

Early African Exodus | Rivers Aloft | Mind Sharpeners

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# ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ FEBRUARY 26, 2011

## Pursuit of Pleasure

How your brain knows  
what you want



**Feeling for  
Lost Limbs**

**A Profusion  
of Planets**

**Incest No  
Problem for  
Ant Clones**

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*Neutronic Ear is the easy, virtually invisible and affordable way to turn up the sound on the world around you.*

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## The Evolution of Hearing Products

Invention	Date	Easy to Use?	Invisible?	Affordable?
The Ear Horn	17th Century	No	Hardly	Maybe
Wearable Hearing Aid	1935	Weighed 2.5 pounds	No	No
Digital Hearing Aid	1984	No	No	Not for most people
Neutronic Ear	2010	Yes	Yes	Yes

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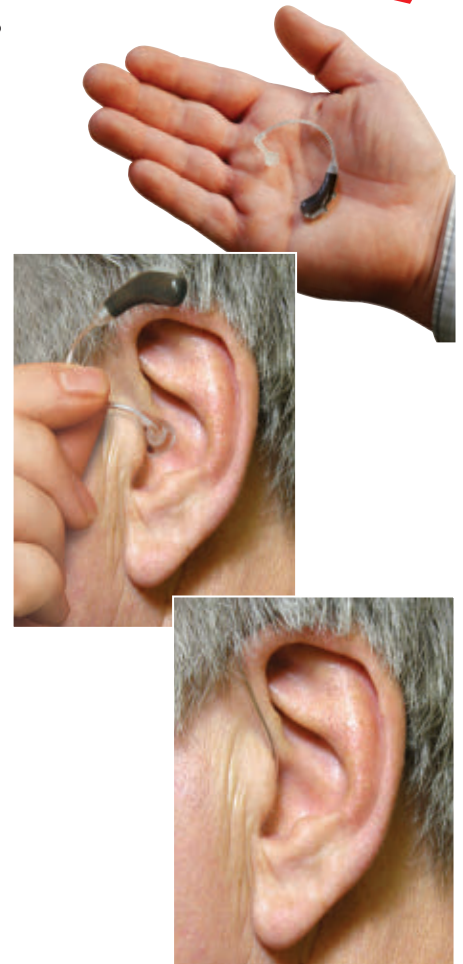
- Parties
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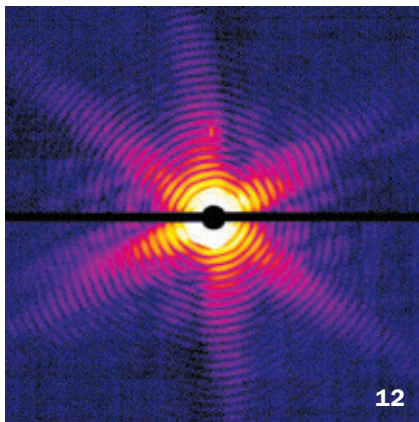
Neutronic Ear is not a hearing aid. If you believe you need a hearing aid, please consult a physician.



# ScienceNews



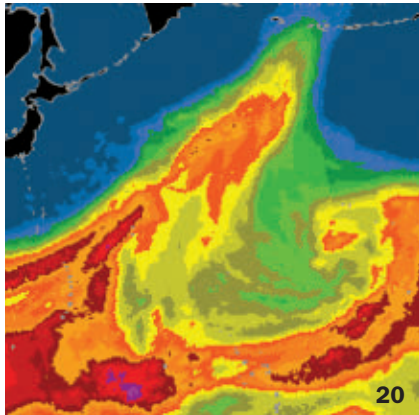
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*Michael Morgenstern*

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FROM THE EDITOR

## Warnings of phony science need occasional revisiting



In the early days of *Science News*, editor Watson Davis compiled an extensive list of “stories that should be handled with care.” By that he meant that they should be avoided altogether.

Among the obvious prohibitions were stories about “telepathy and mind reading,” claims of perpetual motion, and reports of sea serpents or “man-eating trees.” Watson also issued warnings about divining rods, death rays and “messages from or to Mars or other planets.” In the medical realm he cited claims of cancer cures, baldness cures, obesity cures and “cure of rabies by a stone or by shooting the dog.”

Davis did not mention another common sort of claim — for drugs or foods that could enhance human brainpower.

For much of human economic history, unscrupulous hucksters have attempted to persuade unsuspecting consumers that ingesting some secret formula would boost mental ability. Nearly all such claims deserved to be on Davis’ list.

In recent years, though, dietary ingredients for sharpening certain aspects of intellect have begun to achieve enough respectability to warrant a relaxation of the old warnings. As Janet Raloff reports (Page 26), researchers have identified natural substances in drinks and foods that do appear to come to the aid of beleaguered brains. Caffeine does not just help keep you awake, for instance, but can also help improve performance on mental tasks even if you weren’t sleepy to begin with. Various experiments have shown that other dietary substances may exert beneficial influences on the brain’s abilities.

Apart from the intrinsic interest in enhancing mental function, these studies illustrate a deeper lesson: that things once only imagined may eventually become proved, to paraphrase William Blake’s *The Marriage of Heaven and Hell*. Crazy-fictional ideas like invisibility cloaks (Page 12) now appear regularly in respected scientific journals. And death rays (aka lasers) appeared in *Science News Letter* a mere decade after Davis published his two-decades-old list (*SNL*: 7/1/50, p. 12). But that was not an inconsistency, as his warning list was not meant to be the final word on what was forever false.

“These are not forbidden stories,” Davis had written, “for some of the impossible things of today may become possible tomorrow.” One way to think about science, after all, is as the process for sorting out the possible from the impossible. There’s still a long way to go before that task is finished.

—Tom Siegfried, Editor in Chief



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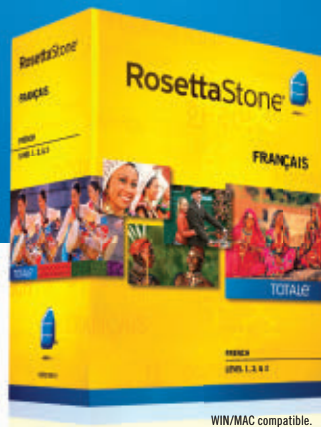
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### Scientific Observations

“Why would you use rats [to sniff for land mines and tuberculosis infections]?... Rats have more genetic material allocated to olfaction than any other mammal species. They’re extremely sensitive to smell.... Whereas a microscopist can process 40 [tuberculosis patient] samples in a day, a rat can process the same amount of samples in seven minutes.... Can you imagine the potential offspring applications—environmental detection of pollutants in soils, customs applications, detection of illicit goods in containers.... You may think this is about rats, these projects, but in the end it is about people. It is about empowering vulnerable communities to tackle difficult, expensive and dangerous humanitarian detection tasks, and doing that with a local resource.” —ENGINEER BART WEETJENS OF APOPO-HERORATS, IN HIS TEDXROTTERDAM 2010 TALK “HOW I TAUGHT RATS TO SNIFF OUT LAND MINES” (SN ONLINE: 12/23/10)



### SN Online

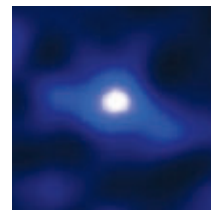
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#### MOLECULES

Researchers make strides in understanding how anesthetics work, plus more in “News in Brief: Molecules.”

#### ATOM & COSMOS

Astronomers spot what may be the most distant object ever observed. Read “A galaxy far, far, far away.”



### Science Past | FROM THE ISSUE OF FEBRUARY 25, 1961

TRAFFIC CONGESTION SEEN AS FUTURE SPACE PROBLEM — Traffic congestion may be one of the most serious problems man may have to face when he starts commuting regularly from earth to outer space.



This new frontier gradually is becoming cluttered with earth-launched orbiting vehicles and other debris.... [A]stronomical observatories, weather, TV and other communication satellites as well as the larger economy-sized USSR spacecraft to be boosted upward

in the future also promise to diminish the wide open look that has up to now characterized outer space. Control over the amount of traffic plus the travel routes will depend on international agreement. United States space scientists already are worrying about this problem.

### Science Future

#### February 28

Learn about the good and bad of fat tissue at an afternoon symposium in New York City. Go to [www.nyas.org/events](http://www.nyas.org/events)

#### March 7

At the Houston Museum of Natural Science, a geneticist describes efforts to track humanity’s migratory routes with DNA. See [www.hmns.org](http://www.hmns.org)

#### March 11–12

Dig into the past at the Milwaukee Archaeology Fair. Go to [www.mpm.edu/events](http://www.mpm.edu/events)

#### MATTER & ENERGY

Physicists discover why a swinging pendulum speeds up in an unusual ultracold liquid. See “Quantum pendulum trick explained.”

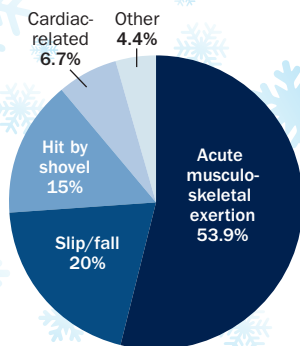
#### BODY & BRAIN

Older adults who walked regularly gained volume in a brain area involved in memory, while those who didn’t walk experienced shrinking. Read “Aerobic exercise boosts memory.”

### Science Stats | TROWELING ALONG

More than half of the 195,000-plus snow shovel-related injuries treated in U.S. emergency rooms from 1990 to 2006 were from overexertion, often affecting the lower back, a recent study found. About 63 percent of injuries were sustained by 18- to 54-year-olds.

#### Causes of snow shovel-related medical mishaps, 1990–2006



SOURCE: D.S. WATSON ET AL / AMER. J. OF EMER. MED. 2011

### For Daily Use

Teaching kids to read well may help their spatial skills. An international team of researchers reports online January 14 in the *Journal of Experimental Child Psychology* that kindergartners scored higher on a visual spatial relationships test when they were good readers. The researchers tested children with training in one of four types of writing: alphabetic (Spanish), abjad (Hebrew), logography (Chinese) and syllabary (Korean). Chinese and Korean readers also performed better on the test than Spanish and Hebrew readers, perhaps, the researchers claim, because Chinese and Korean have more characters and are more “visually dense” — only small differences distinguish the two Korean words at left, for example.

모래

Sand

모레

Day after tomorrow



“ A blood vessel that comes right off the shelf for a bypass—that’s potentially groundbreaking stuff. ” —ALAN KYPSON, PAGE 11

**Environment** Insulated glaciers stay icy

**Body & Brain** Prosthetics get in touch

**Matter & Energy** Invisibility cloaks go big

**Life** Ants’ genetic tricks

**Humans** ‘Love’ hormone can cut both ways

**Genes & Cells** From skin to heart in a beat

**Atom & Cosmos** Exoplanet jackpot

# In the News

STORY ONE

## Stone tools hint at earlier human exit from Africa

Controversial find could push expansion back 65 millennia

By Bruce Bower

Stone Age people apparently took a surprisingly fast track out of Africa, reaching Arabia’s eastern edge as early as 125,000 years ago, according to a report in the Jan. 28 *Science*. That’s a good 65,000 years earlier than the generally accepted date for the first substantial human migrations beyond Africa.

Stone tools unearthed at an Arabian Peninsula site called Jebel Faya resemble sharpened points and cutting implements from East African sites of about the same age, says a scientific team led by physical geographer Simon Armitage of the University of London and archaeologist Hans-Peter Uerpmann of the University of Tübingen in Germany. Jebel Faya is located in what’s now the United Arab Emirates.

“New dates at Jebel Faya reveal that modern humans migrated out of Africa much earlier than previously thought, helped by global fluctuations in sea level and climate change in the Arabian Peninsula,” Armitage says.

Modern humans originated in East Africa around 200,000 years ago, according to fossil and genetic evidence (*SN*: 2/26/05, p. 141).

DNA analyses of people living in dif-

ferent regions of the world today suggest that modern humans rapidly migrated from Africa to Asia around 60,000 years ago. Most researchers suspect that those ancient travelers moved through the Middle East or along Arabia’s south coast to reach Asia.

Many advocates of this later African departure suspect that a massive eruption of Indonesia’s Mount Toba around 74,000 years ago created a global “volcanic winter” that decimated modern human populations in Africa and rendered the Indian subcontinent uninhabitable for thousands of years. But supporters of an earlier out-of-Africa migration contend that the eruption had a relatively minor and short-lived climatic effect.

Finds at Jebel Faya further call the volcanic winter scenario into question, Armitage says. By about 130,000 years ago, decreased sea levels narrowed the Bab el Mandeb Strait separating East Africa from southwest Arabia to about 4 kilometers, allowing easier passage, the researchers estimate. Travelers could have then moved across the peninsula through a network of Arabian lakes and rivers created by warm, wet conditions at that time.

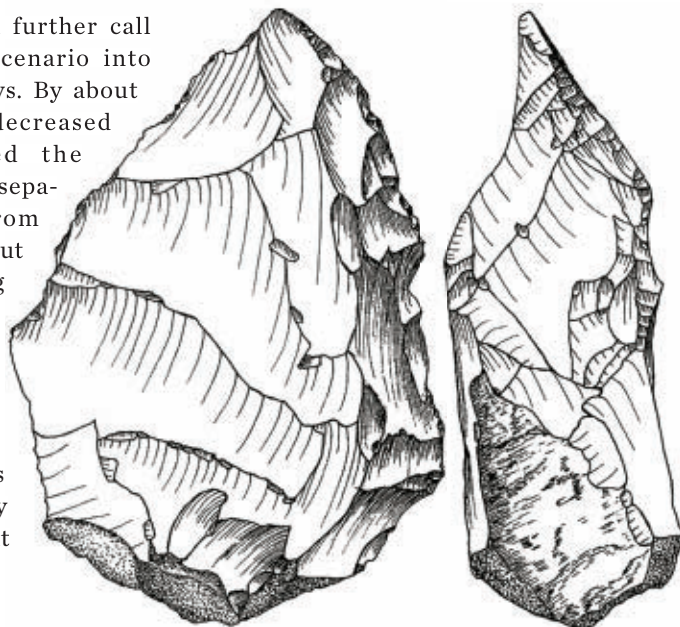
Jebel Faya sits just across the Persian Gulf from Iran, at another narrow water crossing where low sea levels would again have

eased passage, Armitage says.

Excavations began at Jebel Faya in 2003. Initial finds came from settlements dating to between about 3,000 and 10,000 years ago. Stone tools from roughly 38,000 years ago then turned up. In March 2006, investigators began to unearth tools from an ancient rock shelter that was occupied between 100,000 and 125,000 years ago.

Estimated ages are based on a widely accepted method that measures accumulated natural radiation in sand grains to determine the amount of time elapsed since the grains were exposed to sunlight.

Another cache of stone tools encased in sediment just above the rock shelter has not been dated.



Stone tools unearthed near the Persian Gulf, such as this hand ax shown from different angles, suggest to their discoverers that modern humans left Africa and trekked across Arabia as early as 125,000 years ago.

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 SN Today at [www.sciencenews.org](http://www.sciencenews.org)

Findings at Jebel Faya consist of stone points, a few teardrop-shaped cutting implements known as hand axes and a variety of other sharpened rocks. These tools, in particular the points and hand axes, closely resemble African Stone Age artifacts from around the same time, the scientists assert. So far, the site has yielded no modern human fossils.

Still, archaeologists familiar with the new report say that Jebel Faya provides an important glimpse of what may be an early push by modern humans into Arabia. That's where agreement ends.

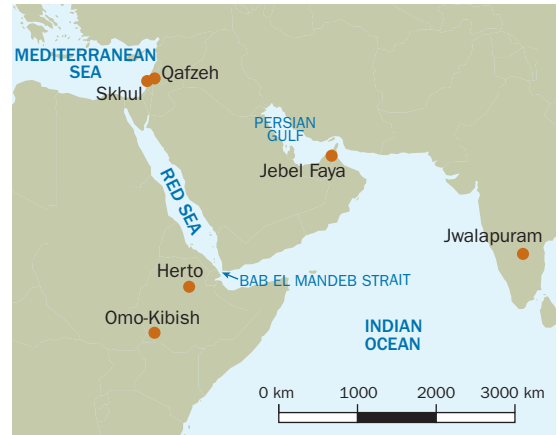
Tough, adaptable modern humans could have forged into Asia at least 100,000 years ago, agrees John Shea of Stony Brook University in New York. But stone points from Jebel Faya are shorter, thicker and less pointy than those found throughout Africa beginning 100,000 years ago, he says.

Ravi Korisettar of Karnatak University in Dharwad, India, agrees that Arabia possibly served as a hub for early modern human migrations between Africa and Asia. Korisettar has

excavated Stone Age sites in southern India's Jwalapuram Valley since 2003. Modern humans' stone tools found there come from sediment just below and above an ash layer deposited by the Toba eruption, he says, suggesting that people arrived before the blast and endured its devastation.

Jebel Faya and Jwalapuram tools display some similarities, but the oldest Indian finds date to shortly before Toba's detonation 74,000 years ago and look more like African implements from that time, Korisettar holds.

It's more likely that warm, wet conditions 100,000 years ago prompted dead-end migrations of modern humans into Arabia and the Middle East, argues Stanley Ambrose of the University of Illinois at Urbana-Champaign. Previously unearthed fossils from several



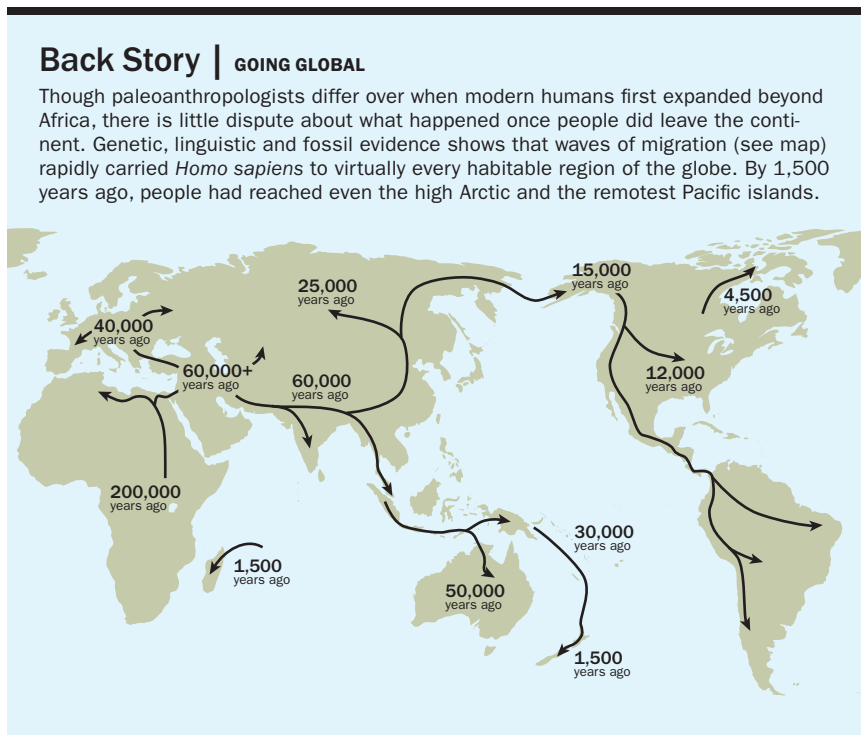
**Some archaeologists believe tools at Jebel Faya suggest that humans setting out from East African sites such as Omo-Kibish might have reached South Asia before a volcanic eruption 74,000 years ago.**

Israeli sites, including the caves at Skhul and Qafzeh, indicate that modern humans moved from Africa to the Middle East approximately 100,000 years ago but, either because they died out or returned to Africa, gave way to Neanderthals by 70,000 years ago. Another nearby cave, Kebara, holds Neanderthal remains.

Pollen evidence indicates that the Toba explosion set off 10,000 years of extreme cold and environmental devastation that nearly wiped out African *Homo sapiens*, Ambrose contends. Modern human survivors of the blast's aftermath then colonized Asia, in his opinion.

Paul Mellars of the University of Cambridge agrees with that scenario. But like Shea, he sees crucial size and shape differences between Jebel Faya and African stone tools, casting doubt on the African origins of the Arabian toolmakers. "These Arabian finds are too ambiguous to say what was happening with human movements out of Africa," Mellars remarks.

If the Arabian discoveries indeed signal an early human migration to Asia, then excavations of Stone Age sites in Iran should produce similar tools, Shea predicts. Iran's current political climate, however, makes such work difficult, he says. ■







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— JAMES T. FENT,  
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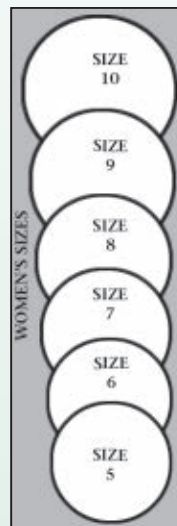
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# Environment



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## Who should stay and who could go

Carefully removing species can prevent more extinctions

By Rachel Ehrenberg

A little human meddling may prevent the mess of extinctions that can ripple through disturbed ecosystems.

A new analysis of how perturbations propagate through a network of organisms reveals that when an ecosystem is already off-kilter, proactively removing particular species can halt the cascade of destruction that may follow. The approach, described online January 25 in *Nature Communications*, could help well-defined areas such as islands deal with the effects of invasive species.

“At the end of the day, methods based on inflicting locally controlled damage—despite being damaging—can have a positive effect on the entire network,” says study coauthor Adilson Motter of Northwestern University in Evanston, Ill.

To understand how such tinkering plays out, Motter, an expert in complex networks, and his Northwestern colleague Sagar Sahasrabudhe developed an algo-

rithm that takes into account two classic ecological models of species interactions. By simulating who eats whom and how the exchange of biomass leads to changes in population levels over time, the researchers could identify species whose removal or suppression would contain damage. Tactics such as birth control for deer that are overrunning an area, or encouraging fishing of a species, may end up helping multiple other species, the analysis suggests.

Human interference to compensate for previous human interference has had some success. Destructive feral pigs on Santiago Island in the Galápagos, which were introduced a few years after Darwin visited the archipelago in 1835, were finally cleared from the island in 2000 after the removal of more than 18,000 pigs. But predicting how such meddling may affect the big picture isn’t always obvious.

In fact, the dynamic nature of networks means that such interference can prevent the majority of secondary extinctions, the researchers report.

“Some extinctions you cannot prevent, but most are caused by this speedy perturbation wave sweeping the network,” Motter says.

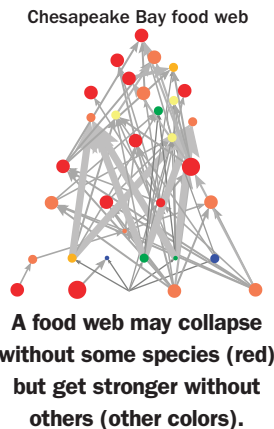
He notes that the team isn’t advocating large-scale abolition of any species. But for contained spaces such as islands, lakes or parks—places that often grapple with

invasive species or otherwise out-of-whack distributions of critters—the approach may be useful.

“This is a significant advance over prior related work,” says computational ecologist Jennifer Dunne of the Santa Fe Institute in New Mexico. “If we make bad decisions it doesn’t just affect ecosystems; it affects us,” she says.

“So it behooves us to get beyond overly simplistic ways to confront and manage perturbations.”

The approach provides a potentially helpful tool to conservationists, says Josh Donlan of Advanced Conservation Strategies in Midway, Utah, and a visiting fellow at Cornell University. “These are exactly the kinds of questions that theoretical ecologists should be asking.” ■



## Dispersants persisted after BP spill

Chemicals used to break up oil lasted for months in plumes

By Janet Raloff

Nearly 3 million liters (some 771,000 gallons) of a chemical dispersant ejected into oil and gas from the *Deepwater Horizon* oil spill last spring and summer lingered until at least September, a new study shows. The chemicals moved in concert with plumes of oil deep beneath the Gulf of Mexico’s surface.


David Valentine of the University of California, Santa Barbara and his colleagues periodically sampled plume water

that flowed at depths of 1,000 meters or more between May and September 2010. They shipped these samples to chemist Elizabeth Kujawinski at the Woods Hole Oceanographic Institution in Massachusetts and her colleagues for analysis.

With rare exception, the dispersant did not degrade but instead moved with the plumes until both were lost to dilution, the team reports online January 26 in *Environmental Science & Technology*.

To scout for the dispersant, known as Corexit 9500A, Kujawinski focused

on an active ingredient called DOSS, or dioctyl sodium sulfosuccinate. DOSS levels in the plume matched what would be expected if the dispersants remained with the oil. That, Kujawinski says, suggests no biodegradation of DOSS—and shows why remnants of dispersant applications could be detected up to 300 kilometers from the wellhead and two months after the last application.

“Corexit is made up of multiple chemicals, so each might have different biodegradation rates,” notes Carys Mitchelmore of the University of Maryland’s Center for Environmental Science in Solomons. As for whether dispersants help degrade oil, “the jury’s still out,” she says. 

**30**  
million | Number of U.S. users of soft contact lenses

**2**  
people | Yearly cases of an amoeba-linked corneal disease per million lens users

**158**  
people | Cases diagnosed during 2005–07 U.S. outbreak

## Amoebas common in drinking water

### Study finds widespread contamination could be a health risk

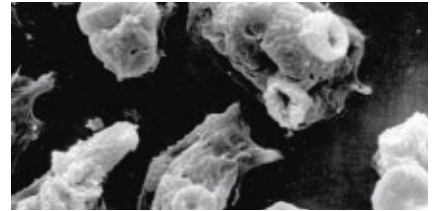
By Janet Raloff

Amoebas — blob-shaped microbes linked to several deadly diseases — contaminate drinking-water systems around the world, according to a new analysis. The study finds that amoebas are appearing often enough in water supplies and even in treated tap water to be considered a potential health risk.

A number of amoebas can directly trigger disease, from a blinding corneal infection to lethal brain inflammation. But many possess an equally sinister if less well-recognized alter ego: Like Trojan horses, they can carry around harmful bacteria. Hidden in amoeba cells, many bacteria can multiply and evade disinfection agents at water-treatment facilities.

U.S. water systems aren't required to screen for amoebas, says Nicholas Ashbolt of the U.S. Environmental Protection Agency's National Exposure Research Laboratory in Cincinnati. He and Jacqueline Thomas of the University of New South Wales in Sydney report on amoebas as a "yet unquantified emerging health risk" in the Feb. 1 *Environmental Science & Technology*.

In a review of more than 100 studies, the team identified 26 conducted in 18 countries that had found amoebas in drinking-water systems. Among 16 studies that looked for tap water contamination, 45 percent found amoebas. Five studies reported finding amoebas in anywhere from 75 to 100 percent of surface waters, such as rivers, that could



**Naegleria fowleri amoebas found in water supplies can trigger encephalitis, a nerve infection that is quickly lethal.**

serve as a source for drinking-water supplies. Water treatment appears to reduce amoeba concentrations to a tenth or one-hundredth of starting concentrations, "but breakthrough events do occur," the authors write.

The new study "shows there's just overwhelming evidence that this microorganism is occurring at levels that are a health concern," says environmental scientist Marc Edwards of Virginia Tech in Blacksburg. [t](#)

## Some Himalayan ice not shrinking

### Glaciers in the Karakoram region may even be growing

By Janet Raloff

An important portion of Himalayan glacier cover is currently stable and, thanks to an insulating layer of debris, may even be growing, a new study finds. The conclusion contradicts a portion of the 2007 Intergovernmental Panel on Climate Change report that had to be retracted last year because it could not be substantiated.

Though the IPCC report stated that the risk of the region's glaciers "disappearing by the year 2035 and perhaps sooner is very high," the new study finds

that ice cover is stable in the Karakoram Mountains, a northern range that holds about half of the Himalaya's frozen water.

That's not to imply that water reservoirs on what's often called the roof of the world aren't under stress. Throughout most Himalayan ranges, at least 65 percent of the studied glaciers were shrinking, Dirk Scherler of the University of Potsdam in Germany and his colleagues report online January 23 in *Nature Geoscience*. But in the Karakoram range, 58 percent of studied glaciers were stable or



**Thick coatings of rocky debris, such as on this stretch of India's Jaundhar Glacier, are stabilizing some glaciers even as ice cover in neighboring ranges shrinks.**

slowly expanding up to 12 meters per year.

Scherler's team pored over satellite images of 286 glaciers throughout the Himalayas. Collected between 2000 and 2008, the images showed a consistent trend everywhere except the Karakoram: a reduction in the area of glacial cover. Many glaciers in those regions also were stagnant — not flowing — an indicator of poor health, Scherler says.

"The picture of climate change effects in high Asia is much more complicated than most people realize," says Kenneth Hewitt of Wilfrid Laurier University in Waterloo, Canada. For much of the past century, Karakoram's glaciers were in retreat. In 2005, Hewitt documented a turnaround that began in the late 1990s.

In that region, it seems, rocky rubble eroded from uphill peaks serves to protect glaciers from the effects of regional warming. The new analysis finds that retreat rates varied in the Himalaya "from high for debris-free glaciers to zero for glaciers with debris cover greater than 20 percent." [t](#)

FROM TOP: F. MARCIANO-CABRAL/VA. COMMONWEALTH UNIV. SCH. OF MED.; D. SCHERLER/UNIV. OF POTSDAM



# Body & Brain



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## Helping artificial limbs to feel real

Prosthetics with a 'sense of touch' more like part of body

By Laura Sanders

Rerouting nerves helped amputees view their artificial limbs more like body parts, a study to appear in *Brain* suggests. Such enhanced sense of ownership, scientists say, might lead to prosthetics that seamlessly replace a missing limb.

The new study was conducted with two amputees who had undergone a surgery called targeted reinnervation, in which the remaining nerve ends from their severed arms were rerouted to areas above the amputation site. These patches of skin served as proxies — touching different parts of the areas made the amputees feel as though distinct parts of their missing arms were being touched.

The research “tells us about the brain — that the brain can take this abnormal sensation and attribute it to the hand, to the arm,” says neuroscientist Steven Hsiao of Johns Hopkins University in Baltimore, who wasn't involved in the work. “These people are feeling something. They feel like they're really touching something, presumably.”

To create that feeling of limb ownership, or “embodiment,” researchers led by Paul Marasco designed a pressure-sensing system for prosthetics. Each time a sensor on a prosthetic hand detected a touch, it would send a signal to a small robot that would poke a targeted area of the reinnervated skin.

Using the robot system, Marasco and his team had each participant sit at a table, with the prosthetic arm unattached but arranged in a natural position. As the participant watched a researcher touch the prosthetic hand, the robot would simultaneously press on the reinnervated skin.

Seeing and feeling the touch at the same time created a powerful illusion in both amputees that the prosthetic hand was part of the body. When they saw but did not feel the researcher's touch, the participants didn't feel a sense of ownership over the prosthetic, says Marasco, now at the Advanced Platform Technology Center at the Veterans Affairs Medical Center in Cleveland. “It was really when the touch matched what they saw that we saw these changes.”

Also, when one of the participants both saw and felt a touch on her prosthetic arm, the temperature of the arm just above the site of the amputation rose. This boost, Marasco says, may reflect the body adopting the prosthetic. When sensory information is blocked

from a limb, such as an arm with nerve damage from a stroke, the limb's temperature drops slightly.

Although the new study is “a baby step,” it's important, says bioengineer Michael Goldfarb of Vanderbilt University in Nashville. “What makes you feel something is a part of you is not just being able to move it.” Sensory input can't be overlooked, he says, when creating good prosthetics.

“People feel like these are tools attached to their body. Even though they are very sophisticated, they are tools,” Goldfarb says. “So the idea of trying to get sensory information back in would help integrate this limb as part of the body, help [people] control it and, one would argue, help them feel more whole.” ■

## U.S. falters in life expectancy gains

Smoking, obesity, sedentary habits all contributing factors


By Nathan Seppa

Although life expectancy has edged up in the United States in recent decades, several other developed countries have made bigger gains, according to a report prepared by a panel of the National Research Council of the National Academies.

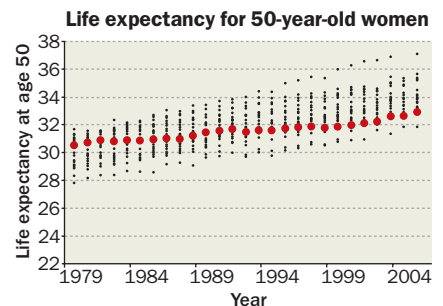
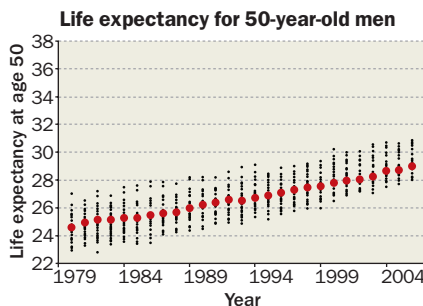
Despite high health care spending, the overall mental and physical wellness of Americans “is relatively poor,” says study coauthor Samuel Preston of the Univer-

sity of Pennsylvania in Philadelphia.

Among nations studied, the United States vies with Poland for the dubious status of most sedentary country, followed by Italy, England and Spain.

Americans have been among the heaviest smokers in the past, but the Japanese hold that distinction now. Even so, deaths attributable to smoking in past decades continue to hurt life expectancy in the United States, Belgium, Hungary, Denmark and Canada. 

**Losing ground** The United States (red) has fallen behind other developed countries (black) in life expectancy gains. The charts below show the average number of additional years of life expected for men (left) and women (right) who have reached age 50 in selected nations.



SOURCE: E.M. CRIMMINS ET AL./NRC 2011

**33.06**  
years

Life expectancy  
at age 50 for U.S.  
women, 2007

**31.95**  
years

Life expectancy at  
age 50 for Danish  
women, 2007

**37.26**  
years

Life expectancy at  
age 50 for Japanese  
women, 2007

## Cells build blood vessels for surgery

### New technology could prove useful in bypasses and dialysis

By Nathan Seppa

Using human cells as tiny factories, researchers can grow new blood vessels that might someday provide a valuable option for patients undergoing surgery for kidney dialysis or a heart bypass. A new study testing the bioengineered vessels in baboons and dogs raises the prospect of mass-producing such natural-tissue vessels, researchers report in the Feb. 2 *Science Translational Medicine*.

In coronary bypass surgery, a vein is typically stripped out of a part of the body that can manage without it and implanted on the heart as a conduit supplying blood to the heart muscle. But in some patients, vessels are inaccessible due to obesity, deterioration or having been used up in other operations. Those individuals have few alternatives beyond medication, says study coauthor Alan Kypson, a surgeon at East Carolina University School of Medicine in Greenville, N.C. “A blood vessel that comes right off the shelf for a bypass — that’s potentially



**Coaxed by scientists, human cells built this bioengineered blood vessel. It could one day be implanted in kidney patients.**


groundbreaking stuff,” he says.

The first population to benefit from these bioengineered vessels would probably be kidney failure patients who need to undergo dialysis, in which the blood is cleansed every few days. Dialysis needs fast blood flow to work well, so a patient’s best option is surgery to join a large artery directly to a vein to create a circulatory shortcut. But many patients have vessels unfit for that surgery or the surgery does not succeed; those people often get implanted with a synthetic vessel to join an artery and vein. Both operations, typically done in an arm, carry risks of infec-

tion and clogging from a buildup of cells.

In the study, Kypson and colleagues tested large bioengineered vessels in baboons. To make the vessels, the scientists cultured smooth muscle cells, obtained from human blood vessels, on a biodegradable micromesh tube. After the cells had built a vessel by depositing collagen and other compounds on the mesh, the scientists removed the cells to leave behind a vessel of tough human proteins. Removing the living cells discourages immune attack on the vessels and also allows them to be stored in refrigerators for up to a year, says study coauthor Shannon Dahl, a biomedical engineer at Humacyte Inc. in Durham, N.C.

The vessels were tested for suture strength, stretchiness and ability to withstand pressure. “If you’re going to grow blood vessels, you have to make sure they won’t burst,” Kypson says.

The researchers implanted these bioengineered vessels into baboons in the same way synthetic vessels are grafted into dialysis patients. The vessels showed little evidence of clotting and cell buildup even after six months, the longest large-animal test of a tissue-engineered vessel grown in a lab, Dahl says. 

## Flu vaccine not linked to illness

### No connection with Guillain-Barré found in Chinese data

By Nathan Seppa


Speculation drawing a link between H1N1 flu vaccination and the risk of a rare neuromuscular disorder has been dashed by a huge study. An analysis of side effects among nearly 90 million people in China vaccinated during the 2009–2010 flu season found that only 11 were subsequently diagnosed with Guillain-Barré syndrome, a rate no greater than what normally appears in the population. The

study appears online February 2 in the *New England Journal of Medicine*.

In 1976, a strain of swine flu in the United States prompted the manufacture and delivery of more than 40 million doses of vaccine. An epidemic never materialized, but hundreds of Guillain-Barré syndrome cases were reported after the vaccination campaign. The vaccine was withdrawn. In 2003, the Institute of Medicine found that the data pointed to an association between the 1976 vaccine and the syndrome. IOM found no clear evidence of such a link with subsequent flu vaccines, but some concerns have lingered vis-à-vis flu vaccination.

These fears intensified in 2009 when another swine flu emerged, this time known as the H1N1 flu, and a vaccine

was made for it. After mass vaccinations, physician Yu Wang and colleagues at the Chinese Centers for Disease Control and Prevention in Beijing collected data on all adverse effects reported by 89.6 million people in China who received the flu vaccine in 2009 and 2010. The researchers found an exceptionally low rate of Guillain-Barré syndrome among those who had been vaccinated — less than the background rate in the population.

“This was a generally well-done study given the limitations of a voluntary reporting system,” says Penina Haber, an epidemiologist at the U.S. CDC. The Chinese results are similar to a U.S. CDC analysis of adverse events for vaccines and provide further evidence of the safety of the 2009 H1N1 vaccine, she says. 

# Matter & Energy



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## An X-ray for the cell's machinery

New laser method can probe single molecules in action

By Rachel Ehrenberg

An X-ray laser so bright and fast that it puts a paparazzi zoom lens to shame has allowed researchers to snap pictures of celebrity molecules that typically avoid scientists' prying eyes. The method should prove useful for investigating the structure and activity of drugs, molecules for fuels and other materials.

Scientists have used the technique to image an important photosynthesis protein and a virus. Eventually, researchers may be able to use it to make movies of molecules interacting with each other.

"This will be extremely interesting in just about all biological systems," says physicist Henry Chapman of the Center for Free-Electron Laser Science in Hamburg. Chapman is a member of two international teams that report the technique's success February 3 in separate papers in *Nature*.

Scientists already use X-rays to image protein molecules; by collecting the diffraction patterns made when X-rays strike a molecule, researchers can piece together its three-dimensional structure. But current techniques require hefty, pure samples that must be isolated and crystallized before they can be looked at.

The X-ray laser used in the new work is so much brighter and faster than its

predecessors that researchers don't need to grow their molecule of interest into a big, sturdy crystal. Researchers hope that one day the laser may reveal molecules interacting in their native habitats, such as within a cell or its membrane.

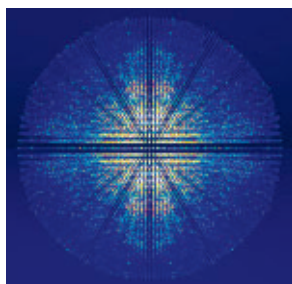
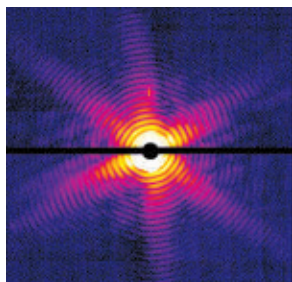
"The biggest problem has been membrane-bound proteins — they are very hard to get a detailed view of," says biophysicist Sebastian Doniach of Stanford University. "But these are the proteins that are really important for understanding how things enter the cell, how cells such as nerves signal, how drugs interact with a target cell."

The new method uses the Linac Coherent Light Source, which came online in 2009 at the SLAC National Accelerator Laboratory in Menlo Park, Calif. This free-electron laser produces pulses of hard X-rays a billion times brighter than the synchrotron X-rays used in traditional protein crystallography. The laser light's wavelength is close to the width of an atom, allowing resolution on an atomic scale. And its pulses are so short that it can capture images with a "shutter speed" on the femtosecond scale, quicker than a trillionth of a second.

By feeding a stream of molecules or another microscopic sample into the X-ray beam, scientists can take snapshot after snapshot, capturing meaningful structural information moments before each particle explodes into oblivion.

"The molecule in the beam doesn't know what hit it," says Chapman. "It just disappears in a flash of light."

Measurements suggest that the samples, be they proteins or virus particles, get hotter than the surface of the sun. ☺



**Diffraction patterns from a free-electron laser can reveal molecular structures, such as a mimivirus (top) and photosynthesis protein.**

## Invisibility goes macroscopic

New approach can conceal objects big enough to see

By Daniel Strain

Professor Snape beware — invisibility cloaks aren't just for the microscopic anymore.

Using natural crystals, two independent research teams have designed "carpet cloaks" that can abracadabra 3-D objects as big as an ant or a grain of sand seemingly into nothing. Up to now, making things invisible has relied on tiny structures called metamaterials. These fabrications are often a mix of stacks and crisscrosses of nanosized metals and other materials that can guide electromagnetic rays, such as microwaves or infrared and visible light, around objects. If researchers tweak metamaterials just right, they can make tiny things disappear — at certain light wavelengths and from certain angles, at least.

But now two teams, an MIT group that published its results in *Physical Review Letters* in January and another from England and Denmark that published February 1 in *Nature Communications*, don't bother with metamaterials. They use calcite prisms, a type of naturally occurring crystal that shares some optical properties with metamaterials, to build carpet cloaks.

Carpet cloaks aren't true now-you-see-them-now-you-don't apparatuses. The bottom of the cloaking device is notched with a small triangle that's coated with silver so that it works like a bent mirror. Thanks to calcite's optical properties, the bent mirror can look like a flat plane when viewed from some angles. Anything hiding in the notch vanishes.

This low-tech design sidesteps some of the limitations of metamaterial invisibility cloaks, says Ulf Leonhardt, a physicist at the University of St. Andrews



“The molecule in the beam doesn’t know what hit it. It just disappears in a flash of light.” —HENRY CHAPMAN

in Scotland who was not involved in either study. His 2006 paper in *Science* helped to launch invisibility research.

Because metamaterials require intricate sculpting by lasers or other tools, scientists can make them only so big; Harry Potter would need to be more than paper-thin to hide under early carpet cloaks. The calcite shields, on the other hand, can disappear objects 1 to 2 millimeters tall. Metamaterial designs “liberated the imagination,” Leonhardt says. “Now, it’s time to come back to reality.”

But with such tricky optical sleight of hand, reality may seem like a misnomer. With the right type of light, calcite prisms can bend laser beams in different directions based on the crystal’s orientation. Light enters the cloak — a triangle or trapezoid made of two prisms glued together — and bounces off the bent mirror at the bottom into the second prism, then out. By the time the beams leave the



**A piece of pink paper vanishes under a new invisibility cloak, made from calcite, that can hide macroscopic objects.**

cloak, they have changed directions four times but look like they changed direction only once, says George Barbastathis of MIT, coauthor of the *Physical Review Letters* paper. His team used the cloak to hide a small metal wedge. “Putting calcite on top of the wedge, the light goes back into the same direction that it would have with a flat mirror,” he says. But it’s not just the same direction — the

light looks exactly like it bounced off a flat mirror. The metal wedge vanishes.

“It’s not a Harry Potter cloak,” says Shuang Zhang, a physicist at the University of Birmingham in England and one of the coauthors on the *Nature Communications* paper.

For one thing, the cloak works only using one particular form of polarized light. And it cloaks only when Zhang aims the light source dead-on at the crystals, not at an oblique angle. But, he says, improving the method to allow other angles isn’t too big of a leap. Zhang imagines similar technology one day concealing submarines on the seafloor.

Leonhardt says the future of optical legerdemain lies not in hiding things, but in revealing them. He uses the same geometric tools to design better microscopes. “We use similar ideas not to make things disappear but to make them visible,” he says. ■

✓Yes (Mirror)      xNo (Red car)      ✓Yes (Wix oil filter)      ✓Yes (Tools)      ✓Yes (Suspension)      ✓Yes (Motor)      ✓Yes (Belt)      ✓Yes (Coupler)

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# Incestuous ant escapes inbreeding

## Unorthodox family structure may have helped insect spread

By Susan Milius

An odd reproductive biology lets longhorn crazy ants mate with their siblings without producing inbred young—and also turns out to be useful for world domination.

The strange ability may have helped *Paratrechina longicornis* become one of the most widespread invasive ants in the tropics, says evolutionary biologist Morgan Percy of the Free University of Brussels. The tiny ants with long antennae, nicknamed crazy ants because they dash along erratically instead of following foraging trails, now occupy so much territory that scientists haven't figured out where the insect originated.

In lab tests, queens produce some daughters that are clones of themselves and that will also become queens. The queen's sons—very oddly—turn out to be genetically identical to her mate. So a queen's son can mate with her daughter in a pairing that's genetically equivalent to a pairing of nonsiblings. The next generation thus does not suffer the loss of genetic diversity that comes from brother-sister inbreeding.

There is still some normal sexual gene shuffling among longhorn crazy ants, however. When the queen produces daughters that will grow up to be workers, they turn out to carry the usual blend of mom's and dad's genes, Percy and his colleagues report in a paper posted online February 2 in the *Proceedings of the Royal Society B*.

The novelty of the report is in linking the biology to the ant's invasive success, comments Jürgen Heinze of the University of Regensburg in Germany. Such double-clone reproduction has been detected only twice before; the first known case was in the little fire ant (not the species bedeviling the southern United States but an invader all the same).

Percy and his colleagues worked with ants that had been collected in Bangkok and brought back to the lab to reproduce in single-queen colonies. Outdoors, colonies typically have multiple queens, sometimes hundreds, so that just checking genetic markers in a multiple-queen colony without knowing which eggs came from which mother could miss the unusual clonal descent



**Longhorn crazy ants have an unusual reproductive cycle that lets siblings mate without genetically inbreeding.**

of the reproductive females and males.

Uncovering the system was “a complete accident,” says coauthor Mike Goodisman of Georgia Tech in Atlanta. What was supposed to be a routine genetic analysis as part of another project turned out to have weird results.

Just how that clonal reproduction works, especially on the male side, remains to be explored. Percy says that when the news of dual-cloning broke for the little fire ant in 2005, researchers suspected that dad's genes would kick mom's genes out of fertilized eggs. Now, however, he points out another hypothesis: that some trait of the queens lets them produce “empty eggs” with none of the queen's DNA in them at all. So when sperm reaches the eggs, they become clones of dad. [ⓘ](#)

### NEWS BRIEFS

#### Ant genome triple play

Nourishing hopes for the fight against an ant takeover, international research teams have unveiled genetic blue-



prints for the notoriously invasive fire ant and Argentine ant. The genome for a species with a smaller range, the red harvester ant (shown here carrying a seed), appears along with the other two online January 31 in the *Proceedings of the National Academy of Sciences*. As well as offering new material

to mine for ideas on pest control, the studies reveal insights into ant biology. All three species, for example, show extraordinary richness in genes for taste- and smell-detecting molecules: 344 genes for red harvester ants versus 165 for honeybees. —Susan Milius

#### Nostrils not equal in pigeons

When pigeons sniff their way home, the right nostril comes in much handier than the left, researchers report January 27 in the *Journal of Experimental Biology*. Previous evidence of this asymmetry led an international team of researchers

to investigate 28 homing pigeons outfitted with GPS devices. The team plugged either a pigeon's left or right nostril and then released the birds about 40 kilometers from home. While all the birds headed out in the correct direction, pigeons with a blocked right nostril took a more circuitous path, stopping and exploring more en route, suggesting that the right nostril is important for processing navigation-related odors. The team notes that people also favor the right nostril when detecting and evaluating the intensity of odors, hinting at a broader olfactory asymmetry. —Rachel Ehrenberg

# Humans



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## The ‘love’ hormone has a dark side

Oxytocin may accentuate social tendencies for good or ill

By Bruce Bower

Oxytocin, a hormone with a rosy reputation for getting people to love, trust and generally make nice with one another, can get down and dirty, according to evidence presented on January 28.

This brain-altering substance apparently amplifies whatever social proclivities a person already possesses, whether positive or negative, said psychiatrist Jennifer Bartz of the Mount Sinai School of Medicine in New York City.

Previous work shows that a nasal blast of the hormone encourages a usually trusting person to become more trusting (*SN Online: 5/21/08*), but now Bartz and her colleagues find that it also makes a highly suspicious person more uncooperative and hostile.

“Oxytocin does not simply make everyone feel more secure, trusting and prosocial,” Bartz said.

These new results raise concerns about plans by some researchers to administer oxytocin to people with autism and other psychiatric conditions that include social difficulties, she added.

Her team studied 14 people diagnosed with borderline personality disorder and 13 volunteers with no psychiatric conditions. Symptoms of the disorder include severe insecurity about relationships, abandonment fears and constant, needy reassurance-seeking from partners.

Borderline personality disorder occurs mostly in women, but Bartz’s sample included four men. Her group of healthy participants included seven men.

Members of each group played a computer game with an experimenter posing as another research volunteer. In each of three rounds, volunteers had to predict whether their partner would

cooperate with them, enabling each player to earn \$6, or if the partner would leave the game in order to claim \$4 alone. Volunteers who suspected the partner of bad intent could leave the game early and claim \$4 for themselves.

Borderline personality players left the game early far more often after receiving an oxytocin nasal spray than after whiffing a placebo spray. Inhaling the hormone prodded their already high levels of hostile suspicion and depleted minimal reserves of trust, Bartz suggested.

Psychiatrically healthy players became more cooperative in the money game after getting oxytocin, relative to their placebo responses.

Nasally inhaling oxytocin also magnifies men’s memories of their mothers as being either supportive or not, Bartz said. Her team had 31 men fill out surveys on the quality of their relationships with their mothers up to age 16.

Those who described good maternal relationships remembered mom as substantially more caring and supportive after receiving oxytocin compared with a placebo spray. Those whose early home life had been troubled remembered mom as much less caring and supportive after oxytocin.

Bartz’s team initially described oxytocin’s two-sided influence on men’s maternal memories in the Dec. 14 *Proceedings of the National Academy of Sciences*.

Other researchers have recently reported that oxytocin stimulates greater trust of one’s own ethnic group and greater suspicion of other ethnicities.

These findings underscore that “oxytocin is not a love hormone; its effects vary in different people,” remarks psychologist Greg Norman of Ohio State University in Columbus. ■

**“Oxytocin does not simply make everyone feel more secure, trusting and prosocial.”**

JENNIFER BARTZ

### MEETING NOTES

#### Fishy is more than a smell

Saying that something smells fishy because it arouses suspicion is more than just a pungent metaphor. People become more mistrustful and uncooperative when divvying up money with others in a lab game if they smell fish oil spray, as opposed to fart spray or no odor, social psychologist Spike Lee of the University of Michigan in Ann Arbor reported in San Antonio January 29. Also, volunteers who encounter an experimenter who acts like he’s hiding something about the study become better able to identify a fishy smell, but not other food smells, than they could before. An understanding of abstract concepts such as suspicion relies on metaphorical references to sensations, such as fishy smells, Lee hypothesizes. —Bruce Bower

#### Unhappy in its own way

About one in three first marriages end in divorce within 10 years, but their paths to breaking up differ, clinical psychologist Justin Lavner of UCLA reported January 29. A majority of new husbands and wives who display negative personality traits, communicate poorly with each other and experience unrelenting stress in their lives split up in the next 10 years, Lavner said. Among couples whose marriages do well for several years, he noted, divorce occurs for nearly 20 percent whose poor communication skills eventually undermine their union. Lavner and UCLA’s Thomas Bradbury observed 172 newlyweds talking about their relationship conflicts and monitored them for the next 10 years. —Bruce Bower



## Genes &amp; Cells



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## Superbug's DNA reveals its past

Analysis tracks resistance to antibiotics and a vaccine

By Tina Hesman Saey

Sometimes natural selection gets a helping hand from humans. In tracing the genetic history of a nasty strain of pneumonia-causing bacteria, a new study shows how antibiotics and vaccines helped shape the microbe's evolution.

An international team deciphered the complete genetic blueprints of 240 samples of a drug-resistant strain of *Streptococcus pneumoniae* taken from people in 22 countries between 1984 and 2008, allowing the researchers to see how the bacteria changed over time.

This strain, known as the Pneumococcal Molecular Epidemiology Network clone 1 or PMEN1, was first recognized in a hospital in Barcelona in 1984. But the new analysis indicates the strain probably first arose around 1970, the team reports in the Jan. 28 *Science*.

"When this clone emerged, it emerged into a world in which penicillin was frequently used," says Stephen Bentley, a study coauthor and molecular microbiologist at the Wellcome Trust Sanger Institute in Hinxton, England. The strain wasn't killed by penicillin, and so spread quickly. The new study reveals some of the genetic tricks the organism used to develop drug resistance.

Since its emergence, the strain has changed one of its DNA letters (the chemical units of its genetic material) about every 15 weeks, the analysis finds. That rate of mutation is rapid but similar to rates seen in the deadly antibiotic-resistant *Staphylococcus aureus* bacterium called MRSA.


The PMEN1 strain also occasionally swaps or recombines DNA with other bacteria, and such recombination may be far more important in developing

drug resistance. Each DNA-swapping episode brings about 72 single-letter changes on average and sometimes introduces entirely new genes, or new versions of genes. "Although it's already got a winning formula for spreading around the globe, it's constantly rearranging its DNA," says Bentley.

One way bacteria evade the body's immune system is by wrapping themselves in a sugar coating called a polysaccharide capsule. The PMEN1 strain's capsule is designated serotype 23F to distinguish it from other capsules that use slightly different sugars. The capsule is one target of a vaccine called PCV7, first introduced in 2000.

But the new analysis shows that the pneumonia bacteria were already ahead of vaccine makers. By the time the vaccine hit clinics, a small number of pneumonia bacteria had already swapped DNA with

other bacteria and changed their sugar coats to serotype 19A. That switch probably happened in the United States around 1996 and independently in Spain in 1998. When the vaccine was introduced, it drastically reduced the number of infections with bacteria coated in the 23F capsule, leaving the field clear for 19A infections to take over. Newer vaccine versions target more types of capsules.

The study "illustrates that these genes are under enormous selection pressure due to human interference with antibiotics and vaccines," says Garth Ehrlich, a bacterial pathologist at the Allegheny-Singer Research Institute in Pittsburgh. Mapping the organism's past genetic contortions may not help researchers predict what the bacteria will do next, but the analysis shows that some genes are particularly prone to changes and probably are not good vaccine targets, he says. 

## A direct route to reprogramming

New method transforms skin cells into beating cardiac cells

By Tina Hesman Saey

Skin cells can be converted directly into beating heart cells, a new study shows.

The transformation occurs with a little help from cellular reprogramming factors that are usually used to make embryonic-like stem cells, scientists from the Scripps Research Institute and the University of California, San Diego report online January 30 in *Nature Cell Biology*.

Instead of taking mouse skin cells all the way back to a stem cell state and then coaxing them to form heart tissue, the researchers switched the cells directly by briefly introducing the reprogramming factors and then giving the skin cells a bath in chemicals

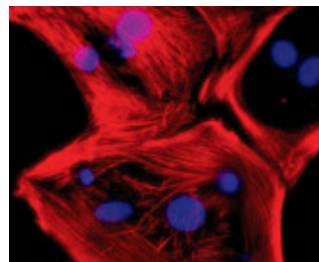
that induce heart cell development.

Others have turned skin cells directly into nerve cells (*SN*: 2/27/10, p. 5), and previous studies have grown heart cells from embryonic-like stem cells. But the

new process is faster. It took 11 days to make beating cells, whereas it could take weeks to convert skin cells to an embryonic-like state and then more time to develop them into heart cells.

Direct reprogramming may one day be used to grow new hearts for transplant

from a patient's own skin or to help repair damage after heart attacks. Scientists also want to use such cells to learn how some genetic defects affect development of the heart and other organs. ■



**Skin cells can now be turned directly into heart muscle cells (shown) in just 11 days.**



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## Atom &amp; Cosmos

68 | Number of Earth-sized candidate planets found by Kepler mission in first four months of operation

54 | Number of potentially habitable planets found by Kepler mission during the same time

## First stars might still shine today

Slow-burning remnants from the early universe may exist

By Ron Cowen

Talk about glimmers from the past. Some of the universe's first stars may still shine in the Milky Way 13.4 billion years after they formed, new simulations suggest.

The study, reported online February 3 in *Science* and posted at arXiv.org on January 28, contradicts the prevailing view that the first stars were all behemoths that burned brightly and died young.

In their simulations, Paul Clark of the University of Heidelberg in Germany and his colleagues showed that gas clouds in the early universe could have forged several stellar embryos rather than just one. Clark and another team of collaborators confirm that finding in an article posted at arXiv.org on January 31.

Infant stars in each simulated gas cloud were closely spaced, and the team suggests that their mutual gravity could kick the lowest-mass embryo from the tightly packed group — before that infant had a chance to grow into a massive, short-lived star.

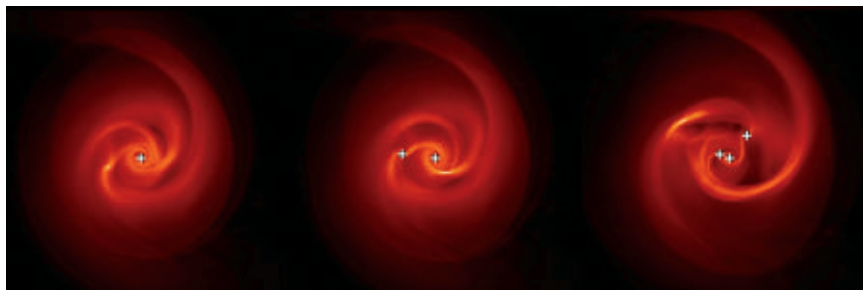
A few of these ejected stars could have survived to the present day — if they managed to accumulate no more than

the equivalent of 80 percent of the sun's mass, Clark says.

“This is an interesting and tantalizing result, but it is not based on computational physics but rather an ad hoc assumption” about the evolution of disks surrounding the birth clouds of the first stars, contends Michael Norman of the University of California, San Diego.

Clark and his colleagues simulated a longer period of early star formation than other teams have — the first 100 to 1,000 years of a process that lasts for several hundred thousand. Still, the simulations weren't long enough to determine the final masses of the primordial stars, says Tom Abel of the SLAC National Accelerator Laboratory in Menlo Park, Calif. The simulation technique is not as mathematically rigorous as other methods, he says, even though it can probe the star-formation process for longer.

To search for any surviving early stars, astronomers would need to develop a way to determine which of the hundreds of millions at the galaxy's center are most likely to be primordial, says Simon White of the Max Planck Institute for Astrophysics in Garching, Germany, a coauthor of the January 31 paper. [f](#)



As star embryos (white crosses in this simulation) formed from gas clouds in the early universe, the smallest may have been ejected before having a chance to grow.

## A thousand-plus worlds to explore

Kepler mission releases details on newly discovered planets

By Ron Cowen

Astronomers have identified 1,235 candidate planets beyond the solar system, including 54 where life might have a chance of gaining a foothold.

When extrapolated, the results — which are based on observations of bright stars in a tiny patch of sky monitored by NASA's Kepler spacecraft — suggest that some 20,000 planets in the Milky Way may lie at the right distances from their stars for liquid water to be stable, says Kepler chief scientist Bill Borucki of NASA's Ames Research Center in Mountain View, Calif.

He reported the findings, which come from Kepler's first four months of operation, at a February 2 press briefing.

“I'm just exhilarated we've found all these things already, and I'm awed that there are so many,” Borucki said. The Kepler contenders are separate from the more than 500 confirmed extrasolar planets that astronomers have discovered since 1995. Borucki said he and his collaborators are confident that at least 90 percent of the candidates will turn out to be real planets.

Of the 54 potentially habitable candidates, five are roughly Earth-sized and

the other 49 range from twice the size of Earth to larger than Jupiter. Though probably gaseous themselves, the larger planets might be able to support liquid water — and thus life — on solid moons, Borucki said. Some of those moons could be the size of Earth.

“This is definitely our best first look at the galactic planetary census,” says theorist Greg Laughlin of the University of California, Santa Cruz, who is not part of the Kepler team.

Overall, the Kepler census includes 68 planet candidates roughly the size of Earth, 288 that are a few times the size of Earth, 662 with diameters about equal to that of Neptune and 165 the size of Jupiter. About 30 percent of the candidates belong to multiple-planet systems. [f](#)



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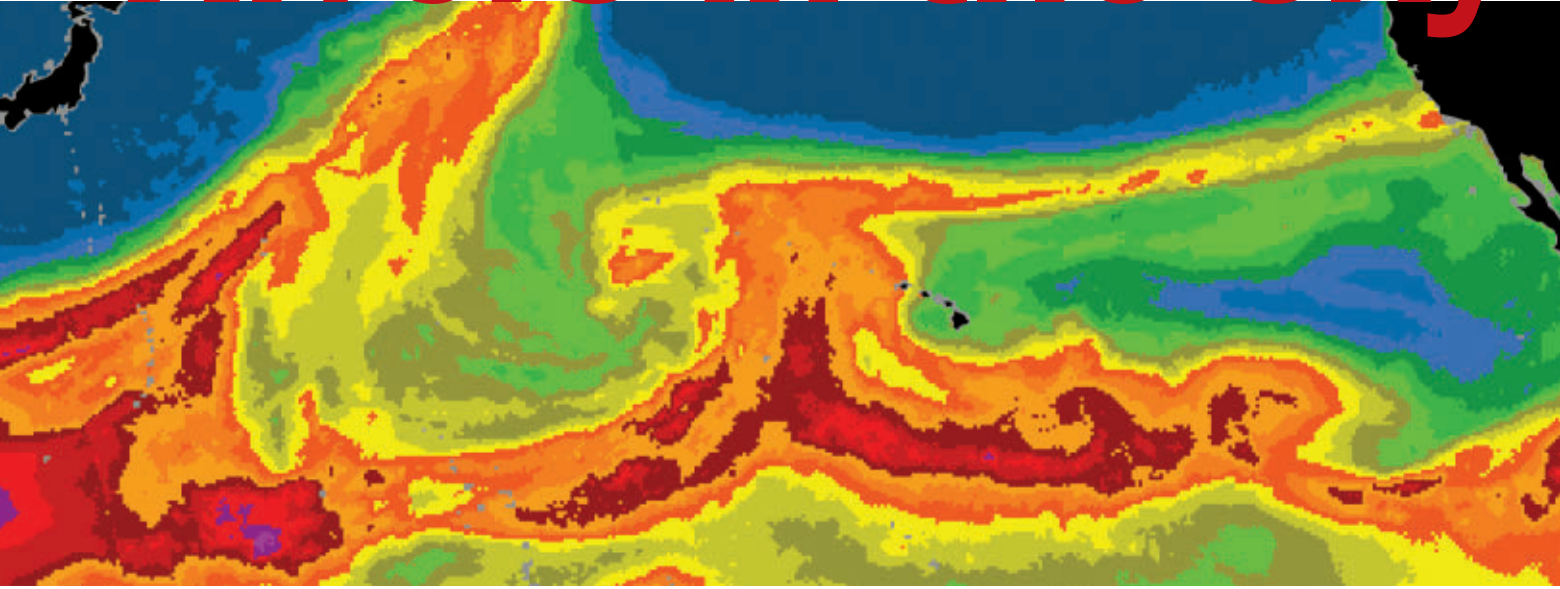
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# Rivers in the sky



## Atmospheric bands of water vapor can cause flooding and extreme weather

By Alexandra Witze

Scientific conferences usually don't physically experience their subjects. But during a session on "atmospheric rivers" last December at a geophysics meeting in San Francisco, one of those very rivers was barreling down on meeting attendees.

Like freight trains loaded with water vapor, atmospheric rivers are long, narrow bands whose winds funnel huge amounts of moisture through the sky. When they hit coasts, these rivers can drop their moisture as rain and cause destructive flooding, as in January 2005 when more than 20 inches of rain soaked southern California, killing 14 people and causing hundreds of millions of dollars in damage.

Scientists (and San Francisco) managed to escape December's atmospheric

river without such harm, but the storm dumped more than 10 feet of snow in parts of the Sierra Nevada, putting the mountains on track for their wettest recorded season. That sort of impact underscores why researchers have recently become fascinated with atmospheric rivers. Completely unknown just over a decade ago, these rivers turn out to be not only a key factor in Western flooding and water supply, but also a major player in the planet's water cycle.

"Water is life, and atmospheric rivers provide water," says Paul Neiman, a meteorologist at the National Oceanic and Atmospheric Administration's Earth System Research Laboratory in Boulder, Colo. New research is revealing how these rivers work, as well as helping forecasters better predict their consequences.

At any given time, somewhere between three and five atmospheric rivers are typically ferrying water in each hemisphere. More than 1,000 kilometers long, they are often no wider than 400 kilometers and carry the equivalent, in water vapor, of the flow at the Mississippi River's mouth. "That has really captured the imagination of scientists," says Marty Ralph, also a meteorologist at the Boulder lab. "There

**An atmospheric river that hit California in late December (warmer colors signify more water vapor) ferried moisture from southwest of Hawaii.**

are only a handful of these events, and yet they do the work of transporting 90-plus percent of water vapor on the planet."

Ordinary clouds don't carry lots of water vapor long distances; they rain out as soon as water droplets coalesce and get heavy enough to fall as precipitation. In the 1990s, MIT researchers calculated from wind and moisture data that jets in the atmosphere, which the scientists termed atmospheric rivers, must exist to help ferry water around the planet.

Since then researchers have gotten a better look at the rivers, using microwave-sensing instruments carried on polar-orbiting satellites. Solar radiation bouncing off Earth's surface in microwave wavelengths is affected by the amount of water vapor between the ground and the satellite, but microwaves aren't affected by clouds the way visible and infrared radiation are. So microwave instruments are able to photograph ribbons of water vapor coursing through the atmosphere.

In the early days of atmospheric river

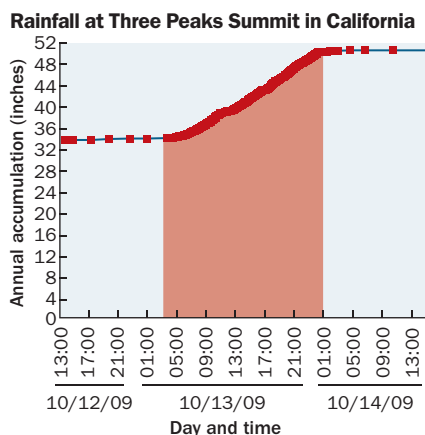


research, scientists weren't sure that the bright bands of water vapor in microwave satellite images really translated to super-soggy conditions. So teams flew research airplanes into storm systems, some of which spawned atmospheric rivers, to measure how wet things got. "You could really sense the juiciness," Ralph says. "You could smell it in the cockpit."

Atmospheric rivers are born because of temperature differences between Earth's tropics and its poles. During winter, a pole cools compared with the equator, creating a strong temperature gradient across the hemisphere, a difference that causes low-pressure storms to spin off in the midlatitudes. Winds within the storm can funnel moisture into a narrow band at its leading edge — the atmospheric river. At the San Francisco meeting, George Kiladis of the Boulder lab described a March 2005 river that apparently sucked moisture into the Pacific Northwest all the way from the tropics, in the "inter-tropical convergence zone" where winds from both hemispheres meet. Kiladis and colleagues describe the river in a paper to appear in *Monthly Weather Review*.

People living on the West Coast are familiar with atmospheric rivers such as the famous "Pineapple Express," which occasionally ferries moisture directly from Hawaii. But the rivers can also come up through the Gulf of Mexico or along the eastern seaboard.

**One wet day** An atmospheric river that hit California's coastal mountains in 2009 delivered 16 inches of rain, increasing the year's accumulation by almost 50 percent in one day.



SOURCE: M. RALPH, MONTEREY COUNTY WATER RESOURCES AGENCY

Scientists are now moving from spotting atmospheric rivers to understanding them and trying to predict their impact. Leading the way is California, which is setting up four atmospheric river observatories along its coast to track the rivers as they arrive. Each river can have strikingly different effects depending on the angle and speed at which it approaches mountain ranges and watersheds.

"To be able to nail down specific water basins that are most prone to flooding, you really need to know precisely where that atmospheric river will make landfall," Neiman says. "That's the tough part."

During a November 1994 storm, now known to be an atmospheric river, for instance, forecasters predicted that less than one-tenth of an inch of rain would hit some parts of the San Francisco Bay area. In places, more than 11 inches fell, David Reynolds, a meteorologist with the National Weather Service's office in Monterey, Calif., said at the geophysics meeting. How that moisture is distributed within the river and how long it sits in one location determine what areas will see the most flooding.

Not all atmospheric rivers are devastating — in fact, most of them are weak — but they cause many of the most extreme West Coast floods. In one study, Ralph and colleagues looked at all seven floods that occurred on California's Russian River between 1997 and 2006. All were due to atmospheric rivers, the researchers found. The amount of intense rainfall the West Coast gets from atmospheric rivers over time, says Ralph, is comparable to the soakings the Gulf Coast and southeastern United States receive from major landfalling hurricanes.

In January, California emergency planners met in Sacramento to run through a doomsday scenario dubbed ARkStorm. Officials tested how they would respond if a series of atmospheric rivers hit the coast one after the other. That scenario was modeled on the rivers that hit in the winter of 1861–62 and flooded the state's central valley. The capital had to be temporarily moved from Sacramento to San Francisco, and the governor took a rowboat to his inauguration.



**In December, an atmospheric river led to flooding in parts of Orange County, Calif.**

To better predict such disasters, researchers at NOAA and the Scripps Institution of Oceanography in La Jolla, Calif., are working with state officials to pinpoint the most vulnerable areas. Many times, the river of humidity runs into a mountain, is forced upward, and rains out its water. Other times the river hits the base of a range and shifts to flow around it. Figuring out which process dominates in which locations will help officials better prepare, Ralph says.

For instance, in 2009 planners in Washington faced a crisis when the Howard Hanson Dam, on the Green River above Seattle's southern suburbs, began leaking just as an atmospheric river was aiming right at it. The scientists analyzed how the river would run into the watershed and dump its water, and predicted it would not cause lots of rainfall above the dam. The U.S. Army Corps of Engineers decided not to assume emergency control, and the rain did taper off quickly.

Atmospheric rivers may become even more relevant as global temperatures rise. Researchers aren't sure exactly how climate change will affect the rivers, but warmer air generally means that the atmosphere can hold more water vapor, says Neiman. On the other hand, winds may weaken in a globally warmed world, meaning the rivers might carry more water but be less effective at delivering it.

More answers may come within the next few months, as NOAA scientists plan to fly unmanned aircraft into several storms to try to learn even more about atmospheric rivers. ■

### Explore more

- NOAA atmospheric rivers website: [www.esrl.noaa.gov/psd/atmivers/](http://www.esrl.noaa.gov/psd/atmivers/)

FROM TOP: ALEX GALLARDO/AP PHOTO; ADAPTED BY T. DUBÉ





The amygdala, a part of the brain known for its role in fear, also helps people spot rewards — and go after them

By Susan Gaidos

# Cerebral Delights

**Y**ou know the feeling — the flush of excitement when your boss hands you a bonus check, or you unexpectedly run into an old friend, or you discover a way to get tickets to the big game that was long ago sold out. When life throws you a gift or a gain, it's not just your mood that perks up. Two small almond-shaped masses of nerve cells buried deep in your brain take notice too.

Those clumps of cells, one on each side of the brain, are known as the amygdala (uh-MIG-duh-luh). For years the amygdala has been regarded primarily as the brain's center for fear. Scores of studies have shown that it is essential both for perceiving fear and expressing it.

In recent years, though, a surge of new research has expanded scientists' view of the amygdala's importance. It turns out that the amygdala helps shape behavior

in response to all sorts of stimuli, bad and good. It plays a role not only in aversion to fright, but also in pursuit of pleasure.

Studies of the brain's anatomy reveal good reasons for the amygdala's power: It is very well connected. In humans and other primates, the amygdala is linked through a complex network of cells to brain regions involved in all five senses. Signals about everything you encounter are passed from the brain's sensory

MICHAEL MORGENSTERN

processing areas directly to the amygdala. And the amygdala shares elaborate communications channels with the prefrontal cortex — the brain's control center for planning and decision making.

Its strategic location allows the amygdala to act as a spotlight, calling attention to sensory input that is new, exciting and important. In this way, it helps predict the timing and location of potential dangers, helping you dodge many of the things you dread. But those same connections also help you acquire the good things in life, by identifying and assessing rewards such as food, sex and other delights.

Though much more is known about its fear job, researchers are now vigorously gathering evidence about how the amygdala evaluates information and events for their reward potential. Recent studies offer clues to how the amygdala assigns value to rewards and adjusts that value as circumstances change. Other work provides insights into how the amygdala links actions and rewards, suggesting that the amygdala plays a role in goal-directed behavior. Still others are finding out how neural circuits in the highly connected human amygdala work with other brain structures to recognize good things and find ways to get them.

Such studies may help scientists understand how rewards can sway attention or learning and help people make choices. Recent results may also lead to new therapies for those suffering from depression and anxiety disorders, as well as providing insights into reward-seeking behaviors such as addiction.

## Recognizing reward

The amygdala is part of the limbic system, a primitive set of brain structures involved in emotion and arousal. Studies going back to the mid-1950s show that the amygdala, located near the hippocampus in the front part of the temporal lobe, serves as a type of watchdog to identify potential threats and danger. Because it is highly interconnected with the senses, the amygdala can take in danger signals — the sight of a snake or the sound of a gunshot — and flash messages almost instantly through the nervous

system, alerting the body to respond. Chemical messengers are then released into the bloodstream to ready a flight-or-fight response, providing the energy needed to run faster or hit harder.

Early humans relied on this system to avoid all types of deadly threats, from saber-toothed tigers to falling trees.

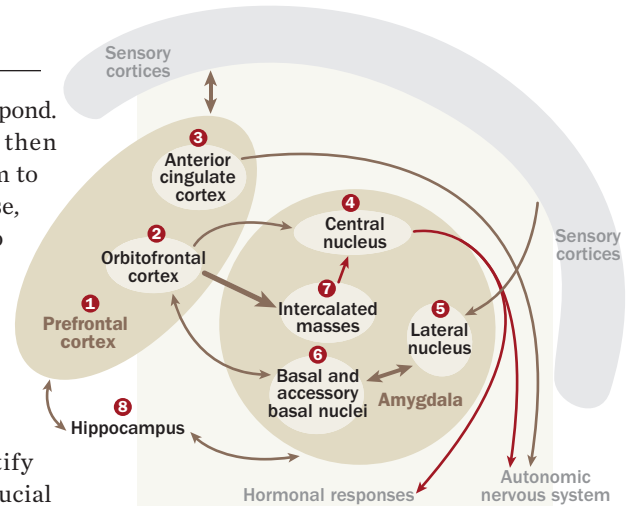
But being able to identify potential rewards is also crucial for survival, says Elisabeth Murray, a neurobiologist at the National Institute of Mental Health in Bethesda, Md. People, and other animals, face countless reward-related decisions as they go about their daily business, foraging for food, finding mates and passing on genes. Identifying pleasant situations and avoiding aversive ones can boost well-being and chances for survival.

Murray says many scientists are now coming to understand that at least part of that reward-based behavior is driven by some sort of interaction between the amygdala and the frontal lobe, known to be involved in thought, memory and consciousness. Her lab is especially interested in circuits connecting the amygdala with the orbitofrontal cortex, a part of the prefrontal cortex that sits just behind the eyes.

“Those parts of the brain are anatomically interconnected, and we think that they’re interconnected in this way to help animals make good decisions,” Murray says.

In recent years, Murray and others have initiated studies to better understand how the amygdala processes information that feeds into decisions.

In 2006, researchers at Columbia University provided a clue, showing how the amygdala judges the emotional value of stimuli. A team led by C. Daniel Salzman taught monkeys to associate two patterns on a TV monitor with either a rewarding sip of water or an irksome puff of air to the face. By recording the electrical activity in the amygdala as animals watched the screen, the scientists showed that different amygdala nerve cells are tuned to



→ Inhibitory connections      → Excitatory connections

**Linked in** Two clumps of cells, one on each side of the brain, the amygdala has many connections with parts of the prefrontal cortex and brain areas involved in the senses.

1. As the brain's command center, the **prefrontal cortex** is responsible for making social choices, predicting future events, planning behavior and controlling emotions.
2. A part of the prefrontal cortex, the **orbitofrontal cortex** appears to be active during sensory integration and decision making.
3. The **anterior cingulate cortex** plays a role in attention, motivation and error detection.
4. The amygdala's **central nucleus** is involved in fear responses, including freezing in place, rapid heartbeat and increased respiration. It is also linked with stress-hormone release.
5. After receiving information from the senses, the **lateral nucleus** forms associations with memories.
6. Clusters of nerve cells, the **basal nuclei** and **accessory basal nuclei** are responsible for body movement and coordination.
7. The **intercalated masses** are cell groups thought to play a role in emotional learning and memory.
8. The **hippocampus** plays an important part in learning and memory.

handle positive and negative events.

In a follow-up experiment with a slightly different setup, Salzman's group found that a set of nerve cells is specifically tuned for processing surprise. Some among those nerve cells were dedicated solely to the rewarding surprise, the water sip.

“These neurons were not registering whether something aversive was surprising,” Salzman says, suggesting they play a specialized role in rewarding surprises.

Other amygdala neurons did the opposite — registering surprise when it was aversive but not rewarding. By carrying two different sets of neurons for surprise, the amygdala may be better able to predict what’s coming in order to prepare appropriate actions, Salzman says.

“If you get something that’s highly rewarding by surprise, you want to be able to take actions in advance that would help you acquire that rewarding stimulus again,” he says. “By contrast, if you receive a bad surprise you normally would want to take some defensive actions or avoidance actions to avert a similar outcome.”

**Ensuring a good hand**

But the same stimulus, depending on the circumstances, can be rewarding or not, Salzman explains. He uses an example from the card game blackjack.

The object of the game is to hold cards with a total value as close as possible to 21, without going over. Players are initially dealt two cards and then can request additional cards.

Say a player is dealt two cards with a total value of 11 and then gets a 10 of hearts, worth 10 points, to reach a perfect 21. Now suppose that in the next hand, after the cards are shuffled, the same player is dealt two cards that total 15.

The third card reveals the exact same 10 of hearts. While golden in the first hand, the 10 becomes an unfortunate deal the second time around. Most people would have no difficulty recognizing this point, Salzman says, evidence that the amygdala’s emotional response to the same sensory stimulus can be flexible.

Murray sees such flexibility among monkeys making food choices in the lab. Given a choice between two foods, monkeys (like most people) will invariably reach for their favorite. But after gorging on a favored food for a while, the reward value of that treat diminishes, the way the value of the 10 drops when a blackjack player already has 15 points in hand. At that point the monkeys shift their choices and select a new food.

Monkeys without a working amygdala, however, show little change in behavior and continue to stuff themselves with the first food choice, Murray’s studies have found. These findings suggest that the amygdala is needed to revise the assessment of a reward’s value.

“What we think is happening is that the amygdala is helping update the food value, and sending that information somewhere else — probably the orbitofrontal cortex,” Murray says. This same circuitry may also help animals, including humans, automatically calculate and update the value of goals or outcomes

on the fly. “If you’re an animal out there and you’ve just learned something about either a harmful stimulus or a predator, you may not get a second chance.”

Murray’s group is now using a similar method to see how values assigned to various rewards can be linked with actions. In a recent experiment, Sarah Rhodes, also of the National Institute of Mental Health, trained monkeys to

perform two actions, tap and hold, to receive a reward. Six rapid taps to a touch-sensitive screen were rewarded with one kind of food, while a continuous touch for two seconds was rewarded with another.

Rhodes, Murray and their colleagues wanted to see if the animals, once filled with

their favorite food, would shift their actions along with their choices. Normal monkeys did, choosing a new action once they got their fill of the first food. Animals without an amygdala, however, didn’t make the switch.

Those findings, reported in November in San Diego at the annual meeting of the Society for Neuroscience, suggest that the intact control animals engaged in goal-directed behavior, and that the amygdala played a role, Murray says.

“It means the animals literally know and somehow represent a goal. And that if the value of the goal changes, they can therefore change their behavior,” she says. “We think this is what humans do, so it’s really helpful to understand the neural circuitry.”

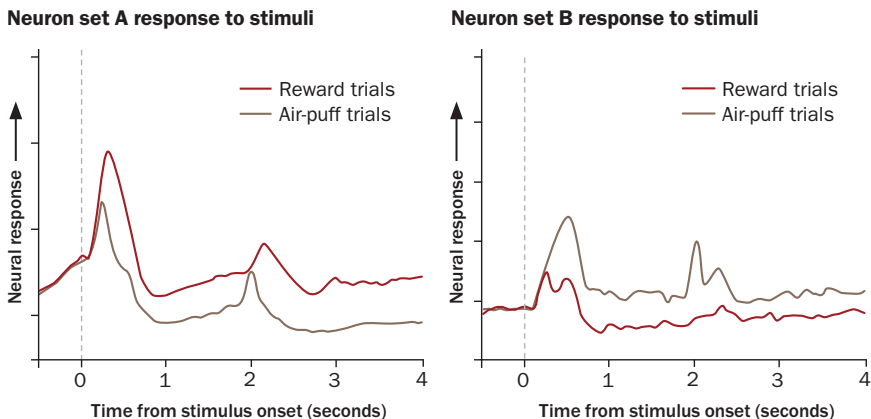
Another recent study shows that people, like monkeys, do indeed use the amygdala to judge the value of a particular item. Rick Jenison, who studies neuroeconomics at the University of Wisconsin–Madison, and his colleagues recruited three volunteers who were already undergoing a procedure that required electrodes to be implanted in the brain. Using the electrodes, the researchers eavesdropped on 51 amygdala nerve cells as the volunteers put price tags on a series of junk food items.

Listening in on nerve cell chatter,

**“I’m kind of glad that the brain isn’t as simple as we sometimes make it out to be.”**

PETER RUDEBECK

**Cell-by-cell responses** Different nerve cells in the amygdala respond differently depending on the stimulus. A study in monkeys found that while one set of cells (A) responded more robustly to a reward, a sip of water, another (B) responded more to an annoying puff of air.





Jenison's group found 16 individual cells that responded in a way consistent with the values that participants assigned to individual foods. The study, published January 5 in the *Journal of Neuroscience*, is the first to show how single neurons in the human amygdala work to assess the value of an object (*SN*: 1/29/11, p. 8). In addition, the study shows how amygdala neurons compute value in real time, while decisions are being made.

"These findings suggest that the human amygdala's involvement in decision making happens at the time of the choice and is not restricted to familiar situations," he says.

Many of the animal studies, on the other hand, are based on learned tasks, so value could be assigned over a number of trials, Jenison says.

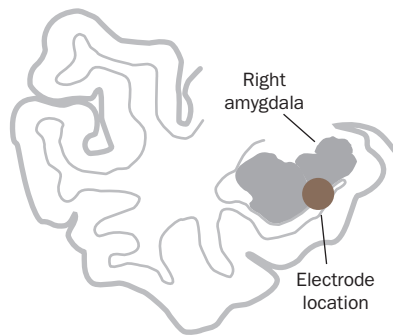
Using functional MRI to map the location of the electrodes, Jenison's group created an anatomical map showing the precise location of the value-coding neurons. Such information may serve as a starting point in figuring out how such neurons connect to other structures in the brain.

Because value-coding neurons in the amygdala intermingle with neurons that do other things, sorting out connections could be crucial for understanding how people respond to particular cues, says neuroscientist Patricia Janak of the University of California, San Francisco, who studies the amygdala's role in reward and addiction. "The idea would be to see where those [value-coding] neurons are going, and then hence what behavior they affect," she says.

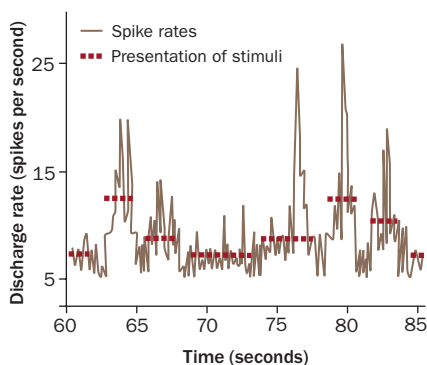
### Untangling connections

While recent studies show that the amygdala plays a role in assigning value to actions or things, other findings show that parts of the prefrontal cortex also signal what things are worth.

"We were really interested to know: Is the amygdala the thing which supplies that value information or is it the other way around — the prefrontal cortex that tells the amygdala?" says Peter Rudebeck, a postdoc in Murray's lab. "The anatomy suggests that it's the amygdala telling



**Nerve cell response during value rating**



**Tracking chatter** By monitoring nerve cell activity in patients as they rated the value of various junk foods, researchers were able to locate specific cells in the amygdala whose responses corresponded with value ratings. The graph shows how one neuron's firing rate (electrode location shown above) peaked after junk foods were presented.

these other parts of the brain what these certain things are worth. But we wanted to test that."

Rudebeck and his group trained monkeys to play a computer game in which they assessed the value of different rewards. The animals were shown two different pictures and allowed to choose between them. One picture brought a large juice reward, and the other brought a much smaller amount of juice. The animals chose the picture associated with the larger reward more than 98 percent of the time.

After turning off the amygdala in some animals, the scientists used single-cell recordings to listen in on brain cell chatter in the orbitofrontal cortex and anterior cingulate cortex. To the team's surprise, the monkeys still chose the picture with the "best" outcome on pretty much every trial, just as they had done with a working amygdala.

Though the animals continued choosing in the same manner, the scientists found that fewer neurons in the anterior cingulate cortex changed their firing

rate in response to an expected reward. When looking at the animals' emotional responses — as measured by pupil diameter and heart rate — researchers found that monkeys without a working amygdala didn't react to a reward in the typical way, Rudebeck says. "They seemed to have no idea of what reward was, despite the fact that they could still choose perfectly well."

The findings, reported at the neuroscience meeting, suggest that the brain uses various mechanisms to calculate how much something is worth. While the amygdala may be important for assigning an emotional value, Rudebeck says, it may not be the "be-all and end-all" in valuing objects. "I'm kind of glad that the brain isn't as simple as we sometimes make it out to be," he says.

By understanding how the amygdala guides reward-based behavior, scientists hope to someday reap rewards of their own. A deeper knowledge of the neural circuitry that regulates emotional responses may help scientists understand what goes awry in addiction and may allow scientists to find new ways to intervene in times of distress.

New discoveries could lead to medications and therapies designed to treat mood disorders such as depression, where stimuli that were previously pleasing aren't anymore, says Salzman.

The studies also hold hope for developing new therapies for anxiety disorders, phobias and panic disorders that involve stimuli that can generate emotional responses even when they are presented in a nontraumatic situation.

"I believe that the best generation of psychiatric treatments is still to come," Salzman says. "And it will ultimately be based on elucidation of the interconnected circuitry involving the amygdala, the prefrontal cortex and other brain structures." ■

### Explore more

■ C.D. Salzman and S. Fusi. "Emotion, Cognition, and Mental State Representation in Amygdala and Prefrontal Cortex." *Annual Review of Neuroscience* 2010.

# Brain Boosters

Some nutritional supplements provide real food for thought | **By Janet Raloff**

**O**n his third consecutive evening of air combat, a military pilot closes in on the night's quarry, a suspected Taliban fuel depot in Afghanistan. Fatigued, his alertness flagging, the pilot throws some chewing gum into his mouth. Laced with caffeine, it's the cockpit alternative to a cup of coffee.

This pilot would probably suspect that the gum is just a perk-me-up. But several caffeinated military rations — including this relatively new one — do more than stave off sleepiness. Emerging data indicate that these rations boost not only attention but also cognitive performance, features that do not necessarily climb in lockstep.

The U.S. Department of Defense has been investigating such supplements to improve the ability of U.S. armed forces to maintain sustained periods of intense vigilance and focus, explains Harris Lieberman, a psychologist at the Army Research Institute of Environmental Medicine in Natick, Mass. Another hope, he notes: These dietary aids might minimize the risk of “friendly fire.”

Army researchers at the institute, including Lieberman, are at the forefront of a small but growing cadre of investigators exploring how to boost what they call mental energy. This rather fuzzy phrase embraces wakefulness, but also includes mood, motivation and the capacity to perform key mental tasks.

Increasing mental energy is important for those enervated because of a lack of sleep or for those whose jobs, like those of fighter pilots, require

vigilance even in the face of sleep deprivation. Compounds that keep you awake, it turns out, can also boost other aspects of mental performance. Improved cognition is emerging as a quantifiable side benefit of many of these substances — in some cases, even for those folks who aren't sleepy to begin with.

But the data can be hard to interpret, primarily because no test exists to directly measure mental energy, explains Patrick O'Connor of the University of Georgia in Athens. It must be inferred from other indicators. Still, it is fair to view fatigue and mental energy as anchoring opposite poles of a common spectrum, he says.

Similarly, caffeine anchors the stimulatory end of a spectrum of natural products exhibiting promise in hiking or sustaining cognitive aspects of mental energy. Others include L-theanine in tea, guarana, cocoa constituents and ginseng.

Learning how these compounds work, at what doses and under what circumstances, is important, argues O'Connor, because “mental energy underlies everything in our lives.” It's key, he says, to achieving goals at home and work — and even to the success of the economy.

## Perky brews

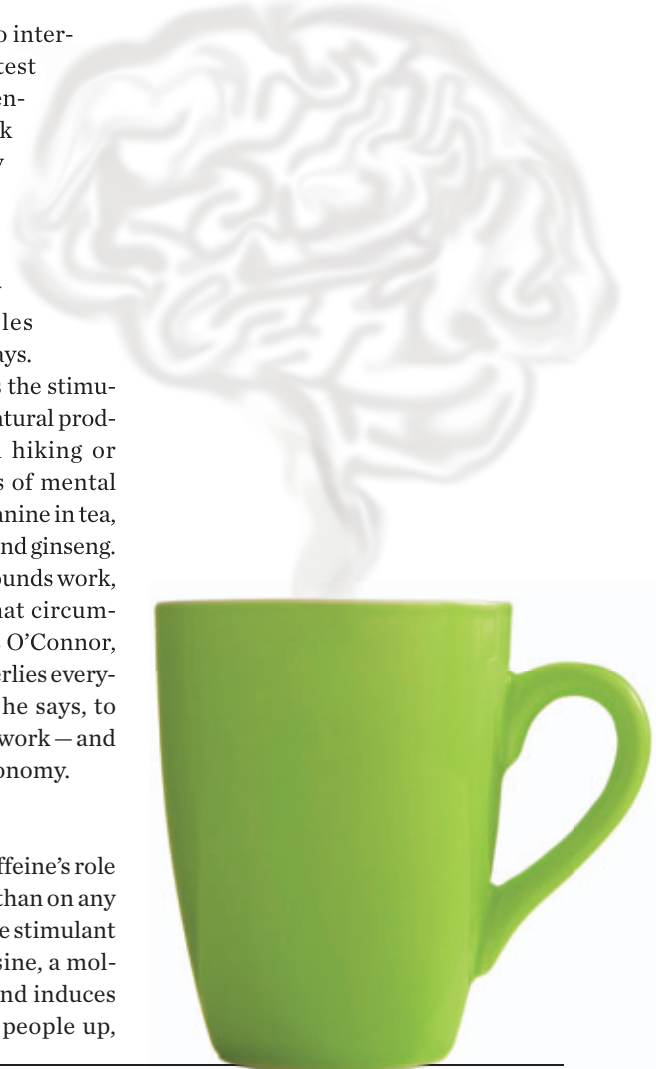
More data has emerged on caffeine's role in promoting mental energy than on any other dietary constituent. The stimulant blocks the activity of adenosine, a molecule that slows heart rate and induces drowsiness. Caffeine perks people up,

Lieberman says, “by blocking something that normally slows you down.”

At the Experimental Biology 2010 meeting in April in Anaheim, Calif., he described how, some 25 years ago, his team found that as little as 32 milligrams of caffeine — equivalent to what's in a 12-ounce can of cola or less than a cup of regular coffee — improved attentiveness for auditory and visual cues.

People had thought that any improved performance from caffeine might be limited to people who were tired. Here, though, the young men in the study were well rested, suggesting broader benefits.

Lieberman's more recent work has tested caffeine's effects on tasks especially relevant to the military. For instance, a study conducted during the training of 68 Navy SEALs assayed the effects of caffeine after 72 hours of sleep



deprivation and round-the-clock exposure to cold and other stressors. The men were taking part in a weeklong test of endurance known as Hell Week.

Not surprisingly, the exhausted trainees didn't do nearly as well on tests of vigilance and other measures of cognitive performance three days into Hell Week as they had before the training marathon began. But those who got between 100 and 300 milligrams of caffeine an hour before a battery of mental tests made fewer mistakes and responded more quickly.

One task asked SEALs to scan for faint images that appeared for a couple of seconds on a computer monitor. Trainees who got no caffeine scored an average of 7.9 correct hits out of 20, while those given caffeine averaged between 10.6 and 12.2 correct responses. Caffeine recipients also had nearly 30 percent shorter response times. Scores on several other tasks, including a test of marksmanship, were unaffected.

Other scientists have been exploring caffeine's impacts on the brain. Andrew Smith of Cardiff University in Wales, for instance, asked 118 students to watch a computer screen where three-digit numbers appeared at a rate of 100 per minute. When two consecutive numbers matched, participants were to note it with a keystroke. Before the tests, 84 students were given chewing gum; roughly half (41) got gum laced with 40 milligrams of caffeine.

Students reported feeling substantially more alert after chewing the caffeinated gum. They also performed better on some tests, including the one in which they had to identify repeated numbers. Those given caffeine were 4.4 percent faster than those who worked gum-free and 4 percent faster than noncaffeinated-gum chewers. The stimulant also appeared to speed up people's ability to learn new information, Smith reported in the April 2009 *Human Psychopharmacology*.

### Tea's bonus

Tea, which people worldwide drink more of than any other beverage except water, is a major dietary source of caffeine. Unlike coffee, it contains another

potentially powerful ingredient for brain activity: L-theanine, an amino acid that can alter alpha brain wave rhythms, inducing wakeful relaxation.

In 2008 in *Nutrition Reviews*, Janet Bryan of the University of South Australia in Adelaide observed that alpha wave activity has been linked to "increased performance under stress and improved learning and concentration" and reduced anxiety. L-theanine seems to enhance caffeine's mental benefits, she noted.

Unilever, which owns Lipton, is actively investigating L-theanine's effects. Neither caffeine nor tea's caffeine-theanine combo augment performance on all types of mental tests, says Eveline De Bruin, a cognitive neuroscientist with Unilever's R&D facility in Vlaardingen, the Netherlands. The biggest impacts, she says, are in enhancing what's known as executive function — the ability to perform complex tasks that rely on planning or decision making.

For instance, in an upcoming issue of *Appetite*, De Bruin's team reports that tea brings boosts in executive function that increase with dose. On each day of a two-day study, 26 volunteers drank either strong tea or a tealike placebo before testing. One test asked participants to listen to rules on how to respond to sounds or images on a computer screen — and the rules changed every few seconds during each five-minute session. The men and women responded correctly in the auditory test almost twice as often (around 15 to 20 percent of the time versus 8 or 9 percent) after drinking tea rather than the placebo. Participants were also

marginally — but reliably — more accurate after tea on a test that looked at the ability to plan and execute decisions (see "Switch test" below).

While Unilever has demonstrated that tea enriched with triple the normal amount of L-theanine improves attention, De Bruin says Lipton has no plans to market such a product. "It is an interesting idea," she concedes, "but at present Lipton is proud of producing an all-natural leaf-tea product that is unmodified yet capable of noticeably improving attention and alertness."

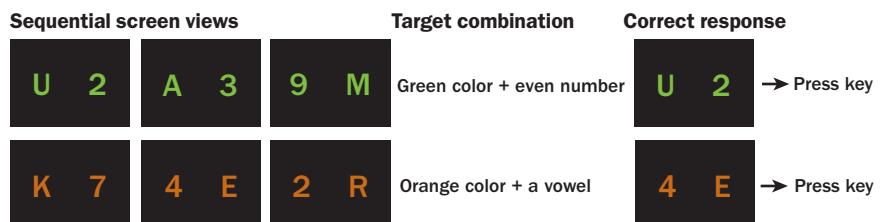
### Sweet paradox

Thinking, calculating, planning, learning, remembering — such mental tasks consume plenty of energy. Because glucose, better known as blood sugar, fuels body and brain, it might seem that a good dose of something sweet would be just what Mother Nature ordered to kick-start your neural hardware. Yet people with diabetes and high blood sugar levels can suffer from cognitive impairments.

Studies have begun probing this seeming contradiction. Two papers in August in *Psychopharmacology*, for instance, report a boost in mental performance when healthy people down a drink fortified with at least 50 grams of glucose (about 10 teaspoons worth) following a 12-hour overnight fast.

Christine Gagnon of the University of Quebec at Montreal and colleagues showed that in 44 people age 60 and up, drinking the glucose 15 minutes before the start of testing led to better scores on some tests than did the sugar-free

**Switch test** Used to assess some cognitive impacts of food supplements, this test asks participants to hit a computer key when either of two combinations appears on-screen. Screens refresh once a second for five minutes, and target combinations may switch during the task. The example here prompts participants to respond when they see a letter and an even number (but only if green) or a number and vowel (but only if orange). L-theanine-rich tea boosted scores on this task, which measures one aspect of attention: the ability to plan and execute decisions.



SOURCE: E. DE BRUIN/UNILEVER



alternative. Those on a sugar rush performed faster and accrued fewer errors when asked to quickly read a color name or name the color of words (even if a color word, such as *green*, appeared in a different color, say red). Glucose appeared especially beneficial in tasks that required switching and dividing attention, the researchers observed.

Among 90 undergrads, a sugary drink improved immediate recall of words, not faces, compared with a sugar-free one, reported a team led by Lauren Owen of the Brain Sciences Institute at the Swinburne University of Technology in Melbourne, Australia. Recall of large numbers that had appeared in earlier math calculations also improved.

Doses given in each study were high and would be ill-advised for people with trouble controlling their blood sugar, such as those with diabetes or metabolic syndrome. But David Benton of Swansea University in Wales has shown there may be a way to get the benefits of a glucose burst without overdoing sugary drinks. At the experimental biology meeting, he

presented data indicating that for mental performance, it's actually better to deliver glucose parsimoniously. He does it by giving subjects foods containing carbohydrates that digest slowly.

In an early study, Benton's team gave cereals, breakfast bars or biscuits with roughly equal calories to 106 undergraduate women. The main difference between the meals was their glycemic index — how quickly the carbs break down into glucose.

Thirty minutes later and at regular intervals thereafter, the women took memory tests. Those who got the low-glycemic breakfast performed progressively better than those eating the rapidly digested meals. The difference was most dramatic for a later testing, 3.5 hours after breakfast, Benton says.

His group ran a similar test in rats, feeding them either quickly or slowly digested carbs. The rodents exhibited a similar improvement in learning when they got the slowly digested chow.

In a follow-up test, Benton's group administered breakfast to kids in an

elementary school class for four weeks. Kids got a meal with high-glycemic carbs on one-third of the days, low-glycemic foods on another third, and carbs that broke down at an intermediate rate on the remaining days.

On various days throughout the trial, hidden cameras recorded the 19 children while they were supposed to be working independently on a reading or math assignment. The behavior of each child was recorded over a 30-minute period and scientists later logged what the youngster had been doing: working, looking around the room, talking to others, fidgeting, acting out or moving around the room. On days when the kids had eaten the low-glycemic breakfast, they were much more likely to remain on task — 26 percent of the time versus 18 percent or less on the other days.

The kids also took simple memory tests and played with a video game that was rigged to be frustratingly difficult to master. On days they had eaten the slow-to-digest breakfast, kids exhibited more initial patience with the game. Their recall was also better — “about 10 percent better,” Benton says. It's a small difference, he acknowledges. “But if your child came home with 10 percent better scores on a test, would it matter to you? Most parents would say yes.”

## On the mental menu

Recent work suggests dietary substances such as caffeine and glucose may boost mental skills. Evidence for others (“Emerging substances”) is preliminary.

### Caffeine

Increases visual and auditory vigilance; speeds reaction times, improves accuracy and limits false positives on vigilance tasks; and increases learning and short-term memory on computer tests that require keystroke responses.

### L-theanine

Increases speed and accuracy of pattern recognition that switches arbitrarily over time, increases relaxation, boosts accuracy of processing of rapidly delivered visual information and reduces susceptibility to distracting information during memory tests. May improve aspects of cognitive performance when delivered with caffeine, as in tea.

### Glucose

Enhances memory of recent words or images, increases verbal fluency, improves pace of some types of serial subtraction, speeds decision times, enhances facial recognition and, among children, limits vulnerability to distraction when working alone.

### Guarana

Increases alertness and the ability to recall words and images at a later point in time.

### Emerging substances

#### Ginkgo biloba

Improves pattern recognition and sustained attention, enhances delayed recall and memory of faces, and improves pace of serial subtraction and executive decision making.

#### Chinese ginseng

Enhances speed of recall, improves performance on simple arithmetic tasks and decreases false alarms on tests that require rapid processing of visual information.

#### Cocoa flavanols

Increase processing of rapid visual information and improve the ability to count backward (though have led to more errors in some serial subtractions).

—Janet Raloff

### Herbal therapies

Tea and coffee aren't the only natural stimulant-laced plant extracts to show energizing as well as brain-boosting attributes. There's also guarana. Seeds of this Amazonian plant are an especially potent source of caffeine, which can constitute 5 percent of dried extracts. But guarana may have more than caffeine going for it.

At the experimental biology meeting, David Kennedy of Northumbria University in Newcastle upon Tyne, England, described cognitive benefits in young adults given small amounts of guarana — more benefits than when those volunteers received high doses. Indeed, Kennedy noted, guarana amounts needed to boost



SUZANNE TUCKER/SHUTTERSTOCK

test scores and mood contained just 4 to 9 milligrams of caffeine. “That’s only about a tenth as much as you’d find in a cup of coffee,” Kennedy points out. “So guarana was doing something that wasn’t attributable to its caffeine” — although his team doesn’t yet know what.

He and colleagues have also been investigating other natural products that might elevate energy, attention and mental performance. Among these: Chinese ginseng (*Panax ginseng*). Young adults scored better on a battery of mental tests — including serial subtraction of numbers in their heads — and exhibited less mental fatigue after getting this herbal supplement rather than a placebo.

How Chinese ginseng may improve performance is unknown, but Kennedy suspects the effect might have to do with ginseng’s ability to moderate blood sugar levels. At least at the 200-milligram dose used by his group, this supplement caused a drop in blood-glucose levels one hour after consumption.

Researchers report that American ginseng (*P. quinquefolius*) also shows promise. Compared with a placebo, all doses improved some aspect of cognition, Swinburne’s Andrew Scholey and colleagues report in October in *Psychopharmacology*. One difference: This herbal supplement had no effect on blood glucose.

The Northumbria researchers are also exploring the idea that some natural products bolster brain function by affecting blood flow. For instance, if they dilate vessels, the products might allow more fuel — glucose — in to power brain activities. Kennedy and colleagues tested the idea by giving 30 students a cup of cocoa on three mornings. Each day’s formulation contained a different amount — 46, 520 or 994 milligrams per serving — of cocoa flavanols, natural agents that have antioxidant and sometimes heart-healthy properties.

The cocoa packages used in the study were prepared by Mars, a candy company that has been exploring health attributes of some chocolate products.

Both higher-dose formulations, especially the middle one, improved

performance during mentally challenging tests involving math and the visual processing of information, the scientists report. At the same time, the college students receiving the middle dose reported a reduction in mental fatigue. Maximum benefits showed up two hours into testing, which roughly corresponds to the expected peaks in concentrations of flavanols in the blood and in blood flow to the brain, Kennedy’s team reported in the October *Journal of Psychopharmacology*.

### Buyer beware

The concept of mental energy is hardly new; recognition of it, on some level, dates back to Aristotle. But only during the last two decades has a steady trickle of studies begun quantifying how various dietary constituents battle fatigue and the fuzzy thinking that may accompany it.

The food industry has paid rapt attention to study findings (and, as is the case with Unilever and Mars, has even helped pay for some of the research). Indeed, O’Connor observes, hundreds of new products claim to boost mental energy. And their appeal is understandable since mental energy helps motivate people not only to work but also to stick with it when the going gets hard.

“Unfortunately,” he adds, product claims “rarely are supported by compelling, unbiased scientific evidence.”

Michael Falk and colleagues at the Life Sciences Research Organization in Bethesda, Md., recently conducted a major review of supplements and ingredients (other than caffeine) that purport to boost attentiveness and mental performance in people. The researchers identified 265 research reports in the scientific literature that met certain criteria.

Falk’s team focused on 35 dietary constituents or factors, such as meal timing and the number of calories consumed. Promising data exist for ginkgo, ginseng, glucose and a few others, Falk says. But overall, his team concluded, for most “insufficient evidence is available to evaluate mental energy claims.”

Much of the problem may reflect how the testing was conducted, he points out. For about three-fourths of the substances, there were no more than 10 qualifying studies; for more than half, there were five or fewer, the team reported in the December 2010 *Nutrition Reviews*. And for any given nutrient, Falk notes, different trials often applied different tests to assess mood, motivation and mental prowess — which made comparisons difficult.

Many of the reports also tested very different populations (young adults in some, the elderly in others), had

different criteria for whether subjects were healthy, and failed to establish baseline measures of mood and mental proficiency before administering a potential brain booster. Further complicating the picture: “You’re looking at what are relatively small effects and hard to measure,” he says. “And these are against a background of high methodological and statistical noise.” Such variations “undermine our ability to make strong conclusions.”

But Falk suspects that may change fairly soon. Researchers have been investigating what to measure and how to do it. And they’ve determined that agents with promise don’t always point to common benefits. Some may aid memory. Others may sharpen mental focus or speed up reaction times. Still others might make decision making easier.

When scientists begin standardizing tests, “I’m betting they’ll come out with stronger, more narrowly focused and more [scientifically] supportable conclusions,” Falk says. Findings that he says should point to whom these dietary supplements will benefit — and under which real-world conditions. ■

**Hundreds of products claim to boost mental energy, but few claims are supported by evidence.**

### Explore more

■ H.E. Gorby, A.M. Brownawell and M.C. Falk. “Do specific dietary constituents and supplements affect mental energy? Review of the evidence.” *Nutrition Reviews*, December 2010.

**Blowout in the Gulf**

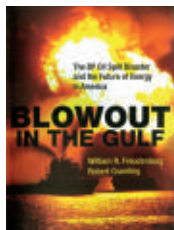
William R. Freudenburg and Robert Gramling

For a century, America was the world's biggest producer — and user — of petroleum. Today, the country remains the biggest user while supplying less than 7 percent of world demand. Although this book is nominally about the 2010 BP oil spill, it's really a primer on the oil industry: where it started, the companies and regulations it spawned, and how it has seduced nations everywhere to think and act as if they can't live without it.

The authors sifted through mountains of news accounts, reports and transcripts of hearings on the BP spill. They've woven statistics, quotes and observations into a riveting account of the accident, as well as the track record of the principal parties and the largely unfettered environment in which they were allowed to operate. Taken together, the evidence suggests that the April 20 blowout — or one like it — was just waiting to happen.

But that's just a teaser, really. Two-thirds of the text focuses elsewhere — on

the perpetual cycles of boom and bust that have defined the birth and ascendancy of the oil industry, and especially that component of it that extracts crude through offshore drilling.



Although today's generations were nurtured on the notion that oil is a limitless resource, it's really quite finite, Freudenburg and Gramling point out.

And it is being mined so rapidly that there simply isn't enough to fuel the globe at current rates for much longer.

Freudenburg, an environmental scientist, died shortly after this book was published, and it encapsulates his career-long effort to use environmental science in society's service: to understand and, most important, to prevent man-made disasters. Indeed, he and Gramling argue that Ben Franklin's adage "a penny saved is a penny earned" should apply "thousands of times over for a barrel of oil." — *Janet Raloff*  
MIT Press, 2010, 254 p., \$18.95.

**Honeybee Democracy**

Thomas D. Seeley

Some smart aleck is going to pick up *Honeybee Democracy*, an account of decision making among bees, and snicker that the book should be titled *Honeybee Monarchy*. After all, everybody knows that a beehive has a queen.

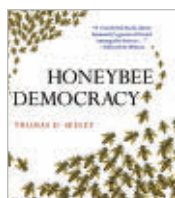
Yes there's a queen, but Seeley, a Cornell entomologist, writes that one of the biggest misconceptions about how bee colonies work is that queens direct colony doings. Actually she's not a Royal Decider, as he puts it, but a Royal Ovipositor, laying 1,500 eggs or so on a summer day while leaving the rest of colony affairs to the group.

Seeley describes a colony as a smoothly functioning group that makes life-or-death decisions rather democratically. Bees' methods work so well,

he says, that evolution has favored some of the same features elsewhere, as in behavior among human brain cells.

To illustrate bee decision making, Seeley details how swarms choose a new home. Seeley presents his material with charm, and the bees' system of house-hunting becomes surprising and awe-inspiring. The bees swarm out of their old home before looking for a new one. As thousands of now-homeless honeybees dangle in a beardlike mass from a branch, scouts scour the countryside. They report back, through elaborate dances, and debate possible locations.

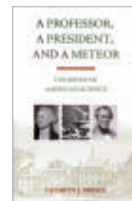
Evolution has honed bees to balance the need for accuracy and individual points of view from scouts against the need for speed. The process so impressed Seeley, he says, that when he became chair of his department, he instituted measures to make faculty meetings a bit more beelike. — *Susan Milius*  
Princeton Univ. Press, 2010, 273 p., \$29.95.



**Moon: A Brief History**  
Bernd Brunner  
Revisit the wonders of Earth's next-door neighbor with this cultural and scientific exploration. Yale Univ. Press, 2010, 290 p., \$25.



**The Skull Collectors**  
Ann Fabian  
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**Religion at Sacred Ridge?**

I follow your magazine with zeal. I was somewhat surprised by “Massacre at Sacred Ridge” (SN: 11/6/10, p. 22), which seems to attribute the slaughter to some action by those who were murdered and does not discuss potential religious overtones of the attack. Is organized religion the culprit in this incident? Man’s inhumanity to man has often been triggered by some form of religious belief system.  
**Charles Havnen**, New Orleans, La.

*Religious beliefs of the Ridges Basin groups are poorly understood, though the documented ethnic differences would imply at least some religious differences. How religion may have played into the massacre at Sacred Ridge is unknown.*  
 — Bruce Bower

**Measured confusion**

There is a subtle but fairly egregious error in “Science Stats: Reading

between the lines” (SN: 1/1/11, p. 4). The short article is (ironically) about the unclear labeling of medication measuring devices, but the graphic contains a huge infographic gaffe: It shows the values as regular markings up the side of a representation of a 3-D cup. But the cup is not cylindrical, being wider at the top than the bottom (just as many medicinal cups are). This implies that what’s being measured is the volume, not the height.

Since the cup is a right frustum (a chopped-off cone), the volume contained does not scale linearly with height. It may not look like it, but this false implication suggests that each point gained near the top of the scale is worth much more than each point that is gained near the bottom of the scale.

Even putting this aside, the graphic has another problem: The top label (“148 products ... with measuring devices”) looks like it represents the white area at the top of the cup, but it

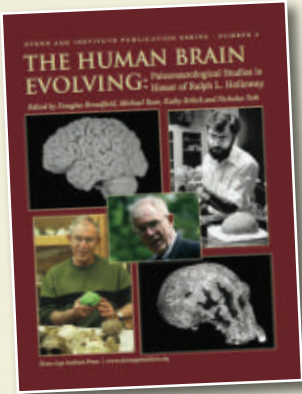
doesn’t actually represent that area.  
**Erik Max Francis**, San Jose, Calif.

*The reader is correct: While the markings on the graphic were meant to reflect height, not volume, the 3-D drawing of the cup does misleadingly imply volume. And the top label, the total, should have been more clearly linked to the entire pink area that it was supposed to describe. Apologies for adding to the confusion.*  
 — Eva Emerson

**Correction**

Due to a typographical error, the element strontium (Sr) is mislabeled as Si in the periodic table of the elements accompanying the article “Chemists want you to know that atomic weights aren’t constant” (SN: 1/29/11, p. 5).

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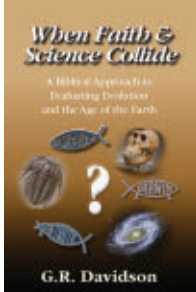
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## David Nichols



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## The costs of putting knowledge into the wrong hands

*As a chemist at Purdue University in West Lafayette, Ind., David Nichols studies psychedelic compounds in a quest to understand the brain, often creating new compounds as part of his research. He was recently dismayed to find himself cited by name in a newspaper article about an amateur chemist who scours the scientific literature for recipes that he can use to produce designer drugs that are legal but untested and often unsafe. In fact, street drugs based on a paper that Nichols published years ago have contributed to a number of deaths. Nichols recently spoke with Science News neuroscience writer Laura Sanders about the misuse of his research and the dangers that can accompany the free exchange of scientific information.*

### How did you learn that people were using your published research to create new drugs?

There was a *Wall Street Journal* article in their health section in October, and in that article the writer had interviewed a chemist, I believe in Belgium, who was making these so-called 'legal highs.' And he was very open about what he did. He said, 'You know, what I'm doing is legal.' A former crack addict, by the way.... He said, 'Well, I search the literature, and the work of David Nichols is particularly valuable to us.'

### Were you surprised to see your name?

Well, the thing that happened earlier, in the late 1990s, was that we had been doing research on ecstasy, MDMA, and we had made a compound called MTA. I got an e-mail from a colleague one day that said, 'Did you know that people have been making tablets with MTA in it, I think in the Netherlands, and a couple of people have died?' So that was kind of a shocker to me because the work that we had done suggested if anything, it might have utility as an

antidepressant that would be a little faster acting than Prozac and the standard antidepressants.

So I thought about that — how did these people die? We didn't think it was particularly toxic. What I concluded was that maybe they didn't get the effect they expected, so they took more and more of it....

It was really kind of ironic that the tablets they made with MTA in it were called 'flatliners.' And I had to think, who would buy a drug, a black market drug, called flatliners? I checked later on, and as of 2002, there were five or six people who had died of overdoses....

In general, these molecules, these so-called psychedelics, are not toxic. They don't kill people because the receptors that they are targeted to are not involved in life-sustaining functions ... so I haven't thought very much about people dying.

I've always known people are interested in this class of substances. Even as a graduate student in 1969, if I'd tell people I'm doing research on these types of substances, other graduate students would always say, 'Oh, do you need any volunteers?'.... My idea has been to try and find tools that unravel how the mind works, and find things that improve memory and cognition, those kinds of things, and if a few people took them and got high, that wasn't a big concern. But with these things being very widespread now, and being manufactured in large quantities, and of unknown toxicity, you just don't know what the long-term consequences are.



**What do we learn from that incremental bit of information compared with the potential for, perhaps, widespread disaster?**

### You chose not to publish some research because you thought it might be used to create a dangerous new drug. Why did you decide that?

In the case of MTA, I never imagined that people would take it and it would be toxic and kill people. So publishing there,

I really had no concern.

The case you're mentioning, there's a specific molecule that I was aware of in that general class, that I thought if this ever got out and people started using this at raves, it was my impression from what I knew about the molecule that it would have effects very much like ecstasy — it was very toxic.... And when I looked at that one, I said, 'Well, I can pretty much predict what it's going to do, but I can also predict that it'll be much more toxic than anything else out there.' ... So the point was, what do we learn from that incremental bit of information compared with the potential for,

perhaps, widespread disaster?...

I say in general, you should publish your information.... But nevertheless, that was one specific case [where] I've never talked about the molecule. Nobody knows what the molecule is or anything. But that was one specific case where I said, 'You know, we're just not going to learn enough to justify the possible negatives if this really gets out.' And the way they've been watching the literature and what I do, as soon as I publish it I'm sure it would get out, because it would be very cheap to make and all of a sudden there it would be and we'd have serious problems. And I just didn't want to do that. ■



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