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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ SEPTEMBER 27, 2008

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NASA preps the space telescope for its finale

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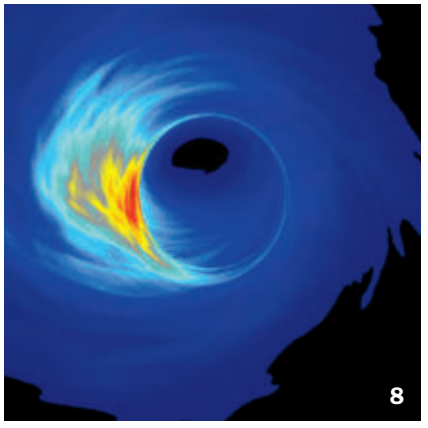

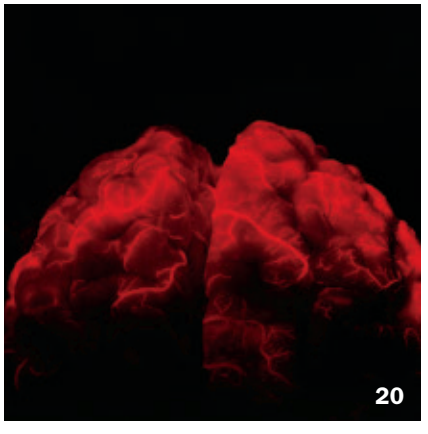

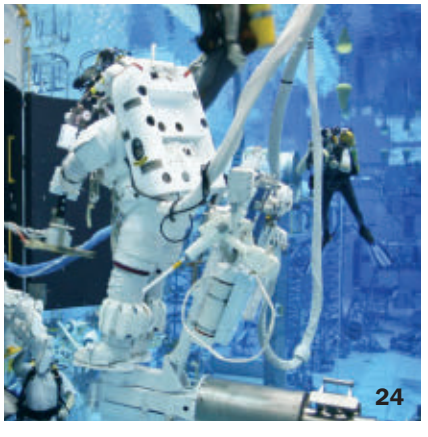

FROM TOP: S. DOELEMAN, M. WEISS/CXC, S. NOBLE, C. GAMMIE, NASA; MAZAR, TEL REHOV PROJECT; LENNART NILSSON; JSC/NASA

ScienceNews

In The News

Features

Departments

COVER These cameras, part of the Relative Navigation Sensor system, will play a role in the capture and deploy phases of the Hubble servicing mission. *NASA*

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FROM THE EDITOR

Hubble's repair sets stage for telescope anniversary

Next year astronomers will celebrate the International Year of Astronomy, commemorating the 400th anniversary of Galileo's original use of the telescope to study the skies. It might just as well have been designated the International Year of Science, for in many ways modern science began when Galileo saw farther than anyone had seen before.

Four centuries from now, Galileo will still be remembered. And so will Edwin Hubble, the astronomer who saw even farther than Galileo did.

Both men's names will forever be linked to telescopes — Galileo's to the one he used, Hubble's to his namesake. Both opened the eyes of humankind to a reality vaster than their predecessors had imagined.

Galileo showed that material existence extended to the realm of the heavens, detecting mountains on the Earth's moon and finding that heavenly bodies (specifically, Jupiter) could, like Earth, possess moons of their own. Hubble (the man, using conventional telescopes) showed that the galaxy of stars housing the sun and its planets was just one of countless others, within an ever-growing universe. Hubble (the telescope) helped astronomers establish that the universe not only grows but also expands at an ever more rapid rate.

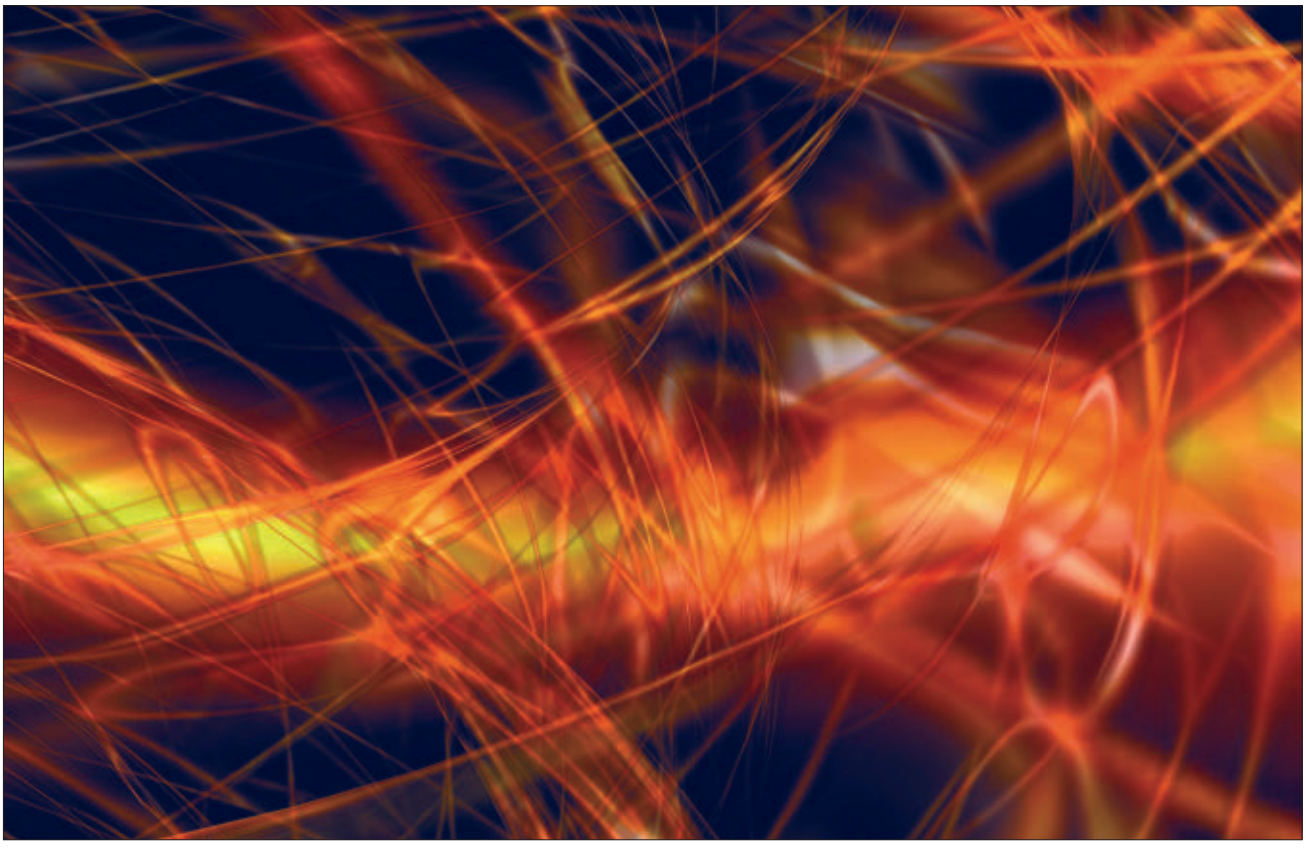
By providing other precision measurements enabled by a space-based telescope, Hubble has helped astronomers to greatly reduce uncertainties about the universe's age, mass and origin. That knowledge hints that the universe accessible to Hubble is only one in a vast multiverse of cosmic bubbles, suggesting that science has still only glimpsed a small fraction of space-time's ultimate expanse.

All this would be fitting commentary for Hubble's obituary (the telescope), except for the happy circumstance that it isn't yet dead. Soon astronauts will refurbish the aging orbiting observatory for one more round of wresting secrets from the sky (as Ron Cowen describes on Page 24).

Hubble's chance to extend its quest for cosmic insight comes only after contentious debate about how its benefits compare with the risks of a complex space shuttle mission. In the end, the scientific spirit prevailed over the timidity of bureaucracy.

Four centuries from now, let's hope, society will still hold in such high regard the value of exploring unknown realms strictly for the sake of knowledge. If so, there should be another worldwide celebration of science, honoring Galileo, Hubble and, if all goes as it should, someone who is just now reading about all this in *Science News*.

— Tom Siegfried, Editor in Chief



Could String Theory Be the Long-Sought "Theory of Everything"?

One of the most exciting scientific adventures of all time is the search for the ultimate nature of physical reality. The latest advance in this epic quest is string theory—known as superstring or M-theory in its most recent versions. Based on the concept that all matter is composed of inconceivably tiny filaments of vibrating energy, superstring theory has potentially staggering implications for our understanding of the universe.

In **Superstring Theory: The DNA of Reality**, you explore this intriguing idea at a level deeper than that available in popular articles. Your guide is Dr. S. James Gates Jr., the John S. Toll Professor of Physics and Director of the Center for String and Particle Theory at the University of Maryland at College Park. Throughout these 24 lectures, he explains the concepts of superstring theory and mathematical ideas like hidden dimensions, dark matter, and black holes—all at the level of the nonscientist. He also draws on the illustrative power of graphics and animations to enhance your understanding and take you to the heart of these cutting-edge ideas.

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17. The Fundamental Forces Strung Out
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Scientific Observations

"Where there are natural resources in Africa, the rush to exploit them is at a pace that no one ever dreamt possible.... The value of this announcement of this large population is, hopefully, people will realize this is a chance to get there before the other guys do. And to figure out a better way to plan ... than leaving it up to people with chain saws and bulldozers."

RICHARD RUGGIERO OF THE U.S. FISH AND WILDLIFE SERVICE SPEAKING TO NPR AFTER A PREVIOUSLY UNDISCOVERED GROUP OF WESTERN LOWLAND GORILLAS WAS FOUND IN THE REPUBLIC OF CONGO.

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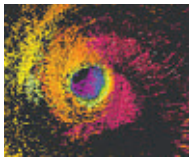


EARTH

Studying decades of satellite data, a group of researchers found that the winds in already fierce storms, such as the strongest hurricanes, have actually strengthened in the past three decades.

ATOM & COSMOS

The European Space Agency's Rosetta craft made the first up close visit to a main-belt asteroid, 2867 Steins, on September 5. Images reveal a diamond shape with many craters.

ARCHIVES

Read the Digital Edition of past print issues by clicking "Archives" on the upper right corner of the *Science News* website.

Science Past | SEPTEMBER 27, 1958

PARKINSON'S DISEASE NO LONGER INCURABLE — Parkinsonism, or shaking palsy, is no longer a hopeless, progressive, incurable disease. A five-year follow-up study of 700 brain operations for parkinsonism revealed that 80% of the properly selected cases found relief from the tremor, rigidity, deformity and incapacitation of parkinsonism after basal ganglia surgery. Furthermore, these symptoms can be relieved by operation without fear of any psychological or neurological damage to the patient, Drs. Irving S. Cooper and Gonzalo J. Bravo of the department of surgery, New York University-Bellevue Medical Center, and the department of neurosurgery at St. Barnabas Hospital, New York, report in *Neurology* (Sept.).

Science Future

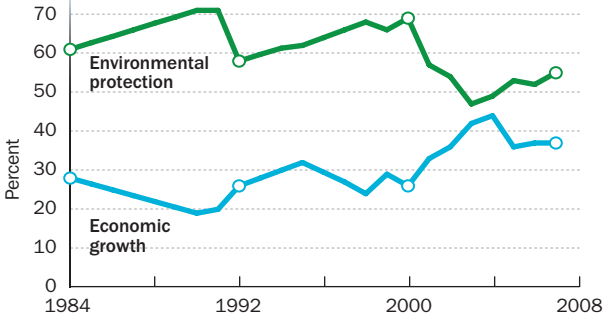
October 3
Grid Fest at CERN in Geneva marks LHC's computing grid going live. Visit lcg.web.cern.ch/LCG/lhcgridfest

October 12–18
Earth Science Week 2008, sponsored by the American Geological Institute, celebrates "No Child Left Inside." Visit www.earthsciweek.org

October 20–21
Orionids meteor shower expected to peak. Visit www.imo.net/calendar/2008

Science Stats | GREEN VERSUS GREENBACKS

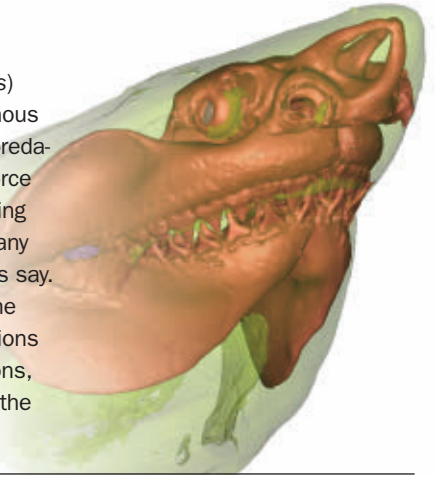
Public's stated priorities for environmental protection versus economic growth in the United States from 1984 to 2007



SOURCE: GALLUP'S PULSE OF DEMOCRACY POLL

The (-est)

The great white shark (*Carcharodon carcharias*) doesn't let its cartilaginous jaws hold it back. The predator can chomp with a force of 18,000 newtons, giving it the strongest bite of any living species, scientists say. The findings, which come from digital reconstructions and computer simulations, are published online in the *Journal of Zoology*.



CLOCKWISE, TOP LEFT: R. RUGGIERO; NASA/GSFC/LARC/JPL, MISR TEAM; ESA ©2008 MPS FOR OSIRIS TEAM MPS/UPM/LAM/IAA/RSSD/INTA/UPM/DASP IDA; S. WROE *ET AL.*, *JOURNAL OF ZOOLOGY*

“This much later discovery is just another feather in the cap of this excellent theory.” — MICHAEL PESKIN, PAGE 9

In the News

STORY ONE

Creating new nerve cells makes sense for the brain

Neurogenesis seems to aid memory, depression drugs

By Tina Hesman Saey

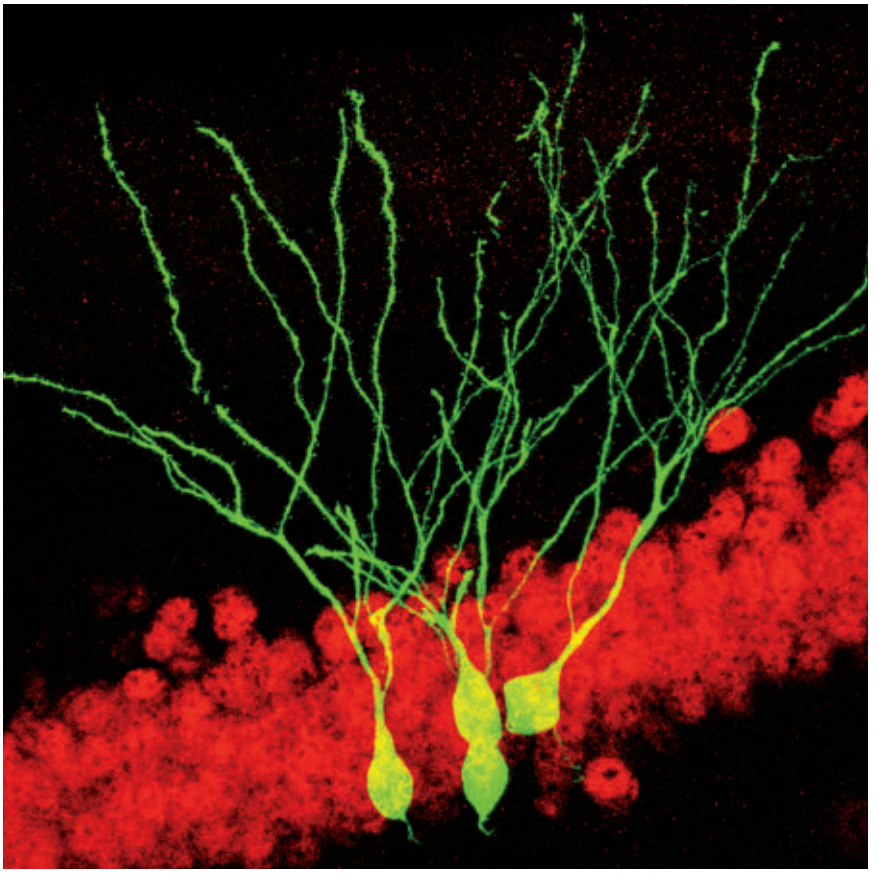
Most of the brain does fine with its original brain cells, but parts involved in smelling and remembering sometimes need new recruits.

In mice, new neurons are needed to remember mazes and keep scent-sensing organs plump (but aren't necessary for detecting smells), a new study shows. Another recent study demonstrates that some antidepressants require neurogenesis — the creation of fresh neurons — to work.

Both studies are part of a new wave of research that shows neurogenesis — once thought to be impossible in the adult brain — plays an important role in the organ's function.

“These are both very good papers and consistent with the growing appreciation for the importance of adult neurogenesis in general and in particular in behavior,” says Fred “Rusty” Gage, a neuroscientist at the Salk Institute for Biological Studies in La Jolla, Calif.

Neurogenesis creates new neurons in the hippocampus, a part of the brain linked to learning and memory, and in the olfactory bulb, an organ that detects smells and pheromones. But scientists haven't known why it is necessary to make new cells in those brain regions.



CHUNMEI ZHAO/GAGE LAB/SALK INSTITUTE

Understanding the role of newborn neurons, such as these in an adult mouse hippocampus (green), has been difficult. Two new studies shed light on the question.

Now researchers led by Ryoichiro Kageyama, a neuroscientist at Kyoto University in Japan, report online August 31 in *Nature Neuroscience* that neurogenesis plays different roles in the two brain structures.

Nearly all of the cells in the olfactory bulb are replaced, and that regular refreshing of neurons is required to maintain the shape and volume of the bulb, the researchers report. But mice with shrunken olfactory bulbs had no trouble sniffing out sweet treats, suggesting that a few old neurons are all that's needed to maintain a sense of smell.

Neural stem cells that make the new olfactory bulb neurons seem to act like the adult stem cells that maintain skin, blood and gut, Kageyama says. But the researchers don't yet understand why a breakdown in maintenance doesn't destroy the mice's sense of smell.

“Smell is so important for mice that ››

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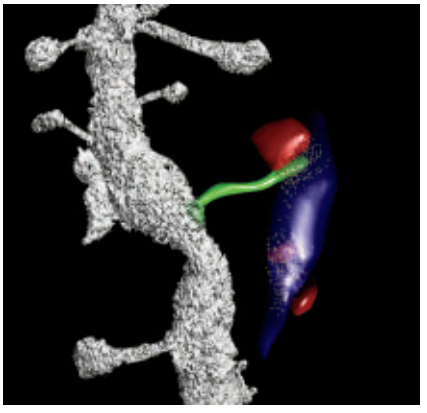
›› redundancy in olfaction could be intensive," Kageyama says. "It is also possible that the mice have some olfactory defect that we are so far not aware of." The team has not yet tested whether these mice, the ones with atrophied olfactory bulbs, can still detect pheromones.

In contrast to the olfactory bulb, far fewer new neurons are added to the hippocampus. More than 10 percent of neurons are replaced in the hippocampus, but their addition doesn't make the brain region bigger, and blocking neurogenesis doesn't make the hippocampus shrink, Kageyama and his colleagues found. There might be only a few new neurons, but they are important for mice to form new memories, the researchers say. Blocking neurogenesis impaired mice's ability to remember a maze for more than week, while mice with intact hippocampi remembered the maze two weeks after learning to run it.

"It's not a straightforward linkage between neurogenesis and memory," says Paul Frankland, a neuroscientist at the Hospital for Sick Children Research Institute in Toronto, Canada, who was not involved in the new studies. Memories can still form in the absence of neurogenesis but may be subtly different from those made when new neurons are present, he says. Neurogenesis may help form a timeline for memories, with new neurons helping to keep track of memories formed at the time the cells joined the hippocampus.



Once born, neurons must integrate into the adult brain. Above, a reconstruction shows a newborn cell (gray) sending an extension (green) toward the juncture of two mature neurons (blue and red).

Neurogenesis in the hippocampus slows down as mice age. Similar slowing in people could help explain why memory fails as people get older, Kageyama says.

Another mystery about neurogenesis concerns antidepressants known as selective serotonin reuptake inhibitors or SSRIs, the class of drug that includes Prozac. Those drugs were previously shown to stimulate neurogenesis in the hippocampus, but scientists were not sure if that was a side effect of the medication or necessary for its action.

Now, a study on mice in the Aug. 14 *Neuron* shows that neurogenesis in the hippocampus depends on the action of a protein called TRKB, and that neurogenesis is required for the antidepressant effects of SSRIs.

That doesn't mean that depression is caused by a defect in neurogenesis, says Luis Parada, who led the study with colleagues at the University of Texas Southwestern Medical Center at Dallas.

But the research could shed light on why some people don't respond to antidepressant therapy and could lead to the development of new drugs to treat depression.

"There is exciting evidence that, in a variety of animal models, neurogenesis accompanies response to antidepressants," Parada says. "We're getting an idea of what molecules mediate this." ■

Back Story | OVERTURNING THE NEUROGENESIS DOGMA

1960s
Experiments on rhesus monkeys help cement a dogma that had been building for more than a century—no new neurons form in the adult brain. Scientists believed that people are born with all the neurons they will ever have.

1965
Joseph Altman and Gopal Das at MIT report the birth of new brain cells in the olfactory bulb and hippocampus of adult rats, casting some doubt on the dogma. But the researchers can't say for sure whether the new cells are neurons or support cells known as glia.

1980s
Canaries make new neurons when learning songs, and rats' brains weigh more after learning to run a maze, researchers learn. These experiments suggest that new neurons are born in the adult brain, but most scientists cling to the old dogma.

1992
Elizabeth Gould publishes the first in a series of observations of neurogenesis in the adult brain. Gould first saw the signs of newborn neurons in rat brains and later in marmosets.

1998
Peter Eriksson and Fred Gage show that adult human brains also make new neurons. Experiments by many researchers follow, but controversy lingers about where new neurons are made and why.

2000
Reports linking depression and neurogenesis in the hippocampus begin to appear. Scientists learn that increasing serotonin levels can stimulate the growth of new neurons, leading to the idea that enhancing neurogenesis could treat depression.

Neurogenesis in adult mouse brain.

FROM TOP: NICOLAS TONI/SALK INSTITUTE; CHUNMEI ZHAO/GAGE LAB/SALK INSTITUTE (SOURCE: THEBRAIN.MCGILL.CA)

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Atom & Cosmos

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PAMELA spots the dark stuff, maybe

Orbiting observatory records excessive positron production

By Ron Cowen

Cosmologists are agog about the possibility that an orbiting observatory may have discovered particles of dark matter—the invisible material that researchers believe makes up most of the mass of the universe.

At two meetings in August, researchers analyzing data from the Russian-European observatory PAMELA, short for Payload for Antimatter Matter Exploration and Light-nuclei Astrophysics, reported preliminary evidence for the detection of more positrons from the Milky Way than could be accounted for by the standard model of particle physics.

At the International Conference on High Energy Physics, held in Philadelphia, Mirko Boezio of the Italian National Institute of Nuclear Physics in Trieste suggested that the surplus of positrons—the electron's antiparticle—could be accounted for by the annihilation of pairs of dark matter particles. When dark matter particles collide, one theory predicts, they decay into a spray of ordinary particles, including positrons.

"We plan to have final results ready by early October and submit a paper to a peer-reviewed journal," Boezio told *Science News*. Until then, he says, "We prefer to withhold further comments." But that hasn't stopped other researchers from posting their interpretations of the data on the Internet.

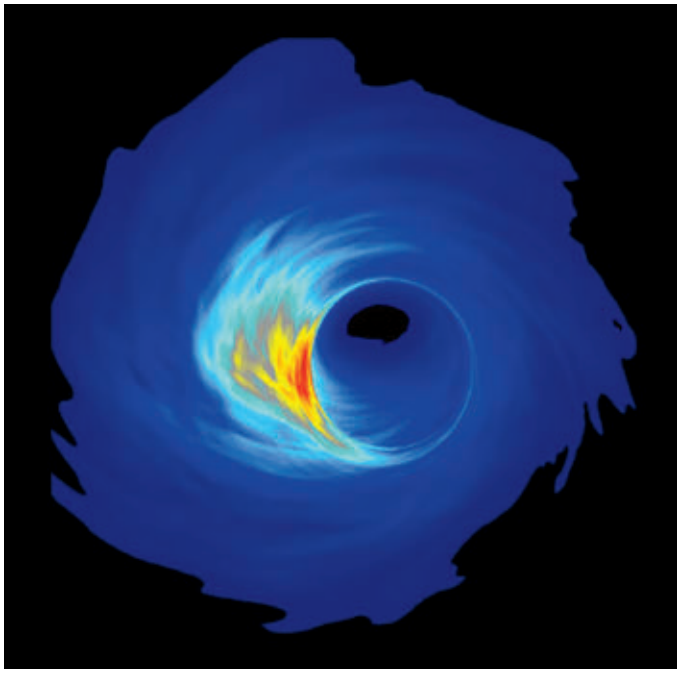
One report suggests that the PAMELA findings are consistent with the existence of a proposed dark matter particle known as minimal dark matter.

The model that predicts that particle would introduce a set of five new elementary particles that interact only through the weak nuclear force, wrote Marco Cirelli of the Institute of Physical Theory of the French Atomic Energy Commission and Alessandro Strumia of the University of Pisa and Italy's nuclear physics institute in a paper posted August 28 (arxiv.org/abs/0808.3867). Their theory suggests that a dark matter particle is about 10,000 times heavier than a proton.

One promising feature of the PAMELA data, Cirelli and Strumia say, is that the observatory appears to have recorded an abrupt rise in positrons with energies of about 10 billion electronvolts—just what the annihilation of dark matter particles predicts. In contrast, known astrophysical processes would produce a more gradual increase in positrons.

In another recently posted paper, Lars Bergström, Torsten Bringmann and Joakim Edsjö of Stockholm University suggest that PAMELA may have found evidence of a type of dark matter predicted by supersymmetry, an extension of the standard particle physics model that would double the number of elementary particles (arxiv.org/abs/0808.3725).

Astronomers infer the existence of dark matter because it would provide the unseen glue that keeps galaxies intact and galaxy clusters from disassembling. But dark matter has never been convincingly detected directly.



S. DOELEMAN, M. WEISS/CXC, S. NOBLE, C. GAMMIE, NASA

Black hole, in detail

An array of radio telescopes has given astronomers their closest look yet at the Milky Way galaxy's center, depicted in this illustration. Yellow and red indicate emissions from Sagittarius A*. This bright, widely studied radio emissions source appears to be located off-center from the supermassive black hole—4 million times the mass of the sun—thought to reside at the galaxy's core. By combining the signals from three radio dishes, Sheperd Doeleman of MIT and colleagues effectively created a single radio telescope nearly as wide as the continental United States. Using this "very long baseline interferometer," the team examined Sagittarius A* in unprecedented detail, resolving for the first time features about as small as the black hole's event horizon—the surface from beneath which nothing can escape. "We have now entered a new era, one in which we can directly image structure at the event horizon of a black hole," asserts Christopher Reynolds of the University of Maryland in College Park in a commentary accompanying the report in the Sept. 4 *Nature*.—*Ron Cowen*

7.7 billion Light-years to the most massive distant galaxy cluster

3.5 billion Light-years to the previous record-holder

Galaxy cluster outweighs neighbors

Distant find could support the existence of dark energy

By Ashley Yeager

A new cosmic crowd has captured the heavyweight title for galaxy clusters discovered deep in the universe. The record-breaker sits billions of light-years from Earth and has about a thousand times the mass of the Milky Way, astronomers report in August in *Astronomy & Astrophysics*.

"To discover a cluster that is so distant yet so big was quite lucky," says study coauthor Georg Lamer of the Astrophysical Institute of Potsdam in Germany.

Lamer and his Potsdam colleagues first spotted the massive cluster, dubbed 2XMM J083026+524133, when scrutinizing data from the European Space Agency's XMM-Newton telescope, which captured the cluster's signature in 2001 while imaging a distant, active galaxy.

Optical images from the Sloan Digital Sky Survey established that the light could not be coming from a nearby galaxy in that cosmic region. So the team took a deep-field exposure with the Large Binocular Telescope at the Mount Graham International Observatory near Safford, Ariz. The cluster appeared and was calculated to be 7.7 billion light-years from Earth. The previous record-holder sits 3.5 billion light-years away and weighs slightly less than a thousand Milky Ways.

This optical image, taken by the Large Binocular Telescope, confirmed that the fuzzy blue dot is a distant cluster.

"The new cluster," Lamer says, "can only be explained by the existence of dark energy."

Dark energy is an unexplained force that accelerates the expansion of the universe. Without this force, Lamer says, nearby clusters should be much more massive than those that are billions of light-years away. Distant clusters, he says, should be less massive because they had less time to conglomerate.

"It is notoriously hard to compare cluster masses," he notes. "But, the 'neighboring' Coma Cluster and this new, distant cluster actually seem to have comparable masses."

Stephen Murray of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., says it is an overstatement to claim dark energy exists based on one cluster. But he says the discovery will further the study of galaxy clusters.

Proton has a strange cousin

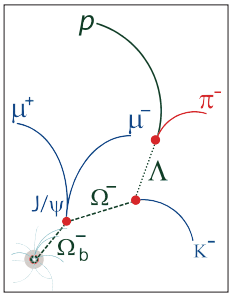
Fermilab finds new particle predicted by standard model

By Davide Castelvecchi

Physicists have found a new heavy cousin of the proton hiding in a pile of data at the Fermi National Accelerator Laboratory in Batavia, Ill.

The new particle, long predicted to exist, is made of a bottom quark — the second-heaviest of all quarks — with two, much lighter strange quarks essentially orbiting around it, says Fermilab physicist Dmitri Denisov. The laboratory announced the discovery on September 3 and submitted a paper for publication to *Physical Review Letters*.

The particle, known as omega-b-minus, is one of many possible combinations of quarks predicted by the standard model of particle physics. The 1964 discovery of a particle made of three strange quarks was the landmark that established the mathematical basis for what would become the theory of quarks, says physicist Michael Peskin of the Stanford Linear Accelerator Center in Menlo Park, Calif. "This much later discovery is just another feather in the cap of this excellent theory," he says.



Decay debris identifies omega-b-minus.

Researchers at Fermilab's DZero detector, which smashes together protons and antiprotons circling almost at light speed in the Tevatron accelerator, took about a year to sift through data gathered between 2002 and 2006. The data described the debris from the collisions, in which the particles' huge energy creates hundreds of new quarks and other particles.

"We needed 100 trillion events to select events which can be interpreted as an omega-b-minus," and just a handful fit the bill, says Denisov, a DZero spokesperson. In each case, the researchers did not observe the new particle itself because it decayed almost immediately. Instead, the DZero detector picked up a signature combination of five particles left over by omega-b-minus decay. The physicists calculated the new particle's mass at 6.2 billion electronvolts, about six times that of a proton and very close to theorists' predictions.

FROM TOP: ESA XMM-NEWTON, EPIC, LBT, LBC, AIP J. KOHNERT; DZERO COLLABORATION

Humans

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Path to math

Math ability may be related to ingrained number sense

By Bruce Bower

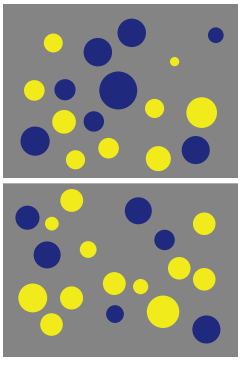
Count on evolution to play favorites. When it comes to math, some kids may start with an inherent advantage.

Some 14-year-olds deftly estimate approximate quantities without counting, whereas others do so with moderate or limited success, a new study finds.

Large variations in this number sense parallel youngsters' mathematics achievement scores from kindergarten to sixth grade, Justin Halberda of Johns Hopkins University in Baltimore and colleagues report online September 7 in *Nature*.

Earlier studies indicated that a faculty for rapid estimation appears by age 4 months, long before any math instruction, Halberda says. How precisely a child can estimate amounts may influence math learning, he proposes. He suspects, based on earlier studies, that effects of intensive math instruction are relatively small.

In the new study, 64 14-year-olds viewed arrays of blue and yellow dots on a computer screen. Each array included five to 16 dots and appeared for a fraction of a second, making counting impossible. Top-performing teens estimated quantities as well as adults, discriminating between numerical ratios of blue and yellow dots as close as 9 to 10. Other teens had trouble with ratios higher than 2 to 3.



Researchers found great variation in teens' abilities to estimate quantities of blue and yellow dots.

Individual performance corresponded with scores on two math achievement tests, and the findings held after researchers accounted for IQ, spatial reasoning ability and other cognitive measures.

Brian Butterworth of University College London says it's unclear how estimation helps kids learn arithmetic. "Arithmetic requires a sense of exact number," he says. "Approximate numbers just won't do."

Blindfolded babies show ability to learn how others see the world

Personal experience leads to social thinking in 1-year-olds

By Bruce Bower

Infants make sense of the social world from the inside out. By age 1, kids rapidly incorporate visual experiences into a framework for understanding what other people can or can't see, a new study finds.

Personal experience enables social thinking in early childhood, say Andrew Meltzoff and Rechele Brooks, both of the University of Washington in Seattle.

In their experiments, blocking the vision of 1-year-olds with a blindfold led the youngsters to appreciate that a blindfolded adult couldn't see toys on a table, an insight that usually eludes 1-year-olds.

Brief use of a trick, see-through blindfold led 18-month-olds to assume that a blindfolded adult could see objects in plain view, even though 18-month-old children rarely make such a mistake.

"This first-of-its-kind training study shows how infants use themselves and their own experiences to understand the inner lives of others," Meltzoff says. He and colleagues report their work in the September *Developmental Psychology*.

Speculation that children's actions and experiences shape social cognition extends back more than 50 years, to Swiss psychologist Jean Piaget. Yet little research has explored how personal experiences animate social learning, says psychologist Amanda Woodward of the University of Maryland in College Park.

"Meltzoff and Brooks have conducted one of the first successful efforts to study this phenomenon in the lab," she says.

In the main experiment, 96 healthy 1-year-olds played with pieces of black cloth that had been placed under toys on a table. Children were then randomly assigned to receive no more play time or to play a game in which an experimenter periodically held either of two black blindfolds in front of the children's eyes and asked them to point out certain toys. One blindfold had eyeholes.

Next, infants watched as a blindfolded experimenter turned to face a toy. Video analyses showed that kids given experience with a regular blindfold spent little time following the experimenter's presumed gaze, a sign that they assumed the blindfolded person couldn't see.

Children who had played only with cloth or had used a see-through blindfold persistently looked in the direction of the adult's presumed gaze, acting as if the blindfolded experimenter could see.

The researchers then trained 72 18-month-olds. Children first played with pieces of cloth, some made of mesh that could be seen through. Kids were then randomly assigned to play the game either with a regular or see-through blindfold.

The 18-month-olds followed the assumed gaze of a blindfolded adult for an especially long time only if they had trained with a see-through blindfold.

During training, infants learned about spatial relations among a viewer, a barrier and an object, Meltzoff hypothesizes. The infants then applied this visual knowledge to other people, he suggests.

HALBERDA

"This first-of-its-kind training study shows how infants use themselves and their own experiences to understand the inner lives of others." — ANDREW MELTZOFF

Study evaluates kids' therapies

Most trauma treatments lack scientific support

By Bruce Bower

There's good news and, not surprisingly, bad news for children and teenagers grappling with the psychological aftermath of trauma. On the up side, research shows that cognitive-behavioral therapy eases post-traumatic stress disorder and other trauma-related problems in the young. On the down side, most mental-health practitioners use other therapies for kids and teens that lack scientific support.

These conclusions come from a research review conducted by the Task Force on Community Preventive Services, a group of 12 investigators partly funded by the federal government. Its findings appear in the September *American Journal of Preventive Medicine*.

Although the review focuses on Western countries, research has also just started to explore the use of trained nonprofessionals to treat traumatized children in developing nations, where mental-health workers are scarce.

Kids with trauma-related psychological problems tend to do poorly in school if they are untreated or inadequately treated, remarks psychologist and social worker Marleen Wong of the University of Southern California in Los Angeles.

An estimated one in eight children have experienced physical or sexual abuse, neglect, bullying and other types of maltreatment. More than one in three have witnessed violence or experienced it indirectly, such as losing a parent to murder. Children experiencing trauma can develop PTSD or other disorders.

Evidence indicates that individual and group cognitive-behavioral therapy reduces symptoms of PTSD, depression, anxiety and related behavior problems in traumatized children and adolescents, the task force reports. Cognitive-behavioral techniques include discussing or writing about traumatic experiences, learning relaxation techniques and replacing paralyzing fears with more realistic assessments. Weekly sessions can extend over one to three months.

The review finds insufficient evidence to recommend any of five other common treatment approaches — play therapy, art therapy, drug therapy, psychodynamic therapy or psychological debriefing.

Psychodynamic therapy focuses on changing unconscious reactions to traumatic events. Debriefing consists of group discussions and education conducted one to three days after a traumatic event.

More than three-fourths of U.S. mental health professionals who treat children and teens with PTSD report using treatments that have not been scientifically reviewed or for which effectiveness could not be determined by the task force.

"That's disappointing, but it's encouraging that a substantial body of evidence supports both individual and group cognitive-behavioral therapy," says task force member and epidemiologist Robert Hahn of the Centers for Disease Control and Prevention in Atlanta.

Common therapies

Cognitive-behavioral Confronts traumatic experience, offers relaxation training, identifies ways to correct maladaptive responses

Play/Art Uses play or art to help children express, understand and gain control of emotions

Psychodynamic Unravels emotions, integrates traumatic event into patient's self-concept

Drug Prescribes psychiatric medications to children with stress-related symptoms

Psychological debriefing Survivors discuss and share reactions, receive advice for coping

Excavators find honey of a discovery

Israeli site yields oldest known example of beekeeping

By Bruce Bower

The Bible refers to ancient Israel as the "land flowing with milk and honey," so it's fitting that one of its towns milked honey for all it was worth. Scientists have unearthed the remains of a beekeeping operation at a nearly 3,000-year-old Israeli site, dating to the time of King David and King Solomon.

Excavations in northern Israel at a huge earthen mound called Tel Rehov revealed the Iron Age settlement. From 2005 to 2007, workers there uncovered the oldest known remnants of human-made beehives, excavation director Amihai Mazar and colleagues report in the September *Antiquity*. No evidence of beekeeping has emerged at any other archaeological sites in the region.

"The discovery of an industrial apiary at Tel Rehov constitutes a unique and extraordinary discovery that revolutionizes our knowledge of this economic endeavor, particularly in ancient Israel," says Mazar, an archaeologist at the Hebrew University of Jerusalem.

MAZAR, TEL REHOV PROJECT

A researcher grasps the lid handle to a 3,000-year-old beehive in northern Israel.

Body & Brain

40 percent | Men in a new genetic study who had at least one 334 allele

To bond or not to bond may depend on common hormone gene variant

Vasopressin receptor may contribute to commitment phobia

By Laura Beil

There's news for women who want a man who bonds rather than a James Bond: Scientists have identified a genetic variation that appears to weaken a man's ability to emotionally attach to one partner.

The study, published online September 2 in the *Proceedings of the National Academy of Sciences*, is the first to try to examine whether a hormone that encourages monogamy in animals plays a similar role in male humans. Before ordering a DNA-fidelity test, though, women should consider that the study wasn't designed to determine whether the gene in question is responsible for monogamy in humans.

"We can't with any accuracy predict effects on behavior," says Hasse Walum of the Karolinska Institute in Stockholm. "A lot of different things determine how happy you will be in a relationship." But women can now wonder, "What about his vasopressin 1a receptor subtype?"

The hormone vasopressin affects several body systems, including cardiac and urinary function. In addition, scientists have long studied how vasopressin influences behavior in prairie voles. The mouselike animals, found in the grasslands of North America, are famous for social monogamy. Males tend to be family guys, sticking close to home and helping to raise the pups.

Over years of study, scientists have concluded that prairie vole bonding has much to do with vasopressin activity in the brains of males. Scientists have even manipulated vasopressin levels in the vole brain, making the animals more, or less, faithful. Vasopressin is not a love potion, though. Nerve cells also must be equipped with specific receptor molecules that allow the hormone to bind to the cells and activate certain internal circuitry.

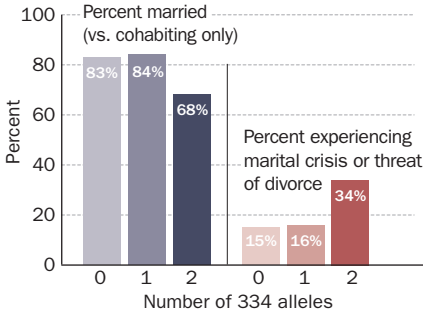
The new study examined a gene that codes for a vasopressin receptor in the human brain. Walum and an international team of collaborators also asked about 550 couples, who had been together at least five years, to fill out questionnaires measuring their level of "pair-bonding" and marital strife.

In the end, one common variation of the gene, called the 334 allele, was associated with lower scores on partner bonding and greater odds of marital conflict, especially in men. Among men with either no copies or just one copy of the 334 allele, about 15 percent reported a marital crisis in the past year. When men had two copies of the 334 allele, the odds of marital crisis jumped to 34 percent.

"This is actually a real breakthrough paper," says Steve Phelps of the University of Florida in Gainesville. "The magnitude of effect is really astonishing." But he and others were also cautious.

"The results are really intriguing," says Larry Young of Emory University School of Medicine in Atlanta, who in 2005 reported in *Science* that, in male voles, a variation of the same gene predicted the quality of pair-bonding. "I still remain skeptical until this can be replicated."

Commitment and the 334 Allele in Men



A particular gene variant seems to predispose men to relationship issues.

GRAPHIC: A. NANDY, SOURCE: WALUM *ET AL.*

News Briefs

Eye protection

A gene variant may guard against a common, blinding eye disease. The gene, *TLR3*, may play a pivotal role in the dry form of age-related macular degeneration, the leading cause of blindness in the elderly. The new finding, reported online August 27 in *The New England Journal of Medicine*, reveals that roughly three in 10 people harbor a variant form of *TLR3* that subdues its normal activity, seeming to provide a partial safeguard against the eye disease. —*Nathan Seppa*

Amniotic infection

The amniotic sac that envelops the fetus during pregnancy harbors never-before-seen pathogenic microbes, Daniel DiGiulio of Stanford University and colleagues report online August 26 in *PLoS ONE*. In the amniotic fluid of 166 pregnant women, the team found infectious bacteria or fungi in 25, a prevalence 50 percent higher than in past studies. The study also supports the premise that microbes found in amniotic fluid can cause premature birth. —*Ashley Yeager*

Cancer-calcium connection

Even a slight excess of calcium in the blood may increase a man's risk of developing lethal prostate cancer, researchers report in the September *Cancer Epidemiology, Biomarkers & Prevention*. Of 2,814 men participating in a long-term health study, 25 had died of prostate cancer after 10 years. Men whose blood calcium levels ranked in the top third were 2.7 times as likely to have died from prostate cancer as those in the lowest third. —*Nathan Seppa*

Genes & Cells

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Gene activity makes the difference in development of human qualities

'Junk DNA' helps to distinguish people from other primates

By Rachel Ehrenberg

Genes alone don't make the man—after all, humans and chimps share roughly 98 percent of their DNA. But where, when and how much genes are turned on may be essential in setting people apart from other primates.

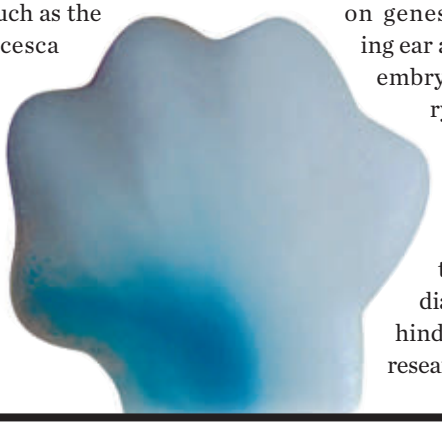
A stretch of human DNA inserted into mice embryos revs up gene activity in developing thumbs, toes and limbs. But the chimp and rhesus macaque version of that DNA spurs only faint activity in the limbs, scientists report in the Sept. 5 *Science*.

The research supports the notion that changes in gene regulation—rather than changes in the genes themselves—were key evolutionary steps in humans' ability to use fire, invent wheels and ponder existential questions, like what distinguishes people from their primate cousins.

"We're trying to find out what makes us human," says James Noonan, now at Yale University, who led the study with colleagues from Lawrence Berkeley National Laboratory, the Genome Institute of Singapore, Caltech and the United Kingdom's Medical Research Council. "We know that the things that make us human biologically are encoded in there somewhere."

Noonan and colleagues combed through vast regions of human DNA that do not contain code for making proteins. Formerly dissed as "junk DNA," sections of these nongene regions are now known to play a regulatory role, dialing down or cranking up the activity of actual genes.

Like electrical wiring in a house, genes may be turned on in many places at once, even though the genes might only be needed in one area, such as the eye, comments Francesca Mariani of the Broad Center for Regenerative Medicine and Stem Cell Research at the University of Southern California in Los Angeles. So while the new study can't say what these regulatory changes might do in a human embryo, "this does show how a few small changes could make a big difference," she says.



A stretch of human DNA, when inserted into a mouse embryo, cranks up gene activity in the developing thumb (shown in blue).

The researchers identified a DNA region made up of 546 base pairs, or "letters" of code, which have barely changed during the evolution of backboned creatures. But that region has accumulated 16 changes since the ancestors of chimps and humans split, some 6 million years ago. Thirteen of these changes were clustered within an 81-base-pair region, the researchers report.

To see the effects of the changes, the researchers inserted the human, chimp and rhesus macaque versions of the region into mouse embryos. All turned on genes in the developing ear and eye, and in the embryonic gills, or pharyngeal arches.

But the human version dramatically boosted the activity of genes in the mouse's primordial thumb, forelimb, hind limb and toe, the researchers found.

Thank mom, dad for extra years

Study identifies gene variant that extends people's lives

By Patrick Barry

Life's just not fair. Some lucky people are born with a gene variant that makes them almost three times more likely to live to be 95, new research suggests. On average they're healthier, too.

The gene, *FOXO3A*, is the second that's been shown to affect life span in people. Confirming the discovery requires further studies, scientists agree. But this study, of men of Japanese ancestry, is consistent with previous experiments showing that versions of this gene can extend some animals' life spans by as much as tenfold.

"This is the first evidence in humans that all of these things that we see in animals appear to work in people," says Bradley J. Willcox, a geriatrician at Pacific Health Research Institute in Honolulu and coauthor of the new study, published online September 2 in the *Proceedings of the National Academy of Sciences*.

Previous studies that compared the life spans of family members suggest that genes can account for as much as 50 percent of a person's longevity. Diet, lifestyle and other factors also matter.

If the body were a company, *FOXO3A* would be a middle manager: It takes instructions from a few "big boss" molecules such as insulin, and in turn directs the activity of hundreds of other genes. These underlings control functions that can stem the tide of aging, from repairing DNA to regulating cell death.

Scientists don't know how the variant of *FOXO3A* operates to boost longevity. In previous experiments, animals lived longer if their version of the gene was more active.

AAAS/*SCIENCE*

Numbers

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Quantum physics may offer clues to solving prime number problem

Electron energy levels linked to Riemann hypothesis

By Davide Castelvecchi

If two physicists are right, a single electron might know more about numbers than all of the world's mathematicians. In an upcoming *Physical Review Letters*, the researchers hint that the dynamics of an electron can embody the solution to the nearly 150-year-old Riemann hypothesis, a crucial unsolved problem that has wide and deep consequences for number theory.

Germán Sierra of the Spanish National Research Council in Madrid and Paul Townsend of the University of Cambridge in England propose that when an electron is confined to moving in two dimensions, its possible energy level values might encode the key to the hypothesis.

"They have gone a step forward toward giving a physical description of the Riemann hypothesis," says Jonathan Keating of the University of Bristol in England. He warns, though, that the problem may not have gotten easier as a result.

The hypothesis, or conjecture, was proposed by German mathematician Bernhard Riemann in 1859. It is regarded as important in large part because proving it would help reign in the apparent chaos in the world of prime numbers — whole numbers, such as 2, 3, 5, 7, 11 and so on, that can't be wholly divided by any numbers except 1 and themselves.

The hypothesis also has a $1 million "wanted" sign: The Clay Mathematics Institute in Cambridge, Mass., has offered a cash prize in exchange for the proof.

Mathematicians, at least since Euclid, have known that the list of prime numbers is infinite. But only one pattern has ever emerged from this list of primes. The prime number theorem, proved in the late 1800s, describes how primes become less frequent among larger numbers.

Roughly, it says that from one to 1 million (or 10^6), about one in every six numbers is prime; between one and 1 billion (or 10^9), it's about one in every nine. In general, between one and 10^n, about one number for every n is a prime. (The actual statement includes a correction factor but is similar in spirit.)

At first sight, the Riemann hypothesis has nothing to do with prime numbers. It is a conjecture about a formula called Riemann's zeta function, which calculates a number for every point on a plane. Riemann's intuition was that the "zeros" of the function — points where zeta calculates the value zero — can lie along one of only two straight lines on the plane.

Mathematicians have shown that if the hypothesis is true, it would bolster the prime number theorem, implying there are no wild statistical fluctuations in the distribution of primes. While primes would still be unpredictable, complete chaos wouldn't rule.

Researchers have long suspected that there might be a way to convert the Riemann hypothesis into an equation similar to those used in quantum physics. The zeros of the zeta function could then be calculated the same way physicists, for example, calculate the possible energy levels for an electron in an atom.

Building on the ideas of Keating and others, Sierra and Townsend make that connection a bit more concrete. They suggest that an electron constrained to move in two dimensions, and subject to electric and magnetic fields, might have energy levels that match the zeros of the zeta function.

Demonstrating the existence of such a system, even on paper, would confirm the Riemann hypothesis. The physicists haven't quite done that, though. Their explicit model gives only an approximation of the energy levels they needed.

The Riemann hypothesis says the zeta function cannot be zero except for along two particular lines on the plane. The points where all colors converge into color wheels show some known zeros.

JEFFREY STOPPLE/UC SANTA BARBARA

In the opinion of mathematician Enrico Bombieri of the Institute for Advanced Study in Princeton, N.J., the paper constitutes modest progress. He says physicists still haven't demonstrated a true connection between the function and physics. Until then, he adds, "attempts of this type belong to the works based on 'wishful thinking,' or even 'pie in the sky.'"

Keating, however, is more optimistic. "Maybe it will suggest further developments in the subject," he says. ■

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Sting Op

eration

Scientists use bees and wasps to sniff out the illicit and the dangerous

By Susan Gaidos

It's the ultimate way to pull off a sting: Teach a group of ordinary honeybees to ignore flowers and, instead, focus on vapors from explosives used in bombs. Then send the bees off in teams to sniff out terrorists. Or track the molecular trail of illicit drugs, or even point police to a rotting corpse.

In recent years, researchers have shown that with just a few minutes of training, undercover bees can detect the smell of TNT, methamphetamine or almost any other scent just as the bees would respond to pollen. Wasps' sniffing abilities may also be put to use finding bodies in search-and-rescue missions or helping farmers track infestations that, unchecked, could lead to crop failure or foodborne illness.

Based on these findings, scientists have begun devising an array of chemical detection devices that exploit the insects' powerful sense for scents. At Los Alamos National Laboratory in New Mexico, researchers are putting bees to work in a portable system that, like a trained police dog, could sniff out drugs and bombs at airports, border crossings, military installations and schools. A similar device, called the Wasp Hound, is under development at the University of Georgia. And a British company is working on insect-based detection systems to find explosives in luggage or minefields.

"The general premise is, if it smells, we believe we can train our bees to detect it," says chemist Robert Wingo of Los Alamos' Stealthy Insect Sensor Project.

Wingo says insects are not only cheaper to keep and quicker to train than dogs, but also can pick up scents that canines can't detect. In some cases, the bees perform better than instruments used in the lab.

While these insect abilities have long attracted interest from military and security personnel on the lookout for highly sensitive and portable devices, the concept has been slow to gain favor in the scientific community. Even though insect-based devices have performed well in laboratory settings and controlled field studies, some scientists question whether these devices can be used as reliably as other sensors.

Glen Rains of the University of Georgia's Tifton campus, who coleads the Wasp Hound project, outlined these concerns in the June *Trends in Biotechnology*. "Not only is there a laugh factor in working with insects, but biological systems are sometimes known to be unreliable," he says. "Even search dogs — which are considered the gold standard in the industry — can get tired, bored or cold."

Still, no one denies that insects have a phenomenal sense of smell. Their antennae are covered with thousands of microscopic sensors, allowing them to pick up the faintest odors. Bees, wasps and even moths can learn and remember a wide range of target odors, making them ideal for use in chemical detection systems.

Now several laboratories are stepping up efforts to test insect devices in real-world conditions. Scientists say the studies will provide empirical evidence needed to make the devices more widely accepted as biological sensors. If all goes well, commercial insect sniffing devices may become available within a year.

Buzz bombs and stinger missiles

Military uses for honeybees and other insects date back to ancient times. The Romans used catapults with beehives as projectiles, to unleash the fury of angry bees on the enemy. During World War I, beehives were rigged to topple with trip wires to thwart an approaching enemy.

More recent studies on honeybees and other foraging insects show these small, winged creatures possess other traits that can sting enemy agents. For example, despite their tiny brains, honeybees are quite intelligent and can be easily trained using classical conditioning techniques. Just like Pavlov's dogs, which learned to associate a ringing bell with dinner, bees and wasps can be trained to associate a smell — vapors, say, of a liquid explosive or decaying corpse — with a sugary treat.

In the early 1990s, the U.S. military began studying ways to use free-flying bees to help search for hidden explosives. The idea was to train the bees to prefer the scent of a particular explosive, and then set them free in the hope that they would hover over any nearby threats.

"The problem was, it's hard to track a bee whizzing by at 15 miles per hour,"

POLKA DOT IMAGES/SUPERSTOCK

Wingo says. Never mind tracking a large group. "Technologically, it's an extraordinary challenge. Number two: How do you prove the associative conditioning?"

Enter Tim Haarmann, an entomologist working at Los Alamos at the time. With Wingo and microbiologist Kirsten Taylor-McCabe, also of Los Alamos, Haarmann found a more practical way to harness honeybees' scent-abilities by restraining and individually training bees in a box. The team then combined insect behavior and technology to track the bees' responses. The result: a portable device with a team of five bees as its sensor.

The bee bomb detector is about half the size of a shoe box and weighs roughly two kilograms (four pounds). From the outside, it looks like a plain box with a few air holes. Inside, lined up in a row and strapped into strawlike tubes, bees are exposed to puffs of air as a video camera monitors their reactions. The camera is tied to pattern-recognition software that signals when a bee responds to a scent.

A, Bee, C's of detection training

Though bees can't bark when they encounter a target scent, they do have a way of communicating that the camera can catch. It turns out that a hungry bee will stick out its tongue in anticipation of a meal. Bees will also stick out their tongues when a drop of sugar water is touched to their antennae. Pair the sugar drop with the scent of TNT or C-4 plastic explosives half a dozen times, and the bees will extend their tongues at a whiff of the explosives alone. This response, called the proboscis extension reflex, can assess the bees' reaction to a particular scent.

"A honeybee will not stick out its tongue for any other reason than to eat. So we can train bees to associate food with a particular scent," Taylor-McCabe says. "It's an unambiguous signal that the honeybee gives us to indicate yes or no."

Wingo and Taylor-McCabe are using this approach to train forager bees to detect a wide range of compounds, including methamphetamine and cocaine. The honeybees can even detect triacetone triperoxide, or TATP, an explosive that canines often have trouble detecting. TATP was the detonator carried by the "shoe bomber" in his attempt to destroy a commercial aircraft with plastic explosives in his shoe.

Bees can be trained to detect multiple scents and taught to pick up a single scent from a bouquet. The bees can also pick up the scant molecular trail of vapors too faint to be detected by lab instruments. In trials at Los Alamos, the bee detectives performed better at detecting minute traces of explosives than ion mobility spectrometers, which are used to swipe luggage and clothing in airports.

"We haven't quantified exactly how low their threshold is, but the bees are able to detect the explosives at concentrations below that stated of the detection instruments in our lab, and that's generally in the low parts per trillion," Wingo says.

A British firm, Inscentinel Ltd., is developing a bee-based detection device that relies on a team of 36 bees. Mathilde Briens, research and development manager, says the company is investigating ways to pack twice that many bees in a single unit, allowing them to screen up to a dozen chemicals at once.

"It's mainly an engineering issue," she says. "We need to make sure all the bees are exposed to the scent and find ways to manage all the bees so we know when they are responding."

Dances with wasps

While wasps don't stick out their tongues in response to a scent, they do communicate with each other—through dance. The University of Georgia's Rains and his collaborators have developed a small, portable odor detector that relies on the body movements of tiny black wasps called *Microplitis croceipes* to sense odorants. Also known as parasitic wasps, these social bugs use their keen sense of smell to seek out meals and find a host in which to implant their offspring. If their efforts prove successful, they signal the news to peers through a series of carefully choreographed movements—with different dances to signal food versus host.

Rains' group is exploiting the wide range of such movements to build biological sensors with wasps capable of detecting more than one odor. For example, a wasp trained to associate a specific odor with a food reward will press its antennae down onto the source of an odor. If scientists present a different target odor while the wasp is stinging its host, the wasp will display coiling behavior, rearing up on its hind legs and

Training Wasps to Detect Odors

	Wasp	Stimulus	Response
Before conditioning		Food	Food-searching behavior
		Target odor	No response
Conditioning		Target odor and food	Food-searching behavior
After conditioning		Target odor only	Food-searching behavior

Through Pavlovian conditioning, wasps can learn to associate odors with food. These wasps will display food-searching behavior when presented with the odor alone.

RAINS *ET AL.*

bending its antennae the next time it encounters that scent.

Similar to the bee-based detector, the Wasp Hound houses a team of trained wasps in a handheld, ventilated cartridge. At one end of the cartridge, a small fan draws outside air through a hole. If the wasps don't recognize an incoming odor, they continue flying about. If they do recognize the scent, they cluster around the opening, where a miniature video camera records their movements and sends images to a laptop for analysis.

In an early field trial designed to compare the detection limits of the Wasp Hound to an "electronic nose," the insect detector proved to be 74 times more sensitive to fungi than the mechanical device, and 94 times more sensitive to plant odors. That study appeared in *Transactions of the ASAE* in 2004.

Rains and his collaborators are now working to make the device even more sensitive. Don Kulasiri of Lincoln University in Christchurch, New Zealand, is developing mathematical models that will enable him and his peers to better understand and interpret insect responses.

By analyzing the wasps' responses to chemical stimuli at different concentrations and tracking any resulting changes in their behavior, the scientists aim to develop a device that not only detects a specified chemical but also can accurately measure its concentration.

"What that holds for us is potentially developing a device that's not just yes-or-no but is concentration-specific to some level," says Rains, who along with his colleagues, reviews the efforts in the August *Entomologia Experimentalis et Applicata*.

Ideally, the scientists say, the device could be carried into farm fields and grain stores to check for contaminants and disease. The group is now using a prototype Wasp Hound to detect aflatoxin, a toxin produced by a fungus that grows on peanuts, corn and other plants. Trials suggest the device may provide a better way of detecting the toxin before crops enter the food supply, Rains says.

"Current detection methods rely on just a subsample of a large quantity of material, so there's a possibility of missing it when it's there," he says.

A honeybee receives a fragrant reminder of its target scent each morning and responds by sticking out its proboscis.

LEROY N. SANCHEZ, LOS ALAMOS NATIONAL LAB

The group is also investigating ways to detect infestations of *E. coli*, salmonella and other food contaminants. The Wasp Hound may also be used for security and forensics, and has the potential to detect volatile compounds in human breath associated with diseases such as cancer and tuberculosis, Rains says.

Giving it the sniff test

Though insect sensing systems have performed well in laboratory settings and controlled field studies, the devices have yet to prove themselves to be reliable in real-world applications.

This summer, scientists began putting the devices to the test. In a field trial in July, the Wasp Hound went nose-to-nose with a team of five nationally certified human rescue dogs to detect soil contaminated with the scent of human remains. The results will be presented in February at a meeting of the American Academy of Forensic Sciences.

This fall, the bee bomb-detection device is being used in a blind test by a small-town police force to sniff out explosives during a training exercise, and will be done in concert with a canine team.

Jeffery Tomberlin, an entomologist at Texas A&M University in College Station, is working with Rains to carry out the field trials with rescue dogs. He says using insects as biological detectors offers several advantages over dogs. For example, insects can be used to detect chemicals in situations such as arson, where toxic fumes may pose a danger to the dog or its handler. Living-insect sensors can also be put in the hands of someone who is not trained to work with dogs.

"Another advantage is that you don't have to worry about the wasp trying to provide a response simply because it wants to please its owner," he says.

Still, not all scientists are convinced that the insect sniffing devices will fly. University of Hawaii biologist M.E. "Jeff" Bitterman, a pioneer in the field of honeybee learning, says insects such as bees are constantly picking up on new chemical cues in the environment. Even when trained to only one scent, the bees will generalize and begin to respond to other similar scents, he says.

"In order to get a bee to respond only to the odor you're interested in, you have to do what's called differential reinforcement, which means you present some other odor without sucrose until the animal responds differentially, and that may take several trials," Bitterman says.

Moving to the real world presents other obstacles, Bitterman notes. "It is one thing to assert that a forager from an established hive can detect explosives in a dish under standard field conditions but quite another to decide how to use that ability in screening the contents of a shipping container at a pier or on a highway."

Still, scientists working to build the insect devices say these obstacles can be overcome. Wingo and his group reinforce their bees' learning every day with a "breakfast boost," providing the scent of interest with the bee's morning meal.

Despite the repeated training sessions, and the occasional sting, Taylor-McCabe says the effort is worth it.

"Bees are wonderful insects for detection devices," she says. "They give us an unambiguous answer, and they work until the minute they die." ■

Susan Gaidos is a freelance science writer based in Cape Elizabeth, Maine.

Explore more

- Glen Rains *et al*. "Using insect sniffing devices for detection." *Trends in Biotechnology*. June 2008.

Breaking the Barrier

A technique combining ultrasound pulses with microbubbles may help scientists move therapeutic drugs across the brain's protective divide

By Tia Ghose

A blog entry on the Sussex Amateur Brain Surgery Club's website boasts that "these days, brain surgery is very much the preserve of professional surgeons, but we at the Amateur Brain Surgery Club believe that anyone can do it, with a few basic tools and a little care."

The post is a spoof, but whoever penned those words may be on to something.

The right tools *could* make treating the brain a simpler, less invasive process. Researchers have zeroed in on two such tools — sound waves and microscopic bubbles — that may eventually allow doctors to tackle a range of brain ailments, all without opening the head.

Although many medicines could work wonders for certain brain disorders, the majority of drugs can't get from the blood to the brain. Tumor-shrinking compounds used in other parts of the body are too big to float through the tiny gaps in the brain's blood vessels. So doctors treating brain tumors must still poke a hole in the head and cut out the offending mass. Without effective methods for drug delivery, promising treatments for brain ailments like Alzheimer's have also stalled.

"People have calculated that about 97 percent of large molecules that could be useful in treating brain disorders cannot be used because they cannot get through the blood-brain barrier," says Kullervo Hynynen, a medical biophysicist at the University of Toronto in Canada.

But researchers have been making inroads, finding ways to slip larger molecules into the brain's tissue. Those deploying microscopic bubbles and ultrasound — sound waves above the audible range — to squeeze drugs through vessel walls and into the brain are leading this trend. The method has been tested only in animals so far. But if perfected, the technique could combat diseases like Alzheimer's, Parkinson's and cancer.

Keep out

In the late 19th century, bacteriologist Paul Ehrlich injected dyes into rats' bloodstreams, hoping to gain insight into the structure of cells. But when he dissected the animals, he found a peculiar thing: While the liver, lungs and other organs were stained bright red, the brain didn't soak up any color. He didn't realize it then, but Ehrlich had inadvertently discovered the blood-brain barrier.

The barrier, a tightly packed layer of cells lining the brain's blood vessels, protects the brain by keeping most molecules out. A molecular bouncer, the barrier uses special gatekeeping receptor molecules to actively escort in a select few chemicals, like energy-packed glucose, while denying entry to most large and highly charged molecules. The restrictive junction makes sure blood, toxins or nasty bacteria can't enter the brain and wreak havoc. But when a person develops a tumor or Alzheimer's disease, this same neural lockdown prevents doctors from getting medicine where it's needed most.

More than a hundred years since Ehrlich's work, methods for safely relaxing the barrier are still in short supply. Some chemicals, such as mannitol, can do the trick, but they have broad effects, opening the barrier across the entire brain, says neurologist Brian Bacskai of Harvard Medical School and Massachusetts General Hospital's campus in Charlestown. Mannitol, used to lower blood pressure inside the head, can also alter cellular function in other parts of the body. A few small molecules, such as those used to treat depression and epilepsy, can cross the divide. For the most part, though, getting medicine into the brain still requires opening the head and injecting drugs directly into the tissue.

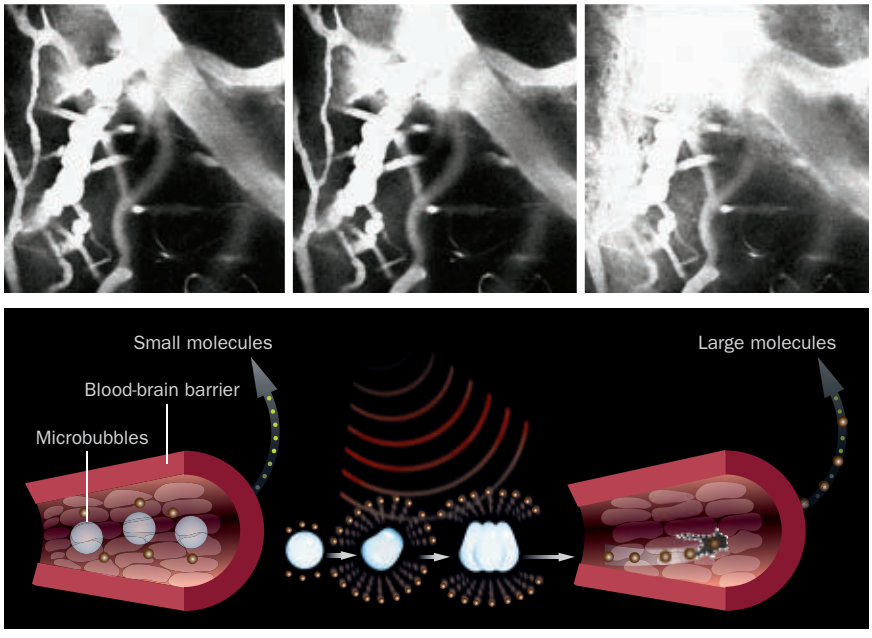
Blowing bubbles

Since the 1950s, scientists have known that pulsing ultrasound through the brain can temporarily open the blood-brain barrier in animals, but only at intensities that cooked the tissue, says Hynynen, a pioneer in the field. For many years, every attempt to relax the barrier with ultrasound caused permanent brain damage.

Then researchers looked to an existing ultrasound method — enhanced Doppler blood flow imaging. Like the sonar used by bats and ships, basic ultrasound images the inside of the body by measuring reflected sound waves. Doppler ultrasound shows movement, such as blood flowing through blood vessels. Clinicians can increase the sensitivity of the technique by injecting commercially available microbubbles into a patient's circulatory system. Short ultrasonic pulses trigger the microbubbles to oscillate, enhancing the images.

Microbubbles can encase a gas or fluid within shells made of water-soluble proteins or fatty lipids. The secret weapon is "just like a soap bubble, only it's stable in

LENNART NILSSON



Ultrasound and microbubbles enable a fluorescent dye in blood vessels to cross the blood-brain barrier (top) and seep into surrounding brain tissue. The bubbles' movements, triggered by sound waves, somehow open temporary spaces between the cells lining the brain's blood vessels, letting larger drugs pass through the barrier (bottom).

the bloodstream," says Ralph Shohet of the University of Hawaii at Manoa, who uses ultrasound and microbubbles to deliver gene therapy to the heart, brain and pancreas.

The bubbles, typically a bit smaller than red blood cells, can travel through the circulatory system without forming an embolism — an air bubble that lodges in the heart, lungs or brain, Shohet says. What's more, the FDA has already cleared microbubbles for clinical use.

By tweaking the existing Doppler approach, Hynynen and his colleagues have nudged the blood-brain barrier open. Their technique involves injecting microbubbles as well as a target drug into the blood vessels of mice or rabbits. The bubbles and drug quickly reach capillaries in the brain. The team then aims ultrasonic pulses at the microbubbles floating in the brain's blood vessels, usually for several milliseconds.

Lengthening the burst duration from microseconds to milliseconds makes the blood-brain barrier permeable to the medicine.

"The difference between therapy and imaging is the pulse length," says biomedical engineer Elisa Konofagou of Columbia University.

In 2001, Hynynen's group reported in *Radiology* that the microbubble-ultrasound combination could send molecules through the barrier without lasting damage. Focused ultrasound can also target regions just a few millimeters wide.

In animal models, the treatment made vessel walls leaky for up to six hours, Hynynen's team found. After that, at least in those animals treated with the lowest power ultrasound, the barrier sealed up. Studying these animals' brains under a microscope, researchers found no obvious signs of damage — no errant blood cells in brain tissue and no quirks in the shape or structure of nerve cells. At certain powers and frequencies, ultrasound and microbubbles seem to open up the brain in a reversible way.

Under pressure

Researchers haven't pinpointed exactly how the technique causes reversible opening of the blood-brain barrier. The short ultrasound bursts don't generate much heat, so people doubt the effect is thermal. Instead, mechanical forces may play a crucial role, says Kathryn Nightingale, a biomedical engineer at Duke University in Durham, N.C., who studies advanced ultrasonic imaging techniques.

Sound waves are simply localized waves of pressure variation. So when researchers target microbubbles with ultrasound, the bubbles shrink and expand in response to these changes in pressure.

When the microbubbles undergo these quick oscillations, the blood flowing around the bubbles gets squeezed and expanded too. The streaming blood appears to shear the nearby blood vessel wall, according to a paper in the June *Advanced Drug Delivery Reviews*. Hynynen's team speculates that the forces caused by these streams may lead the receptor molecules in the barrier membrane to actively transport more molecules across the blood-brain divide.

The rapid pressure changes can also pitch the throbbing bubbles themselves against the vessel walls. This may stretch the tightly joined barrier cells, widening the narrow spaces between them and letting larger molecules sneak through.

At higher pressures, ultrasound forces bubbles to pop violently, creating shock waves that send jets of fluid slamming into vessel walls. The jets may poke tiny holes into the barrier that chemicals could pass through.

Many questions remain about how the microbubble-ultrasound duo opens the barrier and how to optimize the technique. Scientists are looking at, among other things, different sizes and motions of microbubbles — popping or vibrating — to better understand how to use the technique most safely and effectively.

Early research is beginning to offer clues. In past experiments, scientists had no way of knowing whether small or large bubbles were essential for opening the barrier. But Konofagou's team has been sorting microbubbles by size and studying their effects separately.

Her group, reporting July 1 in Paris at the Acoustics '08 meeting, found that bubbles larger than 4 micrometers — those that are more likely to expand and contract without popping — tend to produce larger open regions in the blood-

FROM TOP: S.B. RAYMOND *ET AL./JOURNAL OF CEREBRAL BLOOD FLOW & METABOLISM*, 2006; J. KORENBLAT

brain barrier. When larger bubbles swell, they may get stuck in the capillaries and push on the vessel walls around them, Konofagou says. Smaller bubbles — which models predict are more likely to collapse violently — open smaller spaces.

And bubble collapse may do more harm than good. In the August *Ultrasonics*, Hynynen and his colleagues report that the blood-brain barrier can be opened without bubbles popping, which appears less damaging to nearby tissue. Popping bubbles have been linked in some studies to more red blood cells seeping into brain tissue, a sign of stroke.

Different diseases, same bubbles

A number of groups have harnessed this bubble behavior to test potential new therapies in animals. Shohet's gene therapy research group combines ultrasound and microbubbles to ferry genes into brain tissue. Naked DNA injected into the bloodstream would get chewed up before it could enter a cell. But attaching a gene to the outside of a bubble protects the DNA until it reaches its target. So Shohet's group tags the bubbles with DNA and sends them through the bloodstream into the brain's vessels. Then the team hits the bubbles with ultrasound.

The collapsing bubbles pockmark surrounding cells. Part of a bubble's shell juts through a tiny hole and hurtles a bit of the gene into the brain tissue, where the gene makes its way into brain cell nuclei, Shohet speculates.

Hynynen's group uses focused ultrasound to deliver cancer-fighting compounds to the brain. One drug is Herceptin, an antibody used to treat breast cancer. Since breast cancer often spreads to the brain, the drug could be a powerful tool for battling secondary tumors. On its own, though, the bulky molecule cannot cross the barrier.

To get around this, the team injected microbubbles into mice and rabbits with brain tumors. Using MRI to locate the brain tumor, researchers directed bursts of ultrasound at the blood vessels near the tumor, opening the barrier locally and allowing the intravenously administered Herceptin to enter.

Both Bacskai's and Konofagou's groups use the new technique to study Alzheimer's disease. Bacskai uses ultrasound to push larger chemicals into brain tissue for improved imaging. Konofagou's team targets the hippocampus, a brain region important for memory. Her group hopes to move antibodies across the barrier that will target amyloid-beta deposits — clumps of toxic proteins implicated in Alzheimer's. She also studies the substantia nigra region of the brain, where problems appear in Parkinson's disease.

All these techniques require that the drugs — whether bound to microbubbles or not — be administered through an IV. This can cause problems with some chemotherapy medicines, which can enter various organs along the way to the brain, sickening the entire body.

Konofagou says that one approach to improve targeting would be to encapsulate therapeutics inside the bubbles. In this scenario, bubbles would sequester medicine, keeping it from acting on any other parts of the body. The drug could be activated only when the bubbles are hit with sound waves, so treatments could be delivered just to the brain tissue, where needed.

Obstacles ahead

Though promising, the method is "still a pipe dream," Bacskai says. "But it's not completely out of the realm of possibility."

Researchers first need to show that the treatment is safe, Hynynen says.

His group does this by carefully examining brain tissues from treated mice and rabbits. The team looks for signs of red blood cell leakage, any unhealed openings and damage to brain cells and the cells that make up the blood-brain barrier.

"People have calculated that about 97 percent of large molecules that could be useful in treating brain disorders cannot be used because they cannot get through the blood-brain barrier."

KULLERVO HYNYNEN

But such measures can't reveal more subtle damage. Looking at the tissue of a dead animal is an imperfect measure of brain function, and tracking behaviors like grooming in mice can only uncover severe problems, Bacskai says. "Permeabilizing the membrane, even temporarily, is most likely going to have side effects you might not like, at least a headache," Bacskai says. "But mice don't complain about having a headache."

Also unclear is whether getting drugs across the blood-brain barrier is enough. No one has shown that ultrasound-targeted drugs can penetrate nerve cells. Yet that's where the drugs are most needed for diseases like Alzheimer's and Parkinson's, says Konofagou. "Just getting through the barrier is not the whole story."

And though Hynynen can target cancer drugs to tumors, he hasn't shown that treated animals live longer than their untreated counterparts. So his team has begun testing to see if the approach prolongs survival in mice.

Shohet believes scientists will also need to boost the amount of material reaching brain tissue. The tactic he uses to deliver gene therapy, for instance, "is a very inefficient method because only a little bit of the payload of the bubble is delivered," he says. But a small amount of gene therapy can have big effects downstream.

Scaling the technique to human skulls may also stymie researchers, Shohet says. Ultrasound easily penetrates the delicate skulls of rats and mice. But thicker human skulls pose more of a challenge. Researchers may have to amp up the power of the ultrasound, which could increase the risk of tissue damage, he says.

Still, the need for barrier-breaking is all too apparent. Promising new drugs may be waiting in the wings, but most will be shelved until someone finds a safe way to get them across the divide. ■

Explore more

- K. Hynynen. "Ultrasound for Drug and Gene Delivery to the Brain." *Advanced Drug Delivery Reviews*. June 30, 2008.

Working in an underwater tank that simulates the weightlessness of space, astronaut Drew Feustel practices using a power screwdriver specially designed for Hubble repair.

Last Call

By Ron Cowen

The final mission to the Hubble Space Telescope, set for early October, could radically transform the observatory, but the crew faces some special challenges

Loosening a half-inch screw may not sound like a job for a rocket scientist.

But now imagine performing that task 32 times with your hand inside a pressurized glove so stiff it's hard to bend your fingers, let alone grab a screwdriver. Now try holding on to the screwdriver in your gloved hand but while you're floating in space. One additional obstacle: A strut blocks direct access to the screws.

That's just one of the challenges facing the crew of the space shuttle Atlantis, set to pay a final servicing call to the most celebrated observatory in history—the Hubble Space Telescope.

From its breathtaking images of star-forming regions in the Milky Way to its measurements of distant supernovas confirming that the universe is revving up its rate of expansion, Hubble has both revolutionized astronomy and captured the imagination of the public.

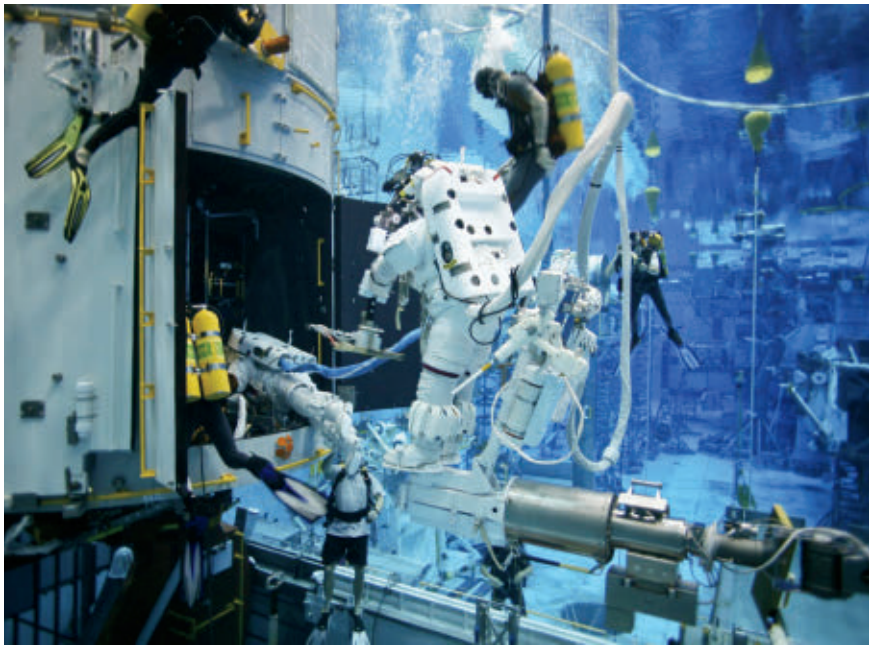
If all goes according to plan, this last mission will transform Hubble, in orbit since 1991, into the most powerful imaging tool and spectral analyzer ever to operate in space.

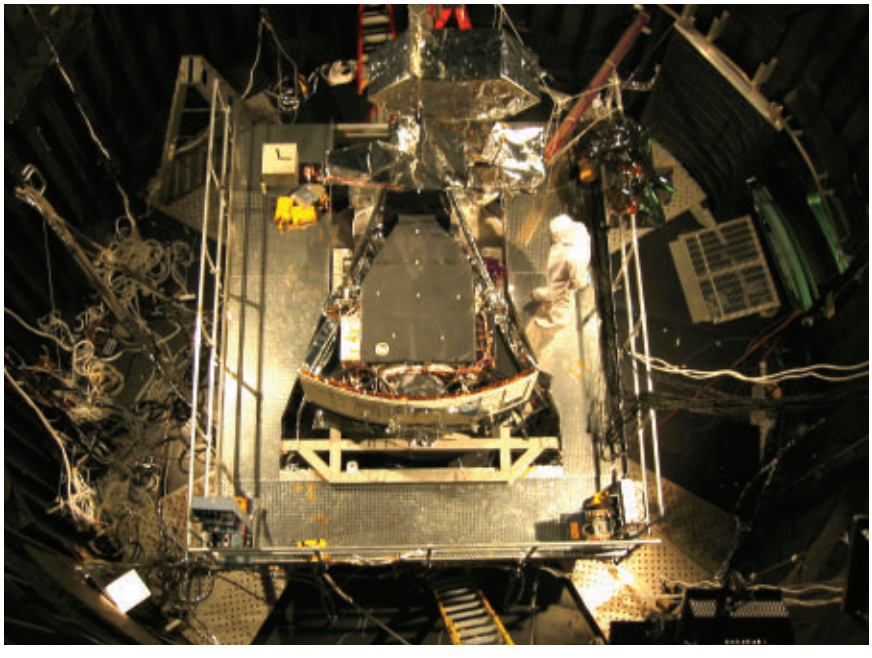
A new instrument, the Wide Field Camera 3 or WFC3, will capture the portraits of stars and galaxies at wavelengths ranging from infrared to ultraviolet and examine the evolution of galaxies over 13 billion years of cosmic history. Because it can capture such a range of colors, the camera will be able to record, for example, the entire population of stars in a nearby galaxy—both elderly, reddish stars and newborn, bluish stars.

"The Wide Field Camera is going to blow people's socks off," says astronaut and Atlantis crew member John Grunsfeld. About 20 times more sensitive than Hubble's current wide-field camera, WFC3 can record across many wavelengths, simultaneously. With it, astronomers can take a multiwavelength portrait of a celestial object in a single snapshot. "This is the first hyperspectral camera to go up on Hubble," Grunsfeld says.

WFC3, in tandem with a revived Advanced Camera for Surveys, or ACS, "is

JSC/NASA





Astronauts do what they can to prepare for the conditions they will experience in space. At NASA's Johnson Space Center, astronauts practice repair maneuvers on an underwater, life-size mock-up of the Hubble Space Telescope (top). In a clean room at NASA's Goddard Space Flight Center in Maryland, technicians prepare by testing instruments to be installed in space (bottom).

FROM TOP: JSC/NASA; GSFC/NASA

just a gangbusters combination for imagery," says senior Hubble scientist David Leckrone of NASA's Goddard Space Flight Center in Greenbelt, Md.

The mission's success would also give Hubble a full toolbox of instruments for the first time since 1993, when the observatory's photometer was removed to make room for COSTAR, the corrective optics that compensated for Hubble's flawed primary mirror.

And the upgrade, expected to last five years, could make Hubble a leading observatory for studying the atmospheres of planets beyond the solar system.

With a repaired and refurbished Hubble, "this could be the decade when we find an Earthlike planet" beyond the solar system, Grunsfeld says.

Not bad for a mission that almost never happened.

Temporarily grounded

It was in January 2004, nearly a year after the demise of the Columbia space shuttle and its crew, that then–NASA-administrator Sean O'Keefe announced there would be no more shuttle missions to service Hubble. It was just too risky, he said. Despite the results of a National Academy of Sciences study indicating that the risk to service Hubble was not significantly greater than a shuttle trip to the space station, O'Keefe refused to reconsider.

"For the first time in my life, I was truly stunned," recalls Grunsfeld. "It was like someone had hit me with a two-by-four.... The fact that I was the chief scientist at NASA and wasn't in the decision matrix is another whole story."

O'Keefe did tell scientists at NASA-Goddard that they could work on other ways, short of a shuttle repair mission, to prolong Hubble's life. And that they did. "We managed to keep the team intact, and managed to do engineering work that was useful not just for Hubble" but also for other missions, Leckrone says.

"We knew fools would come and go, but if we could stick together and keep doing work toward the mission, that some day it would be made to happen," he adds. "Of course the wonderful thing is that we got an administrator [Michael Griffin] who was a very technically astute person. And he didn't just have to rely on what people told him."

Moreover, notes Leckrone, the new spectrograph and camera for Hubble were already in the works, first designed in the mid-1990s. "We're just trying to finish the work that we started," he says.

A new task not in the original plan is to fix two dead instruments on-orbit. "We've learned how to take instruments out and put them in, how to open the

telescope, how to close the telescope," says Hubble deputy program manager Mike Weiss of NASA-Goddard. "But now we're adding something to it that we do not have any experience for — in situ instrument repair."

Maneuvers in space

"I describe [the mission] as running a marathon at a sprint pace," says Grunsfeld, who has flown on three other missions to repair Hubble. After inspecting the shuttle for damage and reconfiguring the shuttle's orbit, the astronauts will grapple with the telescope, installing it in the shuttle's payload bay. Each space walk, notes Grunsfeld, requires a different set of some 40 tools.

"One trait that makes this mission unique compared with the others is the instrument repair work," says Hubble mission manager Preston Burch of NASA-Goddard. "We've raised the bar on this mission, in terms of complexity and difficulty for the astronauts. We've had to build a lot more tools for this mission, and we've had to do more training than was anticipated."

Another new device the crew will install is the Cosmic Origins Spectrograph, or COS, which will separate ultraviolet light into its component wavelengths. The spectra will provide new information on supernova remnants, the expanding rings of debris encircling exploding stars. COS will also examine young stellar objects, trace the largest visible structures in the universe — galaxies that have clumped into mammoth superclusters — and search the gas between galaxies for missing ordinary matter. The Big Bang model predicts that more of this matter exists in the universe than has been detected.

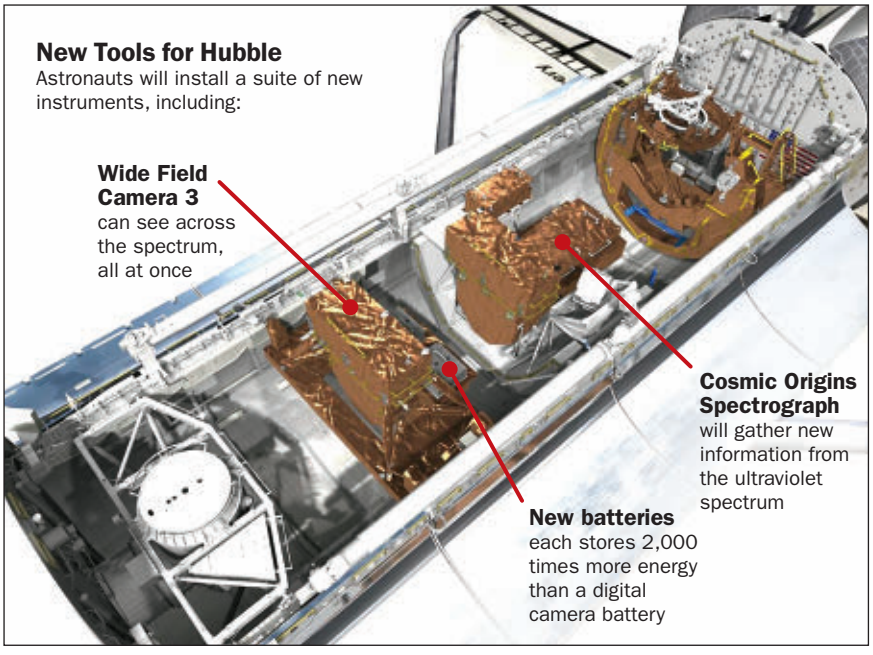
Along with installing new instruments, astronauts will revive two existing workhorses, the ACS and the Space Telescope Imaging Spectrograph, or STIS. ACS has taken the sharpest visible-light images in orbit and has been the main camera capturing Hubble's historic images. STIS is equipped to study planets outside the solar system.

Neither instrument was designed to be taken apart and repaired in space, but that's just what Grunsfeld, along with a crew of six other astronauts, will attempt.

Sprucing up a planet hunter

Installed in 1997, STIS separates ultraviolet light into its component wavelengths to reveal the chemical composition and temperature of gas and stars. It adeptly measures the composition of the atmospheres of extrasolar planets.

In combination with STIS, WFC3 would also hold particular promise for finding planets beyond the solar system and studying their atmospheres, notes Grunsfeld. The new camera can find small transiting planets — orbs as small as twice Earth's diameter that periodically block a tiny amount of light from their



parent stars as seen from Earth. Spectra taken by STIS will help scientists study the starlight that filters though the transiting planet's atmosphere, revealing its chemical composition.

In 2004, the STIS power supply failed and engineers determined that the problem resided within a printed circuit board. NASA scientists were already planning to repair STIS when ACS stopped operating in 2007 after a backup power supply of a unit that had failed a year earlier also experienced a short circuit.

Leckrone says that it had seemed at the time that fixing both STIS and ACS on one, already oversubscribed repair mission would overtax astronauts. But as engineers explored the possibility, they realized some of the maneuvers required to fix ACS were similar to those already planned for STIS.

STIS and ACS require access to failed or no-longer-needed circuit boards, which astronauts will have to pull out of the instruments while wearing pressurized gloves. To open up STIS, astronauts will need to remove 111 screws — all in the few hours allowed for a typical space walk.

Engineers at NASA-Goddard have developed a high-speed power screwdriver with low twisting action that can remove the screws quickly without breaking them. Metal shavings, loose screws and other floating debris from the repairs could damage the delicate, precisely aligned instruments on Hubble.

To contain the screws, engineers have developed capture fastener plates that fit over the access panels of the two instruments. Tiny holes in each plate, which match up with the positions of the screws, are big enough to allow astronauts to insert a drill bit but small enough to contain the loosened screws. When all the screws are loosened, the entire capture plate is removed as a single unit, safely taking all the debris with it.

Unwanted or damaged circuit boards will be removed and a new cover panel will be snapped in place with leverlike latches instead of screws.

Although STIS has many more screws than ACS, the instrument is directly accessible. "When you open the doors to Hubble for the STIS repair, you look right at the panel," Weiss notes. "If you keep going you'd run into it."

In contrast, the ACS repair involves only 32 screws. Because the camera is partially hidden behind a strut, Grunsfeld, the designated astronaut for this repair, will have to operate the power screwdriver at an angle and perform some of the maneuvers solely by feel rather than by sight. He will also hang a new low-voltage power supply outside the instrument, overriding the damaged components.

"I'm actually looking forward to it in a sick kind of way," Grunsfeld says.

During five planned space walks, the crew will replace all six of Hubble's gyroscopes, devices that keep the telescope stable and pointing precisely at celestial targets. Only three gyros are still working, and Hubble has been relying on only two since 2006, reserving one in case of failure. One of the two now in use recently showed a spike in its motor current, a sign that it could be failing, Burch says.

Astronauts plan to replace all six nickel-hydrogen batteries, which unexpectedly have survived 18 years. The batteries weigh a collective 960 pounds, and each stores 2,000 times as much energy as that in a typical digital camera battery.

The crew will also cover Hubble's thermal blankets with new stainless steel panels, ensuring that the craft is protected from the extremes in temperature it experiences 15 times a day, each time it passes out of Earth's shadows and into sunlight. Over time, the exterior of some of the old blankets, made of 16 layers of aluminum with an outer layer of Teflon, have cracked.

The astronauts will be on a particularly tight schedule, notes Weiss. The crew will spend the first day and a half photographing the heat-shield tiles on the shuttle and making sure the tiles haven't fallen off or severely degraded as they did in February 2003 on the doomed Columbia flight. Adding an extra space walk to the five already scheduled isn't an option, says Grunsfeld, since exhaustion usually sets in after four or five space walks, even with crew members alternating tasks.

"The new instruments, the batteries and the gyros that will be changed out, we've tested the bejabbers out of them," Burch says. "Those jobs have been done routinely on other missions. The in situ repairs, we've never done that before, and all we can say is stay tuned." ■

Explore more

■ For more on Hubble, visit www.nasa.gov/mission_pages/hubble

NASA

Hyping Health Risks: Environmental Hazards in Daily Life and the Science of Epidemiology
Geoffrey C. Kabat

Health scares come and go, but they often have a tenuous scientific basis. Kabat, a cancer epidemiologist,

systematically rips through cancer alerts that overrode scientific rigor in recent decades. In so doing, he dispels the dubious science underlying the scares and explains how public confusion can come about.

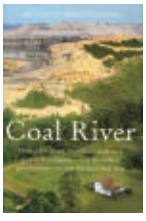
A 1993 study, to take an example, linked breast cancer and environmental pollutants. The study connected DDT exposure to breast cancer at the very time women on New York's Long Island had begun an activist campaign to "discover" the cause of what appeared to be a cluster of breast cancers there. Only after a federally funded, seven-year study found no link to DDT or other pollutants did the issue subside.

People want explanations for cancer. "In retrospect, it is striking how disposed the public was to believe that some form of environmental pollution ... must be involved in the development of breast cancer," Kabat writes.

He extends his critique to debates linking radon gas exposure and secondhand cigarette smoke exposure to lung cancer. Those chapters will ruffle some feathers, but Kabat is unafraid of controversy.

"The potential for isolated or limited findings to be transformed into major health hazards should alert us to the need for skepticism," he concludes. And the need for good science. —*Nathan Seppa*
Columbia University Press, 2008, 250 p., $27.95.

The Brightest Stars: Discovering the Universe through the Sky's Most Brilliant Stars
Fred Schaaf
Facts and legends about the 21 brightest stars in the night sky.
John Wiley & Sons Inc., 2008, 281 p., $19.95.



Coal River
Michael Shnayerson
A *Vanity Fair* journalist exposes the ongoing battle between West Virginia activists and the company whose mountaintop mining threatens their homeland.
Farrar, Straus and Giroux, 2008, 321 p., $25.

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A climate tipping point

In Janet Raloff's article "Forest invades tundra" (*SN: 7/5/08, p. 26*), there seems to be a paradox. Raloff says that the albedo from normal snow coverage of the tundra "helps maintain the region's chilly temperatures," implying that the coverage also preserves the mats of plant matter. A little later in the article, Ken Tape explains how the arrival of tiny shrubs traps snow, insulating and warming the soil beneath and stimulating the growth of bacteria. At what point does snow's effect change from a chilling blanket that preserves the tundra ecology to a warming blanket that stimulates bacterial and plant growth?
Doug Stuart, Glenview, Ill.

Once shrubs move in, the effect can change. Although snow cover can keep the establishment of such greens at bay, if shrubs can make it in and establish roots during warmer summers, then the snow can serve as a warming blanket to help those shrubs survive harsh winters. With each successive summer, the greens can become increasingly larger solar collectors. If they become large enough, they may continue to absorb solar energy even during part of the winter — as trees are doing now in the area of the Urals discussed in the story. — Janet Raloff

Go for the gold

The article "Finding the golden genes" (*SN: 8/2/08, p. 16*) makes it sound like gene boosting is horrible and focuses entirely on those who wish to cheat in an athletic competition. Really, this is great news. I don't want to win the Olympics; I just want access to things that may improve my quality of life. Erythropoietin is wonderful for someone with asthma. Building muscle mass is great news for seniors. Take your tired view of bioethics and darken someone else's door.

As for me, when these items become available on the black or gray market, I will be waiting, cash in hand. We are discussing my quality of life, and the bioethicists don't get a vote.

Additionally, get to work on memory- and intelligence-enhancing products. I fail to see any issues since we are all stuffing ourselves with supplements, vitamins and other enhancement products. Something that actually works would be welcome.
Ralph Hoefelmeyer,
Colorado Springs, Colo.

Super bonding

In "Small, but super" (*SN: 6/21/08, p. 14*), models of the superatoms are shown. I have a question on the first model ($Al_4H_7^-$). You show hydrogen with two bonds. How can it have two single bonds with only one electron?
Skip Hackett, Tampa, Fla.

Indeed, hydrogen can't share electrons with more than one other atom at a time. The bonds in question are hydrogen bonds in which no electrons are shared, similar to the bonds between water molecules in ice. In this case, hydrogen atoms form two such bonds, acting as a bridge, says Shiv Khanna of Virginia Commonwealth University in Richmond. "In atom clusters, it is not unusual for hydrogen atoms to occupy a bridge site between two atoms," he says. — Davide Castelvecchi

Gender in the classroom

Regarding "Girls could give preschool boys learning boost" (*SN: 7/19/08, p. 14*), I am wondering if any difference among the boys would have been seen had the preschool teachers been male.
Elizabeth Oscanyan, Philomont, Va.

This is an interesting possibility that would be hard to test, given the scarcity of male preschool teachers. — Bruce Bower

Unseen whales

The article "Stranded: A whale of a mystery" (*SN: 7/19/08, p. 22*) was disappointing because the tone and quotes implied that the whales found stranded represent the totality of the problem. For example, "We're talking about five animals a year," and "Fewer than 300 whale deaths can be attributed to naval sonar." How do we know that for every stranded whale there are not many more dead ones spread across the ocean floor?
Frank Lawlor, Austin, Texas

The reader is correct. Part of the reason scientists have difficulty assessing how many whale deaths are associated with sonar is that only whales that are found can be counted. Even assessing live whale populations is difficult. — Rachel Ehrenberg

Look at them go

Regarding "Built for speed" (*SN: 8/16/08, p. 14*), my wife and I were on a cruise ship leaving Glacier Bay in 2003. I had my GPS set on miles per hour. Here is an excerpt from my trip journal:

July 17, 2003. It's almost 4 p.m., and we leave the bay and head west through the strait for the Gulf of Alaska. As we move along, at about 13 mph, we notice a seagull flying along beside us 30 feet or so off the water and about 100 yards out. Then there are two, then three.... The boat begins to accelerate and passes 16 mph. The gulls, seven now, are in tight formation, still 100 yards out....

We are up to 22 mph, and the gulls have dropped to the wave tops but now are gaining and climbing. They begin to pull away as we top out at 24 mph, and they disappear ahead. They effortlessly cruise at whatever speed we can go.... By now our boat is at cruising speed, but I think we could put it all the way to flank speed and the gulls would still flank us. It went on for 20 minutes....

No human could do that. Twenty minutes at from 15 to 25 mph is beyond our capacity. I have new respect for the lowly seagull.
Steve Fletcher, Sierra Vista, Ariz.

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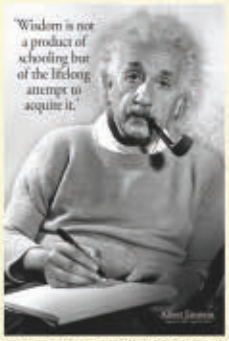

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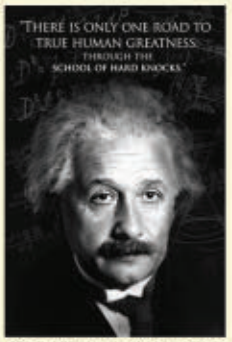

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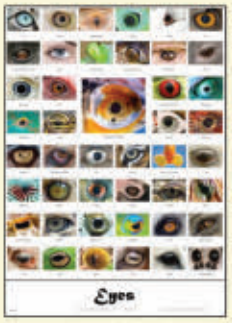

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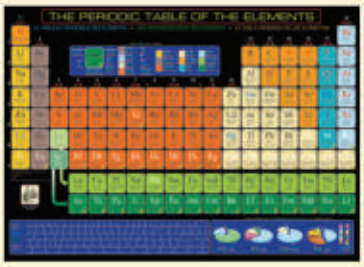

Periodic Table of the Elements Regular
Poster -This periodic table of the elements has the regular information on it. Also it has a picture of Dimitri Mendeleev, a legend denoting: atomic number, electron configuration, atomic weight, atomic symbol and whether the element is radioactive or not. It has the typical color designations according to alkali metals, alkaline earth metals, transition metals, etc...The bottom portion indicates when the element was discovered and the percentage of certain types of elements found in the atmosphere, biosphere, hydrosphere, and lithosphere.Size: 26.5" X 38.5" Laminated. **Order #JPT-JPT-3103, Cost: $16.95**

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Corporate campaigns manufacture scientific doubt

In Doubt Is Their Product, *published in April, epidemiologist David Michaels describes the growing corporate practice of "manufacturing" scientific uncertainty to thwart regulation of products that appear to pose risks. Michaels encountered the practice firsthand with beryllium, a metal used at U.S. nuclear weapons facilities, while he was the Energy Department's Assistant Secretary for Environment, Safety and Health. Now head of George Washington University's Project on Scientific Knowledge and Public Policy, or SKAPP, Michaels spoke with senior editor Janet Raloff about this doubt-generation movement.*

Where did you get your book's title?
It comes from a 1969 memo by a Brown & Williamson tobacco executive. He said: "Doubt is our product since it is the best means of competing with the 'body of fact' " linking smoking with lung cancer.

That tobacco campaign continues to this day, now focused on the issue of secondhand smoke. Before the 1980s, industry could always say that even if smoking does cause cancer, individuals choose to smoke. But as studies emerged showing that nonsmoking spouses also face an increased risk of lung cancer, the stakes changed. Recognizing this potential new liability, the industry hired more and better scientists and strategized how to disparage the cancer studies in order to avoid regulation.

You can document all this?
Absolutely. In great detail. And not just for tobacco. Interestingly, many scientists who initially pioneered this work for the tobacco industry on secondhand smoke now defend producers of beryllium, chromium, pesticides and a whole range of other chemicals by manufacturing doubt about their risks. I even have internal minutes of meetings with trade associations where scientists describe the strategies and studies they need to do for a suspect product to avoid regulation. My research shows that a campaign to generate scientific uncertainty has grown into a very lucrative product-defense industry.

I know I'm making very strong statements, but I support every one of my assertions with powerful documents. We've placed all of my book's 1,100 references at www.defendingscience.org, the SKAPP website.

How widespread is this doubt generation?
A number of corporate scientists, even in the chemical industry, are good researchers with great integrity. But when a product is found to be dangerous, companies and their lawyers increasingly have been turning to what I call mercenary scientists, researchers who will produce the studies needed to question scientific findings suggesting increased risk.

When a product is found to be dangerous, companies and their lawyers increasingly have been turning to … mercenary scientists.

I'm especially familiar with beryllium because I was in charge of protecting the health of workers in the nuclear weapons complex where beryllium is used. This metal slows down neutrons, which makes for a better nuclear blast. Studies … have shown it also causes lung disease at very low exposure levels.

The National Toxicology Program has classified beryllium as a carcinogen, as has the International Agency for Research on Cancer. A National Academy of Sciences panel also came out saying beryllium's a carcinogen.

It's clear the current exposure standard is inadequate. I question whether it's even possible to use beryllium safely.

The beryllium industry has spent many millions of dollars over the past 30 years attacking studies on beryllium's toxicity in order to delay — successfully — revisions to the current Occupational Safety and Health Administration workplace standard. (It was set in 1948 in the back of a taxi by two scientists on their way to a meeting. It's often referred to as "the taxicab standard.") The chromium industry also employed product-defense scientists to question the science OSHA eventually used to issue a more protective standard.

How visible are these doubt campaigns?
The science community is for the most part unaware of what's going on because industry publishes much of this work in "vanity" journals where the peer review is done by scientists who work for the same industries or contract firms. These journals are not widely read. But the papers in them, which can run over 100 pages in length, are often used in regulatory proceedings and the courts. When independent researchers encounter such work, it's important that they draw attention to it — and get critiques of it on the record.

As long as there are corporations looking to limit regulation, they will be looking for scientists who will manufacture scientific doubt for them. It is a strategy that works all too well, and its success can be dangerous to the public's health and to the environment. ■

DAWN GARROTT/GEORGE WASHINGTON UNIV. MEDICAL CENTER

Time travel at the speed of a 1935 Speedster?

The 1930s brought unprecedented innovation in machine-age technology and materials. Industrial designers from the auto industry translated the principals of aerodynamics and streamlining into everyday objects like radios and toasters. It was also a decade when an unequaled variety of watch cases and movements came into being. In lieu of hands to tell time, one such complication, called a jumping mechanism, utilized numerals on a disc viewed through a window. With its striking resemblance to the dashboard gauges and radio dials of the decade, the jump hour watch was indeed "in tune" with the times!

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