SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

MAY 19, 2007 PAGES 305-320 VOL. 171, NO. 20

our bacterial buddies

familial link in x-ray risk

fruit flies' flight plans

diversity in depth

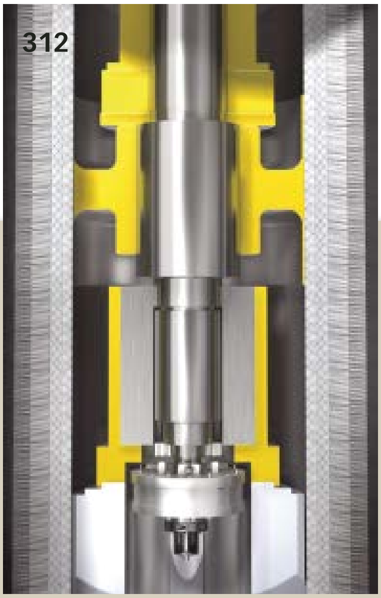
www.sciencenews.org

power on the fly

THE WEEKLY NEWSMAGAZINE OF SCIENCE

SCIENCE NEWS

MAY 19, 2007 VOL. 171, NO. 20



Features

This Week

Of Note

Departments

Cover High-speed, lightweight flywheels, as illustrated here, could replace batteries in hybrid vehicles and make the electrical grid more stable. (Beacon Power Corp.) Page 312

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

Food for Thought Vitamin D may prevent symptoms of asthma in toddlers.

MathTrek Scientists have developed a new technique for calculating the ecological value of roadfree areas of land and representing them geometrically.

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 Science Service, 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 1925, Marion, OH 43306. 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 1925, Marion, OH 43306. For new subscriptions and customer service, call 1-800-552-4412.

Science News (www.sciencenews.org) is published by Science Service, a nonprofit corporation founded in 1921. The mission of Science Service is to advance the understanding and appreciation of science through publications and educational programs. Visit Science Service at www.sciserv.org.

SCIENCE NEWS This Week

X-Ray Kin

Radiation risk is hereditary

Susceptibility to radiation-induced tumors runs in families, according to an unusual study.

In the 1950s, Jewish immigrants from North Africa and elsewhere streamed into the new country of Israel. Many arriving children carried a fungal scalp infection called tinea capitis, also known as ringworm. Standard treatment included a quick dose of X rays that zapped the fungus and induced temporary baldness. Unbeknownst to anyone at the time, it also damaged the children's DNA.

Decades later, some people irradiated as youths developed tumors. Particularly common were meningiomas, noncancerous tumors that grow in the lining of the brain and spinal cord.

"We asked ourselves, 'Why does a certain person develop meningioma following ... irradiation and another does not?'" says Siegal Sadetzki, an epidemiologist at Chaim Sheba Medical Center in Tel Hashomer, Israel. Because tumor rates turned out to be much higher in some families than in others, "we thought the answer must be susceptibility, or genes," says Sadetzki.

Tinea capitis is highly contagious, and the families involved were relatively large, averaging nearly six children. This provided unique circumstances for testing the idea of genetic susceptibility. If one child had the fungus, then several siblings typically got it and all received the radiation treatment.

Overall, fewer than 1 in 100 irradiated children developed meningioma. However, the researchers found that in the most-susceptible families, four out of five children developed it. "This is really stunning," says Sadetzki, who reports her group's findings in the May *Lancet Oncology*.

Eric Hall, a radiation researcher at Columbia University Medical Center, calls the pattern "an incredible concentration of risk."

Sadetzki points to one family's experience as particularly striking: Of seven children, four were irradiated, and all four later developed meningioma. In some susceptible families, Sadetzki and her colleagues also noted radiation-associated cancers such as leukemia.

The new finding "upsets all of our ideas about patient protection [from X rays]," says Hall. If susceptibility differences exist, "most people in the population don't need to be stringently protected ... but the minority should be kept away from any radiation exposure."

Currently, there is no way to determine which families might be at high risk. "That's the $60,000 question," says Hall.

The Israeli team doesn't yet know which genes account for the increased sensitivity to radiation, but it has collected DNA and is zeroing in on several possible genes. "These are the perfect families [for trying] to locate the genes," Sadetzki says.

Hall notes that scientists have suspected for years that some people are more radiation sensitive than others. In animals, Hall has identified a handful of genetic variations that might cause radiation sensitivity. The variations occur in certain genes crucial for cellular functions, such as repairing DNA damage, that are disrupted by radiation.

Two candidate genes in people include *BRCA1* and *BRCA2*, says Hall. Mutations in these genes are already well known as risk factors for breast cancer. If future research confirms the *BRCA*-radiation connection, women carrying the mutations will face a double bind: Getting mammograms to check for early breast cancer might increase their risk for developing the disease.

Says Hall: "We have to figure out the genetics of this." —B. VASTAG

QUOTE

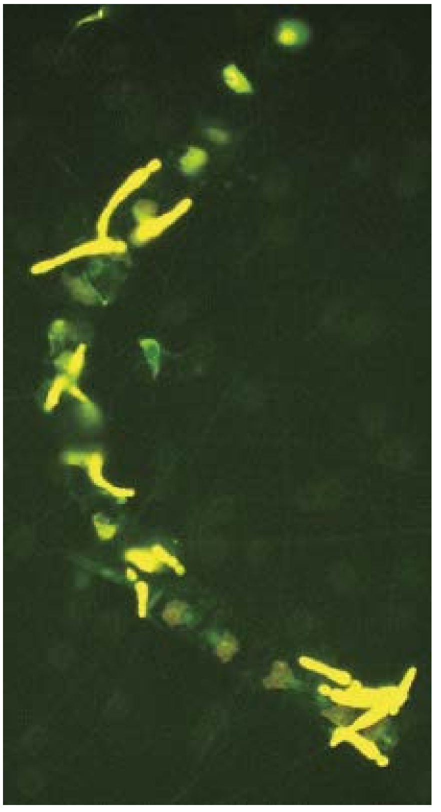
"We have to figure out the genetics of this."
ERIC HALL, Columbia University Medical Center

Biological Hot Spots

Ocean eddies may not always lock away carbon

Large blooms of plankton often appear in ocean eddies, temporary swirls that sometimes bring cool, nutrient-rich water to the surface. When those organisms die, the carbon they contain has to go somewhere, but new studies suggest that very little of it sinks to the ocean floor and gets locked away in sediments. The new data might quash hopes that fertilizing the ocean surface could pull enough carbon dioxide from the atmosphere to substantially affect climate.

Scientists find a larger average concentration of organic matter in deep ocean waters than can be explained by biological productivity at the sunlit surface above. To balance the budget, some researchers have pointed to the immense biomass generated in large ocean eddies (*SN: 6/14/03, p. 375*), much of which has been presumed to eventually fall to the ocean floor.



CHAIN OF LIFE Within an eddy, diatoms such as those in this chain can lock away immense amounts of carbon. However, that sequestration may be only temporary.

S. BROWN/UNIV. HAWAII

Compared with the waters around them, eddies can be productive indeed, says Dennis J. McGillicuddy Jr., an oceanographer at the Woods Hole (Mass.) Oceanographic Institution. In 2004 and 2005, he and his colleagues collected data from eddies in the North Atlantic. For some samples, the researchers estimate that each liter contained about 8,000 colonies of the *Chaetoceros* diatom, each of which held around 15 cells. Long-term studies in the area suggest that the concentration of *Chaetoceros* in water outside eddies typically ranges between 1 cell and 10 cells per liter, he notes.

The water hundred of meters below those eddies is low in oxygen but high in carbon, McGillicuddy's team found. That suggests that much of the eddy-produced organic matter decomposes and dissolves as it sinks, so it doesn't end up locked away for eons in ocean sediments, says McGillicuddy. Instead, the carbon stays in deep water for no more than a few millennia, a temporary removal that wouldn't have much effect on climate. McGillicuddy and his colleagues report their findings in the May 18 *Science*.

Another study reported in that journal suggests that in some cases, eddy-produced organic matter doesn't even reach deep water. Claudia R. Benitez-Nelson, an oceanographer at the University of South Carolina in Columbia, and her colleagues studied a 200-kilometer-wide eddy that formed west of Hawaii in February 2005. In the 40-km-wide core of that swirl, surface waters were "teeming with life," she notes.

At first, the populations of some diatoms within the eddy were 100 times as great as those found in waters nearby. But within days, diatom numbers within the eddy crashed, probably because the organisms had consumed all the water's dissolved silica, which they need to build their skeletons. After the population bust, samples of water gathered at a depth of 150 m were full of broken diatom shells that had been stripped of their organic carbon, says Benitez-Nelson. "That was a big surprise," she notes.

Both teams' new findings suggest that fertilizing the oceans in the hope of removing large quantities of planet-warming carbon dioxide from the air might not work, says Benitez-Nelson. "Just because there's a diatom bloom, it doesn't necessarily mean the carbon is going to go away," she adds. —S. PERKINS

Low Life

Cold, polar ocean looks surprisingly rich

The first survey of life in deep waters around Antarctica has turned up hundreds of new species and a lot more variety than explorers had expected.

A team of scientists from eight countries sampled bottom dwellers during three cruises in the ocean south of the Atlantic. Some of the researchers offer their "first insights" into these Southern Ocean depths in the May 17 *Nature*.

The new work is the "first systematic and comprehensive study" of biology in the south polar depths, says one of the study leaders, Angelika Brandt of the Zoological Museum in Hamburg, Germany.

A researcher not on the team, Richard Aronson of Dauphin Island Sea Lab in Alabama, welcomes the work "as a significant step forward.… The last great frontiers in marine biology are the deep sea and Antarctica."

SMALL CATCH An isopod in the *Munna* genus, from the depths of the Southern Ocean, has long appendages, unlike the stubby ones of its terrestrial cousins the pill bugs.

W. BRÖKELAND

The Southern Ocean team spent weeks aboard the German research icebreaker *Polarstern* in 2002 and 2005. The ship's low center of gravity keeps it stable enough for researchers to work in all but the heaviest seas. "It sits there like a bus," says Brigitte Ebbe of the Senckenberg Research Institute in Bonn, Germany.

The team sampled deep-sea life by dropping devices that scooped sediment and its inhabitants from the bottom. It took the scientists 6 to 8 hours to lower the device and then bring up a single scoop. The ship stopped above 40 sampling sites at depths ranging from 774 to 6,348 meters.

Ebbe says researchers often speak of the deep ocean as beginning around 1,000 m, below which there's a largely undiscovered world. In any water that deep, "half the species are new to science," she says.

The Southern Ocean offered even more unknowns, the team reports. Of the 100 or more species of the small crustaceans called ostracods that the team found, some 70 percent are new to science. Of the 674 marine isopods—little crustaceans related to pill bugs—585 are new.

Life wasn't abundant down there, but it was varied. The survey turned up more new isopod species than had been found in the past century of exploring the entire Antarctic continental shelf, says Brandt.

The diversity was indeed a surprise, she adds. Analyses of mollusks and isopods in the Northern Hemisphere have inspired the idea that diversity dwindles the closer a habitat is to the pole. So far, "we doubt that," she says.

"For the first time, we have a huge data set on the Southern Ocean deep-sea diversity," says Sven Thatje of the University of Southampton in England, a polar ecologist not on the team. He says that he looks forward to using the data to test hypotheses about the development of Antarctic marine ecosystems.

For the newfound creatures, "the big question that remains is, 'How do they make a living?'" says Ebbe. Deep-sea creatures anywhere typically survive on debris settling from above, what biologists call "marine snow." The debris "has usually already been through two or three bodies on the way down, so there's not much nutrition left," she says.

"The take-home message is that there is no place on this Earth that is not teeming with life," says Ebbe. —S. MILIUS

Water World

Extrasolar planet is loaded with hot ice

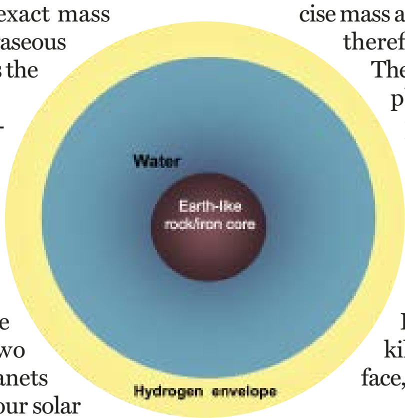
Astronomers have found a Neptune-size planet outside the solar system that's composed mainly of water—albeit in solid form. With a torrid surface temperature of 600 kelvins, the planet can't support life. But its existence bodes well for finding watery planets that could provide a haven for life, say Frédéric Pont of the Geneva Observatory in Sauverny, Switzerland, and his colleagues, who report the discovery in an upcoming *Astronomy & Astrophysics Letters*.

This is the first time that researchers have determined the size, mass, and composition of such a small extrasolar planet, only about 22 times as massive as Earth. The planet, which closely orbits the dwarf star GJ 436, has a diameter about four times Earth's and appears to be a hot version of the ice giants Neptune and Uranus. Researchers had previously measured the exact mass and size of Jupiter-size gaseous planets, some 300 times the weight of Earth.

"This is one [of the discoveries] for which we have been waiting for several years," says theorist Alan Boss of the Carnegie Institution of Washington (D.C.). "This provides the proof that we have found at least two classes of extrasolar planets similar to those seen in our solar system—namely, gas giants and ice giants."

Another team reported in 2004 that an unseen planet at least as massive as 22 Earths whips around GJ 436 every 2.6 days. A tiny wobble in the motion of the star revealed the planet's presence. But the wobble method reveals only the minimum mass of an orbiting planet and nothing about its size or density.

In April, Pont's team found that the star's brightness dims by six-tenths of a percent for about an hour during each orbit. That happens when the planet passes in front of the star, creating a minieclipse, as seen from Earth.



PLANET UNDER PRESSURE Proposed structure of an extrasolar planet that may contain hot water that remains solid under high pressure.

PONT

Because the eclipse reveals the orbit's orientation, the team could determine the precise mass and size of the planet, and therefore its average density. The density suggests that the planet is a water world, possibly enveloped by a thin layer of hydrogen and helium.

Because the orb lies close to its star, the water at the planet's surface would be steam. But beginning about 300 kilometers below the surface, extreme pressure would turn the water solid, says Pont.

Although she calls the result "a big breakthrough," theorist Sara Seager of the Massachusetts Institute of Technology cautions that for now, scientists know only the planet's average density, not the specific materials it contains.

Dwarf stars such as GJ 436, which is less than half the sun's mass, are the most common stars. Just last month, members of Pont's team announced that they had found a planet orbiting a dwarf star in the habitable zone—a region in which the planet's average temperature would allow for liquid water (*SN: 4/28/07, p. 259*). But because astronomers don't know that planet's composition, they can't say whether it can actually support life.

Pont says he's optimistic that the search for planets that eclipse dwarf stars will soon identify one with the right stuff—the proper composition and temperature for life. —R. COWEN

Fly Moves

Insects buzz about in organized abandon

Flies aren't deep thinkers. Yet these humble creatures display a penchant for spontaneous behavior that represents an evolutionary building block of voluntary choice, also known as free will, a controversial new study suggests.

By mathematically analyzing flight maneuvers, a team of scientists showed for the first time that fruit flies move in a way that is neither wholly random nor predetermined. An evolved brain mechanism in the fly must generate spontaneous, unpredictable flight shifts to aid in vital tasks such as avoiding predators and tracking potential mates, con-

Another Layer of Complexity

Short lengths of RNA could provide new form of genetic control

Most of the human genome is so-called junk DNA, which contains no code for proteins and was long thought to be useless. Now, researchers have found that a relatively large portion of this genetic material could help regulate the activity of nearby genes.

"This points to a new layer of control and complexity of the genome," says Aarron Willingham, a member of the team that conducted the study at Affymetrix, a Santa Clara, Calif., company that sells DNA-analysis tools.

The new research could explain a puzzling 2002 discovery by Affymetrix researchers. They found that human cells transcribe large regions of junk DNA into strands of RNA. For true genes, this RNA would serve as a template for making proteins, but for junk DNA, producing RNA seemed like a waste of a cell's energy.

The new study shows that the extra RNA may have a function after all. The long strands of RNA serve as a raw material from which the cells make snippets of RNA containing fewer than 200 "letters" of the genetic code. The researchers also found an apparent link between those short strands, called sRNAs, and the activity of certain genes, suggesting that the sRNAs might influence a cell's behavior.

After examining thousands of active and inactive genes in cultured human-liver and -cervix cells, Willingham and his colleagues found that about 44 percent of the active genes had sRNA-encoding regions nearby, while only 20 percent of inactive genes had such neighbors. While the mechanism tying sRNAs to the genes' activities remains unknown, the researchers say that the correlation is striking.

"I'm really impressed," comments Katalin Fejes Toth, who studies RNA at Cold Spring Harbor (N.Y.) Laboratory. "The fact that they looked at thousands of genes makes it more believable."

"It does strongly point to a regulatory role" for sRNAs, agrees Thomas Gingeras of Affymetrix, who led both the 2002 study and the new one, reported online and in an upcoming *Science*.

An alternative explanation is that DNA coding for an sRNA simply gets transcribed by accident along with the nearby gene, Gingeras says. This scenario could give the appearance of a connection without the sRNA serving any function. But the scientists compared the human and mouse genomes and found that the genetic code for sRNAs hasn't changed much over millions of years of evolution, suggesting that the sRNAs play an important role in cells.

If so, this additional of layer of control could help explain how animals, such as people, with more-complex bodies can have a similar number of genes as more-primitive animals, such as roundworms, Gingeras says.

Another kind of RNA, known as microRNA, also plays a role in regulating gene activity. But while microRNAs work by silencing genes, sRNAs correlate with increased gene activity and probably work by a different mechanism, Gingeras says.

The researchers estimate that 1.3 percent of the human genome codes for sRNAs. In comparison, genes make up only about 1 percent of the genome. —P. BARRY clude neuroscientist Björn Brembs of the Free University of Berlin and his colleagues.

"Our results provide strong evidence that the exact prediction of an individual [fly]'s behavior is impossible," Brembs says. This finding dovetails with other evidence that people must have a neural ability to generate spontaneous behavior. Without such an ability, "it's hard to imagine people having access to free will," he adds.

The researchers reject the traditional assumption that flies and other animals search for food and engage in other critical behaviors primarily by using their senses to glean clues from their surroundings. Instead, the new results suggest that circuitous foraging routes and other behavioral signatures of flies arise spontaneously, although sensory clues may also play a role. Brembs' team describes its findings in the May *PLoS ONE*.

The researchers placed a drop of glue between the head and thorax of a fly to attach it to a hook inside an experimental chamber. Each of the 13 flies tethered in this way could still beat its wings and move its body. Uniformly white surroundings offered no visual feedback to the animal. A special device recorded the timing and magnitude of each fly's movements.

In this barren environment, the flies rarely stayed still and frequently changed direction. Mathematical methods developed by study coauthors George Sugihara and Chih-hao Hsieh, both of the University of California, San Diego, indicated that flies' spontaneous flight maneuvers were neither totally random nor completely regular or repetitive. Instead, they had a structured variability that mathematicians describe as fractal order.

Brembs plans to identify brain areas responsible for flies' spontaneous movements.

At least part of the so-called default network in people's brains generates spontaneous behavior according to rules similar to those operating in flies, Brembs speculates. The default network exhibits spontaneous activity in people at rest (*SN: 5/5/07, p. 276*).

Neuroscientist Randolf Menzel, a bee researcher also based at the Free University of Berlin, suspects that the brain stimulates spontaneous behavior in flies and other insects as one way of producing decision options from which the animal automatically makes a choice. Brembs' results bear no relation to the concept of free will, Menzel holds.

Psychologist David L. Gilden of the University of Texas at Austin also sees no reason to connect Brembs' results to free will. Flies' spontaneous behavior resembles the fractal structure of many biological and physical systems poised between stability and chaos, Gilden notes. These systems include traffic flow, quasar emissions, and people's memory for time and spatial intervals.

Fractal organization endows a system with the flexibility to change and adapt to new circumstances, Gilden theorizes. "This issue goes way beyond biology," he says. —B. BOWER

FACE SAVING A detail of the Brancacci Chapel frescoes by early-15th-century Florentine master Masaccio. The frescoes were among the first to be cleansed with microemulsions. On the left is the fresco before the restoration.

CSGI/UNIV. FLORENCE

Cleaning Treasures

Safer solvents for restoring frescoes

By suspending small amounts of solvents in nanoscale droplets, chemists have found an environmentally safer method of cleaning centuries-old frescoes and saving them from the unintended consequences of previous restorations.

The preservation of historic frescoes often involves firming up the paint and slowing its degradation by oxygen, light, and air pollution. In the 1970s, synthetic resins seemed like an ideal fix. Conservators began coating frescoes with protective layers of these acrylic polymers. However, the use of the synthetic chemicals created unforeseen problems, says Piero Baglioni, a chemist at the University of Florence.

For one thing, the polymers obstructed microscopic pores within the paint, preventing the natural perspiration of the underlying walls. This accelerated the accumulation of damaging salts, such as sulfates, under the coating.

Furthermore, within 2 decades, the protective layers themselves began to degrade. They often turned yellow from photooxidization, and they tended to shrink, creating stresses on the underlying paint, says Baglioni's collaborator Rodorico Giorgi.

Conservators began using solvents to remove the polymers. But the solvents were toxic materials such as aromatic compounds, which could be hazardous to the user. Moreover, the solvents couldn't clear the paint's pores, according to Baglioni. "It's impossible to remove these resins using a normal solvent," he says.

In the 1990s, Baglioni's team began replacing pure organic solvents with less toxic, water-based microemulsions of the aromatic compounds. That meant using surfactants to suspend the solvents in microscopic droplets of water. These water-based microemulsions cut the concentrations of hazardous solvents by at least 95 percent.

Microdroplets of solvents could easily get inside paint pores, where they would gobble up the resins. Conservators could then absorb them with a wet poultice.

The microemulsions were effective at removing not only synthetic polymers, but also organic materials such as soot and wax from burning candles, Giorgi says.

Using a new class of surfactants and new processing techniques, the Florence team has now brought down the concentration of hazardous solvents to less than 1 percent. Their new emulsions contain droplets as small as 10 nanometers. This increases their surface area per unit volume and enables conservators to use less-toxic concentrations of the solvents. The team describes its results in the May 22 *Langmuir*.

As an alternative to synthetic resins for saving frescoes, the Florence team favors the use of nanoparticles of calcium hydroxide, or slaked lime. These can also penetrate the paint's porous surface, providing a natural way of integrating them with the original, calcium carbonate–based paints.

Ramón Carrasco, an archaeologist at the National Institute of Anthropology and History in Campeche, Mexico, says that he has enlisted the help of the Florence team for preserving frescoes in the Mayan ruins of Calakmul, in the Yucatán. "We were very careful not to use synthetic resins," says Carrasco. "They prevent the original materials from breathing." —D. CASTELVECCHI

SPINNING INTO CONTROL

High-tech reincarnations of an ancient way of storing energy

BY DAVIDE CASTELVECCHI

Departing trains at a rail station could someday get their initial oomph for free, each time saving the equivalent of several days' worth of electricity usage by an average U.S. household. The trains would rely on a concept already used in today's hybrid gas-electric cars: reuse of energy stored while braking to a stop. But while hybrid cars stockpile energy in massive arrays of batteries, the heart of the hybrid train might be a deceptively low-tech device—a flywheel.

A flywheel stores the energy that was used to make it spin, and it retains that energy as long as the wheel is free to turn. Slow down the flywheel, and you can draw some of that energy back out.

Potters have taken advantage of flywheels for thousands of years. Since ancient times, they've shaped their bowls and cups on a wheel that they've turned by pushing on a pedal. The wheel's stored energy, or rotational inertia, keeps it turning at a roughly constant speed, despite the unevenness of the pedaling.

Engineers at the University of Texas in Austin are now experimenting with an improved flywheel that can store enough energy to get a standing passenger train up to cruise speed. Although such a wheel in a locomotive may weigh 5,000 pounds and its rim may move at the speed of sound, it would work on the same principle as the pedal-driven pottery wheel.

To store energy, either a mechanical system or alternating magnetic fields make a flywheel turn faster. To release energy, the systems slow it down.

Batteries are the most widely used way of storing energy and are the staple of hybrid vehicles of all kinds. But batteries are slow to recharge and typically can't give back their energy in quick bursts. After a few years, they lose their capacity to hold a charge and, because they contain toxic metals, can end up as hazardous waste.

Flywheels, their advocates say, can pack more energy than batteries of comparable weight. Flywheels can also last decades with little or no maintenance and are environmentally sound.

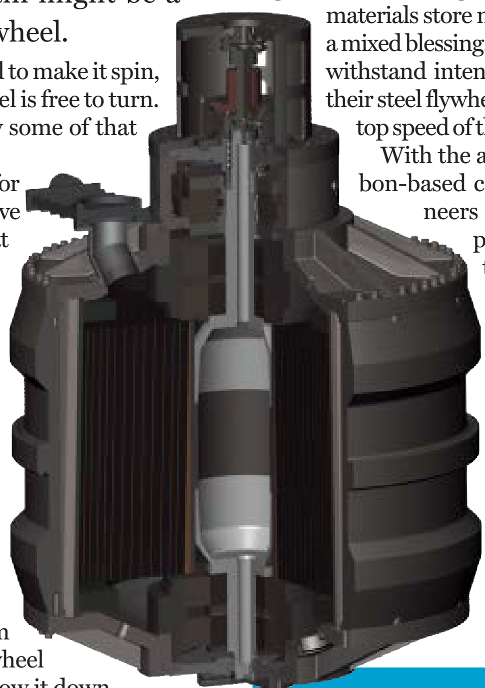
For decades, some engineers have fought a lonely battle as they've tried to promote flywheels for energy storage. Now, flywheels may be slowly starting to find wider acceptance—and practical applications. Several companies in the United States and Europe are developing flywheel-based hybrid buses and trams. Flywheels are also being cast in an important role in the post–fossil fuel economy. They might be used to stabilize the output of solar, wind, and other energy sources, thereby reducing the risk of blackouts.

FREEWHEELING TRAVEL Interest in flywheels has come and gone in waves over the past several decades, as have investor interest and research funding. In the 1950s, cities were interested in clean mass transit that could replace trams and electric buses without needing tracks or suspended wires. A small Swiss company tried to commercialize what it called the Gyrobus. This vehicle's only source of power was a steel flywheel that was spun up while the bus docked briefly at specially equipped stops. But the Gyrobus was heavy, and its range was limited to a few kilometers, so it never reached mass production.

For decades, steel was the material of choice in flywheel engineering because of its high density. Other things being equal, denser materials store more mechanical energy. But density can be a mixed blessing. The outer rims of high-density wheels must withstand intense centrifugal forces. Engineers often saw their steel flywheels self-destruct. So, they had to restrict the top speed of the wheel rim to about 50 meters per second.

With the advent in the 1970s of light but strong carbon-based composite materials such as Kevlar, engineers realized that lighter could be better. The polymer fibers of composite materials make them several times as sturdy as steel. Their rims can move at more than 1,000 m/s. The high speed more than offsets the reduced density of composites. Doubling the spinning speed of a flywheel quadruples its stored energy, while doubling its density only doubles that energy.

To reduce energy losses from friction, engineers began enclosing flywheels in vacuum containers and suspending them on electromagnetic, rather than mechanical, bearings. And by embedding magnets in such flywheels, designers could arrange for their speeds to be controlled by magnetic systems, so that the flywheels would have no physical contact with the rest of the world.



QUIET WHIRL — Magnetically levitated in a vacuum enclosure, the 1.2-meter-tall carbon-composite flywheel (black material) in this cutaway could store enough energy to accelerate a train to cruising speed.

UT CENTER FOR ELECTROMECHANICS

In the mid-1990s, some start-up companies proposed flywheel designs to replace batteries or other power sources in electric cars. The flywheels came up to speed in a matter of minutes, rather than the hours needed to recharge a battery. But car manufacturers, with little interest in electric cars, didn't invest in the unproved technology.

Also in the 1990s, NASA became interested in using flywheels to power the International Space Station. Once every hour and a half, the station's orbit brings it into Earth's shade, where its solar panels are useless. For about 30 minutes, the station relies on batteries. But frequent charge-and-discharge cycles wear out the batteries within a few years.

At NASA's request, engineers at the University of Texas in Austin started developing a flywheel pack that could store twice as much energy as batteries of the same weight and last the entire life of the station without maintenance. The project, however, fell victim to budget cuts.

Nevertheless, the Austin team achieved remarkable flywheel spinning speeds. Its carbon-composite prototype reached more than 50,000 rotations per minute and a rim speed of 1,400 m/s.

More recently, the team has had locomotives in mind. In late April, inside a concrete bunker that provides safety during high-energy experiments, the researchers began testing their largest flywheel yet. It's a cylinder 1.5 m in diameter and 1.2 m tall, spinning on a vertical axis. It is designed to store 133 kilowatt-hours (kWh) of energy, which the team claims as a record for carbon-composite flywheels. That energy would take a train from a standing start up to cruising speed.

The flywheel is made up of concentric shells, each one prestressed in a different way to withstand centrifugal forces that vary greatly from the axle to the rim. The new machine rests inside a 2.1-m-tall steel containment vessel that houses the electromagnetic suspension and a magnetic system that can spin the flywheel at up to 15,000 rotations per minute.

The team estimates that a flywheel-based hybrid locomotive could attain a 15 percent increase in efficiency on a route such as New York to Boston. "But the best payoff would be for commuter rail," says University of Texas physicist Robert Hebner. Although his team hasn't calculated the probable savings, stop-and-go travel in conventional vehicles wastes a lot of energy in braking that could be retained by a flywheel, he says.

FAVORABLE SPIN — Engineers lower a flywheel prototype into a concrete bunker for a safe test at high speeds.

UT CENTER FOR ELECTROMECHANICS

Flywheels might also make a comeback in smaller-scale transit. Several teams in Europe and the United States—including the one at Austin—have recently proposed modern analogs of the Gyrobus. In Rotterdam, the Netherlands, a company called Centre for Concepts in Mechatronics developed a flywheel-powered hybrid bus and tested it in passenger service last year, says project manager Rien Beije.

The prototype bus incorporated a small car engine whose only task was to keep the flywheel spinning. The engine ran at the constant speed at which its fuel efficiency was optimal. The flywheel stored up to 3 kWh, ran on conventional ball bearings, but was kept within a vacuum. When needed, the flywheel could supply bursts of 300 kilowatts, the equivalent of about 400 horsepower.

The bus "ran like a Porsche," Beije says, and had 35 percent better mileage than a comparable-size conventional bus.

The company now has a contract with French engineering giant Alstom to develop a wireless tram that could recharge at stops.

BLACKOUT PROTECTION Meanwhile, some companies are now producing larger, stationary flywheels intended to make electric power more reliable. The electric power grid is "a subject that involves little passion until the system fails," says Ruth Howes, a physicist at Marquette University in Milwaukee.

The Electric Power Research Institute in Palo Alto, Calif., estimates that hundreds of brief power outages cause the U.S. economy to lose at least $120 billion a year, for example, by causing computer users to lose data. A single major disruption, such as the one that left the northeastern United States and Ontario in the dark on Aug. 14, 2003, can cost extra billions of dollars.

The electric-power grid operates on a careful balance of supply and demand. Sudden imbalances in one place create disruptions that propagate over the grid by affecting the current's frequency or voltage. Increased reliance on inherently erratic power, such as solar or wind, will only make matters worse, according to a committee summoned by the American Physical Society and chaired by Howes. The committee is about to release a report highlighting the problem and listing flywheels as one of the possible solutions.

Flywheels are one of several types of devices, known as power-quality units, that can dampen changes in current's frequency or voltage by injecting extra juice into the grid. Such units would respond to fluctuations within fractions of a second and could prevent major emergencies such as the 2003 blackout.

"That entire power outage could have been suspended if the grid had had power-quality units," says Jim Fiske, a senior engineer at LaunchPoint Technologies, a company based in Goleta, Calif.

Some U.S. companies are already producing commercial flywheels for power-quality applications. Beacon Power, based in Wilmington, Mass., has designed and installed a 9-kWh model for large telecom clients that need stable power in remote locations. More recently, the company gained approval from grid operators in California and New York after testing its flywheel on both states' grids.

Beacon is now developing larger, 25-kWh flywheels meant to be installed in arrays of as many as 200. Such arrays would provide 20-megawatt bursts of power when needed to stabilize a grid's frequency.

Amory Lovins, chief scientist at the Rocky Mountain Institute, an energy- conservation think tank in Snowmass, Colo., agrees that a quick injection of power into the grid could have prevented the 2003 blackout. "It would have taken a few hundred extra megawatts, at most," he says. However, Lovins says that the best way to avoid a major power outage is to fine-tune the supply side by enlisting the help of large, industrial customers. "They will take demand off the grid [on short notice] if you pay them to do so," he says.

But for preventing smaller, more frequent disruptions, flywheels offer a better solution, maintains Beacon spokesperson Gene Hunt.

Meanwhile, LaunchPoint is looking into an alternative design for flywheels. Even when made of composite materials, flywheels such as those produced by Beacon or the University of Texas team are still limited in size by centrifugal forces. Those forces increase from axle to rim, and so tend to pull apart concentric layers.

Countering those forces adds complexity and cost, says LaunchPoint engineer Fiske. "Each separate rim has to have the right structural characteristics," he says. The LaunchPoint team proposes to remove everything except the outer rim, leaving just a hollow cylinder. The stress in the radial direction is minimized, and the wheel can be much larger and weigh up to tens of tons, Fiske says.

LaunchPoint's hollow design is further simplified by putting the entire electromagnetic bearing system on the inner side, instead of the outer side or the bottom of the rim. Fiske's team is building a small prototype with a capacity of 3 kWh. He says that the design will be easy to scale up, reaching a storage capability of at least 1 megawatt-hour—six times the Austin team's record.

Recent infusions of research money from the U.S. Department of Energy, the National Science Foundation, and NASA are helping small companies and university research labs bring flywheel technology to maturity.

Consumers are just beginning to get used to hybrid cars. A new generation of flywheels might bring the hybrid concept into systems ranging from from trains to the nation's entire electric grid. ■

OUR MICROBES, OURSELVES

How bacterial communities in the body influence human health

BY ALEXANDRA GOHO

In the womb, a fetus enjoys the protection of a sterile environment. Only when the mother's amniotic sac ruptures before delivery does her baby face microbes for the first time. As he's squeezed through the birth canal, he picks up millions of bacteria from his mother. Most of the microbes are friendly and quickly take up residence on the baby's skin and in his gastrointestinal tract.

The bacteria not only persist but also form complex communities throughout the newborn's body that will aid in his general well-being throughout life. The body's microbes play a critical role in digesting food, metabolizing drugs, and maintaining overall health.

In fact, in every person's body, there are 10 times as many microbial cells as there are human cells. "The microbial part of ourselves is highly evolved," says Jeffrey Gordon, a microbiologist at Washington University in St. Louis. "These organisms have learned to adapt to life with us."

It's no wonder then that this vast microbiota has captured the attention of researchers working to understand not just health, but also diseases, particularly those lacking clear diagnoses or effective treatments. With new laboratory techniques, these researchers have begun to survey the microbial communities in the body. Several groups already report that disruptions in these communities are related to conditions including obesity, inflammatory bowel disease, vaginal infections, and gum disease.

Scientists have long recognized that the body's microbiota matters. In the 19th century, Louis Pasteur declared that normal microbes are important in human health and that their disruption can lead to disease. Until recently, however, scientists studying human-microbial populations had been hampered because the majority of such microbes can't be cultured in the lab. Now, researchers can extract DNA from a sample and rapidly identify thousands of bacterial species at once without having to grow each bug in a dish.

New studies are also showing that microbes within a community work together to influence health, a finding that may have a large impact on conventional views of disease. Instead of an illness being caused by the presence or absence of a single pathogen, "the real pathogenic agent is the collective," says David Relman, an infectious-disease investigator at Stanford University.

GUTTING IT OUT Washington University's Gordon regards the gut as a bioreactor—something like a living septic tank that breaks down organic matter. The human gut is filled with microbes that interact with one another and their host in mutually beneficial ways (*SN: 5/31/03, p. 344*).

Several years ago, Gordon and his group conducted a series of experiments in which they transplanted microbial communities from the guts of normal mice into mice reared in a sterile environment. The formerly germ-free mice began to accumulate fat in their tissues. The transplanted microbes not only permitted the mice to metabolize nutrients that would otherwise have been lost but also appeared to manipulate mouse genes in a way that increased the animals' capacity to store fat, the team reported in 2004.

The researchers homed in on the gene for a protein called fasting-induced adipocyte factor, which is known to regulate energy storage. Normally, the protein is secreted from the cells lining the gut. The protein blocks lipoprotein lipase, an enzyme that controls the transfer of fat molecules from the blood into fat cells.

In mice that had received the transplanted gut microbes, fasting-induced adipocyte factor was suppressed. This increased the lipase's activity, resulting in more fat being stored.

The results prompted Gordon and his colleagues to hypothesize that differences in gut-microbial communities might explain differences in how well people harvest energy from food and store it as fat. So, the group decided to compare the gut microbiota of lean and obese mice.

> "In any one human, there are a hundred times as many microbial genes as there are human genes."
>
> — DAVID RELMAN, STANFORD UNIVERSITY

"We saw this amazing, mind-boggling shift in the relative representation of the two principal groups of bacteria that normally inhabit mammalian guts," says Gordon. Those bacterial types are called Firmicutes and Bacteroidetes.

The researchers identified the members of the animals' gut microbial communities by sequencing a specific gene whose sequence varies from one species to the next. Researchers frequently use this gene, called the 16S ribosomal gene, as a mini–bar code for identifying bacteria.

Mice bred to be obese had a larger proportion of Firmicutes and a smaller proportion of Bacteroidetes than their lean counterparts did. The change wasn't the result of one bacterial species taking over a group or of another species being suppressed. "Everything moved up or down," Gordon says.

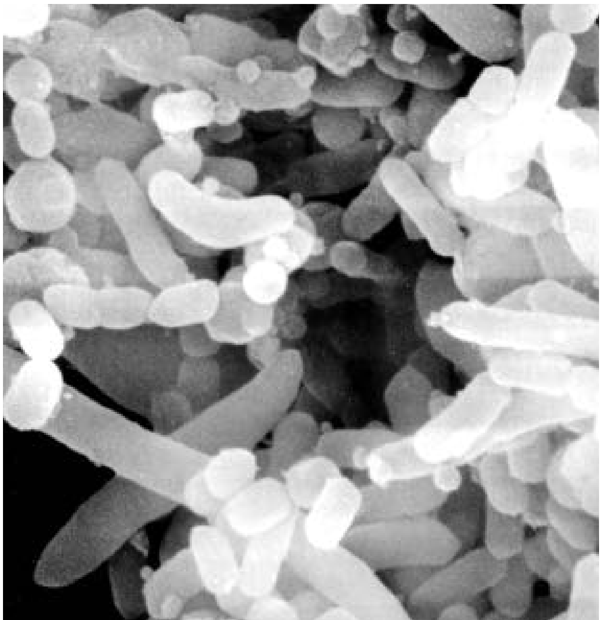
To determine how changes in the bacterial communities relate to the animals' body weights, Gordon and his team transferred gut microbes from the obese and lean mice to germfree mice. The mice receiving gut bacteria from obese animals gained significantly more fat than did mice receiving gut microbes from lean animals, the team reported in the Dec. 21/28, 2006 *Nature*.

In a separate report published in the same issue, the researchers addressed whether a similar pattern exists in the human gut. The team studied 12 people who volunteered to be randomly assigned to either a low-calorie, fat-restricted diet or a low-calorie, carbohydrate-restricted diet. The researchers monitored changes in the volunteers' gut-microbial communities over the course of a year. Sure enough, as individuals of both groups lost weight, the proportion of Firmicutes in their guts rose, while the proportion of Bacteroidetes dropped.

Gordon is quick to point out that gut-microbial ecology isn't the only factor affecting body weight. Genetics and easy access to high-calorie foods play important roles. Still, the research suggests that microbial communities in the gut form alliances with one another as well as with their host, and that scientists will need to understand the entire community to understand obesity and many other complex conditions.

Inflammatory bowel disease, for instance, is a perplexing spectrum of conditions that includes Crohn's disease and ulcerative colitis. In a preliminary study, Relman and his colleagues identified signs of altered microbial communities in people with Crohn's disease.

Using tissue samples obtained from the colons of about a dozen individuals, the researchers found that people with Crohn's disease had more *Escherichia coli*, *Pseudomonas*, and other microbes known as proteobacteria than did people with ulcerative colitis or healthy individuals. However, the researchers still don't know whether these microbes cause the disease and whether other microbes contribute to it.



INTESTINAL INSIGHTS — The bacterium *Bacteroides thetaiotaomicron* is a prominent member of the diverse community of microorganisms that inhabit the human gut. In collaboration with other microbes, these natural symbionts boost the gut's efficiency in extracting calories from food and storing them as fat.

Z. HE AND L. T. ANGENENT/WASHINGTON UNIV. (ST. LOUIS)

MICROBIAL SIGNS Microbial communities are not only critical to maintaining a healthy gut; they also play vital roles in many other parts of the body. David Fredricks, a microbiologist at the Fred Hutchison Cancer Research Center in Seattle, has been investigating a syndrome called bacterial vaginosis, a vaginal infection that affects 10 to 20 percent of women in the United States.

"It's a curious disease because we still don't fully understand what causes it," he says. Although doctors can treat the infection with antibiotics, the rate of relapse is high. About half of affected women will develop another infection within a year after treatment.

In late 2005, Fredricks and his colleagues described experiments in which they sampled vaginal fluid from women with and without bacterial vaginosis. Using the 16S ribosomal gene, the researchers identified 35 bacterial species associated with the syndrome. More than half of these species had never before been identified. Three strains in particular showed up in almost all patients with bacterial vaginosis and were rare in women free of the syndrome.

Fredricks says that the findings support his hypothesis that bacterial vaginosis is "a disease by microbial community." He believes that these bacteria are always found together because they are metabolically interdependent. "These bacteria can't exist as single species," he says.

Fredricks' lab is currently monitoring a group of 30 women for changes in their vaginal flora over a month. The goal is to determine how women acquire bacterial vaginosis and how the microbial community causing the syndrome responds to antibiotics.

Investigations of the human microbiota could also shed light on complex skin conditions such as psoriasis and eczema. At present, most researchers consider psoriasis to be caused by the immune system gone awry. But because human skin is home to a complex ecosystem of mostly unidentified bacteria, Martin Blaser, a microbiologist at the New York University School of Medicine, suggests that microbes are involved. "The field of investigative dermatology has almost completely ignored the role of microbes," he says.

To demonstrate the complexity of the skin's microbiota, Blaser's group analyzed skin swabs taken from the inner forearms of six healthy people. Reporting in the Feb. 20 *Proceedings of the National Academy of Sciences*, the researchers identified 182 species of bacteria. Each person showed a unique microbial makeup—only four species of bacteria were found in all six participants, and each participant carried an average of 48 species. The results offer a first glimpse of the diverse array of microbial species inhabiting healthy skin, Blaser says.

The researchers resampled four of the participants 8 to 10 months later and found many of the microbes previously identified along with 65 new bacterial species. All the volunteers had retained some of their previous microbial residents and had acquired new ones. The result suggests that each individual's skin harbors both a core set of microbes and a group of transient members.

Blaser's lab is now examining people with psoriasis to see whether there's a microbial signature for the skin disease.

However, identifying individual species may be irrelevant in some cases of disease caused by microbial communities. "It might not matter who is there but rather what the collective is doing," says Relman.

For instance, he's found that some people with severe gum disease harbor an abundance of hydrogen-consuming microbes called methanogens. Related to bacteria but properly classified as archaea, methanogens live in the deep gaps between gums and teeth.

But not everyone with severe gum disease hosts methanogens. Other people's afflicted mouths instead support large populations of hydrogen-consuming bacteria called treponemes.

Hydrogen is a by-product of fermentation in oxygen-deprived environments, such as the tooth-gum gaps, and it also limits growth among hydrogen-producing microbes. Relman says that through a behavior called syntropy, the hydrogen-consuming microbes—whether methanogens or treponemes—work together with the other microbes to stabilize the microbial community and keep it going.

Similarly, Gordon's group found that two common species of gut microbes work together to boost fat storage in germ-free mice (*SN: 6/17/06, p. 373*).

These observations reinforce the notion that to develop new medical therapies, researchers will need to consider all the interacting members of a microbial population.

HUMAN GENOME II As they delve deeper into this area, scientists expect to find great variation in the composition of microbial communities that inhabit different parts of the body. The skin microbes on a person's forearm probably differ from those on his or her back, and the microbial communities in the colon most likely differ from those that inhabit the small intestine, the stomach, and the esophagus. Considering that the gastrointestinal tract is 6.5 meters long and contains up to 100 trillion microbes representing 1,000 different species, "we have our work cut out for us for a while," says Gordon.

Improvements in DNA-sequencing technology and computational tools are accelerating the pace of research. Last year, a group of scientists led by University of Buffalo (N.Y.) microbiologist Steven Gill and including Gordon and Relman completed the first survey of the microbial genes in the human colon. In samples from two healthy adults, the team tallied more than 60,000 genes. The researchers reported their findings in the June 2, 2006 *Science*.

Rather than isolating each microbe and sequencing its entire genome, the researchers treated the microbial community as a collective with a single genome. The team analyzed all the microbial genes present without regard to any single gene's cell of origin.

Called metagenomics, this form of analysis doesn't produce a list of bacteria but instead describes the metabolic activities going on within a microbial community. These activities include energy conversion and the transport and break down of carbohydrates and amino acids.

Scientists have been using metagenomics for several years to describe microbial communities in soil and in the ocean. Only recently have they started applying the technique to the microbiota in people.

The National Institutes of Health is considering a Human Microbiome Project—an extension of the Human Genome Project—that would create a genetic inventory of the microbial communities inhabiting the body's major niches, such as the mouth, vagina, skin, and intestinal tract. This spring, NIH is expected to decide whether to proceed with the project.

The Human Genome Project was an international effort that took 13 years to complete. A survey of the entire microbiota of a person would be an even more formidable undertaking. "In any one human, there are a hundred times as many microbial genes as there are human genes," says Relman.

Furthermore, microbial communities may vary significantly over small distances within any given part of the body. For instance, Relman has found that a community's membership changes from one part of a person's mouth to another. There are differences between the front and back sides of teeth, he says, between the gum pockets of two adjacent teeth.

"We will have a broader view of ourselves as a life form."

— JEFFREY GORDON, WASHINGTON UNIVERSITY

To further complicate matters, different people harbor different collections of microbes. Researchers will have to focus on the microbiota within an individual and within groups of individuals. "I think this is a global project in many senses of the word," says Gordon. Ideally, researchers would survey microbes from people living in different ecosystems and under different socioeconomic conditions, he says.

The knowledge derived from such investigations could have an enormous impact not only on understanding human health and disease but also on the development of new therapies. Take, for instance, the chemical signals that microbes in the gut might use to manipulate human genes. "These chemicals then become potential components of a 21st-century medicine cabinet," says Gordon.

Alternatively, pharmaceutical companies could develop drugs that target specific bacterial compounds to restore a microbial community in the body to its normal state.

Ultimately, says Gordon, "we will have a broader view of ourselves as a life form, as a composite of different species." ■

OF NOTE

BIOLOGY

Tiny pool protects flower buds

Rare flower structures—tiny cups that keep flower buds submerged in their own water baths—can protect the blooms from marauding moths, say researchers.

One species with these cups, *Chrysothemis friedrichsthaliana*, grows along riverbanks in Central and South America, says Jane E. Carlson of Louisiana State University in Baton Rouge. A relative of African violets, the plant has hairy leaves and orange, tubular flowers.

As a flower develops, a yellow-green cup, or calyx, forms around the bud. Calyx hairs secrete liquid for 2 to 3 weeks as the bud matures.

To see whether and how the system protects buds, Carlson visited *Chrysothemis* patches daily in Costa Rica and drained some calyxes. The hairs can refill a calyx in 24 hours.

One in three buds failed to develop in calyxes, whether or not she drained them. She concluded that the calyxes' main role isn't in moistening buds.

MINI MOAT The yellow-green cup of water at bottom protects a flower bud. The calyx at top has already yielded a flower.

CARLSON

Drainage did affect attacks from alucitid moths, says Carlson. Emptying calyxes doubled the chance that a moth would inject an egg into the bud. The moth larvae destroy floral sex organs inside. The petals of affected flowers open normally but show no working parts, only a rice-grain-size moth larva.

Instead of the usual four wings, these alucitid moths have arrays of featherlike plumes. Carlson speculates that the wings' fragility prevents the insects from maneuvering well in water.

She and her Louisiana State colleague Kyle Harms describe the experiment online in *Biology Letters*. —S.M.

PHYSICS

Broadband vision

Evolution put a notorious quirk in the vertebrate eye, placing the light-sensing cells on the back of the retina instead of the front. But evolution also seems to have found a high-tech work-around for this apparent mistake. Scientists now say that specialized cells transmit light through the retina's layers of various cells by acting like optical fibers.

In vertebrate retinas, light has to cross up to one-fifth of a millimeter of connective and nerve cells before reaching light-sensing cells.

But a team in Germany has shown that some of the layers' cells, shaped like funnels and called Müller cells, have a higher refractive index than the others. The scientists reached this conclusion by shining a laser through Müller cells taken from guinea pigs.

The higher refractive index would enable Müller cells to channel light with little loss, as optical fibers do. Light traveling along an optical fiber doesn't escape laterally because it gets reflected at the boundary between a high-refractive-index core and a lower-index sheath.

Müller cells probably get their high refractive indexes from tight bundles of polymer fibers extending along their lengths, says team member Jochen Guck, now of the University of Cambridge in England. The findings appeared in the May 15 *Proceedings of the National Academy of Sciences*.

Barbara Finlay, a neurobiologist at Cornell University, says that the cells' behavior should be checked at different wavelengths of light. But she says the new findings could be the kind of unexpected discovery that seems "perfectly obvious" in hindsight. —D.C.

BIOMEDICINE

Therapeutic sorghum?

In terms of production, sorghum is one of the nation's top grains. Most of it now goes to feed livestock. A team of university scientists says that's a mistake because sorghum bran can fight inflammation almost as well as a prescription drug for arthritis does.

In test-tube experiments, sorghum bran significantly reduced white blood cells' production of several inflammation-linked chemicals, including the immune-system activators tumor-necrosis-factor-alpha (TNF-alpha) and interleukin-1-beta (IL-1-beta).

Amy Burdette and her colleagues at the University of Georgia in Athens first stimulated the white blood cells—called macrophages—with an inflammatory agent and then incubated cells with various concentrations of black-sorghum-bran extract. Some of the treatments reduced the production of TNF-alpha by 80 percent and IL-1-beta by more than 99 percent, compared with the production of those compounds by cells free of sorghum bran.

Burdette's team also wounded the ears of mice with a toxic chemical that induced swelling and substantial inflammation within 6 hours. Applying a sorghum-bran extract to the area 30 minutes after the chemical exposure reduced swelling by 60 percent, the researchers found.

The bran treatment also cut by 70 percent the number of neutrophils—another type of white blood cell—sent to the wound as part of the immune response. This effect was comparable to what the researchers achieved by treating the wounded animals with the anti-inflammatory drug indomethacin, often used to treat arthritis. Burdette reported her findings in Washington, D.C., on April 29 at the Experimental Biology '07 meeting.

She says that the preliminary data suggest that enriching diets with sorghum might offer a good alternative to some pain medications. —J.R.

BIOMEDICINE

Embryos, please

Almost half of Spanish couples recently asked to donate their excess embryos to stem cell research did so.

The response of 97 couples who had undergone in vitro fertilization treatment at two Spanish clinics contrasts sharply to the situation in the United States, where a 2003 review found that just 3 percent of surplus embryos were going to stem cell research.

In the Spanish study, 49 percent of couples agreed to donate their embryos to that type of research, 44 percent decided to keep their embryos on ice indefinitely, 7 percent gave their embryos to other infertile couples, and less than 1 percent decided to discard their embryos, according to a report published online and in the July *Cell Stem Cell*.

In-depth briefings from an embryologist and a lawyer prompted the high donation rate, say Pablo Menendez and his colleagues at the Spanish Stem Cell Bank in Granada and Madrid.

Couples learned about specific research projects for which the embryos would be used and received counseling on relevant legal issues. The authors say that the briefings were unbiased but that 2 hours of "per-

OF NOTE

sonal attention could be a persuasive factor" in convincing couples to donate.

Also, the couples had undergone in vitro fertilization at least 3 years prior to the interviews, and a third of the women had successfully given birth, "circumstances that make the decision to donate surplus embryos for research more appealing," say the authors.

An in vitro fertilization attempt typically produces a half dozen or more excess embryos. In the United States, some 400,000 such embryos remain in deep freeze. In Spain, some 100,000 excess embryos exist. —B.V.

ENVIRONMENT

Emissions tied to global warming are on the rise

The United States emitted nearly 1 percent more greenhouse gases in 2005 than it did in 2004, according to an emissions inventory from the Environmental Protection Agency. From 1990 to 2005, the country's greenhouse-gas emissions rose 16.3 percent.

The leading greenhouse gases released in the United States are carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. In 2005, the combined output of these gases was equivalent to the emission of 7,260 billion kilograms of carbon dioxide.

Carbon dioxide discharged by fossil fuel combustion accounted for 79 percent of the 2005 total. Forty-one percent of this carbon dioxide was from electricity generation, and 33 percent came from ground and air transportation, the agency reported on April 15.

Landfills, coal mining, and natural gas systems are the major human-caused sources of methane, while nitrous oxide arises mainly from fertilizer applications and other farming practices, along with the burning of fuel for transportation. —A.C.

FOOD & NUTRITION

Slimming on oolong

Without skimping on portions, rats eating diets including oolong tea gain less weight than those dining teafree, a new study finds. The tea apparently impairs the body's ability to absorb fat.

The finding supports a weight-control strategy—oolong consumption—advocated by practitioners of traditional Chinese medicine, note Lauren E. Budd and her colleagues at the University of California, Davis.

The researchers worked with a strain of adult female rats that spontaneously become obese on a normal diet. For 10 weeks, the team let the animals eat all they wanted but laced the chow of some with a dried extract of brewed tea. Although all the animals ate about the same amount, Budd says, those getting 2 and 4 percent of their food as tea extract by weight gained only about 40 and 20 grams, respectively, over the period. Rats consuming unsupplemented chow packed on roughly 120 grams each.

The 2 percent dose corresponds to the amount of solids in about six cups of strongly brewed tea per day, Budd says.

Blood concentrations of triglycerides—fats—were about 80 percent lower in the tea-treated rats than in those eating unsupplemented chow, Budd reported on May 1 in Washington, D.C., at the Experimental Biology '07 meeting. Tea-treated animals also accumulated just 12 to 20 percent body fat, versus about 35 percent in animals eating unsupplemented chow.

Saponins, waxy substances from the tea leaves, alter how the body processed some fat, which then moved through the gut without being absorbed, says Budd's colleague Judith S. Stern. —J.R.

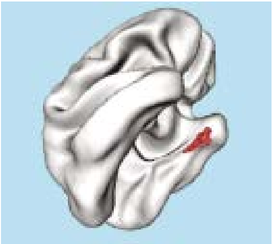
NEUROSCIENCE

Alzheimer's clues from thin brains

Some kids on the cusp of adolescence display a genetically influenced brain trait that may raise their likelihood of developing Alzheimer's disease later in life. The entorhinal cortex, a neural area targeted by this devastating condition, is substantially thinner in youths who possess a gene variant previously linked to Alzheimer's disease than it is in their peers who inherit other versions of the same gene, say Philip Shaw of the National Institute of Mental Health in Bethesda, Md., and his coworkers.

Young people with the Alzheimer's-related variant of the *apolipoprotein* (*ApoE*) gene, which influences brain-cell repair, showed no IQ differences compared with those who had other variants of the gene, Shaw's group reports in the June *Lancet Neurology*.

However, such individuals may be prone to mental declines as the entorhinal cortex shrinks with age, the scientists theorize.



THINNED OUT A view from beneath the brain, with its front at top, shows the left entorhinal cortex (red). Youths with an Alzheimer's-related gene variant display an especially thin entorhinal cortex.

SHAW/NIMH CHILD PSYCHIATRY BRANCH

Prior studies implicated one of three versions of the *ApoE* gene in Alzheimer's disease. The critical variant occurs in 40 percent of people who develop the brain disorder late in life. That's at least double the prevalence of that variant in the general population.

Shaw and his colleagues studied 239 children and teens, 65 of whom possessed the Alzheimer's-related *ApoE* variant. Magnetic-resonance imaging scans measured tissue thickness in each volunteer's entorhinal cortex. Most participants returned for one or more scans at roughly 2-year intervals.

A relatively thin entorhinal cortex represents a stable trait in people with the Alzheimer's-related *ApoE* variant, the researchers add. From one brain scan to the next, the entorhinal cortex didn't get thinner during the study. —B.B.

ZOOLOGY

Face it: Termites are roaches

Termites are just cockroaches with a fancy social life, according to the biggest DNA study yet of the two groups.

The idea's been "simmering," says Paul Eggleton of the Natural History Museum in London. To perform a definitive test, he and his colleagues assembled a set of specimens including 107 species of termites, roaches, and the closely related mantids. Analysis of five DNA sequences that appear, with variations, in all the insects revealed their evolutionary relationships, which the researchers describe in the June 7 *Biology Letters*.

"We have to face the fact that termites are cockroaches," says Eggleton. His sober tone comes from expecting resistance to changing the classification of termites, which currently boast their own insect order. They would become instead a family in the roach order, Eggleton says. He studies termite ecology and will feel the pain himself. "I'm guilty of killing my own order," he says.

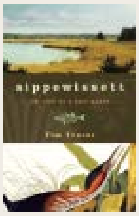
The upside, he says, comes from refining insect classifications to reflect evolutionary relationships.

For example, Eggleton says, the new classification shows termites closely related to wood-eating roaches. He proposes that the highly developed social life of termites got its start when ancient roaches began sharing specialized gut protozoa that digest wood. —S.M.

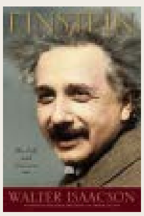
Books

A selection of new and notable books of scientific interest

SIPPEWISSETT, OR, LIFE ON A SALT MARSH
TIM TRAVER
The Sippewissett Marsh on Cape Cod represents a microcosm of the planet, environmentalist Traver asserts. The author recounts personal memories as well as environmental-research findings. Scientists including Louis Agassiz and Rachel Carson studied the ecosystem and its wildlife. Traver's own visits have been for both recreation and learning. His stories introduce readers to anglers who attest to declining populations of striped sea bass, bird-watchers looking for golden plovers, and researchers from Woods Hole Oceanographic Institute. Each chapter is devoted to a different, and generally disheartening, aspect of the marsh, from the oysters and clams threatened by pollution to the eroding sand dunes and thinning stands of eelgrass. Finally, he addresses how both spiritual and scientific understandings of the marsh might increase its chance of survival. ***Chelsea Green, 2006, 250 p., b&w illus., hardcover, $22.50.***

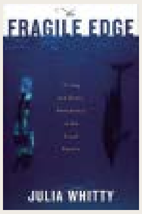


EINSTEIN: His Life and Universe
WALTER ISAACSON
In this first full biography since the release of a hoard of Albert Einstein's letters, Isaacson, the chief executive officer of the non-profit Aspen Institute, chronicles the life of the past century's most famous scientist. Isaacson begins by following Einstein through his unremarkable childhood, education, and young adulthood to the miracle year 1905, when he wrote three seminal papers that would make him world famous. The story then turns to the physicist's relationship with and eventual marriage to Mileva Marić and his personal challenges in completing his doctoral degree. Einstein's subsequent professorship marked the beginning of the end of his marriage. Facing havoc in his personal life, he retreated to his work. Isaacson profiles Einstein's support for arms control after his work led to the creation of the atomic bomb. Late in life, Einstein searched in vain for a theory to unify the physics that he had redefined. ***Simon and Schuster, 2007, 675 p., b&w plates, hardcover, $32.00.***

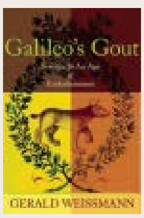


THE SONGS OF INSECTS
LANG ELLIOTT AND WIL HERSHBERGER
Late summer is characterized by symphonies of crickets, katydids, and cicadas, a cacophony that can go on day and night. This book profiles the songs of 77 insects in the eastern and central United States and Canada. Following a guide to spotting singing insects, naturalist-photographers Elliott and Hershberger provide details of the anatomical mechanisms behind sound production, insect hearing, songs' structures, and their functions in courtship and other parts of the insect life cycle. For each species of insect musician, the authors provide the common and scientific names, a general physical description with pictures, a range map, and a description complete with frequencies and a visual representation in the form of a sonogram. The book includes maps of where 17-year cicadas live and predicts their years of emergence. An audio CD is included. ***Houghton Mifflin, 2007, 228 p., color images, paperback, $19.95.***

THE FRAGILE EDGE: Diving and Other Adventures in the South Pacific
JULIA WHITTY
Thousands of miles from continental landmasses, in the southern Pacific Ocean, lies the Rangiroa atoll. Whitty, a diver and author, travels to this remote location to dive in one of the most dynamic reef systems on Earth. In this vivid and personal account, she details her underwater encounters as well as her experiences with local people topside. She delves deep into the Polynesian people's connection with the ocean. Her travels extend to the Funafuti atoll, where rising sea levels are an immediate threat to inhabitants, not just an environmentalist's talking point, Whitty writes. The author's bottom line is that people rely on the ocean and so conservation efforts must include the seven-tenths of the planet that lie underwater. ***Houghton Mifflin, 2007, 292 p., hardcover, $25.00.***



GALILEO'S GOUT: Science in an Age of Endarkenment
GERALD WEISSMANN
Weissmann laments the science illiteracy of many U.S. citizens: One in five believes that the sun revolves around the Earth. He calls the trend the "endarkenment," the opposite of the Enlightenment of the 18th century and akin to the Spanish Inquisition. He also deplores the encroachment of the intelligent design concept —creationism—on modern science. He sees danger in the fact that at least 10 states have pending legislation to mandate that intelligent design be taught as an alternative to Darwinian evolution. Weismann, a physician and research professor at New York University, presents a wide-ranging history of science and medicine. He discusses how various inspired experiments led to discoveries such as that DNA is the blueprint for life. While praising methodologies that produced such findings, Weismann doesn't shy away from discussing science's and medicine's failings. These include the stem-cell fraud perpetuated by Korean scientists and the problems caused by overly expensive medical care. Returning to the encroachment of faith on science, Weissmann frets over the threat of religion and politics to dictate appropriate and inappropriate research, as seen in protests against embryonic stem cell research and the increased credibility given to dubious folk and herbal-medicine treatments. ***BLP, 2007, 192 p., hardcover, $25.00.***



HOW TO ORDER Visit *http://www.sciencenews.org/pages/books.asp* to order these books or others. A click on a book's title will transfer you to the Amazon.com bookstore. Sales generated through these links contribute to Science Service's programs to build interest in and understanding of science.

LETTERS

Merry go round

When considering a spin rate of 1,122 revolutions per second, has anyone determined the diameter of the neutron star XTE J1739-285 ("Dance of the dead," *SN: 3/17/07, p. 173*)? If, for example, it were the same diameter as Earth, it would be traveling far in excess of the speed of light at its equator. In order to remain within the limitations of the speed of light its diameter would have to be less than a hundred miles!
R.G. PAUL, UPLAND, CALIF.

What is the maximum rate before the star flies apart from the rotation forces?
SEAN WALTON, OREM, UTAH

The speed of light would limit the star to a 43-kilometer radius, says astronomer Phil Kaaret of the University of Iowa in Iowa City. He adds that there's little surprise in that, since the expected radii of neutron stars are in the range of 10 to 20 km. The maximum rotation rate would be between 1,000 and 2,000 rotations per second, depending on the properties of the ultradense matter in the star, says Kaaret. —R. COWEN

Captcha gotcha

It is ironic that the article "Games Theory" (*SN: 3/17/07, p. 170*) describes a captcha [completely automated Turing test to tell computers and humans apart] and then goes on to demonstrate how to defeat it. An automated program that is supposed to pass this difficult computation test just has to forward the captcha image to a real person, at a different Web site, who will then unwittingly assist the automated program. The only challenge is to make it "fun" or otherwise compelling for the unwitting person.
JOHN HASELSBERGER, ALLENTOWN, PA.

Plant with caution

I find it absolutely incredible that anyone is seriously contemplating an escalation of "natural" herbicides ("Herbal Herbicides," *SN: 3/17/07, p. 167*). As there is no "additive" sprayed on the crop, no testing is likely in animal or human clinical trials. We in the first world must bear the brunt of this wholesale testing on populations, as we have with so many other advances in agriculture and technology.
CARSON BARNES, LOMA MAR, CALIF.

SEND COMMUNICATIONS TO:
Editor, Science News
1719 N Street, N.W., Washington, D.C. 20036
or editors@sciencenews.org
All letters subject to editing.