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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ OCTOBER 25, 2008

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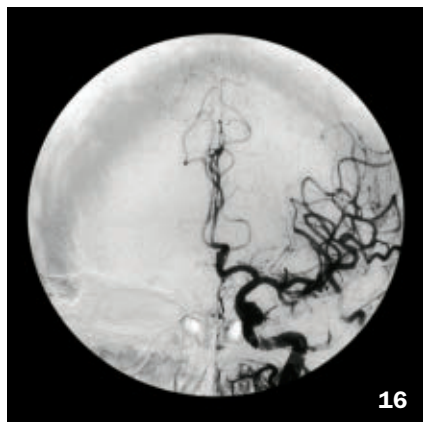
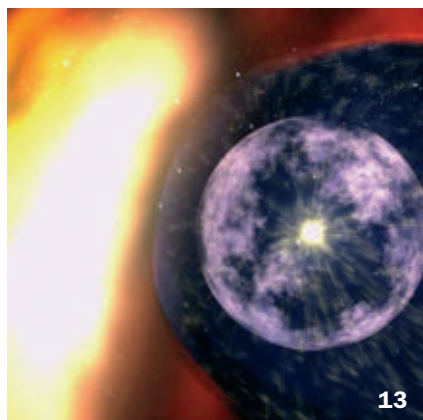
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ScienceNews



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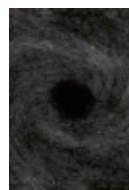
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Nobel laureate Steven Chu discusses how the United States should tackle the looming energy crisis.



COVER A black hole at the center of a galaxy (depicted in this artist's illustration) can grow to tens of billions of times the mass of the sun.
Aaron Horowitz/CORBIS

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FROM THE EDITOR

Aim for 20/20 foresight, then adjust as necessary



"When the facts change," the economist John Maynard Keynes once remarked, "I change my mind. What do you do?"

Science is supposed to work like that, too.

As new evidence comes in, old ideas should be abandoned, or modified, or refined. It is no disgrace — rather, it is a sign of open-mindedness and intelligence — to alter previous judgments in the light of new knowledge.

Still, it would be nice to think that science works well enough so as not to require drastic reversals of conventional wisdom too often. It did look bad, in the eyes of some, for atmospheric scientists of the 1970s to sound warnings of impending global cooling, only for the evidence of the 1980s to suggest just the opposite.

At least that is how skeptics of global warming have portrayed the past, implying that atmospheric science is uncertain enough that prevailing opinion is likely to switch once again. In reality, though, the science of future climate change has not been so metronomic. A new analysis of the science of the '70s shows that most research already was warning of rising temperatures, as Sid Perkins reports on Page 5 of this issue.

True, a few scientific papers had reported signs of long-term cooling, suggesting the possibility of an icy future. But plenty of other evidence portended warming, and further work negated or modified the assumptions in the analyses that predicted cooling. As more evidence accumulated, the preponderance of scientific opinion moved toward a consensus on future warming. Uncertainties remained, but as scientific investigation of the issue accelerated in the 1980s and 1990s, the case for warming became stronger and stronger.

Of course, as the authors of the new study note, media coverage of the science in the '70s might have generated an erroneous impression by emphasizing the minority reports about cooling. (Critics of climate experts still sometimes cite such media reports.) But in fact, while some popular magazines featured global cooling stories, there was no consensus about cooling among science journalists. *Science News*, for instance, did report on the cooling issue with a cover story in 1975 (*SN*: 3/1/75, p. 138). But as the new study notes, the *Science News* feature provided context and qualifying language, including comments that the evidence didn't warrant extrapolation to a long-term cooling trend, and that experts even then foresaw a likely rise in global temperature by the end of the 20th century.

Also (please be sure to note), the cover headline — "The Ice Age Cometh?" — was punctuated with a question mark. —Tom Siegfried, Editor in Chief

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Scientific Observations

"There is always an applied side to thinking deeply. In any society there are many complicated issues that unfortunately get simplified to the point where short-sightedness wins.... Science teaches us to think more broadly than that. If we really had wise leaders, they would take the long-term perspective seriously precisely because we are so prone to ignore it. They should listen to scientists and philosophers much more than economists who tend to be interested in what happens in the next annual quartile."

ANIMAL ECOLOGIST HANNA KOKKO OF FINLAND'S UNIVERSITY OF HELSINKI, IN A Q&A IN THE SEPT. 9 *CURRENT BIOLOGY*.



SN Online

www.sciencenews.org

ATOM & COSMOS

A malfunction in the Hubble Space Telescope delayed until next year a mission to repair and upgrade the orbiting observatory. Read about it in "Hubble suddenly silent."



HUMANS

The words "Neanderthal" and "advanced" are rarely spoken together, but new findings from caves in Gibraltar suggest Neanderthal behavior was relatively advanced. See "Stone Age seafood fans."

SCIENCE & SOCIETY

During the 1908 presidential race, William Howard Taft and William Jennings Bryan sounded off in a new way as use of the phonograph got serious. Read "The first sound bites," which also offers historical images and early phonograph recordings.

Science Past | OCTOBER 25, 1958

PIONEER LACKED EXTRA PUSH — Pioneer, man's first space probe, came within a fraction of the 35,250-foot-per-second velocity needed to put it into an orbit around the moon. It reached a maximum velocity of 34,400 feet per second. Even though the vehicle burned up in the earth's atmosphere, its successful flight to a distance of 79,316 miles from the earth's center showed the chances are good for hurling a rocket around the moon very soon.... Dr. T. Keith Glennan, administrator for the National Aeronautics and Space Administration, stressed the international value and significance of Pioneer, and said that all scientific information gathered by it would be made available to all nations, "completely, accurately and quickly."



Science Future

November 15

The Museum of Science in Boston will unveil a skeleton of *Triceratops horridus* as part of its *Colossal Fossils: Triceratops Cliff* exhibit. Visit www.mos.org

December 7–12

The 4th IEEE International Conference on e-Science will be held in Indianapolis. Visit escience2008.iu.edu

April 30, 2009

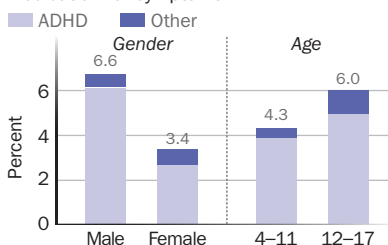
Deadline for Nikon's Small World Photomicrography Competition. Visit www.nikonsmallworld.com

Science Stats

CHILLING THE CHILDREN

Percent of kids in the United States who received drugs for emotional or behavioral difficulties, 2005–06

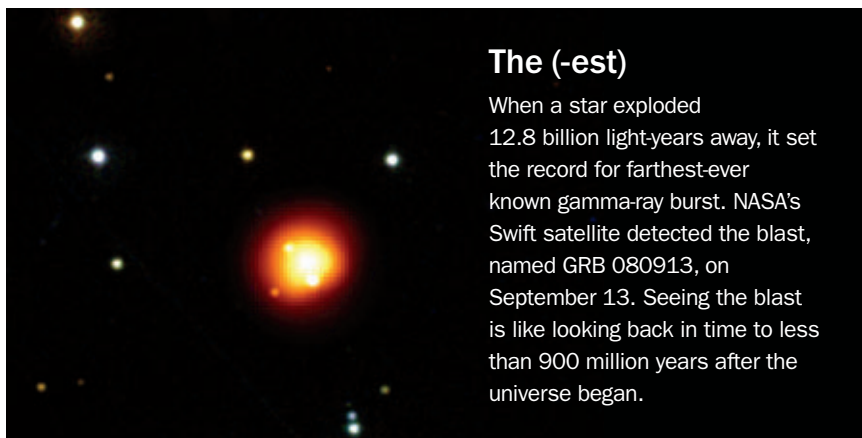
Medication for symptoms



SOURCE: CDC/NCHS, NATIONAL HEALTH INTERVIEW SURVEY

The (-est)

When a star exploded 12.8 billion light-years away, it set the record for farthest-ever known gamma-ray burst. NASA's Swift satellite detected the blast, named GRB 080913, on September 13. Seeing the blast is like looking back in time to less than 900 million years after the universe began.



CLOCKWISE FROM TOP LEFT: COURTESY OF HANNA KOKKO; FINLAYSON/GIBRALTAR MUSEUM; NASA, SWIFT, STEFAN IMMLER

“ These guys aren’t expected to last that long—they are running very close to empty. ” — PETER NONACS, PAGE 15

Genes & Cells Stem cell milestone

Matter & Energy A jolt for fuel efficiency

Science & Society Nobel Prize winners

Atom & Cosmos Galaxies go with the flow

Life New dino breathed like a bird

Body & Brain This is the brain on age

In the News

STORY ONE

Cooling climate ‘consensus’ of 1970s never was

Myth often cited by global warming skeptics debunked

By Sid Perkins

The reasons to disbelieve that humans are causing global warming are many and varied, skeptics say. For example: Natural factors such as long-term variations in solar radiation are causing the rise in worldwide average temperature. The urban heat island effect is skewing modern weather data, so the warming observed in recent decades isn’t real. And besides, not long ago experts all believed the Earth was cooling, not warming.

Actually, research has shown that many such ideas are bogus. While changes in solar output have slightly increased global average temperature since the beginning of the Industrial Revolution, the planet-warming effect of man-made greenhouse gases is about 20 times larger (“Heated dispute” letter, *SN*: 10/27/07, p. 271). And although cities are warmer than neighboring rural areas, that phenomenon doesn’t mask recent warming trends in long-established cities (“Don’t blame the cities,” *SN Online*: 9/5/08).

Now, new research also skewers the global warming skeptics’ claim that, in the 1970s, scientists believed that an ice age was imminent. Researchers of the day had discovered that Earth had been cooling since the 1940s. Some believed



Global warming naysayers point to past media coverage of cooling trends to suggest the fallibility of today's climatologists. But most evidence suggested a warmer future.

that continued increases in the amount of planet-cooling aerosols kicked up or emitted by human activity—dust and smog, for example—could easily tip the planet into an ever-deepening cycle of cooling, skeptics have repeatedly pointed out. That wave of concern was obviously a false alarm, the skeptics note, so maybe today’s scientists are equally mistaken about global warming.

Not true, climatologist Thomas C. Peterson of the National Climatic Data Center in Asheville, N.C., and his colleagues report in the September *Bulletin of the American Meteorological Society*. The team’s survey of major journal papers published between 1965 and 1979 found that only seven articles predicted that global average temperature would continue to cool. During the same period,



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44 journal papers indicated that the average temperature would rise and 20 were neutral or made no climate predictions.

The findings were “a surprise to us,” Peterson says. For decades the “skeptics had repeated their argument so often and so strongly that we misremembered the tenor of the times.”

When these skeptics mention previous concerns about global cooling, they typically cite media reports from the 1970s rather than journal papers — “a part of their tremendous smoke screen on this issue,” says Peterson. Among major magazines, *Time* and *Newsweek* ran articles expressing concern about the previous decades’ cooling trend, juxtaposing the specter of decreased food production with rising global population.

But even a cursory review of 1970s media accounts shows that there was no consensus about global cooling among journalists, either, Peterson says. In May 1975, the headline of a *New York Times* article warned that “major cooling may be ahead.” Three months later, another headline in the same paper — atop a feature written by the same reporter — stated that two recent journal articles “counter [the] view that [a] cold period is due.”

When skeptics do cite a research paper that predicted the possibility of global cooling, it is almost invariably a 1971 article in *Science* coauthored by Stanford University climatologist Stephen Schneider,

then a graduate student at Columbia University. That paper suggested that a four-fold increase in atmospheric aerosols could increase worldwide cooling enough to trigger an ice age.

But soon after the paper was published, new information emerged, Schneider says. First, the global cooling effect of aerosols wasn’t as large as estimated, in part because the tiny particles appeared in high concentrations over only about one-fifth of the planet, primarily around major cities. Second, Schneider adds, scientists discovered that many other minor constituents of the atmosphere — including methane, ozone and man-made gases such as chlorofluorocarbons — have the same warming effect that carbon dioxide does.

By the late 1970s, these realizations, along with insights from studies of the cooling effects of aerosols spewed from an Indonesian volcano in 1963, helped climatologists better estimate the balance between greenhouse gas warming and aerosol-induced cooling. This rapid evolution of understanding, says Schneider, is a testament to the self-correcting nature of the scientific process — a question is posed, data are collected, analyses are performed and then opinions and theories are modified, if need be, based on results of the research.

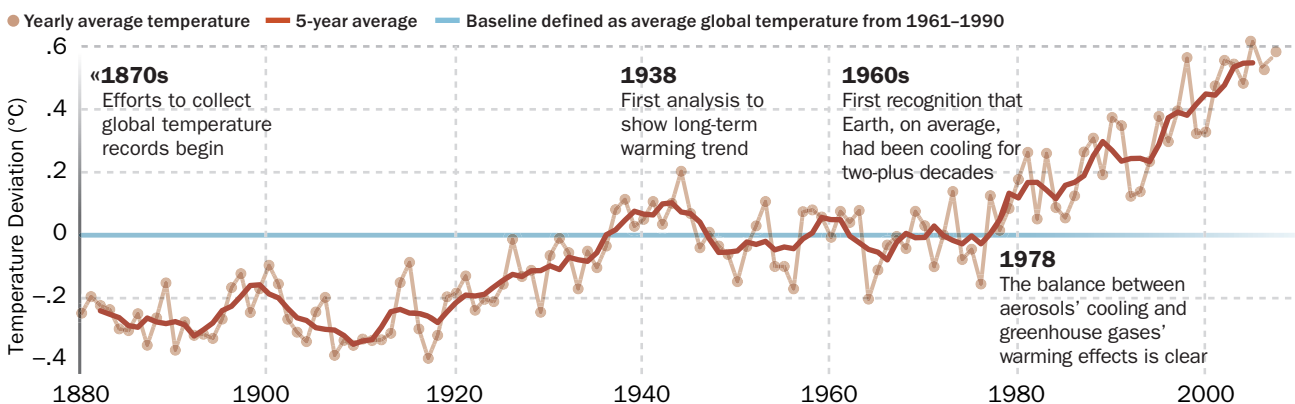
When global warming skeptics draw misleading comparisons between scien-

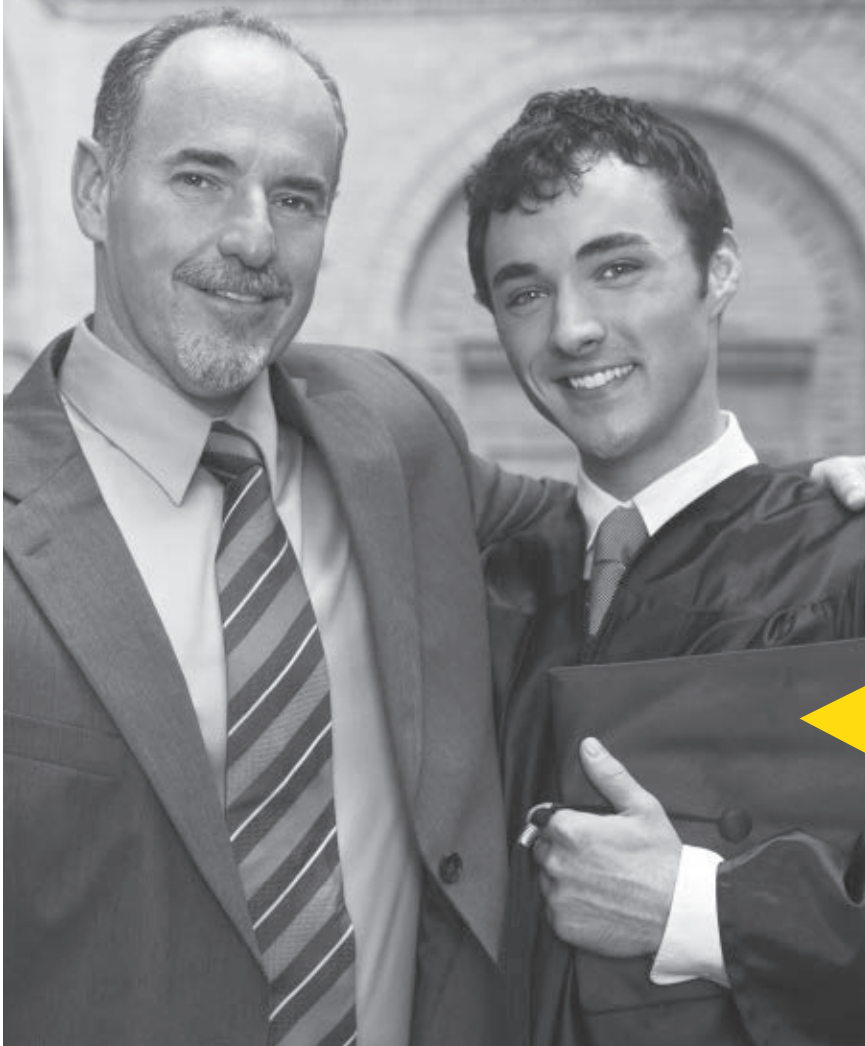
tists’ nascent understanding of climate processes in the 1970s and their level of knowledge today, “it’s absolute nonsense,” Schneider says. Back then, scientists were just beginning to study climate trends and their causes, and the probability of finding evidence to disprove a particular hypothesis was relatively high. Nowadays, he contends, “the likelihood of new evidence to overthrow the concept of global warming is small. Warming is virtually certain.”

Most climatologists have long shared a feeling that discussions in the 1970s about global cooling were common in the media but not in scientific journals, says Richard Somerville, a climatologist at Scripps Institution of Oceanography in La Jolla, Calif. Peterson’s research “is a level-headed, not strident” documentation of that contention. Somerville says the new findings “will not stop the critics [of global warming] from repeating their myth, but for people who are willing to listen with an open mind, this is a nice piece of work.”

Despite the lopsided tally of journal articles that predicted global warming versus those that foretold a long-term cooling trend, the new findings may not sway many hard-core skeptics, says Alan Robock, an atmospheric scientist at Rutgers–New Brunswick in New Jersey. Peterson “is wasting his time by addressing these global warming critics,” he says. “There are only a few of them.” ■

Back Story | UPS AND DOWNS IN GLOBAL TEMPERATURE





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New gene delivery method takes major step toward safer stem cells

Reprogramming works without DNA-altering viruses in mice

By Patrick Barry

Get rid of DNA-altering viruses — check.

In a step toward medical treatments based on embryonic-like stem cells, researchers have found a safer way to revert adult mouse cells to an embryonic state. The new technique, reported online September 25 in *Science*, avoids using viruses that alter the cells' DNA, a major goal for stem cell research because these DNA mutations can lead to cancer.

Such reprogrammed cells could sidestep the controversy surrounding therapies based on embryonic stem cells, many scientists believe, because the embryonic-like cells can be made from a person's skin or blood cells without creating or destroying an embryo. Coaxing reprogrammed cells into becoming, say, fresh heart or pancreas cells for transplantation back into the patient could offer new, personalized ways to treat ailments such as heart disease and diabetes.

Before, reprogramming adult cells in lab dishes required infecting the cells with viruses that carry four reprogramming genes. Although scientists cripple the viruses so they can't replicate, the viruses still insert those genes directly into the cells' DNA at random locations. These willy-nilly DNA changes can disrupt the cells' own genes, occasionally in ways that cause the cells to grow out of control and form a tumor. And any process that alters a cell's DNA complicates government approval for medical use.

The new technique overcomes these problems by using a different kind of delivery virus that does not alter the cells' genetic code, researchers report.

"None of the cells that we produced had any evidence of any virus left" after reprogramming, says study coauthor Matthias Stadtfeld, a molecular biologist at Mas-

sachusetts General Hospital in Boston.

The safer virus carries the same four genes into adult cells — *Oct4*, *SOX2*, *KLF4* and *c-Myc* — but instead of inserting those genes into the cells' DNA, the virus lets the genes float freely within the cells. The cells' protein-making machinery can still read the four adrift genes, so proteins encoded by these genes can do the actual reprogramming. Eventually, the cells degrade the genes and the inactive viruses.

"It's very exciting because it's the first demonstration of [reprogrammed] cells

without viral integration," comments W. Robb MacLellan, a stem cell expert at the University of California, Los Angeles. "It's a proof of concept."

Stadtfeld and colleagues reprogrammed skin and liver cells from adult mice, permitting the ultimate test for whether the resulting reprogrammed cells possessed the quintessential trait of embryonic stem cells: the ability to become any type of cell in the body. That test is to insert the reprogrammed cells into mouse embryos that then grow into adult mice. Just as embryonic stem cells would, the reprogrammed cells gave rise to all types of cells in every organ of the adult mice bodies.

While the question remains whether the reprogramming technique will work for human cells, MacLellan says it's likely.

X chromosome is extra diverse

Men with multiple mates cause more genetic variety

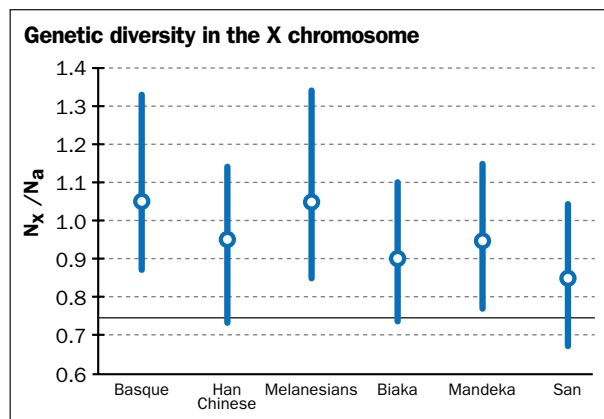
By Tina Hesman Saey

Men who have children with multiple women spread genetic diversity along with their wild oats, a new study shows.

DNA analysis of nonfunctional regions on the X chromosome and on the non-sex chromosomes in six groups of people from three continents reveals that the X chromosome is more genetically diverse than would be expected if men and women passed along their genes equally.

Michael Hammer of the University of Arizona in Tucson and colleagues provide evidence in the Sept. 26 *PLoS Genetics* that polygyny, the practice of men siring children from many women, accounts for the genetic diversity.

"Overall, these results underscore the importance of sex-specific demographic factors in understanding the history of human populations and patterns of diversity in our genome," says John Pool, a population geneticist at the University of California, Berkeley.



A measure of diversity on X chromosomes compared with other chromosomes (N_X/N_A) was higher than the expected value (black line) in six groups of people.



Manipulating diamond's impurities may lead to finer-scale microscopes

Nitrogen atoms could be used as magnetic field detectors

By Davide Castelvetti

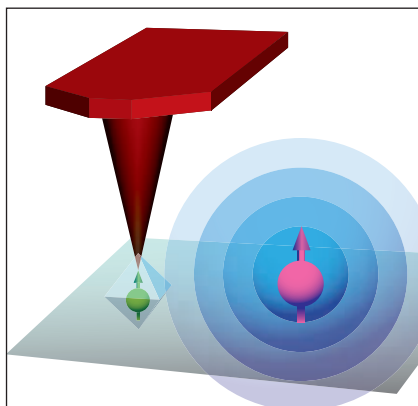
The nearly occult arts of quantum computing research could soon help biologists.

Two teams of researchers, from the United States and Germany, have found a way to make diamond nanocrystals into microscopes that could see at the resolution of a single molecule. Such resolution could image the structure and motion of single molecules and reveal previously unseen inner workings of a living cell.

The researchers manipulated the quantum properties of single nitrogen atoms embedded in diamond crystals, turning the atoms into magnetic field detectors.

"It's a real-world application of a quantum manipulation technique," says Mikhail Lukin of Harvard University, a member of one of the teams. Both teams report their results in the Oct. 2 *Nature*.

Daniel Rugar of IBM's Almaden Research Center in San Jose, Calif., says the teams have introduced an important tool. "It will be exciting to see how far



A diamond crystal at the tip of an atomic force microscope could image a nanoparticle (pink) using magnetic field lines.

this technique can be pushed," he says.

Diamond is promising as a possible information storage space for future quantum computers because its rigid crystal structure can shield atoms from outside disturbances, even at room temperature. A computer could then store information in a single atom, for example, by orienting the atom's spin.

Researchers have been especially interested in nitrogen-vacancy centers, impurities in diamond that are single atoms of nitrogen sitting next to a gap in the carbon structure. The spin of an NV-center is easy to read and manipulate using laser pulses and radio-frequency waves.

In their study, Lukin and his collaborators show how a single NV-center in a diamond nanocrystal can detect magnetic fields as weak as one-tenthousandth of Earth's magnetic field. Lukin first described the new technique in February at a meeting in Boston of the American Association for the Advancement of Science (*SN*: 3/1/08, p. 141).

In a separate paper, Fedor Jelezko of the University of Stuttgart in Germany and his collaborators describe how they placed a diamond nanocrystal on the tip of an atomic force microscope to scan the magnetic fields of cobalt nanoparticles.

Jelezko says that if the sensitivity improves, the technique could be used to resolve the structure of proteins that are hard to image using other techniques.

Diamond nanocrystals could also be injected into cells, Jelezko says, where the crystals could monitor the passage of ions through the cellular membrane or the changes in the shapes of proteins bound to the membrane. 

Thinning fuel before injection boosts efficiency

New device could improve gas mileage in cars, trucks

By Patrick Barry

A little voltage can jolt existing cars to get better gas mileage, new research shows.

Applying a strong electric field to fuel a moment before it was injected into the engine's cylinders boosted fuel efficiency of a Mercedes-Benz 300D from 32 to

38 miles per gallon—an increase of more than 18 percent, scientists report in November in *Energy & Fuels*.

Others say that the increase in fuel efficiency may be closer to 5 to 10 percent in real-world scenarios. If applied to all the cars and trucks in the United States, that fuel savings would add up to more than 300 million barrels of gasoline and about 150 million barrels of diesel per year.

The field-generating device, which costs about \$50 per cylinder and could be retrofitted to many existing car engines, applies 1,000 volts per millimeter across the fuel line as it enters the fuel injector. This strong electric field makes the fuel 10 percent thinner. Thinner liquids break

into smaller droplets in the combustion chamber—think of spraying water instead of molasses through a nozzle—and smaller droplets have more surface area.

"Making the droplets smaller has been a goal for a while," says Rongjia Tao of Temple University in Philadelphia, who led the research.

Droplets of fuel burn at their surfaces, where the fuel meets oxygen in the air, so having more surface area means the fuel will burn more cleanly and efficiently.

"The potential of this idea is outstanding," comments Matthew Thomas, a combustion engineer at CFD Research Corp., a commercial research company in Huntsville, Ala. 



2008 Nobel Prize winners in the sciences announced

Committee recognizes work with viruses, symmetry breaking and a fluorescent protein

Physiology or Medicine



Luc
Montagnier

Françoise
Barré-Sinoussi

Harald
zur Hausen

The \$1.4 million Nobel Prize in physiology or medicine in 2008 will be shared by three European scientists for identifying the roles of sexually transmitted viruses in causing cervical cancer and AIDS.

Half of the prize goes to Harald zur Hausen of the German Cancer Research Center in Heidelberg for his discovery that the human papillomavirus, or HPV, causes cervical cancer. He and his team isolated HPV DNA from cervical tumors in the lab and identified HPV-16 and HPV-18—the two strains that cause most cervical cancers. Zur Hausen made his recombinant samples of viral DNA available to other scientists, and the subsequent research cleared the way for the HPV screening and vaccines available today.

“It’s certainly very satisfying to see that the vaccines are very efficient,” zur Hausen says.

The other half of the prize will be shared by Françoise Barré-Sinoussi and Luc Montagnier for work at the Pasteur Institute in Paris that culminated in the 1983 discovery of HIV.

Their research was confirmed by Robert Gallo and his colleagues at the National Cancer Institute in Bethesda, Md. Eventually both teams were credited as codiscoverers. But the Montagnier and Barré-Sinoussi paper came first, says Anthony Fauci, director of the National Institute of Allergy and Infectious Diseases in Bethesda, Md.

The early HIV findings paved the way for a test for the virus, for blood supply screening and for the development of drugs to combat HIV. — *Nathan Seppa*

Physics



Yoichiro
Nambu

Makoto
Kobayashi

Toshihide
Maskawa

Three theorists will share the 2008 Nobel Prize in physics for advances involving symmetry breaking, a cornerstone of the standard model of particle physics.

Half of the \$1.4 million prize goes to Yoichiro Nambu of the University of Chicago. He began formulating his mathematical description of a type of symmetry violation, known as spontaneous broken symmetry, as early as 1960.

“Nambu was the first to apply the idea of a spontaneously broken symmetry in elementary particle physics—that is, a symmetry that is an exact property of the underlying equations of the theory, but is not realized in the solutions of these equations, and hence not easily apparent in the properties of elementary particles,” says 1979 Nobel laureate Steven Weinberg of the University of Texas at Austin.

The other half of the 2008 physics Nobel is shared by Japanese researchers Makoto Kobayashi of the High Energy Accelerator Research Organization in Tsukuba and Toshihide Maskawa of Kyoto University.

Kobayashi and Maskawa discovered the origin of another type of symmetry violation that had been observed but not explained. Their work successfully predicted that nature must have at least three families of quarks, the building blocks of neutrons and protons and various other particles.

The winners’ accomplishments tie in to the “most essential ideas in our understanding of modern physics,” says physicist Brian Greene of Columbia University. — *Ron Cowen*

Chemistry

The 2008 Nobel Prize in chemistry will be awarded to Osamu Shimomura, Martin Chalfie and Roger Tsien for the discovery and development of green fluorescent protein, or GFP. The men will share the prize equally.

The barrel-shaped protein makes jellyfish glow green under ultraviolet light and has become an important and widely used tool for biologists studying living cells and proteins.

Shimomura, of both the Marine Biological Laboratory in Woods Hole, Mass., and Boston University, discovered the protein in the jellyfish *Aequorea victoria* in 1962. He also discovered the chemical mechanisms that jellyfish use to glow, or bioluminesce.

Chalfie, of Columbia University, realized that the protein was more than a curiosity and could be used as a tag to track and study cells. He went on to develop the gene for the fluorescent protein for use as such a biological tag. He demonstrated its usefulness by coloring six cells in the nematode *Caenorhabditis elegans*.

Tsien, of the University of California, San Diego and the Howard Hughes Medical Institute, tweaked the structure of the protein to make it glow in a rainbow of colors. That ability enables scientists to track a number of different proteins or cells at the same time, allowing for a deeper understanding of biological interactions.

In 1968, at age 16, Tsien won the top prize in the Westinghouse Science Talent Search competition (now the Intel Science Talent Search). His project explored the orientation of an ion in transition metal complexes. The competition is owned and operated by Society for Science & the Public (then Science Service), which publishes *Science News*. — *Tina Hesman Saey*



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— JAMES T. FENT,
GIA Graduate
Gemologist

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Galaxy clusters slide to the south

Mysterious flow could call universe's uniformity into question

By Davide Castelvecchi

Clusters of galaxies are flowing through space, seemingly under the influence of a mysterious attractive force outside the visible universe, a new study suggests.

Researchers detected what they have dubbed “dark flow” while surveying 700 galaxy clusters. Each contained hundreds to thousands of galaxies all lying no farther than approximately 1 billion light-years from Earth. On average, the clusters appeared to move at about 1,000 kilometers per second in a uniform direction toward a point in the southern sky.

While no one knows the cause of the motion, the scientists suggest whatever the cause is, it may no longer lie in the visible universe. The work appears online in two separate papers, one in the Oct. 20 *Astrophysical Journal Letters* and one at arxiv.org/abs/0809.3733.

“We expected to find something completely different,” says astrophysicist Alexander Kashlinsky of NASA’s Goddard Space Flight Center in Greenbelt, Md. “It’s basically a slope across the universe,” in a direction somewhere between the constellations Centaurus and Vela.

This flow flies in the face of one of cosmologists’ most cherished assumptions — backed by a wealth of data — that the universe is uniform. That is, its structure and the density of matter in it are about the same in all regions of the sky.

Glenn Starkman of Case Western Reserve University in Cleveland says the findings add to anomalies discovered in recent years in the cosmic microwave background, or CMB, the ubiquitous bath of cold radiation left over from the Big Bang. “It’s yet another piece of evidence that, on the largest scales, either we’re misunderstanding something or discovering something about the universe,” Starkman says.

The researchers’ work built on an X-ray spectrum survey of the entire sky taken by the orbiting telescope ROSAT in the early 1990s. Galaxy clusters are suffused in a thin but hot plasma, which emits X-rays. Back then, Harald Ebeling of the University of Hawaii’s Institute for Astronomy in Honolulu and others used the ROSAT data to identify hundreds of large galaxy clusters by their X-ray halos, and matched that with optical-telescope data to estimate the clusters’ distances from Earth.

In the new study, the team estimated the motion of each cluster with respect to the CMB radiation, which is believed to be “the ultimate reference” of movement on a cosmological scale, says Ebeling, a coauthor of the new papers.

As CMB radiation crosses a galaxy cluster, it gets scattered by electrons in the intergalactic plasma, Ebeling says. The scattering affects the radiation’s frequency. The frequency goes up if the cluster is moving toward Earth and down if it’s moving away. This is called the kinetic Sunyaev-Zeldovich effect, analogous to the familiar Doppler shift of sound waves, which explains why an ambulance’s siren sounds different depending on whether the ambulance is approaching or moving away.

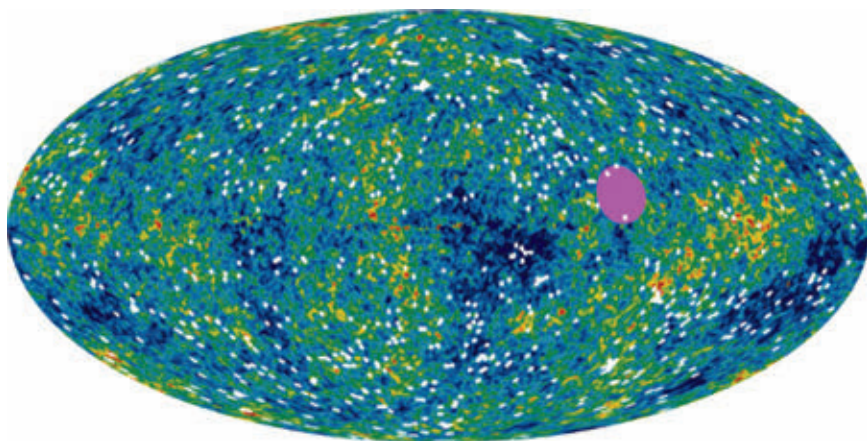
Using data released two years ago by NASA’s Wilkinson Microwave Anisotropy Probe, the team looked for the effect and found it was extremely small — comparable to a temperature change of millionths of a kelvin, Ebeling says.

For a single cluster, a variation this small easily drowns in the larger experimental errors. Moreover, each cluster tends to move in its own direction, tugged by clusters nearby. But on average, the velocities showed a clear trend.

“People will be inherently skeptical of any such results,” Starkman says, since the results question the standard, homogeneous model of the universe. “Even those who have doubts about the model don’t have better alternatives.” But, he adds, the study should still be taken seriously.

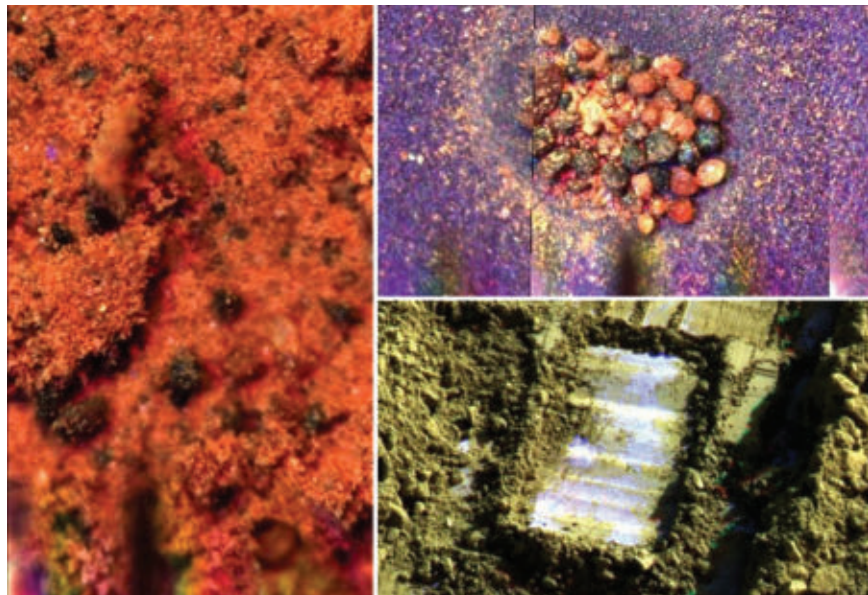
Kashlinsky says that random energy fluctuations in the earliest split second after the Big Bang — the epoch of expansion called inflation — could have created a large imbalance in the distribution of matter. This imbalance could have left its mark on the structure of spacetime.

Such a large-scale imbalance is “absolutely possible,” says cosmologist Andrei Linde of Stanford University. But it would require some rather contrived tweaks to the still-tentative models of how inflation works. ■



Galaxy clusters (white spots), shown on a survey of the cosmic microwave background, appear to move, on average, in one direction (toward the purple patch).

“It’s yet another piece of evidence that ... either we’re misunderstanding something or discovering something about the universe.” — GLENN STARKMAN



The Phoenix Lander investigated Martian soil samples (left and top right under an optical microscope). Phoenix’s stereo camera also captured frost (bottom right).

Get the lowdown on the solar wind

Long decline in sun’s activity drops barrier to cosmic rays

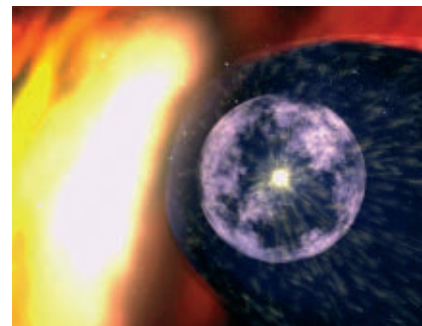
By Ron Cowen

Every 11 years, the sun gets the doldrums. Solar storms are fewer and the strength of the solar wind, the stream of charged particles blown from the sun, declines. New spacecraft observations report the true lowdown: The current solar minimum is the lowest — and one of the longest—recorded in almost 50 years, since modern measurements began.

This period of low solar activity has already lasted six months longer than the most recent solar minimum, in 1994 and 1995, and the newest minimum offers hints about the wind’s origins.

The sun’s current state suggests that the protective magnetic cavity carved by the solar wind has temporarily shriveled, letting more harmful galactic cosmic rays into the solar system.

The solar wind’s low pressure, and other studies showing reduced solar activity, suggest that the wind is not only guided by the sun’s global magnetic field but is also powered by it, says David McComas of the Southwest Research Institute in San Antonio. He and colleagues describe the findings September 18 online in *Geophysical Research Letters*. 



The solar wind (light purple) blows out from the sun. Both are shown within the larger heliosphere (dark purple).

More clues to Martian chemistry

Phoenix Lander data reveal mineral interactions with water

By Ron Cowen

NASA’s Phoenix Mars Lander has found new evidence that liquid water once interacted with minerals in the Red Planet’s arctic region, scientists reported September 29 at a news briefing.

Two Phoenix experiments identified calcium carbonates and clays in soil samples scooped up by the craft’s robotic arm. On Earth, both minerals are associated with the presence of liquid water.

Carbonates such as limestones form on Earth when carbon dioxide from the air dissolves in water, making carbonic acid. The acid eats away at rocks, eventually forming carbonate deposits such as the White Cliffs of Dover in England.

Interaction between CO₂ and water is “just what we think is going on on the surface of Mars,” says Bill Boynton of the University of Arizona in Tucson. Boynton is lead scientist for Phoenix’s eight miniature ovens and one mass spectrometer collectively known as the Ther-

mal and Evolved Gas Analyzer, or TEGA.

Spacecraft orbiting the planet have found evidence of carbonates elsewhere on Mars, Boynton notes, but never before in a smooth region devoid of channels that would suggest the flow of water.

TEGA’s evidence for calcium carbonates comes from Martian soil delivered into an oven by the robotic arm. The high temperature at which carbon dioxide was released from the samples matches the temperature at which calcium carbonates decompose. In addition, Phoenix’s wet chemistry experiment, known as MECA, found that a dissolved soil sample’s calcium concentration was exactly that expected from a solution in which calcium carbonate stabilizes the pH level.

In the meantime, winter is about to begin in the arctic region, where Phoenix landed on May 25. Scientists are racing against the clock to fill TEGA’s remaining four ovens and continue other experiments. The craft is not expected to survive past November. 

Life



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Cichlids divide along color lines

Sensory changes may be splitting a fish species in two

By Patrick Barry

Some cichlid fish see red better while others only have eyes for blue. This difference in vision, observed in fish in an African lake, could be pushing red-tinged cichlids to branch off from their blue-tinged brethren and to form a new species.

If so, it would be the first time that scientists have caught evolution in the act of creating a new species because of changes in sense organs. For one species to diverge into two, some barrier must prevent two groups of individuals from interbreeding. Physical separation of groups and changes to reproductive organs are two of the wedges that scientists have shown can drive the formation of new species, and evolutionary biologists are always keen to discover new mechanisms.

“Speciation can occur even without physical isolation when individuals are adapted to a particular environment by

[their] sensory system,” says Norihiro Okada, an evolutionary biologist at the Tokyo Institute of Technology.

Okada and his colleagues had previously shown that cichlid fish in Lake Victoria’s shallow waters are bathed in bluer light, while the turbid water of the lake predominantly lets redder light filter down to fish living in deeper water. The researchers showed that the fish’s eyes have adapted to this difference: Deep-dwelling fish have a pigment in their eyes that is more sensitive to red light while shallow-water fish have a pigment that’s sensitive to blue.

By looking at the DNA of fish from both groups, Okada’s team showed that each has accumulated genetic changes not shared by the other, which suggests that the two groups aren’t interbreeding, Okada and his colleagues report in the Oct. 2 *Nature*. They also showed in experimental studies that female fish from the red-light-sensitive group preferred slightly red-colored males. Taken together, the results suggest that changes in the fish’s vision could be starting to split the fish into two species.

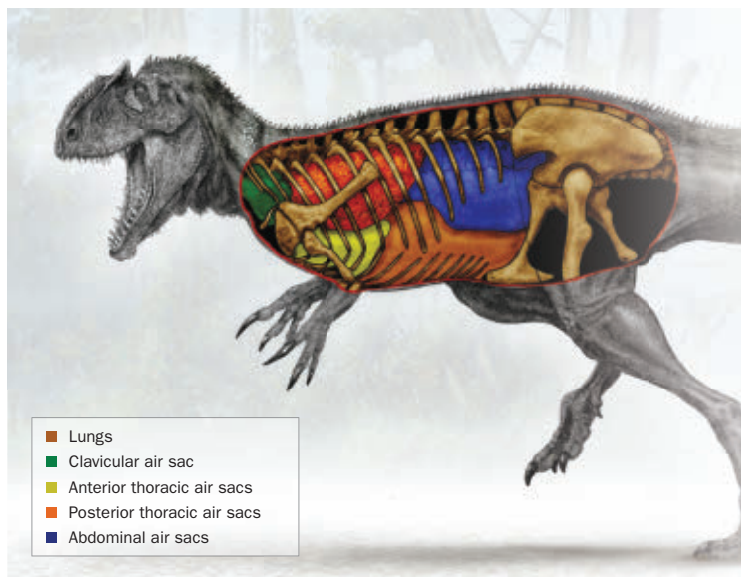
“It’s pretty spectacular,” comments Michael J. Ryan of the University of Texas at Austin. “When they encounter



Females in shallow water prefer blue-hued males (top) while females in deep water prefer red-hued ones (bottom).

members of neighboring populations, they don’t recognize them as potential mates.”

Speciation is only occurring at locations in the lake where there is a large blue-lit area for the blue-tinged fish. In more turbid areas, the blue-light zone is much smaller, so the two groups of fish intermingle and interbreed. The researchers say lake pollution is making the water more turbid, which could increase interbreeding of the two groups and also reduce the total number of cichlid species in the lake. ■



Forget bird-brained

Paleontologists have discovered a new species of carnivorous dinosaur that breathed like a bird. Unlike mammals, birds have a system of breathing in which multiple bellows, or air sacs, in the rib cage push oxygen-rich air through a fixed lung. The fossils from this new dinosaur, called *Aerosteon riocoloradensis*—which means “air bones from the Río Colorado,” the Argentine river near where the fossils were found—show characteristically avian features, Paul Sereno of the University of Chicago and his colleagues report online September 30 in *PLoS ONE*. Scientists are left to wonder why a birdlike system of breathing would be used by a 10-meter-long predatory dinosaur that weighed as much as an Indian elephant, and by a chicken. “Since generally all we have is bones in the fossil record, we hit the jackpot with *Aerosteon*, which shows the presence of these air sacs,” Sereno says. —Laura Sanders

FROM TOP: OLE SEEHAUSEN, INKE VAN DER SLUIJS; TODD MARSHALL, PROJECT EXPLORATION

Bluefins mingle across the ocean

Findings could complicate fish management plans

By Rachel Ehrenberg

Bluefin tuna get around. The highly prized fish traverse the Atlantic with a disregard for international boundaries that has set nations quarrelling over who gets to fish and who sets the limits. Now new research on the whereabouts of Atlantic bluefins could provide the hard numbers needed for developing effective strategies to save the fisheries from collapse.

"This is a substantial step forward in providing a comprehensive data set for management," says Michael Sissenwine, former director of scientific programs and chief science adviser for the U.S. National Marine Fisheries Service and now at Woods Hole Oceanographic Institution in Massachusetts.

Because Atlantic bluefins have spawning grounds on both sides of the Atlantic (and perhaps in the middle, some scientists say), management agencies have treated them as two distinct populations: western bluefins that spawn in and near the Gulf of Mexico and eastern bluefins that spawn in the Mediterranean. While scientists have known for several years that these populations mix, that socializing hasn't been incorporated into management strategies.

The new study, published online October 2 in *Science*, reports that substantial numbers of juveniles from the Mediterranean spend time in waters off the U.S. eastern coast. The western Atlantic population is already thought to be considerably smaller than the Mediterranean-based stock.

"The mixing may have caused people to overestimate the abundance of western bluefins," comments John Magnuson of the University of Wisconsin–Madison.

Waters off the eastern United States

may serve as a refuge for Mediterranean-born fish, since fishing quotas are much lower on the west side of the Atlantic, says Jay Rooker of Texas A&M University at Galveston and lead author of the new study. But bluefins born in the Gulf of Mexico may also be spending time abroad, he says. "This trend of juveniles not keeping to their side of the pond — it could go the other way as well."

The new study examined otoliths, or



Otoliths, found in the inner ears of bluefin tuna, can be used to determine where the fish have been swimming.

"ear stones," from nearly 200 Atlantic bluefins caught over a six-year period from both eastern and western stocks.

Found in the inner ear, these ear stones start out as tiny calcium carbonate grains, but grow in layers as the fish age. For fish, the stones act as sound receptors, but scientists use them as a sort of tracking device. Carbon and oxygen are incorporated into the ear stones as they grow, and depending on the geochemistry of the water the fish spends time in, the ratios of the forms of oxygen and carbon differ.

Otolith analysis also revealed that more than 90 percent of the older, "giant" bluefins found in the Gulf of Maine and Gulf of St. Lawrence were born in the Gulf of Mexico. This suggests that the entire eastern seaboard should be considered a priority for conservation, says Molly Lutcavage of the Large Pelagics Research Center at the University of New Hampshire in Durham. 🌐

Curtain drops after ants' final act

Securing the nest means death for some Brazilian ants

By Rachel Ehrenberg

A Brazilian ant colony leaves some members out in the cold each night — literally. Tasked with closing the nest door from the outside, these ants complete their final mission and wander off, never to be seen again, researchers report in the November *American Naturalist*.

Self-sacrifice for the sake of the colony isn't unusual in social insects — individuals will often take one for the team, improving the chances that close relatives survive. But unlike a guard bee that dies after stinging an intruder, there is no blaze of glory for these ants. They are probably old workers, whose days are already numbered and who meet death alone after fulfilling the door-closing duty.

"If you use the workers for this task, it is not that big of a cost to the colony," says Adam Tofilski of the Agricultural

University in Kraków, Poland, who led the new study.

Forelius pusillus ants nest in the sandy roads that crisscross sugarcane fields near São Paulo, Brazil. During the day, the ants transport sand excavated from the nest to a pile surrounding the entrance. But at sundown all the ants go inside, save for a handful of workers who drag and carry sand from the pile back to the entrance to cover it. In the finale, one to eight ants kick sand backward, doggy-style, until the entrance is obscured, presumably to protect the colony from predators, parasites or rain. Then the ants depart. In the morning the entrance is opened from the inside and the door-closers never return to the nest, the researchers report.

"These guys aren't expected to last that long — they are running very close to empty," says Peter Nonacs of the University of California, Los Angeles. 🌐

Body & Brain



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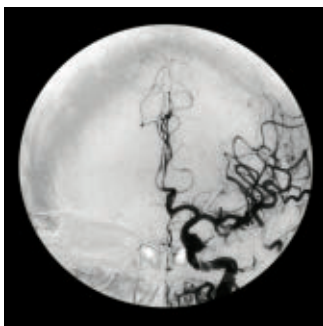
Window of opportunity for stroke treatment widens to 4½ hours

Finding could benefit patients, clarify treatment procedures

By Nathan Seppa

Emergency room physicians can deliver clot-busting treatments to a wider range of stroke patients than previously thought, European researchers report in the Sept. 25 *New England Journal of Medicine*. The finding could help ER doctors prevent some cases of disability caused by strokes, scientists say.

Most strokes result when a blood clot lodges in the brain, blocking blood flow to other parts of the organ. A powerful drug called tPA, or tissue plasminogen activator, can dissolve these clots. But medical dogma holds that it must be given within three hours of a stroke's onset. Beyond



Using tPA to dissolve a clot allows blood in the middle cerebral artery to flow.

that, the thinking goes, the bulk of the brain damage is done and adding the risk of internal bleeding that accompanies clot-busters seems unwise. The new study extends that window of effective

tPA treatment by 90 minutes, to 4½ hours.

This precious extra time could benefit tens of thousands of patients in the United States each year, says study coauthor Werner Hacke of the University of Heidelberg in Germany.

"This is big news because suddenly they have substantially extended the number of patients who get intravenous tPA," says neurologist Scott Kasner of the University of Pennsylvania in Philadelphia.

Only about 4 percent of stroke patients arriving at U.S. hospitals get tPA, says Patrick Lyden of the University of California, San Diego. The new data should clarify the time frame and allay doubts about the treatment's effectiveness, he says.

In their study, Hacke and his colleagues identified patients who arrived at hospitals with a stroke that had begun more than three hours but less than 4½ hours earlier, excluding those who had severe strokes or brain bleeding. That left 730 patients; half were randomly assigned to get infusions of the tPA drug while the others received a placebo.

After three months, roughly 52 percent of patients treated with tPA within the extra 90-minute time window had normal daily function and were living independently, compared with 45 percent of those getting the placebo. The death rate over three months was about 8 percent in both groups. Doctors detected brain bleeding among treated patients about as often as seen in previous studies in which tPA was limited to a three-hour window.

More hospitals need to grasp the value of tPA and have doctors on site or on call who can deliver it, Lyden says.

Patterns differ in aging brains

Gene activity in men changes earlier than it does in women

By Tina Hesman Saey

Men's and women's brains age differently, a new study demonstrates.

Researchers led by Carl Cotman and Nicole Berchtold of the University of California, Irvine find that the activity of genes in men's brains begins to change earlier than in women's brains. The types of changes also differ between the sexes.

The study, published online October 1 in the *Proceedings of the National Academy of Sciences*, also found that in both

genders each part of the brain examined had its own pattern of aging.

"This is a very interesting study in what is, curiously, an under-studied area, normal aging," says Etienne Sibille of the University of Pittsburgh.

Cotman and Berchtold and their colleagues collected brains from people who had died between ages 20 and 99. The researchers isolated messenger RNA, or mRNA, which carries instructions for building proteins. Active genes produce higher levels of mRNA.

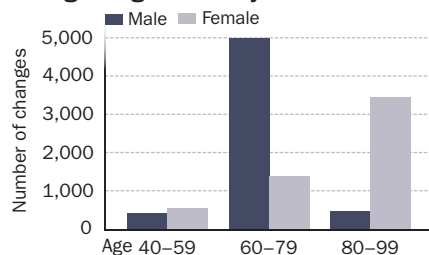
The team discovered that disease-susceptible parts of the brain have the least amount of change in gene activity with age. The postcentral gyrus, an area dedicated to perception, changes most.

While men showed changes in metabolic activity with age, women showed changes

in genes that establish neural connections and control information exchange.

"What I think it means, especially for men, is that interventions — either lifestyle or medication — may be needed to keep these energy pathways robust," Berchtold says.

Changes in gene activity in the brain



Men in their 60s and 70s show more changes in gene activity, relative to the preceding two decades, than women.

Diet details may influence longevity

Cutting protein may be as important as cutting calories

By Tina Hesman Saey

Beefing about your diet probably won't lengthen your life, but a new study suggests that cutting down on beef and other protein-laden foods might.

A group of researchers at Washington University in St. Louis, led by Luigi Fontana and John Holloszy, is investigating how nutritious, calorie-restricted diets affect people. Cutting 25 percent or more calories from the diets of rodents, dogs, worms and other animals has been shown to prolong life. But no one knows whether restricting calories in people will also make them live longer.

Previous studies from the same group have shown that members of the Calorie Restriction Society, who have voluntarily followed a calorie-restricted diet for years, have improved cardiovascular health compared with people of the same age who eat 20 to 30 percent more calories.

In their latest study, in the October *Aging Cell*, the scientists found that people who eat a high-nutrition, minimal-calorie diet don't get all the benefits from calorie restriction that rodents do. But restricting proteins along with calories seems to mimic the full effect seen in other animals.

This new study focused on the diet's effect on amounts of insulin-like growth factor, or IGF-1. The growth factor stimulates cells to grow, and high levels have been linked to cancer. Lowering levels of the growth factor may be a key step in slowing down aging.

In previous studies, rodents on a calorie-restricted diet showed a drop in IGF-1. The researchers examined IGF-1 levels in people who followed a calorie-restricted diet, but the diet did not lower IGF-1 levels.

"It was a little surprising," says Andrzej Bartke of Southern Illinois University School of Medicine in Springfield. "IGF-1 reduction is kind of a textbook response to caloric restriction, and in this study it didn't happen."

Vegans — people who do not eat meat, milk, eggs or other animal products — did have slightly lower levels of IGF-1, even though their diets are higher in calories. However, the vegans did not have all the cardiovascular benefits that people on calorie restriction do.

Fontana and his colleagues realized that the vegans get only about 10 percent of their calories from protein, while people in the calorie-restriction group get nearly a quarter from protein.

Six members of the Calorie Restriction Society agreed to lower their protein consumption to slightly below the recommended daily intake. After three weeks on the lower-protein diet, IGF-1

levels in these volunteers' blood dropped 25 percent on average. The result suggests that caloric restriction works differently in people than rodents and that restricting protein consumption is important to achieve maximal health benefits, Fontana says.

"This study says, 'Pay attention: Too many proteins can increase your risk of getting cancer, and it can speed up your aging.'"

it can speed up your aging," Fontana says.

The findings suggest that diet composition may be as important as calorie consumption for controlling aging, Bartke says. But the importance of IGF-1 to longevity is not as clear in humans as in rodents, because while rodents often die of cancer, people die more often of heart disease. 

"This study says, 'Pay attention: Too many proteins can increase your risk of getting cancer, and it can speed up your aging.'"

**LUIGI FONTANA
WASHINGTON UNIVERSITY
IN ST. LOUIS**

News briefs

Anthrax vaccine makeover

Less may be better for the much-maligned anthrax vaccine, a new study in the Oct. 1 *Journal of the American Medical Association* suggests. People getting a slightly different kind of injection had less pain but no diminished protection against the disease, even when getting fewer shots, Conrad Quinn of the Centers for Disease Control and Prevention in Atlanta and his colleagues report. The currently approved vaccination regimen uses subcutaneous injections that enter the skin at an angle and deposit the vaccine in the layers of tissue underneath. The delivery tested in the new, preliminary study uses an intramuscular shot that is more direct and goes deeper. — *Nathan Seppa* 

Genetic link to dyslexia

Unlike speaking, reading is a thoroughly unnatural act. But that doesn't mean biology has no role in literacy. A gene involved in early brain development influences a range of reading problems, including dyslexia, a new study published online October 1 in the *American Journal of Psychiatry* finds. British children ages 7 to 9 who inherited a particular genetic sequence on human chromosome 6 tended to perform poorly on tests of reading and spelling abilities, whether or not they had already been classified as dyslexic, say Silvia Paracchini of the University of Oxford, in England, and her colleagues. On average, carriers of the key genetic sequence scored as well on IQ tests as other kids did. Decreased protein production by the gene, *KIAA0319*, prompts subtle brain changes that contribute to reading problems, the researchers propose. — *Bruce Bower* 



Ultra massive:

A black hole can consume anything in its path. T

as big
as it
gets



A supermassive black hole, surrounded by a disk of hot gas, powers the explosive outburst of an active galactic nucleus, illustrated here based on data from the Chandra X-ray Observatory.

These monsters can become huge — but perhaps only so huge. **By Charles Petit**

If asked to name stupendously amazing things in space, most people would probably pick black holes. These evil-tinged clowns of the universe are definite wows. Insatiable is their middle name. Grand and merciless, voracious and monstrous, pure appetite and deep mystery. The biggest fatten themselves in galaxy cores mainly via a seemingly limitless hunger for a main source of sustenance: fat, circular wads of gas that gather around the black holes and are sometimes given a name to delight any glutton, Polish doughnuts. Black holes cloak their innards behind an “event horizon,” from inside which no message

can be sent (which explains the one-liner physics joke: “Two protons walk into a black hole”).

What a parade of jaw-droppers that is. Well listen up, this just in: It looks like there is a limit to the superlatives. Black holes can’t eat everything. If a new analysis from a Yale astronomer is correct, even black holes run out of steam, and at a fairly precise point. The biggest black holes may reach only a few tens of billions of times the mass of the sun.

To be sure, that’s huge. Most galaxies harbor central black holes of a few million solar masses (about 4 million for the Milky Way). Fifty million light-years away in Virgo, the giant elliptical galaxy M87 is believed to harbor one having about 3 billion solar masses. The record heft for a suspected black hole, 3.5 billion light-years away and part of a double-black-hole system with a partner’s orbit that reveals its mass with some precision, is 18 billion solar masses.

Any possible cap on the size of these monsters occupying galactic centers shouldn’t diminish the place of black holes in popular imagination. And for astronomers, the newly proposed mass limit illustrates how the status of black holes, as both scientific challenge and principal player in the universe’s appearance, is on the rise.

Astrophysicists and cosmologists thought they had black holes pretty well pegged about 10 years ago. Black holes eat, they grow and they can sure produce a bright light from X-ray to radio wavelengths while on a binge. Their quasar-pumping conversion of matter to outward-beamed energy as they consume gas, dust and the occasional unlucky star is believed to reach about 40 percent efficiency. It’s not only $E=mc^2$ at which black holes excel. They also provide wonderful playgrounds for a panoply of other Einsteinian gymnastics. They bend time, warp space and, along their borders, they spawn a fizz of evanescent virtual particles popping in and out of space’s fabric.

But all in all, to many pros interested in the big picture, black holes have been seen as intriguing and flashy character

actors, bit players in the grand story of galaxy evolution and in the overall distribution of ordinary matter in the universe. Even supermassive black holes’ gravity, after all, dominates only a few parsecs radius in the crowded hearts of galaxies many thousands of parsecs across.

A consuming influence

A budding new paradigm is that black holes — in a dance of mutual self-regulation — may influence almost everything about galactic origins, growth, form and ultimate fates. They are not just the overstuffed kernels in the middle of galaxies. For reasons not fully understood, it appears that the sizes of central black holes and the masses of their galaxies, especially the central bulges, are almost perfectly in step.

The relation has become clear only since the late 1990s. Even the halo mass of dark matter — the mysterious invisible stuff that seems to make up more than 80 percent of all matter — around galaxies seems correlated with the size of supermassive black holes in galactic centers. That is a surprise. And when the black holes stop growing, galaxies themselves appear to stop evolving. “Now, we think we cannot understand galaxies without understanding black holes,” says Abraham “Avi” Loeb, director of the Institute for Theory and Computation at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass.

The proposed limit on black hole mass comes from Yale University cosmologist Priyamvada Natarajan and Chilean astronomer Ezequiel Treister of the European Southern Observatory. Their paper, to appear in the *Monthly Notices of the Royal Astronomical Society*, was posted online in August.

Declaring an upper mass limit to black holes is notable, even were such a limit not part of a bigger relationship to overall galactic physics. For one thing, it would give bounds to the specs of the black hole bestiary.

Ignoring hypothetical mini-black holes of subatomic size that might briefly form under exotic conditions, astronomical black hole taxonomy would

go like this, from smallest to largest: *Substellar-mass* or *primordial* black holes, still unproven, proposed by physicist Stephen Hawking to have formed in the dense soup of particles shortly after the Big Bang. A *stellar-mass* black hole is what remains after some supernovas. *Intermediate-mass* black holes, conjectured to form from runaway mergers of stars into dense clusters that undergo gravitational collapse, would be 100 to a million times as massive as the sun. Next up are *supermassive* black holes, which can grow as gas accretes into galactic centers and when galaxies hosting central black holes merge. The Milky Way’s central black hole, at 4 million solar masses, is supermassive. And at the top of the scale are *ultramassive* black holes, the name Natarajan gives those with 10 billion to a few tens of billion solar masses.

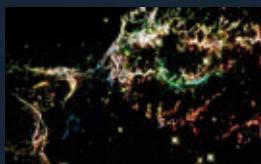
Natarajan, a native of New Delhi, went in 1997 from MIT to the University of Cambridge in England as a graduate student during a transition time in black hole and cosmology studies. Experts were already suspecting that extremely massive galactic black holes in the current universe are not as common as one would expect. The fast growth of numerous quasars — galactic core black holes glowing fiercely as matter falls into them — seen at great distances and as they were long ago, implied that many were bound to reach masses exceeding 10 billion suns. There is no way to see how those black holes turned out at the end of their quasar days, but astronomers can check nearby galaxies that presumably went through similar youths. And the current universe seems to have a shortage of the fatties that it appears should have grown from earlier epochs.

A basic picture of black hole growth had been worked out in the 1970s and 1980s by Bohdan Paczynski of Warsaw University (and later Princeton) and others. When Paczynski died in 2007, his obituaries all mentioned Polish doughnuts. That was his name for the fat rings of gas that ought to form in any gas-rich region around a large black hole. These torus-shaped rings would feed a steady stream of matter into a hot, brilliantly

FROM TOP: COURTESY HUBBLE HERITAGE TEAM, STSCI; AURA/NASA; COURTESY BRAD WHITMORE, STSCI; CHART BY J. KORENBLAT

Black Hole Taxonomy

Black holes can be classified into categories based on size, which depends directly on mass. Apart from small “primordial” black holes that possibly formed in the early universe, the least massive are the size of a large city; the largest are huge enough to reach from the sun out beyond Neptune. New research suggests that there is a limit to how massive a black hole can become.



Stellar-Mass Black Holes

About 5 to 10 solar masses, formed when a massive star exhausts its fuel, central pressure falls and the core collapses to black hole density. (A shock wave blasts the rest of the star off in a supernova). The Hubble Space Telescope image above is of a supernova remnant in the constellation Cassiopeia.



SIZE: Roughly 30 kilometers across, or about 10 km longer than Manhattan.

MASS: 5 suns

Intermediate-Mass Black Holes

About 100 to a million solar masses, conjectured to form in dense star clusters from a merger of stars into a giant mass that then undergoes runaway gravitational collapse.



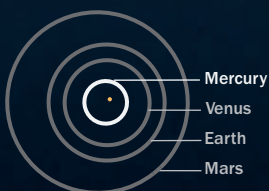
SIZE: About 60,000 km across, or almost five times Earth's diameter. If a stellar-mass black hole were the size of the period at the end of this sentence, this black hole would be about 2 feet across.

MASS: 10,000 suns



Supermassive Black Holes

From a million to a few billion solar masses, formed by accretion of gas in galactic centers and by mergers of black holes as their host galaxies collide. The Milky Way's central black hole is in this group. The above Hubble image shows the collision of two galaxies.

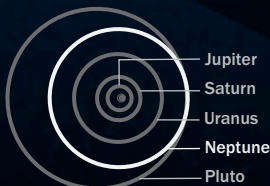


SIZE: About 25 million km across, it would fit within Mercury's orbit around the sun. If a stellar-mass black hole were period-sized, this black hole would be 250 meters across.

MASS: 4 million suns
(central black hole in the Milky Way)

Ultramassive Black Holes

Newly proposed category for black holes from 10 billion to tens of billions of solar masses. At such sizes, the event horizon diameter can reach hundreds of billions of kilometers.



SIZE: 60 billion km across, it would stretch from the sun to far past Neptune, even beyond some distant comets. If a stellar-mass black hole were a period, this black hole would stretch from Cleveland to Washington, D.C.

MASS: 10 billion suns

glowing flat disk of plasma spiraling down — the inner accretion disk. Most of the matter spirals down to its doom, while some gets ejected as powerful polar jets — gouts of radiation.

The result can be a quasar that shines from a region smaller than Earth's orbit of the sun with a brilliance 100 times that of the rest of the quasar's host galaxy. To achieve such power, the quasar must be bumping up against a barrier called the Eddington Limit. The limit's namesake, English astronomer Arthur Stanley Eddington, in the early 20th century worked out how brightly a star can shine before its radiation pressure starts blowing its outer layers into space. Turned around and applied to black holes, that limit is the brightness at which a black hole's accretion disk is so great that it stops more gas from falling in. And to reach that, a quasar of a million solar masses must nearly triple its mass every 10 million to 100 million years. By the time it reaches a billion solar masses, it consumes 20 suns' worth of gas every year.

A quasar's brightness is related to how much matter the black hole is consuming. When matter stops falling in, the light goes out. Each quasar shines for only a few hundred million years. But there was no obvious reason why galaxies should run short of gas to feed into Polish doughnuts that quickly.

Stunting growth

Working in a Cambridge group headed by Great Britain's Astronomer Royal, Martin Rees, Natarajan first decided 10 years ago to calculate how a supermassive black hole might shut off its own food supply and stop growing. Rees, in partnership with University of Oxford cosmologist Joseph Silk, at about the same time worked out one plausible way. "As the black hole grows, we felt it would expel a lot of energy in a jet. It sort of fans out and clears a bubble in surrounding gas," Silk says.

For her thesis, Natarajan worked out another plausible way: A quasar, fueled by a growing, supermassive black hole, reaches a point at which its radiation

"The only way to fit the data is to physically cut off the ability of black holes to grow beyond some point, and that is at about 10 billion solar masses."

PRIYAMVADA NATARAJAN

YALE UNIVERSITY

not only slows the infall of more gas, but also turns the gas around and clears out a large region around itself — leaving a nearly gas-free or "dry" galaxy. This, she estimated, would occur as the black hole reached about 10 billion solar masses.

With this theoretical exercise complete, Natarajan a few years ago tackled another aspect of galactic behavior that would eventually lead her back to how black holes might stunt their own growth. She worked with Marta Volonteri — a former fellow Cambridge postdoc now at the University of Michigan in Ann Arbor — who had developed a model for how the mysterious dark matter would behave early in the universe. Specifically, the astronomers wanted to see how dark matter's clumping under gravity shapes evolution of galaxies that form from the regular matter accompanying them.

Observations with space telescopes had shown that quasars started to pop off when the universe was less than a billion years old, and at immense power. Small black holes cannot do the job. That takes black holes of around a billion solar masses.

Earlier theorists had thought the seeds of galactic black holes were sown by the collapse of the first, immense "Generation III" stars, but those looked too puny to grow fast enough to get quasars going so soon. The two women joined a cadre of cosmologists imagining a direct-collapse model. In it, the first galaxies would form mostly from hydrogen and early stars

within blobs of cold dark matter. And in these galaxies' dense centers, gas would congregate so fast it would spiral directly into multimillion-mass black holes, not stopping to form stars first.

With their primordial dark matter blobs set up in their model — each with one or several galaxies and each of those equipped with sizable, often quasar-worthy black holes — the two scientists ran the process to the present time. Out came a universe with, sure enough, galaxies, galaxy clusters and black holes in the middles. But, as others have found, the model predicted more immense galaxies and more black holes of 10 billion solar masses and beyond than are actually evident in nearby (and therefore current) regions.

To be certain, Natarajan needed a more complete history of quasars over the lifetime of the universe for closer comparison with the model, so she could see better where reality and mathematical simulations had parted ways. Her coauthor of the recent paper, Chilean astronomer Treister, gathered the necessary stats from the ground-based Sloan Digital Sky Survey and from some of the most powerful new telescopes in the heavens, including the Chandra X-ray Observatory and Europe's Integral, a gamma-ray observatory. These data informed her not only on the optically obvious quasars shining at visible wavelengths and first identified in the 1960s, but also on roughly twice as many others cloaked by the belts of dust and gas feeding them.

"This was the aha moment," Natarajan says. Early models showing that black holes can turn off their own feeding station were combined with models of galaxy evolution and the populations of quasars and other active galactic nuclei over time. "The only way to fit the data is to physically cut off the ability of black holes to grow beyond some point, and that is at about 10 billion solar masses."

Physically, she explains, the largest black holes reach the end of the line by heating gas not only in their own vicinity but, in a final stage of frenzied luminosity, heating gas throughout their enormous host galaxies and often among the

galaxies of the clusters where they reside. Furthermore, it appears that black holes can keep the gas too hot to settle in large quantities back to the galaxy's nucleus or to form stars through most of the galaxy's bulk. Only in the past 10 years have other observations, in fact, revealed that the thin gas permeating massive galactic clusters is heated to tens of millions of degrees. "Nobody expected that," says Harvard's Loeb. "So galaxies reach the point where you don't make stars. This must be intimately related to black hole growth and why it stops."

Case closed? Not likely. Oxford's Silk, one of the grand figures in contemporary cosmology, calls the paper "very nicely done, very competent," but also says that "this is pretty speculative territory." He continues: "She starts with a weak set of assumptions. You don't really know how to make the first, seed galactic black holes in the first place. The first galaxies and the first halos of dark matter were not so big. How exactly did billion-

mass black holes form? It is one thing to say that, if you have the right ingredients, you can make the cake. But these ingredients are not so natural, I think."

Natarajan expresses similar concern about those original seeds. "The big question that remains is the early merging history of dark matter halos. This has opened up an absolutely new theoretical simulation to see if we can understand the formation of those black hole seeds." New instruments may help explore that question. Some answers may come in 10 years or so when a joint NASA and European trio of widely spaced satellites, called the Laser Interferometer Space Antenna or LISA, may detect the gravitational waves from black holes forming and coalescing in distant galaxies. That could provide vital info on the origin of the seeds for eventual, super-massive black holes.

While the scaffolding of a coherent hypothesis linking galaxy evolution and massive black hole behavior is rising, it

is not a monument yet. Other questions loom as well. It remains a puzzle that objects of such enormous difference in scale — gigantic galaxies and tiny (if massive) black holes in their centers — seem to move in smooth coordination of growth and evolution. Says Michigan's Volonteri, "Yes, black hole growth has to stop at some point. Priya [Natarajan] suggests black holes stop their own growth."

Then Volonteri adds, "Are black holes stopping the galaxies too? Or are the galaxies stopping the black holes?" ■

Charles Petit is a freelance science writer based in Berkeley, Calif.

Explore more

- P. Natarajan and E. Treister. "Is there an upper limit to black hole masses?" Available at arxiv.org/abs/0808.2813
- University of Cambridge relativity group's black hole website: www.damtp.cam.ac.uk/user/gr/public/bh_home.html

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Leo (shown here without all of his outer covering) can learn from others. He is programmed to develop thinking skills from what he senses.

With gargantuan ears, gleaming brown eyes, a fuzzy white muzzle and a squat, furry body, Leonardo looks like a magical creature from a Harry Potter book. He's actually a robot powered by an innovative set of silicon innards.

Like a typical 6-year-old child, but unlike standard robots that come pre-programmed with inflexible rules for thinking, Leonardo adopts the perspectives of people he meets and then acts on that knowledge. Leonardo's creators, scientists at the Massachusetts Institute of Technology's Personal Robots Group and special effects ace at the Stan Winston Studio in Van Nuys, Calif., watch their inquisitive invention make social strides with a kind of parental pride.

Consider this humanlike attainment. Leo, as he's called for short, uses sensors to watch MIT researcher Matt Berlin stash cookies in one of two boxes with hinged, open covers. After Berlin leaves the room, another experimenter enters and creeps over to the boxes, a hood obscuring his face. The mysterious intruder moves the cookies from one box to the other and closes both containers before skulking out. Only Leo can unlock the boxes, by pressing buttons on a panel placed in front of him.

Berlin soon returns and vainly tries to open the original cookie box. He asks Leo to unlock it for him. The robot shifts his gaze from one box to the other, his mental wheels seemingly turning. Then Leo unlocks the second box. The robot has correctly predicted that Berlin wants the cookies that were put in the first box, and that Berlin doesn't realize that someone moved those cookies to the other box.

Leo sits on the cusp of a new scientific approach to untangling the nature of biological intelligence and cognitive feats such as memory and language.

For the past 30 years, standard theories of cognition have assumed that the brain creates abstract representations of knowledge, such as a word that represents a category of objects. This abstract knowledge gets filed in separate neural circuits, one devoted to understand-

ing and using speech, for example, and another involved in discerning others' thoughts and feelings. If that's so, then cognition operates on a higher level apart from more mundane brain systems for perception, action and emotion. Mental life must occur in three discrete steps: Sense, think and then act.

The new approach, often called embodied or grounded cognition, turns standard thinking on its head. It argues that cognition is grounded in interactions among basic brain systems, including those for perception, action, memory, emotion, reward and goal management.

These systems increasingly coordinate their activity as an individual gains experience performing tasks jointly with other people. Complex thinking capacities — in particular, a feel for anticipating what's about to happen in a situation — form out of these myriad interactions within and between individuals, somewhat like the novel products of chemical reactions.

In short, people often act in order to think and learn, using immediate feedback to adjust their behavior from one moment to the next.

According to this view, bodily states — say, smiling — stimulate related forms of cognition, such as feeling good or remembering a pleasant experience. Researchers emphasize that the ability to think about an observed action or event, such as a friend biting into a peach, stems from neural reenactments of one's perceptual, motor and emotional states — biting into your own peach.

"It's really through the body, and the dynamic coupling of neural systems for perception, action and introspection, that cognition emerges," says developmental psychologist Linda Smith of Indiana University in Bloomington.

Leo has been created with the new approach in mind. He represents a new wave of artificial intelligence designed to learn rather than follow rules.

Although grounded cognition lacks an overarching theory to guide research, supportive findings are rapidly accumulating. Speakers at the annual meeting of the Cognitive Science Society, held in

Body In Mind

Long thought the province of the abstract, cognition may actually evolve as physical experiences and actions ignite mental life

By Bruce Bower

Washington, D.C., in July, described several strains of this work.

Studies suggest that toddlers rapidly learn words by coordinating their activity and attention with what their parents do. Other work indicates that bodily experiences orchestrate the widespread, but apparently not universal, belief that right-handedness and the right side of space are good, while left-handedness and the left side of space are bad.

Then there's the budding field of social robotics, in which machines such as Leonardo manage to interact with and learn from people. This new generation of robots may eventually provide key insights into the way human minds develop, says psychologist Lawrence Barsalou of Emory University in Atlanta.

"I predict that in the next 30 years grounded processes will be shown to play a causal role in cognition," Barsalou says.

Nearly all prescientific views of the mind, going back to ancient Greek philosophers, assumed that knowledge resides in mental images that are based on what we perceive, he adds. That idea has found new life in embodied cognition.

Grow-bot

Ancient philosophy is all Greek to Leo. That's because he's a social robot, not an academic type. Leo contains a built-in emotional empathy system that enables him to figure out the goals and intentions of people he meets.

Berlin and his MIT colleagues, led by computer scientist Cynthia Breazeal, were inspired by a notion — imported from embodied cognition — that imitation is the sincerest form of empathy. People understand those they interact with by imitating their behavior, either overtly or via imagination, in order to generate personal feelings and memories that inform empathic judgments.

Leo's architecture reflects that idea. The robot contains a mechanism that orchestrates the appraisal and imitation of observed facial expressions. In laboratory interactions with people, Leo learns to associate particular facial expressions with his corresponding reactions. Leo's

reactions are guided by sensors that tag incoming information as positive or negative, strongly or weakly arousing, and new or familiar.

The robot also contains hardwired sensors that similarly appraise acoustic features of human speech, such as pitch. This vocal feedback reinforces links that Leo makes between others' facial expressions and his own feelings.

Another built-in system directs Leo's attention to nearby objects and to signs of movement, as well as to a person's gaze and other body language. The same system allows Leo to review his own recent actions and reactions, and even what his goals were when he performed those actions.

Interplay among Leo's sensory, motor and attention systems during social interactions eventually yields new thinking skills, Berlin says. Think of this process as cyber-cognitive growth. Leo's new achievements include discerning a partner's emotional reaction to a never-before-seen object in order to guide his approach to that object. He has also succeeded in coordinating the direction of his gaze with that of a partner while working on a joint task.

Such feats allow Leo to learn from

human tutors in relatively subtle ways. In one task, Leo sits in front of a touch-sensitive computer screen that allows him to manipulate a variety of blue, red, green and yellow block shapes. A human volunteer sits across from Leo after getting instructions from an experimenter to work silently with the robot and generate a specific block figure, such as a blue and red sailboat.

People put in Leo's position use a tutor's nonverbal cues to assemble correct block figures about 90 percent of the time. In a series of trials with 18 tutors that he'd never met, Leo assembled three-quarters of the predesignated shapes.

"Leo makes mistakes at times, but he's able to use an internal architecture organized around understanding his environment from another's perspective to learn from social interactions," Berlin says.

Traditional artificial intelligence has largely focused on programming disembodied expert systems to carry out mental operations using specific sets of built-in rules. At the Cognitive Science Society meeting, psychologist John Anderson of Carnegie Mellon University in Pittsburgh expressed optimism that integrating basic insights from such systems — including his own, known as



Equipped with headcams, mother and child play with toys that mom names. This research approach explores how a child's shifting visual perspective invigorates a pronounced surge of early word learning.

L. SMITH, ALFREDO PEREIRA AND COLLEAGUES/INDIANA UNIV.

ACT-R — will illuminate how the brain creates the mind.

Berlin and his colleagues disagree because they see the mind as a product of interactions among basic systems, not preset rules. The MIT group wants to focus on how Leo's cognition develops over time. A new set of social robots designed by the team may offer further insights into the bodily origins of social thought. These machines move about on wheels and feature humanlike heads and torsos, relatively nimble arms and hands, and an internal architecture like Leo's.

Name game

For Leo and his cybernetic relatives to flourish, scientists need to flesh out developmental principles in the ultimate social learners — infants and young children. New studies directed by Indiana's Smith, cognitive scientist Chen Yu and their colleagues suggest that cognitive development rises, like steam from a boiling pot, out of daily collaborations between children and their caretakers. Such experiences prod children to notice things that go together, such as realizing that the same sounds come out of mom's mouth whenever she holds up a particular toy. Neural systems for perception, action and other

“It's really through the body, and the dynamic coupling of neural systems for perception, action and introspection, that cognition emerges.”

LINDA SMITH
INDIANA UNIVERSITY, BLOOMINGTON

noncognitive functions become increasingly intertwined, prompting learning, similar to the learning that researchers have observed with Leo.

“That's all there is to cognition,” Smith somewhat defiantly told an audience at the cognitive science meeting. Symbolic representations of knowledge in the brain, cherished by many cognitive scientists, simply don't exist, in her view.

Smith explores how toddlers learn words by looking at the world from their pint-sized perch. Children sit across from their mothers at small tables and play with toys. Youngsters and adults wear headbands equipped with tiny cameras that show each person's shifting visual perspective. A high-resolution camera mounted above the table provides a bird's-

eye view of the action. Mothers also wear headsets that record what they say.

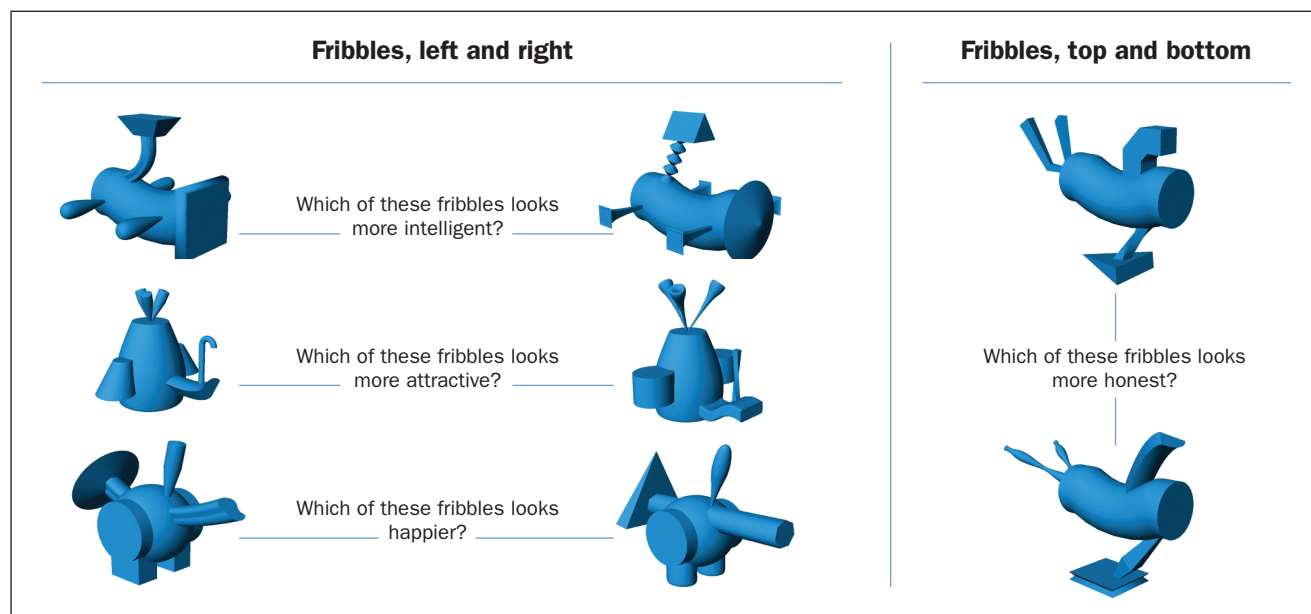
Over five to 10 minutes of continuous play, parents try to engage their children and teach them the names of each toy in whatever way the parents deem appropriate.

In a recent study, five parents played with their 17- to 20-month-old children while trying to teach them made-up names, provided by the researchers, for nine plastic, simply shaped objects.

After the play period, an experimenter placed groups of three toys in front of each child, looked directly at the youngster and asked for one object by name. The experimenter would say, “I want the dax! Get me the dax!”

The researchers attributed word understanding to children who looked at the correct object when it was named.

Children's visual take on the exercise differed considerably from that of adults. Kids rotate their heads to shift visual attention, yielding a bouncy, unstable perspective on toys that are typically held close to the face as the parent's body looms above. Adults primarily shift their gaze while holding the head still, giving them a stable platform from which to look down on their children.



To observe how movement and cognition are related, a study asked volunteers to identify which “fribble,” made-up creatures, had good qualities, such as honesty or intelligence. Left-handers usually judged fribbles shown on the left side kindly, and right-handers the reverse. But all judged a fribble shown in a top position in a better light than they did one on the bottom.

Word learning in Smith's study depended far more on when mothers named toys than on how many times they uttered a toy's name. Toddlers recognized some object names mentioned only once or twice by their mothers. Other names uttered five or six times elicited no reactions from children later on.

But if a child and mother simultaneously looked at a toy as it was named, even if only once, the youngster was especially likely to recognize the word for that toy at testing.

Word learning also hinged on parents speaking a toy's name as children held that toy in their hands. A third learning aid consisted of mothers naming toys while children held their heads relatively still, a sign of sustained attention.

Another head-camera study from Smith's team, published in the June–September *Connection Science*, finds that toddlers learn new words particularly quickly if they and their mothers take turns during playtimes. Turn-taking refers to mutually coordinated activity, such as a mother keeping her head still while a child's hands move or a child stopping activity while a mother holds up a toy.

Parents take the lead in promoting either turn-taking or disjointed activity during play, the researchers say.

These findings challenge an influential hypothesis that toddlers infer that an adult who utters a word must be thinking about and referring to a specific object. Instead, 1- to 2-year-olds notice how certain words get spoken by adults when specific objects get picked up and manipulated, Smith contends.

Taking sides

Adults weave far more complex forms of thought out of physical experience than children do, says Daniel Casasanto of the Max Planck Institute for Psycholinguistics in Nijmegen, the Netherlands. His latest research suggests that people with different kinds of bodies think differently about abstract concepts such as goodness and badness.

Right- and left-handers intuitively associate positive concepts with the side of space on which they act most dexter-

ously, and negative concepts with the side of space where they have difficulty, Casasanto reported at the cognitive science meeting.

Cultures everywhere celebrate right-sidedness and denigrate the left side. Consider the English phrases “the right answer,” “my right-hand man,” “out in left field” and “two left feet.” Linguists who support embodied cognition have argued for more than 20 years that verbal metaphors — say, being “high on life” or feeling “down in the dumps” — reflect universal bodily experiences, such as standing tall when proud versus slouching when dejected.

Yet left-handers' physical experiences yield a “left is best” perspective that clashes with cultural beliefs and common metaphors shaped by a right-handed majority, Casasanto hypothesizes.

He conducted experiments with 886 college students. About 11 percent reported being left-handed. In one task, participants were told to draw a “good” animal in one box and a “bad” animal in another box. Boxes either appeared on the left or right side of a page or one above the other. Righties routinely put good animals on the right and bad ones on the left; lefties did the opposite. Everyone, regardless of handedness, put good animals above bad animals.

Concepts of up and down are universally associated with positive and negative bodily states, respectively, whereas ideas about the merits of right and left are shaped by the different physical experiences of right- and left-handers, Casasanto proposes.

In a second task, right- and left-handers viewed pairs of similar-looking, computer-generated alien creatures and chose one as representative of certain characteristics, such as being “more intelligent” or “less honest.” Righties generally favored creatures displayed to the right and disliked creatures on the left; again, lefties took the opposite approach.

The same split between right- and left-handers characterized preferences for similar-sounding shopping choices or job applicants described in boxes on the right and left sides of a computer screen.

Conceptions of time are rooted in physical experience as well, according to Casasanto and Lera Boroditsky of Stanford University. People often talk about time using spatial language, as in the phrases “taking a long vacation” and “moving the meeting forward two hours.” The metaphorical link between space and time grows out of a deeper, nonverbal tendency for people to incorporate spatial information into time estimates, the researchers contend in the February *Cognition*.

In one experiment, participants watched a series of lines on a computer screen expand to various lengths over durations that ranged from one to five seconds. Some lines grew to different lengths over the same amount of time. Volunteers judged lines that traveled a relatively short distance to have taken less time than they actually did. Lines that covered long distances were judged to have taken more time than they actually did.

In contrast, participants' estimates of line lengths were not altered by differences in the amount of time lines took to grow.

Such findings fit with the view that fundamental abstract concepts, such as how time works, stem from perception and behavior, not cultural dictums or vivid metaphors, remarks computer scientist Jerome Feldman of the University of California, Berkeley.

“Cognition is being reunited with perception, action and language, but nobody understands how all of the pieces fit together,” Casasanto says.

Perhaps some day in the not-too-distant future, a group of social robots will tire of watching computer scientists hide food from each other and start arguing among themselves about the nature of cognition. Just imagine the experiments that they'd dream up. ■

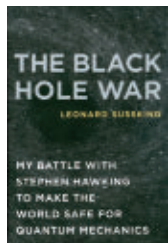
Explore more

- MIT's Personal Robots Group page: robotic.media.mit.edu
- Linda Smith's website: www.indiana.edu/~cogdev
- Daniel Casasanto's website: www.stanford.edu/~casasan

The Black Hole War: My Battle with Stephen Hawking to Make the World Safe for Quantum Mechanics

Leonard Susskind

For a good view into the real world of physics — not the sanitized version of textbooks and newspaper reports — you need a native guide.



Stanford physicist Leonard Susskind (widely known as “Lenny”) is your guy. His quasi-autobiographical account of the quest to understand black holes offers an insider’s view of physics-in-the-making over the past few decades.

He treats the deepest issues conversationally and accessibly, recounting his efforts to persuade the physics community to appreciate the crisis

that Stephen Hawking’s work on black holes had created. Hawking uncovered a potential contradiction to quantum mechanics — black holes seemed to destroy information contained in the material they swallowed; quantum mechanics insisted that information must be preserved.

Susskind relates how he and Nobel laureate Gerard ‘t Hooft developed ideas for addressing the crisis, and how the work of others, particularly Juan Maldacena, resolved it (in favor of quantum mechanics) — at least to the satisfaction of most physicists, including Hawking.

Engagingly written and well illustrated, Susskind’s tale brings anyone with an interest in reality’s foundations up to the edge of current understanding, and even offers a glimpse beyond.

— *Tom Siegfried*

Little, Brown and Company, 2008, 471 p., \$27.99.

Natural History of the Point Reyes Peninsula

Jules G. Evens

A historical and scientific guide to this diverse seashore.

Univ. of California, 2008, 366 p., \$24.95.



The Symmetries of Things

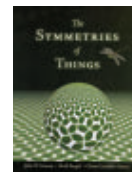
John H. Conway, Heidi

Burgiel and Chaim

Goodman-Strauss

Three mathematicians illustrate their theory for describing and classifying symmetries.

A.K. Peters, 2008, 426 p., \$69.



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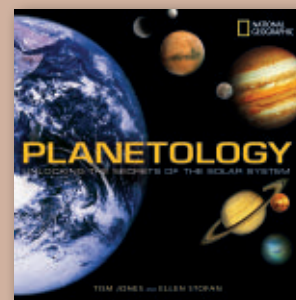
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Defining death

Allowing doctors to absolutely define death (“Doctors debate death definition for transplants,” *SN: 9/13/08, p. 5*) as “irreversible brain damage” is a slippery slope. There is a lot of pressure from transplant coordinators for body parts. While there is no absolute point in brain damage, heart stoppage is an absolute point. Allowing a vague definition will certainly lead to earlier and earlier use of such a definition. Temptation — the need for organs to maintain transplant programs and the cost of caring for a dying child — will certainly increase the pressure to back up the diagnosis.

F. E. Rector Jr., Grosse Pointe Shores, Mich.

Reality bytes

The introduction to Alex Szalay’s commentary (“Preserving digital data for the future of eScience,” *SN: 8/30/08, p. 32*) says “... files that will soon approach the petabyte (10^{15} — or quadrillion — byte) scale.”

But bytes are not measured in powers of ten but rather powers of two. A kilobyte is not 10^3 or 1,000 bytes, but 2^{10} or 1,024 bytes, a difference of 24 bytes. As the number of bytes grows, the inaccuracy of these approximations grows as well.

I recently purchased a Western Digital “terabyte” disk drive. When I installed it on my computer, the computer immediately recognized its capacity as one trillion bytes, 10^{12} bytes, rather than a terabyte, 2^{40} bytes. It’s short by 9.1 percent.

A petabyte is not 10^{15} or 1,000,000,000,000,000 bytes but rather 2^{50} or 1,125,899,906,842,624 bytes, a difference of 12 percent.

Matthew H. Fields, Ann Arbor, Mich.

ing, not even science will be able to save us. Why isn’t this a component of our foreign policy?

Barry Demchak, La Jolla, Calif.

Chemical on Mars

In the article titled “Mars lander confirms water ice” (*SN: 8/30/08, p. 11*), the author says the chemical compound perchlorate was found. Does this compound occur in a state of nature or is it only synthetic, made by man? If it is not natural, how did it end up on Mars?

Jeanette Grimshaw, Royal Oak, Mich.

On Earth, perchlorates occur in nature. After first discovering the perchlorate on Mars, researchers thought it might be a contaminant from rocket fuel. But the Phoenix Mars Lander’s instruments have now confirmed that the compound’s abundance is too high to have leached from the spacecraft’s rockets. Perchlorate, therefore, naturally occurs on Mars, scientists say. — Ashley Yeager

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Petabyte can refer to either 10^{15} bytes or 2^{50} bytes. As the reader correctly points out, the term is not well-defined.

— Alex Szalay

Population pressure

Regarding “Science should be prominent in U.S. foreign policy” (*SN: 8/2/08, p. 32*): Science and technology have bettered the lives of millions, and the future remains bright as long as human imagination thrives. A troubling trend, though, is that no new farmland is being created, and neither is air or open space.

The question is not whether science can continue to pull off miracles. And it’s not whether human population will continue to grow. The real question is at what point will science not deliver enough to stop humans from crowding themselves and every living thing off our planet?

If we don’t seek an equilibrium, Mother Nature will enforce one. If we don’t stop the population from grow-

A triathlon of sorts

I very much enjoyed Susan Milius’ feature article on animal athletes (“Built for speed,” *SN: 8/16/08, p. 14*). Before relegating humans to the root cellar of couch potatoes, however, name an animal capable of besting a human (and not just an Olympian) running a mile, swimming a mile and then climbing a tree.

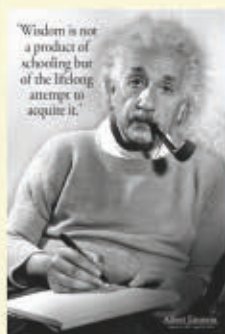
Ralph Protsik, Brookline, Mass.

Correction: *An article in the Aug. 30 issue (“Invisibility is almost within sight,” *SN: 8/30/08, p. 15*) incorrectly said that when light bends at the surface of a pond it can make fish look larger and closer. The article should have said only that the bending light can make fish look closer.*

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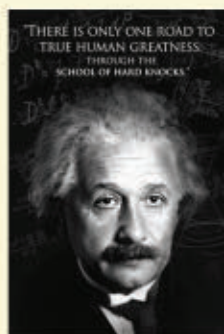
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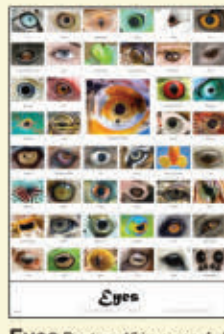
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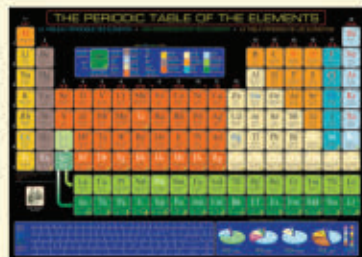


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U.S. must invest in technologies to avoid energy crisis

Steven Chu, director of Lawrence Berkeley National Laboratory and a Nobel laureate in physics, has advocated for energy thrift. During a September visit to Washington, D.C., he spoke with senior editor Janet Raloff about how he believes the United States can tackle what he sees as a looming energy crisis.

You've said the United States needs to launch an energy research program that's comparable to the Apollo mission. What did you mean?

That we need big investments and that our country needs to act quickly. In that respect, the programs would be similar. But the Apollo mission was essentially an engineering project with one goal: Put a man on the moon. And cost was not an issue. The energy situation is very different.

Today, carbon emissions are the 800-pound gorilla in the room. They're there but largely ignored by most people. Industry is waking up to the importance of these. But industry is also reluctant to invest in transformational technologies that won't pay for themselves within 10 years. This means that effective technologies have to be affordable.

What do you mean by transformational technologies?

They have to be revolutionary, the way transistors changed electronics or fertilizers changed agriculture. They must allow us to do much more with less — and in an entirely new way.

If you asked people 100 years ago whether our planet could feed 6 billion people, the answer would have been no, because we didn't have high-yielding plants. But with fertilizers and advanced crops, today we can feed billions.

Can we provide enough energy for everyone to enjoy a middle-class lifestyle?

I believe we can. No law of physics

says we can't. Consider energy efficiency, the lowest-hanging fruit. Buildings consume about 40 percent of the total energy produced in the United States. New buildings today can run on 50 to 60 percent less energy than those constructed 50 years ago.

But we've been talking very seriously ... about forming a consortium to make buildings become even more energy efficient — ones that could run on only 20 to 25 percent as much energy as they do today.

Who's "we"?

We at Lawrence Berkeley National Laboratory, at the University of California, Berkeley, and at heating, ventilating and air-conditioning companies like United Technologies. New features will have to be integrated into the design of these buildings. They may even have to generate some of their own energy with photovoltaics or other technologies.

Or take cars. There's a hope that we can have plug-in hybrids in two to five years that would dramatically reduce a car's need for liquid fuels. But to make these really attractive — transformative — they'll need a different battery.

What's the status of those batteries?

Current batteries for hybrid and electric cars last just five to six years, take a car only 40 miles on a charge — and cost \$10,000. These aren't going to sweep the market. But if you had a battery that was three times better, cost only a couple thousand dollars, could go 100 miles on a charge and used an electrolyte that wasn't flammable, then you'd have a

technology that could penetrate the market without tax credits.

Berkeley Lab has developed a battery that has about a factor of two higher energy density than the best lithium-ion battery (and a factor of three better than the one they're thinking about putting in the GM Volt). It's

inherently safe because the electrolyte is nonflammable. And it can be made for about the same cost as current-generation batteries — maybe even less.

Still, there's a way to go yet because it doesn't have a high enough current at 0° Celsius. So it wouldn't start when it's freezing.

What do you see as the role of government?

The government has got to allow investment tax credits so that companies have an incentive to invest in long-term energy research. It will also need to help build a workforce. The way students are supported in science and engineering is through research grants to professors.

Unless the government invests more in these grants, we won't be able to train the next generation of researchers for careers in transformative research.

The federal government can also offer policy incentives. The average American consumes about 10 to 12 kilowatts of electricity, 24/7, while some European countries with comparable lifestyles, like Denmark and Holland, use only 60 percent as much. What encouraged their efficiency was the very price of their energy. So the government can give people a price signal today that will influence purchases and energy use in years to come. ■



Industry is reluctant to invest in transformational technologies that won't pay for themselves within 10 years.



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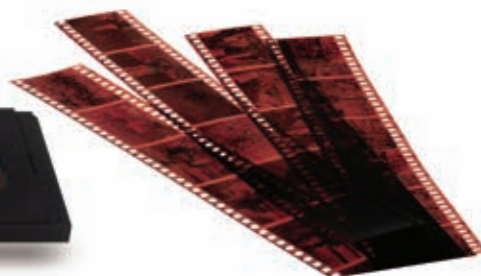


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The Slide & Negative Converter gets life's important moments off those old 35mm slides & negatives and onto your computer, where they are easy to see, sort, edit and retouch!

- View your memories effortlessly
- Compact 6 1/2 -inch slide & negative converter
- No professional photo lab expenses
- High quality color
- Knife-edge clarity
- Scans up to 3600 dpi



ories. Convert them to digital images before the people and places of your past are lost forever!

Easy to Use

The Slide & Negative Converter is a 6 1/2 -inch high tech device that converts old slides and negatives into high quality 5 MP digital images. It actually transforms your negatives into positive digital images.

There's nothing to it. A touch of a button scans it instantly. Do it at home without the expense and trouble of going to a professional photo lab!

Bring Your Slides and Negatives into the Digital Age

Convert your slides and negatives in an instant, and do the viewing, as well as organizing, deleting or retouching the easy way on your PC! The converter comes with software that lets you do it all easily. It attaches to your PC with the supplied USB cable to download the images.

No More Hard to View Slides!

Memories are so precious. Too bad many of us captured our memories on 35mm slides and negatives. Now those slides are packed away in stacks of little boxes, in the back of a closet. And the projector probably doesn't even work anymore! Now you never have to deal with slides or annoying negatives again.



Don't Let Time Destroy Your Memories

The wear and tear of time can fade fragile negatives and slides or they can be easily lost or mishandled losing all those great mem-

Enjoy Precious Memories Instantly

How many times have you thought about looking at slides and negatives you haven't seen in years, but decided it was just too much trouble? Perhaps they are the pictures of baby's first birthday party, your holiday vacation, or your friends from the old neighborhood. Digitize and preserve those memories forever.

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- Converts slides & negatives into 5 megapixel digital images
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- Works with both color and black & white
- Comes with software to edit, crop and retouch pictures
- Scans images up to 3600 dpi
- 10 bits per channel for conversion
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