SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

APRIL 5, 2008 PAGES 209-224 VOL. 173, NO. 14

lab dish as guinea pig

baby planet pictures?

ADHD meds & substance abuse

botox, what nerve

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diamond in the spotlight

A BRIGHT PROSPECT FOR QUANTUM COMPUTING

THE WEEKLY NEWSMAGAZINE OF SCIENCE

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Cover Diamond's unique properties may make it a match for developers of tomorrow's quantum computers. Physicists are testing the crystal's ability to store information in single atoms, insulate information from outside disturbances, and transmit information as light rather than through electrical currents. (iStockphoto) Page 216

THIS WEEK ONLINE
http://blog.sciencenews.org/

MathTrek Mathematicians move a step closer to unraveling the mystery of primes.

SCIENCE NEWS is printed in the United States on process chlorinefree paper containing 90% recycled fiber with 30% postconsumer waste.

Science News (ISSN 0036-8423) is published weekly on Saturday, except the last week in December, for $54.50 for 1 year or $98.00 for 2 years (foreign postage is $18.00 additional per year) by Society for Science & the Public, 1719 N Street, N.W., Washington, DC 20036. Preferred periodicals postage paid at Washington, D.C., and an additional mailing office.

POSTMASTER Send address changes to **Science News**, P.O. Box 1205, Williamsport, PA 17703-1205. Two to four weeks' notice is required. Old and new addresses, including zip codes, must be provided.

EDITORIAL, BUSINESS, AND ADVERTISING OFFICES 1719 N St. N.W., Washington, D.C. 20036 202-785-2255; scinews@sciencenews.org.
LETTERS editors@sciencenews.org

SUBSCRIPTION DEPARTMENT P.O. Box 1205, Williamsport, PA 17703-1205. For new subscriptions and customer service, call 1-800-552-4412.

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Without Substance

ADHD meds don't up kids' drug abuse risk

Stimulants have long been prescribed to children diagnosed with attention-deficit hyperactivity disorder, or ADHD. Over the past decade, child psychiatrists have debated the long-term potential for these medications to trigger drug abuse. Two new studies indicate that the stimulants do not increase children's risk of abusing cocaine, nicotine, and other drugs as adults.

Although these findings come as a relief to child psychiatrists, not all the news is good. The new investigations, already published online and slated to appear in the May *American Journal of Psychiatry*, underscore earlier evidence that youngsters with ADHD frequently become drug abusers, whether or not they take prescribed stimulants.

"It is still critical that young people with ADHD be screened for substance abuse," says Nora D. Volkow, director of the National Institute on Drug Abuse in Bethesda, Md.

Boys with ADHD who start stimulant treatment early, at age 6 or 7, face a lower risk of later drug abuse than do those who begin taking medication later, between ages 8 and 12, report psychologist Salvatore Mannuzza of New York University's Child Study Center and his colleagues.

In the 17-year study, 27 percent of early-treated participants abused drugs by their mid-20s. That roughly equaled the drug abuse rate among young men who had never had any psychiatric ailments.

In contrast, 44 percent of late-treated boys became drug abusers by young adulthood, a rate comparable to earlier estimates for ADHD kids regardless of their treatment. Most of these late-treated children were diagnosed as grown-ups with another psychiatric ailment—antisocial personality disorder, a condition often accompanied by drug abuse. These volunteers likely became adult drug abusers because of this condition, not because of stimulant treatment as children, Mannuzza says.

Mannuzza's team studied 176 white, middle-class boys, ages 6 to 12, who were treated for ADHD with methylphenidate, often marketed as Ritalin. None of these youngsters displayed conduct disorder, regarded as a precursor of antisocial personality disorder.

Follow-up interviews with volunteers occurred at around ages 18 and 25. The researchers also tracked 178 psychiatrically healthy males from age 18 to 25.

Early stimulant treatment may protect kids with ADHD against conduct disorder, thus lowering later drug abuse rates, Mannuzza suggests.

Yet preliminary results from a large study of ADHD treatments, published in 2007, don't support that hypothesis, remarks psychologist James M. Swanson of the University of California, Irvine, a coauthor of the article. Over that study's first three years, early-treated children showed no decreased chance of acquiring conduct disorder, says Swanson.

The second new study, directed by psychiatrist Joseph Biederman of Massachusetts General Hospital in Boston, evaluated 112 boys with ADHD, ages 6 to 17, and then re-examined them 10 years later. Of those boys, 82 received stimulant treatment for all or part of the follow-up period.

In early adulthood, treated and untreated boys displayed comparable drug abuse rates, similar to those reported for late-treated boys by Mannuzza. But Biederman's group found no tendency for early stimulant treatment to protect against later drug abuse. —BRUCE BOWER

Caught in the Act?

Images may reveal planetary birth

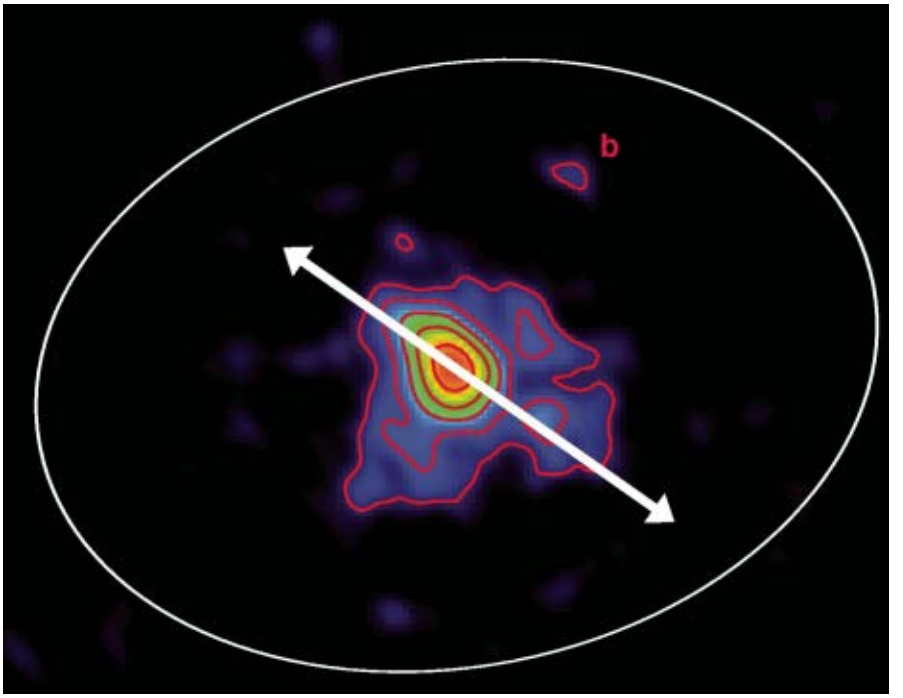
They might be planets.

Peering into disks of gas and dust that surround young stars, two teams of astronomers have for the first time imaged dusty clumps that could be planets in the making.

Material within the disks, ubiquitous around newborn stars, can coalesce into planets. It's uncertain whether the faint clumps seen in the new images are planets, heavier objects known as brown dwarfs, or just background objects that happen to lie in the same patch of sky.

The glare of starlight makes it difficult to study the faint light from disks. One team, led by Ben Oppenheimer of the American Museum of Natural History in New York City, used a U.S. Air Force telescope in Maui, Hawaii, to examine a disk surrounding the young star AB Aurigae, some 460 light-years from Earth. A telescope mask blocked the bright light from the parent star, and a polarizing filter further suppressed that light. Also, a mirror on the telescope rapidly flexed to remove the twinkling caused by Earth's turbulent atmosphere.

Infrared images show a gap in the disk, along with what appears to be a barely discernible point of light at the center of this hole. The researchers suggest that the point



VLA, PIE TOWN ANTENNA

PUTATIVE PLANET This false-color radio map shows the young star HL Tau, center, and the disk of gas and dust, enclosed by the white ellipse, surrounding it. Hot gas flows from the developing star in the direction of the white arrows. A candidate protoplanet marked "b" lies about twice the distance from its star as Neptune does from the sun.

represents a place where gas and dust has begun to gather into a small body—either a planet or a brown dwarf—and has cleared the area around it. "We may be witnessing such a process for the first time," the astronomers will report in the June 10 *Astrophysical Journal*.

The body lies about 2.5 times farther from the star than Pluto's average distance from the sun and is presumably the same age as AB Aurigae, a youthful 1 million to 3 million years old. It has a mass between 5 and 37 times that of Jupiter, Oppenheimer adds.

Another team, taking advantage of a rare chance to use the Very Large Array of radio telescopes near Socorro, N.M., in conjunction with another radio telescope 50 kilometers distant, examined the disk around the star HL Tau. The star, about 520 light-years from Earth, is only about 100,000 years old. Jane Greaves of the University of St Andrews in Scotland and her colleagues observed radio emissions that indicate the disk hosts pebble-sized rocks—a clue that some material has begun to coalesce into planets.

Greaves also spied an enormous clump of gas and dust "which is exactly how a very young protoplanet should look," she says. The clump has a diameter about five times the distance between Jupiter and the sun. "We are seeing [this object] at an incredibly early stage," Greaves says.

The candidate protoplanet is about 14 times Jupiter's mass and lies about twice as far from HL Tau as Neptune does from the sun, Greaves announced this week in Belfast at the Royal Astronomical Society National Astronomy Meeting.

Alan Boss of the Carnegie Institution of Washington (D.C.) says the two new discoveries are "equally exciting, equally promising, and equally dubious. The safest course of action right now is to call both of these clumps candidate protoplanets or candidate brown dwarfs."

Next year, Greaves' team plans to observe the protoplanet with an upgraded array of radio telescopes in the United Kingdom. —RON COWEN

Night Flights

Migrating moths may use a nighttime compass

It was a dark and windy night, but millions of moths migrating over Britain could still tell which way they were going.

Radar showed that silver Y moths heading south for winter selected winds sweeping them in the right general direction, says Jason Chapman of Rothamsted Research in Harpenden, England. Moths even seemed to adjust their flight direction to compensate for somewhat off-course winds, he and his colleagues report in the April 8 *Current Biology*.

"This is the first good evidence for some kind of compass in nocturnal migrating insects in the wild," Chapman says.

A Rothamsted engineer custom built radar systems to study insects flying between 150 and 1,200 meters overhead. The radar systems don't scan around like conventional ship radar but instead look straight up while moving slightly. The arrangement reveals extra details, explains Ian P. Woiwod, also of Rothamsted. This radar detects the rough size and height of an insect winging overhead plus the orientation of its long body axis.

Two of Rothamsted's radar systems run continuously, and from 2000 to 2003 they recorded 42 bursts of *Autographa gamma*, or silver Y, migration. The researchers didn't identify the species just from radar but used other methods, such as traps attached to balloons in the region.

In fall the moths fly south-southwest toward the Mediterranean. The year 2003 was a boom year for silver Ys, and some 200 million migrated across England. Chapman says entomologists aren't sure exactly where the moths go for the winter but their ultimate refuge probably lies somewhere in North Africa. When that region dries up months later, the silver Ys fly north again.

VOYAGER The migrating silver Y moth is named for the bright white squiggles on its wings.

After analyzing moths whisking over the radar, Chapman, Woiwod, and their colleagues contend that the silver Ys can manage sophisticated orientation. On fall nights, the winds at migration-height can blow in any direction, but the moths flew only when winds blew roughly in the right direction.

On a given night, moths flew at the height with the fastest winds, according to detailed weather service extrapolations. And if the wind blew more than 20 degrees away from south-southwest, the moths oriented their bodies in a direction that compensated, the researchers report.

The moths can't see the sun, and they probably aren't finding direction by the moon since it was still below the horizon during some of the migration flights, says Chapman. He doesn't expect moth vision to resolve stars well enough for navigation, so he speculates that they have a magnetic sense. Nocturnally migrating birds do, but "there's not any really good evidence for free-flying nocturnal insects," he says.

Robert Dudley of the University of California, Berkeley remains skeptical. He says he would like to see the researchers measure wind speeds on-site instead of relying on the weather service models. —SUSAN MILIUS

Curbing Chemo

Fasting cushions drug's side effects in mice

A new study in mice suggests a connection between short-term starvation and the ability to tolerate chemotherapy.

Starving cancer-ridden mice for two days sent the animals' bodies into a "maintenance mode" that protected their healthy cells from a harsh chemo drug but left cancerous cells vulnerable.

Chemotherapy drugs kill healthy cells as well as cancerous ones, so targeting drugs more narrowly at tumors is a major goal of cancer research. The new study suggests a novel way to protect healthy cells from chemo, but translating the discovery into therapies for people might not be straightforward.

"If just skipping breakfast would make the chemotherapy easier to tolerate that would be great, but we have common clinical experience that tells us that this is not the case," comments Michael Pollak, a clinical oncologist and researcher at McGill University in Montreal. "We have lots of patients who have poor nutritional status because they're so sick but who still have poor responses to chemotherapy."

Because many cancer patients are already undernourished, further starvation could be risky and ill advised, Pollak says. "There are many questions that would have to be addressed before this could be considered for people." But he says understanding the molecular mechanisms that protect the mice's healthy cells could lead to drugs that directly trigger those mechanisms without the need for fasting.

A team of researchers led by Valter D. Longo of the University of Southern California in Los Angeles injected mice with human cancer cells and later starved one

WOIWOD

group of animals for 48 or 60 hours. The researchers then treated both groups of mice with abnormally high doses of etoposide, a common chemotherapy drug. Nearly all of the starved mice survived the initial dose, but about half of the non-starved mice died within a few days, the team reports online March 31 in *Proceedings of the National Academy of Sciences*.

"It seems that the healthy cells are much more protected" in the starved mice, says research team member Federica Madia, who is also at USC.

Scientists have known since the 1930s that many animals fed an austere diet of about one-third fewer calories live 30 to 50 percent longer. Starving animals every other day has produced similar results in some experiments. The theory goes that a scarcity of food activates ancient repair mechanisms in the animals' cells, diverting energy from growth and reproduction to help the animals hang on until lean times pass.

Many kinds of cancer cells ignore the signals to switch from growth to repair, so starvation affords them less protection, the researchers say.

"I have what I would call guarded enthusiasm," comments James M. Harper, who researches aging at the University of Michigan School of Medicine in Ann Arbor. "It's too early to really hang my hat on it, but there's a lot of exciting follow-up work to do." —PATRICK BARRY

Salty Old Cellulose

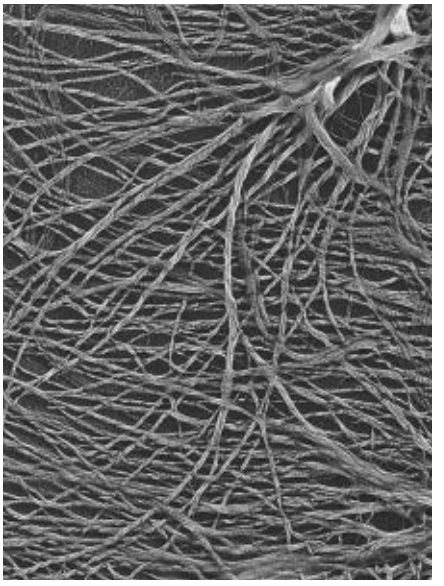
Tiny fibers found in ancient halite deposits

Researchers have unearthed the planet's oldest-known intact biological macromolecules, microscopic bits of cellulose from 253-million-year-old salt deposits in the southwestern United States.

The remarkable preservation of the material suggests that under the right conditions, cellulose could last more than 1 billion years. Such a long-lived molecule, a chain of simple sugars, might give scientists searching for past extraterrestrial life on other planets a new target.

Cellulose, best known as the tough material in trees, shrubs, and grasses, is one of the most abundant biological materials on Earth. Altogether, plants, algae, and some bacteria produce an estimated 100 billion metric tons of the stuff each year, says Jack D. Griffith, a biochemist at the University of North Carolina in Chapel Hill. He and his colleagues analyzed samples of salt mined about 650 meters below ground at a site some 50 kilometers east of Carlsbad, N.M. Previously, scientists have grown bacteria from ancient spores found in the same deposits (*SN: 6/12/99, p. 373*).

The newly discovered cellulose, like those bacterial spores, was recovered from brine-filled pockets, or inclusions, within large crystals of salt, says Griffith. Radioactive dating of the 600-meter–thick halite



ANCIENT ROPES This mat of small cellulose fibrils, each between 5 and 16 nanometers across, was extracted from 253-million-year-old salt deposits in New Mexico and includes the oldest intact biological macromolecules yet isolated and analyzed.

deposits, and of the sediments above and below them, indicates that the salty strata formed even before dinosaurs walked the Earth. The configuration of layers suggests that the salts crystallized on the floor of a shallow marine lagoon and haven't been disturbed since.

The researchers analyzed only material taken from inclusions in salt crystals that weren't cracked, thereby ensuring the contents of the inclusion hadn't washed in after the salt had formed. The team also dissolved material from the outer surface of the crystals to remove any modern contaminants that might have been introduced during excavation, says Griffith.

Most of the fibers found in the inclusions were small and flexible, Griffith and his colleagues report in the April *Astrobiology*. The bits didn't dissolve in a concentrated 65°C solution of sodium hydroxide and sodium borohydride, as all biological materials except cellulose would. Also, the material quickly dissolved when placed in a 37°C solution of cellulase, a cellulose-digesting enzyme.

"This is a beautiful discovery," says R. Malcolm Brown Jr., a molecular biologist at the University of Texas at Austin. "It's incontrovertible that this is cellulose." Further analyses of the microstructure of the fibers and mats found in the salt deposits may allow researchers to identify the organism that produced the cellulose, he adds. —SID PERKINS

Traveling Toxin

Botox may hitch a ride on nerve cells

Botox can make your face muscles stay put, but it may not stay put in your face. Evidence from experiments with rodents suggests that the neurotoxin can cruise along nerve cells and remain active beyond the injection site.

Understanding the mechanisms and pathways that toxins use is "of fundamental importance," comments Giampietro Schiavo, of Cancer Research UK in London, who studies a related toxin that causes tetanus and also travels in the body via nerve cells.

Botox is actually a trade name for one of several toxins that target nerve cells and are made by the rod-shaped bacterium *Clostridium botulinum*. While extremely poisonous in the wrong dose—the neurotoxins have been developed as biological weapons and cause the sometimes-lethal illness botulism—the toxins are also used therapeutically. And not just for erasing wrinkles. The toxins can help calm hyperactive muscles that accompany many disorders, including Parkinson's disease and multiple sclerosis.

The new findings "should not deter any physicians, nor should patients be discouraged," says J. Oliver Dolly, director of the International Centre for Neurotherapeutics at Dublin City University in Ireland, who adds that the toxin is important for treating many diseases. "From a basic science point of view, this has more relevance for studying the transport of proteins."

Botulinum toxins act by interfering with nerve-muscle communication. When a nerve cell wants a muscle to contract, the

BOTOX ON THE GO Known for their muscle-relaxing action, botulinum toxins are used therapeutically. But they are able to migrate from an injection site, probably via nerve cells.

GRIFFITH ET AL.; ISTOCKPHOTO

nerve sends the order via the chemical messenger known as acetylcholine. Botulinum toxins slice up proteins that are in charge of passing the acetylcholine message to muscle fibers. Since they never get the memo, the muscles relax and sit tight. The effects can last from days to months, depending on the toxin used.

In the new study, scientists tracked two botulinum toxins by looking for the sliced up proteins that the toxins leave in their wake. Led by Matteo Caleo of Italy's National Research Institute (CNR) in Pisa, the researchers injected a botulinum toxin into each rodent's superior colliculus, a part of the brain that deals with input from the eye. Three days later, sliced up protein appeared in the retina, suggesting that the toxin traveled and moved opposite the direction of nerve signals, the researchers report in the April 2 *Journal of Neuroscience*.

The team also injected botulinum toxins into the rodents' whisker pads and found evidence that the toxins had traveled to the part of the brain stem that controls muscles used for facial expression. When toxin was injected into one side of the hippocampus, it traveled to the other side, dampening the activity of nerves in both areas.

The depression of nerve activity in the untreated side of the hippocampus "was a real surprise," says Caleo, adding that clinicians have assumed that the toxins' action is localized and restricted. Because the cleaved protein always turned up in nerve populations directly connected to the injection site, the toxins likely travel within the nerve cell. —RACHEL EHRENBERG

Take a Breath

Fatty substance may play role in cystic fibrosis

Accumulation of a fatty compound called ceramide in the lungs could set the stage for the chronic lung infections of cystic fibrosis, a study in mice suggests. The finding offers a new twist on the still-unresolved course of this hereditary disease.

Patients with cystic fibrosis have a mutation in the *CFTR* gene. The protein normally encoded by this gene shuttles ions in and out of cells, ushering needed chemicals through the cell's membrane. But because cystic fibrosis patients' CFTR protein is missing or defective, the shuttling goes awry and sets off a process that leaves patients' lungs cluttered with mucus. The ultimate result is the respiratory failure characteristic of this disease.

Earlier studies had shown that a faulty or missing CFTR protein could make cells more alkaline. In the new study, physician Erich Gulbins of the University of Duisburg-Essen in Germany and his colleagues observed a rising pH over time in the cells of mice genetically engineered to lack a functional *CFTR* gene. The higher pH resulted in an enzyme imbalance that caused cells to overproduce ceramide.

Excess ceramide accumulation caused inflammation and cell death in the animals' lungs. When the scientists exposed the mice to a bacterium called *Pseudomonas aeruginosa* that commonly infects cystic fibrosis patients, mice lacking a functional CFTR protein proved significantly more susceptible to it than normal mice. But when the engineered mice received the drug amitriptyline, they fended off *P. aeruginosa* and survived longer than mice not getting the drug, the authors report in the April *Nature Medicine*.

Amitriptyline is an antidepressant that received regulatory approval in 1983. In these new tests it inhibited the enzyme that synthesizes ceramide, returning ceramide levels to near-normal. With ceramide under control, the mice were able to beat back *P. aeruginosa*.

STATS

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Average life span in years of people with cystic fibrosis

The mucus in the lungs of cystic fibrosis patients provides cover for infective agents such as *P. aeruginosa*, says Gerald Pier, an immunologist at Harvard Medical School and Brigham and Women's Hospital in Boston. His team has found that in healthy people, cells with normal CFTR bind to *P. aeruginosa* and dispatch the microbe routinely. But in cystic fibrosis patients, the bacterium dodges this binding and evades immune detection. The microbe lingers in the mucus and causes long-term infection, he says.

The German team tested cells obtained from cystic fibrosis patients' lungs and nasal cavities and found they contained four times as much ceramide as did similar cells taken from healthy individuals.

Ceramide "could play a significant role," says study coauthor Anna van Heeckeren, a veterinarian at Case Western Reserve University in Cleveland. "These are intriguing data and fascinating results, but I don't think it's the ultimate answer" to the cystic fibrosis puzzle, she says.

Pier agrees that the biological course of cystic fibrosis is far from clear. But the findings might lead to a clinical trial testing amitriptyline in cystic fibrosis patients, despite the drug's history of side effects that include dizziness, headache, dry mouth, and diarrhea. —NATHAN SEPPA

S. HADDOCK

Comb jellies take root in a new tree of animal life

Amorphous, gutless, and brainless, simple sponges were the first multicellular animals. That's what scientists have said for a century. Now a team of biologists suggests demoting sponges and placing comb jellies at the base of a new tree of animal life. These gelatinous marine predators, including *Aulacoctena acuminata* pictured here, have more cell types and organs than the sedentary and filter-feeding sponges. Casey Dunn doesn't think the new placement is preposterous, though other biologists might. "It's a problem when people think that evolution marches toward increased complexity," says Dunn, the project's lead researcher who is now at Brown University in Providence, R.I. The new tree, based on a comparison of 150 genes from a plethora of animals, is described in a report online and in an upcoming *Nature*. —AMY MAXMEN

The Operator's Manual for the Universe Is Called Classical Physics

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You know more physics than you think, says Professor Steven Pollock, an award-winning science educator who takes you step by step through the great ideas of classical physics. Dr. Pollock shows that landmark concepts such as Newton's laws of motion are intuitively understood by anyone who has ever ridden a bike, thrown a ball, or simply picked up an object and set it down.

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QUANTUM COCOON

Diamonds are a physicist's—and perhaps quantum computing's—best friend

BY DAVIDE CASTELVECCHI

Diamond is cool—even at room temperature. The stiff crystalline structure that makes diamond nature's hardest material can shield an atom from heat vibrations—not forever, but a lot longer than in other materials.

Physicists have now learned to use that ultimate cocoon quality to store and manipulate information in single atoms at room temperature—feats that in other materials require getting to the neighborhood of absolute zero. Because its atoms can store the notoriously peculiar quantum information, diamond has become a candidate material for use in future quantum computers. Such devices would rely on quantum weirdness to perform certain tasks that would take an ordinary computer till the end of time.

Diamond, specifically artificial diamond, could also find more imminent applications, such as communicating data with unbreakable encryption or even advancing the understanding of quantum theory itself. Powering these applications would require just tiny artificial-diamond chips along with inexpensive tools such as simple lasers.

"The beauty of diamond is that it brings all of this physics to a desktop," says David Awschalom of the University of California, Santa Barbara (UCSB).

Diamonds can be sharp cutters, but from the point of view of ordinary electronics, they are pretty dull, at least in their purest form. Diamond's crystal lattice of carbon atoms doesn't conduct electricity and has virtually no magnetism. There's no such thing as a 100 percent–pure crystal, though, and diamond's impurities are in fact Marilyn Monroe beauty marks that make it attractive for physics. "It's the dirt that gives rise to the unusual properties," Awschalom said during a recent talk in Boston at the annual meeting of the American Association for the Advancement of Science (AAAS).

Nitrogen is the most common impurity in diamond, where it can replace a carbon atom in the crystal. The most useful nitrogen impurities are those that happen to be next to a vacancy—a gap in the crystal where a carbon would otherwise be. Two of the nitrogen's electrons stretch their orbits into the vacancy and form a moleculelike structure, even though one of the molecule's atoms is missing. This virtual molecule, called a nitrogen-vacancy (NV) center, possesses spin, the quantum form of magnetism.

Spins are like microscopic bar magnets and can encode and store information by pointing in different directions. A single unit of information, called a bit, can be, say, a 1 if the spin points up or a 0 if it points down.

Spins can also be simultaneously up and down, and in such cases are said to be in special "quantum states." Quantum states contain quantum bits of information, or qubits. A quantum computer could perform calculations using the multiple states of qubits, which is essentially like doing several calculations at the same time. That might enable it, for example, to search databases or to find prime factors of whole numbers at speeds unattainable with ordinary computers.

But quantum states are notoriously delicate, and even a small disturbance can result in the complete loss of the information stored in a qubit. Researchers have so far managed to store and manipulate only a handful of qubits in superbly well-controlled systems, such as single ions suspended in an electromagnetic trap or superconducting materials cooled to very low temperatures. In a paper to be published in *Science*, Awschalom and his collaborators describe how they achieved a similar level of control over NV centers in diamond.

GREEN WITH NV In addition to having a spin, NV centers have a unique way of standing out in the limelight. They have a signature response to light, meaning that they will fluoresce with blue or green light when the rest of the material doesn't. Typically, they are also few and far between—spaced by micrometers—so that they can be spotted individually using an optical microscope and a sensitive light detector.

Jörg Wrachtrup, now at the University of Stuttgart in Germany, and his collaborators first imaged single NV centers in diamond in 1997. The researchers first tried at cold temperatures, where NV centers were supposedly easier to isolate. That didn't work. But when the researchers let temperatures go up, they were startled to see the NV centers' light begin to stand out from a noisy background of scattered light.

> "The beauty of diamond is that it brings all of this physics to a desktop."
>
> — DAVID AWSCHALOM, UNIVERSITY OF CALIFORNIA, SANTA BARBARA

In their recent experiments, Awschalom and his team explored for the first time the full extent to which they could manipulate the states of NV centers. The researchers zeroed in on a single NV center. They used a laser pulse to kick the NV center's electrons down to a known, lowest-energy state, readying it to record a qubit. They then tickled its spin gently using microwave radiation. The spin took different mathematical combinations of three simultaneous directions, thereby simultaneously encoding different information, explains Awschalom's colleague Adrian Feiguin, part of the Microsoft Corp. research team at UCSB. With a second laser pulse, the researchers also made the NV center fluoresce, so they could measure its state at different times, essentially reading out the information.

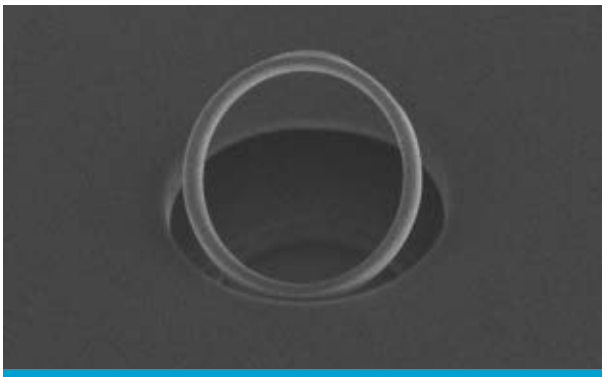
At the same time, the NV center also felt the presence of other spins nearby, just like several bar magnets will exert magnetic forces on each other when they're close together. The other impurities were mostly "dark" nitrogen atoms, meaning that they were not fluorescing because they were not paired with vacancies. In principle, all spins in a small region of a solid can influence one another, and the team needed to test how such a web of interactions would affect the information stored in their NV center qubit.

The team expected that in some cases the NV center would quickly lose its quantum weirdness, and go from its multiple states

to a well-defined single state, like any macroscopic object. What the researchers found was that the states of the spins surrounding the NV center in a sense determined the richness of the qubit. Tuning the spins with a magnet enabled the spin to encode more or less information. But in all cases, the qubit worked, keeping the information safe.

According to David DiVincenzo of IBM's T.J. Watson Research Center in Yorktown Heights, N.Y., Awschalom and colleagues "demonstrate a very high degree of control" over the quantum states of NV centers, comparable to what's been done with ion traps, the state of the art in quantum information.

But the experiment also has broader implications, says Mikhail Lukin of Harvard University. It shows that "diamond qubits can now be used as a test bed for probing fundamental physics." To physicists, interacting spins are almost an emblem of complexity. Simulations can predict how a few dozen spins will flip each other back and forth, and theories describe the statistical behavior of huge numbers of atoms in macroscopic chunks of a magnetic material. But experimentally, no one has been able to see what happens to a single iron atom in, say, the magnet inside a loudspeaker while music plays. Diamond provides a rare opportunity to see how a single spin interacts with its neighbors, Awschalom says.



RING CYCLE — At just 300 nanometers thick, this is the world's smallest diamond ring. Steven Prawer and his colleagues at the University of Melbourne in Australia are creating structures such as this one to guide light pulses inside future diamond-based computers.

B. FAIRCHILD AND P. OLIVERO/UNIV. OF MELBOURNE

THIS WON'T HURT A QUBIT Complete control over the states of a qubit is one step toward making diamond viable for quantum computing, physicists say. That path will be long, but encouraging steps have already been made.

Among the most significant was the realization that diamond can keep quantum states undisturbed at room temperature. For example, the spin states of NV centers can last up to a millisecond, Awschalom says, which in the quantum world is an eternity. In one millisecond, a quantum computer would be able to perform thousands of calculations, each involving multiple states at once.

Earlier this decade, a team led by Thomas Kennedy of the Naval Research Laboratory in Washington, D.C., was the first to manipulate a single NV center within diamond, alerting the quantum-computing community to diamond's potential.

In more recent years, teams led by Awschalom and Wrachtrup performed the first quantum logic operations between two diamond qubits. Logic operations—calculations on bits—are the building blocks of any information processing. In a typical logic operation, a bit can be flipped (from 0 to 1 or vice versa) if a second bit is set to 1, or be left alone if the second bit is set to 0. The two teams performed this simple operation on an NV center using a nearby nitrogen impurity as the second bit. More precisely, they did a more complex version of the operation, involving the quantum states of the two qubits. In the process, the two qubits became a single unit of information by taking up a shared quantum state, which physicists call an entangled state.

Last year, Lukin and his collaborators showed how a single NV center could essentially write information into the nuclei of nearby carbon atoms. While the most common isotope of carbon, carbon-12, has virtually no magnetism, about 1 percent of the carbon in nature is carbon-13. That isotope's extra neutron endows its nucleus with a spin. A carbon-13 atom's magnetism is much weaker than that of a nitrogen atom. But Lukin and his team used purified-diamond crystals that had low concentrations of nitrogen, so that the carbon-13 spins would stand out. That way, the researchers could use the NV centers to control the quantum states of several carbon-13 atoms at once, the quantum equivalent of storing information in ordinary RAM.

At a meeting of the American Physical Society in New Orleans in March, Lukin said that carbon-13 nuclei might keep information safe for much longer than even NV centers do, perhaps even for several seconds.

REMOTE ENTANGLEMENT Entangling a few qubits is a good step, but a practical quantum computer will need to have dozens or even hundreds of them. With diamond, no one has been able to do that yet; the current record for any type of entangled qubits is eight trapped ions.

A goal more nearly within reach is to entangle two diamond qubits at a distance. Remote entanglement is a crucial requirement for quantum networking, in which a sender and a receiver would share a secret encryption key using sequences of entangled qubits. Any eavesdropper trying to steal the key would destroy the entanglement, and that would let the two legitimate parties know that their communication channel was tapped.

Entangling two diamond qubits is easy in principle, says Lukin. When an NV center emits a photon by fluorescence, and that photon happens to hit another NV center, the two qubits will become entangled. Trouble is, fluorescence photons tend to fly off in random directions. The trick is to somehow guide the photon from one qubit to the other. Lukin, Awschalom, and others are trying various approaches, which they say should soon enable them to entangle pairs of NV centers.

Lukin's approach, described in the Nov. 15, 2007 *Nature*, is to turn the photon into a signal traveling on the surface of a metallic nanowire. That would be enough to entangle qubits within the same chip. Awschalom's team is working on a different technique, described in the Nov. 12, 2007 *Applied Physics Letters*, in which the qubit is kept inside a tiny cavity. Essentially a hall of mirrors, the cavity traps fluorescence photons of a specific wavelength. By exchanging these photons, two qubits inside the same cavity would then become the optical equivalent of strings vibrating in resonance. Or, an optical fiber could collect photons from the cavity and take them to another destination, possibly far away.

AS NANO AS IT GETS Meanwhile, other kinds of impurities will bring more options to the menu. Several labs, including Steven Prawer's at the University of Melbourne in Australia, are creating designer impurities by shooting atoms or molecules into diamond crystals one at a time. At the recent AAAS meeting, Prawer said that nickel-vacancy centers are especially promising for quantum satellite communication, since they fluoresce with infrared photons that can get through even a cloudy sky.

Atoms sit at the extreme edge of nanotechnology, being themselves much smaller than a nanometer. "That's about as nano as you're going to get," as Awschalom puts it. Computing will probably get to atomic scales eventually, but it's hard to predict in what form—be it diamond, ion traps, or other candidates. "It's dangerous to say which technology is more promising," Awschalom says.

Diamond's advantage is that it could do logic, storage, and communications on the same chip. But perhaps different technologies will find different applications, Awschalom says.

Kennedy, who has since switched to another candidate technology called quantum dots, agrees. "You have a healthy competition," he says. "And it's likely to remain that way for a while." ■

YOU, IN A DISH

Cultured human cells could put lab animals out of work for chemical and drug testing

BY PATRICK BARRY

At 8 o'clock on a March morning last year, doctors at Northwick Park Hospital in London began injecting six healthy men with an experimental arthritis drug. It was the drug's first safety trial in humans, and it had passed all the necessary tests on mice and monkeys with no indication of danger.

Once inside each man's bloodstream, the drug bound strongly to the "seek and destroy" cells of the immune system, the T cells. As a result, these attack cells became hyperactive and began leaving the blood vessels and entering tissues—something T cells normally do only at the site of an infection. The T cells proceeded to attack and kill healthy cells of vital organs such as the heart, liver, kidneys, and lungs.

Within an hour, the men were vomiting and writhing in excruciating pain as their immune systems began attacking their bodies from the inside out. All six nearly died, and they still suffer from lingering health impairments.

Clearly, the animal tests had missed something.

As invaluable as mice have been for medical research, differences do exist between human and mouse biology. Sometimes, these differences generate misleading test results. In the case above, for example, the drug bound to a receptor molecule on the human T cells more tightly than it did to the mouse version of that receptor. The drug also activated a kind of T cell that the lab mice lacked.

A better way to find out how a drug will affect human cells, some scientists say, is simply to test it on human cells. That's now becoming a practical option.

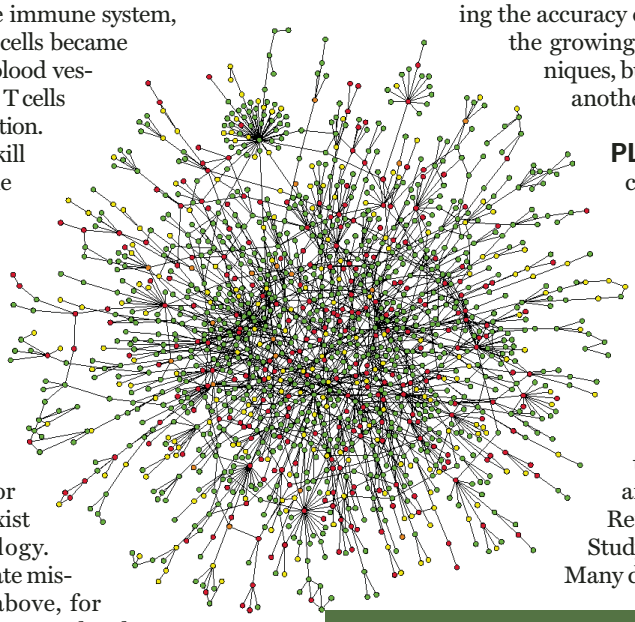
Over the past few years, scientists have developed sophisticated ways to screen drugs and other compounds on lab-grown cells from various human organs. Coupled with the burgeoning knowledge of cells' inner workings that comes from genomics, proteomics, and other "-omics," these screening techniques offer a way to test compounds on human biology long before they're tested on actual humans.

These screens could aid pharmaceutical development by identifying promising candidates and weeding out compounds earlier if they don't work in humans (even though they may work in mice). Many scientists think that in the wake of genomics, such screens are the next logical step.

"Everybody in the industry thinks this is the right way to go," says Aled M. Edwards of the Ontario Cancer Institute in Canada, who has no connections with companies offering such screening services. "I know that pharmaceutical companies are doing this."

And drug companies aren't the only ones. The Environmental Protection Agency and the National Institutes of Health are launching a joint program to test potentially toxic industrial chemicals on human cell cultures instead of on animals, the agencies announced in February during a meeting in Boston of the American Association for the Advancement of Science, as well as in the Feb. 15 *Science* (*SN: 2/23/08, p. 117*).

Sparing animals from serving as guinea pigs and improving the accuracy of test results are both reasons for the growing interest in these screening techniques, but the pharmaceutical industry has another reason as well. Money.



WEB OF LIFE — Networks showing the interactions among proteins help scientists understand how a drug affecting one protein will affect overall cell functioning. This protein network for brewer's yeast shows which proteins are critical for survival (red), which are important for growth but not critical to survival (orange), which can be removed without slowing growth or killing the cells (green), and which are of unknown importance (yellow).

HAWOONG JEONG/KOREA ADVANCED INSTITUTE OF SCIENCE AND TECHNOLOGY

PLAYING THE NUMBERS The cost of developing new drugs has been steadily increasing for decades, yet the number of new drugs that make it to market each year has remained essentially constant. As a result, the average development cost for each new, approved drug exceeds $800 million, by some estimates.

"Plenty of drugs are going into the pipeline—it's just that too many are dropping out," says Janice M. Reichert of the Tufts Center for the Study of Drug Development in Boston. Many drugs make it through the gauntlet of laboratory and animal tests successfully, only to fail during human trials. Some drugs simply prove to be ineffective in people; others turn out to be unsafe or to have unacceptable side effects.

Recruiting people to serve as subjects and running clinical trials can cost tens of millions of dollars. So when a drug fails near the end of trials, the financial loss can be enormous.

In a sense, this rising dropout rate is a consequence of the genetics revolution. In the 1970s, pharmaceutical companies adopted shotgun tactics for screening thousands of chemicals using high-throughput chemistry. The search focused on compounds that hit the same protein targets as did existing, proven drugs. Researchers

tested any matching compounds on animals in the hope that the drug was more effective and had fewer side effects than the old drug, often with great success.

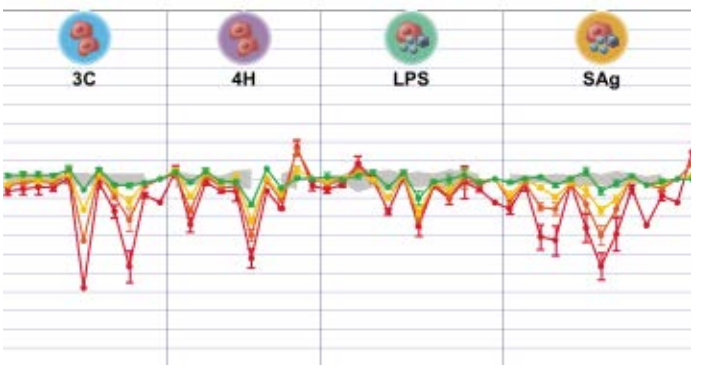
The rise of human genetics yielded a windfall of novel biological targets for treating diseases, and companies applied the same shotgun techniques to find drugs for these new targets. The effects of these drugs, however, were less predictable because no previous drugs bound to the same targets. Scientists relied on animal tests to show that a drug worked and to reveal dangerous side effects, but differences between animal and human biology meant that some effects of the new drugs were inevitably missed.

"What's going in the pipeline is perhaps less validated than in the past," Reichert says. "Not as much is known about them."

Tests on human cell cultures could help to fill that knowledge gap, many scientists believe.

The concept is straightforward: Grow cells from various human tissues in the lab, add a dose of the compound, and measure the resulting changes in the cells' activities.

Dosing and measuring are performed en masse by automated tabletop machines. These use standard laboratory techniques to monitor what happens to individual functions, such as insulin production, or to record changes in the amounts of proteins known to be good indicators of the cells' inner workings. Computers can immediately sift the resulting data and pop out a response profile for the compound.



PILL PROFILE — The effects of a candidate drug on four human cell cultures are apparent in this graph, which shows the drug's characteristic "fingerprint." Each dot represents the concentration of a telltale protein in the cells, and each colored line signifies a certain dose. Dots that fall outside of the normal range (gray) show a change in concentration of that protein. This profiles compound UO126, which inhibits an enzyme involved in stress and inflammatory responses.

Two innovations in recent years have made this approach possible. The first is the explosion of knowledge that resulted from the sequencing of the human genome. Trying to make sense of this torrent of data has spawned the field of systems biology, an attempt to put all the genetic pieces together and understand how the cell operates as a whole. Systems biologists produce complex maps of how genes and proteins interact, and these maps help scientists to analyze results from a drug screening.

The other advance is less sexy but perhaps more important—learning how to grow human cells in the lab so that they continue behaving like human cells.

"When you take the cells and put them in the dish, you lose all their specialized functions," says Mina J. Bissell of Lawrence Berkeley National Laboratory in Berkeley, Calif. That's because cells "talk" to each other by passing chemical signals back and forth. They also sense their physical surroundings through proteins on their surfaces called integrins. All these cues serve to orient the cells in the body and inform them about how to behave so that they cooperate with the rest of the cells in the tissue.

"The cells are not complete by themselves. They need signals from outside," Bissell says. "The unit of function literally is the tissue."

Pharmaceutical companies have tested compounds on human cells for decades, of course, but these tests have involved only simple cultures of one type of cell. Typically, the goal has been merely to check for blatant toxicity. Researchers expose the cells to a drug candidate and observe whether the cells continue growing or die.

Such tests are far simpler than these new screening techniques, which attempt to extract much more information from the cultured cells than just a live-or-die response. To do so, scientists must grow cells in conditions that mimic life inside the body. Often, that entails growing several different types of cells from a tissue in a single dish so that the cell types can "socialize." Researchers also add hundreds of special chemical factors that are normally present in the tissue milieu, such as signaling molecules called cytokines.

"It's been a slow process to refine techniques for growing cells so they retain their normal behavior," explains Ellen L. Berg, chief science officer and cofounder of BioSeek, a biotech startup in Burlingame, Calif., that tests compounds on cultured human cells. "There was really no one breakthrough. It has just taken a long time to learn how to grow human cells."

To confirm that cells in these more advanced cultures truly feel right at home, Berg and her colleagues checked whether the cultures responded to older drugs in the same ways that people's tissues do in the clinic, and whether those responses were repeatable.

Berg's team combined endothelial cells and white blood cells called leukocytes, and then added a carefully prepared recipe of signaling molecules. The researchers placed small samples, each containing about 1,000 to 10,000 cells, into tiny wells in laboratory plates. Each plate is only a few inches across and contains several hundred wells arranged in a grid. Automated machines then exposed these samples to a long list of well-studied drugs, including old standbys such as the anti-inflammatory ibuprofen. The resulting changes in key protein concentrations closely matched the responses of cells in people, the team reported in the January-February 2006 *Journal of Pharmacological and Toxicological Methods*. Repeating the screens produced similar results.

ENTER THE MATRIX For rapid, high-throughput techniques, time constraints often limit scientists to making flat, 2-D cell cultures such as those used by Berg's team. But some scientists are taking mimicry of real tissues a step further by growing cells in 3-D matrices.

Embedding cells in a medium that contains nutrients as well as a mesh of fibers such as collagen simulates the environment that surrounds cells when they're within a tissue. For some diseases, cues from that 3-D environment make a big difference.

For example, breast cancer cells grown in 3-D cultures develop resistance to chemotherapy drugs at a similar pace as they do in patients, Valerie M. Weaver of the University of California, San Francisco reported in Washington, D.C., at the December 2007 meeting of the American Society for Cell Biology (*SN: 12/15/07, p. 382*). Cancerous cells grown in conventional cultures become resistant to drugs more slowly, giving doctors a false sense of security, Weaver says.

But the 3-D environment isn't always essential, says Bissell, a pioneer of 3-D cell culture techniques. "What we find is that some drugs more or less behave similarly" in 2-D and 3-D cultures, "while some drugs behave very differently," she says.

Even with the most realistic cultures, tests on cells outside the body will always have some limitations, of course. "Nothing that's done pre-clinically will assure with 100 percent certainty what you'll see in a human being," Reichert says. "There are just too many unknowns."

And regardless of which kind of culture scientists use, they must somehow decide which indicators will best tell them how the cells are responding to the test compound. To choose which proteins to monitor—and to interpret the results—scientists draw from tra-

BIOSEEK

ditional clinical data on patients with the disease and from the relatively new discipline of systems biology.

If the Human Genome Project was a blockbuster movie, systems biology is the sequel.

REVENGE OF THE GENOME Once scientists had the human genome's enormous parts list of roughly 25,000 genes in hand, next came the daunting task of assembling all those pieces and trying to understand how they work together as a whole.

After all, it's the net effect of all those interacting parts that produces the behaviors of cells, organs, and people. These byzantine interactions vary in sickness and in health, from tissue to tissue, from cell to cell, and over time. Understanding the dynamics of all these interactions in all these scenarios is the goal of systems biology.

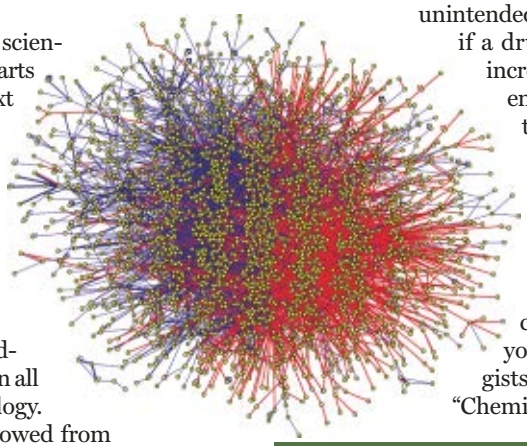
"It came out of the problems that followed from doing the human genome. Because once you have all this information, what are you going to do with it?" Berg says. "The human genome gave us more questions than answers."

To make sense of the genome, systems biologists think in terms of networks. If two kinds of proteins or other biological molecules interact, they are connected on the network. Link by link, these connections reveal the web of interacting proteins that form metabolic pathways. Each protein in a pathway plays a role in multistep cell processes such as breaking down glucose or making insulin.

These network diagrams also show how individual pathways crisscross to form a tangled web. Each protein in a pathway can interact with molecules in other pathways, sometimes dozens of them. "There is no such thing as a single pathway," says Eugene C. Butcher, a pathologist at Stanford University and cofounder of BioSeek. "There's only a complex network, and this network topology changes in different conditions."

By mapping this web of connections, scientists can see that a drug designed to target a protein in one pathway could also have unintended consequences for other pathways. Also, if a drug produces a bewildering pattern of increased and decreased protein activity, scientists can look at the links among the proteins and identify key places on the map where the drug must be acting to produce the observed effects.

Such techniques run counter to established ways of thinking at large pharmaceutical companies, which have traditionally been focused on the biochemistry of individual drug targets. "If you look at any pharma company, biologists are low on the totem pole," Berg says. "Chemists rule the roost."



TIP OF THE ICEBERG — Mapping the interactions of 2,784 proteins in human cells reveals a complex network. Yet this represents only roughly 1 percent of all human proteins. Blue lines show data from existing studies, and red lines are from a 2005 study.

JEAN-FRANÇOIS RUAL ET AL, NATURE

But even Big Pharma has started to dabble in these new screening techniques. Eli Lilly and Co., based in Indianapolis, has started a systems biology–based research department that tests compounds on human cells. And Butcher says that his company routinely screens compounds for three of the five largest pharmaceutical companies, which he declined to name.

"Drug companies definitely want to try it," says Edwards of the Ontario Cancer Institute, "because human cells are certainly better than rat cells." ■

OF NOTE

BIOLOGY

High CO_2—a gourmet boon for crop pest

Increases in atmospheric carbon dioxide could weaken soybean defenses—and be the best news Japanese beetles have had in a long time.

Two new papers suggest that the higher CO_2 concentrations predicted for 2050 will mean extra trouble for farmers fighting insect pests, says Evan H. DeLucia of the University of Illinois at Urbana-Champaign (UIUC). The research was inspired by experiments at the SoyFACE facility on the UIUC campus, where researchers are boosting CO_2 concentrations in soybean plots to mimic future atmospheres.

Researchers noticed that the plots with CO_2 pumped up to 550 parts per million (ppm) were particularly popular with Japanese beetles, which briskly chew soybean leaves into tatters. DeLucia and his colleagues tested beetle diets in the lab. Eating leaves from soybean plants grown in the 550 ppm CO_2 prolonged the beetles' life spans by up to 25 percent. Female beetles living off those leaves laid twice as many eggs as moms eating regular soybean leaves, the team reports in the April *Environmental Entomology*.

The beetle bonanza seems to occur because the extra CO_2 impairs the soybean's normal defenses against ravening insects. Like many plants, a soybean that gets bitten by a bug produces a surge of defensive chemicals that jam an insect's digestive enzymes. Under high CO_2 concentrations, the genes controlling that surge weren't as active, the research team reports in the April 1 *Proceedings of the National Academy of Sciences*. —SUSAN MILIUS

PUBLIC HEALTH

Microbes weigh in on obesity

Overweight children host intestinal bacteria as babies that are different from those hosted by other kids, a new study finds. The results, which suggest that some gut microbes may protect against developing obesity, could lead to new approaches for managing unhealthy weight gain in childhood.

Infants receive their first dose of microbes from mom during birth, and that bacterial population is reinforced during breast-feeding. *Bifidobacterium*, a genus of branched, rod-shaped microbes, dominates the guts of healthy, breast-fed infants, and the bacteria's presence has been linked to a well-functioning immune system. (Previous research had correlated breast-feeding with a reduced likelihood of childhood obesity, hinting at a more direct link between mom's milk and weight development.)

A new study from the University of Turku in Finland of 25 overweight or obese 7-year-olds and 24 healthy 7-year-olds compared the intestinal microbes the children had hosted as infants (fecal samples were taken and analyzed when the kids were 6 and 12 months old, as part of a different study).

Bifidobacterium microbes were twice as abundant in the poop of infants who grew up to be kids of a healthy weight than of those who became overweight, the researchers report in the March *American Journal of Clinical Nutrition*. What's more, the overweight kids had more *staphylococcus aureus* in their guts as infants. Famous for its resistance to many antibiotics, staph has also been linked to chronic, low-grade inflammation, which has been linked to obesity. —RACHEL EHRENBERG

BIOMEDICINE

New drug curbs rheumatoid arthritis in adults, children

A novel drug that takes a narrow approach to quelling inflammation might be just the ticket for people with rheumatoid arthritis who react poorly to broad-spectrum medications, a new trial from Austria indicates.

The drug, called tocilizumab, might also offer a reprieve for children with hard-to-treat juvenile idiopathic arthritis (JIA), formerly known as juvenile rheumatoid arthritis, a Japanese study shows.

Tocilizumab specifically blocks the action of the inflammatory protein interleukin-6, which shows up in excessive amounts in joints of rheumatoid arthritis patients.

Josef Smolen of the Medical University of Vienna and his colleagues enlisted 622 people with moderate to severe rheumatoid arthritis. All had failed to improve on methotrexate, a frontline drug. Two-thirds of

the patients received intravenous infusions of tocilizumab every 4 weeks for 24 weeks, while the others received placebo infusions.

Those getting the drug reported significantly less joint pain and stiffness as well as a better quality of life, the researchers report in the March 22 *Lancet*.

Meanwhile, Shumpei Yokota of Yokohama City University in Japan and his team enlisted 56 children with JIA, which is marked by chronic arthritis, fever, rash, and other symptoms. All the patients received tocilizumab for 6 weeks. At that point, the researchers randomly assigned 43 who were faring the best to get the drug or placebo for 12 more weeks. Those getting tocilizumab were five times as likely as those on placebo to maintain improvements in symptoms, Yokota and his colleagues report in the same *Lancet* issue.

Tim Bongartz, a rheumatologist at the Mayo Clinic in Rochester, Minn., says the findings might clear the way for regulatory approval—although he would prefer to see more studies to reveal any long-term side effects tocilizumab might cause.

In any case, he says, "it's a huge step forward," particularly for children with JIA, who have access to few approved medications. —NATHAN SEPPA

EARTH SCIENCE

Tibetan Plateau history gets a lift

The Tibetan Plateau, a land mass nearly the size of the lower half of the United States, was thrust skyward when the Indian and Eurasian tectonic plates collided about 50 million years ago. But existing models of the order of events following the impact may be wrong, according to a recent report.

By claiming that the more northern regions of the plateau formed early in the aftermath, the report contradicts current views, which suggest that crustal contortions and uplift began where continents collided at the southern border of the Eurasian plate and gradually rippled northward.

In search of hard evidence to test the models, researchers ventured into the Hoh Xil Basin, a northern region of the plateau in China where few dare go because of the snow, high altitude, visas, military headquarters, and other challenges, explains Xixi Zhao, a geophysicist from the University of California, Santa Cruz, who participated in the study.

"Our understanding was driven largely by models that predict that [the plateau] is older in the south and younger in the north," comments Paul Kapp of the University of Arizona in Tucson. "Then [those researchers] got on the ground and realized the actual land doesn't match the model."

Uplift in the central part of the plateau happened before uplift in the south, the team reports in the April 1 *Proceedings of the National Academy of Sciences*. Fossils of radiolarians, or unicellular marine protozoans, recovered from the Himalayas at the southern border revealed that the mountains must have been underwater 40 million years ago—after the central plateau had already emerged.

These findings aren't only about dates, Kapp says. "They provide support for a new story on plateau growth, from the inside out." —AMY MAXMEN

MATERIALS SCIENCE

Squid beaks are hardly soft

Although "mollusk" comes from the Latin word for "soft," squid beaks are so hard they can crack a fish's spine with one bite. Yet somehow, a squid's soft-tissue mouth can clench the beak without cutting itself—something akin to holding the naked blade of an X-Acto knife with a block of Jell-O, says biochemist Herbert Waite of the University of California, Santa Barbara.

The secret, Waite and his collaborators write in the March 28 *Science*, is that squid beaks are not uniformly hard. Instead, they transition smoothly from a relatively soft base—soft enough not to damage the muscle they rest on—to a tip that's about a hundred times harder.

SQUID PRO QUO Water content softens a squid beak toward its base, so that the beak doesn't cut into a squid's soft mouth tissue.

Counterintuitively, the researchers also found that chitin, a complex carbohydrate that makes insect exoskeletons hard, is not more abundant at the tip of the squid's beak than at the base. But it's not just chitin that matters. Another molecule, a protein, is actually more abundant at the tip. The protein "micromanages" how water molecules wrap around chitin, as Waite puts it. More of the protein squeezes the water out. "You pack the bigger molecules more tightly," and those molecules can link more robustly, leading to a harder tissue, Waite says.

Similar transitions exist elsewhere in nature where soft and hard tissues meet, says Waite, such as between our teeth's enamel and dentin layers (enamel is a lot harder) or on the inside of an insect's exoskeleton.

Bioengineers could take inspiration from squid beaks, Waite says. For example, prosthetics such as hip replacements are a lot harder than the surrounding bone tissue, and a smoother transition could help prevent long-term wear and tear. —DAVIDE CASTELVECCHI

GENETICS

Rare mutations tied to schizophrenia

DNA mutations that likely disrupt brain development occur at relatively high rates in people with schizophrenia, according to data jointly reported by two research teams.

These genetic mutations, many of which are critically situated in genes that have been implicated in various facets of brain development, were present in 15 percent of people diagnosed with schizophrenia in young adulthood or later and in 20 percent of those diagnosed with the severe mental disorder before age 13, the scientists report in an investigation published online March 27 in *Science*.

There was no one combination of mutations that characterized all the people with schizophrenia. Rather, most people displayed their own unique genetic alterations.

In contrast, novel genetic deletions and duplications appeared in only 5 percent of people who had no psychiatric ailments.

A team led by geneticist Jonathan Sebat of Cold Spring Harbor Laboratory in New York analyzed DNA from 150 adults with schizophrenia and 268 adults who were free of psychiatric illness. Most genetic deletions and duplications linked to schizophrenia were unique to each individual.

Psychiatrist Judith L. Rapoport of the National Institute of Mental Health in Bethesda, Md., and her coworkers examined DNA from 83 youngsters with schizophrenia and from 154 of their parents. Individually rare mutations showed a slightly stronger link to childhood-onset schizophrenia than they did to adult-onset schizophrenia. Most of the alterations associated with the childhood-onset disorder appeared to have been inherited, some from parents who showed no signs of schizophrenia.

These findings come after evidence, reported earlier by Sebat's group, that many children with autism possess individually rare genetic mutations that form spontaneously rather than being inherited (*SN: 3/24/07, p. 189*). —BRUCE BOWER

SCIENCE

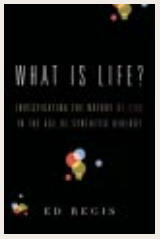
Books

A selection of new and notable books of scientific interest

WHAT IS LIFE? Investigating the Nature of Life in the Age of Synthetic Biology

ED REGIS

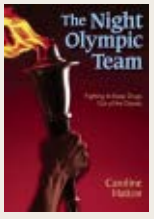
Physicist Erwin Schrödinger's 1944 book—the first to be titled *What is Life?*—reportedly helped inspire the discoverers of the structure of DNA. Since then, scientists have kept peeling back layers of complexity in the workings of life. Another, now-fledgling field of research might eventually have an impact on technology and society equally as dramatic as understanding existing organisms—creating artificial ones from scratch. Science writer Regis is intrigued by an even more ambitious approach. Instead of imitating life-as-we-know-it, some researchers are reinventing it. In this short, eminently readable overview, Regis touches on some of the advances and setbacks in synthetic biology, as well as the ethical and philosophical implications of fashioning ourselves as creators of life. ***Farrar, Straus and Giroux, 2008, 198 p., hardcover, $22.00.***



THE NIGHT OLYMPIC TEAM: Fighting to Keep Drugs Out of the Games

CAROLINE HATTON

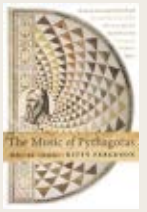
Steven Elliott, who led the Amgen team that created the endurance-boosting drug NESP (also known as darbepoetin alfa and Aranesp), was shocked at the results of drug tests taken from athletes at the 2002 Winter Olympics. Hatton—a scientist who has worked in the University of California, Los Angeles (UCLA) Olympic Lab—recounts the discovery of extensive doping during the 2002 Winter Olympics. After confirming that some athletes' urine samples indeed showed traces of NESP, the director of the UCLA lab, Don Catlin, sent a letter to the International Olympic Committee. Hatton asks lab scientists how they felt about spoiling some Olympic near-wins. "Proud!" exclaims one scientist involved in the testing. In this book geared toward adolescents, Hatton relays the science and politics behind the trials of science sleuths who catch sports cheats. ***Boyds Mills Press, 2008, 56 p., color illus., hardcover, $17.95.***



THE MUSIC OF PYTHAGORAS

KITTY FERGUSON

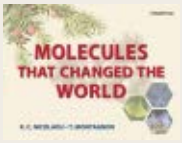
Anyone who has taken—and passed—high school geometry knows the Pythagorean theorem: In a right triangle, the square of the hypotenuse is equal to the sum of the squares of the other two sides. But Pythagoras, the Greek mathematician and philosopher for whom the theorem was named, contributed more than this seemingly simple equation to our current understanding of the world. Pythagoras and his followers believed that the universe is rational and that mathematics can guide people to truth about nature and the cosmos. However, because few records exist, his ideas have survived, but not the details of his life. Ferguson presents a conventional biography of Pythagoras, explaining how his work underpinned that of Copernicus, Kepler, and Newton. But then she takes her work a step further by explaining how Pythagoras contributed, in a less obvious way, to the architecture of Andrea Palladio, interpretations of the French Revolution, and the characters in Louisa May Alcott novels. ***Walker & Company, 2008, 366 p., b&w illus., hardcover, $26.95.***



MOLECULES THAT CHANGED THE WORLD

K.C. NICOLAOU AND TAMSYN MONTAGNON

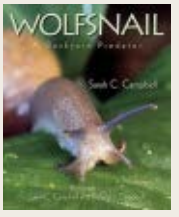
Chemists aren't afraid to show off their love for molecules. Some wear chemistry-themed jewelry, including necklace pendants shaped like the hexagon and pentagon of serotonin. Others get tattoos of their favorite molecules. On the same wavelength, this book by chemists Nicolaou from the Scripps Research Institute in La Jolla, Calif., and Montagnon from the University of Crete, in Greece, is an "enthusiastic celebration of many organic molecules," according to the foreword by chemistry Nobel laureate E.J. Corey. The authors explain the synthesis and story behind more than 30 unique substances. This celebration blends science and history with a bit of anthropology. The chapter on morphine, for example, highlights the history of opium use; the first verse of Samuel Taylor Coleridge's poem "Kubla Khan," which he wrote under the drug's influence; and a history of the morphine molecule's place in pharmaceuticals. ***Wiley-VCH, 2008, 366 p., color illus. and photos, hardcover, $55.00.***



WOLFSNAIL: A Backyard Predator

SARAH C. CAMPBELL AND RICHARD P. CAMPBELL

A snail may seem an unlikely candidate for most ferocious predator, but the wolfsnail certainly deserves consideration. The Campbells begin the snail's story on a rainy day: Water drips from a porch into the shell of a sleeping wolfsnail, who awakens and climbs a hosta leaf in search of food. Sarah Campbell sets an intentionally ambiguous stage for what the meal might be: Is it the hosta leaf? Then she calls out the snail as the carnivore it is: The wolfsnail eats meat. A few lines of text per page accompany bright, close-up color photographs that not only detail the snail's search for its prey (leaf-eating snails and slugs leave detectable trails of slime), but also the prey's demise. The text, like the photos, makes no bones about it. The final two pages of this children's book provide additional details. Native to the southeastern United States, the wolfsnail has become a pest in many countries where it has been introduced to control populations of unwanted leaf-eating snails. ***Boyds Mills Press, 2008, 32 p., color photos, hardcover, $16.95.***



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LETTERS

Follow the glow

"State of the Universe: Microwave glow powers cosmic insights" (*SN: 3/15/08, p. 163*) brings up a question. This glow should be stronger in one direction, which can point us to the center of the universe. Is this possible?

DONALD BURR, NOVATO, CALIF.

Studies of the microwave glow reveal that Earth is moving surprisingly quickly relative to the cosmic background radiation. But this motion is not evidence that the universe has a center, and most cosmologists believe that there is no center of the universe. —RON COWEN

Nothing to write home about

Regarding "Black Hole of Light" (*SN: 3/8/08, p. 149*): A black hole is in a geometrical sense an end to the universe. If we picture the universe using Euclidean geometry, we can imagine going straight out forever. As we approach a black hole, the huge mass changes the geometry so that we also go on forever reaching the surface. We cannot therefore speak about the "inside" of a black hole. The final state of an observer falling down is the singularity at the center of the black hole. A singularity is a division by zero. This means the solution is not valid.

SANFORD ARANOFF,
MONROE TOWNSHIP, N.J.

Someone falling into a black hole will indeed seem to take infinitely long to cross the event horizon, at least as seen from far away. But the falling person will have a different notion of time and will actually experience crossing the horizon and entering the black hole. What happens inside, only the falling observer will know, as no signals escape. The nature of the "singularity" inside a black hole—the region where the space-time curvature becomes infinitely sharp—nevertheless inspires active theoretical research. —DAVIDE CASTELVECCHI

Correction *An editing error introduced a mistake in "Small Wonders: Tiny islanders elevate 'hobbit' debate" (*SN: 3/15/08, p. 165*). The statement that Robert B. Eckhardt of Pennsylvania State University in University Park says the Palau discoveries support his argument that the Flores skeleton comes from a pygmy of* H. floresiensis *with a growth disorder is incorrect. Eckhardt's view is that the Flores skeleton comes from a pygmy of* H. sapiens *with a growth disorder.*

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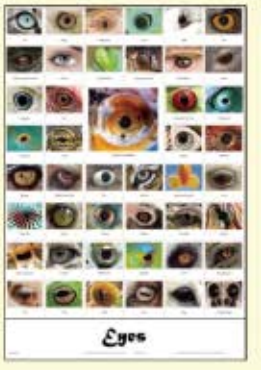

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