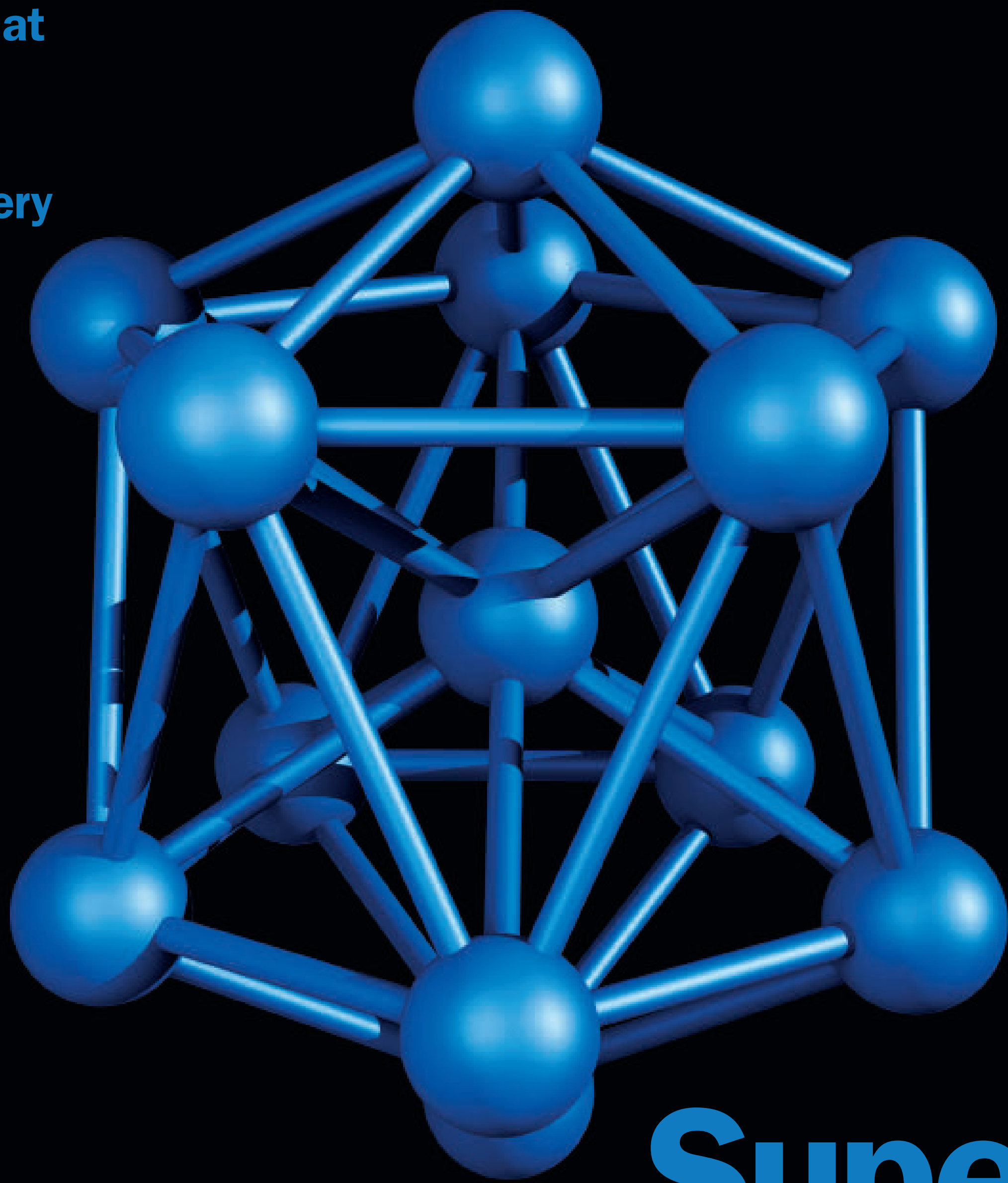
Science News

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ JUNE 21, 2008

What Happened at Tunguska

Crystal Skullduggery

Monkey Thinks, Does



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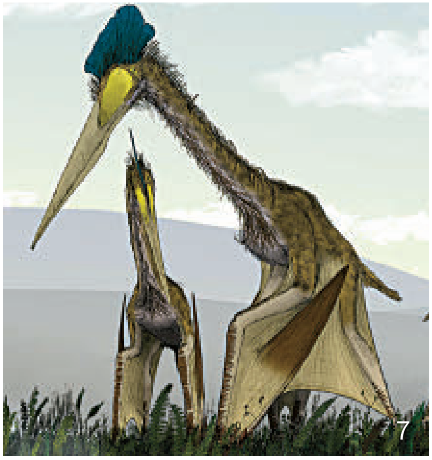

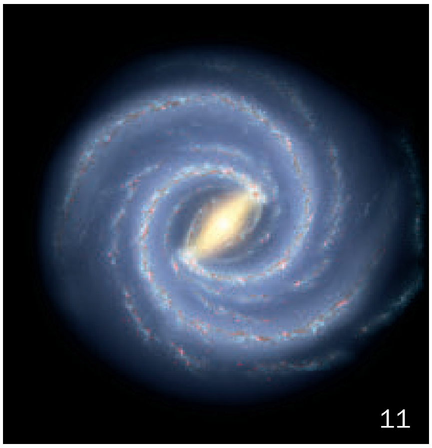

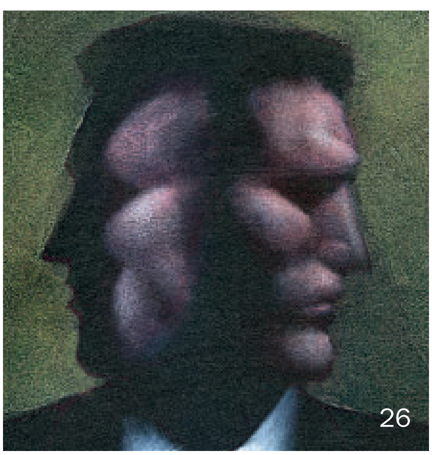

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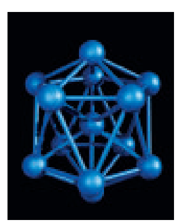
In the News

Features

Departments



On the cover: A cage built of 13 atoms of aluminum is among the new structures that scientists call "superatoms." **Art: Charles Floyd**

ScienceNews

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FROM THE EDITOR

Scrutinizing science behind the scenes

Every issue, *Science News* delivers reports from the front lines of science — the latest findings from scientific journals, accounts of presentations at conferences, descriptions of events such as the Phoenix Lander's arrival on Mars. But reporting the news isn't the only task of science journalism. To put the news in perspective and context, it's important to go behind the scenes.

In this issue, freelance writer Regina Nuzzo explores the backstage machinations underlying much of today's biomedical science news — the mathematical methods used for analyzing studies of genes and disease. Over the past couple of decades or so, thousands of scientific papers have been published linking human diseases or other maladies to variants of specific human genes. In the preponderance of cases, those links turn out to be false. It seems that, very often, the math is misleading.

That is not very surprising to anyone who truly understands the ins and outs of probability and statistics, the branches of mathematics researchers rely on to draw inferences from complicated data. There is never any absolute guarantee that a statistical inference will turn out to be correct — just a likelihood. And standard methods are really not very good at quantifying that likelihood. Often statistical methods are improperly applied, and even when the math is done correctly the results are frequently misinterpreted, even by the scientists themselves.

In her article, Regina (herself a trained statistician) explores a relatively new approach that attempts to rectify some of the problems with previous studies linking genes to diseases. These "genome-wide association" studies employ a multistep process for paring down the massive amounts of data produced by genome studies, building in internal replication to eliminate (well, reduce) the prospect of false links.

It's certainly an advance over previous methods, which were overmatched by the complexity and massiveness of genomic data. But even the whole-genome approach has its limits and pitfalls. Our report on it should serve not just as a look behind the scenes at the methods that produce the news, but also as a reminder that science news is often flawed because it describes an imperfect process — science. Shortcomings that reduce the reliability of science's methods (and hence the news coverage of it) will be a topic for future discussion in these pages. It is the case, after all, that how scientists find out what they find out is sometimes as important as what they (say they) find out.

—Tom Siegfried, Editor in Chief

Scientific observations:

It is now clear that we were naïve to think there would be a straight path from the discovery and characterization of HIV to the development of a vaccine.... We must solve the mystery of how to prompt the human body to produce a protective immune response that is even better than the one elicited by natural infection. This will require a commitment to fundamental research to address the many questions that remain about HIV and its interaction with its human host. **—ANTHONY S. FAUCI, DIRECTOR OF THE NATIONAL INSTITUTE OF ALLERGY AND INFECTIOUS DISEASES, REFLECTING ON 25 YEARS OF HIV RESEARCH IN THE MAY 15 *NATURE*.**

Science Past: 50 Years Ago

From *Science News Letter*, June 21, 1958

NEW SHOCK TREATMENT — Neither electric stimulation nor convulsion may be necessary components in the electroshock treatment of certain types of mental illness.... A group of 97 mental patients ... were assigned at random to one of five treatment groups: 1. conventional electroshock therapy (EST); 2. a combination of EST and the drug, anectine; 3. EST and truth serum (pentothal); 4. pentothal alone, and 5. laughing gas (nitrous oxide) alone.... All types of treatment led to marked improvement in the patient as measured by psychiatric evaluations and psychological tests. There were no statistically significant differences in the benefit from variations of electroshock therapy and the anesthetics alone. These results suggest neither electrical stimulation nor convulsion is a necessary component of treatment, particularly for chronic schizophrenics.

Science Future

June 30–July 3

The Royal Society Summer Science Exhibition. Visit **www.summerscience.org.uk/08/**

July 6–10

Growers and researchers gather in Romania, for the European Association for Potato Research's four-day congress. Visit **www.eapr2008-brasov.com**

August 1

Total solar eclipse visible in parts of Canada, Greenland, Russia and China. Visit **eclipse.gsfc.nasa.gov/eclipse.html**

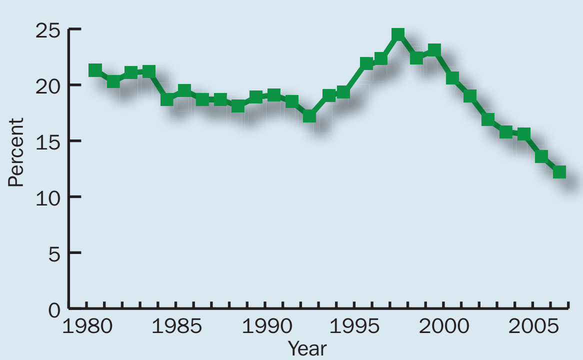
The (-est)

In Prince Edward Island, scientists have begun what may be the largest ever exhumation of a single creature. A blue whale was buried whole there nearly 21 years ago after washing ashore. Blue whales are the biggest creatures on Earth, and this one was 25 meters long with a heart the size of a car. Once cleaned of remaining flesh and oil, the bones will be reassembled for display at the Beaty Biodiversity Museum in Vancouver.

Science Stats

EXTINGUISHED BUTTS

Percent of 12th-graders who reported smoking cigarettes daily.



SOURCE: CHILDSTATS.GOV

SN Online

www.sciencenews.org

SCIENCE & THE PUBLIC

Researchers at Columbia University are turning the idea of agriculture on its side — literally — by imagining farms in the city. Learn about their plans and what they hope to accomplish in Janet Raloff's blog posts.

MATHTREK

In Julie J. Rehmeyer's column, find out how a radical approach to modeling networks can help scientists understand relationships in food webs and terrorist cells, and even predict connections that scientists didn't know existed.

NEWS

Daily stories explore everything from the bizarre — caterpillars attacked by parasitic wasps end up serving as zombie bodyguards to the wasp larvae — to the historic, such as the recent arrival on the Red Planet of the Phoenix Mars Lander.

SN BOOKSHELF

Browse recent book reviews on topics ranging from the quest for long life to the physicists behind the atomic bomb on the *Science News* website.

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REUTERS; JOSÉ LINO-NETO/FEDERAL UNIV. OF VIÇOSA

“I know it looks a little like a parking lot, but that’s a safe place to land, by gosh.” — PETER SMITH, PAGE 10

In the News

STORY ONE

A century later, scientists still study Tunguska

Asteroid or comet blamed for Siberian blast of 1908

By Sid Perkins

The Tunguska blast shook Siberia in 1908, but on-site investigations were delayed for two decades. One of the first photos showed a large area of flattened trees.

ASTRO.WSU.EDU

Early on the morning of June 30, 1908, a massive explosion shook central Siberia. Witnesses told of a fireball that streaked in from the southeast and then detonated in the sky above the desolate, forested region. At the nearest trading post, about 70 kilometers away from the blast, people were reportedly knocked from their feet. Seismic instruments in the area registered ground motions equivalent to those of a magnitude-5 earthquake.

Effects of the event — often called the Tunguska blast, after a major river running through the area — weren’t restricted to Siberia. Sensitive barometers in England detected an atmospheric shock wave as it raced westward and then detected it again after it traveled around the world. High-altitude clouds that formed over the region after the event were so lofty that they caught light from beyond the horizon, illuminating the sky so much that people at locales in Europe and Asia could read newspapers outdoors at midnight.

A number of factors — including the site’s remote location, World War I and the Russian Revolution — prevented scientists from mounting an expedition to the blast zone for almost two decades, says physicist Giuseppe Longo of the University of Bologna in Italy. When researchers eventually reached the region, they found that a 2,150-square-kilometer patch of forest had been flattened, with most of the 80 million trees lying in a radial pattern. What the researchers didn’t find, however, was an obvious crater.

A century later, scientists are still debating the cause of the Tunguska blast. Through the years, Longo notes, a variety of scenarios have been proposed, many of them involving the explosion of an unusual extraterrestrial object — everything from a small black hole or a chunk of antimatter to a UFO. Most researchers, however, now pin the blame on the midair explosion of a small comet or asteroid, which typically can’t stand up to the pummeling received while blazing through the atmosphere (*SN: 7/19/03, p. 36*).

The damage in Siberia suggests that the Tunguska detonation happened at an altitude of between 6 and 8 kilometers and released the energy of about 15 megatons of TNT, about a thousand times more than the bomb that destroyed Hiroshima.

Data gathered by military satellites — including those designed to detect clandestine nuclear explosions — suggest that tiny versions of the Tunguska blast occur rather frequently, says Philip A. Bland, a planetary scientist at Imperial College London. The largest airburst detected during the 1990s measured only a few tens of kilotons, the energy release expected from the explosion of an asteroid measuring about 7 or 8 meters across. Impacts of objects measuring at least 1 meter in diameter occur, on average, about once a week, the data suggest. Tunguska-sized airbursts »

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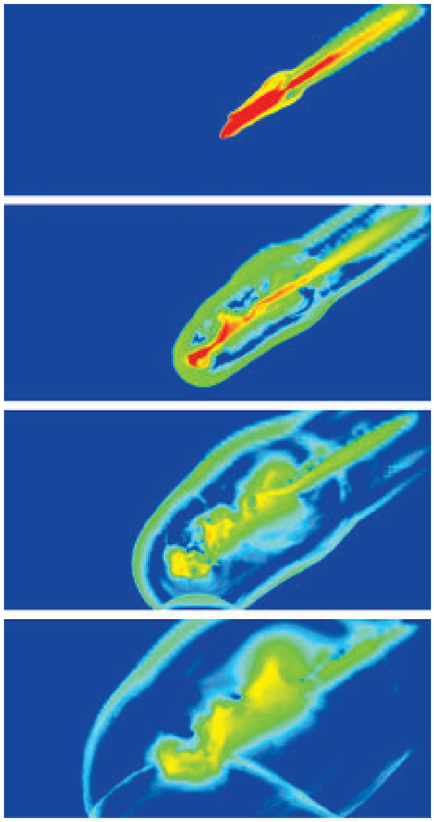
SN Today at **www.sciencenews.org**

» would be expected to happen about once every 500 years, says Bland.

Previous studies have estimated that the Tunguska asteroid was between 50 and 80 meters in diameter, says Mark Boslough, a physicist at Sandia National Laboratories in Albuquerque, N.M. However, new supercomputer simulations by Boslough and his colleagues hint that a much smaller object could have produced the damage. New models account for the downward momentum of the air compressed beneath the incoming object, a component of the process "that previously had been thrown away," says Boslough.

So the Tunguska asteroid may have been only 30 to 50 meters across, he notes. Simulations suggest that it entered the atmosphere traveling about 15 kilometers per second at an angle about 35 degrees above the horizon. The shock wave produced by the airburst could have slammed into the ground at 180 kilometers per hour, a gust with the wind speed of a category-3 hurricane, the team reports in an upcoming issue of the *International Journal of Impact Engineering*.

Late last year, Longo and his colleagues reported that Lake Cheko, a 400-meter–wide lake about eight kilometers northwest of the Tunguska blast's epicenter, could be the long-sought crater produced by a chunk of asteroid that actually reached the ground. The lake is about 50 meters deep, has a cone-shaped bottom unlike other lakes in the region and — possibly most important — lies directly along the estimated path of the fireball. Sonar studies reveal a buried object or a densely compacted layer of sediment about 10 meters below the center of the lake bottom, the researchers reported in the August 2007 *Terra Nova*.



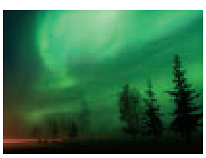
Supercomputer simulations show how an asteroid would approach and explode with the force and extent known for the Tunguska event.

But other factors suggest that Lake Cheko isn't a water-filled impact crater, says Gareth Collins of Imperial College London. For one thing, he notes, a hole the size of this lake typically would be one in a series of holes excavated by pieces of the disintegrating object, whereas Lake Cheko apparently has no companions. And the area around the lake isn't covered with a layer of material that would have been thrown out of a crater during the impact. Also, pictures of the lake from an aerial survey in 1938 show mature trees (more than 30 years old) on the lakeshore — a sure sign that this body of water has a more benign provenance, Collins and colleagues write in the April *Terra Nova*.

The lack of an impact crater, along with the dearth of geochemical anomalies in rock in the region, has spurred some scientists to seek an alternate explanation for the blast. One favorite down-to-Earth idea points to the modern-day formation of a kimberlite deposit, an eruption that brings diamonds to Earth's surface (*SN: 6/30/07, p. 412*). Such an eruption could have injected about 10 million tons of methane into the atmosphere, a plume that if detonated would have released a forest-flattening burst of energy.

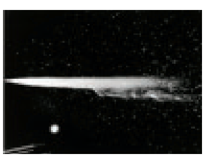
Scientists will attend conferences in Moscow at the end of June to commemorate the blast and discuss the latest findings. Those proposing an extraterrestrial cause will be meeting at the Russian Academy of Sciences. Those who favor an Earth-based origin of the blast will gather across town, at the Polytechnical Museum. ■

Back Story Explanations for the Tunguska event have spanned science and fiction



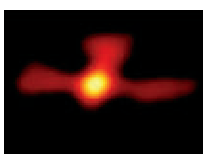
1925

A Russian scientist says the explosion's recorded seismic and air waves suggest a meteorite as the culprit.



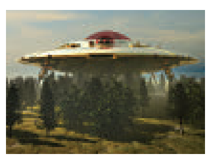
1934

A British scientist and a Russian scientist say the blast must have been an in-air comet explosion.



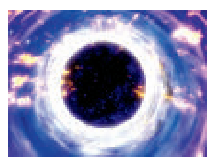
1941

An American researcher claims an antimatter meteoroid was annihilated when it encountered matter.



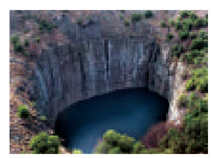
1946

Russian sci-fi writer Alexander Kazantsev tells the tale of Tunguska as a UFO that vaporized.



1973

Two theorists suggest a black hole as small as a comma passed through Earth and exited via the North Atlantic.



2001

Ideas go down: The blast perhaps was a kimberlite eruption, which lifts diamonds and methane from Earth's depths.

ISTOCK PHOTO OF METEORITE AND AURORA; NASA; NASA; ISTOCK PHOTO: NASA; WWW.EARTH.OX.AC.UK; SANDIA NATIONAL LAB

Life

1 billion Possible number of microbes in each gram of rock along the East Pacific Rise

Microbes thrive in seafloor rock

Diversity and abundance surprise research teams

By Sid Perkins

As much as 70 percent of the microbes alive on Earth reside on and below the ocean floor, two new studies suggest.

The seafloor was once thought to be a barren expanse of muck dotted with an occasional thriving ecosystem near a hydrothermal vent. But recent discoveries suggest that microorganisms can fuel their metabolisms by taking advantage of the chemical energy stored in various minerals, including those that make up the ocean crust.

Even relatively fresh, basalt rocks formed by lava oozing from mid-ocean ridges are home to many microorganisms, says Katrina J. Edwards, a biogeochemist at the University of Southern California in Los Angeles.

Edwards and her colleagues recently conducted a biological census of rocks that formed during the past 20,000 years at a spot along the East Pacific Rise, a mid-ocean ridge segment that lies off the northwestern coast of South America.

While the deep water in that area contained only between 8,000 and 90,000 microorganisms per cubic centimeter, the seafloor basalt held, in its pore spaces, between 3 million and 1 billion microbes per gram. “Bacteria were jam-packed on the rocks,” Edwards says.

The team’s genetic analyses suggest that, while deep water in the region contained, on average, just 12 distinct types of microorganisms, the ocean-bottom basalt was home to about 440 different types. For comparison, farm soil—long thought to be one of the richest microbial ecosystems on the face of the planet—hosts more than 1,400 distinct types.

Similar tests on seafloor samples taken near the Hawaiian Islands, several thousand kilometers to the northwest, confirmed the abundance and diversity of microbes that reside in ocean-bottom sediments. “This makes it likely that rich microbial life extends across the ocean floor,” Edwards says. She and her colleagues report their findings in the May 29 *Nature*.

Freshly formed basalt isn’t the only seafloor ecosystem where bacteria can thrive. Another study indicates that microorganisms can prosper in sediments that were deposited millions of years ago but now sit hundreds of meters below the ocean bottom.

R. John Parkes, a microbiologist at Cardiff University in Wales, and his colleagues analyzed nine samples of sediment drilled off the shore of Newfoundland at depths between 860 and 1,626 meters beneath the North Atlantic seafloor. Those sediments, on average, hold around 1.5 million microorganisms per cubic centimeter, the researchers reported in the May 23 *Science*.

About 60 percent of those cells are alive and could reproduce, the team’s tests suggest. Also, microscopy reveals that many of the cells found in the North Atlantic samples – in one sample, nearly 12 percent – were caught in the act of dividing.

The temperatures of rocks at the depths the team drilled range from 60° Celsius to more than 100° C, Parkes says. Known types of microbes can survive in temperatures up to around 120° C, which corresponds to a sediment depth of about 4 kilometers. If microorganisms thrive throughout seafloor sediments above that depth, the material could house about 70 percent of the microbes now alive on Earth, Parkes says. ■

These wings were made for walking

Most fossils of pterosaurs, flying reptiles that soared the skies while dinosaurs strolled below, have been found in marine sediments. Scientists thought the creatures spent a lot of time flying over the seas, possibly snatching fish from the water, says Mark Witton, a vertebrate paleontologist at the University of Portsmouth in England. After studying fossils, Witton and colleague Darren Naish suggest a different lifestyle for a group of large pterosaurs called azhdarchids. “Analyses suggest that azhdarchids were quite capable on the ground,” Witton says. The team reports in May in *PLoS ONE* that most azhdarchid fossils—such as those of *Quetzalcoatlus northropi* (illustrated at right), whose wings spanned 10 meters—are found in locales that would have been far from the coastline, likely in lakes or floodplains. Also, azhdarchids’ feet were too small and slim for wading or swimming; their necks, lower jaws and beaks weren’t built for in-flight fish catching; and fossilized footprints hint that they walked upright. —*Sid Perkins*

WITTON

Body & Brain

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Lead exposure leaves its mark

Metal affects brain size, risk of violent behavior

By Rachel Ehrenberg

In the '50s, children were exposed to lead where they lived and played, including this Ohio building.

CINCINNATI HISTORICAL SOCIETY

The effects of lead weigh heavy on the minds of people exposed to the metal during childhood. Two new studies of adults who lived in lead-contaminated housing as kids find that higher lead levels in the blood during childhood are associated with smaller brains and with an increased risk for violent criminal behavior.

"Lead has special status as a risk factor because we can prevent it," comments David C. Bellinger, an epidemiologist at Harvard Medical School in Boston and an expert in environmental and public health. Bellinger, who was not involved in the research, wrote a commentary that appears with the two studies in the May 27 *PLoS Medicine*. "There are a lot of risk factors for these kids and lead was one among many. It's hard to prevent poverty," he says. "But with lead, we know the pathways to exposure and we can prevent it."

Mothers of the studies' participants were recruited from 1979 to 1984 from neighborhoods in Cincinnati with a lot of old, lead-contaminated houses and historically high rates of childhood lead poisoning. Blood lead levels were measured in the pregnant moms and then in the children at several intervals after birth, until they were at least 6 years old. Of the children, now 19 to 24 years old, 250 participated in the study examining the association with criminal behavior and 157 participated in the brain imaging study.

MRI scans of the young adults' brains revealed that the more lead the participants were exposed to as children, the smaller their adult brains were, the researchers report. The anterior cingulate cortex — a brain region associated with mood regulation, decision making and impulse control — was particularly affected, says Kim Dietrich of the University of Cincinnati College of Medicine's epidemiology and biostatistics division. Male brains were significantly more affected than female brains, he notes.

Childhood lead exposure has been linked to lower IQ scores and to attention and hyperactivity problems, but the brain imaging work is the first to look beyond performance to how lead affects the underlying neural substrate, Bellinger says. The study's results "are red flags," he says.

The second study looked at the participants' current arrest records and compared them with the participants' childhood levels of lead in the blood. Total arrests and arrests for violent crimes increased with each 5 microgram per deciliter increase in blood lead level, the researchers report.

"This is a real problem for this generation," Dietrich says. "We're not doing a very good job right now for these kids."

Dietrich says the average childhood blood lead level in the brain imaging study was about 13 μg/dl (almost everyone has background levels of 1 to 2 μg/dl). The Centers for Disease Control and Prevention "action level" for lead — the blood level that is supposed to prompt an investigation of environmental exposure — is 10 μg/dl.

"Ten is no bright line," he says. "The real problems remain where there is still lead paint in older homes."

The good news, says Bellinger, is that levels of lead in the blood have gone down a lot since the early 1980s. CDC surveillance data show that by 2006 only 2.3 percent of children in Ohio had blood lead levels of more than 10 μg/dl, compared with 16.6 percent in 1997.

"Lead is difficult," says Bellinger. "People refer to it as a multimedia pollutant because there are so many ways that people get exposed. There's gasoline, paint, fallout in air. It gets into the soil and tracked into homes. It's in interior paint, which deteriorates and gets into dust. It was used in can solder.... It's a ubiquitous and useful metal — I suppose that's why it is still around." ■

15 percent — Portion of U.S. children who were overweight between 1963 and 1970

32 percent — Portion who were overweight between 2003 and 2006

Monkeys move arm with mind

Technology may eventually lead to improved prostheses

By Patrick Barry

If these monkeys were 1970s TV stars, they would play crime-fighting cyborgs in *The Six Million Dollar Monkeys*.

Macaque monkeys with electrodes implanted in their brains learned to control a robotic arm with their thoughts, researchers report.

Scientists gently restrained the monkeys' own arms and positioned the mechanical arm at each animal's left shoulder as if it were a real arm. After practicing for several days, the monkeys appeared to treat the robotic arm as their own and could feed themselves with the arm using fluid, rapid motions.

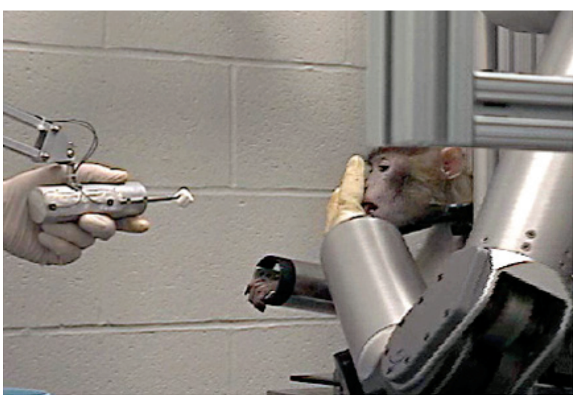
In previous research, monkeys and even quadriplegic people have controlled the movement of cursors on computer screens through electrodes implanted in their brains. Animals have also learned to open and close a simple robotic hand.

But the new research, performed by Andrew Schwartz and his colleagues at the University of Pittsburgh and Carnegie Mellon University in Pittsburgh, is the first to use animals' brain activity to manipulate a physical object that moves in complex ways.

"The thing that struck me was how naturally the animals interacted with the device," comments John Kalaska, a neuroscientist from the University of Montreal who wrote a commentary that appeared with the research online May 28 in *Nature*. "It's a further proof of principle that, down the line, we will be able to develop all the hardware necessary to allow paraplegic or quadriplegic patients to have prosthetic limbs that they can control in a natural way with their thoughts."

Such devices for humans are still years away, Kalaska cautions. The computers that interpreted the monkeys' brain signals in the current experiments are bulky, and thus impractical for a portable prosthetic. In past research, electrodes implanted into the brains of animals or humans soon lost contact with the nerve cells because brain cells treated the electrodes as foreign objects and attacked them. Both cases are obstacles to making thought-controlled robotic arms or legs for people feasible, Kalaska says.

Schwartz's team implanted an array of tiny electrodes in a region of the monkeys' brains called the motor cortex, which controls voluntary movement, to see how patterns of electrical activity in this region associated with the monkeys' desire to reach toward pieces of food. Software interpreted where the monkeys wanted to reach — and whether they wanted to open or close the hand — based on that brain activity. The computer did the rest, calculating the specific movements of the robotic arm's shoulder and elbow joints to perform the task. The computer's rapid interpretation of the monkeys' brain signals helped the robotic arm to move in a natural way and almost as quickly as a real arm. ■



SCHWARTZ, SCIENCE/AAAS

By thinking about reaching for food placed in front of them, monkeys with electrodes implanted in their brains used a robotic arm to grab the food and put it in their mouths.

NEWS BRIEFS

Young keep the old young

On a visit to China, Chun-Fang Wu, a fruit fly researcher at the University of Iowa, observed extended families and noticed how vibrant elderly people living with younger relatives seemed. He wondered if living in a mixed-age setting would make the fruit fly *Drosophila melanogaster* live longer too. He and his colleagues showed that some fruit flies with mutations in a gene that encodes an antioxidant enzyme can live longer simply by living with young flies that do not carry the mutation. The researchers also report in the May 27 *Proceedings of the National Academy of Sciences* that social interaction — much of which involves wing movement — and increased activity are necessary to generate the life-extending effect. The work might lead to a molecular explanation for why social interactions help people fend off degenerative brain diseases. — *Tina Hesman Saey*

Childhood obesity levels

The nonstop rise in U.S. childhood obesity that began more than two decades ago is showing the first signs of slackening, a new study finds. But it also confirms the unsettling reality that one-third of U.S. children remain overweight or obese and thus face a higher risk of medical problems later. Based on health exam data from 8,165 children ages 2 to 19, researchers with the Centers for Disease Control and Prevention determined that the percentage of overweight or obese kids did not significantly change between 1999 and 2006. The findings appear in the May 28 *Journal of the American Medical Association*. "This study provides the first glimmer of hope," says David Ludwig of Harvard Medical School and Children's Hospital in Boston. "But it's too soon to tell whether the data present a true plateau of obesity rates or just a temporary lull." — *Nathan Seppa*

Atom & Cosmos

For more on the Mars Phoenix Lander mission, visit **www.sciencenews.org**

The Phoenix has landed

Safe on Mars, craft seeks signs of subsurface ice

By Ron Cowen

After a nerve-wracking but carefully choreographed seven-minute descent, NASA's Phoenix Mars Lander arrived on the Red Planet at 7:38 p.m. EDT on May 25.

The first spacecraft to land on the northern polar region of Mars, the craft's mission is to dig into the frigid topsoil for evidence that the subsurface may have offered a haven for microbial life.

After slowing down at the top of Mars' atmosphere, Phoenix reached a temperature of 1,426° Celsius during its flight. The craft then deployed its parachute, jettisoned its heat shield, deployed its three landing legs and activated its radar. It jettisoned its parachute and fired its thrusters the last 18 seconds before landing.

At NASA's Jet Propulsion Laboratory in Pasadena, Calif., scientists cheered after radio signals confirmed that Phoenix had safely landed about 20 kilometers from a crater called Heimdall. The signals were relayed by the Mars Odyssey spacecraft, which was orbiting overhead.

"We're almost dead on," said mission project manager Barry Goldstein of JPL. "I'm in shock. Not in my dreams" did the landing go so well, he added.

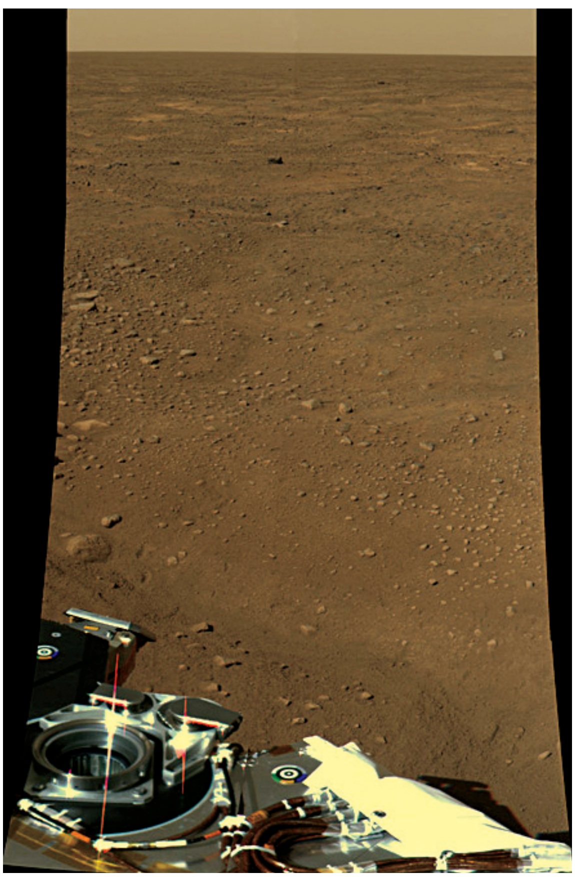
The lander's first images showed a flat valley, devoid of rocks. "I know it looks a little like a parking lot, but that's a safe place to land, by gosh," said Phoenix project scientist Peter Smith of the University of Arizona in Tucson. "Underneath this surface, I guarantee you there's ice."

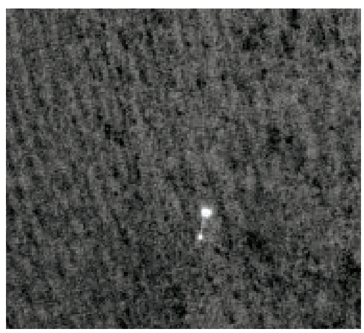
Cracks in shallow troughs suggest that ice is still modifying the surface, buckling and creating polygonal shapes as it expands and contracts during summer and winter, Smith noted. By a week after landing, the craft's robotic arm succeeded in making a test dig of the soil.

Early on, researchers also got a bonus image. A camera on the Mars Reconnaissance Orbiter, passing overhead, caught an image of Phoenix dangling from its parachute just before touchdown. It was the first time one spacecraft photographed another in the act of landing on Mars.

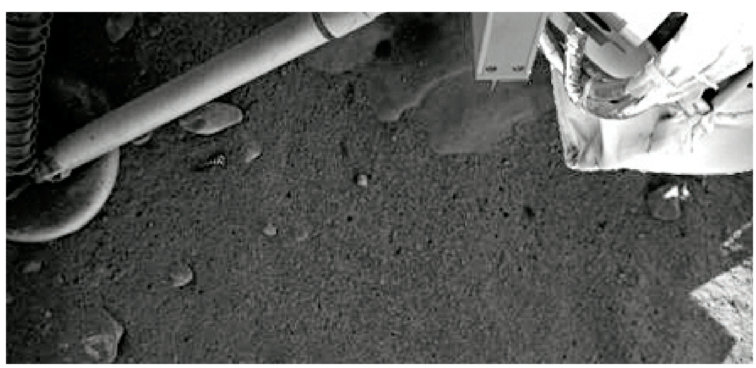
In addition to studying the history of water-ice in the polar region, Phoenix has begun monitoring the weather there. Laser pulses shot into the atmosphere reveal the abundance of dust and clouds up to an altitude of 20 kilometers.

The craft reached its destination after journeying 675 million kilometers since its August 4, 2007, launch. Designed to last for 90 Mars days, the craft could survive for another 60. By then, the sun, which Phoenix relies on for power, will have sunk below the horizon. ■

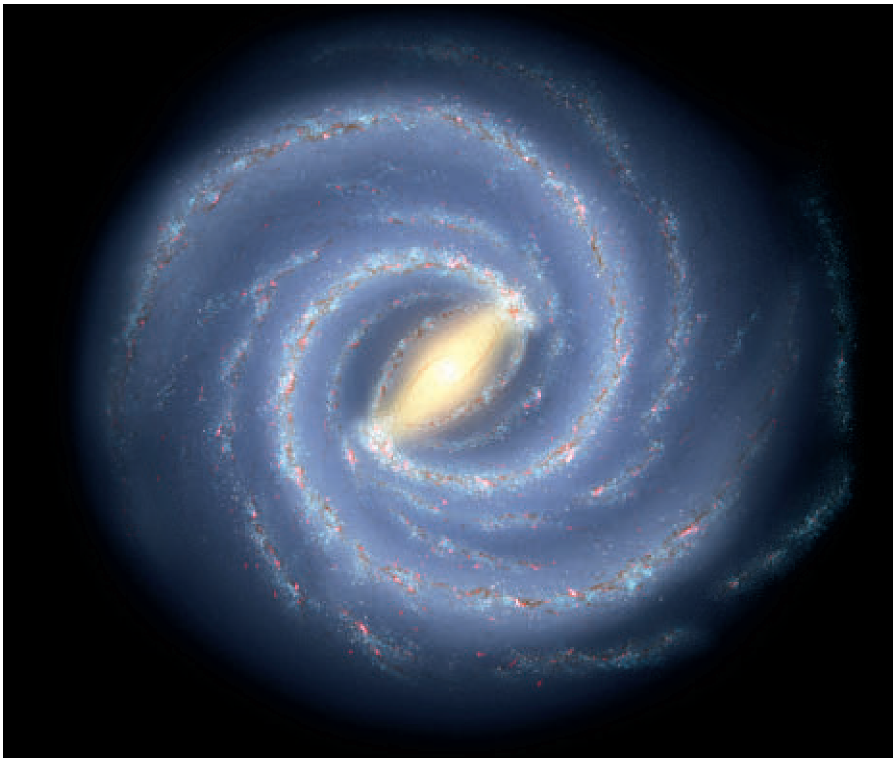




The Mars Reconnaissance Orbiter captured a historic image (above left) of the Phoenix Mars Lander as it deployed its parachute before descending to the Red Planet's surface. In the week after its successful May 25 landing, Phoenix captured images of the polygonal texture in nearby soil (above right), possible ice chunks near the lander's leg (bottom) and a panoramic view of the arctic landing site (left).



NASA JPL, UNIV. OF ARIZONA



NASA JPL-CALTECH

Using infrared images from NASA's Spitzer Space Telescope, scientists have found that the Milky Way galaxy's elegant spiral structure, shown in this artist's rendition, is dominated by just two arms, instead of four as previously believed.

Astronomers remap Milky Way

Two spiral arms not so bright, new observations show

By Ron Cowen

ST. LOUIS — Astronomers are in the midst of a Milky Way makeover.

New images from NASA's Spitzer Space Telescope revise the standard view that four major star-forming arms spiral around the disk-shaped Milky Way. Two of the arms are merely faint, minor-league players in the galaxy's structure.

"We propose that there are two major arms, consisting of a concentration of gas and star-forming regions, and two minor arms, consisting of regions where gas gets compressed and some stars form," Robert Benjamin of the University of Wisconsin–Whitewater reported June 3 at a meeting of the American Astronomical Society.

Radio maps of the galaxy from the 1950s suggested that the Milky Way has four major star-forming arms, called Norma, Scutum-Centaurus, Sagittarius and Perseus. The sun lies in a small partial arm, dubbed the Orion Spur, between the Sagittarius and Perseus arms.

By counting stars along different directions of the Milky Way, researchers found a jump in the density of stars in the direction of the Scutum-Centaurus arm. But no such jump was seen in the directions of the Sagittarius and Norma arms. Those arms exist but should now be demoted in importance because they do not contain high densities of young, bright stars and older stars, Benjamin says.

Leo Blitz of the University of California, Berkeley, says he finds the work intriguing but would like to see how the star counts match up with radio maps of the same regions.

MEETING NOTES

American Astronomical Society
June 1–5, St. Louis

Sizing up black holes

Astronomers are all wound up over a new method for sizing up supermassive black holes found at the cores of galaxies. The method allows researchers for the first time to estimate the weight of these black holes in spiral galaxies up to 8 billion light-years away, or halfway across the universe, reports Marc Seigar of the University of Arkansas at Little Rock. In a study of 27 spiral galaxies, Seigar's team found that galaxies such as Andromeda, with the tightest spiral arms, have the biggest black holes, while those with the loosest arms have the smallest. Previously researchers had to measure the velocities of stars in the central region of a galaxy, a method that worked only for relatively nearby galaxies. Details appear in the May 10 *Astrophysical Journal Letters*. *—Ron Cowen*

Small world phenomenon

Astronomers have discovered the smallest known planet orbiting a star or brown dwarf beyond the solar system. The planet, three times the Earth's mass, orbits at a distance similar to that of Venus' from the sun, but is probably colder than Pluto because its parent body is most likely a faint, cold brown dwarf, reports David Bennett of the University of Notre Dame. Nonetheless, the detection gives astronomers hope of one day finding an alien Earth similar to home, says David Charbonneau of the Harvard-Smithsonian Center for Astrophysics. Bennett and colleagues found the planet because it and its parent acted as gravitational magnifying lenses, bending and brightening the light of a background star. The planet, dubbed MOA-2007-BLG-192Lb, lies 3,000 light-years from Earth. *—Ron Cowen*

Humans

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

New math traces human roots

Americas may have been populated in two waves

By Tia Ghose

The Americas may have been initially settled in separate migrations, a new method for tracing human ancestry reveals.

The report supports most previous findings, including the "Out of Africa" hypothesis that all humans share common ancestors who spread from Africa about 60,000 years ago. "The conclusions aren't all that novel, but the way that they've reached the conclusions is extremely novel," says Donald Conrad, a population geneticist at the Wellcome Trust Sanger Institute in Cambridge, England, who was not involved in the study.

A few surprising results emerged from the analysis, published May 23 in *PLoS Genetics*. Native Americans from North and South America may have had different predecessors. The North American Pima, genetically similar to Colombian populations, also had connections to present-day Mongolians. That genetic link suggests that two waves of migrants crossed the Bering Strait into North America. The first group probably made it all the way to South America, while a second group mixed with the first but never made it past North America, says Garrett Hellenthal, a statistician at the University of Oxford in England who was involved in the study.

To determine the genetic relationships, Daniel Falush of the Environmental Research Institute in Cork, Ireland, and his colleagues analyzed a data set from the Human Genome Diversity Project, which contained more than 2,500 single gene variations from 927 people of 53 different ethnicities. Similar to past methods, the technique tracks variations in the nucleotides — the building blocks of DNA. In contrast with other methods, though, the length of similar strips of DNA code is taken into account. "What it specifically does, compared to other methods, is look for sharing of not just individual nucleotides but of stretches of chromosomes," Falush says.

One limitation of the current study is that it can't date migration events or place them in chronological order, says Hellenthal. And researchers needed to assume certain facts about human history to interpret the model, which could skew the results, Conrad says.

Skullduggery worthy of a film

Famous crystal skulls shown to be counterfeits

By Bruce Bower

Welcome to this summer's scientific blockbuster, *Indiana Jones and the Kingdom of the Crystal Skullduggery*. In his latest cinematic adventure, the bullwhip-cracking Jones chases down an ancient skull carved out of crystal that contains supernatural powers.

But a new analysis of two actual crystal skulls — skulls carved out of a type of quartz rock — fingers the artifacts as forgeries. Smithsonian anthropologist Jane Walsh and colleague and British Museum archaeologist Margaret Sax published the findings online May 18 in the *Journal of Archaeological Science*.

The supposed treasures have been attributed to either the Aztecs or a related pre-Columbian society in Mexico, the

New research indicates that this crystal skull was made in the 1950s, not by Aztecs more than 500 years ago as some have thought.

SMITHSONIAN INSTITUTION, JAMES DI LORETO

Mixtecs. One of the two life-size carvings was purchased in 1897 by the British Museum in London, and the other was delivered anonymously in 1992 to the Smithsonian Institution in Washington, D.C. These and other skulls like them helped to inspire not just the new Indiana Jones movie but also public speculation about whether crystal skulls obtained by museums and collectors since the late 19th century originated on a long-lost continent or even in outer space.

Like all other crystal skulls, the British Museum and Smithsonian pieces don't come from documented excavations. Sax and colleagues examined the detail of carved features on the skulls to determine what types of tools were used to make them. The scientists also assessed a Mixtec rock crystal goblet and five Aztec rock crystal beads excavated at sites dating from about 1,000 to 500 years ago.

The goblet and beads exhibit shallow, irregular indentations consistent with the use of stone and wood tools tipped with an especially hard material, such as almandine garnet or corundum. In contrast, both crystal skulls display deep, regular incisions indicating that they were carved with rotary wheels. The makers of the British Museum skull used an instrument like a jeweler's wheel that was powered by hand or foot, the researchers suggest. Its metal rotary wheel was coated with a hard material such as emery or diamond.

Analyses of the rock used for the British skull suggest that it came from Brazil, Madagascar or the Alps, areas outside Aztec and Mixtec trade networks.

“Stonehenge was the biggest graveyard of the third millennium B.C.” —MIKE PARKER PEARSON

Ancient site was devoted to death

Stonehenge may have been cemetery for rulers

By Bruce Bower

New radiocarbon measurements of burned human bones (right) excavated from the famous Stonehenge site (left) in southern England indicate that it served as a cemetery for half a millennium, from around 5,000 to 4,500 years ago.

Stonehenge, a set of earth, timber and stone structures perched provocatively on England’s Salisbury Plain, has long invited lively speculation about its origin and purpose.

There was nothing lively about Stonehenge in its heyday, though. Ancient bigwigs used Stonehenge as a cemetery from its inception nearly 5,000 years ago until well after its large stones were put in place 500 years later, according to a new investigation of the ancient site.

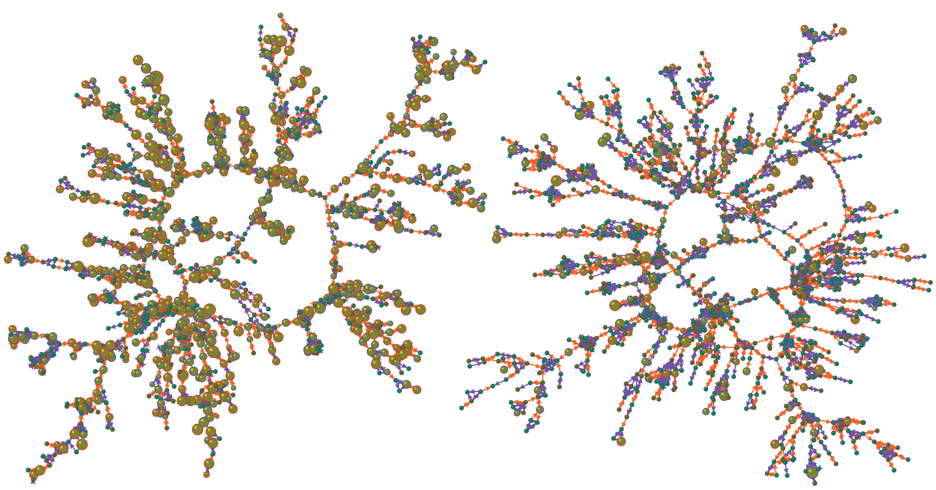
The findings challenge a long-standing assumption that the deceased were buried at Stonehenge for only a 100-year window, from 4,700 to 4,600 years ago, before the large stones — known as sarsens — were hauled in and assembled into a circle. But the new study indicates that Stonehenge was a cemetery for at least 500 years.

“Stonehenge was the biggest graveyard of the third millennium B.C.,” says archaeologist Mike Parker Pearson of the University of Sheffield in England. “From its beginning, it was used as a cemetery for a large number of people.” Parker Pearson directs the Stonehenge Riverside Project, which began in 2003 and runs through 2010. He and archaeologist Julian Thomas of the University of Manchester in England described their latest findings May 29 at a teleconference held by one of their funding organizations, the National Geographic Society in Washington, D.C.

The researchers obtained the first radiocarbon age estimates for cremated human remains excavated earlier at Stonehenge. These burned bones were unearthed more than 50 years ago.

The earliest cremation, a small pile of burned bones and teeth, dates from 5,030 to 4,880 years ago, about the time when a circular ditch and a series of pits were cut into the Salisbury Plain. The human remains originally lay in one of those pits. An adult’s burned bones, originally found in a ditch that encircles Stonehenge, date from 4,930 to 4,870 years ago. Remnants of a third cremation date from 4,570 to 4,340 years ago. An estimated 150 to 240 cremated bodies were buried at Stonehenge over a span of 500 to 600 years.

Andrew Chamberlain, a biological anthropologist at the University of Sheffield who did not participate in the dig, suspects that Stonehenge functioned as a cemetery for 30 to 40 generations of a single family, perhaps a ruling dynasty. The head of a stone mace buried with one set of cremated remains supports that hypothesis. Maces symbolized authority in British prehistory.



Butting out

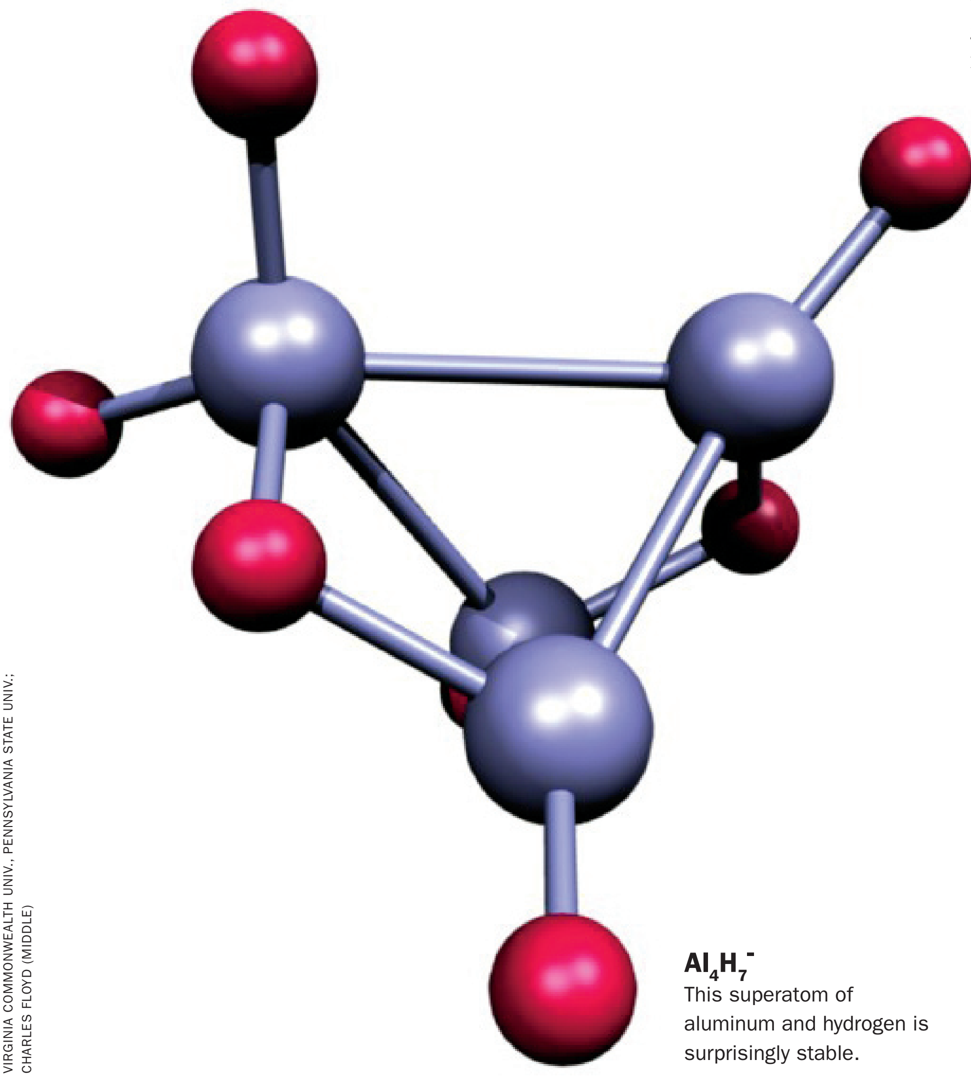
Decisions to quit smoking are often made by groups of people connected to each other at up to three degrees of separation, say Nicholas Christakis of Harvard Medical School and James Fowler of the University of California, San Diego, in the May 22 *New England Journal of Medicine*. Images show social connections of smokers and nonsmokers in 1971 (left) and 2001 (right). Yellow nodes represent smokers and green represent nonsmokers. Orange arrows denote friendship or marital ties and purple arrows denote family ties. —*Bruce Bower*

Small, Bu

These 'atoms' can't leap tall buildings in a single bound, but they have special powers

By Davide Castelvecchi

Gold comes in many colors. Since ancient times, glass artists and alchemists alike have known how to grind the metal into fine particles that would take on hues such as red or mauve. At scales even smaller, clusters of just a few dozen atoms display even more outlandish behavior. Gold and certain other atoms often tend to aggregate in specific numbers and highly symmetrical geometries, and sometimes these



$Al_4H_7^-$
This superatom of aluminum and hydrogen is surprisingly stable.

VIRGINIA COMMONWEALTH UNIV., PENNSYLVANIA STATE UNIV.; CHARLES FLOYD (MIDDLE)

ut Super

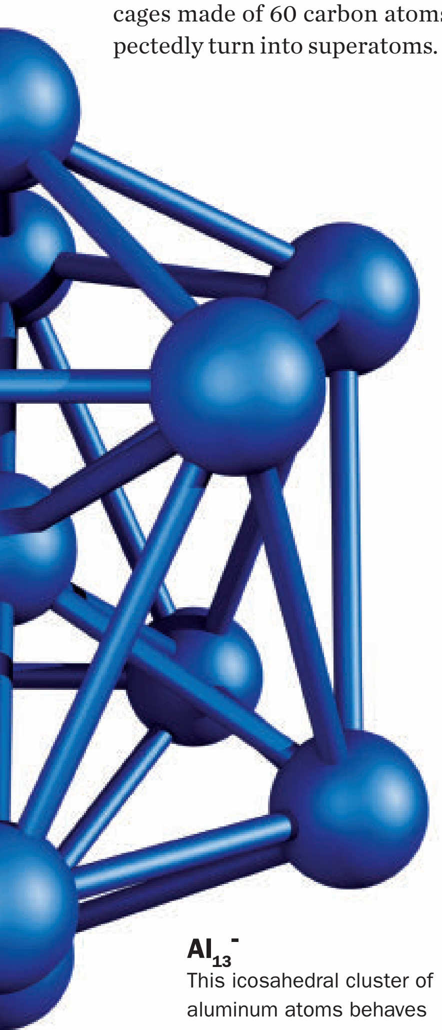
clusters can mimic the chemistry of single atoms of a completely different element. They become, as some researchers say, superatoms.

Recently researchers have reported successes in creating new superatoms and deciphering their structures. In certain conditions, even familiar molecules such as buckyballs — the soccer-ball–shaped cages made of 60 carbon atoms — unexpectedly turn into superatoms.

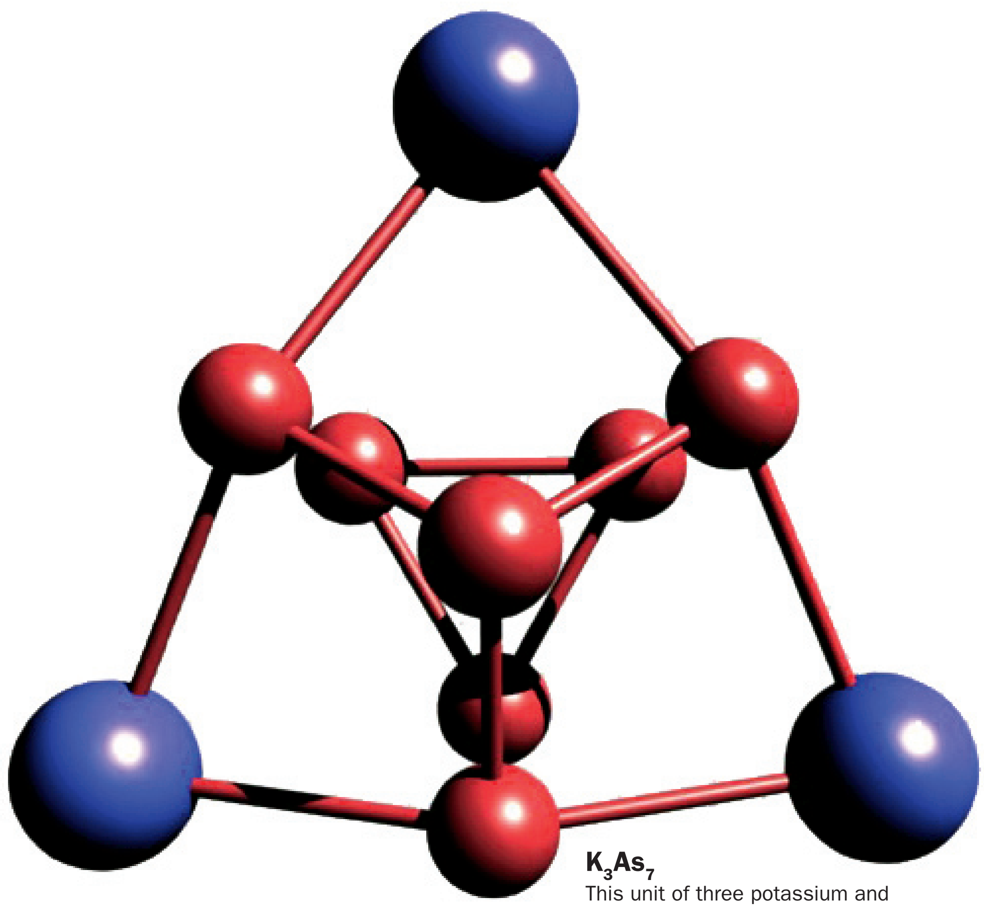
Scientists are already studying how superatoms bind to each other and to organic molecules. Tracking superatoms can help researchers learn how biological molecules move inside cells and tissues, or determine the structure of those molecules precisely using electron microscopes.

And by assembling superatoms of elements such as gold, carbon or aluminum, researchers may soon be able to create entirely new materials. Such materials could store hydrogen fuel in solid form at room temperature, make more powerful rocket fuels or lead to computer chips with molecule-sized features.

"Designer" materials made of superatoms could have combinations of physical properties that don't exist in nature. As Kit Bowen, a chemical physicist at Johns Hopkins University in Baltimore, puts it, it's as if you felt like eating something hot and something cold at the same



Al_{13}^-
This icosahedral cluster of aluminum atoms behaves like a halogen.



K_3As_7
This unit of three potassium and seven arsenic atoms has been used to make a variety of materials.

time, and could have it both ways. "Like a hot-fudge sundae."

Small numbers of atoms often form structures as symmetrical, and almost as intricate, as those of snowflakes. But while no two snowflakes, even if they have the same number of water molecules, are identical, a small, specific number of atoms of the same element typically will assemble into the same, specific shape. The quintessential example is how 60 carbon atoms form buckyballs. Metal atoms such as gold, aluminum or tin also like symmetry. For example, 20 atoms of gold will assemble into a solid pyramid, but 16 will form cage-like structures, as Lai-Sheng Wang, a physical chemist at Washington State University and at the Pacific Northwest National Laboratory in Richland, Wash., and his collaborators have discovered in recent years (*SN: 5/20/06, p. 308*).

The strange behavior of atoms in small groupings has been known for a long time, though only recently have scientists begun to understand it in detail.

"The whole idea is that small is different," says Bowen, quoting what he says is a motto of Uzi Landman of the Georgia Institute of Technology in Atlanta. The physical properties of a material, such as hardness and color, are the same for a 1-pound lump of the stuff as they are for a 100-ton chunk. But when you get to specks made of a few million atoms or less, properties usually begin to change.

A material such as silicon, which is usually brittle, can become as ductile as gold, researchers from the National Institute of Standards and Technology reported last November in *Applied Physics Letters*. Another example is particles called quantum dots, which fluoresce in a rainbow of different colors depending on their size (*SN 2/15/03, p. 107*).

But with even fewer atoms — a few hundred or less — the changes become more dramatic. "If you keep going smaller, then you enter a region where properties are erratic," Bowen says. "Often, one atom counts." For example, Wang and his collaborators have shown that tin clusters behave like conductors or semiconductors, depending on their size; Bowen found something similar with magnesium.

A job for superatom

For larger clusters, it's not always clear when atoms will aggregate into regular structures or into shapeless blobs with any number of atoms. "What's to stop the cluster from adding a few more atoms?" asks Roger Kornberg, a structural biologist at Stanford University's Medical School.

Last fall in *Science*, Kornberg and colleagues described an intricate cluster they created with exactly 102 gold atoms. He and his team synthesized their gold superatoms in a liquid. To control the clusters' growth, the team added sulfur-based organic molecules called thiols, which bind easily to gold. Forty-four thiols bound to each gold cluster's surface, preventing the 102-atom clusters from coalescing to form larger clusters.

What resulted was a superatom (or maybe a "supermolecule") with a core of 79 gold atoms arranged into a truncated decahedron: two pyramids with pentagonal bases joined together into a diamond shape, but with the pyramids' tips chopped off. Around the core, more gold atoms formed an unusual pattern, joining the thiols in shapes looking like handles. "The thing that surprises me the most," says Kornberg's collaborator Pablo Jadzinsky, "is that the geometry of the cluster cannot be described in simple words."

The team determined the cluster's structure using X-rays, which required first coaxing the clusters into forming a crystalline solid. Jadzinsky says that the very fact that the clusters could form a crystalline solid means that they are all identical and that their shapes are fixed. At 1.5 nanometers, the clusters' shapes may have fluctuated, as other nanometer-scale shapes often do (*SN: 3/15/03, p. 174*).

But the numerology seems sort of random: Why 102 gold atoms? Why 44 thiols? As it happens, superatom theory has a good explanation.

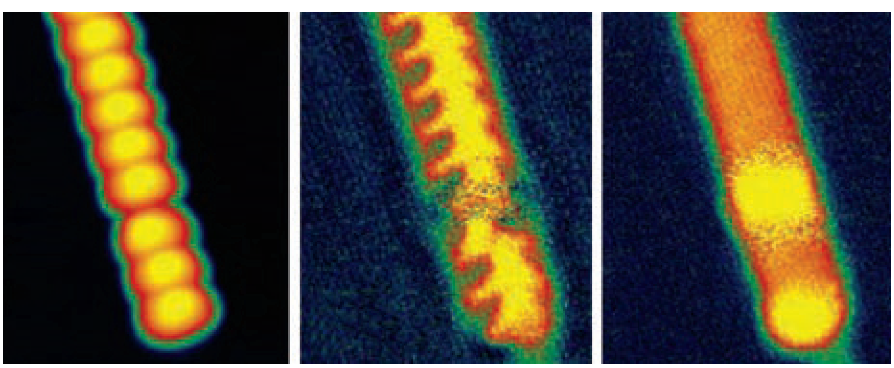
Each of the gold atoms donates an electron to the cluster, just as inside larger chunks of metal, where mobile electrons can conduct electricity. Forty-four of those electrons get immobilized in bonds between gold atoms and thiols, leaving 58 electrons free to roam. These 58 electrons then orbit the cluster's core — made of positive gold ions — just as they would orbit the nucleus of a stand-alone atom. And 58 happens to be a "magic number." It's the number of electrons needed to fill a shell around the superatom, so that it won't feel a desire to add or shed electrons, which would destabilize its structure.

This process is similar to what happens in noble gases, which are chemically inert because they have just the right number of electrons to fill a shell around the atom.

Chemist Royce Murray of the University of North Carolina at Chapel Hill and his collaborators describe the structure of a similar, though smaller, gold-thiol cluster in the March 26 *Journal of the American Chemical Society*.

Kornberg says that by tweaking the conditions in their lab's vials, he and his colleagues can obtain clusters of different numbers of gold atoms and thiol molecules, although they haven't determined the precise structure in those cases yet.

Under a scanning tunneling microscope, energetic electrons occupy high-energy orbits around each of a chain of buckyballs (left and center). At even higher energies, the electrons "see" each buckyball as a single atom, and can flow along the chain as they would in a wire (right).



SCIENCE

Superbucky

Thiol-gold clusters could have medical uses because they easily hook onto organic molecules. For example, clusters could help deliver drugs through cellular membranes, or, once inside cells and tissues, act as dyes for biomedical imaging.

Kornberg has another application in mind. His specialty is figuring out the exact structure of proteins and other complex biomolecules. "We have devoted decades to solving one structure," Kornberg says, referring to his work on the crucial enzyme RNA polymerase, for which he earned the 2006 Nobel Prize in chemistry. Superatoms could speed up the process dramatically. The idea is to attach superatoms at specific sites on biomolecules in solution, then flash freeze the superatoms and put them under the electron microscope. Because their shapes are precisely known, the superatoms would act as signposts, forming reference frames around each biomolecule. Computer processing of the electron-microscope data could then pinpoint the exact position of each atom in the biomolecule, producing an image of its structure, Kornberg says.

"This would open up a whole new vista for structural biology," potentially revealing the structure of molecules that can't be imaged by standard methods.

In other recent work, Hrvoje Petek of the University of Pittsburgh and his collaborators found that buckyballs can also turn into superatoms in some situations. Normally, superatoms are made of metal atoms, which pitch electrons into a common pot. In buckyballs, carbon atoms share electrons only with their neighbors, the way they would in ordinary graphite. But researchers were surprised when they placed buckyballs on a surface and made electrons flow through them to the tip of a scanning tunneling microscope. The data showed that the electrons briefly orbited the buckyballs, rather than just the individual carbon atoms, the way they would orbit an atom. The electrons occupied high energy orbits, from which they essentially couldn't see the single carbon atoms.

"Above some energy, the structure of the molecule disappears," Petek says, and looks virtually like a smooth, hollow sphere. He and his colleagues report in the April 18 *Science* that a buckyball pair with added electrons might even form molecular bonds, similar to those in hydrogen molecules.

Petek says rows of buckyballs aligned on a surface might form circuits and be the basis of molecular-scale electronic chips. At less than a nanometer thick, the circuits in buckychips would be tens of times thinner than those in state-of-the-art silicon chips, allowing engineers to pack more power into a chip.

Petek's buckyballs are not the first superatoms to be discovered that can behave like single atoms. Sometimes, clusters with a particular number of atoms can even mimic the chemistry of a single atom of a different element. The first hints of this surfaced more than two decades ago.

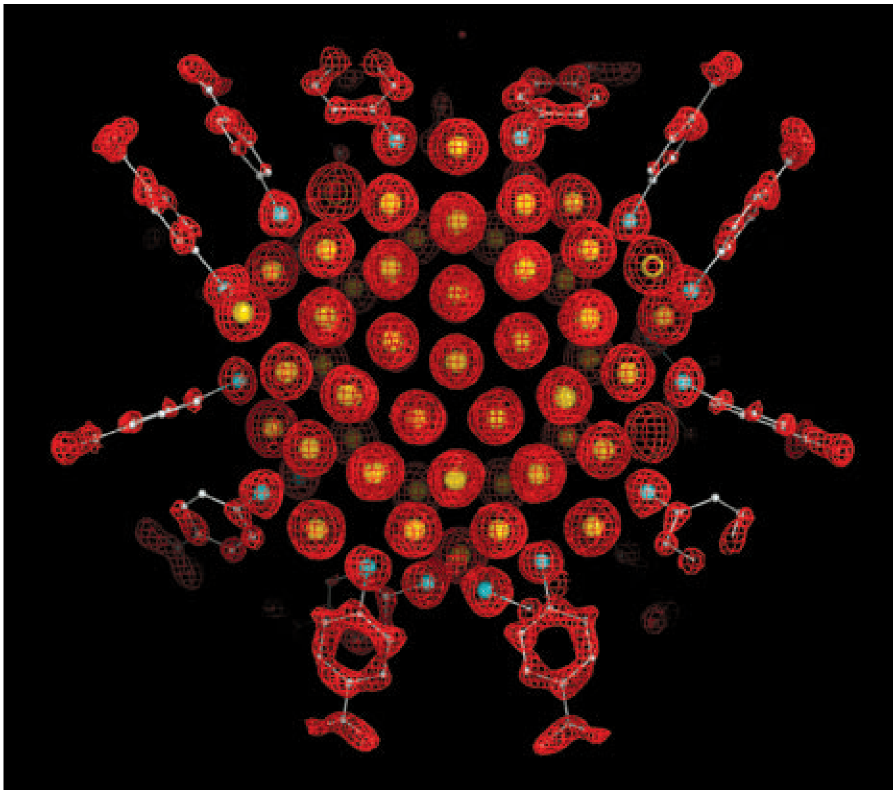
Spreading jellium

The story of the superatom begins when two physicists walk into a barber shop. Marvin Cohen of the University of California, Berkeley recalls how he and a colleague, the late Walter Knight, ran into each other at their favorite barber's one afternoon in 1984.

While waiting for his haircut, Knight talked about some surprising data from an experiment in which he had baked a block of sodium and then measured the masses, and thus the sizes, of vaporized particles that came out.

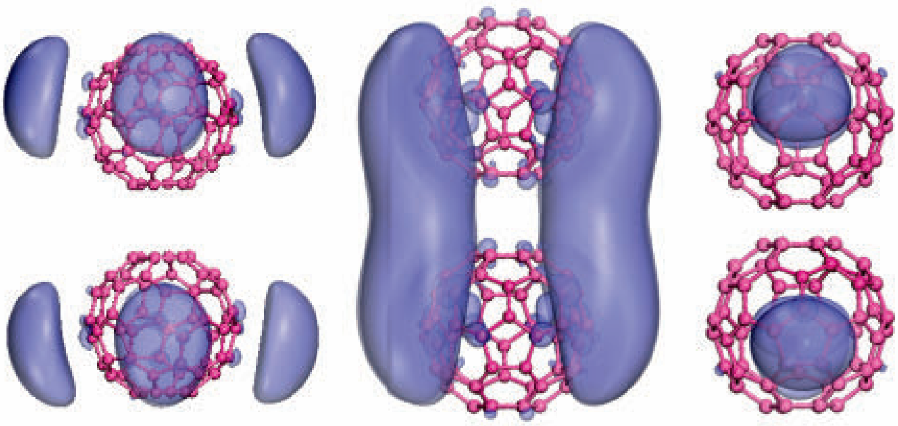
Knight's particles came in a range of sizes. But those made of eight, 20, 40, 58 (remember 58?) or 92 atoms were a lot more abundant. Cohen guessed what might be happening, and he started scribbling some back-of-the-envelope calculations. "Tony, the barber, thought we were figuring out a way to beat the stock market," Cohen recalls.

Sodium is a metal, with a propensity to shed one of its 11 electrons. In a cluster, atoms share these electrons in a "socialistic" way, Cohen says. For simplicity, in his calculation he imagined the positive electric charge of a cluster's sodium ions (each of them an atom minus one electron) as being spread uniformly like jelly, rather



This superatom has a core made up of a cluster of gold atoms. Sulfur-based organic molecules called thiols bind to the gold cluster's surface (arms sticking out), and electrons (red) orbit the atoms. More electrons (not shown) orbit the cluster as if it were a single atom.

JADZINSKY



This computer simulation shows clouds of electrons (blue) forming bonds between two buckyballs (red). Each buckyball acts like a single atom in the resulting hydrogen-like molecule.

JIN ZHAO/UNIV. OF PITTSBURGH

than concentrated at the ions. Nuclear physicists use a similar model for atomic nuclei; they call it the "jellium" model.

Jellium gave the right answer. The shared electrons orbiting the cluster do so in different energy levels, or shells, just as they would in an atom, Cohen figured. Computer calculations confirmed his guess. Like ordinary atoms, clusters with unfilled electron shells are chemically reactive. Full shells, with "magic numbers" of electrons, are not. Sodium clusters with eight, 20 or 40 atoms are the analog of helium, neon, and the other noble gases, which rarely form molecules. Clusters with non-magic numbers of atoms tend to lose or gain electrons, making them more likely to also lose or gain atoms (to get a magic number) through collisions with other clusters.

A year later, Exxon Corporate Research Lab chemist Robert Whetten, now at Georgia Tech, and his collaborators noticed that clusters of six aluminum atoms could split hydrogen molecules at room temperature, something smaller clusters couldn't do. "Only aluminum-6 jumped up and shouted 'Here I am, I can do this!' " says Whetten. And in the late 1980s, Welford Castleman of Pennsylvania State University in University Park and his colleagues discovered that clusters of 13, 23 or 37 aluminum atoms, plus an extra electron, become chemically inert, even though pure aluminum usually reacts violently with oxygen.

The researchers realized that Cohen and Knight's magic numbers could explain the perplexing phenomenon. In an aluminum cluster, each atom donates three electrons to the cause. The 13-atom cluster, or Al_{13}, for example, ended up with 39 common electrons (3 x 13), and the extra electron in the ion Al_{13}^- was just what the cluster needed to reach the magic number 40.

Researchers say that chemically stable forms of aluminum, which can be destabilized and burned when needed, could someday yield a powerful yet safe-to-handle additive for rocket fuel.

But the team went further. It showed that the neutral clusters Al_{13}, Al_{23} and Al_{37} get into similar chemical reactions as do elements that crave one extra electron. Those are the elements such as chlorine or fluorine, which in the periodic table are the halogens, the column directly to the left of the noble gases.

Then in 1995, Shiv Khanna and Purusottam Jena of Virginia Commonwealth University in Richmond found a theoretical explanation for Castleman's discovery. While Cohen's calculation could predict which clusters would be stable, understanding chlorinelike behavior required calculating the energetics of adding or removing an electron from the cluster, which is what Khanna and Jena did. They proposed the term "super atom" (two words, originally) for such clusters.

Hot-fudge sundae

Jena and Khanna then predicted that Castleman's aluminum clusters should form tightly bound ion pairs with elements such as sodium or potassium, which like to donate one electron. Ionic bonds are what occur in sodium chloride (Na^+Cl^-), also known as table salt. Aluminum clusters, Jena and Khanna proposed, could become part of the first all-metal salts, clusters that include superatoms of one metal (which act like halogen atoms) and atoms of the same or a different metal.

Two years ago, a team led by Bowen indeed produced $K^+Al_{13}^-$ (potassium-aluminum) molecules and showed that their chemical properties resemble those of molecules like K^+Cl^- or Na^+Cl^-.

In the last few years, researchers have also begun looking for ways to use superatoms to store hydrogen in solid form. The difficulty of transporting and storing hydrogen at room temperature poses a formidable obstacle to the much-touted hydrogen economy.

Several teams are now trying to create superatom-based salt crystals — something that's proving trickier than expected, since once the molecules start aggregating, the superatoms tend to merge with each other, forming clumps more than crystals. "When you put them together, they slag themselves," Bowen says. One approach is to coat superatoms with other kinds of stuff, as Kornberg did. On the other hand, Castleman hopes that replacing potassium ions with larger molecules might prevent superatoms from coalescing. "You have a chance of keeping them away from each other," he says.

The interest in making crystals out of superatoms goes beyond pure curiosity. By adjusting the types, shapes and sizes of a material's ingredients, scientists and engineers could tune physical properties to their likes. "You would have a way of making materials with tailored properties," Bowen says.

For example, a material that can be transparent typically won't conduct electricity, and vice versa. But a suitable all-metal salt, say, might be able to do both. And with a stretch of imagination, all-aluminum salts could make airplanes with see-through fuselages possible. Almost as cool as a hot-fudge sundae. ■

Explore more

- Min Feng, Jin Zhao, Hrvoje Petek. "Atom-like, Hollow-Core–Bound Molecular Orbitals of C_{60}." *Science*, 18 April 2008.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Nabbing suspicious snps

Scientists search the whole genome for clues to common diseases

By Regina Nuzzo

Old-fashioned gene hunting wasn't terribly efficient. Geneticists typically pursued one gene at a time, armed only with guesses — usually wrong — about which chunks of genetic code might be linked to human disease.

Geneticists managed to bag a few trophies anyway — genes for Huntington's chorea and cystic fibrosis, for example — mostly in rare diseases caused by a problem in a single, high-powered gene. Unfortunately, most of the more common diseases, such as type II diabetes, are instead controlled by a whole crowd of gene variants, each playing a small and often subtle role in the path to disease.

To spot these quiet genes lying in the genomic underbrush, disease geneticists realized they'd better try a new tack. In the mid-1990s, the most foresighted among them asked, "What if someday we could take a bunch of unrelated people and compare their genetic blueprint in lots of different places, all at once? Could it revolutionize the study of human disease?" International partnerships soon formed to figure out if this was even possible.

It was. Now, new technology, buttressed by new analytical methods and enhanced knowledge of the genome, allows scientists to do just that: Researchers can test up to a million of the most important spots across the entire genome at one time. These "genome-wide association" studies excel at detecting the subtle effects from common versions or variants of genes that went unnoticed before. Researchers can now put their guesswork aside and watch as a single study hauls in thousands of potential gene suspects.

Not surprisingly, geneticists are cheered by the prospect of leaving behind their days of hapless gene-hunt bumbling. "After years as 'Keystone Cops,' complex-trait geneticists can now find culprits not previously suspected and establish guilt beyond a reasonable doubt," geneticists David Altshuler and Mark Daly of the Broad Institute in Cambridge, Mass., wrote last July in *Nature Genetics*.

In the past two years alone, genome-wide association studies have found about 100 new genetic variants linked to 40 common diseases, including type II diabetes, prostate cancer and heart disease. These studies point to genes that researchers never suspected of being involved with certain diseases, or to uncharted regions known as "gene deserts" where genes are not known — at least yet — to exist.

Researchers hope the new studies will help explain how common diseases develop and also will help guide the search for new treatments and drugs. "I think it is absolutely clear that we have learned a tremendous amount about a whole range of complex, common, genetic diseases in the human population, and we have much greater knowledge than we did just a very short time ago," says biostatistician Michael Boehnke of the University of Michigan in Ann Arbor. But for all the promise and hype, finding genes with the new methods may not prove as easy as shooting DNA ducks in a genomic pond. Genome-wide association studies come booby-trapped with potential pitfalls.

Ironically, some of these problems stem from the studies' biggest strength: an unprecedented avalanche of data. Other challenges arise from the lingering genetic effects of migrations out of Africa 60,000 years ago. Ignoring these issues might cause scientists to waste valuable time investigating innocent sus-

Sorting out SNPs

Most human cells contain a complete set of genetic instructions — the genome — comprising about 20,000 to 25,000 genes packaged in bundles called chromosomes. The locations of those genes can be mapped to specific regions along those chromosomes.

From person to person, those genes are substantially the same, consisting of nearly identical strands of DNA. But many genes are found in variant forms that may differ by as little as one letter of the DNA alphabet. An alteration in one of those letters is known as a single nucleotide polymorphism, or SNP (pronounced "snip" and shown by red flag). SNPs give people their genetic individuality, and some SNPs lie within or near genes that predispose their owners to certain diseases. Scientists compare the SNPs of a healthy person to that of someone with a disease (far right, top and bottom).

pects, while the truly significant genes slip away unnoticed.

As results from huge new studies roll in, these challenges are attracting more attention. The National Institutes of Health held a special meeting in March to discuss how to translate genome-wide association data into clinical research and practice. And scientific journals are publishing special papers instructing researchers in the art of interpreting genome-wide association studies.

"First you have to go through a sifting process, filtering the true signals from the false signals and making sure you don't miss any," says epidemiologist Muin Khoury of the Centers for Disease Control and Prevention in Atlanta. "I think this is as much of an art as a science right now."

Deluge of data

For all the apparent variation among people, the human genetic code is actually 99.5 percent identical from person to person. That remaining individualistic half percent can help explain how diseases develop in some people and not others. Genome-wide association study researchers rely on results from two big projects to guide them to these crucial areas.

The first project, the government-sponsored Human Genome Project, analyzed a human genome archetype and transcribed the 3.2 billion nucleotide "genetic letters" that make up human DNA. Using this framework, the nonprofit International HapMap Project is pinpointing the 11 million specific sites along the genome where genetic information differs by a single letter. About 4 million sites have been cataloged so far.

Usually these one-letter sites, called single nucleotide polymorphisms, or SNPs (pronounced "snips"), do not themselves cause disease. But the SNPs often lie near important genes that can. So the SNPs serve as convenient signposts — pointing researchers to important disease-related genes in the neighborhood.

To find SNPs linked with a certain disease, the simplest approach is to compare groups of volunteers side by side. Researchers recruit a group of breast cancer patients, say, and a group of similar people who are breast cancer-free. The researchers use "SNP chips" — microchips that test up to 1 million selected SNPs at once — and record the versions of each SNP that each person possesses.

Then researchers statistically compare SNPs in the groups. If most breast cancer patients had two "T" versions of the SNP known as ESR1002, for example, and most disease-free volunteers had two "G" versions, then researchers would flag ESR1002 as a possible breast cancer suspect. Further investigation might then point to an important gene nearby.

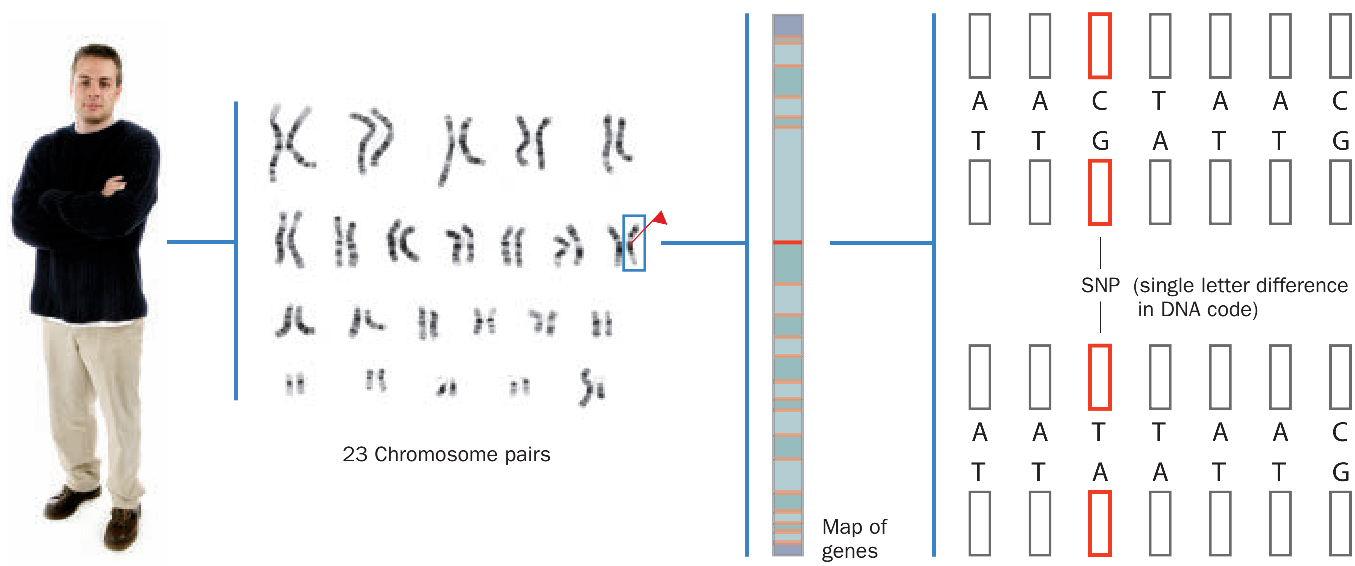
Yet a million SNPs on a chip still means a million potential suspects to sift through — most of which are ultimately not related to the disease. The flood of information is potentially overwhelming. As the title of a *New England Journal of Medicine* editorial last summer described it, genome-wide association studies are like "drinking from the fire hose."

In fact, most statistical methods were built to deal with data scarcity, not to handle a data deluge. So when a genome-scan delivers its data — four to five thousand times more information than in traditional epidemiology studies — standard statistical methods can easily choke.

For example, a genome-wide association study of 1 million SNPs will flag about 50,000 SNPs as significant. But most will be false alarms, indistinguishable from real results. Worse yet, truly interesting SNPs may be ignored and never get flagged in the first place.

The problem lies in how results get flagged. Statistical methods essentially set a cutoff value that any result must surmount before being flagged as significant — a statistical hurdle, in a sense. Traditional hurdles do a good job of separating true results from bogus ones when there aren't many competitors in the race.

Humans share the same genes, but those genes can carry slight variations



GRAPHIC BY CHARLES FLOYD, NED FRISK PHOTO/BRAND X/CORBIS

Scanning the genome

To link diseases to specific genetic differences, researchers must sort through a mass of data

1 | Study sample with microarray SNP chip

Microarray chips analyze the genomes of volunteers with a particular disease (the cases) and similar people without the disease (the controls). Statistical comparisons indicate which single genetic code differences, or SNPs, are more common in people with the disease.

- SNPs tested: up to 1 million

2 | Select the best SNPs

If people with a disease share a SNP not common in healthy controls (grayed at left), researchers flag it as a candidate SNP. With such large numbers of SNPs, many will appear to be linked to the disease just by chance. So a stringent statistical test is applied to reduce the number of candidate SNPs for further study.

- Statistical hurdle: High

3 | Test candidate SNPs in another sample

The candidate SNPs are checked in a larger sample of cases and controls. The statistical test applied at this stage is less stringent to avoid eliminating SNPs truly linked to the disease. Only the SNPs most likely to be important should pass this test.

- SNPs tested: 10–500
- Statistical hurdle: Medium

NED FRISK PHOTO/BRAND X/CORBIS; BLOOMIMAGE/CORBIS; MARTIN BARRAUD

But in a million-SNP blitz, too many false results manage to scramble over the hurdle just by random luck.

"There have been problems in the past when people have declared victory prematurely," says geneticist Joel Hirschhorn of the Broad Institute, by declaring SNPs to be significant based only on the traditional statistical hurdles. "It was hard to convince people that [the old level] was not an appropriate threshold. People are starting to accept that now."

The simplest solution is just raising the hurdle. Traditionally, researchers have permitted a bogus result to sneak through about 1 time in 20. With the new genome-wide scans, it's now usually no more than 5 in 100 million. This raises the bar considerably, Hirschhorn says.

Statistical demands

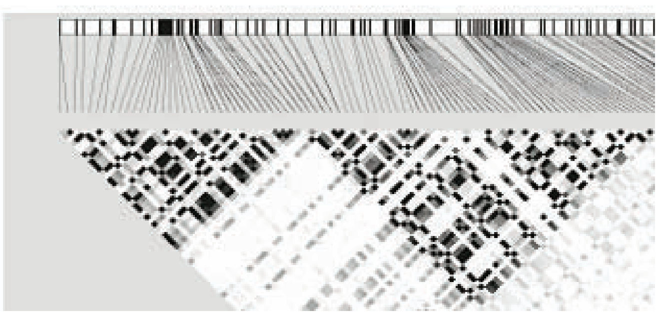
But higher hurdles require bigger studies. That's because much of the muscle power behind these studies depends on how many participants are included. New studies need an extra boost of muscle to hoist the important SNPs over the now-higher bar — otherwise no SNP might get flagged. So researchers have to scramble to find money and volunteers. Typical sample sizes for genetic association studies can now run in the tens of thousands.

Even then, added muscle power might not be enough. So researchers are turning to multistage studies, too. In such studies scientists first scan the full genome, then try to replicate the strongest findings with new subjects in subsequent studies. "That really leads to a new type of epidemiology,

4 | Test candidate SNPs in lots of samples

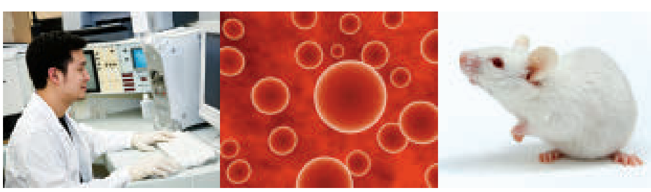
SNP candidates surviving the first two rounds are then tested in many other groups of people, comparing cases and controls to come up with a final short list of candidate SNPs.

- SNPs tested 5–50
- Statistical hurdle: Low



5 | Which genes are involved?

After identifying the SNPs linked most strongly to the disease, the next step is to identify which genes are involved, using the previously identified SNPs as a guide. Those SNPs will probably lie within or near the important genes.



6 | What do the genes do?

Using other tools, such as computer simulations, animal studies and cell cultures, scientists try to figure out what the identified genes do in the body, how the genes' activity relates to the disease and what steps might be taken to combat the disease.

because basically no one study is remotely definitive," says epidemiologist David Hunter of the Harvard School of Public Health in Boston. "We have to put together consortia and large-scale collaborations."

Still, data-sharing is becoming easier. For example, researchers who conduct genome-wide association studies funded through the National Institutes of Health must now deposit their data into a common database for immediate access.

Surprisingly, the earlier that researchers collaborate, the better — at least from a statistical point of view, Hunter says. Researchers originally thought that if small, independent groups each did their own study and then compiled a running list of all the important SNPs from their results, everything would be fine.

Not so, Hunter says. It turns out that the running list of results will still miss important SNPs. It's better for those groups to pool all their subjects at the beginning and run one big scan, he says. The final list from the pooled study will be more accurate and complete than the running list from independent studies.

The reason, Hunter says, is that subtle genetic effects (such as those likely to contribute to diseases) can be picked up only with a sufficiently large sample size — in the same way that a larger magnifying glass is needed to spot the smaller bugs in the undergrowth. "So this will be a long-running story for common diseases," he says, "because as we put together more and more scans, we'll find more and more truly associated variants."

Also afflicting these multistage studies

MARTIN BARRAUD; FROM DUERR ET AL. SCIENCE 314:1461(2006), REPRINTED WITH PERMISSION FROM AAAS; ISTOCKPHOTO (AREKMALANG, RAYCAT, JOEZELLNER); AFFYMETRIX is the peculiar "winner's curse" phenomenon, in which top results in small initial studies don't always pan out in later studies. This is a close cousin of the "*Sports Illustrated* curse," in which star rookies featured on the magazine's cover end up with a crash-and-burn second season.

There's a simple statistical explanation, says epidemiologist Teri Manolio of the National Human Genome Research Institute of the National Institutes of Health in Bethesda, Md. Researchers will naturally try to replicate the most extreme top-scoring results in an initial study. But these huge effects probably owe their super-high ranking in part to a true effect and in part to sheer random luck. Small follow-up studies — designed to look for these big effects — will miss the more subtle, true effects, Manolio says.

Thus initial studies may appear flawed, even if they aren't. The solutions — increasing sample sizes and recognizing that extreme initial results are likely overinflated — are beginning to take hold. "It's happening," Manolio says, "but it's happening slowly."

The trouble with ancestry

Complications from race and ancestry can also play a role in genome-wide association studies. That's because people with European, Asian and African ancestries have different genetic patterns. These patterns can be misleading. "There is a big debate about this in the genetics community," says geneticist Eric Jorgenson of the University of California, San Francisco. "Does race matter? Individual genotypes are what matter, but at the same time, race is correlated with genotype."

Take a simplified example: Suppose most people of European ancestry in a sample had blue eyes and also happened to have disease X, while most people of Asian ancestry were brown-eyed and disease-free. A naïve analysis might conclude that the blue-eyes SNP is responsible for disease X, even if eye color and disease are completely unrelated.

That is, the methods are likely to nab the wrong SNP suspects, simply because these innocent SNPs tend to show up in the same situations as truly guilty SNPs. This genetic-mixing issue shows up in other kinds of studies, too. But it's a particular problem for studies of the entire genome because of the huge number of ancestry-related SNPs being tested.

Traditionally, researchers have addressed this genetic-mixing problem largely by balancing the number of study volunteers belonging to different racial groups. But this strategy goes only so far, Jorgenson says. Genetic heritage is more complicated than skin color or grandparents' birthplace, and the ancestral variation in the gene pool can't be conveyed with a simple check-off survey box.

Some nifty statistical tricks, however, can help researchers spot and fix this problem in their analyses, Jorgenson says. For example, one method comes up with a mathematical summary of every volunteer's personal genetic ancestry and incorporates that into the analysis. This effectively allows researchers to "strip" each volunteer of his or her genetic ancestry and simply investigate the important genetic patterns that are left over.

Ancestry can cause other problems. Waves of migration out of Africa — starting about 60,000 years ago — were led by a relatively small number of people, resulting in a narrower gene pool in the new communities. Plus, as populations spread throughout Europe, Asia and the Americas, settlers faced limited mating choices, further reducing genetic variability.

These conditions — founder effects and bottleneck populations — meant that new emigrant groups had less genetic diversity than the original African population. Over time, these effects became more pronounced. People with recent African ancestry now have more variability across their genome than do people with European and Asian ancestry.

Problems arise when people with different genetic ancestries are included in one study, Jorgenson says. Scanning a group with greater genetic variability requires more refined tools. "If you're applying genome-wide association studies to a bottleneck population with less variability, you can use a wider-tooth comb," he says. "Populations with more variability need a finer-tooth comb." Current methods may miss disease-linked SNPs in African-Americans, especially if the SNPs are associated with rare gene variants.

The ideal solution would be to sequence every letter of volunteers' genomes — thus providing the finest-toothed comb possible. Cost and logistics are still prohibitive for this approach, however. Still, the more SNPs that manufacturers can squeeze onto their SNP chips, the more likely that important SNPs will be caught, Jorgenson says. And some manufacturers are already starting to design chips that incorporate sets of SNPs suitable for different genetic ancestries.

Beyond SNPs

Genome-wide association studies might indeed prove to be a bonanza for modern gene hunters. But in all the excitement, researchers shouldn't forget the value of good old-fashioned study design, Khoury warns. "I think people are being lulled into a zone of comfort," he says, as some researchers rely on million-SNP chips, large sample sizes and multiple replication studies to cover up study flaws.

And there's still a nagging question: After you've bagged your gene, what do you do? "To me, this is the biggest stumbling block," Khoury says. "You still have to work out the biology of that hit.... That's actually where the hard work begins."

It's clear that clinical applications are still years away, Manolio says. Some companies are starting to sell personalized genetic tests based on results from genome-wide association studies. But researchers hardly know what the study results mean themselves; any immediate translation into personalized medicine will naturally be problematic.

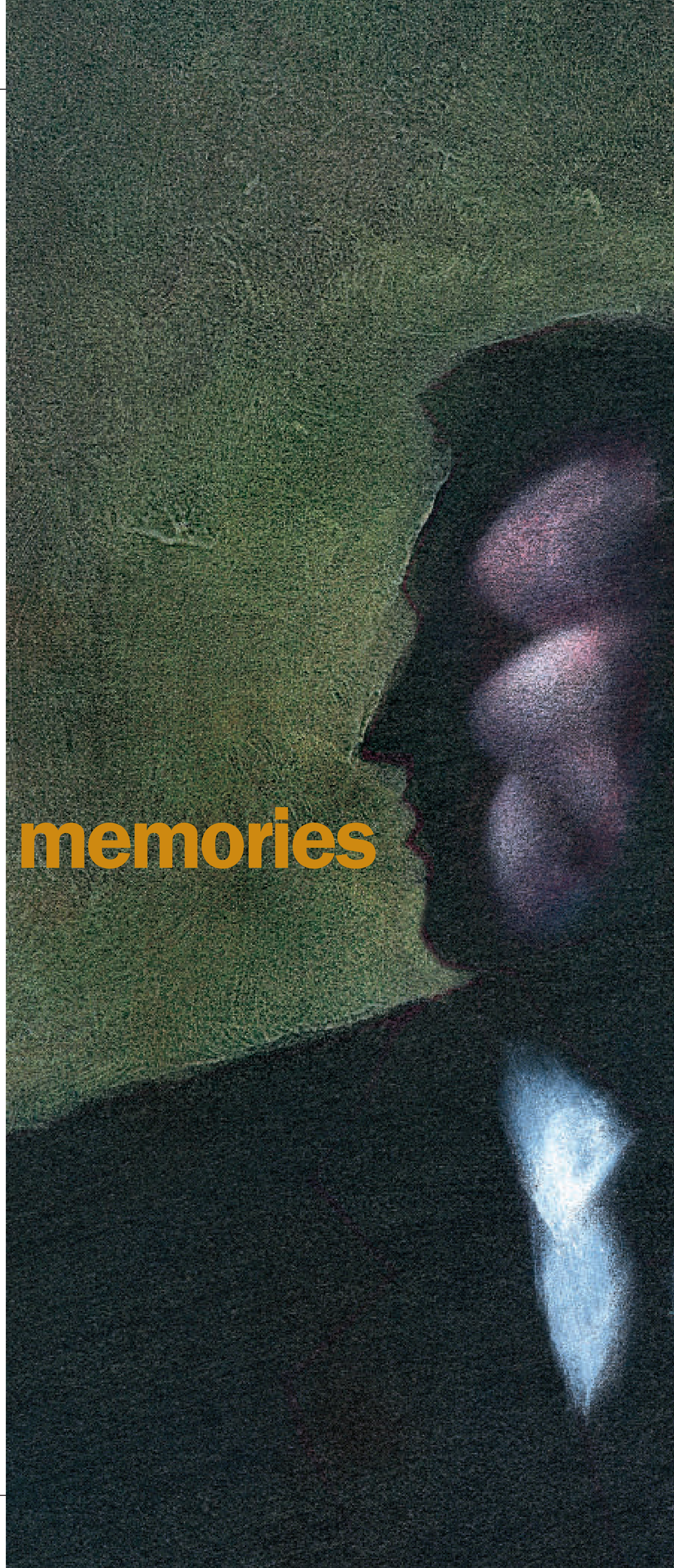
"There is a lot of missing heritability in our results right now," Boehnke says. "If your goal [with these studies] is personalized medicine and developing your own personal genetic report card, we're definitely not there yet. I don't know whether we ever will be." ■

Regina Nuzzo is a freelance writer based in Washington, D.C.

Explore more

■ Thomas A. Pearson and Teri A. Manolio. "How to Interpret a Genome-wide Association Study." *JAMA*, 19 March 2008.

for the future memories



TIM TEEBKEN, GETTY IMAGES

To the brain, remembering the past and visualizing the future look surprisingly similar

By Susan Gaidos

Thanks

When Alice climbs through the looking glass, she encounters a topsy-turvy world. People are punished before committing a crime, and sometimes fingers bleed before a pinprick occurs. Those strange events reflect a memory that works both ways in that world, allowing people to remember things before they happen. As the Queen explains to Alice: "It's a poor sort of memory that only works backwards."

Now, back in this world, scientists are discovering that human memory does indeed work forward. A growing number of studies show that the mental machinery for reliving your past performs another — perhaps more vital — task: envisioning your future.

Other studies show that total amnesiacs report a "blank" when asked about their personal futures. And severely depressed patients, who tend to think about both the past and future in a nonspecific manner, have difficulty visualizing positive future events.

Such findings have stimulated scientists to rethink the role of memory. Rather than viewing it as a mere storehouse of facts and autobiographical data, researchers are beginning to recognize that memory also constructs, simulates and predicts possible future events in an ever-changing environment. Perhaps, some say, this kind of autobiographical memory exists precisely for this purpose.

"It's not entirely clear what we have memory for in the first place," says psychologist Kathleen McDermott of Washington University in St. Louis. "The idea of sitting around reminiscing about the peanuts we ate yesterday just doesn't seem to have a clear and compelling adaptive value."

But if it's the flip side of an ability to envision and so better negotiate an unknown future, then memory's evolutionary usefulness suddenly becomes clear, McDermott says.

Harvard psychologist Daniel Schacter agrees, noting that this reverse role of memory may help explain why the human memory system is designed the way it is. Remembering personal experiences from the past and envisioning the future draw upon many of the same neural mechanisms, says Schacter, who co-organized a session on the topic in Boston at this year's annual meeting of the American Association for the Advancement of Science.

Though current studies focus on episodic memory, or memories of events, times and places, Schacter says that other forms of memory such as semantic memory and generalized knowledge are no doubt also relevant to thinking about the future. "Episodic memory seems to be important when people think about their personal futures because it is the source of the details that allow one to build simulations of what might happen."

Down memory lane

For more than a century, scientists studying memory have focused on its role in preserving and recovering the past. Eventually, memory's neurochemical nuances were mapped mainly to the hippocampus and prefrontal cortex.

In the early 1980s, researchers identified additional regions used in planning and foresight. Studies of patients with brain lesions suggested that such patients struggled in these tasks as well as in remembering the past. About that time, psychologist Endel Tulving of the University of Toronto suspected that the mental powers enabling humans to remember episodes from the past, such as a disagreement with a client, also confer the ability to foresee possible futures, as in planning an upcoming meeting with that client.

Schacter, a graduate student in Tulving's lab at the time, was struck by a patient known as K.C. A motorcycle accident had damaged K.C.'s hippocampus. Though he retained some general knowledge about the world, he couldn't recall any past personal experiences. When asked what he would be doing next week, K.C. had just as much trouble responding. "It was kind of an informal observation, but it always struck me," Schacter says.

Three years ago, while working on why memory can be unreliable, Schacter thought back to K.C.'s lapses and came up with a theory: Perhaps the overlap between memory and imagining could be explained by memory's "constructive" nature. Rather than pulling up a file, like a computer, human memory strings together all the bits and pieces — place, people, sounds — needed to re-create an episode. That flexible, piecemeal system can make memory errors, but it might provide a way to gather information from the past to prepare for future challenges.

At the time, only one imaging study had been done to examine the general brain regions common to both thinking ahead and remembering the past. By using a more systematic approach, Schacter reasoned, he might be able to pinpoint the components involved in both activities.

Using functional MRI to capture patterns of brain activation, Schacter tested his theory by examining the overlap between brain regions used in remembering and imagining. In the study, 14 participants described a series of events from their personal past involving common objects, such as a table. The same participants then envisioned a plausible future scenario with that object.

In the early stage of constructing an event, the left hippocampal region appeared equally active in remembering and imagining. The overlap was most apparent at the "elaboration phase," when subjects gave details on the events. In addition, certain regions in the right hippocampus became active when subjects imagined a future event, but not when they remembered a past one. Schacter says these activations may reflect a process of recombining details from various past events into a new imaginary episode.

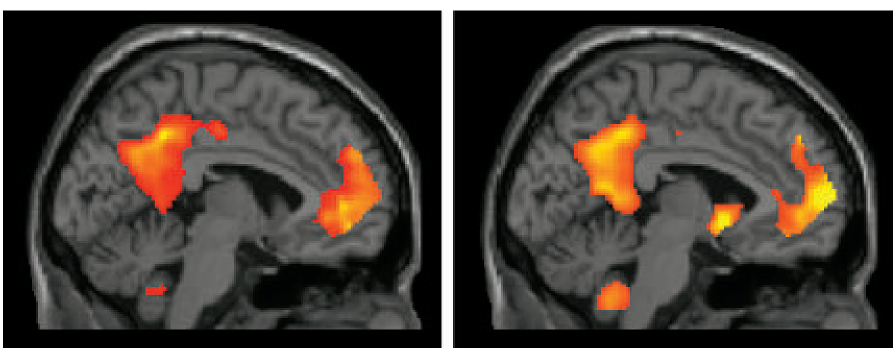
Letting imagination run

Schacter's findings were confirmed last year when McDermott, with doctoral student Karl Szpunar, published another MRI study in the *Proceedings of the National Academy of Sciences*. In that study, participants were given a cue, such as a birthday party, and instructed to recall a personal event from their life and remember it as vividly as possible for 10 seconds. In a second condition, participants thought about a personal event and projected it into the future. They then envisioned a third event, placing a familiar individual (not themselves) in the future.

Brain activity patterns for past and future events looked a lot alike, but only when the participants imagined themselves in the future picture. When imagining a third party's future, the same regions were busy but not to the same extent.

A follow-up study showed that sub-

Many of the same brain regions used to recall vivid memories (left) are engaged during the construction and elaboration of future events (right). These functional MRI images reveal extensive overlap in regions of the brain's memory and planning networks.



D. SCHACTER

jects reported more vivid simulations when imagining events that might occur in the near future, or in a familiar setting. Again, the brain regions used in thinking about the future and remembering the past were almost indistinguishable.

"We sat around scratching our heads about this for a while," McDermott says. "Whatever we're doing when we remember the past, the same things happen when we envision the future."

These results support the idea that autobiographical information is used not just to remember, but also to construct simulations of future events. "Except now you're kind of recombining information from the past and relating it in a new way to think about what might happen in the future," Schacter says.

He and his group recently pinpointed a region in the posterior hippocampus used to construct and elaborate on past and future events. That finding suggests that region may be where memories are "grabbed" during the construction process, Schacter and colleagues reported in the journal *Hippocampus* in February.

Making a scene

Schacter and postdoctoral researcher Donna Addis spelled out their "constructive episodic simulation" hypothesis last year in an essay in *Nature*. About that time, another study emerged linking memory to the future from Eleanor Maguire and colleagues at the Wellcome Trust Centre for Neuroimaging at the University College London. Maguire asked five amnesiacs to imagine and then describe in-detail situations in commonplace settings, such as a beach, pub and market. The patients were also asked to describe plausible future events, such as a Christmas party.

Despite being given cues to help probe their memories, the patients were unable to put together the elements of an imagined event. Instead of visualizing a single scene in their mind, such as a crowded beach filled with sunbathers, the patients reported seeing just a collection of disjointed images, such as sand, water, people and beach towels.

The patients seemed to lack a "spatial context" in which to place the events, Maguire says. "The events in your life happen in a specific location — a store, at work or in a certain room in your house," she explains. "These patients simply didn't have that kind of context to draw from."

> **"Whatever we're doing when we remember the past, the same things happen when we envision the future."**
> **KATHLEEN MCDERMOTT**

Maguire says those results show that the hippocampus, in particular, plays a role in helping humans bind together snippets of events that allow construction of both past and future scenes.

Working to tease out more detail on the mechanism behind spatial context, Maguire and her colleagues recently went back to the scanner. This time, the scientists compared real and imagined experiences to see what, if any, other brain areas were activated under each type of scenario.

"Our argument was, if we compare real memories with imagined, fictitious experiences, it might allow us to identify brain areas concerned with the self, with mental time travel and with that feeling that something actually, really happened," Maguire says. "Because real memories have all of these qualities, while imagined events don't have any of these qualities."

That study revealed that a core network of brain regions — including the hippocampus, parahippocampal gyrus and retrosplenial cortex — provides a basis for mentally generating and maintaining a complex and coherent scene in both real and imagined events. This core network of brain regions appears to underpin the critical scene construction process in such scenarios, Maguire says.

She proposes that this scene construction is a key part of retrieving past experiences in any memory process, including navigation, planning for the future, daydreaming and mind wandering.

"We think scene construction underpins not just autobiographical and spatial memory and imagination, but a whole host of other critical cognitive functions," Maguire says. This includes semantic memory, multisensory information, short-term and long-term memory.

Her findings, published in December in the *Journal of Neuroscience*, also revealed brain areas that help distinguish real from imagined experiences. Maguire says those regions, including the cortex and the posterior cingulate cortex, appear to be co-opted into the scene construction network when the subject recalls experiences that have actually happened.

"Memories that happened to you, very vivid memories, have something about them that help you distinguish them from imagined experiences or things that may or may not happen in the future," she says. "If you take scene construction as the core, you may need other processes on top of that to give you a sense that this is a real experience that happened to you."

Imagining future applications

Maguire and her colleagues are continuing studies to track the neural basis for scene construction. Other scientists are looking at how the autobiographical memory system contributes to memory impairment in aging, depression, Alzheimer's disease and head injuries.

By understanding how this memory system works — what each part does and what each brain area contributes — scientists may be able to develop ways to treat those with memory problems.

The ongoing studies may also provide new insights into other functions of memory as it relates to future-oriented thinking, such as planning, prediction and remembering intentions, scientists say.

Despite the recent progress, Maguire says scientists are a long way off from understanding how memory's various brain components talk to each other and interact to simulate future events.

"We're still at that stage of trying to understand how this amazing thing happens." ■

Susan Gaidos is a freelance science writer based in Maine.

Explore more

- Daniel Schacter. *The Seven Sins of Memory: How the Mind Forgets and Remembers*. Houghton Mifflin, 2002.

Amazon Expeditions: My Quest for the Ice-Age Equator

Paul Colinvaux

In 1964, Paul Colinvaux began his life's work—trying to understand the ice-age climate of the Amazon through mud cores and the pollen found within. Having sharpened his drill in the Arctic, the ecologist looked south to "terra incognita." When he began his effort, no ice-age deposit or site in the Amazon had been identified.

Then in 1969, ornithologist Jurgen Haffer proposed a hypothesis to explain the Amazon's vast biodiversity. During the last ice age (which peaked about 21,000 years ago), he suggested, most of the forest became arid grassland. In pockets of surviving greenery, speciation occurred. The new species repopulated the forest when it returned, contributing to its diversity.

Despite a lack of evidence, the refuge hypothesis gained appeal. Colinvaux's mission took on new meaning. He had the tools to unravel an idea that was quickly becoming a paradigm, and his field data suggested ecological consistency rather than change. "Might not one of the secrets of the Amazon lie here in this history of tolerance and stability?" Colinvaux asked himself.

Colinvaux carries readers along on his adventure to uncover the Amazon's ice-age mysteries—chronicling events, endeavors and emotions every step of the way. The strength of his story comes in his ability to highlight science as a process. He has many false starts, and he encounters barrier after barrier.

Even after Colinvaux collects the data he needs to prove his case, his tale does not immediately transition to one of triumph. The refuge hypothesis does not lie down. "Resulting bruises to the soul can be soothed by the Band-Aid of thought that says, 'We were pioneers,'" he concludes, pushing onward. **—Elizabeth Quill**

Yale Univ. Press, 2008, 308 p., $32.50.

Mortal Coil: A Short History of Living Longer

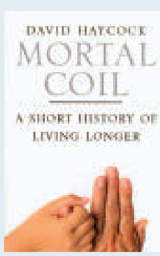
David Boyd Haycock

As Jonathan Swift once said, everyone wants to live forever, but no one wants to be old. Despite that snag, the question has lingered: Must we die so soon?

Some people have lived to be mighty old, and Haycock does them justice in this well-researched ramble through the pursuit of long life. Thomas Hobbes' observation that life in the old days was "nasty, brutish and short" wasn't entirely true. Europeans have shown an obsession with living longer, even publishing texts in the 1700s that mention people who lived a particularly long time. Among them: a French fellow who lived to see 121, a Dane who reached 145 and a Hungarian peasant who survived to 185. But documentation is fuzzy.

As living forever slipped from the grasp of philosophers and into the domain of medicine, early scientists talked about delaying the inevitable. But none did much about it until Louis Pasteur, Edward Jenner and Robert Koch came along and joined the battle against disease. Nowadays, the notion of living super-long through good nutrition and disease avoidance is back in vogue.

Genetics and advanced cell biology whet the appetite further. At first it seemed cells could live on and on. But it's

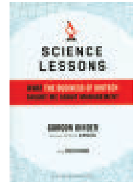


now clear that they can replicate only so many times before expiring. Still, biotechnology pursues eternal life. "Fear of old age and death will always drive at least some research in this subject," Haycock says.

Meanwhile, the facts speak for themselves: The verifiably oldest person, the Frenchwoman Jeanne Calment, died in 1997 at age 122, and no one is close to breaking her record. **—Nathan Seppa**

Yale Univ. Press, 2008, 320 p., $30.

Science Lessons: What the Business of Biotech Taught Me about Management

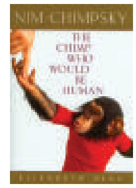


Gordon Binder and Philip Bashe

The former CEO of Amgen narrates the company's rise from start-up to biotech giant.

Harvard Business School Press, 2008, 288 p., $29.95.

Nim Chimpsky: The Chimp Who Would Be Human

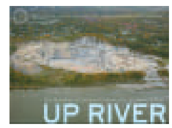


Elizabeth Hess

The story of a chimp being raised by humans—and washing the dishes (p. 130).

Bantam Books, 2008, 369 p., $23.

Up River: Man-Made Sites of Interest on the Hudson from the Battery to Troy

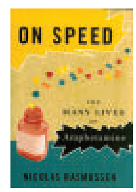


Center for Land Use Interpretation, American Regional Landscape Series

Take a tour through aerial photographs of the Hudson's shore, starting at the tip of Manhattan.

Blast Books, 2008, 174 p., $19.95.

On Speed: The Many Lives of Amphetamine



Nicolas Rasmussen

The rise, fall and resurgence of the original "antidepressants."

New York Univ. Press, 2008, 352 p., $29.95 (cloth).

We Dare You!

Vicki Cobb and Kathy Darling

Make an egg stand on end, suspend a Ping-Pong ball with a hair dryer and do other fun science demos at home.

Skyhorse Publishing, 2008, 321 p., $19.95.

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Feedback

“Why keep devising complex technological schemes to fix problems rather than simply avoiding the technologies that cause the problems?”

Readers share their thoughts on “Down with carbon” (*SN: 5/10/08, p. 18*), which describes carbon dioxide sequestration:

Complex schemes

The article repeatedly mentions liquid CO_2, which has to be under high pressure to become a liquid. Has the CO_2 released from burning fuel to run the necessary compressors and pumps been considered, or would those be powered with wind or solar energy? If so, why not just use those sources directly to replace fossil fuels and make less CO_2 to begin with? Why keep devising complex technological schemes to fix problems rather than simply avoiding the technologies that cause the problems?

BRUCE NOVAK, NEEDHAM, MASS.

Stop burning carbon

It is less economical to patch a broken system with an after-damage repair than to eliminate the problem in the first place — in this case, the use of combustion to generate power. For a smaller investment, and in less time, we can ramp up energy production using proven, non-combustive technologies for stationary power generation from wind, tides, nuclear fission and direct capture of solar energy. These technologies exist and are relatively uneconomical in the United States now merely due to scale, limited engineering commitment and lack of public support. Let’s get real. The sooner we stop burning carbon to make electricity, the better. We can make a big dent with alternative power before we even invent carbon capture from smokestacks.

DAVID P. VERNON, TUCSON, ARIZ.

Underwater logging

Thank you for a thorough article. The idea of digging trenches to bury trees seems extremely work-intensive and destructive. Wood waste could be buried under the overburden in strip mining operations, or sunk to anaerobic depths in deep lakes or off the continental shelf. There are numerous logs being recovered from the deep zones in Lake Superior.

JOHN BRODEMUS, OSWEGO, ILL.

Logs and trees drowned beneath man-made reservoirs suffer little or no degradation in the low-oxygen environments. Bogs and peat lands are also excellent preservers: Kauri trees that fell into New Zealand peat lands and were buried 50,000 years ago are preserved so well that they’re now being unearthed and sold to furniture makers and other woodworkers. — SID PERKINS

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All letters subject to editing.

David Applegate

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Challenges to building a disaster-resilient nation

The deadly typhoon that struck Burma in early May and the devastating earthquake that struck China a week later carried with them echoes of the devastation wrought by the Sumatra earthquake and tsunami on the Indian Ocean region in 2004. In the United States, the vulnerability of Burma's coastal populations to severe winds and storm-surge inundation also served to remind us of Hurricane Katrina and the ongoing recovery in New Orleans and other Gulf Coast communities. Although U.S. cities have not experienced a catastrophic earthquake since the one in Anchorage, Alaska, in 1964, we know that events as large as the Chinese earthquake will strike in the future.

Extreme events are facts of life on an active planet like ours. How those events affect us reflects not only the power of nature but the decisions we make in how we build our societies. Achieving security at home and abroad must reflect an overall resilience to all hazards that confront our communities. Achieving that resilience is a grand challenge, and it will take the collective action of government at all levels, nonprofit organizations, the private sector and above all individuals trying to do what is best for themselves, their families and their communities.

Science and technology can play a critical role in the quest for disaster resilience. To better define this role, the National Science and Technology Council's Subcommittee on Disaster Reduction, representing 22 federal departments and agencies, identified six grand challenges for disaster reduction.

The first of these challenges is to provide hazard and disaster information where and when it is needed. Meeting this challenge requires robust monitoring systems with the capability to reach those in harm's way and provide emergency responders with the information they need. Such systems are only as good as their weakest link, which in many cases is the link to the people at risk. Improving communications to the most vulnerable populations, so that they can protect themselves, requires education.

The second challenge is to understand the natural processes that produce hazards. Targeted research can harness advances in computing power and draw upon data generated by global observational systems to improve predictive modeling. For coastal hazards, this understanding must include assessment of the impacts of climate change on coastal inundation.

Science and technology can play a critical role in the quest for disaster resilience.

MARGARET ANNE BAKER

The third challenge is to develop strategies and technologies to reduce the impact of extreme events on the built environment and vulnerable ecosystems. Meeting this challenge will require understanding social, cultural and economic factors that promote or inhibit promising mitigation technologies.

The fourth grand challenge is to reduce the vulnerability of infrastructure. One major obstacle to recovery in any disaster is the delayed restoration of critical infrastructure such as drinking water, electricity and gas distribution systems. A key step is establishing the technical basis for revised codes and standards for critical infrastructure. Paradoxically, advances in technology can increase society's vulnerability because of reliance on distant resources and just-in-time inventory delivery, with the result that the economic impact of a natural hazard event can be broader than its storm track or rupture zone.

The fifth challenge is to develop standardized methods for communities to measure and assess disaster resilience across multiple hazards. A key step is developing and distributing assessment tools that can be used to set priorities.

The final challenge is to promote risk-wise behavior. The costs of natural disasters are rising as people increasingly move into harm's way in low-lying coastal areas, the wildland-urban interface and geologically active regions. In order to achieve "hazards literacy" and sustained risk reduction, hazards must be real to people. Scenarios are a tool that can spell out the impacts of likely events on high-risk areas, combining scientific and engineering knowledge with local planning and emergency management expertise to deliver a comprehensive picture of potential losses.

The subcommittee has released plans identifying the priority science and technology actions needed to meet these challenges for all major hazards. These plans will help to shape sustained federal science and technology investments in disaster reduction and can also serve as a blueprint for international cooperation.

All the plans identify the same desired outcomes: A nation where relevant hazards are recognized and understood, communities at risk know when a hazard event is imminent, individuals can live safely in the context of our planet's extreme events and communities experience minimum disruption to life and economy after a hazard event. ■

David Applegate is chair of the National Science and Technology Council's Subcommittee on Disaster Reduction and senior science adviser for earthquake and geologic hazards at the U.S. Geological Survey. The Grand Challenges for Disaster Reduction and accompanying implementation plans are available at www.sdr.gov. Applegate can be reached at applegate@usgs.gov.