The Neandertal in You | Phobos Proves Porous | Life's Shared Ancestor

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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ JUNE 5, 2010

Antidepressants and Baby's Brain

Pushing the Periodic Table's Limits

Science Fair Superstars

The climate fixers

Gearing up to cool the planet

World's Most Romantic Man Pleads Guilty

Gem Dealer Confesses to Crimes of Passion, Surrenders 70-Carat Ruby Masterpiece

"When Guillermo calls about a new ruby necklace... I drop everything."

Complete the collection with the luscious Ruby Teardrop Earrings.

She was an international supermodel who could have had her pick of millionaires, movie stars or royalty. But she fell for him. They all did. I begged him to reveal his secret. There had to be a reason that the world's most beautiful women lined up outside his gem shop. Things got clearer once he showed me the ***70-Carat Ruby Teardrop Necklace***. When he told me that he sold his ravishing red masterpiece for only $7 per carat, everything suddenly made sense.

The World's Most Romantic Man doesn't look like a movie star. He doesn't dress in designer clothes. I don't think he even owns a razor. But on any given day, my old friend's showroom looks like backstage at a Paris runway show. They love what he can do with the planet's most passionate stone.

When I asked how he could afford to offer 70 carats of natural ruby at such a low price, he shrugs. "I confess," he said. "I am guilty of romancing too many women. I cannot help myself. I want to make them happy." Selling genuine rubies at $7 a carat is definitely enough to make anyone happy... but I knew he could do even better. And I told him so.

Haggling was brutal, but the talks took a turn in my direction when I pointed out that I was interested in more than just a few necklaces. I was ready to buy thousands of carats at a time and wanted to make the ***Ruby Teardrop Necklace*** available for ***under $300***. "Imagine," I said, "Your necklace could become a Weapon of Mass Seduction." He smiled. I smiled. And now it's your turn.

How can we sell genuine ruby for under $4.25 per carat? Volume. Last year, we believe Stauer was the largest buyer of carat-weight emeralds in the world and this year we're on track to be the largest buyer of carat-weight rubies. High-end jewelers can sell some rubies for more than $5,000 a carat. We think that's ridiculous in today's economy and that's why we use our leverage to get you the best prices possible on the world's most precious gems. By presenting ***70 carats for under $300***, we've really outdone ourselves.

You can now own this sizzling strand of smoldering red rubies. Our designer transformed those stones—70 carats at a time—into our ***Ruby Teardrop Necklace***, an impressive 18" strand of faceted ruby roundels. Each shimmering red gem is linked with hand-twisted, 14K gold-layered wire and meets at a pendulous 10-carat, faceted teardrop ruby. The matching French hook earrings each feature four faceted ruby roundels and an 8-carat ruby teardrop. Each ruby is scientifically color enhanced to bring out the deepest red hues.

Romance guaranteed. I'm absolutely convinced you won't find a more romantic ruby necklace... anywhere. However, if after 30 days this necklace doesn't completely melt her heart, simply return it to us for a full refund of the purchase price. But if past results hold true, more passion won't be a problem.

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- Threaded with 14K gold-layered wire
- 18" necklace with 14K gold clasp

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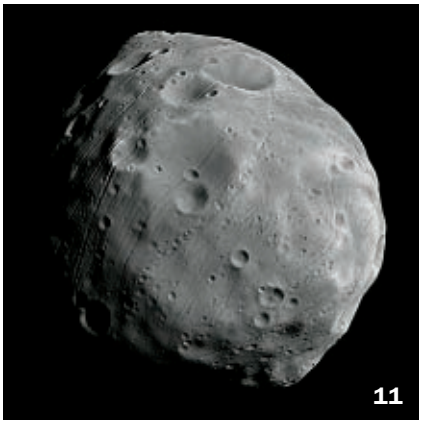

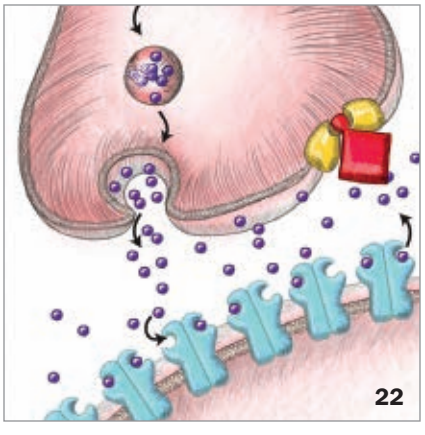

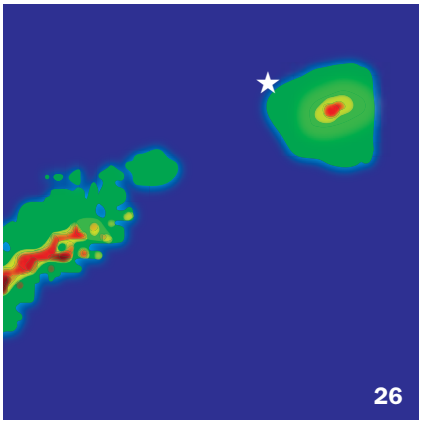

ScienceNews

In The News

Features

Departments

COVER Spraying a mist of tiny particles high into the atmosphere could block some of the sun's rays, cooling the planet. It's one strategy being considered to fight global warming. *Michael Morgenstern*

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FROM THE EDITOR

For atoms and climate, stability can be elusive

If Yogi Berra had been a chemist, he would have said, "It isn't over until you reach the island of stability."

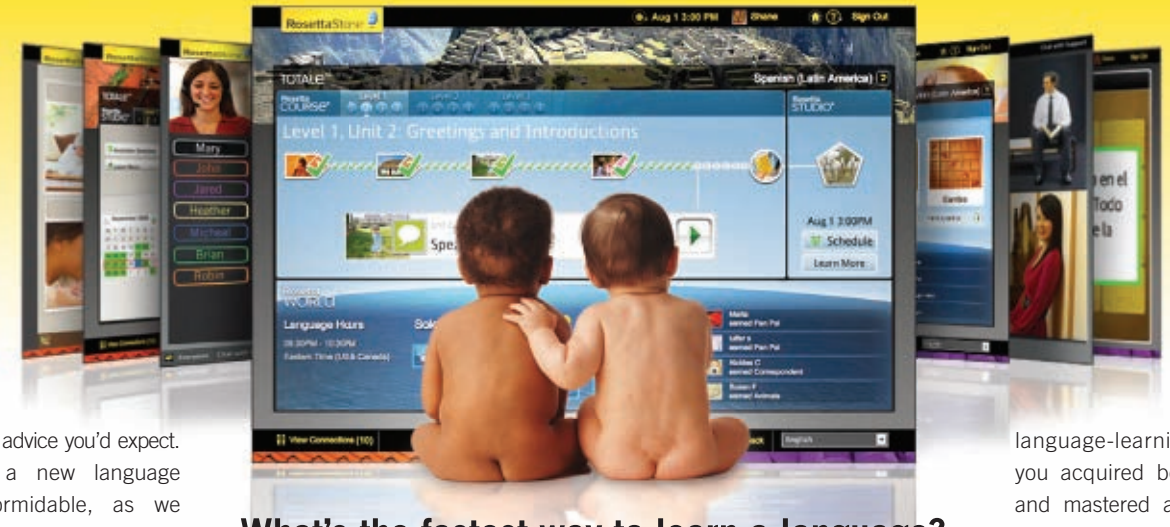
In this case, the game is creating new chemical elements never before present on Earth. These synthetic elements occupy spots on the chemist's periodic table beyond uranium, element number 92. As atomic number gets higher and higher, stability generally diminishes, eventually reaching a point where the new atoms decay away into something else almost as fast as physicists can make them.

Recently scientists announced the creation of element 117, filling the final vacancy in the periodic table as it is drawn today (*SN: 4/24/10, p. 15*). Number 117 lasts longer than some other superheavy elements (those with atomic numbers above the 110–112 range). Its properties suggest that physicists are closing in on superheavy nuclei possessing sums of protons and neutrons that confer relatively long lifetimes, thereby occupying that "island of stability." So the periodic table may yet be expanded, as Alexandra Witze describes on Page 26.

And some new superheavy elements might even be good for something. Certain lighter synthetic elements have commercial uses — americium, element 95, has an isotope that is widely used in smoke detectors (its radioactivity generates the ions that set off an alarm when surrounded by smoke). Much heavier elements, if stable enough to study, may reveal strange properties suitable for other practical tasks. You never know.

It's doubtful, though, whether any new element will be helpful in solving the problem addressed in this issue by Erika Engelhaupt (Page 16): how to engineer the Earth's climate to ameliorate rising temperatures. Scientists are seriously considering schemes such as blocking sunlight or sucking carbon dioxide out of the air in an effort to prevent climate change from disrupting the world's ecological and economic stability (and creating a serious lack of stability for the future of some real low-lying islands). Such "geoengineering" ideas have long been ridiculed as dangerously likely to produce unintended consequences. But doing nothing has consequences, also.

Given the costs, technological hurdles and political paralysis afflicting such issues, though, it's not so obvious that geoengineering proposals, however attractive in theory, would actually work in practice. After all, as Yogi once observed, "In theory there is no difference between theory and practice. In practice there is." —*Tom Siegfried, Editor in Chief*



What's the fastest way to learn a language?

ACT LIKE A BABY.

It's not the advice you'd expect. Learning a new language seems formidable, as we recall from years of combat with grammar and translations in school. Yet infants begin at birth. They communicate at eighteen months and speak the language fluently before they go to school. And they never battle translations or grammar explanations along the way. Born into a veritable language jamboree, children figure out language purely from the sounds, objects and interactions around them. Their senses fire up neural circuits that send the stimuli to different language areas in the brain. Meanings fuse to words. Words string into structures. And language erupts.

Three characteristics of the child's language-learning process are crucial for success:

First, and most importantly, a child's natural language-learning ability emerges only in a speech-soaked, immersion environment free of translations and explanations of grammar. Second, a child's language learning is dramatically accelerated by constant feedback from family and friends. Positive correction and persistent reinforcement nurture the child's language and language skills into full communicative expression. Third, children learn through play, whether it's the arm-waving balancing act that announces their first step or the spluttering preamble to their first words. All the conversational chatter skittering through young children's play with parents and playmates — "…what's this…" "…clap, clap your hands…" "…my ball…"— helps children develop language skills that connect them to the world.

Adults possess this same powerful language-learning ability that orchestrated our language success as children.

Sadly, our clashes with vocabulary drills and grammar explanations force us to conclude it's hopeless. We simply don't have "the language-learning gene." At Rosetta Stone, we know otherwise. You can recover your native language-learning ability as an adult by prompting your brain to learn language the way it's wired to learn language: by complete immersion. Our award-winning, computer-based method does just that. Dynamic Immersion® unlocks the innate language-learning ability you acquired before birth and mastered as a child. By recreating the immersion context in which you learned your first language, you understand, speak, read and write your new language with confidence and accuracy from the beginning — without translations and explanations. At every step and in every skill, you receive instant, actionable feedback, including speech recognition and analysis technologies that prepare you for everyday conversations. And Adaptive Recall® brings back material just when you need it to reinforce and perfect your learning.

Every act of learning is an act of play for children and there's no reason it should be different for learners of any age.

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Scientific Observations

"Though intergovernmental in name, the IPCC is subject to none of the legal or political requirements that constrain, but also legitimate, national expert committees.... [Its review] methods are good enough to satisfy many scientists, but they rest on traditions of scientific, rather than public, accountability.... Creating accountability practices that work at a supranational level will be neither straightforward nor easy.... There is no higher court where science can account for itself to the world. However, the IPCC has demonstrated that it can learn and change in its methods of representing science to scientists. That ingenuity should now be directed toward building relationships of trust and respect with the global citizens whose future climate science has undertaken to predict and reshape." **—SHEILA JASANOFF, HARVARD UNIVERSITY SCIENCE AND TECHNOLOGY STUDIES PROFESSOR, IN THE MAY 7 ISSUE OF *SCIENCE***

Science Past | FROM THE ISSUE OF JUNE 4, 1960

SOLVING OF SUN'S RIDDLES — Future space probes may skim as "close" as two million miles from the sun's visible surface, a report to the National Academy of Sciences suggests. Before this can be done, however, greatly improved materials must be developed since temperatures at that distance would be about 5,000 degrees Fahrenheit, roughly the melting point of the toughest materials now known. A near-sun space probe is one of the several kinds of solar studies from high-flying balloons, satellites and probes recommended by the Academy's Space Science Board. The suggested experiment could yield answers to most of the still unsolved problems of the sun and its mighty outpouring of radiation.

Science Future

June 11–14
American Society of Mammalogists meets in Laramie, Wyo. See www.uwyo.edu/asm2010

July 17
San Francisco's Exploratorium museum launches a series of podcasts on the science of creativity. See www.exploratorium.edu/webcasts/index.php

July 17–21
The American Society for Virology hosts its annual conference in Bozeman, Mont. Get agenda at www.asv.org

SN Online

www.sciencenews.org

ATOM & COSMOS
Planetary orbits in a neighboring solar system are an out-of-planar experience. See "Planets in nearby solar system are off-kilter, measurements show."

LIFE
Climate change could force as many as one in five lizard species into extinction by 2080. See "Lizards threatened by warming."

HUMANS
Good vision is all about great expectations. See "Vision gets better with the right mind-set."

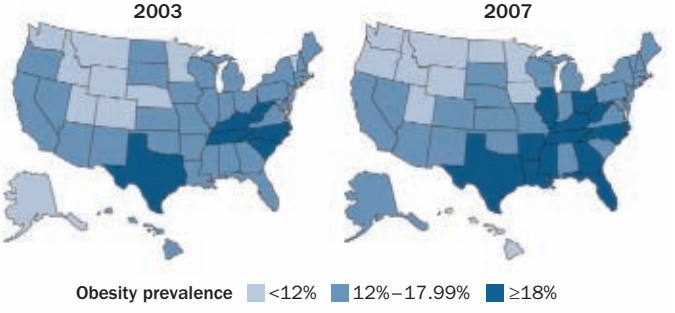
ON THE SCENE BLOG
High schoolers get tips from research giants at the 2010 Intel International Science and Engineering Fair. See "Nobel laureates dispense science wisdom."

How Bizarre

Mice, schmice. It's an insect that frightens elephants into signaling "bee-ware," researchers report. Elephants retreated from the testing area, shook their heads and made rumbling vocalizations more frequently when they heard recordings of African bee swarms compared with a white noise control. The elephants' bee rumbles also had different acoustic properties than did responses to white noise, the international team of scientists notes online April 26 in *PLoS ONE*.

Science Stats | KIDS LIVING LARGE, GETTING LARGER

Childhood obesity rates rose in 35 states between 2003 and 2007, according to a national survey of kids ages 10 to 17.



SOURCE: G.K. SINGH *ET AL./ARCHIVES OF PEDIATRICS & ADOLESCENT MEDICINE* 2010

CLOCKWISE FROM TOP LEFT: MARTHA STEWART; ADAM STOW; BUCKY_ZA/ISTOCKPHOTO

“If you are leaking something or releasing something, other species will use that to their benefit.” —CHARLES DERBY, PAGE 14

In the News

STORY ONE

Modern people carry around Neandertal DNA, genome reveals

Team uncovers long-sought evidence of interbreeding

By Tina Hesman Saey

People of European and Asian ancestry (woman, left) inherited roughly 1 to 4 percent of their DNA from Neandertals (reconstruction, right), genetic work suggests.

PHOTO © JOE MCNALLY/RECONSTRUCTION BY KENNIS AND KENNIS

Some people don’t just have a caveman mentality; they may actually carry a little relic of the Stone Age in their DNA.

A new study of the Neandertal genome shows that humans and Neandertals interbred. The discovery comes as a big surprise to some researchers who have been searching for genetic evidence of human-Neandertal interbreeding for years and finding none.

About 1 to 4 percent of DNA in modern people from Europe and Asia was inherited from Neandertals, researchers report in the May 7 *Science*. “It’s a small, but very real proportion of our ancestry,” says study coauthor David Reich of the Broad Institute of MIT and Harvard in Cambridge, Mass. Comparisons of the human and Neandertal genomes are also revealing how humans evolved to become the sole living hominid species on the planet.

Neandertals formed a new branch on the hominid family tree more than 650,000 years ago and lived in Europe, the Middle East and western Asia before disappearing about 30,000 years ago. The new data, the team suggests, indicate that humans may not have replaced Neandertals, but rather assimilated them into the human gene pool.

“Neandertals are not totally extinct; they live on in some of us,” says Svante Pääbo of the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, and leader of the Neandertal genome project. He and other researchers involved in the effort to compile the complete genetic instruction book of Neandertals didn’t expect to find that Neandertals had left a genetic legacy. Earlier analyses looking at only a small part of the genome had contradicted the notion that humans and Neandertals intermixed (*SN Online: 8/7/08*).

“We as a consortium came into this with a very, very strong bias against gene flow,” Reich says. In fact, when announcing the completion of a rough draft of the Neandertal genome a year ago, the team said such genetic exchange was unlikely (*SN: 3/14/09, p. 5*). Several independent lines of evidence have now convinced the researchers otherwise.

The result came as no surprise to some scientists, however. Archaeologists have described ancient skeletons from Europe that had characteristics of both early modern humans and Neandertals.

“After all these years the geneticists are coming to the same conclusions that some of us in the field of archaeology and human paleontology have had for a long time,” says João Zilhão of the University of Bristol in England.

Pääbo’s team re-created the Neandertal’s genetic blueprints using

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DNA extracted from three bone fragments—each from a different Neandertal woman—found in a cave in Croatia. Then the researchers compared the genomes of these female Neandertals, who lived about 40,000 years ago, with those of five present-day humans from China, France, Papua New Guinea and southern and western Africa. The findings reveal that people of European and Asian ancestry carry Neandertal DNA.

Scientists were surprised to find that people from China and Papua New Guinea (places where Neandertals never lived) have just as much Neandertal ancestry as people from France. The group did not find traces of Neandertal heritage in the two African people studied. The result probably means that interbreeding took place about 50,000 to 80,000 years ago in the Middle East as humans began migrating out of Africa to colonize the rest of the world, Reich says.

It is not clear how extensive the interbreeding was; the data are consistent with either a short period with a great deal of interbreeding or with a long period of little interbreeding, says Richard "Ed" Green, a genome biologist now at the University of California, Santa Cruz and a coauthor of the new study.

Cataloging differences Researchers have identified 73 proteins, some listed below, that have a form in humans that differs from the form found in Neandertals and chimpanzees.

SPAG17	Helps form the structure that makes sperm tails wiggle
PCD16	A skin cell protein involved in wound healing
KR241	Helps form the hair shaft
OR1K1	An odor receptor
NLRX1	Involved in regulating immune response
CALD1	Helps regulate muscle contractions

SOURCE: R. GREEN *ET AL./SCIENCE*

Comparisons of the Neandertal genome to human and chimpanzee genetic sequences have led to some clues about recent human evolution. Neandertals "were not genetically very distinct from us," Pääbo says.

For example, the researchers were able to find only 73 proteins in which humans carry an amino acid different from the one found in Neandertals and chimpanzees. That means that few changes in proteins have taken place in the past few hundred thousand years of human evolution. Researchers don't know yet whether the changes in the proteins alter their function or give humans some survival advantage.

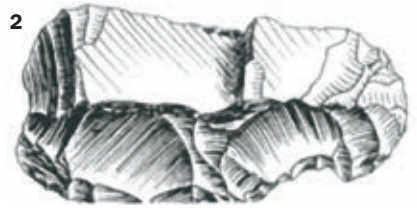
But some parts of the human genome clearly do produce an evolutionary advantage, the researchers say. If nothing of importance had happened in human evolution since humans and Neandertals diverged, differences would be spread evenly across the genome, Green says. Instead, the researchers found large swaths of the genome where humans have evolved differently from Neandertals and chimpanzees. The team identified 212 such regions where "selective sweeps" were likely to have happened, many of which include genes involved in brain function.

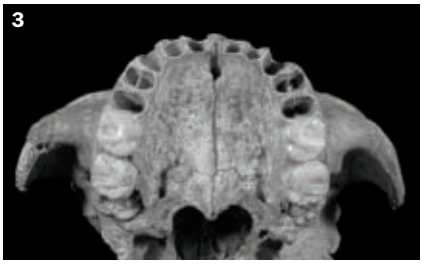
"These data are really a gold mine for understanding recent human evolution," Green says.

Since humans and Neandertals could interbreed, some people question whether the two groups are different hominid species. The question is still unsettled. Genealogically though, says anthropologist John Hawks of the University of Wisconsin–Madison, humans had a Neandertal great-great-great-great ... grandfather. "It's impossible to talk about them as 'them' anymore," he says. "Neandertals are us." ■

Back Story | FOSSIL CLUES TO INTERMINGLING

Some archaeologists have long argued that fossil evidence suggests interbreeding between *Homo sapiens* and Neandertals.





1. Lagar Velho child
Uncovered in the late 1990s in Portugal, this child's skeleton dates to 24,500 years ago and displays a mix of *H. sapiens* and Neandertal characteristics. Human traits include a well-formed chin and small lower arms, while Neandertal characteristics include a huge jaw, large front teeth, short legs and a broad chest (*SN: 5/8/99, p. 295*).

2. Châtelperronian artifacts
Bone and stone tools blending Neandertal and human techniques have been found in a French cave and date to roughly 40,000 and 35,000 years ago. Though not evidence for interbreeding, the artifacts suggest that humans and Neandertals lived side by side for at least a millennium and that there wasn't necessarily a mental gulf between the species.

3. Oase fossils
A 40,000-year-old skull found in a Romanian cave defies traditional anatomical categorization. Though the skull has the proportions of a modern human cranium, it has a retreating forehead and large upper molars (palate shown), among other features typical of Neandertals (*SN: 3/24/07, p. 186*). A similar jaw had previously been found at the site.

CLOCKWISE FROM LEFT: JOSÉ PAULO RUAS; GRAVINA *ET AL./NATURE* 2005; ROUGIER *ET AL./PNAS* 2007

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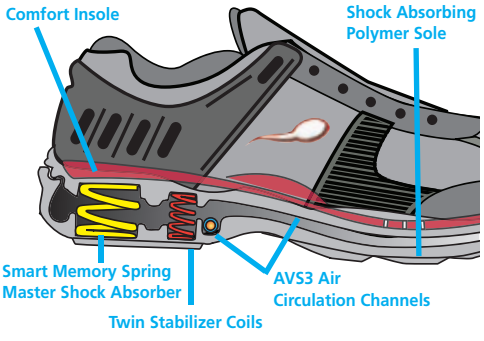

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Body & Brain

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Now where did I put that cheese?

Adding DNA 'packaging' helps older mice make memories

By Laura Sanders

Researchers may have found a clue to age-related memory loss among the coiled strands of DNA in the brain cells of elderly mice. A new study finds that older mice have less of a kind of genetic packaging that helps genes involved in memory formation spring into action.

If the process the researchers have unraveled in rodents also occurs in humans, the discovery could lead to new ways of helping older people remember.

Like some older humans, aging mice often don't remember where they've been and what happened when they were there. So in the study, published May 7 in *Science*, researchers put old and young mice into a box with particular lighting, smells and other cues the animals normally remember, and then delivered a foot shock.

Young mice, encountering the same box 24 hours later, remembered what had happened the previous day and froze in fear. But middle-aged (16-month-old) mice had trouble recalling the danger and scurried about unafraid.

To figure out what caused this memory decline, a team led by André Fischer of the European Neuroscience Institute in Göttingen, Germany, looked for minute chemical changes that might literally hide — and so keep inactive — some of the genes needed for memory formation. Earlier studies had found that as memories are encoded in the brain, a complex of over 1,000 genes turns on to help in the memory-making process. To activate these helper genes, chemical tags called acetyl groups must first loosen the tightly wrapped strands of DNA. This signals that the helper genes are open for business.

> "Everyone's looking for some way to alleviate these age-related deficits."
> FARAH LUBIN

In the new study, Fischer and his colleagues found that older mice had fewer acetyl groups at the time that the rodents should have been storing the memory of the shock. As a result, the suite of genes that should have been unwound and readied for action remained turned off.

In additional experiments, the researchers injected a drug into the brains of older mice to counter the drop in acetyl tag attachment, or acetylation. As a result, the battery of memory genes kicked on, and the mice were able to remember the shock as well as the younger mice did, freezing just as often.

If memory formation works the same way in people, scientists might be able to counter memory loss by boosting acetylation in the brains of older people. One challenge: Acetylation has many roles in the body, so a viable drug would have to somehow specifically target this process in the brain.

"Everyone's looking for some way to alleviate these age-related deficits," says molecular neuroscientist Farah Lubin of the University of Alabama at Birmingham. She notes, however, that "there's a lot more work to be done."

Immunity glitch keeps HIV at bay

Discovery could be helpful in future vaccine development

By Tina Hesman Saey

A lack of cellular education enables some people infected with HIV to keep the virus in check, a new study suggests.

This inadequate schooling takes place in the thymus, where immune cells usually learn to distinguish friendly cells from invaders.

But people with one version of a protein called HLA-B have immune cells that never fully learn this task. A new study published online May 5 in *Nature* shows how these undereducated cells help keep HIV levels down. The discovery may one day be helpful in designing vaccines against HIV and other viruses.

An unusual ability crops up in people who have the special protein, HLA-B*5701: Their immune systems are much better at latching on to the proteins of HIV and other viruses, reports a team led by Arup Chakraborty of MIT and Bruce Walker of the Ragon Institute in Charlestown, Mass. This ability to get a death grip on viral proteins, even when the virus mutates and changes its appearance, comes from immune cells that haven't learned to recognize the body's own proteins, the team found.

Immune cells called T cells are born in the bone marrow and then travel to the thymus, where they encounter and learn to recognize the body's own proteins. Only T cells that ignore the body's own components while reacting to foreign proteins graduate from the thymus to become part of the army of immune cells that fight infection throughout the body, Chakraborty says. His team found that during their education, T cells from people with HLA-B*5701 see fewer bits of the body's own proteins. As a result, once the T cells leave the thymus, they think they see foreigners everywhere.

That can be a problem because these undereducated T cells sometimes mistake normal body proteins for invaders and attack, causing autoimmune diseases such as psoriasis and creating hypersensitivity to some drugs. But these aggressive, undereducated T cells are also better at attacking HIV.

2 grams | Average weight of a rat's brain

1.4 kilograms | Average weight of a human's brain

7.8 kilograms | Average weight of a sperm whale's brain

Eureka! Brain makes mental leaps

Neural activity shifts during "aha!" moments, rat study finds

By Rachel Ehrenberg

Sometimes when a reporter is thinking about how to start a story, she has an "aha!" moment, and clever words are typed. This is not one of those times. But if it had been, a new study could offer clues into what happened during that moment of insight.

An aha moment comes when neurons in the brain alter their activity all at once, scientists report in the May 13 *Neuron*. The study suggests that brain cells act in concert during an insight, says study coauthor Daniel Durstewitz of the University of Heidelberg in Germany.

> "We thought, wait — this is going on — this is sudden insight!"
>
> DANIEL DURSTEWITZ

The findings are evidence that the standard model of learning — in which some brain connections gradually strengthen with repeated use and others wither with lack of exercise — doesn't always apply, says Randy Gallistel of Rutgers University's Center for Cognitive Science in New Brunswick, N.J., who was not part of the new study.

To locate an aha moment in the brain, a team led by Durstewitz and Jeremy Seamans of the University of British Columbia in Vancouver tracked activity in the prefrontal cortices of rats that were learning new tasks. The prefrontal cortex is known to be involved in executive decision making, planning ahead and adjusting to new situations.

The researchers designed an experiment that required the rats to learn that the rules for a task had changed, the kind of challenge that might lead to an aha. "So you not only have to learn something new, but you have to let go of something else," Durstewitz says.

First, the team trained 13 rats on a simple visual task. The researchers presented rats with two levers, each with a light above. When a light blinked on, the rat had to hit the lever below to get food.

After the rats mastered the task, the scientists switched things up. No matter which light was on, only one lever — the left or the right, depending on the rat — brought the reward.

When a rodent figured out the new system, its aha moment could be seen as a change in brain activity. Electrodes implanted in the rats' prefrontal cortices recorded a sudden across-the-board change in the pattern of firing neurons; dimly firing cells amped up, while previously hyper cells calmed down.

About half the rats learned the new rule quickly, accompanied by the sudden switch in neuron activity. Other rats seemed to realize the old rule wasn't working but took a while to figure out the new rule. In their brains, some neurons began to change their firing intensity, then a few more, and then the rats understood the new rule and, bam, the new firing pattern took hold.

It is not clear whether the change in brain activity causes the insight, or the other way around, the researchers say. Sometimes rats appeared to get the new task slightly before neuron activity shifted. Perhaps as the rat learns the new rules, information gradually builds up in one part of the brain and then is suddenly transmitted, the team speculates.

The researchers had their own aha moment while looking at their data, Durstewitz says. The plotted points started to look as though the rats were having a sudden revelation. "We said 'Oh, this looks like sudden insight,' as a joke," Durstewitz says. "Then we thought, wait — this is going on — this is sudden insight!"

NEWS BRIEFS

Epigenetic shifts linked to PTSD

People with post-traumatic stress disorder seem to accumulate chemical modifications to their DNA that are different from those found in unaffected people, researchers report online May 3 in the *Proceedings of the National Academy of Sciences*. The results don't reveal if these differences either cause or are caused by PTSD, says study coauthor Sandro Galea of Columbia University. The team tested 14,000 genes in blood samples from 100 people in the Detroit area who had experienced traumatic events. People with PTSD showed less methylation in several immune system genes and more methylation in genes linked to the growth of brain cells. Methylation is a chemical modification that does not alter genetic information but tends to suppress gene activity.
— Nathan Seppa

Deficits with sickle-cell anemia

People with sickle-cell anemia have cognitive deficits that show up as below-average IQ scores, a new study suggests. The deficits occur even when MRI scans show no brain damage, researchers report in the May 12 *Journal of the American Medical Association*. Elliott Vichinsky of Children's Hospital & Research Center in Oakland, Calif., and his colleagues tested 149 adults with sickle-cell anemia and found 33 percent fell below the normal range of performance IQ, compared with 15 percent of a control group. The team accounted for differences in age, gender and education. A reduced oxygen supply may be to blame for the impairments, Vichinsky says.
— Nathan Seppa

Humans

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Men swap spots with virtual girl

Study gives subjects illusion of inhabiting a virtual person

By Bruce Bower

In experiments using virtual reality, researchers gave adult male subjects the illusion of occupying the another person's body by manipulating the men's perspective.

Virtual reality can get downright unreal. In a simulated realm, grown men given a new perspective on the world suddenly found themselves convinced that they inhabited the body of a young girl.

After viewing a simulated world through a virtual girl's eyes, men felt as if they occupied her body even when their view switched to a third-person perspective, say cognitive scientist Mel Slater of the University of Barcelona and his colleagues. The effect was so intense that seeing the virtual girl slapped elicited heart rate responses in the men.

This illusion derives from a real-world expectation that a person who looks down will see his or her own body, the researchers propose online May 12 in *PLoS ONE*. "When subjects looked down they saw a different body, suggesting that this was a powerful cue for the brain to generate the illusion that the virtual body was their own," Slater says.

He plans to use this phenomenon to study the nature of body consciousness. And the discovery may also lead to games in which players actually feel that they've switched places with virtual characters.

"It's especially compelling that such relatively simple manipulations can profoundly alter our sense of reality," remarks Vilayanur Ramachandran of the University of California, San Diego. He says the study "is an elegant and important culmination of over a decade of experiments that demonstrate a powerful role of visual input ... in maintaining and anchoring body image."

In 2008, another team observed this body-swap illusion in volunteers who adopted a partner's visual perspective while shaking hands with that person (*SN: 12/6/08, p. 16*). Slater's work provides evidence that changing visual perspective alone can induce such a feeling.

Seeing body aids bereaved relatives

Viewing the dead can give comfort in cases of sudden loss

By Bruce Bower

People who lose a spouse or a child to murder, suicide or an accident often benefit from seeing the dead person's body, even if it's badly damaged or starting to decompose, a new investigation finds.

Viewing a loved one's marred body in a morgue or funeral home triggers distress at first, say Alison Chapple and Sue Ziebland, medical sociologists at the University of Oxford in England. But those people who choose to do so rarely regret the decision, especially as time passes, the team reports in a paper published online April 30 in the *British Medical Journal*.

"We were surprised that many people expressed such an intense need to see, touch, hold, talk or sing to the body," Chapple says. Getting up close one last time drove home the reality of loss for some relatives, helping them to move on with their lives, the researchers propose. Other survivors cared for the body in ways that allowed them to say goodbye or to forge a continuing bond with the deceased person.

Relatives who had mixed feelings or regrets about seeing the body said that authorities coerced them into identifying the deceased person or failed to prepare them for what the body looked like.

"People seem to be able to tell whether it will be beneficial for them to view the body," comments psychologist Camille Wortman of Stony Brook University in New York, a bereavement researcher. Requiring someone to look at the body against their will or rejecting a relative's request to view the body can inflict emotional damage that lasts for decades, Wortman says.

Chapple and Ziebland focused on 80 bereaved people in the United Kingdom from different social and ethnic backgrounds. In 2007 and 2008, Chapple interviewed participants about deaths that had occurred from four months to more than nine years earlier. Half the bereaved suffered losses due to suicide; half had relatives who had been murdered or killed in other violent ways.

Of 49 people who had chosen to identify or view the body, 35 said it was the right thing to do. Another nine had mixed feelings, two regretted the decision and three had no comments about how they felt. Six people in the new study found the dead body after a suicide. Three of them chose to view the body again later and said they were glad they did.

M. SLATER, B. SPANLANG

Atom & Cosmos

"Finally we're drifting away from the idea that the Martian moons are captured asteroids." —TOM DUXBURY

Fast-moving star is a heavyweight

But it might be wimpy compared with others in neighborhood

By Ron Cowen

In stellar terms, weighing as much as 90 suns ought to get you some respect.

But the star 30 Doradus 016 was born in a rough neighborhood. New research suggests that it was unceremoniously kicked out of its home by two even bigger bullies. And a study of the same star-forming region concludes that huge stars tipping the scales at twice the mass previously thought possible in today's universe lurk in nearby reaches of the cosmos.

30 Doradus 016 is a refugee from the 30 Doradus star-forming region in the Large Magellanic Cloud, a satellite galaxy of the Milky Way. Astronomer Nolan Walborn of the Space Telescope Science Institute in Baltimore first noticed something strange when a Hubble Space Telescope instrument determined that the star was spewing gas into space at a whopping 3,450 kilometers per second. Calculations based on measurements of temperature, chemical composition and other factors suggested that the gas was emitted from a mass equivalent to about 90 suns.

That finding inspired Chris Evans, an astronomer at the Royal Observatory Edinburgh in Scotland, to sift through observations of 30 Doradus 016 previously taken with a spectrograph on the Very Large Telescope in Chile. He found that the data ruled out the possibility of a close companion to 30 Doradus 016, indicating that the entire heft could be attributed to a single star. Additional observations at the Anglo-Australian Observatory in Australia, revealed that the star, now about 400 light-years from the core of 30 Doradus, is speeding away at more than 85 km/s.

In theory, a supernova might have hurled the star from its birth site at such a high speed. But the 30 Doradus star-forming region is too young for any star there to have already ended its life in a supernova explosion. The most plausible explanation is that some kind of gravitational interaction with two other stars in the region ejected the massive body.

So even though 30 Doradus 016 is extraordinarily heavy, it nonetheless must have been the wimpiest member of a stellar trio. The two heavier stars in the trio gravitationally ganged up on 30 Doradus 016, kicking it out, Walborn and Evans proposed May 3 at a symposium at the Space Telescope Science Institute. Their team, which includes Paul Crowther of the University of Sheffield in England, reports details in the June 1 *Astrophysical Journal Letters*.

New work by Crowther indicates that the region may contain stars as massive as 300 suns. Although such heavyweights were thought to be common in the early universe, theorists have previously calculated that stars in the cosmos today cannot exceed about 150 solar masses.

Martian moon is probably porous

Phobos may be rocky rubble rather than captured asteroid

By Sid Perkins

The interior of Mars' moon Phobos could be as much as 30 percent empty space, new observations suggest. Though it's still not clear how Phobos formed, the finding means the moon is probably not an asteroid captured by the Red Planet's gravity.

Scientists have long debated the origin of Phobos, and these new findings narrow down the possibilities, says Tom Andert, a planetary geophysicist at the University of the German Armed Forces in Munich. He and his colleagues report in the May 16 *Geophysical Research Letters* that Phobos almost certainly isn't a single solid object.

"Finally we're drifting away from the idea that the Martian moons are captured asteroids," says Tom Duxbury, a planetary scientist at George Mason University in Fairfax, Va., who was not part of the study.

Phobos, the larger of Mars' two moons, is a cratered, irregularly shaped object 27 kilometers long. Andert and colleagues measured Phobos' mass by looking at perturbations in the orbit of Mars Express, a Mars-orbiting spacecraft, caused by the moon's gravitational tug.

The researchers estimate that Phobos contains about 10.7 quadrillion kilograms of material — making it about a billionth the mass of Earth. That, plus the improved estimate of the moon's volume gleaned from radar measurements, indicates that its overall density is about 1.88 grams per cubic centimeter, much less than the 3 g/cm^3 average density of the rocks in Mars' crust.

Phobos' density is similar to that of some asteroids, but there aren't many scenarios that would allow Mars to capture an asteroid in a circular orbit without breaking it to pieces, Andert says.

It's also unlikely Phobos is made solely of Mars crust blasted into space by an impact and then reassembled, because the spectral features of the moon's rocks don't match those of the Red Planet.

G. NEUKUM/FU BERLIN, ESA, DLR

An analysis suggests that Mars' larger moon Phobos is not a captured asteroid.

Life

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Two ancient birds didn't make a flap

Archaeopteryx, *Confuciusornis* had flimsy feathers, study finds

By Sid Perkins

The wings were willing, but the feathers were weak. Delicate, thin-shafted plumage would have made flapping difficult if not impossible for two prehistoric birds, a new analysis of fossil feathers suggests.

The feathers probably would have buckled or snapped during strong flapping or sharp maneuvers, says evolutionary biologist Robert Nudds of the University of Manchester in England.

Using a formula often applied to bridges and beams, Nudds and Gareth Dyke, an evolutionary biologist at University College Dublin, estimated the load-carrying capacities of feathers from the ancient birds *Archaeopteryx* and *Confuciusornis*. Their feathers were about the same size as a pigeon's but had smaller-diameter shafts that were much weaker, Nudds and Dyke report in the May 14 *Science*.

"They're so flimsy that they couldn't have supported much weight," says Lawrence Witmer, a paleontologist at Ohio University in Athens who was not involved in the new study.

In level flight, the lift generated by a bird's wings must support its weight. But during extreme maneuvers the forces on wings and feathers are higher, so feathers need to be stronger than necessary for level flight (by a factor of six in vultures to over 13 in gulls). In ancient birds those margins were smaller: 2.9 for *Confuciusornis* and four for *Archaeopteryx*. If their feathers had partially hollow shafts, as modern feathers do, these margins could have been even lower. The birds may have simply glided from one branch to another, the researchers say, or spread their wings to slow their descent during jumps.

The feathers of *Archaeopteryx*, shown in an artist's drawing, had weak shafts.

Life has common ancestral source

Protein study confirms that all organisms are relatives

By Tina Hesman Saey

One isn't such a lonely number. All life on Earth shares a single common ancestor, a new statistical analysis confirms.

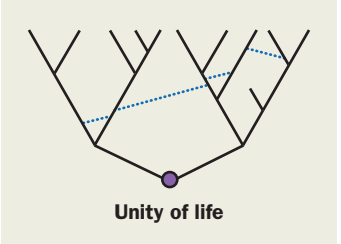
The idea that life-forms share a common ancestor is "a central pillar of evolutionary theory," says biochemist Douglas Theobald of Brandeis University in Waltham, Mass. "But recently there has been some mumbling, especially from microbiologists, that it may not be so cut-and-dried."

Because different microorganism species often swap genes, scientists have proposed that multiple early life-forms could have tossed genetic material into the mix, creating a web, rather than a tree, of life.

When Theobald put various evolutionary ancestry models to rigorous statistical tests, the results, published in the May 13 *Nature*, came down overwhelmingly on the side of a shared ancestor.

A universal common ancestor is at least 10^{2860} times more probable than having multiple ancestors, Theobald calculates.

This aspect of evolution had not previously been tested so stringently, says David Penny, a biologist at Massey University in Palmerston North, New Zealand. "We are not surprised at the answer, but we are very pleased that the unity of life passed a formal test," he says. He and Mike Steel of the University of Canterbury in Christchurch, New Zealand, wrote a commentary on the study in the same issue of *Nature*.



A new study finds life's history can be traced to one ancestor.

Theobald chose 23 common proteins, with structures that differ from species to species, to examine in 12 species — four each from the bacterial, archaeal and eukaryotic domains of life. Computer simulations then gauged the likelihood of producing the observed array of proteins from various evolutionary scenarios.

Theobald found that scenarios featuring one common ancestor defeated even the best-performing multiancestor models.

A model with a single common ancestor but allowing for some gene swapping among species was even better than a simple tree of life. Such a scenario is 10^{3489} times more probable than the best multiancestor model, Theobald found.

Life could have originated on Earth many times, but this study suggests that only one of those primordial events is ancestral to the entire array of organisms living today. "It doesn't tell you where the deep ancestor was," Penny says. "But what it does say is that there was one common ancestor among all those little beasties."

FROM TOP: TODD MARSHALL; M. STEEL AND D. PENNY/*NATURE* 2010

Earth					
9.80 m/s²	Earth's average gravitational acceleration at sea level	**9.83** m/s²	Gravitational acceleration at sea level at North Pole	**9.78** m/s²	Gravitational acceleration at sea level at equator

Gravity lows mark rock burial sites

Ancient watery upwelling may explain gravitational anomalies

By Sid Perkins

Vast "slab graveyards" buried deep near the planet's core may be responsible for several spots detected around the world where Earth's gravitational field is unusually low.

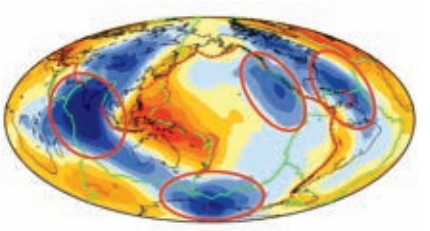
When these slabs of rock were buried long ago, they released water that reduced the density of overlying rock, Caltech geophysicist Michael Gurnis and his colleagues report online May 9 in *Nature Geoscience*. When low-density rock is located near the surface, its lower mass results in reduced gravitational pull.

Scientists had already known that gravity's tug is smaller where tectonic plates, or large sections of Earth's crust, once plunged below the surface, Gurnis says. The team's findings, he notes, help explain why values measured in four regions — areas south of Asia, along the coast of Antarctica, in the northeastern Pacific and in the western Atlantic — are even lower than expected.

Beneath those areas, seismic waves travel slower than normal at shallow mantle depths but faster than normal deeper down, Gurnis' team reports, a difference indicating that less dense material is lying over a layer of very dense material.

Most likely, the top layer's relative buoyancy stems from its water-rich composition, the researchers contend. Water could have been injected deep into the mantle as a result of slow-motion tectonic collisions between lighter and heavier plates. As dense slabs slipped downward, water in those rocks — and in the seafloor sediments that had accumulated upon them — was released. "When that water was added to the surrounding rocks, it lowered their melting point and reduced their density," Gurnis explains.

The notion that an upwelling deep in the mantle could be linked to water that had been carried downward in slabs is new, says Carolina Lithgow-Bertelloni of University College London.



Gravity's effect is lower in some places (circled in red) because water-rich rock sits over dehydrated slabs.

S. SPASOJEVIC ET AL./NATURE GEOSCIENCE

Molecules

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

To fight or flee: It's in the pee

Researchers begin to learn how mice smell a rat, or cat

By Rachel Ehrenberg

A protein found in urine leaves mice quaking with fear when they smell it coming from cats and rats, scientists report in the May 14 *Cell*. Yet when mice smell the same type of protein on their peers, the odor prompts mouse-on-mouse aggression.

Why the mice flee in one instance and fight in the other isn't clear, but the result suggests that the animals have adapted an existing sensory communication system to interpret the scent of danger.

Most animals are hardwired to recognize predators, says study coauthor Lisa Stowers of the Scripps Research Institute in La Jolla, Calif. Lab mice are terrorized by the scent of cat, even though they — and hundreds of generations of their ancestors — have never met one. To explore which molecules trigger this innate fear, Stowers and colleagues exposed lab mice to the scents of several predators, including a cat, a rat and a snake.

The scientists found that the mammal predators' scents contain protein components that signal danger to mice. Oddly enough, the danger molecules were variations on a protein that mice make themselves. And when male mice smell the protein on each other, there's frequently a fight.

"It was quite surprising," Stowers says. "But the more we thought about it, it made sense — how does a mouse evolve the capacity to be afraid of a wide variety of predators, from weasels to ferrets to cats to snakes to rats?"

That question is puzzling because of the biological investment it would take to be able to detect a variety of proteins from numerous potential enemies, many of which an animal might never encounter.

But a protein made in slightly different versions by many animals would do the trick. For the mice, this fear-inducing molecule is a MUP, or major urinary protein. Despite the name, MUPs are secreted not just in urine, but in milk, saliva and tears. And while scientists aren't sure what MUPs do for the animals that secrete them, plenty of animals do make them — including cats and rats.

Earlier research showed that smelling another male's MUPs triggers aggressive, let's-fight behavior in mice. The new work shows that MUPs can also trigger fear, at least when produced by predators. The mice weren't concerned by rabbit MUPs. And Stowers isn't sure if snakes or other reptiles make MUPs at all. The team couldn't isolate any from snakeskin used in the mouse experiments.

It's not surprising that the mice have tuned an existing sensory system to detect dangerous predators, says sensory biologist Charles Derby of Georgia State University in Atlanta.

"If you are leaking something or releasing something, other species will use that to their benefit," Derby says.

The work also nailed down the part of the nose mice use to detect MUPs: a clump of cells previously thought to smell only scents from the same species.

Plastics ingredient raises concern

Bisphenol A's 'twin' may have more potent hormone effects

By Janet Raloff

A largely ignored contaminant doesn't just resemble bisphenol A, the chemical that leaches out of hard plastic bottles. It's BPA's fluorinated twin — on steroids.

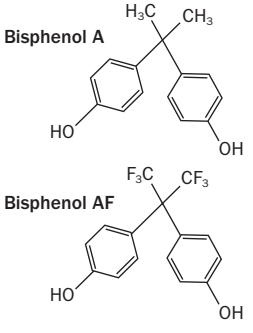
New studies in Japan indicate that the twin, bisphenol AF, may be even more potent than BPA in altering the effects of hormones such as estrogen.

Bisphenol AF, or BPAF, could be "a vicious compound, a very toxic compound," says Jan-Åke Gustafsson, a molecular endocrinologist at the University of Houston. The chemical is an ingredient in many plastics, electronic devices and optical fibers.

Possessing fluorine in place of six hydrogen atoms makes BPAF behave differently than BPA, Yasuyuki Shimohigashi of Kyushu University in Fukuoka, Japan, and colleagues report online April 28 in *Environmental Health Perspectives*.

Both chemicals act on estrogen receptors, molecular locks found in cells. Estrogen hormones serve as these receptors' keys, turning on genes that control activities such as ovulation in young women. BPA and BPAF can mimic those hormonal keys.

Most of BPA's estrogen-mimicking effect comes from activating human estrogen-related receptor gamma, or ERR-gamma.



Near twins: Six fluorine atoms distinguish BPAF from BPA.

The Japanese group finds that BPAF mostly ignores ERR-gamma but has a strong affinity for the estrogen receptors alpha and beta. BPAF proved a potent activator of ER-alpha. BPAF elicited no activity from ER-beta, but did block the body's own estrogen from accessing the receptor and conducting normal cellular operations.

While ER-alpha can promote some cancers, ER-beta–related activity tends to inhibit cancer. "ER-alpha is the bad guy and ER-beta is the good one," Gustafsson says. That makes BPAF a "double-edged sword," he contends.

NIEHS

Science & Society

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ISEF recognizes young scientists

Winners get cash, field trips and astronomical immortality

By Laura Sanders

Amy Chyao (center), Kevin Ellis (left) and Yale Fan earned top honors at the Intel International Science and Engineering Fair 2010, held in May in San Jose, Calif.

CHRIS AYERS/INTEL

SAN JOSE, Calif. — Quantum is so hot right now. At this year's Intel International Science and Engineering Fair, two of the top three awards went to young scientists with projects related to the weirdest realm of physics.

At the end of the weeklong global high school science competition, projects on cancer-fighting quantum dots, quantum computer algorithms and computer programming claimed the highest honors.

In all, 602 of the 1,611 competitors received prizes during the May 14 ceremony at the 2010 Intel ISEF, a program of Society for Science & the Public. Winners got cash awards ranging from $500 to the top prize of $75,000; other prizes included field trips and the official naming of an asteroid in the recipient's honor.

"As a group, you are a force for profound good," Society for Science & the Public President and *Science News* Publisher Elizabeth Marincola told the finalists.

This year's new top prize, the $75,000 Gordon E. Moore award, went to Amy Cindy Chyao, 16, of Richardson, Texas, who created a new cancer-fighting compound based on microscopic quantum dots.

Prizes included cash, field trips and the official naming of an asteroid in the recipient's honor.

Chyao chemically modified titanium dioxide nanotubes that have a property similar to one current cancer treatment: When hit with high-energy ultraviolet light, the nanotubes can produce a toxic, unstable form of oxygen that kills cancer cells. But UV light itself can cause healthy cells to sustain the kind of damage that leads to cancer.

In a quest for a safer alternative, Chyao affixed lead sulfide quantum dots to the nanotubes, changing the type of light required to activate them. She showed that less damaging near-infrared light could be used.

Yale Wang Fan, 18, of Beaverton, Ore., received the $50,000 Young Scientist Award for his project on how quantum computers can solve "some of the hardest problems in computer science," he says. These include searching giant databases quickly, solving major problems in statistics and encrypting data. Fan mathematically showed that a type of algorithm (nonlinear adiabatic quantum algorithms, for the curious) can outperform existing methods.

Fan got interested in quantum mechanics in eighth grade, and he read books and papers about the subject before developing his own projects.

Kevin Michael Ellis, 18, of Vancouver, Wash., also received the Young Scientist Award. He designed a tool that may help computers run faster by spreading the work among multiple microprocessors. A process called parallel programming "splits up the work and it goes twice as fast," he says.

Ellis created a program called Dyn that automatically decides what to split up and how to do it. Unlike other parallelism techniques, Dyn requires no manual work, and its performance doesn't suffer as the task size increases. Ellis put Dyn through its paces on intense applications such as physics simulations, 3-D computations and artificial intelligence problems. He then compared its performance with what a human programmer could do by hand. Dyn performed almost as well as a human programmer, he found.

Three other students won Seaborg SIYSS Awards, named for the late chemist Glenn T. Seaborg, a Nobel laureate who chaired the board of Society for Science & the Public. Seaborg SIYSS Awards come with a paid trip to the Stockholm International Youth Science Seminar in Sweden and admission to the Nobel Prize ceremonies.

In all, 19 Intel ISEF Best of Category awards were granted. The winner in each category received $8,000. First- and second-place category winners, who took home $3,000 and $1,500 respectively, also got the bonus of having an asteroid named in their honor, a gift from MIT's Lincoln Laboratory.

Engineering a cooler Earth

Researchers brainstorm radical ways to counter climate change

By Erika Engelhaupt

None of the scientists in the room so much as blinked when David Keith suggested saving the world with spy planes spraying sulfuric acid.

Keith, a physicist at the University of Calgary in Canada, was facing an audience not likely to be shocked: nearly 200 other researchers, some of whom had their own radical ideas for fighting global warming. His concept was to spray a mist of sulfuric acid high in the stratosphere to form particles called sulfate aerosols, which would act like a sprinkling of tiny sunshades for the overheating Earth.

Keith's idea may sound outrageous, but it is just one of many proposals for bumping the global thermostat down a couple of degrees by tinkering directly with the planet's heating and cooling systems. Plans to cool the Earth range from shading it to fertilizing it, from seeding clouds to building massive supersuckers that filter greenhouse gases from the air. The schemes are all part of a growing field known as geoengineering: a subject once taboo for all but the scientific fringe, but now beginning to go mainstream.

So far the tinkering happens mainly in computer models, where researchers are trying to figure out geoengineering's potential side effects. Yet some technologies are in the prototype stage, governments are starting to consider geoengineering seriously and budding geoengineers are working out how to proceed safely, and ethically, with real-world experiments.

"It truly is asking giant questions which nobody really knows the answers to," Keith says — "like how we manage the whole Earth."

In March, Keith and other experts met in a dimly lit chapel-turned-auditorium at the Asilomar resort near Monterey, Calif. In 1975, molecular biologists met at the same resort to write landmark guidelines to regulate DNA experiments. This time around, cloud physicists, legal scholars and government bureaucrats debated the relative merits of brightening clouds versus building artificial trees. In the end, the meeting-goers concluded that geoengineering research should cautiously proceed, in case Earth's climate proves broken beyond the current means of repair: ratcheting down fossil fuel use.

Researchers have kicked around the idea of large-scale climate manipulation since at least the 1960s, when Soviet scientists suggested damming the Bering Strait as part of a scheme to warm Siberia and free shipping lanes of sea ice. But mainstream scientific attention began only about five years ago.

In a 2006 editorial in *Climatic Change*, atmospheric chemist Paul Crutzen suggested that sulfate aerosols might be used to intentionally cool the planet. Coming from a scientist who had shared the Nobel Prize for helping explain how man-made chemicals ate away the Earth's protective ozone layer, the idea gained some traction.

Geoengineers poked their heads from the closet tentatively at first. But soon, ideas multiplied.

Gauging public understanding

Preliminary results from a survey of 1,001 Americans suggest that few understand the term "geoengineering." When participants were asked, "Have you heard about geoengineering as a possible response to global warming?":

74% Said no

25% Said yes but incorrectly thought the term referred to geothermal energy, green building or some other issue

1% Said yes and described geoengineering correctly as a way to artificially cool the planet

SOURCE: ANTHONY LEISEROWITZ/YALE UNIVERSITY

Quick and dirty

Keith's spray planes fall into one of the most controversial categories of geoengineering: solar radiation management, meant to reflect sunlight away from the Earth. As geoengineering schemes go, solar radiation management would be relatively cheap and fast. It would also be effective: Blocking just 2 percent of the sun's rays, scientists estimate, could cool the planet by about 2 degrees Celsius, roughly balancing the warming effect of doubling carbon dioxide above preindustrial levels.

One obvious way to reflect light would be to hang something shiny between the Earth and the sun. Such proposals feel distinctly like science fiction, ranging from a fine mesh of aluminum threads hung in space to a swarm of reflective disks launched in stacks of a million every minute for 30 years.

A more popular idea among scientists is to pump tiny reflective particles high into the stratosphere, the atmospheric layer between about 10 and 50 kilometers up. To scatter light effectively, the particles need to be solid. But dispersing solid bits without clumping is nearly impossible, so one idea is to spray sulfur gases that turn into solids. Keith's sprayers would use a mist of liquid H_2SO_4, or sulfuric acid, which forms small particles of the right size effectively.

Volcanoes, whose emissions have long been known to cause temporary chills, inspired the idea of using sulfate aerosols as climate coolers. The 1991 eruption of Mount Pinatubo in the Philippines released about 20 million metric tons of

MICHAEL MORGENSTERN

Giant air-capture machines, like artificial trees, could cleanse the atmosphere of excess carbon dioxide.

sulfurous gases and cooled the planet by half a degree for more than a year. Geoengineers wouldn't need to spray that much, because particles shot directly into the stratosphere would cool more efficiently than volcanoes. To reflect 2 percent of incoming light, geoengineers would need to spray between 1 million and 5 million metric tons of sulfur each year.

A single fire hose to the stratosphere, running constantly, could potentially deliver enough. The cost? An estimated $10 billion per year to cool the planet 2 degrees.

The environmental effects are an even bigger question, scientists say. For one thing, sulfur spraying would lead to whiter daytime skies and bolder, redder sunsets, because of the way the sun's rays scatter off aerosol particles.

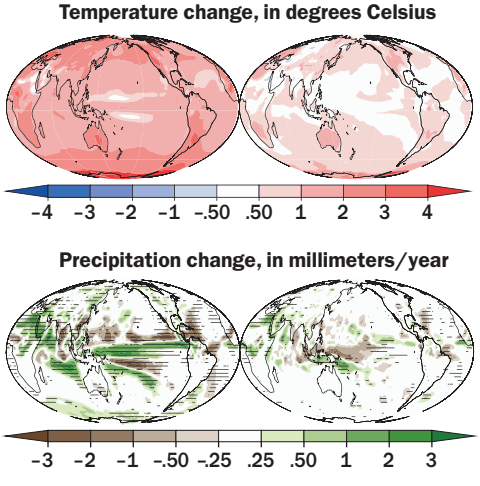
Another question, at least at first, was whether spraying sulfur in the stratosphere would, like sulfur pollution from power plants, cause problems with acid rain and air quality. But where in the atmosphere sulfur is released makes a big difference, says physicist Jason Blackstock of the International Institute for Applied Systems Analysis in Laxenburg, Austria. "The sulfate particles that we would put in the stratosphere would be the same as those which cause acid rain now," he says. "But by putting them higher, they stay up longer because they're above the clouds, which means they aren't raining out as acid rain all the time."

A different problem is that aerosols can damage the stratospheric ozone layer. Chemicals known as chlorofluorocarbons, or CFCs, once common in spray cans and refrigerants, have depleted the ozone layer globally, and in particular over Antarctica. Now that CFCs are being phased out by a global treaty, ozone has been slowly recovering. But spraying enough sulfate aerosols in the stratosphere to push back the effects of global warming by 40 years would delay the recovery of the Antarctic ozone hole by about 30 years, according to a 2009 paper in the *Journal of Geophysical Research-Atmospheres*.

An even more worrying potential effect is on precipitation, says meteorologist Alan Robock of Rutgers University in New Brunswick, N.J. Injecting sulfur gas could reduce rain delivered during the Asian and African summer monsoons, which 2 billion people rely on for growing food, by as much as 15 percent, Robock and his colleagues reported in the *Journal of Geophysical Research* in 2008. That would make the new average rainfall "the equivalent of the worst monsoon year now, and weather would produce bad monsoon years with precipitation much lower than that," he says.

In principle, injecting sulfur in the right way could minimize precipitation changes, says climate modeler Ken Caldeira of the Carnegie Institution for Science in Stanford, Calif. Injecting aerosols uniformly around the globe would result in less disruption of global precipitation patterns than focusing injection at the poles, a strategy some have suggested for saving the ice caps, Caldeira reported in February in San Diego at a meeting of the American Association for the Advancement of Science. In fact, he said, a geoengineered climate would seem more like the one we're used to than would a climate with doubled CO_2 levels. Still, he noted, "stratospheric aerosols are likely to cause some damage in some places."

Cool but different Models suggest that injecting aerosols into the stratosphere would change temperature and precipitation in variable patterns. Shown are worlds with CO_2 levels doubled since preindustrial times, without (left) and with (right) geoengineering.



P. RASCH

Seeing white

Another way to reflect light would be to harness the Earth's built-in solar reflectors, clouds. And where there are clouds, there could be more clouds — or at least whiter ones, some researchers say.

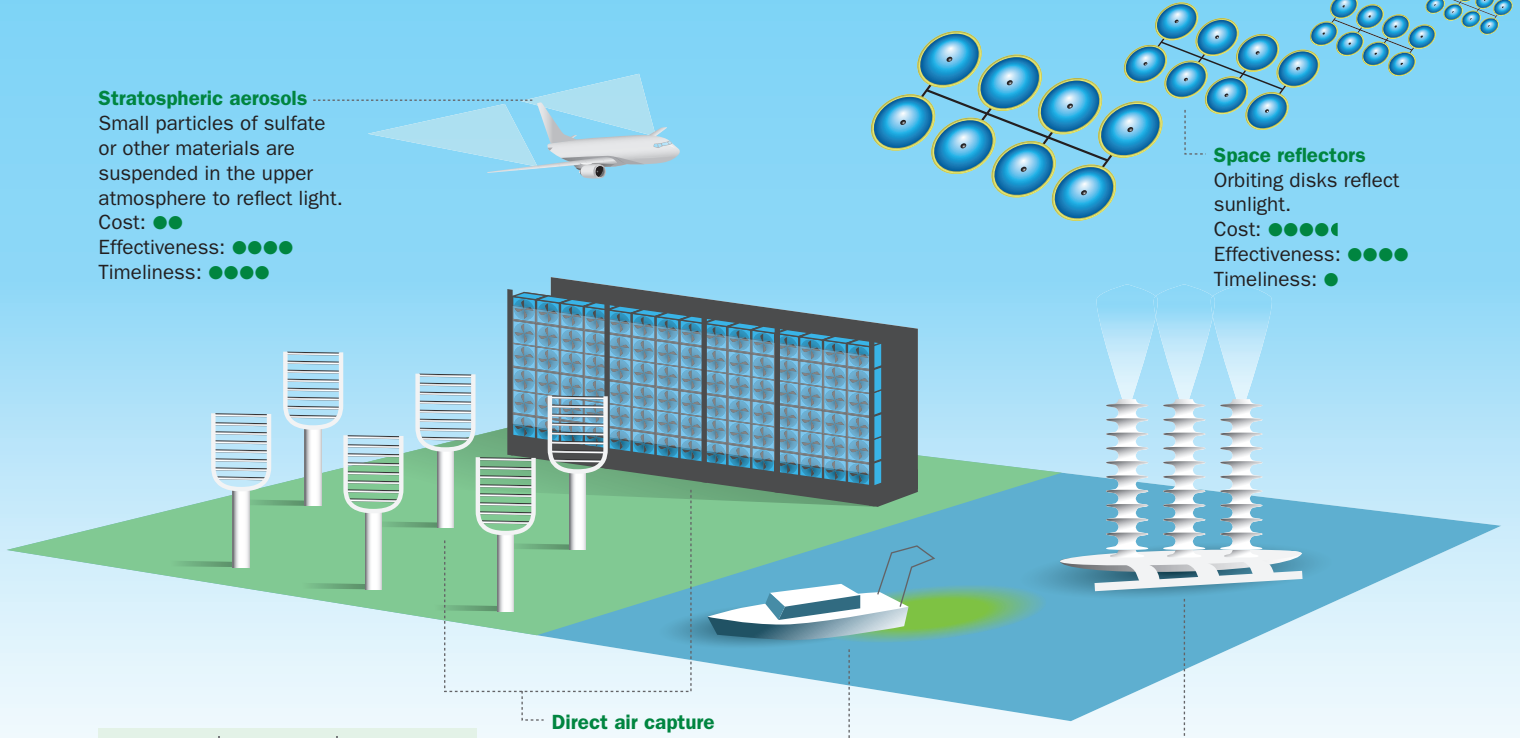
One leading geoengineering idea is to spray a mist of seawater into clouds over the ocean to make them whiter and brighter. Sea-salt particles in the spray would add more "seeds" to the air on which water vapor could condense, amplifying the natural cloud-forming process.

A fleet of 1,500 remote-controlled spray ships could whiten clouds enough to offset the warming created by doubled CO_2, says engineer Stephen Salter of the University of Edinburgh in Scotland. He and John Latham of the National Center for Atmospheric Research in Boulder, Colo., even developed a working prototype spray ship.

One challenge: along with clouds comes rain. So cloud seeding can also affect precipitation patterns, as new computer model studies by Latham and colleagues show. In simulations of cloud seeding across 20 to 70 percent of the ocean's surface area, less precipitation fell at the equator but more fell over the Amazon region on average over a 20-year period, the team reported last year in *Environmental Research Letters*. Other work by Caldeira and his colleagues suggests that brightening ocean clouds would generally increase rainfall over the ocean but decrease it over land.

Models by Philip Rasch, a climate scientist at the Pacific Northwest National Laboratory in Richland, Wash., who works with Latham's team, also show that high levels of cloud seeding could cool the Arctic enough to restore disappearing sea ice. But the team can't find a way to maintain sea ice, temperature and precipitation at desired levels at the same time. "You could optimize the planet to produce a sea-ice distribution that looks like today's, but then temperature and precipitation would be off," Rasch says.

What's more, reflecting light is no permanent solution. Like a celebrity addicted to painkillers, a planet hooked



	●	●●●●●
Cost	Cheap	Expensive
Effectiveness	Little cooling effect	Strong cooling effect
Timeliness	Slow-acting and/or slow to deploy	Fast-acting and/or quick to deploy

Five ways to save the planet The United Kingdom's Royal Society has rated geoengineering techniques according to cost, effectiveness (cooling power) and timeliness (considering both how quickly a technology could be deployed and how fast it would cause cooling).

on sulfur particles or cloud seeding would need to keep its fix coming to stay cool; turn off the juice, and temperatures climb right back up. And any solar management plan does nothing to counteract other ecosystem-wide changes caused by rising CO_2 levels, such as the rising acidity of the oceans as they absorb more CO_2. So most scientists say these methods would work only as a stopgap to head off the worst effects of warming while greenhouse gas levels are brought down by burning less fossil fuel.

Slow but sure

As an alternative, many researchers champion carbon dioxide removal — taking CO_2 from the air using any of a number of materials, such as sodium hydroxide. This solution is essentially permanent, it keeps oceans from acidifying and it has few side effects. But it is expensive and could mean finding storage for billions of tons of carbon-containing stuff each year *(SN: 5/10/08, p. 18)*.

Klaus Lackner of Columbia University and Calgary's Keith have both designed air-capture systems. Using different industrial processes, each system would absorb and separate out CO_2 from the air. That pure stream can be stored in geological formations, as is done in carbon capture and storage systems for power plants being tested in the United States, Canada and elsewhere.

At the Asilomar meeting, Keith announced that he plans to build an air-capture prototype over the next few years. Each unit could lock up 100,000 tons of CO_2 per year, at a cost of more than $100 per ton. At that rate, absorbing all the CO_2 that the United States emits each year would cost more than $580 billion annually and take 58,000 air-capture units. More realistically, Keith hopes to improve the system's efficiency and lock up as much carbon as possible while also cutting emissions. Meanwhile, Lackner is developing his capture devices in a 10,000-square-foot Tucson facility through a partnership between Columbia and the company he cofounded, Global Research Technologies. The company estimates that within two years its prototype units will capture a ton a day for less than $100 per ton.

Machines aren't the only way to absorb CO_2. Some researchers are working on fertilizing ocean plankton with iron to stimulate their growth, enhancing natural CO_2 uptake. Other scientists are looking into using large pipes to churn nutrient-rich waters to the surface for the same effect.

Several private companies have launched iron fertilization efforts in recent years, but with mixed results. One killed its project when faced with environmental concerns, while another faces continuing scientific questions about how much carbon dioxide is sequestered by plankton sinking into the deep ocean and how much is returned to the atmosphere as plankton decompose.

Moving ahead

Despite such uncertainties, public interest in geoengineering has snowballed in recent months. The U.S. House of Representatives held hearings to learn about geoengineering in November and March,

T. DUBÉ

and the Government Accountability Office has launched a major assessment. In September 2009 the Royal Society, the United Kingdom's leading scientific body, called for £100 million in government funding for geoengineering research over the next 10 years. The society is also leading a study, in cooperation with the Academy of Sciences for the Developing World and the Environmental Defense Fund, that late this year will issue recommendations for regulating geoengineering research.

If funding can be found, several geoengineering technologies could be tested in real-world experiments within a few years. Working with Aurora Flight Sciences in Manassas, Va., Keith's group has estimated that a civilian version of a U-2 spy plane could be adapted for less than $10 million to spray a ton of sulfur. That amount of sulfur is less than one-millionth the amount proposed for altering climate, so such an experiment would be used only to test the mechanics of spraying and perhaps study atmospheric chemistry.

But spraying even a small amount of sulfur raises major questions, such as what could go wrong and who is responsible if something does. No international authority is in charge of saying whether Keith can do such an experiment. At Asilomar, scientists called for the development of voluntary guidelines because there is no major treaty or law that clearly covers geoengineering.

Even to scientists who take the idea seriously, the prospect of actually fiddling with the planet's climate on purpose is frightening. "If you'd asked me a decade ago, I would have said that studying these issues is problematic, because the more you know how to do it, the greater the possibility that someone will do it," says M. Granger Morgan, an applied physicist who heads a research program at Carnegie Mellon University in Pittsburgh that examines solar radiation management. "I don't want to see the world do this; I want to abate emissions," he says. "But I think we're at the point where it would be a mistake not to better understand what might be possible or whether it might work."

Then again, not fiddling with the climate is just as scary to some. "We know the risks of CO_2 are serious too," Keith said at Asilomar. That makes geoengineering a lot like chemotherapy, in his view.

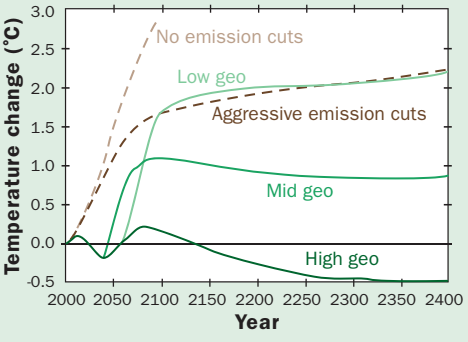
"Would you prefer to avoid eating carcinogens or have chemotherapy?" he asks. "Everybody would rather avoid the carcinogens, but if you already have cancer you might prefer chemotherapy to dying, even though chemo will leave you sick and make your hair fall out."

And, of course, chemotherapy doesn't always work — and sometimes it kills the patient. ■

Desperate times and desperate measures

As climate researchers have grown increasingly alarmed by vanishing sea ice and faster-than-expected growth in greenhouse gas emissions, geoengineering has become less of a laughing matter in scientific circles. "Emissions reduction alone is not going to cause the Earth to start cooling this century," says Ken Caldeira of the Carnegie Institution for Science in Stanford, Calif. Even if all CO_2 emissions stopped today, he says, temperatures would increase for decades, if not centuries, warming the Earth by at least another half a degree Celsius as oceans slowly release stored heat.

Without a dramatic turnaround in emissions, CO_2 levels will probably overshoot targets scientists consider safe, says Steve Schneider, a climate scientist at Stanford University. Today's atmospheric CO_2 level is 380 parts per million, compared with 280 ppm in 1850. Schneider has long advocated a 350 ppm goal — already surpassed — but even 450 ppm, a typical target in international negotiations, is fast approaching (*SN: 12/5/09, p. 16*). Geoengineering methods might work "as a temporary palliative measure you would use to hold the peak down, while you're working on carbon removal and tremendously increasing mitigation," he says.



Implementing different amounts of geoengineering (low, medium or high approaches shown here) would result in differing amounts of predicted temperature rises.

The idea of using geoengineering to "shave the top" off a temperature peak stirs mixed feelings. "Deep down, I think it's a bad idea," says ecologist Rob Jackson of Duke University in Durham, N.C. "But what are we going to do? I can see scenarios now where we don't have any other choice."

Scientists don't agree on whether geoengineering should be seen as part of an ongoing global temperature management plan or only as a possible last-ditch effort. But many do agree that geoengineers need to get cracking now on research and development.

"What happens if in 2040 or 2060 temperature increases are so high that crops are failing throughout tropical regions and billions of people are threatened with famine?" Caldeira says. "We'd better try to understand if there is something we could do, because there's no other way to realistically stop the Earth from warming during the course of this century." —*Erika Engelhaupt*

Explore more

- Read the Royal Society's geoengineering report at http://royalsociety.org/geoengineering-the-climate/

SOURCE: T.M.L. WIGLEY/*SCIENCE* 2006

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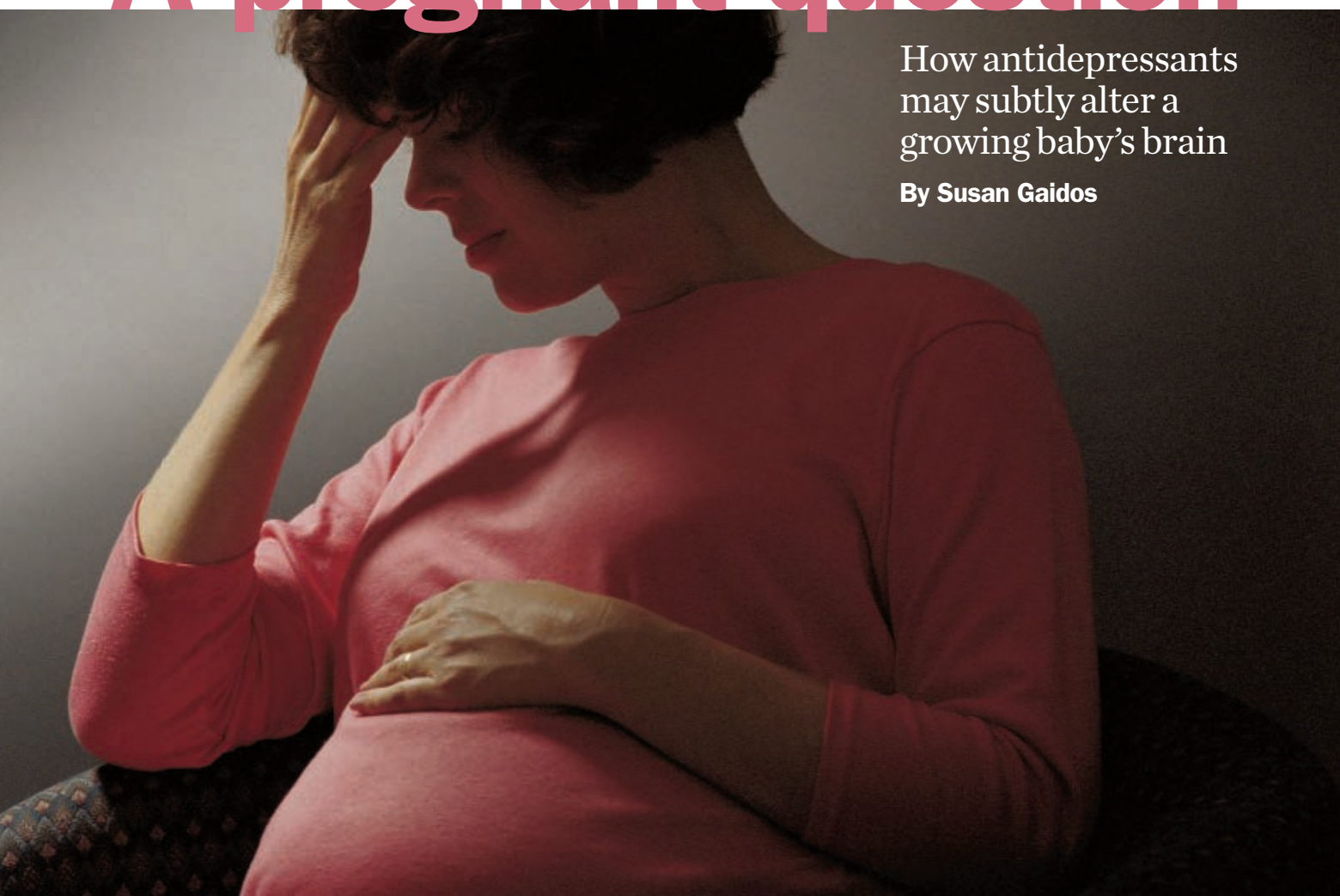
A pregnant question



How antidepressants may subtly alter a growing baby's brain

By Susan Gaidos

The glow of pregnancy is no shield against depression. Millions of expectant mothers rely on antidepressant medication for help. But treating mom with drugs at this time in her life may have long-term consequences for baby.

Around 10 percent of women suffer bouts of despair during the hormonal chaos of pregnancy or in the months after delivery. Some women are already being treated with antidepressants such as Prozac and Zoloft, while others get new prescriptions. For many adults these drugs, known collectively as selective serotonin reuptake inhibitors or SSRIs, work as advertised: lifting mood by temporarily boosting the availability of the brain chemical serotonin. But SSRIs may have a different, more long-lasting effect on a developing baby's brain.

Over the past few years, a handful of studies have found that mice and rats exposed to antidepressants shortly before birth or just afterward grow up anxious and depressed. Other animal studies link early exposure to SSRIs to improved decision-making and spatial-learning abilities. Though many of the documented reactions fall within the normal range of behavior, the drugs can influence how an animal experiences and relates to its surroundings, says Judith Homberg of Radboud University in Nijmegen, the Netherlands.

No one knows for sure if people experience the same risks or benefits over the long haul, but a new study shows that children exposed to antidepressants in the womb are more likely to appear sad or withdrawn at age 3 than those whose moms didn't take the drugs.

Though the mechanism underlying such changes is still unknown, a picture is beginning to emerge. In the February *Trends in Pharmacological Sciences*, Homberg and her colleagues outline research in animals linking exposure to SSRIs during early development to faulty brain organization and abnormalities. And recent studies in fruit flies support a theory that sensitivity to serotonin can be set early in life.

"You don't necessarily get ill because of a change in brain development by serotonin, but it may change your personality traits," Homberg says. "We may be changing the brain in subtle ways that we still don't understand."

Despite these recent findings, doctors caution women against stopping treatment, because the risks of depression — for mom *and* baby — may outweigh

those of the medication. Recent studies grapple with how to separate the effects of SSRI exposure from the damage wrought by depression in mothers.

It's all in the timing

Serotonin works like a nerve cell lubricant that keeps life running smoothly. It excites neurons that control muscle activity and soothes neurons that mediate pain. It takes the edge off neurons in the brain's limbic system, tempering impulses related to behaviors such as sex, aggression and overeating.

Specialized cells in a part of the brain called the raphe nuclei produce serotonin. Located near the base of the skull, these neurons send out branches that extend throughout the brain and spinal cord to connect with other neurons. When a nerve impulse reaches a branch ending, the neuron passes along the message by releasing serotonin into the synapse, a tiny space between one neuron and the next. Within a millisecond, the neuron that released the serotonin takes it back, vacuuming it up in a process known as reuptake.

Serotonin's mood-boosting effects occur while the chemical is in the synapse. The longer it remains there, the better the prospects for pleasant feelings. Antidepressants such as Prozac and other SSRIs work by blocking the protein that accomplishes reuptake — called serotonin transporter protein, or 5-HTT.

In developing brains, serotonin has a much broader role. During brief but critical periods of early development — before and after birth — the 5-HTT protein shows up in various parts of the brain. Scientists believe that some nerve cells temporarily draw on serotonin to help guide the growth and connections of other young cells, a process that lays down circuits crucial for touch, vision, smell, thought and memory.

Changing the level of serotonin in the growing brain by blocking the reuptake process may alter the way these sensory systems develop, a growing number of animal studies suggest. SSRIs can readily cross the placenta, which nourishes the fetus, and the drugs are also detectable in breast milk and in breast-fed children.

In 2004, Columbia University scientists showed that both mice exposed to SSRIs and mice engineered to lack a gene for the 5-HTT protein grew up to exhibit anxiety traits in adulthood, such as a reluctance to eat in or explore unfamiliar places.

Since then, studies have found faulty brain organization in mice lacking the 5-HTT protein. Some of the most convincing evidence comes from studies of the barrel cortex, a brain region associated with processing information that mice gather with their whiskers.

Mice use whiskers like fingertips to feel around in the dark, passing the information to the barrel cortex. If exposed to SSRIs early in development — while neurons in the barrel cortex are being laid down — mice show abnormalities in this region. The neurons are smaller, with fewer branchlike structures, Homberg says.

Though humans don't have a barrel cortex, they do have a brain region, called the primary somatosensory cortex, that processes delicate sensations received from the fingertips.

"It's hard to translate the findings on the barrel cortex in rodents to the role that serotonin plays in development in humans," Homberg says. "There is a kind of gap in between, and we should try to fill it." She now plans to study this brain region in children whose mothers took SSRIs during pregnancy to see if similar structural abnormalities exist.

Getting set up for life

Serotonin may play another important role in growing brains: Organizing the circuitry by which the chemical itself operates throughout life. Serotonin is so essential to life that critters — from flies to frogs to humans — set up elaborate distribution systems to ensure its flow throughout the central nervous system. This is achieved, in part, by parceling out the sites where serotonin is released. But scientists have wondered how a developing brain knows what the density of release sites should be.

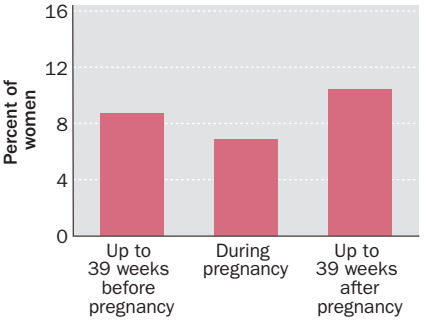
One possibility is that the sites are set up according to how much serotonin is in the system, says neuroscientist Barry Condron of the University of Virginia in Charlottesville. So neurons producing serotonin would have their own receptors that sense how much of the neurotransmitter is out there and adjust accordingly. A lack of serotonin would prompt more release sites to grow; too much would cause release sites to retract.

During development, when the serotonin system is "under installation," it may be especially sensitive to serotonin levels in the brain, Condron says. In 2005, he and then doctoral student Paul Sykes found that developing flies were quick to adjust the number of release sites in response to changes in serotonin levels. But the response depended on the timing: Adding serotonin to the system decreased the overall density of release sites in older larvae, while increasing the density in very young larvae.

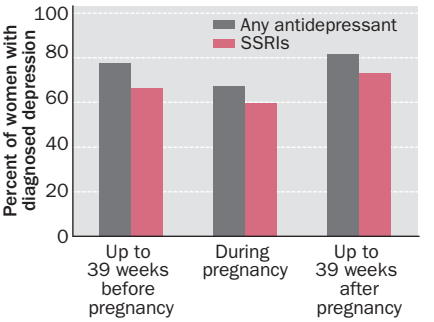
"It's all about timing," Condron says. "There's a fine ballet of timing in serotonin levels and the need for the

Mom's mood One study of women living in the Pacific Northwest found that more than 6 percent face depression during pregnancy. A majority receive treatment for their disorders.

Rates of depression during pregnancy



Portion of depressed women taking drugs



SOURCE: P. DIETZ *ET AL./AMERICAN JOURNAL OF PSYCHIATRY* 2007

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neurochemical during various stages of development."

The levels of serotonin early in development may help determine how the serotonin system responds throughout life, he says. "Which brings with it the fact that if you change that level of serotonin in some artificial way, by taking drugs or experiencing stress, then those circuits could be forever altered."

In a series of experiments directed by doctoral student Elizabeth Daubert, Condron's team engineered fruit flies capable of making either high or low levels of serotonin. Early in development, the flies with excess serotonin showed signs of degeneration in the area around the release sites. The flies had large swellings along the branches that extend from neurons — swellings that resemble structures found in Alzheimer's patients or ecstasy users.

Decreasing the fly's serotonin levels led to a recovery over time, Condron says. Still, the findings, published online April 13 in the journal *Molecular and Cellular Neuroscience,* suggest that nerve cells in the developing brain may be more sensitive to surges in serotonin than are those in the adult brain, he says.

"What it's indicating to us is that the serotonin system goes through a critical period of development where the level of serotonin is gauged, and the neurons determine their sensitivity to serotonin in order to self-regulate the system," Condron says. The study also suggests that the serotonin system has a "set" point, he says. "If you get to a certain high level, it starts to fall apart on you."

From mice to men

Even if the preliminary findings in rodents and flies hold up in people, SSRIs are but one factor that may alter serotonin levels in the brain of a developing baby. Factors such as the child's genetics and the mother's mood can also play a role.

Depressed women are less likely to take care of themselves, sleep well or exercise, leading to higher levels of stress, says Tim Oberlander, a developmental pediatrician at the University of British Columbia in Vancouver. They're also more likely to engage in reckless behavior, such as drinking or using illicit drugs. All of these activities work to change serotonin levels in a growing brain.

Distinguishing between the impact of prenatal SSRI exposure and the fallout of the mother's mental illness, Oberlander says, remains a key challenge.

SSRIs are but one factor that may alter serotonin levels in the brain of a developing baby.

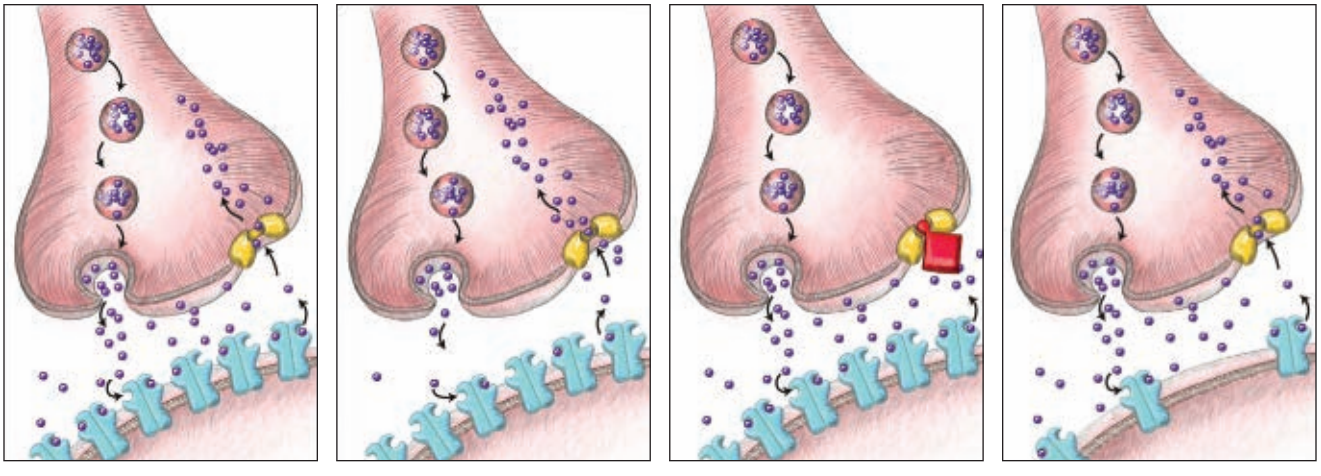
Over the past few years, Oberlander has conducted a number of studies to sort out effects. In 2006, he examined roughly 120,000 birth records and linked the births to mothers who were diagnosed as depressed during pregnancy. Some of the women in the group used SSRIs and others did not. He then compared records with a third group of women who were not diagnosed with depression and not treated with medication during pregnancy. The findings, published in the *Archives of General Psychiatry,* showed that babies born with SSRIs in their systems had lower birth weights and were more likely to experience respiratory distress.

Oberlander's group began a long-term study in 2007. When the researchers looked at behaviors such as aggression, they found that children who had been exposed to SSRIs in the womb had an increased risk for aggressive behaviors at 4 years of age — but only when their mothers were still reporting high levels of depression.

"It didn't matter that kids were exposed prenatally, but it did matter what the mother was feeling at the time of the follow-up study," Oberlander says.

That finding fits with long-established

Two sides of SSRIs Drugs such as Prozac and Zoloft relieve depression in moms, but the medications could leave a lasting impression on baby.



No mood disorder Serotonin (purple) is made in the nerve cells and released into an area called the synapse, where it hits the next nerve and is then reabsorbed.

Depression People with depression have a lack of serotonin in the synapse, either because not enough is produced or because too much is reabsorbed (shown).

SSRI treatment Selective serotonin reuptake inhibitors block the absorption of serotonin, leaving more in the synapse. This means more can hit the next nerve cell.

Developing baby Some animal studies suggest that a developing baby exposed to SSRIs will set its serotonin system differently, resulting in too few nerve cell receptors.

NICOLLE RAGER FULLER

literature that says children who grow up in a household with someone who has a mood disorder are more likely to act out, showing more aggressive or impulsive behaviors, he says.

Still, the story is complicated. The latest study by Oberlander suggests that both SSRI exposure and a mother's current anxiety level matter. Oberlander and his colleagues recruited a group of 33 pregnant women who were taking SSRIs for mood disorders. The team followed the progress of the women and their children over a three-year period, comparing them with a group of pregnant women with a range of mood symptoms who were not on SSRIs.

When controlling for anxiety during late pregnancy, the researchers were able to link prenatal SSRI exposure with sad and withdrawn behavior in kids at 3 years of age. Mom's anxiety at the time of the study was also associated with these behaviors. When controlling for prenatal and postnatal depressed mood, however, only the mother's current mood seemed to matter.

The study, published in the May issue of *Archives of Pediatric and Adolescent Medicine*, also points to a genetic effect. The team found that among the 3-year-olds with mothers who were depressed during pregnancy, only children who had two short copies of a gene called *SLC6A4* tended to be more anxious and depressed. The gene is called the "master modulator" of the serotonin system because variations lead to changes in the amount of serotonin available both inside and outside the cell: A short version leads to less efficient serotonin reuptake, while a long version leads to more rapid reuptake.

Oberlander's group also found that children with two long copies of the gene whose mothers experienced elevated anxiety during the third trimester of pregnancy showed an increased risk for aggressive behavior at 3 years of age — whether mom had been treated with antidepressants or not. No interactions were noted among child genotype and SSRI exposure.

Oberlander says the work shows that SSRIs and mother's mood can have an emotional impact on a child's development, but the child's genetic makeup also plays a role.

"These findings might give us some insight into who might be at increased risk and who might not be," he says.

To treat or not to treat A number of studies have linked prenatal exposure to SSRIs with a variety of symptoms, such as withdrawn behaviors. But prenatal stress exposure, which can be caused by maternal depression, can have some similar, overlapping effects into childhood.

Clinical findings at various ages associated with prenatal stress and SSRI exposure

Age	SSRI exposed	Stress exposed
Fetus	■ Blunted movements ■ Lower reactivity ■ Lower birth weight ■ Higher rate of preterm birth	■ Lower birth weight ■ Higher rate of preterm birth ■ Withdrawn behavior
Newborn	■ Reduced pain reactivity ■ Lower cortisol ■ Poor neonatal adaptation, characterized by jitteriness, weak cry and respiratory distress ■ Reduced serotonin	■ Increased irritability ■ Less responsive to stimulation ■ Elevated cortisol, a marker of stress ■ Reduced serotonin
Infancy	■ Altered activity of the hypothalamus, pituitary and adrenal glands ■ Poor psychomotor development	■ More negative affect with mothers ■ More emotional outbursts
Childhood	■ Reduced task persistence ■ Increase in withdrawn and disruptive behaviors	■ ADHD, anxiety, depressed mood ■ Increase in withdrawn and disruptive behaviors

SOURCE: T. OBERLANDER *ET AL./ CLINICAL PHARMACOLOGY & THERAPEUTICS* 2009

The bad and the good

While Oberlander's study shows that early exposure to SSRIs may have lingering aftereffects, Homberg says it is important to keep in mind that work in rodents suggests the outcome may not always be negative.

While some studies show that mice and rats exposed to SSRIs during development are anxious, a handful of others suggest that, when put in environments with changing conditions, these rodents are quicker to pick up on new routines and make decisions better and faster than those that haven't been exposed.

These positive reactions closely resemble behaviors found in people who carry two short forms of the *SLC6A4* gene, Homberg says. People with this genetic variation are less likely to take risks and are more sensitive to social threats. The common denominator, she says, is increased vigilance and sensitivity to environmental stimuli.

"It could be that they respond emotionally when conditions are stable, but rely on their cognitive skills when conditions are changing," she says. "During changing conditions there are additional stimuli that might distract their attention, drawing it away from the one that is inducing an emotional response."

Homberg is now pursuing studies in animals and humans to see how seemingly positive effects play out over time.

"Being sensitive to the environment can be bad, as you may develop an illness," she says. "But if exposed to more positive stimuli, which are also in the environment, you may even come out better."

So where does this research leave women who are concerned about how antidepressants might affect the neurodevelopment of their children?

"None of our findings suggest that pregnant women should not be treated for depression," Oberlander says. "But we have a lot to learn about who can benefit from pharmacological treatment with an SSRI and its impact on child development. And at the end of day, we need to understand that there is no free lunch, nor an easy route that is totally risk free." ■

Explore more

■ T. Oberlander. "Optimizing neurodevelopmental outcomes in infants and children following prenatal SSRI exposure." *Pediatric Health*. December 2009.

Elemental Esc

Making superheavies may reveal island of stability

By Alexandra Witze

As nuclear physics vacation spots go, the "island of stability" sounds pretty good. But this island isn't in the Caribbean, the Maldives or even Hawaii. It's at the edge of the periodic table of the elements.

Reaching the island would be the culmination of decades of synthesizing artificial elements, those heavier than uranium (*SN: 4/15/78, p. 236*). By smashing smaller elements together, researchers have shoved more and more protons and neutrons into a single atomic nucleus. Jam-packed products that include more than 110 to 112 or so protons in each nucleus are generally called "superheavy" elements.

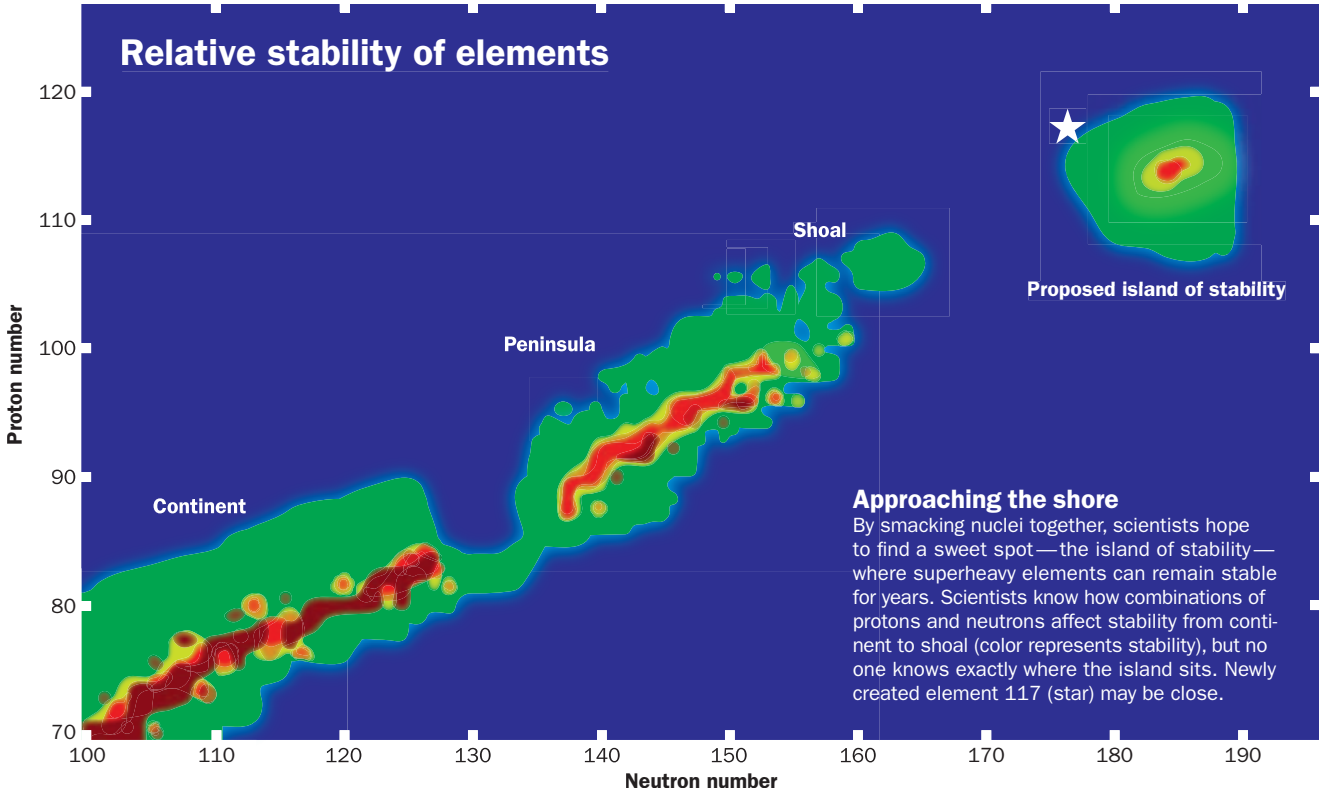
By studying superheavy nuclei, researchers could gain fundamental insights into the nature of matter. But all of the superheavy elements created so far are very unstable, typically decaying into other, lighter-weight elements within fractions of a second.

Theory suggests that if physicists could cram just the right amount of stuff into a nucleus, the resulting element would hit a sweet spot. It could romp on the island of stability for days, months or even years.

When the synthesis of element 117 was announced in April, scientists celebrated it as a sign of getting closer to the island's shore. But they still haven't reached dry land. "I would say we're approaching the island," says Mark Stoyer, a nuclear physicist at Lawrence Livermore National Laboratory in California who was on the team that made element 117. "We still have a lot more exploring to do."

Cramming more in

The quest to make superheavy elements takes chemistry to its limits. In lighter-weight elements, protons and neutrons stick together because of the attractive power of the strong nuclear force. But as more and more protons get packed into a nucleus, the strong force begins to be overwhelmed by the Coulomb force, which causes particles of the same charge to repel each other. Within milliseconds, superheavy atoms begin to spit out alpha particles — made of two protons and two neutrons — and shortly thereafter the



Approaching the shore
By smacking nuclei together, scientists hope to find a sweet spot — the island of stability — where superheavy elements can remain stable for years. Scientists know how combinations of protons and neutrons affect stability from continent to shoal (color represents stability), but no one knows exactly where the island sits. Newly created element 117 (star) may be close.

KAREN CARLO, ADAPTED FROM FIGURE BY YURI OGANESSIAN

ape

superheavy nuclei undergo fission, splintering into multiple lighter nuclei.

Overcoming the repulsive Coulomb force requires a couple of tricks, including getting as many neutrons as possible into the nucleus. Being electrically neutral, neutrons help diminish the amount of repulsion pushing protons away from each other.

The Russian-led team that created element 117 used this trick, powering up a calcium nucleus with eight extra neutrons and slamming it into berkelium, which itself had 152 neutrons. The 20 protons in the calcium and 97 protons in the berkelium combined to make an element with 117 protons. The team created two variants, or isotopes, of the new element, one with 177 neutrons and one with 176 neutrons (*SN: 4/24/10, p. 15*).

Another way to stabilize superheavy elements is to take advantage of the fact that protons and neutrons like to arrange themselves in layers like shells. A completely full shell is extra-stable, and a nucleus that has both filled proton shells and filled neutron shells is said to be "doubly magic."

But researchers don't know exactly what combination of protons and neutrons might be most stable in those shells, says Sigurd Hofmann, a nuclear physicist at the GSI research center in Darmstadt, Germany. Some theories predict that the most stable superheavy element would have 114 protons and 184 neutrons; researchers have been able to make an element with 114 protons, but they haven't succeeded in packing it up with 184 neutrons yet. Other models suggest that proton number 120 or 126, or neutron number 172, might be the ticket.

A further factor in element stability is whether an isotope has an even or odd number of protons and neutrons. For reasons that are not clearly understood, having an odd number slows down the decay process. A nucleus with an odd number of protons plus an odd number of neutrons, says Hofmann, can stick around substantially longer than corresponding even-even ones.

The isotope of element 117 that contains 176 neutrons, for instance, took 21 milliseconds to decay via alpha particle emission to element 115. The isotope with 177 neutrons stuck around longer, for 112 milliseconds. Though the difference might not seem great, for scientists seeking stability it's substantial.

Approaching dry land

The discovery of element 117 filled the periodic table up to the already-found element 118. The long-lived isotopes of 117 bolster the notion that the island of stability exists, say Hofmann and others. But scientists may not know for sure when they land on its shore.

> **"Is there an end to the periodic table? I don't think we're there yet."**
> MARK STOYER

There is no "sudden island of superheavies," says theoretical physicist Witold Nazarewicz of the University of Tennessee Knoxville. "This is a gradual transition from nuclei which live for a short time, to those that live for a longer time, to those that will live for years."

A more philosophical question may be how far chemists can push the concept of synthetic elements. "At some point we'll reach a point where you can't have a nucleus bound with so many protons even if you throw in many more neutrons," Stoyer says. "Is there an end to the periodic table? I don't think we're there yet."

For now, researchers are busy trying to measure the elements that can be made to understand how to get to superheavy shores. One group, led by Michael Block of GSI, reported some progress in February. The researchers captured some atoms of nobelium, atomic number 102, in an electromagnetic trap and measured their mass directly — the first direct mass measurement of an element heavier than uranium. While nobelium itself is not a superheavy element, the improved understanding of its isotopes could "provide reliable anchor points en route to the island of stability," the team wrote in *Nature*.

Other experiments will attempt to probe the physical shape of an atomic nucleus. A nucleus with shells full of protons and neutrons should also be spherical, not deformed by the forces trying to tear it apart. So measuring the shape of a nucleus could provide another way to check its stability.

Research hinted in 2006 that scientists can indeed deduce the shape of a nobelium nucleus by studying how it decays away. The work, from teams led by researchers at the University of Jyväskylä in Finland and Argonne National Laboratory in Illinois, was published in *Nature* and *Physical Review Letters*.

Some theorists envision pushing superheavy elements to their limits. Nazarewicz, for instance, would like to pack as many as 186 protons into a nucleus, at which point the internal forces would warp the nucleus into a bizarre bubble or doughnut shape. "This is a very theoretical nucleus," he admits.

While no one should hold their breath for the discovery of element 186, a few new elements may yet be within reach. Current nucleus-smashing techniques could potentially lead to the discovery of elements 119 or 120 within the next couple of years, says Hofmann. Beyond that, researchers will need to find new ways of pumping extra neutrons into target nuclei.

Such efforts will require a new generation of radioactive ion beam facilities to come online, like the Facility for Rare Isotope Beams being built by Michigan State University in East Lansing. Only then can physicists keep expanding the boundaries of the periodic table, hoping to annex the island of stability. ■

Explore more

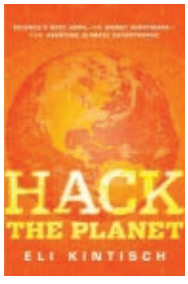
- For more on the periodic table, visit www.webelements.com

Hack the Planet: Science's Best Hope — or Worst Nightmare — for Averting Climate Catastrophe

Eli Kintisch

How to Cool the Planet: Geoengineering and the Audacious Quest to Fix Earth's Climate

Jeff Goodell



Two new books serve as guides to the latest tactic against climate change: geoengineering, the act of deliberately manipulating Earth's climate to cool it down (see story on Page 16).

Kintisch, a reporter for the journal *Science*, dubs geoengineering "planet-hacking." It's an apt description for sci-fi–sounding fixes, such as spewing sulfur particles into the atmosphere or building carbon dioxide–sucking machines.

Geoengineering has gained scientific traction in the past few years, and Kintisch's on-the-scene reporting illuminates tense discussions happening as a result, many behind closed doors. In one example of his reporter's-notebook approach, he takes readers inside the recent Bush administration, where officials debated the wisdom of implementing global climate manipulation.

Goodell, a *Rolling Stone* contributor, takes a more narrative and historical approach, speaking with players such as Lowell Wood, a weapons scientist and geoengineering proponent who sprinkles e-mails about planetary doom with emoticons. Goodell's background as a journalistic observer of technological change positions him well to probe social challenges raised by geoengineering.

Both books send a clear message: In the fight against climate change, planet-hacking may be a necessary, if frightening, option. — *Alexandra Witze*

Kintisch: Wiley, 2010, 288 p., $25.95; Goodell: Houghton Mifflin Harcourt, 2010, 272 p., $26.

The Science of *Doctor Who*

Paul Parsons

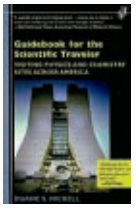
The real science of fake science sounds like a recipe for factual disaster. But this exploration of the long-running TV series delivers on its promise to answer the kinds of questions raised by the best of science fiction. The book takes readers on a satisfying romp through labs around the world where the show's fantastical ideas are explained and, in some cases, shown moving closer to reality.

Doctor Who stars the time-traveling, self-regenerating 900-year-old Doctor, who uses futuristic technologies to protect humankind from aliens. Now on its 11th Doctor (with a new actor for each regeneration), the show serves as a perfect entry point for exploring a wide range of science topics, from general relativity to human evolution.

Parsons, a cosmologist and science writer, starts with the Doctor's unusual biology before tackling major show themes such as space and time. He explains the fictional conceits as well as the real related science. Along the way, Parsons meets dozens of scientists, including *Who* fans with offbeat insights. The tone is light and humorous, and the book's simple illustrations reveal the physics behind, say, a real version of the Doctor's sonic screwdriver (it involves structure-acoustic linear ultrasonics).

A lifelong *Who* fan, Parsons shows off his encyclopedic knowledge of the Whovian universe. But even for those new to the show, or just looking for a soft entry into particle physics, this is summer science reading at its most indulgent. — *Erika Engelhaupt*

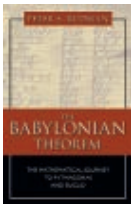
Johns Hopkins Univ. Press, 2010, 294 p., $24.95.



Guidebook for the Scientific Traveler: Visiting Physics and Chemistry Sites Across America

Duane S. Nickell

From Maine to Oregon, the country offers sightseeing for science enthusiasts. *Rutgers Univ. Press, 2010, 258 p., $19.95.*



The Babylonian Theorem: The Mathematical Journey to Pythagoras and Euclid

Peter S. Rudman

Ancient Babylonians and Egyptians paved the way for Greek mathematicians, a physicist contends. *Prometheus Books, 2010, 248 p., $26.*

Manhattan Project to the Santa Fe Institute: The Memoirs of George A. Cowan

George A. Cowan

A chemist reflects on his career in nuclear physics and events in 20th century science. *Univ. of New Mexico Press, 2010, 175 p., $27.95.*

Butterflies and Moths: Portraits from the Tropical Forests of Costa Rica

J.C. Miller, D.H. Janzen and W. Hallwachs

Full-page photos and text unveil Costa Rican Lepidoptera. *Belknap Press/ Harvard Univ. Press, 2010, 256 p., $24.95.*

In Praise of Science: Curiosity, Understanding, and Progress

Sander Bais

Science and reasoning have unique roles in society, a physicist argues. *MIT Press, 2010, 192 p., $24.95.*

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SCIENCE BOOKS FOR YOUNGER READERS

Voyage to the Heart of Matter: The Atlas Experiment at CERN

Anton Radevksy and Emma Sanders

Understanding the intricacies of subatomic physics isn't easy, but in this book the concepts literally leap off the page. The pop-up story about the world's largest atom smasher, the Large Hadron Collider, provides a 3-D tour of the 27-kilometer underground racetrack for colliding protons that straddles the countryside between France and Switzerland.

Author Emma Sanders and paper engineer Anton Radevsky worked with scientists from the ATLAS experiment, one of the four main sets of detectors at the collider, to produce the text and illustrations for the book. Sanders' descriptions of the cavernous particle accelerator, the different types of detectors used by ATLAS to find subatomic particles and the superconducting magnets that make the proton collisions possible mesh well with the pop-up pictures.

Even a reader familiar with the collider's design and goals — re-creating the enormous energies and temperatures present just a sliver of a second after the Big Bang — will get a fresh appreciation of the gargantuan effort required to produce and detect a spray of particles like those generated during the birth of the universe.

Pop-up illustrations also show the fundamental constituents of matter, the universe as it appeared at less than a billionth of a second old and the weblike arrangement of galaxies. Readers can try their hand at assembling a paper model of part of the ATLAS experiment; unfortunately, the instructions proved fairly difficult to follow. And indeed, the book is not intended for the very young but for curious older children — perhaps 10 and up — and young-at-heart adults. — *Ron Cowen*

Papadakis Publisher, 2010, 8 p., $37.50.

Meet the Howlers
April Pulley Sayre
Facts about howler monkeys complement the playful poem in this tale of rain forest life. (Ages 4–7) *Charlesbridge, 2010, 32 p., $16.95.*

Mammoths and Mastodons: Titans of the Ice Age
Cheryl Bardoe
Photos and accounts of real-life research bring extinct mammals to life in this book, published to coincide with a current exhibit at Chicago's Field Museum. (Ages 9–12) *Abrams Books for Young Readers, 2010, 48 p., $18.95.*

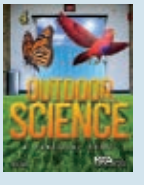
Pythagoras and the Ratios: A Math Adventure
Julie Ellis
A boy's quest to tune a pan flute and a lyre illustrates some of the many uses of mathematical ratios. (Ages 9–12) *Charlesbridge, 2010, 32 p., $16.95.*

Magic Up Your Sleeve: Amazing Illusions, Tricks, and Science Facts You'll Never Believe
Helaine Becker
Optical illusions and magic tricks reveal basic science principles. (Ages 8–12) *Owlkids Books, 2010, 64 p., $10.95.*

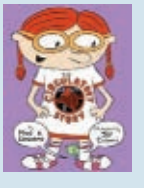
Not Your Typical Book About the Environment
Elin Kelsey
Explanations of ecology and sustainability present kids with a hopeful view of solving environmental problems. (Ages 9–12) *Owlkids Books, 2010, 64 p., $10.95.*

Looking Closely Around the Pond
Frank Serafini
Young readers can guess what will be revealed in close-up photos of pond life, then learn about the plants and animals shown. (Ages 4–7) *Kids Can Press, 2010, 40 p., $16.95.*

Evolution: How We and All Living Things Came to Be
Daniel Loxton
An in-depth guide to life's history gives clear answers to kids' questions about evolution. (Ages 8–13) *Kids Can Press, 2010, 56 p., $18.95.*



Outdoor Science: A Practical Guide
Steve Rich
Teachers looking for ways to get kids excited about science can find detailed hands-on lesson plans for life, earth and environmental sciences. (Ages 3–8) *NSTA Press, 2010, 140 p., $24.95.*



The Circulatory Story
Mary K. Corcoran
Humor pulses through this detailed exploration of how blood moves through the body. (Ages 9–12) *Charlesbridge, 2010, 41 p., $17.95.*

ET, stay home

Your excellent editorial in the April 24 issue of *Science News* ("An intelligent ET would probably just stay home") explained the most obvious reasons for the unlikelihood of an extraterrestrial message, let alone visitors.

Additional obstacles worth mention are 1) the gigantic retro-rockets, parachutes and heat shields required for braking a super-speeding vehicle, and 2) the galactic power needed for aligning the astronomical egos of spaceship builders, launchers and captains.

Curtis L. Brown, Neenah, Wis.

Reading Tom Siegfried's column on extraterrestrial intelligent civilizations raised an immediate question: Since it is highly likely that older societies with vastly more advanced technologies exist and also likely that these societies use means other than the electromagnetic spectrum for interstellar communication, it seems also likely that extraterrestrials would know that a society like us, with our primitive technology, would use that spectrum. The silence of the elders then implies that they do not wish to communicate with us primitives.

There could be many reasons for this, including our own long-televised evidence of violence and injustice to one another, or maybe just that the grown-ups know we need to prove ourselves to be much more civilized before we are allowed to learn of the advanced societies. Like most children, our potential is great, but until we have a better track record, it isn't at all clear that our potential is for good.

Ed Berg, Salida, Colo.

Skin to neuron cells

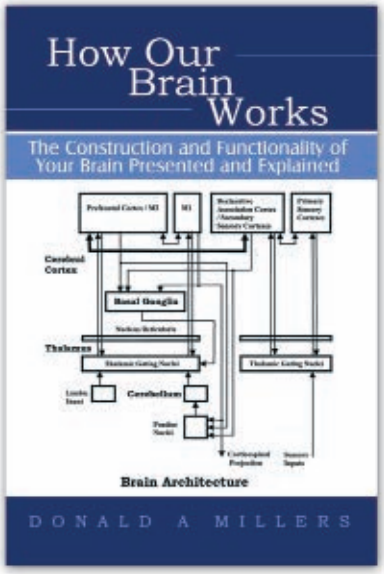
The article "From skin cells to neurons, with no middle man" (*SN: 2/27/10, p. 5*) describes the transformation of "skin fibroblast cells from mice into working neurons by using viruses to insert genes that encode transcription factors."

This is amazing.

I wonder if a similar process could be partially responsible for the spread of cancers through the body or for the growth of tumors — that is, cancer spreading and growing by transforming other cells and not just by metastasis and cell division. Cancer cells have a hyperactive metabolism and higher rates of cell division. Perhaps excess transcription factors (the proteins) for oncogenic genes could be absorbed by other cells after leaking out of a cancer cell. Or perhaps hyperactive oncogenic genes (the DNA) could be absorbed by other cells after an apoptotic (programmed cell death) explosion of a cancer cell.

Elizabeth Mansfield, North Potomac, Md.

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



How Our Brain Works

Donald Millers

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iUniverse, 2010, 300p., $31.95.

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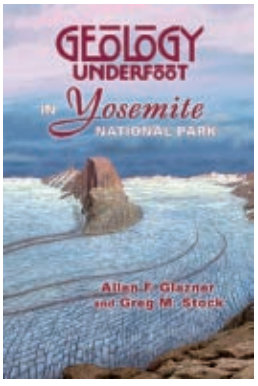

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Eric S. Lander

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Obama adviser weighs 'the rightful place of science'

In an address to scientists attending the 2010 meeting of the American Association for the Advancement of Science, genomics researcher Eric S. Lander, a cochair of President Obama's Council of Advisors on Science and Technology and a founding director of the Broad Institute of MIT and Harvard in Cambridge, Mass., discussed science and technology policy in the United States. Susan Gaidos, a Science News *contributing correspondent, compiled some of his comments and observations, starting with Lander's interpretation of a passage from the president's 2008 inaugural address.*

The president spoke about the economic crisis that was gripping the nation.... He said ... "the state of our economy calls for action, bold and swift ... we will act not only to create new jobs, but to lay a new foundation for growth. We will build the roads and bridges, the electric grids and digital lines that feed our commerce and bind us together. We will restore science to its rightful place and wield technology's wonders to raise health care's quality and lower its costs."

What is the rightful place of science?

As seen from the first year of the administration, its rightful place is in the president's cabinet and policy making; in the nation's classrooms; as an engine to propel the American economy; as a critical investment in the federal budget, even in times of austerity; as a tool for diplomacy and international understanding and as an organizing principle for space exploration.

There is a responsibility to engage actively in the stewardship of science and technology. Science doesn't just happen. It's the result of social systems that promote innovation and exploration. There are also important choices about the balance of projects to be supported. There's curiosity-driven, individual investigator projects. There are projects aimed at tackling well-identified needs, projects at creating shared infrastructure.... The point is that different approaches to the funding of science call forth different sorts of innovation and different sorts of energy. And together they shape an ecosystem of scientific innovation, from early discovery to long-term public benefit.

The second responsibility that has become apparent to me as I've been exposed to some of this over the past year is the need to engage actively with economists. Scientists are often reluctant to talk about the practicality of science. We shouldn't be. The reason that this administration and past administrations have vigorously supported science is not simply because of the beauty of scientific knowledge, although this is true and very important. But [the investment] is justified, at least in significant part, because of its eventual social product. Science drives the innovation that provides productivity and growth for the future economy, and it also adds to our quality of life in many ways.

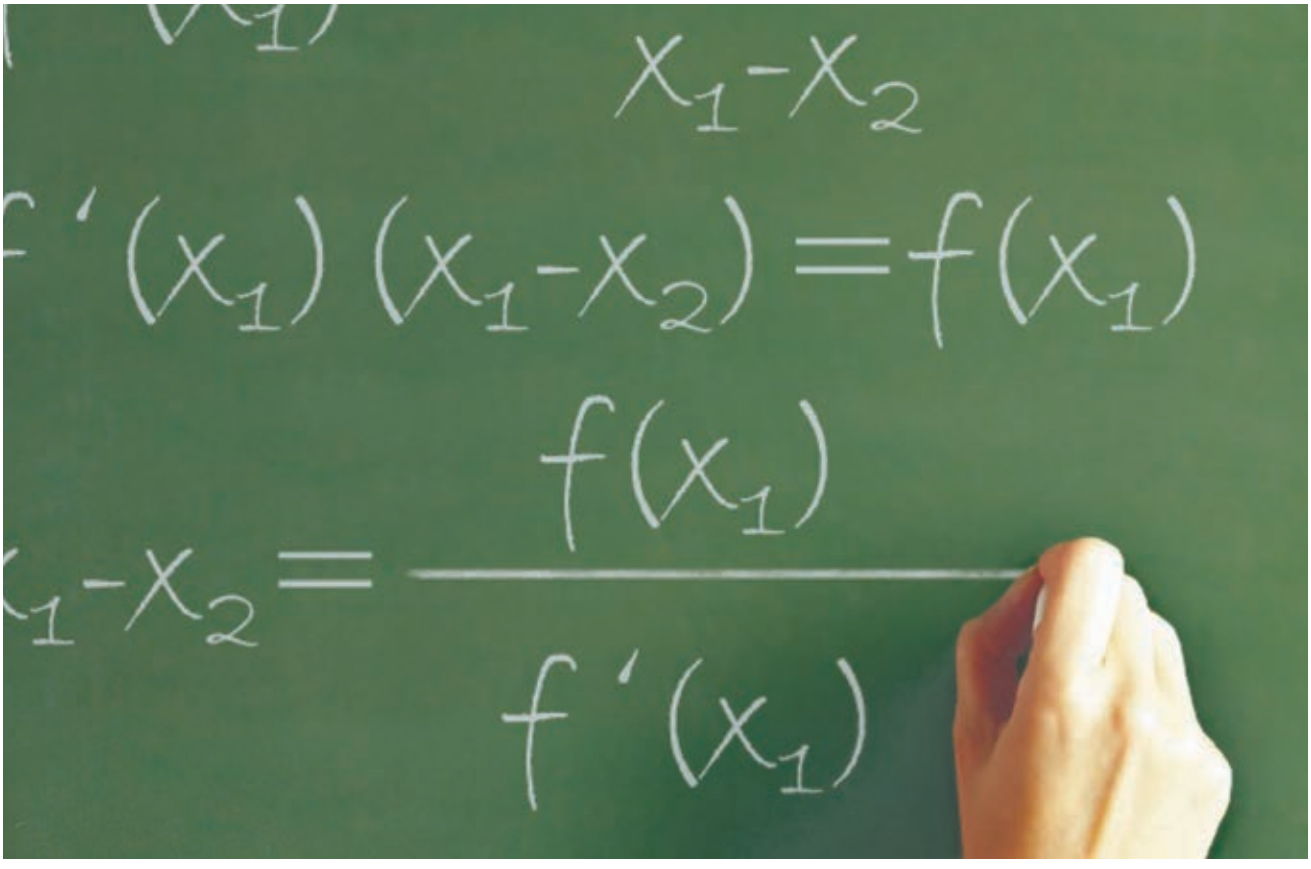
Science drives the innovation that provides productivity and growth for the future economy, and it also adds to our quality of life in many ways.

Finally, to engage with education. We need to engage much more vigorously in STEM [science, technology, engineering and mathematics] education. We do in fact need to focus on this to produce the next generation of scientists and engineers who will press the frontiers of knowledge and transform our economy. But more than that, as the president remarked, it's having an informed citizenry in an era when so many problems we face as a nation are, at root, scientific problems. As individuals and institutions we need to be engaged in supporting STEM education, including supporting teachers and serving as teachers ourselves. Because in the end education depends on great teachers, and in supporting the growing state-led movement to adopt common math and science standards and assessments.

In addition, I think we're entering upon an era when technology can propel enormous progress in STEM education. For the most part, educational technology has been disappointing. There are, of course, good lectures to be found on the Web and good materials, but they're scattered and uneven and unintegrated. A student has to be mighty motivated to truly learn from the materials on the Web. We need new kinds of technology platforms on the Web to make it possible to integrate content from many sources: text and video, and simulations of problems and adaptive tutoring systems. Ideally, much of it open-source so that they can be mashed and repurposed and continually improved. And we need built-in ways to measure and reward their effectiveness. It's going to require efforts from both the not-for-profit and the for-profit sectors. But if done right, we ought to be able to call forth enormous creative energies from the entire science and technology community.

We stand in a unique moment in the relationship of science and technology with government. The administration has made an unprecedented commitment to science and technology, and it is the responsibility of all of us to make sure that we deliver on that promise to the American people and to humankind. ■

LEN RUBENSTEIN



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