Web of Terror | Expanding Consciousness | Bird Flu in the Brain

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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ MARCH 10, 2012

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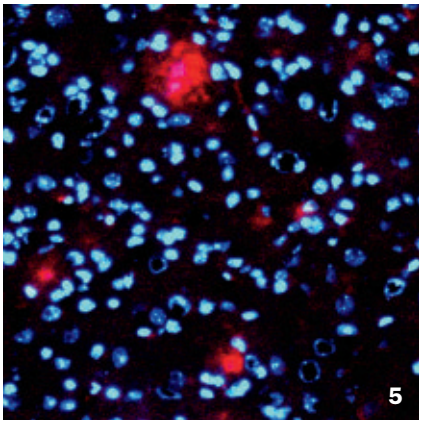

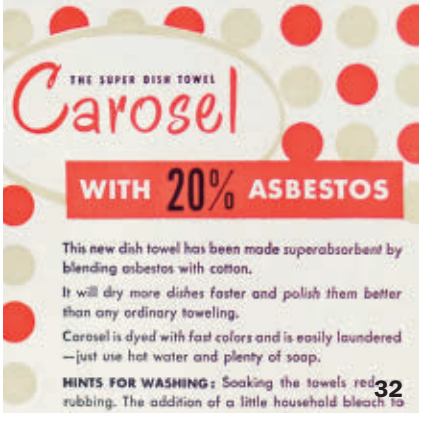

ScienceNews

In The News

Special Report

Feature

Departments

COVER Quantum computers would store data in qubits existing as both 0 and 1 simultaneously. A big advance may come from mixing two competing approaches.
SN *Staff*

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FROM THE EDITOR

On medical news reports, read the warning labels

Science journalists are constantly plagued with the fear of delivering false medical hope.

When medical researchers report a promising new treatment for devastating diseases, there's always a temptation to write about it in dramatic terms, even though science writers are trained to avoid the word *breakthrough*. That temptation is tempered by awareness that most medical "breakthrough" reports turn out to be overblown. After further testing, most potential miracle drugs or other treatment techniques show themselves to be not so effective after all, or cause too many side effects, or work only in the lab and not in real life.

Still, sometimes a new discovery is so intriguing that it warrants attention in spite of all these warnings. One such example appears in this issue (Page 5): the finding that a drug approved for treating cancer shows a surprising ability to fight the amyloid protein associated with Alzheimer's disease.

In mice genetically engineered to develop an Alzheimer's-like disorder, the drug bexarotene cleared most of the amyloid within a couple of weeks. Even more impressive, the treated mice improved their scores dramatically on various tests of mental skills, neuroscience writer Laura Sanders reports.

Yet for all the reasons mentioned above, it's too soon to celebrate dementia's defeat. Studies in mice are notoriously unreliable as guides to what will happen in humans. And human mental functioning, the aspects of learning and memory that are destroyed by Alzheimer's, is much more sophisticated than that in even the brightest mice. Whether the molecular activity that bexarotene instigates in mice would work the same way in people is still a hope, not a certainty.

There's also the nagging suspicion that the amyloid protein plaques and particles are just a by-product of some deeper pathology underlying Alzheimer's. Clearing the amyloid may provide no more than temporary relief in people, if any at all. Nevertheless, bexarotene's success in mice has its pluses. As an already-approved drug, it will be faster to test in humans and to make available if such tests are successful.

As one researcher remarked, the odds are against bexarotene succeeding as an Alzheimer's cure—just as many other promising possibilities have failed before. But it's worth knowing when such possibilities come along. Eventually, one of them will succeed. And then it will be time to break out the word *breakthrough*. —*Tom Siegfried, Editor in Chief*

JIM WEBB

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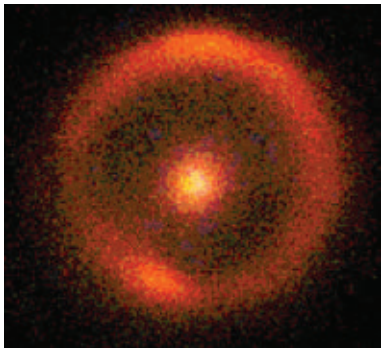

Say What?

Gravitational lens ***\grah-vih-TAY-shun-al LENZ\ n.*** Anything that has a gravitational pull—stars, galaxies, and even dark matter—can bend light passing by, distorting the image of the light's source that is seen on Earth. Scientists can use this distortion to look for objects that would be too dim to see otherwise by picking out anomalies in deflected light. An international team of researchers noticed just such a disturbance in the bright halo (shown) created by the supermassive elliptical galaxy JVAS B1938+666 as it warps the view of a more distant galaxy. Further investigation led to the discovery of a satellite dwarf galaxy located nearly 10 billion light-years from Earth, the researchers report in the Jan. 19 *Nature*. —*Allison Bohac*

Science Past | FROM THE ISSUE OF MARCH 10, 1962

KENNEDY URGES BETTER PAY — President John F. Kennedy's proposal to raise the pay scale for top Government employees should help stem the flow of scientists and engineers now leaving public service for much higher pay in industry.... The top Government salary under most scales is $18,500 a year. Many top positions are not filled because prospective employees would not consider less than $25,000. A comparison of salaries of Government employees and industry employees is remarkable, if not appalling. GS-16 workers, for example, receive between $15,200 and $16,200 while equivalent workers in industry receive at least $20,000 with a median of $25,900.

Introducing

A viney, wild cousin of the potato has become the only species named for Jeanne Baret, the first woman known to travel around the Earth and possibly the only one to do so illicitly, disguised as a male assistant to a botanist. Sailing in 1766 with explorer Louis Antoine de Bougainville's crew, Baret endured about two years of nautical life, including foul water and occasional rat dinners. When the ailing botanist, Philibert Commerson, was too ill to work, she collected specimens herself. More than 70 species are named in Commerson's honor, and on January 3 in *PhytoKeys*, Eric Tepe of the University of Utah and his colleagues christened *Solanum baretiae*. —*Susan Milius*

Science Future

March 30–31
Meet astronaut Richard Linnehan and Nobel winners at the Texas A&M Physics and Engineering Festival in College Station. See bit.ly/SNtamu

March 31
See glowing creatures at a bioluminescence exhibit at the American Museum of Natural History in New York City. Learn more at bit.ly/SNbiolum

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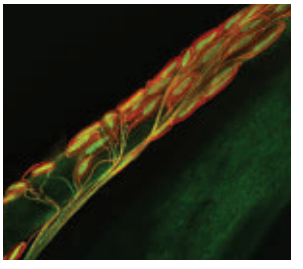
ON THE SCENE BLOG
Science can't hear back in time. Read more in "Archaeoacoustics: Tantalizing, but fantastical."

GENES & CELLS
An eye protein helps mice and people sense vibrations. See "Seeing, feeling have something in common."



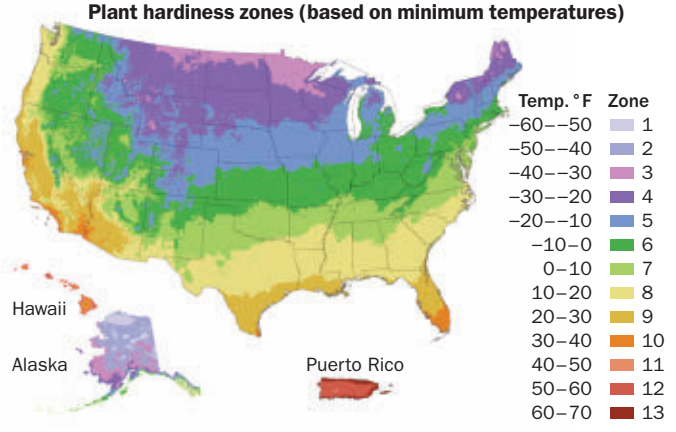
LIFE
Early fliers may have had dark feathers. Read "*Archaeopteryx* wore black."

ATOM & COSMOS
Particles reveal the stuff of space in "Spacecraft captures dust from interstellar wind."

Science Stats | PLANT ZONES SHIFT

A new map of U.S. plant hardiness zones shifts much of the country about half a zone warmer. The U.S. Department of Agriculture says the shift reflects not only any climate warming that has occurred but also better mapping methods and accuracy. Find your zone by zip code at planthardiness.ars.usda.gov SOURCE: U.S. DEPARTMENT OF AGRICULTURE

Plant hardiness zones (based on minimum temperatures)



CLOCKWISE FROM TOP LEFT: D. LAGATTUTA/W. M. KECK OBSERVATORY; COURTESY OF HAGEN WENDE AND CARMEN BIRCHMEIER; E.J. TEPE *ET AL*./*PHYTOKEYS* 2012

“We’ve been able to identify the beginning of the Little Ice Age, something that’s been very difficult to do in the past.”
—GIFFORD MILLER, PAGE 12

In the News

STORY ONE

Cancer drug shows promise as treatment for Alzheimer’s

In mice, medication clears plaque-forming protein

By Laura Sanders

A cancer drug that sweeps an ominous plaque-forming protein from mouse brains within hours and reverses Alzheimer’s-like behavior in days may offer a powerful new way to prevent or even reverse the brain-wasting disease in humans.

The drug, called bexarotene, has been on the market for about 10 years to treat T-cell lymphoma, often after other treatments have failed. But bexarotene can do a completely different job in the brain, researchers report online February 9 in *Science*.

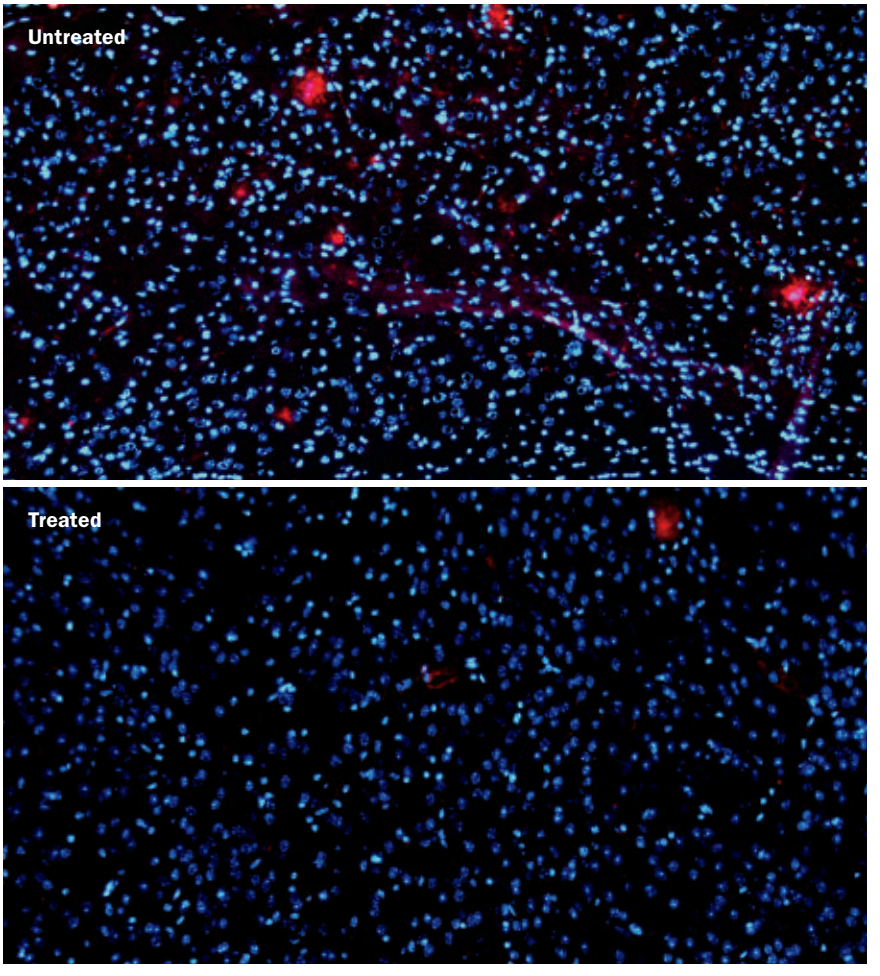
“This is a pretty fantastic drug,” says Paige Cramer of Case Western Reserve University School of Medicine in Cleveland, coauthor of a new study that used bexarotene to treat mice suffering from an Alzheimer’s-like condition.

The brains of people with Alzheimer’s disease are marked by high levels of a protein called amyloid-beta, which can exist in both small fragments that scramble nerve cell communication and in large, sticky clumps called plaques (*SN: 3/12/11, p. 24*).

Cramer and her colleagues studied mice that had brains full of both kinds of A-beta. Just hours after mice began taking bexarotene, levels of the smaller kind of A-beta in their brains fell, reaching a 25 percent reduction after 24 hours. After 14 days of treatment, plaque levels fell by 75 percent, the team reports.

“Nothing tested comes anywhere close to the speed with which existing amyloid is washed away by this drug,” says neuroscientist Samuel Gandy of Mount Sinai Hospital in New York City.

The drug works by changing the behavior of a cholesterol-carrying protein called ApoE by targeting a protein that regulates it. (ApoE is no stranger to Alzheimer’s researchers: People with a particular version of ApoE have a higher



The brain of a mouse with an Alzheimer’s-like disease (top) accumulates plaques of the protein A-beta (red) around brain cells (blue). The brain of a similar mouse after three days of bexarotene treatment (bottom) has fewer plaques.

SCIENCE/AAAS

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risk of the disease.) Earlier studies have found that ApoE shuttles A-beta out of the brain, acting, as coauthor Gary Landreth of Case Western says, like "a garbage disposal." By improving ApoE's ability to remove A-beta, "bexarotene helps Mother Nature do what she normally does," Landreth says.

Clearing A-beta from the brain had a profound effect on the mice's behavior, too. Mice loaded down with A-beta have memory deficits and can't learn new things as well as normal mice. After taking bexarotene for several days, animals showed startling improvements in several different kinds of tests.

Normally, mice that are put into cages with a pile of soft tissue paper begin to chew the paper and form it into a soft pile, making a nest. The mice with an Alzheimer's-like condition lost the ability to make the association between seeing the paper and the possibility of a soft place to sleep. But after three days of taking bexarotene, these mice began making nests again, the team reports.

Another performance measure came from testing the sense of smell, which people often lose in the early stages of Alzheimer's. When mice smell a strong odor repeatedly, they get used to the smell and don't react strongly the third, fourth or fifth time they encounter it.

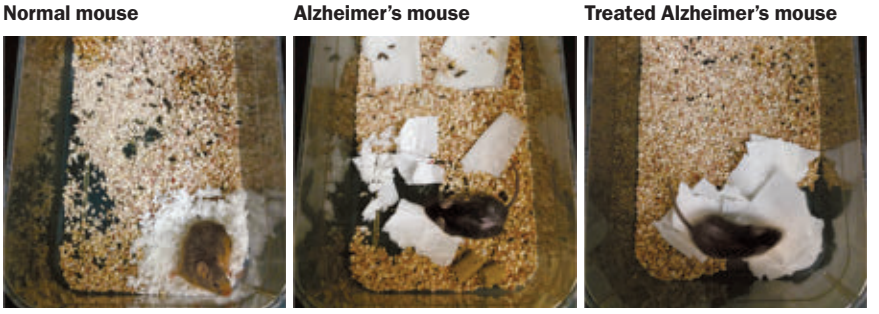
Mice with brains full of A-beta didn't grow accustomed to the odor, though, acting surprised each time they encountered the scent. But after treatment with the drug, the mice recovered the ability to get used to an odor. In these and other tests, abnormal behavior was reversed in mice that had received bexarotene.

More work is required, such as replicating the study with the human version of ApoE (the researchers used the mouse version of the protein). But since the drug is already FDA-approved, says neuroscientist David Holtzman of the Washington University School of Medicine in St. Louis, "you have a very clear path forward in humans."

Landreth and Cramer hold a provisional patent application on using bexarotene as an Alzheimer's therapy, and have started a company called ReXceptor Inc. to conduct more research. The team plans to test bexarotene in people in the coming months.

"Making the leap from mice to humans is the most difficult step in drug development," says Gandy. "Based just on odds, I would bet against the drug, but the mechanism is novel and appealing, so I'm hoping that it beats the odds."

In addition to its promise in treating Alzheimer's disease, bexarotene might offer scientists a way to clarify A-beta's role in the disease. The relationship has gone untested because scientists haven't had a good way to reduce A-beta. "This is a perfect tool for testing the amyloid hypothesis," Gandy says. ■

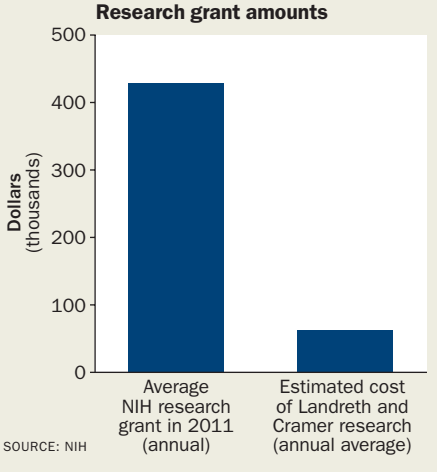


Lab mice typically use tissue paper to build nests for themselves (left). But mice with an Alzheimer's-like condition lose that ability (center). After three days on bexarotene, mice with the condition partially recovered their nest-building ability.

Back Story | SCRAPING BY

Biomedical advances often come from large-scale projects supported by million-dollar grants. Yet Gary Landreth and his graduate student Paige Cramer conducted their study of the effects of bexarotene on Alzheimer's-like dementia in mice on a budget of $250,000 spread out over four years. That's less than a typical single year of support from many funding agencies.

The shoestring budget stemmed in part from the risky nature of the study. Bexarotene was predicted to have a "boatload" of side effects because its target partners with lots of other proteins, Landreth says. "No one in their right mind would have funded this thing initially."



But with a small amount of no-strings-attached cash from the Blanchette Hooker Rockefeller Foundation, Landreth and Cramer were able to get initial results that looked promising enough to land a $200,000 grant from the National Institutes of Health. The pair quickly ran through that money, but not before they had found that bexarotene seems to ease symptoms of Alzheimer's in mice.

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AAAS Meeting

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Wireless drug delivery achieved

Implanted microchip releases medication on command

By Rebecca Cheung

An implanted microchip that releases medication on command from wireless signals has been demonstrated in people for the first time using a drug for osteoporosis.

The tiny device, implanted under the skin, could be useful in treating many diseases that require taking medication regularly, scientists reported February 16.

"This opens up profound possibilities for improving the treatment of patients and the potential of telemedicine," said Robert Farra, president of MicroCHIPS Inc., the company that funded and conducted part of the study. A paper describing the results was also published online February 16 in *Science Translational Medicine* by collaborators from MicroCHIPS, MIT, Harvard, Case Western Reserve University and On Demand Therapeutics.

An implanted microchip (right) about the size of a memory stick (left) can release drugs in patients through wireless control, a new study finds.

The idea behind a microchip that could release chemicals in the body at precise times was first conceived by MIT scientists over a decade ago. But researchers needed to make sure that medications were well-stored in the device. Also, the immune system tends to create a barrier of collagen around implanted devices, which could make it difficult for the drug to make it into the bloodstream.

In the new study, a device with individual doses of the drug teriparatide sealed inside was implanted under the waistline in eight women with osteoporosis. When the device receives a wireless signal, a current runs through the microchip, breaking open the metal layers that contain a single dose of the drug.

About two months after the device was implanted — and after the immune system's protective barrier had formed — wireless signals programmed the device to release daily doses of teriparatide. The drug, which increases bone mass, is usually given by injection.

Based on blood tests, the doses from the device appeared to bump up levels of a molecule called P1NP, which indicates bone building — evidence that teriparatide released from the microchip works as it should.

Still, there are technical limitations with this device. John Watson, a bioengineering researcher at the University of California, San Diego, said that the consistency of the devices needs to be improved. One device didn't release any medication in one patient. ■

Scientists surf Web's dark side

Mathematical tools collect information on extremists

By Rachel Ehrenberg

New mathematical tools that combine Web-crawling techniques, sophisticated algorithms and human expertise are gaining access to the "dark side" of the Web, where extremists discuss and plot terrorist acts.

The Dark Web Project, started partly in response to the 9/11 attacks, has developed ways to track the spread of dangerous ideas through rogue and jihadi Web forums. With a mathematical model known as SIR, also used by epidemiologists to describe disease transmission, researchers have determined that the infection rate for becoming a suicide bomber is 2 in 10,000, Hsinchun Chen of the University of Arizona reported February 18.

Housed at the University of Arizona, the project collects information from blogs, forums and other sites in hidden realms of the Internet. Search engines typically explore only what's known as the "publicly indexable Web." The invisible Web, which includes these Dark Web forums, is estimated to contain 500 times as much information as the surface Web.

Dark Web forums are particularly tough to crack. There's no centralized index of forums, and access is often restricted to people who have to apply and be approved, which can take weeks. Using mathematical approaches to identify and target forums from known extremist sites and less obvious places, such as an AOL group, the researchers then apply for membership. If they can gain access, they then need to assess things like how often the site downloads information and how many connections it has. Then they can use a crawling or "spidering" technique to collect and index information.

Authorship analysis techniques can then reveal what messages come from the same individual. The approach is up and running for English and Arabic, and in process for French, Urdu and Pashto, Chen said.

Such analyses can be fraught with difficulty, said Vinton Cerf, chief Internet evangelist for Google. Words may be misspelled, and new phrases are invented every day.

The new analyses of the Dark Web forums also suggest that the longer participants are involved in a forum, the more violent their messages become.

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Scars from harsh early years linger

Brain changes seen among kids from grim orphanage

By Laura Sanders

Living in harsh conditions in an orphanage early in life has long-lasting consequences for a child's social skills, a new study finds.

Children who spent their first two years in a Romanian orphanage behaved abnormally in social interactions with other children, even years after leaving the institution. Life in an orphanage was also linked to brain abnormalities, Charles Nelson of Harvard Medical School reported February 17.

"I think this work nails the really important issues in trying to understand the effects of early life experiences," said psychologist Janet Werker of the University of British Columbia in Vancouver.

Since 2000, Nelson and colleagues have followed 136 children who were abandoned at birth and placed in Bucharest, Romania, orphanages — which offered a spartan environment where the children spent hours staring at a white wall and followed a highly regimented schedule of activities. The kids received very little attention from caregivers.

Nelson and his team arranged for half of these children to move into individual homes for foster care. (A bias against foster care in Romania made the situation unusual.) Called the Bucharest Early Intervention Project, the experiment offered a way to test the importance of a good environment.

Echoes of a hard start in life persisted long after the orphans had moved into a home, the team found. At age 8, kids who spent their first two years or longer in an orphanage before moving to foster care had profound deficits in how they interacted with other children. The kids couldn't carry on a conversation normally and had other social problems.

> "I think this work nails the really important issues in trying to understand the effects of early life experiences."
> JANET WERKER

But kids who escaped the orphanages before they turned 2 were able to recover normal social skills, performing as well as children who had been raised in their own homes.

In addition to behavioral problems, the children raised in an orphanage showed brain differences, too. MRI brain scans revealed that kids who were institutionalized had dramatically lower volumes of gray matter — which contains the brain's nerve cells — than children who grew up normally in their own home. Whether or not the child moved to a foster home didn't matter: Living in the orphanages for any amount of time was tied to reduced gray matter.

But the story was different for another kind of brain tissue: The volume of white matter — tissue that carries nerve cell signals around the brain — was lower than normal for kids who were in an orphanage for two or more years. White matter volume was greater in children who left the orphanage before age 2 but still lower than that seen in kids who had never been in an orphanage. The results suggest that white matter, a brain tissue that is thought to be heavily responsive to the environment, may be able to bounce back from an early rough start.

"Institutional care should be considered the last resort," Nelson said. "And effort should be made to place a child as soon as possible." ■

MEETING NOTES

Social media didn't spur Arab Spring

The Arab Spring protests and uprisings that began in December 2010 have been characterized as Twitter and Facebook revolutions, but new research suggests that social media platforms had a mixed effect on political change. An analysis of 10 months of news, information and social media use in 18 Arab Spring countries found that the number of Facebook users did swell during that time. But the pattern of increased use of social media didn't cleanly match up with the pattern of protests. Social media sites told people where to find information, not to revolt, Kathleen Carley of Carnegie Mellon University in Pittsburgh reported February 18. Concerns over human rights and international relations issues such as troop movements were more predictive of who protested where, and when.
— Rachel Ehrenberg

Video games improve vision

Violent video games get a bad rap, but they may benefit people with vision problems, psychologist Daphne Maurer of McMaster University in Canada reported February 17. Playing the game *Medal of Honor*, in which the user sees scenes from the perspective of a soldier, for 40 hours over a month improved a host of visual abilities in adults who were born with cataracts. Even though the participants had their cataracts removed when they were young, vision deficits persisted. But 40 hours of gaming that requires users to survey a wide field and react quickly to threats improved multiple visual skills. Maurer and her colleagues are developing a less gory version of the game that can do the same job without all the bloodshed. *— Laura Sanders*

AAAS Meeting

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Carbon dioxide erodes marine ecosystems

Research suggests how sea life will react to acidification

By Janet Raloff

If carbon dioxide emissions don't begin to decline soon, the complex fabric of marine ecosystems will begin fraying — and eventually unravel completely, two new studies conclude.

The diversity of ocean species thins and many survivors' health declines as the pH of ocean water falls in response to rising carbon dioxide levels, scientists from England and Florida reported February 18. What's more, affected species aren't restricted to those with shells and calcified support structures — features particularly vulnerable to seawater acidification.

Jason Hall-Spencer of Plymouth University in England and his colleagues have been collecting data from marine sites off Italy, Mexico and Papua New Guinea, where high concentrations of carbon dioxide percolate out of the seabed from volcanic activity below. Directly above these CO_2 seeps, pH plummets to 7.8 or below, a value that is expected to occur widely by 2100 and which is substantially lower than the normal level for these areas, 8.1. The sites offer a preview of what may happen to seafloor ecosystems as CO_2 levels continue to rise.

Compared with nearby normal-pH sites, species richness in low-pH zones was diminished by 30 percent, Hall-Spencer reported. "Coral and some algae are gone. And the sea urchins are gone," he said. Fish may be present, but unlike in areas with a normal pH, they won't deposit their eggs there.

Although seagrasses appear to survive just fine in the low-pH seawater, close inspection showed that fish had nibbled the fronds, Hall-Spencer found. He identified one likely explanation: At low pH, these grasses no longer produced the phenolic defense compounds that typically deter grazing animals.

His team also transplanted a host of healthy marine species to sites with a gradient of pH values leading up to an Italian seep, then monitored the immigrants' health for a year.

Even shelled animals initially survived from fall to spring, in some cases bumping up their calcification rate in an attempt to cope with the corrosive waters. The surprise, Hall-Spencer noted: When peak temperatures arrived in August, many transplanted corals and mollusks died "due to the double whammy effect of high CO_2 and high temperature."

In lab experiments, Chris Langdon of the University of Miami Rosenstiel School of Marine and Atmospheric Science and colleagues raised coral larvae at pH values representing the South Pacific today and at levels expected in 50 and 100 years. Compared with newly spawned larvae at normal pH, the metabolism of those raised in the lowest-pH environment dropped 65 percent.

"You can think of this as a ball and chain attached to the leg of every coral larva," Langdon said. "It's not killing it outright, but each will have to go through life dragging this ball and chain behind." Langdon found that the larvae's ability to make energy from nutrients in the water also suffered in the reduced pH environment. "So it's like they're starving at the same time," he said.

Finally, there was a 60 percent decline in the number of larvae that could settle out onto a simulated reef surface, Langdon reported. One reason may have to do with the effects of acidification on turf algae in the reef environment. These algae made less of two key pigments. Ordinarily, the pigments "call out to the larvae, saying this is a nice place to settle," he explained.

In Papua New Guinea, Langdon found evidence that the same thing is happening in the wild at CO_2 seeps with comparable pH values.

Others at the meeting reported that at some sites, such as along the West Coast of the United States, seawater regionally — and regularly — falls to a pH of 7.5 or lower owing to natural factors other than CO_2 seeps. Such new data may explain occasional catastrophic wipeouts of young farmed shellfish, said Gretchen Hofmann of the University of California, Santa Barbara. ■

Carbon dioxide bubbling up from seeps on the seafloor lowers the pH and species diversity in nearby waters. Such sites offer a possible preview of climate-related ecosystem changes as oceans acidify.

BRUNO IACONO

"You can think of this as a ball and chain attached to the leg of every coral larva."—CHRIS LANGDON

Indian Ocean set stage for humans

Temperature shifts dried out East Africa 2 million years ago

By Alexandra Witze

Scientists may now be able to explain one of the key events that shaped human history: why East Africa got drier starting around 2 million years ago, with forests giving way to grasslands on which the genus *Homo* further evolved. Ocean temperature changes, especially the arrival of a strong warm/cool difference along the equator in the Indian Ocean, could have triggered the change.

"Those gradients are responsible for shifting rainfall towards or away from East Africa," said Peter deMenocal, a paleoclimatologist at the Lamont-Doherty Earth Observatory in Palisades, N.Y. He presented new details about his idea on February 17.

Researchers infer that East Africa started shifting toward grasslands by looking at the proportion of fossils of grazing animals, which peaked around 1.5 million years ago. Around this time *Homo* began to develop new tools, diversify into new species and make its first tentative forays out of Africa.

But despite a raft of theories, scientists haven't been able to explain what triggered the drying responsible for the shift to grasslands. The ocean gradient idea might do the trick, deMenocal said.

"At first blush it doesn't seem intuitively obvious, but what controls rainfall in the tropics is where the warm water is," he said. More rain occurs where the ocean is warmest, because water can more readily evaporate and fall back as rain.

DeMenocal and his colleagues looked at deep-sea sediment cores, representing the last several million years, drilled across the Indian, Pacific and Atlantic oceans. Most strikingly, a site in the eastern Indian Ocean and another in the western Indian Ocean show temperatures tracking similarly until around 2 million years ago, when the eastern site warmed and the western site cooled. If so, then the cool waters off East Africa would have dried out that part of the continent, deMenocal said.

More rain occurs where the ocean is warmest, because water can more readily evaporate and fall back as rain.

Next the scientists ran computer simulations that erased the east/west temperature difference and showed what might happen if temperatures were the same along the equator across the Indian Ocean. That change shut down a type of atmospheric circulation, making East Africa wetter than it is today.

Taken together, deMenocal said, "I think this is pretty solid evidence for a transition to more open conditions [in East Africa] at this time." What kicked off the change in ocean temperatures, though, remains a mystery.

Other, more recent climate changes may have also shaped the course of human evolution, said Andrew Weaver, a climate scientist at the University of Victoria in Canada. At the conference he reported new simulations looking at climate changes that happened about 105,000 years ago, around the time modern humans, *Homo sapiens*, were moving out of Africa.

When the northern ice sheets dumped great icebergs into the ocean, freshening the water there, rain belts in Africa also shifted, Weaver reported. In this case, the change may have dried out much of northern Africa, compelling *H. sapiens* to leave its birth continent. ■

MEETING NOTES

Fracking isn't tainting groundwater, study finds

Several communities have reported groundwater contamination associated with natural gas produced from deep shale deposits by hydraulic fracturing, sometimes called fracking. A new study by researchers at the University of Texas at Austin concludes that such pollution results not from liquids pumped down to the shale deposits to fracture the deep rock—as often claimed—but instead from poor management of wastes or bore wells thousands of feet above the shale. Funded by the university with no industry contributions, the study doesn't downplay drinking-water pollution associated with shale-gas production. But those risks "are very similar, if not exactly the same, as the impacts that we see from conventional gas development," said Charles "Chip" Groat, who led the study. Groat reported his team's findings February 16.
—Janet Raloff

Lab-grown meat almost done

Hamburger made from meat grown in the lab might be ready to eat this October, Mark Post from Maastricht University in the Netherlands reported February 19. So far, scientists using bovine stem cells have made pieces of skeletal muscle that are about 3 centimeters long. Citing the growing global demand for meat and the environmental costs of raising livestock, Post said "we need to get alternatives." He thinks that lab-grown meat products could be commercially available in 10 to 20 years. *—Rebecca Cheung*

Earth

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Big volcanoes can wake up fast

Crystal chemistry indicates sudden pre-eruption changes

By Alexandra Witze

Long-slumbering volcanoes can jolt to life faster than students drinking Red Bull, a new study suggests.

Studies of millennia-old rocks that erupted at Santorini, Greece, show that the chemical composition of the magma changed just a few decades before the volcano blew its top around 1600 B.C. That blast came after 18,000 years of relative calm.

"There's kind of a rapid wake up," says Tim Druitt, a volcanologist at Blaise Pascal University in Clermont-Ferrand, France. Druitt and his colleagues describe the awakening in the Feb. 2 *Nature*.

Santorini's Bronze Age eruption is one of the most famous in history. But what exactly set the volcano off after such a long quiet period has remained a mystery. "A fundamental question that we know very little about is what happens to reactivate these systems," says Druitt.

To try to answer that question, his team looked at chemical elements within crystals that erupted from Santorini. Many of the crystals are zoned—layered with different chemical compositions that form as new pulses of magma arrive from deep within Earth's mantle, mix and cool. Druitt and his colleagues looked at concentrations of the element magnesium in different crystal zones. Over time magnesium diffuses slowly through a crystal, moving about 10 micrometers a year at the temperature of the Santorini magma, so the scientists could calculate how quickly the crystals had formed.

Essentially all were geologic babies. "This made me sit up because you've got about 18,000 years since the last major eruption, and yet all the crystals seem to be a few decades old," Druitt says.

Viewed from an orbiting satellite, islands can be seen encircling the caldera left by the Santorini, Greece, volcano that erupted around 1600 B.C.

Several cubic kilometers of magma may have welled up from the depths, then melted and mixed with other rocks just below the surface and primed Santorini for its mammoth eruption. It's still not clear what may have caused more magma to rise in the first place, says David Pyle, a volcanologist at the University of Oxford in England.

Little Ice Age began with bang

Frozen moss suggests eruptions kicked off cold era

By Devin Powell

The Little Ice Age, a centuries-long cold spell in Europe and elsewhere, began suddenly late in the 13th century, a new study finds. A string of volcanic eruptions may have set off this climate shift by belching sunlight-reflecting particles that allowed Arctic sea ice to reach epic proportions, researchers report online January 31 in *Geophysical Research Letters*.

"We've been able to identify the beginning of the Little Ice Age, something that's been very difficult to do in the past," says Gifford Miller, a paleoclimatologist at the University of Colorado Boulder.

It has long been known that much of the globe became chillier during the Renaissance. By the 17th century, temperatures in the Northern Hemisphere had fallen half a degree Celsius compared with medieval times.

To pin down when this climate change began, Miller's team traveled to Baffin Island on the northern fringes of Canada. Small glaciers in this region tend to respond quickly to temperature changes. Carbon dating of moss entombed in Baffin's ice revealed two sudden advances of the snow line that killed off the vegetation: a cold spell that started between 1275 and 1300, followed by another between 1430 and 1455.

Testing whether this chill extended beyond Canada took the researchers to the Langjökull glacier, the second largest ice cap in Iceland. Layered sediments from a nearby lake appeared progressively thicker in the 14th century—exactly what would be expected if the glacier expanded and ground away the landscape.

These chillier conditions began during an especially active time for volcanoes. "The second half of the 13th century had the most volcanism of any period of the past 1,500 years," says Alan Robock, an atmospheric scientist at Rutgers University in New Brunswick, N.J.

Sea ice may have been the secret to keeping Earth frosty for centuries. In climate simulations run by Miller's team, eruptions stimulated the growth of Arctic ice. Normally, this ice would melt back during summer months. But a series of four explosions, each within a decade of the last, could have expanded the ice enough to make it stable, says Miller.

Polar ice samples have revealed just such a series of eruptions, says Robock: an especially big explosion somewhere in the world in 1258, and three smaller ones in 1268, 1275 and 1284.

EOS/NASA

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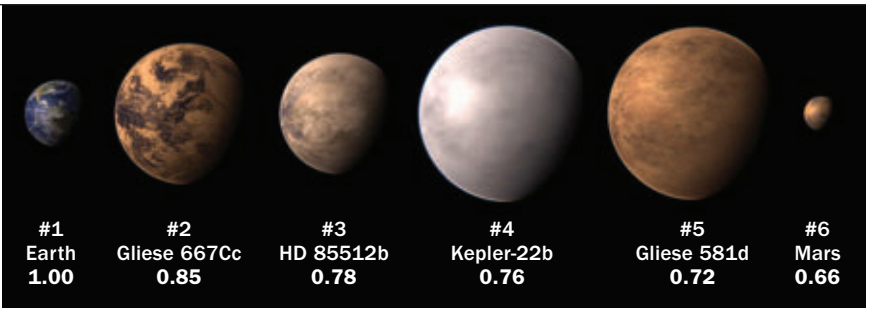
Earth-y orb found in habitable zone

Size, position make planet promising prospect for life

By Nadia Drake



A planetary lineup shows the best bets for life-friendly exoplanets, compared with Earth and Mars. GJ 667Cc (#2) scores high on the Earth Similarity Index (numbers shown).

Inching ever closer toward the goal of finding another Earth, scientists have announced the most promising extraterrestrial incubator so far: a planet of at least 4.5 Earth masses, orbiting its star in the region where liquid water can exist.

Called GJ 667Cc, the super-Earth circles one member of a triple-star system shining 22 light-years from Earth near the curving tail of the constellation Scorpius.

Unlike other recent tantalizing discoveries, the planet is both well within its star's life-friendly zone and just about the right size to host life as we know it. But that doesn't mean GJ 667Cc is habitable, scientists caution.

"It's definitely the best candidate," says astronomer Abel Méndez of the University of Puerto Rico at Arecibo. "If it's rocky, then it will be more compelling evidence that this is a true habitable planet."

An international team spotted the newly announced planet in data from the High Accuracy Radial Velocity Planet Searcher, or HARPS, a Swiss-led project that monitors stars for the gentle gravitational tugs produced by orbiting planets. A star's wobble reveals the mass of a planet circling it. But scientists don't know its radius, how dense the orb is or what it might be made of.

Astronomers debate who really discovered GJ 667Cc; this latest announcement comes from a team with a new method for processing HARPS data. Guillem Anglada-Escudé of the University of Göttingen in Germany and colleagues sniffed out the signatures of as many as three planets circling the star GJ 667C, reporting the results in an upcoming *Astrophysical Journal Letters*.

The closest-in planet, also a super-Earth, zooms around the star every 7.2 days. The second planet — the one of interest — dawdles a bit, with a 28.15-day orbit. The third signature could be a planet on a 75-day orbit, but could also be just an artifact of the star's activity.

Elusive solar neutrinos spotted

Detection reveals more about reaction that powers sun

By Alexandra Witze

In a technical tour de force, physicists have spotted long-sought low-energy neutrinos zipping from the sun. The discovery confirms one of two possible initial steps in the fusion cycle that helps power the star, says Cristiano Galbiati, a physicist at Princeton University and a member of the team reporting the discovery in the Feb. 2 *Physical Review Letters*.

The newfound particles are produced when two protons and an electron interact to make deuterium, a heavy form of hydrogen that helps feed the sun's fusion. About 1 in 400 deuterium atoms in the sun are made in this proton-electron-proton, or *pep*, reaction.

Scientists can probe the sun's inner workings by studying particles produced in its thermonuclear reactions — in particular, neutrinos that flood through Earth but hardly interact with matter.

In 2007, a collaboration known as Borexino started trying to find the elusive solar neutrinos at Italy's Gran Sasso National Laboratory, buried in a mountain so as to screen out other particle chatter. The Borexino detector consists of a giant vat of liquid, which sets off tiny sparkles when neutrinos interact with it.

Scientists knew they could spot solar neutrinos from the more common and higher-energy proton-proton, or *pp*, reaction, but initially didn't expect to be able to see the *pep* neutrino. "We knew it might be possible, but there were huge barriers," says Princeton's Frank Calaprice.

For instance, even though the detector is buried, some cosmic rays do manage to get through the mountain and into the experiment where they can produce radioactive carbon-11. That sets off the detector in the energy range expected for *pep* neutrinos. But new ways to remove carbon-11 from the analysis allowed the Borexino scientists to filter out the unwanted signal, Galbiati says. Once the background interference was gone, the scientists could spot the telltale signs of *pep* neutrinos at the expected energy of around 1.4 million electron volts. About three such flashes happened each day per 100 metric tons of detector liquid.

Borexino's technical accomplishments are already helping other experiments, such as those that hunt for other neutrino events or even dark matter.

HABITABLE EXOPLANETS CATALOG PHL/UPR ARECIBO

Environment

+6.2 percent *Porites* growth rate change at Coral Bay, Western Australia, 1900–2010

–14 percent *Porites* growth rate change on Great Barrier Reef, 1990–2005

Warmer waters aid some corals

Western Australian reefs faring better than eastern

By Devin Powell

Corals on Australia's Great Barrier Reef have fallen on hard times recently. But on the opposite side of the continent, their west coast brethren have been living the good life for at least a century.

Global warming may be helping these creatures out, a new study finds. "To date, it is the changes in temperature that are having the dominant impact on coral growth," says Timothy Cooper, a marine biologist at the Australian Institute of Marine Science in Crawley.

Cooper and his colleagues collected samples of *Porites* coral at six spots off Australia in the southeastern Indian Ocean. *Porites* build skeletons with layers that, like tree rings, can measure growth.

None of the creatures had slowed their growth in the last 110 years, the team reports in the Feb. 3 *Science*. Those at the southernmost sites have even been building reefs faster as surface waters there have warmed markedly.

T.F. COOPER

Samples collected at reefs in Western Australia (one shown) suggest that corals in these locations have been thriving.

On the Great Barrier Reef, the same type of coral is stressed, previous work has shown. *Porites* grew 14 percent slower in 2005 than in 1990, a slowdown blamed on both warming waters and ocean acidification linked to rising carbon dioxide. About a third of all atmospheric carbon dioxide emissions are soaked up by the oceans, where the gas reacts to make carbonic acid. That lowers the water's pH and levels of dissolved carbonate, the raw material corals use to build skeletons.

Ocean acidification is expected to have a greater effect at some of the higher latitudes surveyed in the new study, where dissolved carbonate is less plentiful to begin with. But Cooper and colleagues found no sign that changing pH bothered the corals they sampled. Acidification may still be a problem in the long run, but for now temperature seems to be the bigger factor. Warmth seems to make the reef builders more productive.

"It is good to see some corals doing well in the warming," says marine biologist Charles Sheppard of the University of Warwick in Coventry, England. But he cautions that Australia's west coast may ultimately be heading for a downturn as well. Patches of coral in other parts of Western Australia have already been spotted bleaching — spitting out the symbiotic algae that keeps them alive — when struck by surges of warm water. ■

'Nonstick' chemicals pose risk

Pollutants dampen immune response after childhood

By Janet Raloff

Tiny amounts of two common pollutants — chemicals known as PFOA and PFOS — in the blood may be linked to impaired immunity in children. In kids with the highest exposure, vaccinations can fail to trigger sufficient levels of protective antibodies, a new study finds.

"We were shocked, to be frank, in the magnitude of the effect," says Philippe Grandjean of the Harvard School of Public Health in Boston. He and colleagues report the result in the Jan. 25 *Journal of the American Medical Association*.

The long-lived pollutants — part of a class of chemicals called perfluorinated compounds, or PFCs — have been generated over the years by the production of synthetic substances that impart nonstick properties and water- and stain-repellency to fabrics, cookware and more. These substances include older formulations of treatments marketed under such trade names as Teflon and Scotchgard.

Grandjean's group followed 587 children in Denmark's Faroe Islands from before birth through age 7. The researchers measured PFCs in the blood of the kids' moms during pregnancy and in the kids at ages 5 and 7. Blood levels of the chemicals were in the same ballpark, if a bit lower, than typical in Americans.

The Faroese youngsters got standard childhood immunizations; their antibody responses to tetanus and diphtheria were measured as babies and before and after booster vaccinations at age 5.

Children with the highest perfluorinated pollutant exposures tended to exhibit a less robust response to the vaccines than those with the lowest levels, both before and after their booster shots.

Among children in the top third of exposure to PFOA, PFOS and the related compound PFHxS, "inadequate response to the vaccinations was particularly common," Grandjean says. The findings raise questions about whether the immune deficiencies might also point to a heightened vulnerability to allergy, asthma and, potentially, autoimmune disease.

Toxicologist Margie Peden-Adams of the University of Nevada, Las Vegas finds the new study impressive. "Those of us in the field will be excited to see it."

Body & Brain

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Bird flu leaves tracks in brain

Virus might leave survivors vulnerable to Parkinson's

By Laura Sanders

After surviving a bout of virulent bird flu, a mouse's brain shows short-term reductions of a key chemical and long-lasting signs of infection, a new study finds. The research suggests this type of flu might leave people more vulnerable to brain disorders such as Parkinson's disease.

Recent studies have found that the bird flu virus known as H5N1, which kills about half the people it infects, can set up shop in the brain. But exactly what happens next has been a mystery.

In the new study, scientists at St. Jude Children's Research Hospital in Memphis, Tenn., examined the brains of mice that had survived an initial H5N1 infection. As in people, the virus kills about half of mice affected.

"The first goal with H5N1 was to characterize the neurological effects," says study coauthor Richard Smeyne.

After being infected with H5N1 isolated from a Vietnamese boy who died from the flu, some mice initially got very sick but then seemed to recover completely after about 21 days. Yet the story wasn't so simple in the brain, the team reports in the Feb. 1 *Journal of Neuroscience*.

Nerve cells that make one of the brain's key messengers — the neurotransmitter dopamine, which helps regulate movement — shut down production about 10 days after infection. These nerve cells, which are the same kind that degenerate in people with Parkinson's disease, "basically take a time-out," Smeyne says. "All efforts are to survive."

By day 60, dopamine starts to reappear, and levels are back to normal 90 days later. Signs of inflammation in the brain remain, though.

Just three days into the infection, the brains of the recovering mice showed evidence of a strong inflammatory response, and this response appeared to linger over time. Proteins that accompany inflammation and cells that patrol the brain looking for threats were still present and on duty in parts of the brain 90 days after the initial infection. Scientists don't know whether the response ever goes away. "My guess is that it's permanent," Smeyne says.

An influenza infection might precipitate Parkinson's in someone already at risk.

He notes that it's unlikely that an influenza infection could cause neurological diseases such as Parkinson's, but an infection might be a contributing factor, perhaps even precipitating the disease in someone already at risk.

The results are intriguing because they offer a way to understand H5N1's consequences in the brain, says neuroimmunologist Stephanie Bissel of the University of Pittsburgh School of Medicine. Future experiments on such survivor mice could reveal whether the mice show behavioral signs of neurological impairment, she says.

The research team has evidence that H5N1 breaks into the brain by traveling along the vagus nerve from nerve cells in the gut. The virus might also enter the brain from the nose by crawling along the olfactory nerve, Smeyne says. ■

Impulsive behavior partly heritable

Drug users and their sober siblings share key brain features

By Rebecca Cheung

Brain abnormalities commonly seen in drug addicts are also found in the addicts' sober siblings. The discovery, reported in the Feb. 3 *Science*, suggests that there are inherited but conquerable risk factors involved in drug dependency. Looking at how nonusing siblings compensate for their inherited brain irregularities may uncover clues to treating drug addiction.

"These brothers and sisters might show us strategies that we could teach to drug users," says study coauthor Karen Ersche of the University of Cambridge in England.

It's well known that people with drug addiction problems have irregular features in parts of the brain associated with self-control. Until now, it was unclear whether these abnormalities emerge after long-term drug abuse or if some people are born with brains that are more susceptible to drug addiction.

To answer that question, Ersche and her Cambridge colleagues analyzed brain scans of 47 people who were dependent on stimulants like cocaine, as well as scans from their nonusing siblings and 50 unrelated individuals of similar age and intelligence.

"This is an elegant design that allows them to say, 'No, this was not something that relates to the drug exposure; this has something to do with heritability,'" says Nora Volkow, director of the National Institute on Drug Abuse in Rockville, Md.

The brain scans revealed abnormalities among both the addicts and their siblings in the prefrontal cortex, a brain area that's responsible for self-control. Also, the putamen, a structure involved in forming habits, tended to be larger in drug users and their siblings, while structures that manage responses to cravings tended to be smaller.

Drug users and their siblings were also found to have a weaker ability to exert self-control, based on behavior tests conducted as part of the study. ■

Massage may accelerate healing

Benefits include tissue repair and reduced inflammation

By Nathan Seppa

The relief that comes from rubbing sore muscles seems to have tangible roots: Researchers have found clear molecular signs that overworked muscle cells respond to being manipulated by massage. There are measurable decreases in inflammatory compounds in massaged muscle tissue and indications that muscle cells rev up their energy processors for the inevitable repairs that follow hard exercise, a U.S.-Canadian team reports in the Feb. 1 *Science Translational Medicine*.

"This is the best data I've ever seen addressing possible mechanisms by which this therapy works," says Thomas Best, a sports medicine physician at the Ohio State University School of Medicine.

Justin Crane, a kinesiologist at McMaster University in Hamilton, Ontario, and his colleagues recruited 11 active men to participate in a workout that taxed their quadriceps, the muscles at the front of the thigh. Shortly afterward, one thigh on each volunteer received a 10-minute massage and the other didn't. The researchers took muscle biopsies from both legs of each volunteer right after the massage and again 2.5 hours later.

The biopsies taken immediately after massage showed that muscles in the massaged legs, but not in the untreated ones, had reduced levels of an inflammatory protein called tumor necrosis factor-alpha. The biopsies also revealed activation of two kinds of enzymes called kinases right after the massage.

Massaged-leg biopsies taken 2.5 hours later showed reduced levels of interleukin-6, a different inflammatory protein, and elevated concentrations of a multipurpose compound called PGC1-alpha. PGC1-alpha plays roles in muscle fiber maintenance and cell metabolism.

The analysis also hinted that muscle cells in the massaged legs were setting the stage for growth of mitochondria, the energy factories in cells.

Massage and other alternative therapies have doubters in part because studies of these techniques often measure benefits subjectively or lack biological evidence of an effect, the authors note.

"I'm more convinced now that massage is effective," Crane says. "We see inflammation going down and, conversely, other cell signaling going up — two facets of rehab going the right directions."

Molecules

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

Test ranks best molecules for job

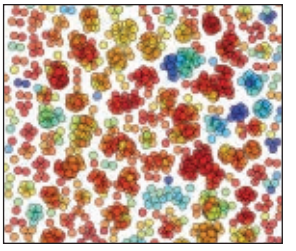
Method refines drug searches by using numerical approach

By Rachel Ehrenberg

A new method that ranks compounds' chemical attractiveness could help chemists discern promising drug candidates from duds. Researchers have come up with a way to quantify a compound's drug potential that moves beyond simply "hot or not."

The approach "takes things a step further, looking at multiple factors instead of yes-no," says chemical informaticist David Wild of Indiana University Bloomington, who was not involved with the research.

The new technique uses eight molecular properties — such as the number of rotatable bonds a molecule has — that influence things like a compound's toxic effects or its likelihood of being absorbed in the body. With some clever math, those properties are turned into a number between zero and one. When researchers tested their method against existing techniques for screening compounds, it outperformed the standard approaches at distinguishing known drugs from other molecules, the team reports in the February *Nature Chemistry*.



Network diagrams characterize drug candidates (dots) for a target called matriptase. Similar candidates are clustered together; red indicates the most promising compounds, blue the least.

Because the new method, called QED, or quantitative estimate of druglikeness, provides a numerical rating, it allows chemists to prioritize molecules for drug development, says study leader Andrew Hopkins, an expert in drug discovery and molecular design at the University of Dundee in Scotland.

Existing screening techniques tend to make pass/fail judgments. The famous Lipinski's Rule of Five, for example, uses measures such as a molecular mass cutoff of 500 daltons to evaluate whether a compound might be absorbed and used by the body. The rule has become a way to filter whole libraries of compounds even though it was just meant as a guideline, Hopkins says. This means potential drugs might be screened out before they even get a chance.

"Our metric suggests that you can break some rules," says Hopkins. "As with people, you can tolerate some bad behavior in someone's personality if they are very good in their other qualities."

Seaweed fuels bioenergy optimism

Engineered *E. coli* convert cell wall component into ethanol

By Rachel Ehrenberg

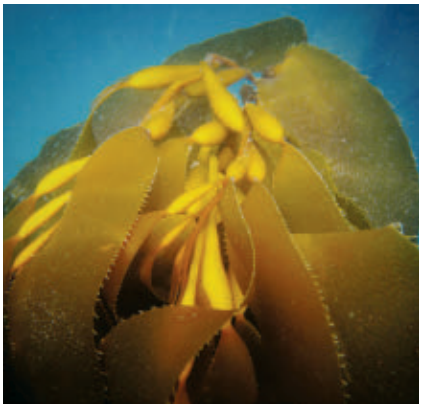
An engineered bacterium that breaks down and digests seaweed's gummy cell walls to yield ethanol may soon make marine algae a serious contender as a source of renewable fuel.

The development "makes a pretty large leap forward," says metabolic engineer Hal Alper of the University of Texas at Austin. Unlike corn and many other biofuel sources, seaweed doesn't need arable land, fertilizer or freshwater. If seaweed can be efficiently munched into ethanol, it broadens the biofuel horizon, says Alper, who was not involved in the work.

Scientists from Bio Architecture Lab, a biofuel and renewable chemicals company headquartered in Berkeley, Calif., were interested in creating a biofuel bacterium that could efficiently break down and digest the cellular building block of seaweed called alginate without pretreatment with chemicals or heat.

Led by synthetic biologist Yasuo Yoshikuni, the team took the microbial workhorse *E. coli* and gave it genes and other parts needed for superior seaweed-to-fuel conversion. From the marine bacterium *Pseudoalteromonas*, the scientists used genes for an enzyme that cuts alginate into smaller molecular bits. The researchers rigged these genes to a molecular transport system already found in *E. coli* so the bacterium would secrete the alginate-slicing enzyme into its environment.

Then the team scoured genetic databases for a microbe with serious alginate-digesting machinery. The scientists hit upon the marine bacterium *Vibrio splendidus*, and took a hefty chunk of *Vibrio* DNA. When the team fed alginate to the engineered *E. coli*, the microbes pumped out ethanol at 80 percent of theoretical maximum efficiency, the researchers report in the Jan. 20 *Science*.



A cell wall component in this *Macrocystis* seaweed can be fed to an engineered form of *E. coli* to make ethanol.

FROM TOP: G.R. BICKERTON *ET AL/NATURE CHEMISTRY* 2012; BIO ARCHITECTURE LAB

Science & Society

$9.6 billion Proposed 2013 NASA R&D budget

22 percent Proposed cut for NASA planetary science program

Nondefense R&D gets boost in White House budget proposal

In tough times, applied research would grow substantially

By Janet Raloff

Research into climate change and advanced manufacturing will see substantially increased federal support next year if President Obama gets his way, as will education in the STEM fields — science, technology, education and mathematics. The president's budget blueprint for fiscal year 2013, unveiled February 13, calls for slight increases across most research spending categories. But in some areas, the recommended spending boosts would vastly outpace inflation.

Proposed spending on research and development generally, both civilian and defense, would total $140.8 billion for fiscal year 2013. That's about the same as this year's $138.9 billion after accounting for estimated inflation of 1.4 percent. (All subsequent funding changes in this article have been adjusted to account for this projected inflation.) But the nondefense portion of that total would rise nearly $3.1 billion to $64.9 billion, a net increase of 3.5 percent.

"This budget follows similar priorities of previous Obama budgets," says veteran budget analyst Albert Teich, who until his retirement in December had been director of science and policy programs at the American Association for the Advancement of Science in Washington, D.C. "And they're worthy priorities," he adds. "Obama has been as good a friend of science and technology as we've ever seen in the White House."

But the president faces a hostile Congress and a very constrained fiscal environment. Teich predicts that various aspects of the president's 2013 spending plan will have a difficult — if not impossible — time surviving the hatchets of congressional budget cutters. "The bigger fights will probably be where they've been in the past," he says, in energy research and climate change.

Obama wants more than $500 million in additional funding for research into renewable energy and energy efficiency, a smaller hike than one turned down by Congress last year. Much of this new money would go to cutting the costs of electric vehicles, geothermal energy and biomass fuels. Funding for solar and wind energy would sag slightly.

The multiagency Global Change Research Program's budget would increase more than 4 percent, funding climate research at agencies including NASA (at $1.47 billion), the Energy Department (at $230 million) and the Commerce Department (at roughly $340 million).

During a press briefing, White House science adviser John Holdren emphasized the president's commitment to revitalizing the nation's manufacturing enterprise. The Obama administration wants to turn around years of flagging investments by directing $2.2 billion in federal dollars into this area — a whopping 17.6 percent increase over FY 2012.

Much of that funding would go to the Commerce Department's National Institute of Standards and Technology, which would see its R&D allocation more than triple under the White House proposal. The former Bureau of Standards would be the lead agency in the $1 billion National Network for Manufacturing and Innovation, which would fund advanced manufacturing research.

"As soon as the administration focused on innovation, the role that R&D plays in promoting economic growth and prosperity, it immediately became clear we were eventually going to be talking about manufacturing," says NIST director Patrick Gallagher. With more than two-thirds of all engineers outside universities and the federal government employed by manufacturing-based firms, this sector "supports the lion's share of private sector investments in research and development," he notes. — *With additional reporting by* Science News *staff*

Proposed FY 2013 federal R&D budget spending

(Dollar values in millions with percent changes from FY 2012 adjusted for projected 1.4 percent inflation)

U.S. agency or department	FY 2011 actual	FY 2012 estimate	FY 2013 proposed	Percent change
Defense	77,500	72,739	71,204	–3.5
NIH (and other HHS R&D)	31,186	31,153	31,400	–0.6
Energy	10,673	11,019	11,903	6.5
NASA	9,099	9,399	9,602	0.7
NSF	5,486	5,680	5,904	2.5
USDA	2,135	2,331	2,297	–2.8
Commerce	1,275	1,258	2,573	101.7
Interior	757	796	854	5.8
EPA	584	568	580	0.7
Education	362	392	398	0.1
All others†	3,657	3,534	4,105	14.6
Total	**142,714***	**138,869***	**140,820***	**0.005***

*Figures reflect rounding; †Includes Departments of Transportation, Homeland Security, Veterans Affairs, the Smithsonian Institution and others

☐ Increase ☐ Decrease

SOURCE: *ANALYTICAL PERSPECTIVES: FISCAL YEAR 2013 BUDGET OF THE U.S. GOVERNMENT*, TABLE 22-1, P. 370, FEBRUARY 13, 2012

T. DUBÉ

Genes & Cells

"What we have is a provocative set of findings that need to be replicated." —PAOLA SEBASTIANI

Centenarians distinguished by DNA signatures

On second try, study finds genetic basis for longevity

By Tina Hesman Saey

People who live to be 100 often credit their aging success to particular dietary or lifestyle habits, religious faith or a generally positive outlook. But scientists have long believed extreme longevity is at least partly in the genes.

Now a group of researchers has identified 281 genetic variants that together distinguish people who live to be 105 or more from everyone else with about 85 percent accuracy.

Further analysis reveals several genetic signatures among centenarians, researchers led by Paola Sebastiani and Thomas Perls of Boston University report January 18 in the online journal *PLoS ONE*. While the findings are drawing some criticism, the results suggest that there is a genetic component to extreme longevity.

Centenarians in the study have just as many disease-associated genetic variants as other people. So the researchers think that the inherited component probably includes versions of genes that protect against age-related diseases.

"What we have is a provocative set of findings that need to be replicated," Sebastiani says.

In an earlier version of the work that was published online in *Science* in 2010, she and the other Boston University researchers claimed to have found a set of 150 genetic variants that could correctly predict who would be a centenarian 77 percent of the time. But the paper soon came under fire for technical flaws. The researchers fixed the technical problem and engaged an independent lab at Yale University to analyze the data.

Despite those revisions, the paper was retracted from *Science* last year because the journal said the results no longer met standards for publication. *Science*'s reasoning is disingenuous, says Nir Barzilai, director of the Institute for Aging Research at Albert Einstein College of Medicine in New York City. "The results, if anything, are stronger," he says. "The data are the data, and it's very striking."

But other geneticists have expressed vague unease with the findings.

"The obvious technical issues have been corrected," says geneticist Greg Cooper of the HudsonAlpha Institute for Biotechnology in Huntsville, Ala. But longevity "is a messy trait" that may be too complicated to explain with a small number of genetic variants. "I'm not totally sold," Cooper says.

In the new study, the researchers combed the genetic blueprints of 801 centenarians and 914 healthy younger people for longevity-associated variants. The researchers also replicated the findings with two additional rounds of testing, first with a separate group of 253 people in their 90s and 100s and a control group of 341 younger people, then with a third set of 60 centenarians and 2,863 other people.

The researchers detected only one variant, linked to the Alzheimer's disease–associated *APOE* gene, that met statistical standards for separating supercentenarians from people with a more average life span. Many other variants also looked as if they might be tied to longevity, but none passed statistical muster.

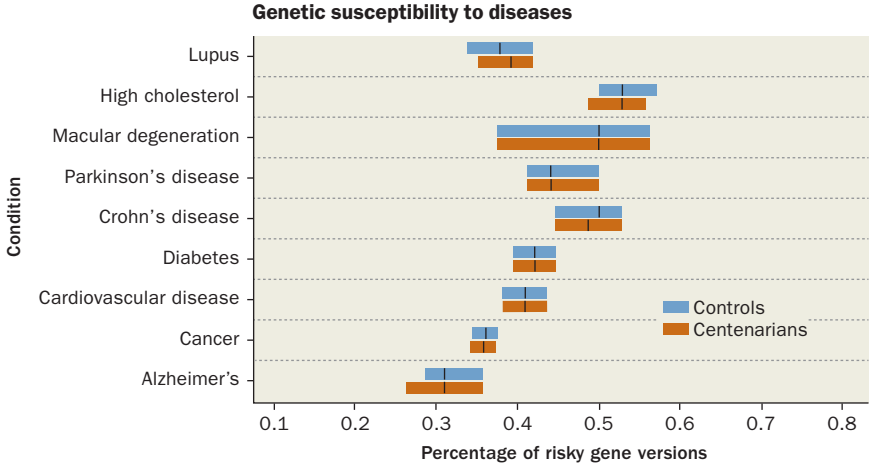
So Sebastiani and her team began summing the effects of variants that didn't quite rise to the statistical threshold to see if those individual differences added up to a genetic signature that could predict longevity. As the researchers added in more and more variants, up to the 281 reported in the study, their power to predict centenarians increased.

Such grouping of genetic variants has been used to study characteristics such as height, body mass and intelligence. That type of analysis may help detect an underlying genetic component to a trait, but it doesn't indicate which biological processes are important, says Elizabeth Cirulli, a geneticist at Duke University's Center for Human Genome Variation.

"It's not that it's invalid," she says. "It's just not helpful."

No disease difference Though 281 genetic variants can be used to distinguish centenarians from younger controls, few of those differences are due to a lack of disease-associated gene variants. A look at 1,214 disease-associated locations in the genomes of 1,054 centenarians and 4,118 controls found similar proportions of high-risk genetic variants in the groups.

SOURCE: P. SEBASTIANI *ET AL*/*PLOS ONE* 2012



ADAPTED BY T. DUBÉ

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Fairy Tales

You may have seen ads telling you of watches of which only a few were laboriously handmade by "little old watchmakers" somewhere in Germany or Switzerland or watches that will lose only one second in a million years (you should live that long!), that wars were fought over them and that recently one of them was sold for over $1 million by one of the great auction houses.

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Enriched with information

New theory doesn't limit consciousness to the brain

By Laura Sanders

As a scientist, Giulio Tononi's goal is as lofty as it gets: He wants to understand how the brain generates consciousness. In his hunt, he and colleagues at the University of Wisconsin–Madison routinely use state-of-the-art brain scanners to produce torrents of information that stream into sophisticated computer programs describing various aspects of brain function.

But Tononi's most profound insight didn't spring from this huge cache of scientific data. It came instead from a moment of quiet reflection. When he stepped away from his scanners and data and the hustle of the lab and thought — deeply — about what it was like to be conscious, he realized something: Each split second of awareness is a unified, holistic experience, completely different from any experience before or after it.

From that observation alone, Tononi intuited a powerful new theory of consciousness, a theory based on the flow of information. He and others believe that mathematics — in particular, a set of equations describing how bits of data move through the brain — is the key to explaining how the mind knits together an experience.

Because of its clarity, this informational intuition has resonated with

MICHAEL MORGENSTERN

Demystifying the Mind
This feature is the final installment in a three-part series on the scientific struggle to explain consciousness. To read the entire series, visit sciencenews.org/mind

other researchers, inspiring a new way to see the consciousness problem. "This insight was very important to me," says Anil Seth of the Sackler Centre for Consciousness Science at the University of Sussex in Brighton, England. "I thought, there's something right about all this."

So far, the new equations exist only as prototypes, like model airplanes that can't fly but still help clarify how jumbo jets stay aloft. But researchers believe that these prototypes may one day lead to a tool that can measure consciousness, even when signs of it are ambiguous. Already, researchers are testing the math that would underpin such a tool in human brains as people lose awareness.

Tononi's idea, though, extends beyond humans. By moving from nerve cells to the math that describes them, he has untethered the theory of consciousness from the physical brain. Like amorphous Silly Putty, the equations can be molded to fit any system. With the right calculations, scientists could test whether a tornado with its innumerable dust particles circling in unison, 2050's iPhone or the trillions of megabytes of information zooming around the Internet could have some degree of consciousness.

In the same way that a thermometer made plain the concept of temperature (for a boiling pot of water or a person's body), a consciousness yardstick could ultimately lead to a better understanding of the substance of consciousness itself.

Because Tononi's theory focuses on the very essence of awareness, neuroscientist Christof Koch believes that it is "the only true theory of consciousness."

Scientists have amassed an impressive list of the brain changes that occur when consciousness comes or goes, Koch says, but such a list can't provide a full explanation of the mysterious process from which conscious experience emerges. "Why is it in this area and not that area? What is it about this area, or this brain, or these neurons that give rise to conscious sensation?" says Koch, of Caltech and the Allen Institute for Brain Science in Seattle. What's needed is an answer to the all-important "why?" "The only theory that does that in a fundamental way is Tononi's."

All about integration

Tononi's theory defines consciousness as the capacity of a system — any system — to connect and use information. The idea rests on two simple observations: First, a single moment of human experience is one of the most information-heavy things in the universe, an observation so simple that it's often overlooked, Tononi says.

People usually talk about information as something gained: Infomercials entreat viewers to call for more information, criminal investors acquire insider information and spies gather clandestine information. But technically, information has more to do with what's lost. In its professional job description, it is a measure of how much uncertainty has been whittled away.

Before it's locked in, any single moment of existence could play out in a nearly limitless number of ways. But the instant an experience gels, the options vanish. Simply existing — getting out of bed on a Sunday morning, watching a touchdown during an afternoon football game or just staring off into space — rules out all alternatives.

Even the brain of a person in a chair in absolute darkness is an information gold mine. "When you see pure darkness, it's a particular scene that differs from trillions of other scenes in a particular way," Tononi says. "And therefore it becomes super meaningful."

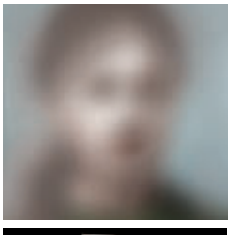
For tribes of specialized nerve cells in the human brain, no subtle distinction is too small: Groups of neurons form cottage industries that can tell cobalt from royal blue, remember your high school lab partner's name and assess whether the Giants receiver stepped out-of-bounds as he made his catch.

But it's not enough for a system to have vast stores of information stashed around the brain in isolation. Those diverse specialists must all talk to one another, the second principle of Tononi's theory. Integration is what makes every conscious experience a unified whole. "Every experience is what it is. You cannot break it into independent pieces," Tononi says. "You cannot experience the right side independent of the left side, the color without the shape."

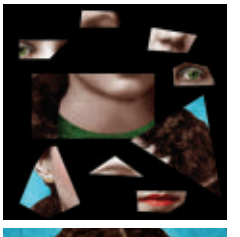
Together, these two concepts — information and integration — describe what consciousness actually feels like, Seth says. "The relevant brain mechanisms are somehow bound together, but somehow doing their own thing, so you get the richness of the experience," he says. A beehive's forager bees, nurse bees and queen all have specialized abilities and knowledge but are required to work together to make the hive buzz along. A similar thing may be going on in consciousness.

Tononi measures the combination of these two properties, information and integration, with a numerical value that he calls phi. This single number represents the information that exists above and beyond that stored by all the individual pieces of a system. For the human brain, with its vast constellations of

Two rules A newly proposed theory defines consciousness as a system's information content and capacity to connect that information.



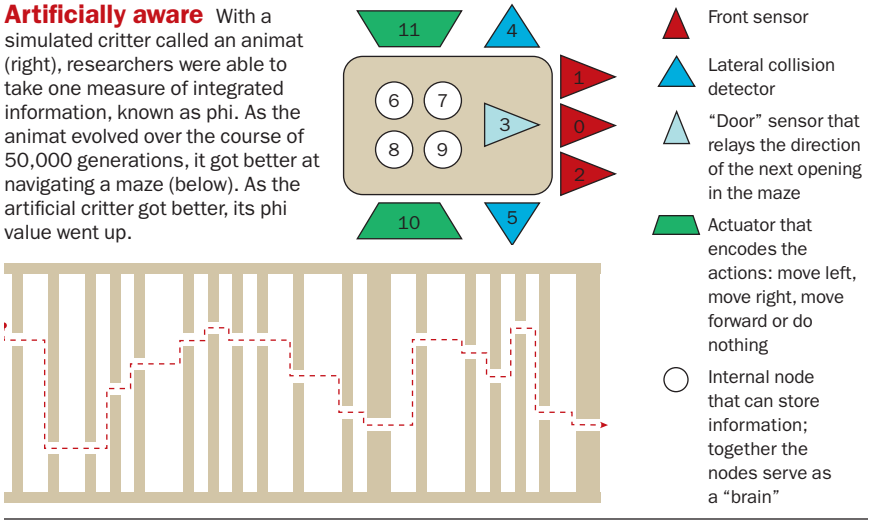
Low information Though recognizable as a face, this image is so information-poor that it could be your mother's, neighbor's or coworker's.



Low integration Here, the pieces — eyes, ears, lips — appear in rich detail. But they don't connect to generate something more.

High information and integration A fully formed face rendered in abundant detail with its pieces connected represents high information and integration.

MICHAEL MORGENSTERN, ADAPTED BY E. FELICIANO



Artificially aware With a simulated critter called an animat (right), researchers were able to take one measure of integrated information, known as phi. As the animat evolved over the course of 50,000 generations, it got better at navigating a maze (below). As the artificial critter got better, its phi value went up.

nerve cell connections and huge repertoire of states, calculating an exact phi is impossible; you'd have to add up all the useful data that's free to flow among all the links in the system and subtract what's held by each subsystem alone.

But even without an exact value for phi, scientists can still get a rough idea of what integrated information — or its absence — would look like in the human brain.

Finding phi

If integration is crucial to consciousness, then altered connections in a person's brain should mean altered awareness. One of the brain's most well-traveled connections is the corpus callosum, an information superhighway made of 200 million fibers shuttling information between the two brain hemispheres. In some severe cases of epilepsy, surgeons cut this link in an attempt to stop seizure signals from moving across it.

Such split-brain patients were studied by Roger Sperry and Michael Gazzaniga at Caltech in the early 1960s. Gazzaniga and Sperry found that with a severed corpus callosum, people essentially had two conscious experiences — one for the left side of space and one for the right. Without this connector, for instance, a person can't easily name an object in the left side of space, because the right hemisphere, which identifies the object, can't tell the speech center in the left hemisphere what it sees.

"We know experimentally that there are two conscious minds in this one skull," Koch says. "One skull, two conscious minds."

But linking everything to everything else doesn't do the trick, either. When people are unconscious in the throes of a seizure, nerve cell behavior is extremely coordinated, like millions of soldiers marching in lockstep. The system is highly integrated, but it loses all diversity. Specialized coalitions of nerve cells, like those that distinguish shades of blue, are stripped of their roles. Instead of possessing richly varied information, the cells are either all on or all off.

So far, the best evidence for Tononi's theory comes from experiments he and others have performed on people in various states of consciousness, such as in a deep sleep, anesthetized or in a vegetative state. In awake people, a jolt of current delivered to one spot on the brain through a technique called transcranial magnetic stimulation, or TMS, moves around, traveling and morphing and shifting for about 300 milliseconds. Yet in people who are in states of diminished consciousness, this TMS signal peters out quickly. Tononi and his colleagues think this signal represents the brain's ability to integrate information, and they are working on ways to convert the signal into an estimate that might capture some scrap of a full-fledged phi.

Seth, of the Sackler Centre, is pursuing a different way of measuring integrated information in the complex interactions among brain cells. Instead of assessing consciousness as a static capacity at any given moment, his method treats consciousness as a property that changes continuously. "For me, consciousness is a process, the properties of a system's dynamics as it unfolds over time," he says.

Because Seth's measure, called causal density, relies on some starting assumptions and comes up with an average instead of an exact value at a single point in time, it is easier to calculate than phi.

In a study reported online in January in *PLoS ONE*, Seth's team managed to make some measure of causal density in human brains. Seven healthy volunteers lost consciousness after they were anesthetized with the drug propofol. Researchers monitored electrical signals in the brain in two particular brain regions known to change behavior as anesthesia takes hold, the anterior and posterior cingulate cortices.

Unexpectedly, when consciousness slipped away, causal density scores went up for these two regions. The local increases could be accompanied by an overall decrease of information integration, Seth says.

Animat insight

Though experiments probing the information structure of the human brain are still in their early stages, mathematical simulations have shown that integrated information can in fact be measured in other systems. Tononi and his colleagues devised a system so simple that its phi can be calculated — a simulated animal called an animat. Relying on sensors that detected the environment, actuators that allowed it to move and places to store data as it learned, this animat worked its way through a computer maze. The animat also possessed an ability that most living organisms take for granted: It could gradually evolve over 50,000 generations of maze running.

At the start, the animat had a hard time navigating. But around generation 14,000, it got good. Along with this performance boost, the animat's phi, the amount of information successfully shuttled among

J.A. EDLUND *ET AL/PLOS COMPUTATIONAL BIOLOGY* 2011

its constituent parts, went up. Different bits learned to communicate. By generation 49,000, the animat whizzed through the maze with its high phi, Tononi and colleagues reported in October in *PLoS Computational Biology*.

The animat is a simple case. Even at its highest, its phi wouldn't compare to that of a person. But this link between high phi and performance might reflect a deeper truth about why consciousness has evolved. With integrated information, the little critter can figure out things about its environment and predict what's coming.

Predictive powers may be one of the prime reasons consciousness exists among humans. "If you see a table and a computer monitor in front of you, you know why it's there and what it means to you, but also what you can do with it and what might happen next," Tononi says. Each experience calls to mind loads of different associations, memories and thoughts. "All of this, of course, is part and parcel of why consciousness is adaptive, why it is evolutionarily something that makes a lot of sense. It allows us to understand the past and predict the future."

Consciousness expands

As the example of the animat suggests, integrated information may not be restricted to just objects in possession of a brain. Such a simple finding has a big implication: If Tononi is right, and integrated information actually is consciousness, then consciousness itself is no longer restricted to the inside of a head. As long as it has the right informational specs, any system, whether it's made of nerve cells, silicon chips or light beams, could possess consciousness.

Such a realization alters the consciousness conversation. In a world full of objects that can move information around quickly — an octopus's brain, a tree's root system, the Internet — the discussion of whether an entity is conscious may lose its meaning. Instead, the question becomes, "How conscious is it?" Small systems with just a few bits of information may have a tiny sliver of consciousness, while large systems such as human brains have a whopping helping.

Expanding the umbrella of consciousness to include systems that don't have brains, a view echoing that espoused by some ancient religions and more modern versions of panpsychism, is an uncomfortable stretch for many researchers. Seth, for one, believes the mathematical language of consciousness offers interesting descriptions but stops short of saying that integrated information is actually the thing itself. "The only systems that we know of in the universe that generate consciousness are biological," he says.

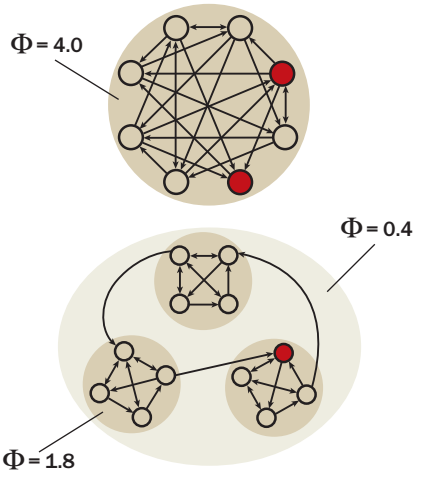
Others have more unorthodox ideas. Koch says he might be wrong, but he believes that consciousness, like an electron's charge, is something inherent in the fabric of reality that gives shape, structure and meaning to the world. "Consciousness is not an emergent feature of the universe," he says. "It's a fundamental property."

Whether consciousness is woven into the very nature of the cosmos is a grand question that, for now, remains unanswerable, Koch says. But that hasn't hindered real progress on other questions about the mind. Systematic studies and leaps of insight have revealed what's required of a conscious brain, traced a particular sight as it journeys into awareness and produced a crop of theories that hint at the true nature of consciousness.

"We make progress by looking where the light is bright," Koch says. "But ultimately, we have to look farther and deeper."

Guided by theoretical insights, scientists may someday escape the confusion that comes from being their own subjects, and see clearly into the minds of man. An understanding of what lies within the skull may then inspire scientists to shift their gazes outward, where an entirely new and mysterious world awaits. ■

Brain metric Simulations based on simplified neuroanatomy suggest that some brain systems generate a higher phi than others. At top is the corticothalamic system; at bottom is the cerebellar system (with phi shown for a subsystem and the whole network).



G. TONONI/BIOL. BULL. 2008

Consciousness, in theory

While a new theory of awareness relies on general mathematical principles, many existing ideas (some below) build on features of the human brain.

Global workspace First proposed by Bernard Baars of the Neurosciences Institute in La Jolla, Calif., this theory posits that consciousness emerges when information residing in a centrally accessible brain system is broadcast to other parts of the brain.

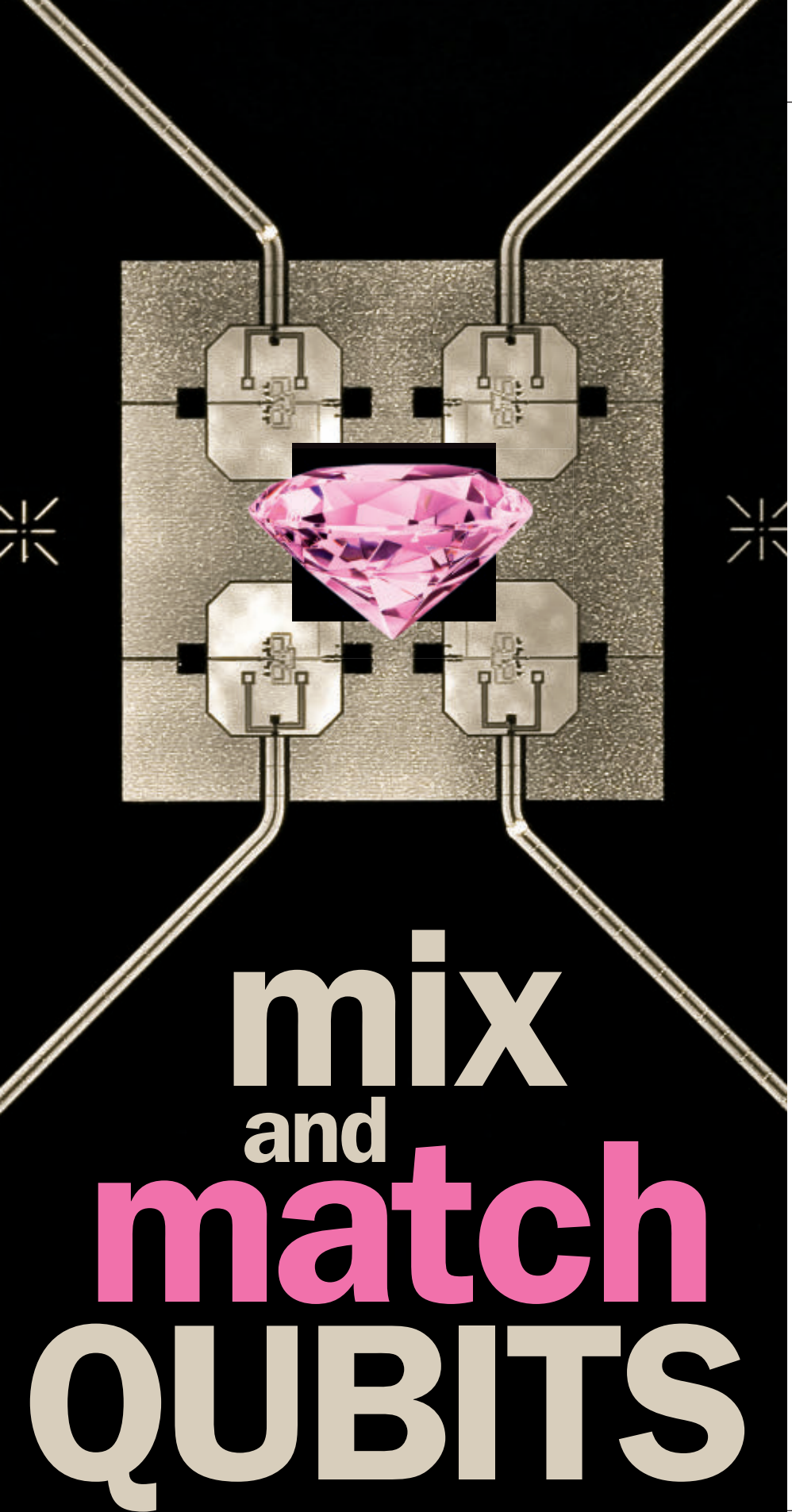
Neural Darwinism Large and diverse cohorts of nerve cells compete with each other, getting stronger or weaker in response to selective constraints, Nobel laureate Gerald Edelman first proposed in 1978. This flux generates consciousness as the mind becomes better able to respond to its environment.

Convergent/divergent zones Antonio Damasio of the University of Southern California suggests that brain regions that send and receive information help the mind form memories, emotions and other mental imagery. Damasio also thinks that consciousness requires a sense of self.

Intermediate level Proposed by Ray Jackendoff of Tufts University and championed by Jesse Prinz of the City University of New York, this theory says that data must be handled at intermediate brain levels in order to reach consciousness. Only info that's neither too specific nor too abstract reaches awareness.

Explore more

- For a list of Giulio Tononi's papers: tononi.psychiatry.wisc.edu/publications.html



mix and match QUBITS

Hybrid strategy may yield long-awaited quantum computers

By Devin Powell

Anybody can find out how to crack the codes protecting your bank transfers and online credit card purchases. The step-by-step instructions for stripping away the secrecy were published years ago.

Nobody is very worried about a possible security breach, though, because the code-cracking formula runs only on quantum computers. These contraptions, which exploit the rules governing the fuzzy world of quantum mechanics, have so far remained laboratory curiosities, less powerful than a slide rule.

New blueprints could change all that. Rival technologies that have steadily matured in recent years — but failed to produce powerful quantum computers on their own — are now being married. Physicists playing matchmaker hope to build hybrid devices greater than the sum of their parts, dynamic duos in the spirit of Batman and Robin.

"There's no clear map for the road ahead," says Jörg Wrachtrup, a physicist at the University of Stuttgart in Germany. "But some quantum processors will be a kind of hybrid system for sure."

Designs currently on the drawing board mimic the division of labor found in today's computers, where the hard drive is a magnetic material good for storing information and the processor is a silicon chip where information can be quickly manipulated. Quantum versions of these components would bring together objects of different sizes and personalities, from atoms to superconducting circuits to chips of diamond.

Early research has shown that these

By blending superconducting and diamond components, researchers may create a quantum computer that beats out any relying on a single approach.

CIRCUIT: ERIK LUCERO; DIAMOND: RYAN MCVAY/GETTY IMAGES

would-be components can communicate with one another. A hybrid approach that stitches them together might one day yield a powerful quantum computer, useful not just for breaking codes. Such a computer could also tackle other problems difficult or impossible for today's ordinary computing machines — from searching through piles of data faster than a conventional computer to simulating how molecules chemically react.

"We can't promise a functional computer in five years," says Klaus Mølmer, a quantum physicist at Aarhus University in Denmark. "But the very first experiments are promising."

A matter of size

Today's computers, whether PC or Mac, work with bits of information that are either a 0 or a 1. But quantum computing, an idea that can be traced to physicist Paul Benioff about three decades ago, works with the quantum analog of classical bits: qubits. Because of the weirdness of the quantum world, a qubit exists in what's called a superposition of states, being both 0 and 1 at the same time. Connect together a dozen qubits, and the group encodes all 4,096 possible combinations of 0s and 1s simultaneously. This uncanny teamwork allows calculations to be performed on many inputs at once. It's the secret to how a quantum computer could solve certain kinds of problems exceptionally rapidly.

Atoms, which live at the small scales governed by quantum laws, have long been a promising candidate for qubits, thanks to their proven ability to store quantum information. Trapped in an electric field, an isolated atom can adopt and maintain a split personality for minutes, an eternity in the quantum world.

But atoms are also shy. Forging the connections between atoms required to perform computations with qubits is technically challenging, especially as more atoms are added to the system. The world record for the most atomicqubits linked together stands at only 14, set last April by Thomas Monz and colleagues working with charged calcium atoms at the University of Innsbruck in Austria.

Instead of using atoms as qubits, some scientists have turned to bigger objects that are easier to work with: superconducting wires etched on circuit boards. In the late 1990s, these bits of metal disclosed a penchant for behaving just as strangely as atoms. When electrons zipping around a superconducting loop are forced to leap through an insulating barrier, unusual things happen. Current can flow in different directions simultaneously, or two different amounts of charge can exist at once.

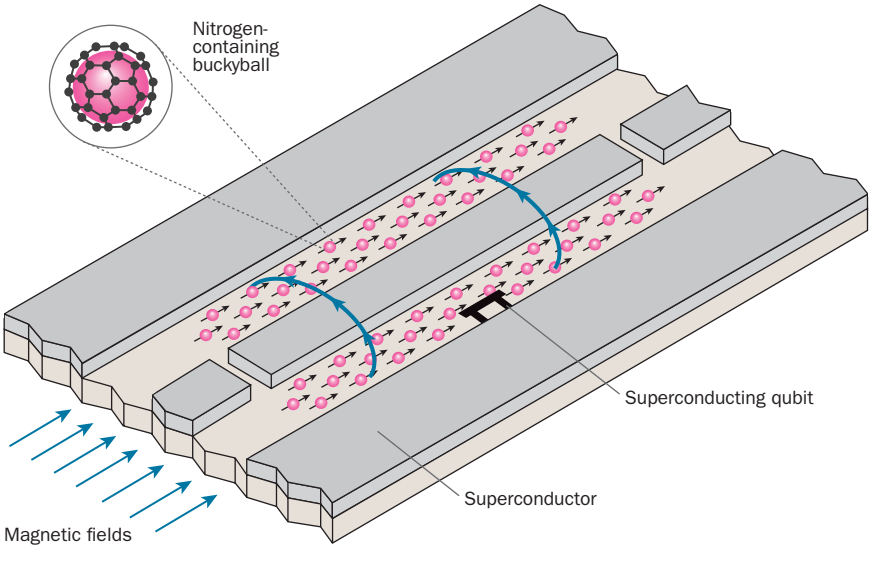
These circuit building blocks promise to be easier to link up than atoms. Techniques borrowed from the computer chip industry have been adapted to join loops of superconducting metal and manipulate the information they contain. In 2007 a team in the Netherlands showed how to quickly change the state of one superconducting qubit using a gate, a basic component required for making a computer processor.

"There's something very powerful about superconducting qubits," says John Martinis, a quantum physicist at the University of California, Santa Barbara. "They're large, so they can be easily wired together to make computer processors." A new superconducting processor with nine qubits ran a simple program that identified the prime factors of 15 (5 and 3), Martinis' team planned to report in February at a meeting of the American Physical Society.

Because of their gawkish size, though, superconducting wires have trouble maintaining their quantum weirdness. Contact with the environment, which destroys qubits, is more difficult to avoid than it is with atoms. The hardiest superconducting qubit ever made that could reliably repeat its performance was described in the Dec. 9 *Physical Review Letters*. It held onto a piece of information for a mere 20 microseconds.

Some scientists are trying to overcome the limitations of atoms or superconducting circuits, relying on just one technique to store and manipulate information in a quantum computer. But other researchers think that combining these two approaches could exploit the strengths of each. A hybrid could have an atomic hard drive, a memory for storing information. As necessary, that information could be dumped into a CPU made of superconducting qubits wired together to perform calculations. The results of these calculations could then be dumped back into the hard drive.

Dual scheme In this proposed quantum computer, nitrogen atoms (pink) within buckyballs serve as memory storage, and a superconductor does the processing (qubit in black). Magnetic fields align the spins of the atoms' electrons and allow the components to communicate.



J.H. WESENBERG *ET AL/PHYSICAL REVIEW LETTERS* 2009

Come together

Several variations on the hybrid anatomy have been proposed. One early scheme, described in 2004 in *Physical Review Letters*, would link individual atoms to superconducting qubits. Another plan, detailed in the same journal in 2006, would move information between superconducting circuits and clouds of molecules that serve as a collective memory.

"We're trying to come up with ideas where you combine the advantages of different systems but not the disadvantages," says Peter Zoller, a theoretical physicist at the University of Innsbruck.

One team is trying to build a hybrid device at the Joint Quantum Institute at the University of Maryland in College Park. Researchers there have coated tiny fibers with rubidium atoms. These atoms, long used to keep time in some of the world's most precise clocks, can store quantum information in their vibrations. In theory, magnetic fields generated by a nearby superconducting wire could serve as a communication channel, so information could be passed to superconducting qubits.

Getting this scheme to work is tricky because of how carefully the atoms have to be held in place. So other groups hope to make hard drives out of atoms that come prewrapped in nice neat diamond packages.

Diamond is a relative newcomer to the quantum community. In 2008, researchers showed how a type of impurity that turns a synthetic diamond pink could be controlled the way qubits made from isolated atoms are (*SN: 4/5/08, p. 216*). The diamond defect occurs when a nitrogen atom takes the place of a carbon atom in the crystal structure and is flanked by a hole where another carbon atom is missing.

> "We're trying to come up with ideas where you combine the advantages of different systems but not the disadvantages."
> PETER ZOLLER

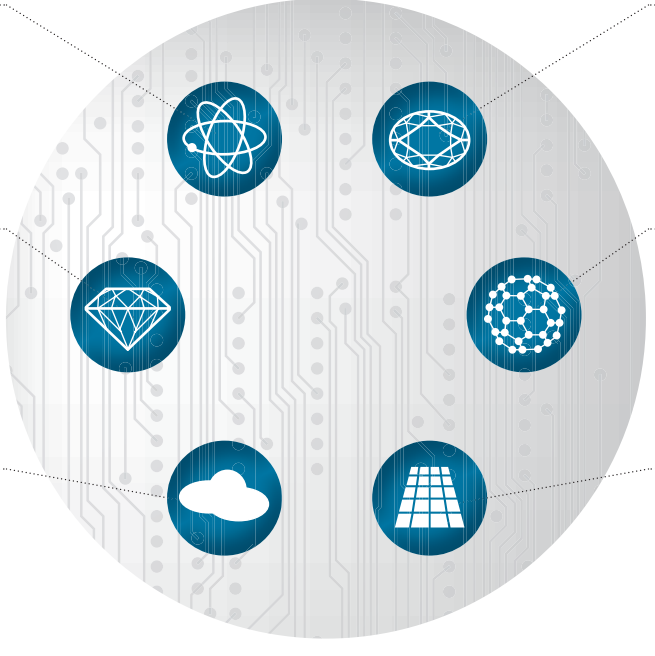
In this situation, a pair of the nitrogen's electrons splay out into the hole and behave as one. The single entity created has a quantum property called spin, which can be thought of as a tiny bar magnet that can point either up or down. But unlike a real magnet, quantum spin can also point up and down at the same time.

Shielded from the hostile world in a diamond womb, the electron duo should be able to preserve its spin for more than a millisecond at room temperature, and even longer when chilled. (This quantum state can also be moved into an atom's nucleus, where its longevity would rival that of the traditional atomic approach.)

"Once you transfer information into a diamond, it lives a really long time," says Anders Sørensen of the University of Copenhagen's Niels Bohr Institute. In 2010 Sørensen and colleagues first proposed a match between diamonds and superconducting circuits.

Arranging this marriage turned out to be surprisingly easy. At NTT Basic Research Laboratories in Atsugi, Japan, Xiaobo Zhu and colleagues simply glued a diamond chip to a circuit board. In this Frankensteinian apparatus, magnetic fields generated by the superconducting qubit changed the spins of the electron duos within the diamond. On October 13, the same day this information swap

Qubit dating game Most current proposals for hybrid quantum computers rely on superconducting circuits to do the information processing. But what material would make the most reliable storage partner is far from clear. Teams around the world are investigating a number of options (some highlighted below) in search of the perfect match; ultimately, the best duo might depend on the problem that is being tackled.



Atoms have many times demonstrated their ability to store quantum information. An isolated atom can maintain its split personality for minutes, but atoms can also be difficult to work with.

Diamonds sometimes contain defects that cause a pair of electrons to splay out and act as a single entity with a quantum property called spin. The electron duo can maintain its identity for more than a millisecond at room temperature.

Clouds of molecules could serve as a collective quantum memory. A 2006 article proposed that clouds of cold polar molecules would have a long lifetime and could be strongly coupled to a superconducting circuit.

Rubies owe their traces of color to chromium impurities. Scientists think they can take advantage of these impurities, just like the impurities in diamonds, to store quantum information.

Buckyballs that contain nitrogen atoms might serve as the memory in a hybrid quantum device. Techniques for controlling the spins of large numbers of encaged atoms' electrons are well-established, offering the potential for scaling up.

Semiconductor chips may offer a practical partner for superconducting circuits. Defects found in silicon carbide chips, used in today's electronics, would serve as the quantum memory.

SUPERCONDUCTOR BACKGROUND: MAGENTA10/SHUTTERSTOCK; ATOM, SEMICONDUCTOR AND CLOUD: T. DUBÉ; RUBY: LASCHON
ROBERT PAUL/SHUTTERSTOCK; BUCKYBALL: OKSANCIA/ISTOCKPHOTO; DIAMOND: ROZALIYA/SHUTTERSTOCK

was reported in *Nature*, a group led by researchers in France announced a similar feat.

"This is the beginning of the field, but we've proven that this is a possible task," says Patrice Bertet, a quantum physicist at the French laboratory CEA Saclay.

Bertet and his colleagues' would-be diamond hard drive, reported online at arXiv.org, isn't very useful right now. One diamond chip stores only a single bit of information, and for just a couple hundred nanoseconds. What's more, only about one in seven attempts to swap information succeeded. Though the Japanese team didn't fare any better, both experiments show that hybrids may turn out to be more than just an idea on a physicist's wish list.

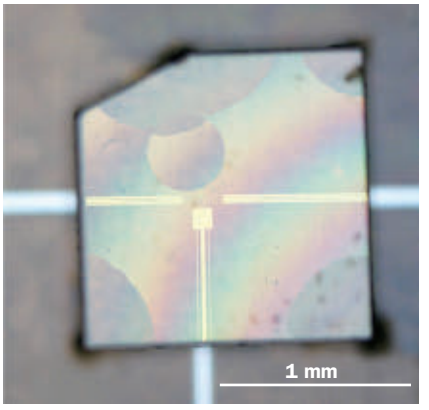
Hidden gems

For all their sparkle, diamonds aren't the only way to bling out a superconducting circuit with prewrapped qubits. Rubies contain interesting chromium impurities with spins that could be the Juliet to the Romeo that is superconducting circuits. One group of researchers wants to use nitrogen atoms caged within buckyballs — carbon spheres that resemble geodesic domes. Another is playing with rare earth atoms that could be useful for storing information.

One set of blueprints calls for exotic entities whose existence hasn't even been confirmed yet. Last spring, a team led by theoretical physicist John Preskill of Caltech extolled the benefits of tucking information inside "anyons." These two-dimensional particles are thought to inhabit the surfaces of bizarre materials known as topological insulators, which behave in strange ways when it comes to conducting electricity. In theory, an anyon would have to be disturbed at two points at once to lose its information, offering the ultimate in reliable storage.

"There are other materials that seem to have the interesting quantum properties found in diamond," says David Awschalom, a physicist at the University of California, Santa Barbara.

Awschalom has taken a pragmatic approach to quantum hard drives. He's testing materials that engineers already know how to work with — mundane silicon semiconductors that star in today's electronics. A semiconductor-superconductor hybrid would be a decidedly practical match.



This hybrid device, created when a Japanese team glued a diamond chip (shown) to a superconducting circuit (hidden below), was able to pass information between its two parts.

Silicon carbide, used in high-power transistors and other equipment, seems to have the right stuff for storing quantum information. Like diamond, the material is dotted with defects. Reporting in the Nov. 3 *Nature*, Awschalom's team controlled the spins of electrons in these defects. Computer simulations done by the researchers have revealed more than a dozen other promising materials, including magnesium oxide, zinc oxide and aluminum oxide.

Hybrid horizon

Hybrids with hardware made of semiconductors or diamond would offer an added bonus: They would have a built-in modem that could allow future quantum computers to broadcast the information they store. Physicists are keen to eventually construct a quantum network spanning great distances.

"You might like to make a quantum Internet some day," says Yale's Robert Schoelkopf, a quantum physicist and superconducting qubit pioneer.

Superconducting circuits can't talk to the particles of light that carry information on fiber-optic cables. But electrons in diamonds and silicon carbide can, while still being relatively easy to work with. Modems made from these materials could extend the reach of quantum information from different spots on the same superconducting chip to different places on the globe.

Ultimately, the anatomy of future quantum computers — whether they are based on one material or many, and which ones — may depend on how many qubits the device needs, which in turn depends on what problem it is intended to tackle.

A small quantum computer with dozens of qubits, for instance, could potentially solve some outstanding mysteries in science. It could probably simulate materials that are too complicated to be understood with today's computers — revealing how high-temperature superconductors work, for instance.

It's not unreasonable to think that a quantum computer based on a single kind of qubit could accomplish this and similar tasks. Atomic qubits have successfully simulated run-of-the-mill magnets that can already be understood using classical computers. And the quantum lifetimes of superconducting qubits, while still lousy, have steadily improved to the point that some people have proposed using them for simulations as well.

"We're close to doing some quantum simulations that we could never do classically," says physicist Chris Monroe, who works with atom qubits at the Joint Quantum Institute. "That' going to happen pretty soon, I think."

But other applications, such as code breaking, will certainly require devices much bigger and more powerful, with a million or more qubits — though no one knows the exact number for sure.

What a device that complex will end up looking like, and how many approaches get mixed and matched to make it, is still anyone's guess. ■

Explore more

- For more about the spooky physics behind quantum computers, check out *Science News*' special quantum issue: www.sciencenews.org/quantum

X. ZHU *ET AL*/*NATURE* 2011

Consciousness: Confessions of a Romantic Reductionist

Christof Koch

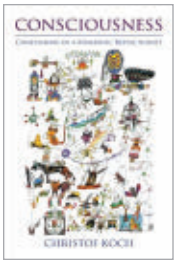
There's a famous quip circulated among writers: The craft is easy. You just sit down at your desk and open a vein. In his latest book, Koch does one better. He pries off his skull, splits open his brain and invites the reader in.

What's inside is fascinating. Through scenes from his life as a wandering child, an ambitious young researcher and an erudite professor, Koch describes his compulsion to discover the roots of consciousness.

The book is a testament to the power of the subjective. Koch lays bare his most profound losses, confronts his mortality and describes his wildest ideas all in the confessional style of St. Augustine.

One of his chief confessions: At heart, Koch is a romantic who sees a world brimming with meaning. This deeply philosophical view anchors the book, which includes quotes from Haruki Murakami, Oscar Wilde and Dante.

Also near Koch's heart, though, is the seemingly contrary scientific desire to untangle the incredibly complex questions of consciousness — what it is, who has it and why. In his wide-ranging discussion of the latest brain science, Koch points out examples of experiments that provide some clues. His crisp descriptions of science capture the essence without a trace of puffed-up jargon.



Along the way, Koch discusses free will (which he calls a "scholarly minefield" before charging straight in); animal consciousness (he no longer eats mammals or birds); and how religion fits into his view of the universe (he has gradually lost his Catholic faith).

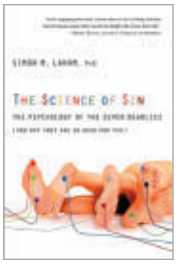
Koch weaves a vivid and poignant story, punctuated by fascinating characters and compelling science. The book will leave you with a small piece of Koch's own consciousness, plucked from his head and delivered into yours. *— Laura Sanders*

MIT Press, 2012, 184 p., $24.95

The Science of Sin

Simon M. Laham

Contrary to popular belief, experiencing anger may make a person more optimistic and more likely to change long-held opinions. Swelling with pride can increase agreeability, while growing lusty could make a person more attentive, more creative and even more charitable, suggests Laham in this promising debut.

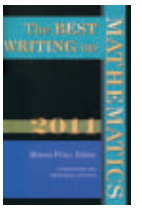


With a provocative wit (in the first chapter he encourages readers to grab a bra so that they can experience a study firsthand), Laham, an experimental psychologist, reveals how indulging in the seven deadly sins can be advantageous. After briefly explaining the history of the deadlies — Pope Gregory the Great, elaborating on the work of monks, popularized them in the sixth century — Laham explores recent research into the "fascinating complexity" of lust, gluttony, greed, sloth, anger, envy and pride and their effects on the human psyche.

In his chapter on envy, Laham describes an experiment in which participants, some of whom read a brief description of an extremely successful peer, were asked to imagine novel uses for a brick. "The envious, upwardly comparing participants were more creative, thinking of more things to do with a brick than the controls," he writes. Laham's favorite use for the brick: as a mock coffin at a Barbie funeral.

As he discusses psychological studies, Laham provides expert analysis without bombarding readers with technical terms. It's a fun, rapid read, but also a probing look at an engrossing field of scientific inquiry. *— Nick Bascom*

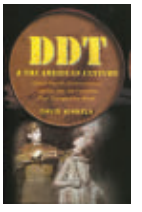
Three Rivers Press, 2012, 224 p., $14



The Best Writing on Mathematics 2011

Mircea Pitici, ed.

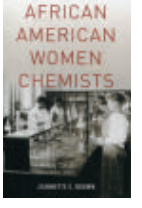
This anthology offers an overview of stories written for a popular audience about the mysteries and everyday uses of math. *Princeton Univ., 2012, 414 p., $19.95*



DDT and the American Century

David Kinkela

Science and politics collide in this history of one of the world's most controversial pesticides. *Univ. of North Carolina, 2011, 272 p., $39.95*



African American Women Chemists

Jeannette Brown

A chemist sketches the lives of women who broke racial boundaries, including Marie Maynard Daly, the first black woman to receive a Ph.D. in chemistry in 1947. *Oxford Univ., 2012, 272 p., $35*

Riddle of the Feathered Dragons

Alan Feduccia

An evolutionary biologist reviews fossil evidence for bird and dinosaur evolution and contests the view that birds are the last living dinosaurs. *Yale Univ., 2012, 358 p., $55*

Eradication

Nancy Leys Stepan

Attempts to wipe out diseases such as malaria come with a cost, this history of eradication campaigns shows. *Cornell Univ., 2011, 309 p., $39.95*

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Sinking heavy ice

The picture in "From the Archive" ("Self-experimenter didn't suffer," *SN: 1/28/12, p. 32*) shows heavy water ice sinking in a glass of water while alongside, light water ice floats. What is not clear is what kind of water is in the glasses. If heavy water ice were in a glass of heavy water, would it also float?
Robert Chester, Tumwater, Wash.

The picture shows a heavy water ice cube sinking in normal water. Like normal water, heavy water expands when it freezes, becoming less dense. An ice cube made of heavy water will thus float in heavy water. Christoph Salzmann of University College London offers an illustrative experiment: Fill a glass halfway with heavy water and halfway with normal water. Then drop in a heavy water ice cube. The cube will sink until it reaches the dividing line between the normal and heavy waters, at which point it will float midglass. —Elizabeth Quill

Studies of light are ancient

The survey of advances in reflective light and camera innovations ("The digital camera revolution," *SN: 1/28/12, p. 22*) recalls the 1964 book *Byzantine Aesthetics* by Gervase Mathew. The subject matter of religious symbols was important, but so was the technique of setting the colorful tiles. It might be good to take another look at Byzantine art and the Neoplatonism of Plotinus (who died about A.D. 270) and the bridge between Plato's shadows and the coming theories of light, especially sunlight.
Cynthia Shepard, Foster City, Calif.

Aura experiences vary

I have never experienced a migraine headache ("Head agony," *SN: 1/28/12, p. 26*) but regularly experience auras like those in the story. The auras come with stress and are quite beautiful, looking much like the opening scene from the old television show *Bonanza* where the flame starts at one point and then spreads outward on the map. No doubt in times past, people may have thought they were being visited by an angel or having a supernatural experience.
Joe Kostka, Natrona Heights, Pa.

Memory falters under pressure

The inability to recall what happened during a feat that requires great concentration doesn't apply only to athletes ("Brainy ballplayers," *SN: 1/14/12, p. 22*). As a U.S. Foreign Service officer in the 1980s, I served as notetaker during high-pressure, high-level meetings between the United States and Soviet Union. Right after meetings, anxious colleagues would ask what happened. "I don't know," I would reply. "I'll have to read my notes." My thanks to *Science News* for explaining why that happened.
Bruce G. Burton, Fairfax Station, Va.

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

Marketplace

From the Archive

For the full 1986 article, visit
www.sciencenews.org/archive_asbestos

EPA moves to phase out asbestos goods

The Environmental Protection Agency (EPA) last week proposed banning five widely used asbestos products, then phasing out over 10 years all mining, importation and remaining uses for the mineral. A known human carcinogen, asbestos is capable of causing lung cancer and mesothelioma (a cancer of the chest and abdominal lining). In announcing the proposal, EPA Administrator Lee M. Thomas said that enacting the law could ultimately prevent about 1,900 U.S. asbestos-related cancer deaths.

EPA only began investigating the hazards posed by some of the now-to-be-banned products after French researchers in 1982 pointed out that asbestos-impregnated floor tiles could, through normal wear, release "important" concentrations of the mineral into the air (SN: 7/10/82, p. 22). In addition to vinyl-asbestos floor tile, the new proposal would immediately ban asbestos-containing roofing felts, flooring felts and felt-backed sheet flooring, cement pipe and fittings, and clothing. These products account for an estimated 40 percent of the U.S. asbestos market.

The remaining products would have to be labeled as containing asbestos. EPA is also considering several alternatives for such products. One would ban all construction and clothing uses now, all friction (brake) products within five years and everything else within 10 years.

At issue is how quickly substitutes can be found for those products — such as asbestos brake linings — not immediately banned. — *J. Raloff*

Science Service once distributed samples of asbestos-laden towels through its "Things of Science" program.

DISH TOWELS: ANTHONY RICH; PAPER: PAPHIA/ISTOCKPHOTO

UPDATE

Asbestos troubles not gone yet

A science-history buff could easily fill a year's worth of From the Archive updates with stories of super materials and wonder drugs whose reputations went rotten following further scientific scrutiny. Asbestos deserves special note because of how long its effects will linger.

By the middle of the last century, this "magic mineral" had made its way into cars, boats, buildings and even ironing boards and dish towels (*SN: 9/25/48, p. 204*). Though scientists had known since the 1920s that asbestos dust is dangerous to factory workers, it wasn't until the '60s that the link to cancer was clearly established.

The U.S. Occupational Safety and Health Administration instituted federal guidelines limiting workplace asbestos exposure in 1971. In 1989, the Environmental Protection Agency formally announced the ban or phase-out of most asbestos products, though much of the plan was declared legally void by the Fifth Circuit Court of Appeals two years later.

Today, asbestos is still found in fire doors, roofing materials and vinyl floor tile. And it remains in the lungs of many who inhaled it, taking up to half a century to deliver its damage. A 2009 report found that deaths from malignant mesothelioma, of which asbestos exposure is the primary cause, are not yet falling in the United States. Globally, the problem may be more serious: A recent study reports that asbestos-related deaths are likely to surge in Asia in the coming decades. — *Elizabeth Quill*

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How I Doubled My Romantic IQ

Take home this stunning 4-carat combination and you too can master the technique passed down by the legendary Professor of Love

You can be a genius. It's easier than you think. Just listen to Ovid. The works of Ancient Rome's most celebrated love poet are full of sage advice that hasn't aged a day. And it works immediately. Want to double your "romantic IQ" right now? All you need are these stunning ***Matrimony Marquise Rings*** and Ovid's all-powerful magic word.

What to say and when to say it. More than 2000 years ago, Ovid declared himself the "Professor of Love." All of Rome was his classroom. His lesson couldn't be simpler. Show up with a gift in hand and say... "Surprise!" That's it, the magic word. **Surprise**. According to Ovid, *"A man who can say that has genius."* Easy, right? But what happens when you say it twice?

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Cut (58 facets)	Brilliant	**Brilliant**
Color	"D" Colorless	**"D" Colorless**
Clarity	"IF"	**Clear**
Dispersion/Fire	0.044	**0.066**
4 ctw ring	$160,000+	**$149**

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Brilliance made simple. When it comes to raising my romantic IQ, I'll admit that I have an unfair advantage. Owning a jewelry company is like having all the answers for the final exam. I can say the magic word whenever I want. It's easy for me to look like a genius. But thanks to science and Stauer, I can make it easy (and affordable) for you too. Call today and we'll make it even easier with $300 in Stauer Gift Coupons. That's $25 to use every month for 12 months, with **NO MINIMUM PURCHASE REQUIRED..ever**. Basically, we're paying you to shop Stauer.

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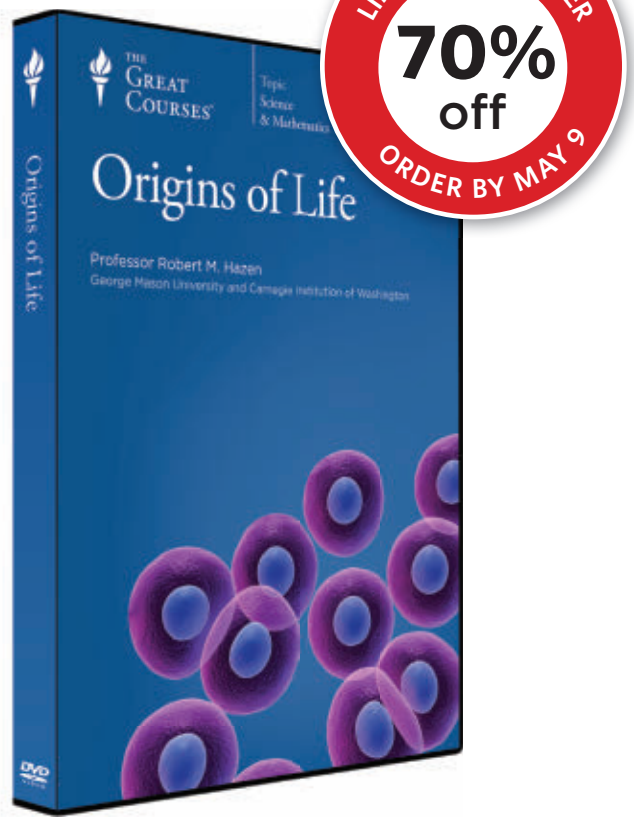

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