MAY 26, 2007 PAGES 321-336 VOL. 171, NO. 21

SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

tuberculosis' telltale genes

sun's violent youth

virgin birth for bonnethead

viagra for jet lag

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soaking up the sun

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Features

This Week

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

Food for Thought Chocolate is the source of a bitter tooth-decay-fighting extract.

MathTrek Mathematicians can cover larger areas than they'd realized using polygons with fixed diameters.

Of Note

Departments

Cover Solar cells cover the roof of the Highlands Patrol Headquarters building at the Aspen Mountain Resort in Aspen, Colo. Scientists are seeking to improve such technologies so that sunlight, the most abundant of all renewable energies, can be a major source of power. (National Renewable Energy Laboratory)
Page 328

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Violent Past

Young sun withstood a supernova blast

A big bully pummeled our sun in its infancy, fatefully altering the composition and evolution of the solar system, a new study suggests. The heavy, in this case, was a nearby, massive star. First, the massive star pounded the young sun with fierce winds. Then, the tyrant exploded, blasting the sun with shock waves that suffused it and its embryonic planets with iron.

Evidence for this early, violent episode comes from meteorites—rocky leftovers from the planet-forming process. Martin Bizzarro of the University of Copenhagen and his colleagues set out to determine the amount of iron in the early solar system. To do so, they measured nickel-60, a decay product of iron-60, in eight meteorites known to have formed at different times during the first 3 million years of the solar system.

The meteorites that formed more than about a million years after the start of the solar system contain significantly more nickel-60 than do those that formed earlier, the team found. In a neighborhood of young stars, only a supernova could have produced iron-60, the parent of that nickel.

In contrast, all the meteorites, regardless of age, contain about the same proportion of aluminum. That element doesn't require a supernova source.

These findings drastically revise a 30-year-old story line for the origin of the solar system, the researchers say in the May 25 *Science*. In that scenario, a supernova triggered the collapse of the ball of gas and dust that became the sun. But the new data suggest that the sun had already formed about a million years before the supernova explosion.

The sun acquired its aluminum at birth or immediately afterward, Bizzarro says. The fact that all the meteorites had about the same amount of that element suggests that its source was a copious wind expelled by a massive star. The star had to be about 30 times as heavy as the sun, Bizzarro's team calculates. Within a million years, that behemoth—which would have resided only about a light-year from the newborn sun—went supernova, driving grains of iron-60 into the sun as well as into surrounding material that would eventually form planets.

"This is a convincing argument that you had an injection of iron-60 about 1 to 2 million years after the birth of the sun," comments Steve Desch of Arizona State University in Tempe. The only source for that iron "that makes any sense whatsoever is a nearby supernova," he adds.

Massive stars tend to be born in clusters, and the study suggests that the sun and its explosive neighbor were products of a star-making factory that might have yielded thousands of stars some 4.5 billion years ago.

It may seem surprising, Desch says, that a massive star could explode so close to the newborn sun without destroying it. But work by Desch and his Arizona State colleagues Jeff Hester and Nicolas Ouellette, to be reported in an upcoming *Astrophysical Journal*, indicates that a newborn star could survive a supernova that pops off as close as a third of a light-year away.

Still, theorist Frank Shu of the University of California, San Diego cautions that a nearby, massive supernova might generate a host of additional effects on the young sun. —R. COWEN

M. ROBBERTO, NASA, ESA, HST ORION TREASURY PROJECT TEAM

ROUGH UPBRINGING The Orion star-making factory is one of the closest stellar nurseries to Earth. New evidence suggests that the sun was born in such a factory and that a massive neighbor exploded soon after the sun's birth.

Virgin Birth

Shark has daughter without a dad

Geneticists have confirmed a case of birth without mating in a bonnethead shark, one of the smaller hammerhead species. That makes sharks the fifth major vertebrate lineage with documented virgin births.

The mother bonnethead (*Sphyrna tiburo*) lives at the Henry Doorly Zoo in Omaha, Neb., far from any males of her kind. Her infant, born nearly 6 years ago, was killed by other fish in the zoo's aquarium. DNA analysis of its preserved tissues revealed no evidence of genes other than its mother's, researchers report online in *Biology Letters*.

Sharks belong to an ancient vertebrate lineage, notes Mahmood Shivji of Nova Southeastern University's Guy Harvey Research Institute in Dania Beach, Fla. As one of the team confirming the shark's sex-free reproduction, he says that the finding "means this ability evolved very early on in vertebrate evolution."

This kind of reproduction, parthenogenesis, "is probably more widespread" than biologists have realized, comments Ed Heist of Southern Illinois University in Carbondale. Parthenogenesis may seem weird to people, but DNA analysis has confirmed some form of it among bony fish, amphibians, reptiles, and birds. "I think mammals are the odd ones," Heist says.

The bonnethead birth came as a surprise. On Dec. 14, 2001, zookeepers in Omaha discovered a newborn along with their usual three bonnetheads, all adult females.

The females, captured near the Florida Keys, arrived at the zoo before they had matured sexually. They had lived in all-female bonnethead groups for about 3 years.

That isolation didn't prove virgin birth. But other scenarios also had problems. For example, bonnetheads can store

sperm, but no one had documented such storage for more than 5 months, or that juveniles would mate in the first place. Alternatively, the mother could have uncharacteristically mated with a male of another shark species at the zoo.

At a shark-biology meeting in 2004, zoo interns described their mystery to Demian Chapman, now at the Pew Institute for Ocean Science at the University of Miami. Chapman gave a talk about

DADS EXCLUDED This infant bonnethead, which had a mother but no father, represents the first documented example of parthenogenesis in sharks.

genetic markers that can identify individual bonnetheads.

He and his colleagues agreed to check the infant tissue and the three possible mothers to figure out the infant's origin. "Ninety percent or more of shark biologists, including myself, thought [the answer] was going to be sperm storage," he says.

Instead, the team found that the infant shark carried a portion of the genes of one Omaha female but no contribution from a male.

That finding suggested a particular kind of virgin birth called automictic parthenogenesis, previously reported in a komodo dragon (*SN: 12/23&30/06, p. 403*) and some snakes. As in sexual reproduction, youngsters acquire one set of chromosomes when the mother's chromosomes split during egg making. But instead of uniting with similarly split chromosomes from sperm, that set somehow pairs with a copy of itself. The resulting baby "isn't a clone," says Chapman. "It's half a clone." —S. MILIUS

Circadian Fix

Viagra may lessen effects of jet lag

The leading drug prescribed for male impotence can counteract the lethargy caused by a disruption in the sleep cycle, a study in rodents suggests. Sildenafil, commonly known as Viagra, helps hamsters rebound from a 6-hour clock change such as a long eastbound plane flight produces.

To mimic conditions that can lead to jet lag, scientists habituated hamsters to a daily routine of 14 hours of light and 10 hours of darkness. The researchers then abruptly switched on the lights 6 hours early and continued the same light-to-dark routine from that point onward, simulating the effects of a flight from Chicago to London.

Just before changing the hamsters' routine, the researchers injected each animal with either sildenafil or saline solution. Then, they observed how long it took the hamsters to restart their daily habit of running on a wheel.

Hamsters receiving a large single dose of sildenafil resynchronized their body clocks and resumed their usual wheel routines within 6 days. Hamsters getting a lower dose took 8 days, whereas those receiving the inert injection took 12 days, the scientists report in an upcoming issue of the *Proceedings of the National Academy of Sciences*.

Circadian rhythm in mammals is controlled mainly by neurons in the hypothalamus, says study coauthor Patricia V. Agostino, a neuroscientist at the National University of Quilmes in Bernal, Argentina. When the vision system detects light, it sends stimuli to the hypothalamus and sets off a series of events that generate wakefulness. "Light is the main synchronizer of the circadian clock," Agostino says.

A compound called cyclic guanine monophosphate (cyclic GMP) plays a role in regulating circadian rhythm. In the hamster study, scientists measured the animals' blood concentrations of cyclic GMP 45 minutes before changing the light-dark schedule. Compared with hamsters receiving saline shots, the animals injected with sildenafil had double the amount of cyclic GMP. Sildenafil shuts down enzymes that would limit cyclic GMP production, but Agostino's team isn't certain that this is how the drug restores circadian rhythm.

"This resetting of the clock seems to be novel," says pharmacologist Joseph A. Beavo of the University of Washington School of Medicine in Seattle. He cautions that the new research is only on rodents, but since sildenafil is a widely used drug, a sampling of men who travel frequently and take it might turn up any stabilizing effect on circadian rhythm, he says.

Most travelers who experience jet lag find that the effects are strongest after an eastbound flight, which shortens the day and pushes the circadian clock forward. Interestingly, sildenafil's circadian readjustment worked only in animals whose circadian rhythms had been advanced, Agostino says. That suggests that the drug would work for eastbound travelers and airline personnel, as well as some shift workers, she says. —N. SEPPA

Fish Free Fall

Hormone leads to population decline

Trace amounts of natural and synthetic estrogens released into the environment by wastewater-treatment plants are known to cause reproductive abnormalities in fish. Researchers have now found an even more dramatic consequence of exposure to the synthetic estrogen used in birth control pills—the near extinction of a fish population.

Women taking birth control pills excrete the synthetic estrogen 17alpha-ethynylestradiol along with natural estrogens. Male fish exposed to estrogens at concentrations of only a few parts per trillion (ppt) can become intersexual, displaying male and female tissues in their gonads (*SN: 3/10/07, p. 152*).

"A big question remained," says Karen A. Kidd, an ecotoxicologist at the University of New Brunswick in Canada. "Can these males still successfully reproduce, or are fish populations at risk?"

In 1999, Kidd, then at Fisheries and Oceans Canada in Manitoba, and her colleagues began a study at the Experimental Lakes Area, a facility in northwestern Ontario set aside for whole-lake experiments. For 2 years, the team gathered data on species in one study lake and in two reference lakes. During the summers of 2001 through 2003, the researchers added 17alpha-ethynylestradiol to the study lake three times per week, maintaining a concentration of 5 to 6 ppt.

The researchers focused on a common species of fish, the fathead minnow, which they collected from the lakes at regular intervals from 1999 through 2005. They examined changes to its reproductive system and monitored its population.

By the spring of 2002, the scientists observed delayed sexual development of all the males collected. A year later, some males also had early-stage eggs in their

HENRY DOORLY ZOO

testes. "These are all the responses we expect to see, based on what's been found in other studies," says Kidd.

But beyond those effects, as the researchers report online and in an upcoming *Proceedings of the National Academy of Sciences*, the number of fathead minnows in the lake plummeted. The estimated fish population dropped by a factor of a thousand from 1999 to 2005. "By the end of the seventh year, only a handful of fathead minnow were left," says Kidd.

Aquatic ecotoxicologist Susan Jobling of Brunel University in Uxbridge, England says that to be clearly environmentally relevant, the study's estrogen concentration would have to be "a little bit lower." Recent studies pin the concentration of 17alpha-ethynylestradiol in the environment to less than 1 ppt, she says, but "that doesn't take away from the importance of the study, that population level effects have been demonstrated."

David L. Sedlak, an environmental chemist at the University of California, Berkeley, agrees that it's an "elegant and useful study," even though the estrogen concentration was on the high side. For waterways that receive most of their flow from sewage-treatment plants, improvements in technology would help. "This is a problem that can be solved with treatment," he says. —A. CUNNINGHAM

LAKE LOSS The population of fathead minnows (top) in a test lake (bottom) collapsed after researchers added the synthetic estrogen 17alpha-ethynylestradiol.

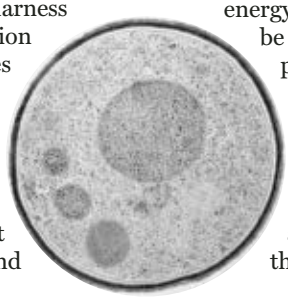
C. PODEMSKI; J. SHEARER; J. NOSANCHUK/PLOS ONE

Dark Power

Pigment seems to put radiation to good use

Call them the Hulk bugs. Just as they do for the comic book hero, gamma rays seem to make certain microscopic fungi stronger. Researchers have found hints that melanin—the same pigment that's the natural ultraviolet filter in people's skin—might enable these fungi to harness the energy of gamma radiation as well as to shield themselves from it.

Microbiologist Arturo Casadevall of the Albert Einstein College of Medicine in New York City recalls learning several years ago that single-cell fungi had been found thriving inside the collapsed nuclear reactor at Chernobyl, Ukraine. He and his colleagues later saw reports that the cooling water in some working nuclear reactors turns black from colonies of melanin-rich fungi.



TAN CELL A dark melanin layer surrounds a *Cryptococcus neoformans* cell. Under intense radiation, the fungus grows faster than normal.

Nuclear reactors are intense sources of gamma rays, which can zap through living organisms and leave behind trails of destruction. Many microorganisms can survive in extreme environments, but Casadevall thought that something more might be going on. Perhaps the fungi were growing thanks to the radiation, not in spite of it. "The thought was that biology never wastes any energy source," he says.

Casadevall says that fungi such as *Cryptococcus neoformans*—which causes grave infections in AIDS patients—have layers of melanin on their membranes. Melanin is rich in radicals—molecules with highly reactive unpaired electrons—that may help fend off attacks by the immune system of any organism that the fungus is trying to infect. But Casadevall wondered whether these layers might also turn gamma ray energy into a form the cell could use.

To test this hypothesis, Casadevall's team exposed colonies of *C. neoformans* to gamma rays 500 times as intense as the normal radiation background on Earth's surface. The colonies grew up to three times as fast as normal. A mutant "albino" form of the fungus, which produced no melanin, grew at a normal pace, the team reports online in *PLoS ONE*.

But the accelerated growth didn't prove that the fungi drew energy from the radiation, Casadevall says, so the researchers took a closer look at melanin.

In one experiment, they found that gamma rays induced a four-fold increase in melanin's ability to catalyze an oxidation-reduction reaction typical of cell metabolism.

They also tested melanin's response to gamma rays using electron spin resonance, a technique similar to nuclear magnetic resonance spectroscopy. Gamma rays changed the distribution of unpaired electrons in the molecule, says Casadevall's Albert Einstein colleague Ekaterina Dadachova.

These findings suggest that gamma rays kick some melanin electrons into excited states, initiating a yet-unknown process that would end up producing chemical energy, Casadevall says. This might be similar to the way in which photosynthesis supplies energy to plants, he adds. He speculates that melanin might collect energy not only from gamma rays but also from lower-energy radiation such as X rays or ultraviolet rays. "I think this is only the tip of the iceberg," he says.

The findings are interesting, says Darrell Fisher, a radiation biologist at the Pacific Northwest National Laboratory in Richland, Wash. However, he says, "one must be careful not to draw unwarranted conclusions." If radiation enhances the growth of fungi, he says, it's "important to understand and test the underlying mechanisms." —D. CASTELVECCHI

Face Talk

Babies see their way to language insights

To a 4-to-6-month-old baby, a talking face that can be seen but not heard still speaks volumes. Infants in that age range can distinguish between two languages solely by looking at a speaker's face, without hearing a sound, a new study suggests.

This ability declines between 6 months and 8 months of age, at least for infants exposed to only one language at home, reports a team led by psychologist Whitney M. Weikum of the University of British Columbia in Vancouver. Previous studies had found that performance drops on similar perceptual tasks toward the end of a baby's first year. Infants around that age, for example, lose the ability to match monkeys' facial movements to the corresponding sounds (*SN: 4/22/06, p. 246*).

However, 8-month-olds can visually discriminate between two spoken languages if they live in bilingual families that use those same tongues, Weikum's group finds.

"Visual information about speech may play a more critical role [in language learning] than previously anticipated," Weikum says. It's not yet clear what facial cues babies use to monitor a speaker's language, she says.

She and her colleagues describe their findings in the May 25 *Science*.

The researchers first studied 36 infants, equally split among 4-, 6-, and 8-month-olds, from English-speaking homes. Each baby sat on his or her mother's lap and viewed a series of silent video clips in

which a woman who was bilingual in English and French read sentences from a storybook in one of the languages.

After a while, infants consistently looked away from the clips, indicating boredom. The woman then read sentences from the other language. Only 4- and 6-month-olds returned to gazing at the clips, a sign of renewed attention or interest.

Another 36 infants of the same ages from English-speaking homes viewed the woman silently reading one set of sentences in English or French. When the babies showed signs of boredom, the woman began reciting different sentences in the same language. At all ages, babies showed no interest in new, same-language sentences.

Among 24 infants raised in families speaking both English and French, 8-month-olds, as well as 4- and 6-month-olds, looked substantially longer at clips after the woman switched from one language to the other.

The new findings support the idea that babies possess a set of perceptual filters that enable them to deal with broad classes of information, remarks psychologist David J. Lewkowicz of Florida Atlantic University in Boca Raton. Experiences during the initial months of life refine these perceptual sensitivities.

The next step is to see whether infants can match the face and voice of a person uttering a foreign language, and whether this matching ability also declines near the end of the first year, Lewkowicz says. —B. BOWER

SAY WHAT? At ages 4 months and 6 months, but not at 8 months, babies from monolingual families discern their own language from a foreign one by watching a speaker's facial movements in silent video clips.

Hot Competition

Students display winning projects

In Albuquerque, visitors must decide between red and green chilies, but last week, a different kind of spice heated up the town. At the 2007 Intel International Science and Engineering Fair (ISEF), more than 1,500 high school students from 51 countries displayed projects with tongue-tingling titles.

BEAMING TEENS Dayan Li, Philip Streich, and Dmitry Vaintrob (left to right) nab the top prizes at the International Science and Engineering Fair.

Students competed for more than $4 million in scholarship money, computers, trips, and other awards. The big-enchilada prizes went to Dayan Li of Eleanor Roosevelt High School in Greenbelt, Md., Philip Vidal Streich, a home schooled student from Platteville, Wis., and Dmitry Vaintrob of South Eugene High School in Oregon.

Each student won the Intel Foundation Young Scientist Award and a $50,000 scholarship. Li, 17, found that nitric oxide, which normally inhibits blood vessel growth, stimulates growth in vessels supporting tumors if a protein called thrombospondin-1 (TSP1) is present. That calls into question the use of cancer drugs that boost TSP1.

Streich, 16, proved that carbon nanotubes are soluble in methyl-2-pyrrolidone, contradicting a general assumption that no solvent would dissolve nanotubes. The discovery, he says, could lead to "revolutionary new composite materials" that could be practical for ultralightweight airplanes and bulletproof vests. Vaintrob, 18, found a new way to connect two kinds of descriptions of mathematical shapes, algebraic structures and topological spaces. "I like the fact that [math is] abstract and beautiful and makes sense always," he says.

Vaintrob also won a trip to the Nobel prize ceremonies in Stockholm this December as part of the Stockholm International Youth Science Seminar. Joining him will be George Francis Hotz, 17, of Bergen County Academies in Glen Rock, N.J., and Temple Mu He, 18, of Troy (Mich.) High School. He modeled a binary star system, and Hotz used flashing lights and a spinning screen to create three-dimensional images.

A team from Trium Udom Suksa School in Bangkok—Natnaree Siriwon, 17, Korawich Niyomsatian, 18, and Nathaphon Supokaivanich, 18—won a trip to the European Union Contest for Young Scientists in Valencia, Spain, this September. They studied how mimosa leaves fold.

For their research on microlithography, Jacob Charles Loewenstein, 17, of Hebrew Academy of the Five Towns & Rockaway in Cedarhurst, N.Y., and Brienne Ashley Kugler, 18, of Jericho (N.Y.) Senior High School will attend the 11th annual Expo Science International for young scientists in Durban, South Africa, in July.

A $5,000 scholarship and an Intel laptop went to the strongest competitor in each of 17 categories. Category winners included Li for cellular and molecular biology; Streich for chemistry; Vaintrob for math; Hotz for electrical and mechanical engineering; He for physics and astronomy; Yihe Dong, 16, of Cedar Shoals High School in Athens, Ga., for animal sciences; Mary Martha Ferrari Douglas, 18, of Manhasset (N.Y.) High School for behavioral and social sciences; Mihika Pradhan, 16, of Hamilton-Wenham Regional High School in South Hamilton, Mass., for biochemistry; Raeez Lorgat, 16, of Rondebosch Boys' High School in Cape Town, South Africa, for computer science; Hannah Louise Wolf, 16, of Parkland High School in Allentown, Pa., for earth and planetary sciences; William Campbell Martin, 18, of Saginaw (Mich.) Arts & Sciences Academy for materials and bioengineering; Siyabulela Lethuxolo Xuza, 18, of St. John's College in Johannesburg for energy and transportation; Chan Ka Kin, 18, of Hong Kong Chinese Women's School for environmental management; Graham William Wakefield Van Schaik, 17, of Spring Valley High School in Columbia, S.C., for environmental sciences; Patrick Ming Chen, 17, of Oregon Episcopal School in Portland, for medicine and health sciences; Eric Nelson Delgado, 17, of Bayonne (N.J.) High School for microbiology; and Tanja Kellerman, 18, of Citrusdal (South Africa) High School, for plant sciences.

"The enthusiastic participation of a record-breaking number of students and countries is a reflection of the global embrace of science," says Elizabeth Marincola, president of Science Service, which publishes *Science News* and has organized the ISEF since its inception in 1950. Intel is the title sponsor of the competition, and other corporations and organizations contribute support. —E. SOHN

SCIENCE; INTEL CORP.

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Teaching algebra in most of today's classrooms is not significantly different from what it was 50 years ago. Certainly, there have been some attempts to change algebra instruction, such as the "new math" reform movement of the 1960s. But the changes that persist in today's algebra curricula as a result of that movement are more superficial than substantial.

On the other hand, mathematics and its applications have changed spectacularly in the past 50 years. The advent of technology, for example, in both applied and pure mathematics, has changed the way mathematicians, scientists, and social scientists do and use mathematics.

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REACHING FOR RAYS

Scientists work toward a solar-based energy system

BY AIMEE CUNNINGHAM

In the bright blue skies that he enjoys from his academic perch in southern California, Nathan S. Lewis sees the answer to the world's energy needs. "The sun is the champion of all energy sources," says Lewis, a chemist at the California Institute of Technology in Pasadena. "More energy from the sun hits the Earth in 1 hour than all of the energy consumed by humans in an entire year."

Lewis and other scientists consider the sun's rays the optimal means of satisfying the planet's substantial—and ever-growing—energy habit. In 2001, the world consumed energy at an average rate of more than 13 trillion watts (terawatts, TW), according to the Department of Energy. Taking into account population increases, worldwide economic growth, and conservation and energy-efficiency measures, some researchers predict that the global energy-consumption rate will double by 2050 and triple by the end of the century.

Of that 2001 energy consumption, 86 percent derived from coal, oil, and natural gas. However, evidence tying global warming to the carbon dioxide that these fossil fuels pump into the atmosphere continues to grow (*SN: 2/10/07, p. 83*). "As we go hunting around for how to replace fossil fuels, solar is the one place where we can see a truly abundant and renewable resource," says A. Paul Alivisatos, a materials scientist at Lawrence Berkeley (Calif.) National Laboratory and the University of California, Berkeley.

Among non–fossil fuel choices, the sun offers by far the deepest energy reserves. To achieve energy generation of 10 TW through nuclear power, a 1-gigawatt electric-power plant fueled by nuclear fission would need to be built every one and a half days for the next 45 years, says Lewis. The remaining exploitable hydroelectric resources around the world could contribute less than 0.5 TW, according to the United Nations. And the Intergovernmental Panel on Climate Change estimates that the total amount of extractable wind power available worldwide is 2 to 4 TW.

The sun, however, showers Earth with energy at a rate of 120,000 TW, notes Lewis. Added together, the other energy sources "aren't even close to the amount of energy the sun gives," he says.

But the planet is taking advantage of only a tiny slice of the sun's largesse. Less than 0.1 percent of the world's electricity came from the sun in 2001, according to the Department of Energy. A major issue is cost. For current silicon-based solar cells, the price of electricity must be around 30 cents per kilowatt-hour to make up for the cost of the installed system, notes Lewis. This can't compete with fossil fuel–derived electricity, which now costs less than 4 cents per kilowatt-hour, he says.

Moreover, "the sun has this nasty habit of going out locally every night," Lewis continues. "Unless you can find a way to cost-effectively store massive amounts of energy, then the sun could only be a peak supplement on a sunny day."

A completely solar-based system would not only create electricity for immediate use but also turn some of the sun's energy into fuel that would power homes or vehicles when the sun isn't shining. Realizing this vision will require breakthroughs in chemistry, physics, materials science, and engineering, scientists say. Some researchers are focusing on solar capture and its conversion to electricity. Others are examining strategies to store that energy in the chemical bonds of hydrogen gas that can later generate electricity in a fuel cell.

If the work succeeds, rolls of electricity-producing solar cells—processed like newsprint—could span rooftops and deserts, while other solar devices churn out hydrogen gas. "Every roof looks at the heavens," says Stephen R. Forrest, an electrical engineer at the University of Michigan in Ann Arbor. "So why can't it be generating energy?"

CREATING A BUZZ Solar cells already adorn some rooftops. The majority of these panels are made of silicon doped with two materials that create an electric field in the cell. When light strikes the cell, its energy frees electrons within the silicon. Driven by the electric field, the electrons travel to an electrode and thence into an electrical circuit. These cells convert 10 to 20 percent of the solar energy striking them into electricity.

> "More energy from the sun hits the Earth in 1 hour than all of the energy consumed by humans in an entire year."
>
> — NATHAN S. LEWIS, CALIFORNIA INSTITUTE OF TECHNOLOGY

Although the cost of purifying silicon has decreased over the years, scientists don't expect traditional silicon-based solar cells to become competitive with fossil fuels for electricity production.

So, researchers are looking for new solar cell technologies that combine high performance with low cost. "To really impact the [energy] problem, we have to come up with something that scales to big areas," Alivisatos says.

Some groups believe that the answer lies in solar cells composed of organic materials, nanomaterials, or both. Researchers have been developing organic solar cells in the laboratory for the past 20 years. Some of the earliest prototypes have been improved during this time, leading to devices that can convert up to 5 percent of light to electricity. Groups also continue to introduce new models in the quest for the right combination of materials, efficiency, and cost.

A common organic-based approach combines two materials in a film, explains Sean E. Shaheen, a physicist at the National Renewable Energy Laboratory in Golden, Colo. When light hits the cell, the sun's energy creates an exciton—an electron paired with its positively charged counterpart, a hole—in one of the materials, called the donor. But to become electricity, the electron needs to separate from the hole. This split occurs when the electron moves from the donor into the other material, called the acceptor. Freed electrons travel through the acceptor to one electrode, while holes

travel to another electrode. Those electrodes act as the poles of a battery do and can power an electric circuit.

Excitons can travel about 5 or 6 nanometers before they decay, so a donor-acceptor boundary should be available every 10 nm, says Shaheen. At the same time, the donor-acceptor mixture must have clear pathways to the electrodes, so that charges don't become trapped in islands of material.

Some of the recent research in organic solar cell technology focuses on ways to introduce a more orderly structure into the system. Forrest and his group make solar cells in which buckyballs—nanoscale cages of carbon—act as the acceptor and an organic material called copper phthalocyanine is the donor. In their latest version of these cells, the researchers formed the two materials into a crystallike network, which improved the mobility of the charges, they reported in March at the American Physical Society meeting in Denver.

A new approach, reported by Alivisatos and his colleagues in the February *Nano Letters*, combines hyperbranched nanocrystals of cadmium selenide with a polymer. The nanocrystals have diameters of 100 to 200 nm, says team member Neil A. Fromer. This matches the thickness of the composite film. Therefore, an electron released in the nanocrystal has a clear path to its electrode at the film's surface, says Fromer.

The structure of these composites is largely determined by the shapes and sizes of the nanocrystals, which the researchers can control. That makes the devices tolerant of slight variations that occur during mixing, which leads to better reproducibility for solar cells of this type, notes Fromer.

While this is an "exciting time" in solar cell research, says Alivisatos, he cautions that the latest technology remains very much laboratory based. "Nobody yet has achieved the kind of performance that's ultimately needed," he says.

"Our efficiency is too low," agrees Shaheen. Before organic solar cells can be ready for large-scale development, they'll need to demonstrate efficiencies of 10 percent or more, scientists say.

But the potential for low-cost manufacturing will also determine the future of this technology. That's "the promise of the organics," Shaheen says. It may be possible for an assembly process to print hundreds to thousands of square meters of these solar cells per day onto sheets of plastic. "Then, ideally, you have this big roll of solar cells," Shaheen says. "You unroll it, anchor it, plug it in, and you're ready to go."

LET THE SUN SHINE — Silicon-based solar cells cover the roof of the Georgia Institute of Technology's Aquatic Center in Atlanta.

HOLDING ON TO HELIOS To bask in the sun's energy at night or on a cloudy day requires storage. Current methods to store energy, such as batteries, aren't yet capable of storing the amounts necessary, says Daniel G. Nocera, a chemist at the Massachusetts Institute of Technology (MIT). "You don't want big, heavy batteries that are 10 times the weight of your car," he says.

Another solution—one that offers a much higher energy density, says Nocera—relies on chemical bonds. Plants store the sun's energy this way. A crucial step in photosynthesis is the splitting of water into hydrogen and oxygen. Plants release the oxygen and ultimately store the hydrogen in sugars.

Nocera and other chemists are working to better understand how nature splits water so that they can "build something artificial outside of the leaf," he says. By developing hydrogen- and oxygen-producing catalysts, chemists could use the sun's energy to break the bonds in water.

Engineers have already developed fuel cells that combine hydrogen and oxygen to create electricity. "What we are really interested in doing is making a fuel cell that runs in the reverse direction," says Christopher C. Cummins, an inorganic chemist at MIT.

Among the challenges is that water is a very stable molecule. Chemists know a great deal about reactions that, thermodynamically speaking, move downhill, releasing heat or some other form of energy as they proceed, says Cummins. But splitting water consumes energy. There is a dearth of chemical know-how about such uphill reactions, he notes.

To establish principles critical to water-splitting, Nocera's group has been working with a complex molecule incorporating ruthenium. This compound catalyzes the production of oxygen from water. With the mechanism in place, chemists could try making catalysts with more-abundant metals, such as iron or manganese, Nocera says.

Cummins' team has begun work on oxygen-producing catalysts that contain manganese or cobalt. The researchers are designing a new type of architecture in their catalysts to foster the formation of oxygen-oxygen bonds.

To complete the splitting of water, however, a second catalyst must jump-start a reaction that forms hydrogen gas. Jonas C. Peters of the California Institute of Technology and his colleagues will soon publish results on a hydrogen-producing catalyst that contains cobalt.

Ultimately, researchers would like to pour their newfound knowledge of water splitting into a device. Although this stage of the project would require some engineering and materials science expertise, the basics are as follows. The device would have two catalyst-containing segments—one to produce oxygen, the other to produce hydrogen. A barrier between the two would capture sunlight, much as a solar cell does, to power the reaction.

Working out the science behind artificial photosynthesis "is a hard problem—we shouldn't expect to be running a car on this soon," says Peters. But the good news, he adds, is that "we already know it's chemically doable, because plants do it."

SOLAR SUPPORT As researchers learn to better tap into the sun's rays, solar energy stands to become an important resource for the planet. Whether sunlight becomes the sole source of sustainable energy or works in concert with wind and other renewables, scientists are optimistic that the planet can break its dependence on fossil fuels.

"The research community really wants to work on this problem," says Alivisatos. "If you talk to young students about this, their eyes light up."

Some researchers point out, however, that the funding doesn't match the urgency of the energy situation. "It's incredible how slow we've been as a nation to actually start pumping the kinds of resources toward this problem that are commensurate with the problem," says Peters.

"We should treat energy in research like we treat health," says Lewis. "It's as great a challenge as curing cancer, except that in 20 years, if we don't cure cancer, the world will be the same. If we don't develop ways to provide people with clean, cheap energy, we absolutely know that we will have emitted so much carbon dioxide that the world isn't going to be the same." ■

NATIONAL RENEWABLE ENERGY LABORATORY

DANGEROUS HISTORY

The genetic secrets of a savvy killer

BY EMILY SOHN

Throughout recorded time, tuberculosis has wrought death among the people infected and frustration among those trying to tame it. As recently as the 1950s, prescribed treatment included little more than rest, sunlight, and fresh air. Today, patients take powerful drug cocktails for months. Even so, tuberculosis kills more people each year than any infectious disease other than AIDS.

And it is still unclear exactly how *Mycobacterium tuberculosis*, the bacterium that causes tuberculosis (TB) in people, does its damage. Other mysteries include why only some people get sick after being infected and why some outbreaks have managed so effectively to dodge vaccines and to resist antibiotic treatment.

In recent years, DNA analyses and fossil finds have revealed a surprising diversity in the genetic makeup of *M. tuberculosis*. Among its 4,000 genes, small but important differences appear to separate thousands of *M. tuberculosis* strains into distinct families, each with its own pattern of infection. A scientific community that long assumed TB had one genetic profile is now adapting to the idea that tens of thousands of years of evolution have sustained a pathogen that foiled human defenses by constantly changing.

As researchers piece together the *M. tuberculosis* family tree, they are finding tantalizing clues about why the pathogen has been so hard to get rid of and why new and virulent strains have repeatedly appeared in various places throughout history and are still showing up in Africa, Eastern Europe, and Asia today. The new information may eventually lead to better vaccines and treatments that target individual strains.

"It's been the default assumption for years that it's not really worth looking at the differences [among *M. tuberculosis* strains] because those differences must be so small," says David Sherman, a molecular geneticist at the Seattle Biomedical Research Institute. "It has become clear in the very recent past that there are differences that are clearly relevant, and we are only just scratching the surface" in understanding what those differences mean.

One-third of the world's population has TB, and a new person becomes infected every second, according to the World Health Organization. Most of those people show no symptoms of the disease until their immune systems become compromised by infection with the AIDS virus (HIV), by age, or by other factors.

When it does become active, TB usually strikes the lungs, though it can affect other organs such as the kidneys, liver, and bones. Nearly 2 million people die of the disease annually, and the death rate shows no sign of slowing. Many of those deaths are the work of new strains that resist most anti-TB drugs.

As the death toll continues to mount, scientists are scouring *M. tuberculosis* for weak spots. The work has been slow going, however, mostly because the bacterium takes its time, says Richard Chaisson, director of the Johns Hopkins Center for Tuberculosis Research Laboratory in Baltimore. Infectious bacteria such as *Escherichia coli* and *Streptococcus* species grow quickly in the lab and respond in minutes to tests with antibiotics or other drugs. But *M. tuberculosis* takes 24 hours to replicate, making lab experiments frustratingly slow. A trial of a new drug in animals, can take a year to complete because it takes that long to know whether all the bacteria in a given animal have been destroyed.

The bacterium is likewise hard to eradicate from an infected person, Chaisson says. A patient must take at least four drugs, for a period of 6 months or more. And if the patient stops treatment too soon, an all-too-common occurrence in developing countries, bacteria that develop drug resistance can survive.

> "We have to find out whether we need six or more vaccines."
>
> — SEBASTIEN GAGNEUX, INSTITUTE FOR SYSTEMS BIOLOGY

DIVERSITY LURKS For years, most TB research rested on the assumption that all cases of *M. tuberculosis* were the same, because the DNA sequences of different strains of the bacterium show much less diversity than the genomes of other bacteria do. In the early 1990s, however, scientists using new genetic-analysis techniques found previously unsuspected distinctions among *M. tuberculosis* strains. In particular, they discovered a DNA sequence called IS6110 that appears anywhere from zero to hundreds of times in a given bacterium. The number and location of repeats can be used to characterize the numerous *M. tuberculosis* strains that exist around the world, says Anne Stone, an anthropological geneticist at Arizona State University in Tempe.

Scientists have used the IS6110 marker to track outbreaks of individual strains, says Sebastien Gagneux, a molecular microbiologist at the Institute for Systems Biology in Seattle. A strain that has lain dormant in someone's body for 20 years and only recently caused an infection, for example, might show one pattern of IS6110 repeats, while a more recently evolved and spreading strain might show another. Such information can help investigators understand how different strains spread among different groups of people, perhaps in ways related to their lifestyles. That knowledge can in turn shed light on which medical and public health interventions might be most effective.

Researchers also noticed that certain strains of *M. tuberculosis* appeared more often in certain parts of the world than in others. Similarities in the pattern of IS6110 repeats can easily arise by chance, however, because this genetic element mutates rapidly and inserts itself into the same gene regions of different strains, Gagneux says. That makes IS6110 a poor marker to use in studies of the evolution and distribution of strains.

To get a more accurate picture, Gagneux's team has begun comparing the DNA of different *M. tuberculosis* specimens by looking for places where genes have disappeared. *M. tuberculosis* loses genes at a relatively slow and predictable rate, and once gone, genes rarely reappear. Deletions therefore provide reliable information about strains' ancestries. Using a set of roughly 4,000 genes from a fully sequenced strain of *M. tuberculosis* as a reference genome, Gagneux's team catalogued deletions in 875 strains from 80 countries.

The 875 strains fell into six distinct families that largely followed geographic lines. Two families are West-African, and the others are East-African-Indian, East-Asian, Euro-American, and Indo-Oceanic, the team reported in the Feb. 21, 2006 *Proceedings of the National Academy of Sciences*.

The discovery that all strains fit into six families shows how previous attempts to understand TB diversity have been misdirected. The first two strains of *M. tuberculosis* sequenced, for example, both turned out to belong to the same family. "It's like looking at two bumps on a hill in Tennessee," Sherman says, quoting a colleague. "There's a whole world out there we completely ignored."

> "There's a whole world out there we completely ignored."
>
> — DAVID SHERMAN, SEATTLE BIOMEDICAL RESEARCH INSTITUTE

Future vaccine and drug studies might include one strain from each family to see how each reacts to treatment, Gagneux says. "Now that we know there are six main groups distributed around the world, we have to find out whether we need six or more vaccines, or whether we can live with just one," he says. "Ten years ago, people would laugh at you if you even mentioned this possibility" that different vaccines might be required to fight different versions of TB.

A BETTER VACCINE Better, if not more, vaccines would be welcome. Today's only TB vaccine, BCG (bacille Calmette-Guérin), was originally derived in the early 1900s from *Mycobacterium bovis*, a strain of TB that occurs mostly in cows but can also infect people. The vaccine is given to some 100 million infants each year, mostly in developing countries. It's supposed to defend people against infection by presenting the immune system with a weakened version of an infectious bacterium.

But BCG doesn't work very well. To the vaccine's credit, although for reasons that aren't clear, it seems to do a good job at preventing tuberculosis meningitis—an infection by *M. tuberculosis* of the membranes that surround the brain and spinal cord—which can be deadly for children. In preventing other forms of tuberculosis, however, the report on BCG is mixed.

In 1994, researchers at the Harvard School of Public Health analyzed several trials conducted over the previous few decades, and found that the vaccine had less than a 70 percent success rate at preventing TB. In some cases, in fact, people who got the vaccine were slightly more likely to get TB than were those skipping vaccination, Sherman says.

A closer look at the vaccine's genome is providing insights into its ineffectiveness. That research is also shedding light on the virulence of some strains of TB. For instance, scientists have known for a decade that all BCG strains lack a nine-gene block of DNA called RD1. Since 2002, several studies have suggested that losing RD1 makes *M. tuberculosis* less virulent—which is probably why BCG is a safe vaccine. "From there," Sherman says, "the race was on to figure out what those genes did."

Researchers now have evidence that RD1 controls the production of three proteins that help the bacteria inject toxic lipids into the cells of their hosts. BCG strains without RD1 therefore can't infect cells. Scientists are zeroing in on these critical genes as potential targets for treatment of virulent *M. tuberculosis* strains.

Genetic changes in BCG may also help explain why it has become still less effective over the years, and more ineffective in some places than others. The vaccine has been kept alive in different conditions at many labs around the world, so that each culture has evolved independently. Some strains may have lost certain virulent genes along the way, and vaccine makers have cultivated strains that cause less soreness after injection, which may have selected out certain genes.

Researchers from the Pasteur Institute in Paris recently found that, compared with earlier strains, vaccine strains produced after 1925 had accumulated a variety of mutations that might make them less effective. The genetic analyses, which appear in the March 27 *Proceedings of the National Academy of Sciences*, further support the idea that evolution during years of growth in the lab has steadily weakened BCG.

Exactly how genetic changes are linked to the vaccine's performance is now "the million-dollar question," says Marcel Behr, a bacterial genomicist at McGill University in Montreal. "We know the vaccine is imperfect, and we know it evolved. We don't know to what extent evolution is responsible for its imperfection."

LOOKING BACK While some researchers are using TB genetics to look toward the future, others are reconsidering the disease's past. For decades, genetic studies have been based on the assumption that people first caught TB from cows, starting when Europeans domesticated the animals about 10,000 years ago and began drinking their milk. In 1492, this theory held, Europeans brought TB to the Americas, where *M. tuberculosis* caused widespread epidemics. Recent studies, however, suggest that both these assumptions are wrong.

The 1994 discovery of *M. tuberculosis* DNA in the lungs of a 1,000-year-old mummified woman in southern Peru was one clue that people were suffering from TB long before Christopher Columbus—or cows—sailed to the New World, says Arizona State's Stone.

In the past 4 years, several teams of scientists working with a variety of new genomic information have created a broadly consistent family tree for *M. tuberculosis*. Because TB loses genes

BETTMANN/CORBIS

FLOATING TB WARD — During a 1924 tuberculosis outbreak in New York City, infected children were kept in isolation on ferries in hopes of limiting the spread of disease. For the children themselves, there was no medical treatment besides rest, fresh air, and wholesome food.

as it evolves, and because *M. bovis* has fewer genes than the human form does, the tree unequivocally shows cows catching the disease from people.

By comparing genomes of *M. tuberculosis* strains taken from people in Europe and Africa, Cristina Gutierrez and her colleagues at the Pasteur Institute found evidence that all modern strains have evolved from a strain that still exists in East Africa. That strain, the scientists estimate, first appeared 3 million years ago. Their results appeared in the September 2005 *PLoS Pathogens*. Only Africa has endemic *M. tuberculosis* strains in all six families, Gagneux says, and two of those families occur nowhere else.

"The most plausible theory is that TB has been in humans pretty much as long as humans have been humans," Behr says, "and the bacteria had an out-of-Africa migration with its host."

It now seems possible that the first inhabitants of the Americas already lived with an African family of *M. tuberculosis* but could not fight off the more virulent Euro-American strain that came across the Atlantic in the 15th and 16th centuries. Anecdotal evidence suggests that the Euro-American family is now outcompeting African strains in Africa, Gagneux says.

The best explanation for these patterns, Stone says, is that *M. tuberculosis* has been evolving to infect people as people have evolved to fight it. "It's an arms race," she says, between the human immune system and TB.

MOVING FORWARD These windows into the past are giving scientists a better sense of which TB-bacteria genes deserve a closer look. Genes that have been lost in some strains were obviously dispensable, Behr says, while genes that are in all modern strains probably are important. Scientists have noticed, for example, that *M. bovis* makes large amounts of two proteins called MPB70 and MPB83, which fire up the immune systems of their hosts, whereas *M. tuberculosis* makes lesser amounts.

If the old theory—that human TB descended from bovine TB—were true, it would seem that evolutionary changes must have dampened the production of these two proteins. That would in turn suggest that the MPB70 and MPB83 genes aren't important in infecting people and would not make good candidates for attention from drug makers.

But with the order of evolution flipped, it now seems these genes' activities grew as *M. tuberculosis* evolved, and that they might be important subjects for research.

> "TB has been in humans pretty much as long as humans have been humans."
>
> — MARCEL BEHR, MCGILL UNIVERSITY

"Having the sequence backwards blinded us," Behr says. "It's a Copernicus thing. If you think the sun is turning around the Earth, you get everything mixed up."

An accurate TB family tree might also help scientists figure out what is behind the extra virulence of certain *M. tuberculosis* strains. As an example, Stone points to a deletion called TbD1 that appears in modern strains but not in ancient ones. Many strains causing recent epidemics have the deletion.

Scientists have also been finding mutations in drug-resistant strains, such as the Beijing strain, which caused an outbreak in New York City in the 1990s, and XDR-TB, which has been spreading ferociously through South Africa. Some mutations are common. Others are unique to individual strains or families.

As some researchers zero in on the genetic peculiarities of individual *M. tuberculosis* strains, others are working to sequence strains from all six of the worldwide families. In the genetic details, there may be pockets of vulnerability that will help scientists finally take down an ancient and stubborn killer. ■

OF NOTE

BIOMEDICINE

Migraines in men linked to heart attack risk

Men who experience migraines are somewhat more likely to have heart attacks than are men who don't get the headaches, a new study suggests.

The curious association comes from a study of more than 20,000 men, ages 40 to 84, who recorded their medical status in annual questionnaires. Seven percent of the men reported migraines during the first 5 years of the trial. During the following 16 years, those men were 24 percent more likely than men without migraines to develop cardiovascular disease and 42 percent more likely to have heart attacks, researchers report in the April 23 *Archives of Internal Medicine*.

The researchers adjusted the data to account for differences among the men that might cloud the findings. Those factors included weight, age, smoking status, diabetes, cholesterol concentrations, blood pressure, alcohol use, family history of heart attack, and exercise.

Other studies have hinted at a correlation between cardiovascular problems and migraines, but scientists have failed to find a biological mechanism linking the two, says study coauthor Tobias Kurth, a neuroepidemiologist at the Harvard School of Public Health and Brigham and Women's Hospital in Boston. "It's still an open question," he says. —N.S.

ANTHROPOLOGY

When female chimps become baby killers

On Feb. 3, 2006, six females from an African chimpanzee community attacked a female from outside their group that was holding a 1-week-old infant. Bloodied and screaming, the outsider tried to flee. The attackers, five carrying their own infants, caught her and pounded on her back. Three adult males from the community tried unsuccessfully to break up the assault. After about 10 minutes, the attackers grabbed the outsider's infant. One of them delivered a fatal bite to the helpless animal's head and neck.

A research team led by Simon W. Townsend of the University of St. Andrews in Scotland observed this incident and collected evidence from two other recent instances of female-led infanticide among wild chimps. Under certain circumstances, it's not unusual for bands of female chimps to become baby killers, the researchers assert in the May 15 *Current Biology*.

K. SLOCOMBE

WILD HOMICIDE Female chimps, such as this one shown with her infant, sometimes band together in order to attack and kill others' infants, a new study finds.

That conclusion challenges the longstanding view that infanticide in chimps and other primate species mainly involves males trying to jump-start the sexual receptivity of infants' mothers.

Female-led attacks on others' infants may stem from an influx of adult females and their offspring into an established group, upsetting residents' foraging and mating practices, the scientists propose. Since 2001, at least 13 females have immigrated into the Townsend-monitored chimp community, many with dependent children. Because of its relatively low number of adult males, the community has not been able to expand its home range. Immigrants thus challenge resident females' access to regular food sources and to a limited pool of potential mates. —B.B.

EARTH SCIENCE

Southern seas slow their uptake of CO_2

The rate at which oceans in the Southern Hemisphere soak up carbon dioxide from the atmosphere has slowed in recent decades, a phenomenon that could cause atmospheric concentrations of the planet-warming greenhouse gas to increase even faster than had been expected.

Today, the atmospheric concentration of carbon dioxide is rising by about 3 parts per million each year. As the concentration of carbon dioxide in the air goes up, the amount that dissolves into the ocean should also rise, says Corinne Le Quéré, an oceanographer at the University of East Anglia in Norwich, England.

Computer models suggest that between 1981 and 2004 the oceans south of 45°S should have absorbed, on average, an additional 18.7 million metric tons of carbon dioxide each year. Instead, Le Quéré notes, comparison of known carbon dioxide–emission rates with measurements of the gas' atmospheric concentration suggest that carbon dioxide absorption in the southern oceans declined by 11.3 million metric tons with each passing year.

In recent decades, the expanding ozone hole over Antarctica and increasing global temperatures have conspired to boost wind speeds over the southern oceans, Le Quéré and her colleagues speculate in an upcoming *Science*. Stronger winds increase the upwelling of nutrient-rich waters, which are less effective than cleaner water at absorbing carbon dioxide from the atmosphere, the scientists propose.

For at least the next 25 years, carbon dioxide absorption in the southern oceans will continue to decline, the team's analysis suggests. Greenhouse-gas buildup in the atmosphere may therefore affect global temperatures more quickly than scientists had previously estimated, says Le Quéré. —S.P.

NEUROSCIENCE

Synesthesia tied to brain connections

People who experience specific colors when looking at particular letters, such as seeing sky blue when shown an *R*, possess an unusual abundance of connections in brain areas involved in word and color perception, a new brain-imaging investigation finds.

The condition, one of several forms of sensory mixing collectively referred to as synesthesia, remains poorly understood. Romke Rouw and H. Steven Scholte of the University of Amsterdam studied 18 women who reported color-letter synesthesia and 18 women who cited no synesthesia.

One imaging technique measured the number of nerve fibers that link cells in various brain areas. Another technique assessed blood-flow changes, a marker of neural activity, as participants with synesthesia viewed letters that evoked colors and as women without synesthesia looked at the same letters.

The volunteers with synesthesia displayed an excess number of connections and showed unusually pronounced activity in three brain areas, the researchers report in the June *Nature Neuroscience*. These

regions are known to influence word and color perception as well as sensory integration and conscious thought. —B.B.

CANCER

Unintended consequences of cancer therapies

Radiation and chemotherapy can destroy a tumor, but they may also indirectly promote metastasis, the spread of cancerous cells to other organs.

Scientists knew that these traditional cancer therapies increase blood concentrations of a protein called transforming growth factor beta (TGF-beta), which performs many functions in a healthy individual. Now, researchers have shown that in mice with a form of breast cancer, TGF-beta promotes survival of stray tumor cells in the bloodstream, which in turn increases the number of new tumors in the lungs 17-fold.

"Nobody before has clearly pointed out the connection between TGF-beta and the increased metastases," says Swati Biswas of the Vanderbilt University School of Medicine in Nashville.

Injecting the mice with an antibody that blocks TGF-beta averted the increase in lung tumors due to radiation therapy or chemotherapy, Biswas and her colleagues report. In another experiment, mice genetically engineered to have no response to TGF-beta also showed no increased metastasis, the team reports in the May *Journal of Clinical Investigation*. Blocking TGF-beta had no effect on the original tumor, however.

The researchers say that if future experiments show that TGF-beta influences tumors in people in a similar way, doctors should investigate therapies that combine cancer treatments with doses of TGF-beta antibodies. —P.B.

BIOMEDICINE

Nail-gun injuries shoot up

Hospital emergency room visits due to nail-gun injuries among do-it-yourself carpenters tripled between 1991 and 2005 in the United States, a new analysis shows. Nails driven into hands or fingers accounted for two-thirds of the wounds.

Between 2001 and 2005, U.S. emergency rooms treated roughly 37,000 people annually for pneumatic nail-gun injuries. Nearly 15,000 of these were weekend carpenters, a yearly figure far outpacing the 4,200 such do-it-yourselfers in 1991.

While people employed as carpenters account for a majority of injuries each year, their mishap rate has held steady since such data on workers' injuries were first collected in 1998, says Hester Lipscomb, an occupational epidemiologist at Duke University Medical Center in Durham, N.C.

Lipscomb teamed with Larry L. Jackson of the Centers for Disease Control and Prevention office in Morgantown, W.Va., to analyze injury data compiled by the Consumer Product Safety Commission (CPSC) from 101 hospital emergency rooms across the country. By sampling these reports, CPSC and the researchers were able to estimate the nationwide incidence rate. The findings appear in the April 13 *Morbidity and Mortality Weekly Report*.

Many of the injuries occur when a nail gun discharges inadvertently—often when a safety feature has been disabled for rapid nailing, Lipscomb says. Also, a properly fired nail can ricochet off one that's already set or run through a piece of wood into a body part, she says.

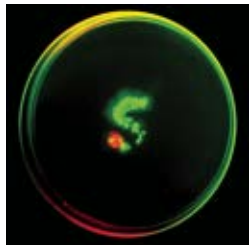
Injuries are up among do-it-yourselfers not only because they are less experienced than professionals but also because nail guns are more available and less costly than ever, says Lipscomb. —N.S.

CHEMISTRY

Onward, microbes

With a tweak to their genetic codes, bacteria have been coaxed to follow a chemical trail of a researcher's choosing.

Chemotactic bacteria, such as *Escherichia coli*, recognize and move toward certain chemicals. The chemicals bind to proteins on the microbe's surface, inducing an internal mechanism to drive the microbe's flagellum, a tail-like structure.



STAY OR GO Bacteria engineered to respond to a chemical follow an S-shaped path (green) painted with that substance, while normal bacteria (red) stay put.

TOPP

Chemists Justin P. Gallivan and Shana Topp of Emory University in Atlanta wanted bacterial cells "to follow things that we want them to follow," Gallivan says. Rather than engineering one of the bacterial-cell-surface proteins to recognize a new chemical, the researchers focused on one of the internal proteins that controls the *E. coli* flagellum. The microbe moves forward when this protein, called CheZ, is present, but stays in place if it's absent.

Gallivan and Topp put the gene for CheZ under the control of a riboswitch—a stretch of RNA that binds to specific molecules—that's sensitive to the chemical theophylline. Only when this chemical binds to the riboswitch does the production of CheZ proceed.

The researchers painted paths of several chemicals on a cell-culture plate. They then grew on that plate *E. coli* carrying the theophylline-sensitive riboswitch. The cells moved along only that chemical's path, Gallivan and Topp report in the May 30 *Journal of the American Chemical Society*.

The researchers are now developing riboswitches for particular applications, Gallivan says. For example, some bacteria can degrade pollutants. Engineered to follow a pollutant's path, the microbes might be used to clean up an environmental waste site, he notes. —A.C.

PHYSICS

The dance of the electron spins

Physicists have used a novel measuring technique to track the motions of electron spins in a tiny magnet as its polarity flips, with north and south poles changing places. Magnetic data recording relies on such reversals to encode bits of data.

At the atomic level, magnetism arises from the intrinsic spin of a material's electrons. Polarity can be flipped by applying a magnetic field to reverse the spin of each electron. The spin's axis spirals away from its initial alignment and into its new one, says Can-Ming Hu of the University of Manitoba in Winnipeg.

Physicists usually detect this motion, called precession, by beaming finely tuned microwaves at the sample and measuring electromagnetic feedback. However, Hu says, picking up that feedback becomes increasingly difficult as the sample size shrinks.

Hu and his colleagues made use of a recently discovered phenomenon called the spin dynamo effect, in which the precession of the spins converts microwave-frequency energy into an electric current. It's then easy to measure the current with high accuracy.

Because the spins influence each other, their precessions coordinate as dancers do in a ballet. The new experiments have revealed surprisingly complicated choreographies, Hu says. The team's results are due to appear in *Physical Review Letters*.

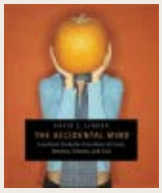
Hu says that spin dynamos could someday power nanoscale electronic devices by extracting energy from microwaves. —D.C.

Books

A selection of new and notable books of scientific interest

THE ACCIDENTAL MIND: How Brain Evolution Has Given Us Love, Memory, Dreams, and God

DAVID J. LINDEN



The human brain's reputation is that of an impeccably designed machine, able to perform functions well beyond the scope of any supercomputer. While the brain's capabilities are remarkable, its design is not, asserts brain researcher Linden. Instead, the 3-pound lump of flesh has been cobbled together by millions of years of evolution. In this survey of the brain for lay readers, Linden attempts to explain the brain's ascendance to the seat of what makes a human human. He describes how the brain's relatively inefficient development through experience explains the need for a long childhood. Finally, the author asserts that the brain's disorganized design and distinct evolutionary features are evidence against a divine creator of human beings. ***Belknap Harvard, 2007, 276 p., b&w illus., hardcover, $25.95.***

ENGINEERING FOR EVERY KID: Easy Activities That Make Learning Science Fun

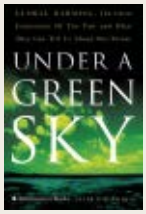
JANICE VANCLEAVE

VanCleave, a former science teacher, introduces young readers to engineering. With various hands-on activities, the author teaches the basic concepts of the field as they apply to many everyday situations. Each activity includes background information and an explanation of engineering terms, exercises that test readers' understanding of that information, a description of an activity that will apply engineering concepts, and solutions to the problems posed. For example, a section on aerospace engineering explains the science behind rocketry, Newton's laws of motion, and the concepts of work and kinetic energy. VanCleave then describes a relevant experiment involving balloons. ***Wiley, 2007, 205 p., b&w illus., paperback, $14.95.***

UNDER A GREEN SKY: Global Warming, the Mass Extinctions of the Past and What They Can Tell Us about Our Future

PETER D. WARD

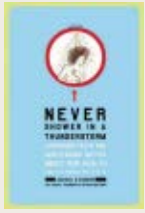
Ward wrote this book, he explains, out of a deep fear about the future. As one of the scientists who discovered that dinosaurs went extinct when an asteroid struck Earth, he contemplates the chances of a mass extinction today. Current conditions eerily reflect those that probably accounted for other mass extinctions in Earth's history, he writes. Ward set out to examine the Permian extinction, which occurred 251 million years ago and wiped out almost 90 percent of all species. A combination of environmental factors was the cause, Ward writes. He recounts his own work and that of other scientists studying microbial biomarkers to determine the chemical composition of Earth's oceans and atmosphere during this period. They have discovered that the oceans were toxic and devoid of oxygen, while the sky was hazy with carbon dioxide and methane. If human influence on the environment continues unchecked, Earth may be due for another extinction, Ward concludes. ***Collins, 2007, 242 p., hardcover, $26.95.***



NEVER SHOWER IN A THUNDERSTORM: Surprising Facts and Misleading Myths about Our Health and the World We Live In

ANAHAD O'CONNOR

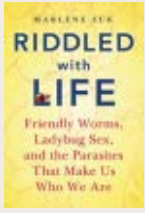
For years, O'Connor has authored a column for the New York Times entitled "Really?" that answers readers' questions—no matter how off the wall they are—about science and health. Does chicken soup really cure a cold? Do you gain more weight by eating late at night? Can the flu vaccine really give you the flu? For each column, O'Connor interviews several experts and scours scientific journals in search of answers. While many of the suppositions are indeed fiction, others have kernels of truth. It turns out that chicken soup does indeed chase away cold symptoms through its effects on mucus. Calories ingested as a midnight stack, however, have no more potential to make a person gain weight than do ones eaten at noon. And it's impossible to get the flu from the flu vaccine. O'Connor answers other perplexing questions about human nature, sex, dieting, sleep, environmental dangers, and threats from technology. ***Times, 2007, 238 p., paperback, $14.00.***



RIDDLED WITH LIFE: Friendly Worms, Ladybug Sex, and the Parasites That Make Us Who We Are

MARLENE ZUK

The popularity of antibacterial soaps and cleaning products, and even specially treated computer keyboards demonstrates that people don't understand the complex and mutually beneficial relationship our bodies have with bacteria and parasites, writes Zuk, a professor of biology. She explains how people have coevolved with bacteria, the microorganisms contributing vital features to our makeup. Indeed, components of all human and animal cells may have begun as separate bacterial entities. Bacteria that inhabit the digestive tract defend against disease. Zuk demonstrates the dangers of overzealous cleanliness, including possibly causing Crohn's disease, asthma, and allergies. The author also looks at why some diseases, such as colds, are mild but others, such as severe acute respiratory syndrome (SARS) and Ebola, are vicious. She outlines how virulence is related to a person's immune response. Zuk ponders the role that parasites played in forming human behavior. Finally, the author explores the reemergence of diseases such as measles. ***Harcourt, 2007, 328 p., hardcover, $25.00.***



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LETTERS

It's cold out there

I couldn't help noticing the last sentence of "World's climate map gets an update" (*SN: 3/24/07, p. 190*): "One of the system's 30 possible climate subtypes—a temperate climate with a cold, dry summer—wasn't found anywhere on Earth." The comment reveals that the writer has never read Mark Twain's comment that the coldest winter he ever spent was a summer in San Francisco.

JAY KOPELMAN, KAILUA-KONA, HAWAII

Mixed messages

Regarding "Mysterious Migrations" (*SN: 3/24/07, p. 186*), has anyone ever considered the possibility that interbreeding between Neandertals and humans would have produced sterile individuals? They would have had the traits of both parents, but with no further reproduction, Neandertal DNA wouldn't be found in humans today.

ERNIE CASBEER, OGLESBY, TEXAS

Researchers who argue for human-Neandertal hybrids say that fossil evidence argues against sterile, dead-end individuals. —B. BOWER

A likely contributing cause of Neandertal's rapid demise in Europe would be the introduction of lethal diseases into their small, previously isolated populations.

JAMES HOLLOWAY, PORTLAND, ORE.

The article mentioned a "third idea" of multiregional evolution. Didn't Carleton Coon propose something similar last century and come to grief because of it? Might be worth a mention.

J. B. POST, PAOLI, PA.

Carleton Coon was controversial for his theory that there are distinctive human racial groups, some of which are more evolved than others. Multiregionalists reject the existence of racial groups. —B. BOWER

Corrections *Discussing the Euler characteristic of a cube, "Sensor Sensibility" (*SN: 5/5/07, p. 282*) stated the obviously false equation 6 – 8 + 12 = 2. It should have read, 6 – 12 + 8 = 2. Also in that issue, a table of contents (*p. 274*) description of the cover picture should have said that the solar observatory at Chankillo dates from 2,300 years ago, not from 2,300 B.C.*

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