SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

DECEMBER 13, 2003 PAGES 369-384 VOL. 164, NO. 24

stressed-out rats

fresh, homemade genomes

gem genealogy

from starvation to therapy

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flower power

PLANTS THAT MAKE HEAT

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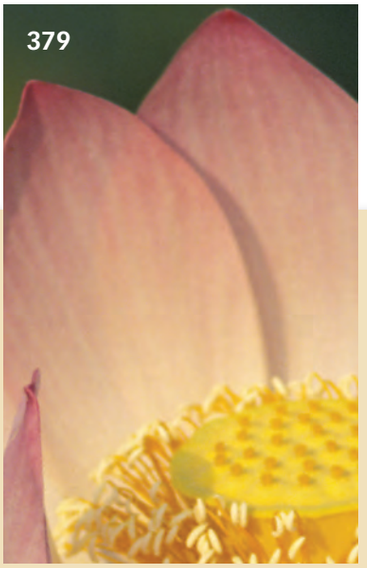

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Of Note

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Cover The Asian sacred lotus, *Nelumbo nucifera*, is one of the few species known to regulate the temperature of its blooms, compensating for extra chills in the air. Other species warm their flowers without the fancy thermostat, and scientists are now making progress in figuring out how and why. (©2003 L. Rosbotham) Page 379

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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. Change of address: 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
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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 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 on the Web at www.sciserv.org.

SCIENCE NEWS
This Week

Gemstone Geography

New technique discerns emeralds' beginnings

Once an emerald leaves its country of origin and circulates around the world, the gem's provenance becomes murky. Scientists have now developed a nondestructive method for determining the source of an emerald, even down to the mine from which it was extracted. That information can affect the gem's price and make it easier for historians to reconstruct ancient trade routes.

An emerald-tracking procedure that measures the ratio of two oxygen isotopes in a microscopic sample from a gem has been available for a few years (*SN: 3/11/00, p. 175*). Unfortunately, that method is not foolproof, says Philippe de Donato of the École Nationale Supérieure de Géologie in Vandoeuvre-lès-Nancy, France. Emeralds from Russia, Pakistan, and Madagascar often have the same ratio of oxygen isotopes, making them indistinguishable from one another.

A new analysis technique focuses on water trapped in an emerald's minute channels, de Donato and his colleagues reported last week at the Materials Research Society meeting in Boston. These channels, distributed throughout the stone, are just wide enough to fit one or two water molecules. The researchers homed in on a naturally occurring form of water in which an atom of deuterium, a doubly heavy isotope of hydrogen, replaces an atom of the more common hydrogen.

In the new technique, de Donato's team shines infrared light on an emerald. Oxygen-deuterium bonds in the gem's water molecules absorb specific wavelengths of the light, yielding an absorption spectrum that serves as an optical signature. The investigators used this signature to link various emeralds with their known sites of origin. "Because this method is completely nondestructive, we can make all the measurements we want," de Donato says.

Not only could the researchers distinguish between an emerald from Russia and one from Madagascar, they could pinpoint the specific mine in each country from which the emerald came. So far, the scientists have distinguished among emeralds from 10 mines in seven countries. They have also discriminated between natural emeralds and synthetic ones.

Why water molecules in emeralds from different parts of the world produce different optical signatures is unclear. De Donato says it may have to do with the presence of soil nutrients, such as sodium and potassium, whose concentrations vary from region to region and that seep into an emerald's crystal structure. The proximity of these elements to water in the gem's channels could influence the spectrum, he says.

"This could straighten out a lot of the confusion surrounding where ancient emeralds come from," says Fred Ward, a gemologist and book author in Bethesda, Md. For instance, when Spanish explorers brought emeralds from Colombia to the Middle East in the 16th century, they kept the origins of their gems a secret to protect their sources, Ward says.

GEM INCOGNITO New method can pinpoint what mine this uncut emerald came from.

The method could also be useful for documenting new emeralds, he says. For example, if gem dealers can confirm that a stone is from Muzo, Colombia, the most famous emerald mine, they can sell it at a premium. —A. GOHO

Model Mice

Blood reveals signs of pancreatic cancer

By the time you find out, it's usually too late. Almost all people diagnosed with pancreatic cancer succumb quickly to the disease, which spreads aggressively to the liver and other organs.

Researchers have for the first time created mice that appear to develop the disease in the same way that people do. The animals offer a "very faithful model of pancreatic cancer," says David Tuveson of the University of Pennsylvania in Philadelphia, who led the new work. The genetically engineered rodents should aid the identification and testing of therapies for the deadly cancer, say Tuveson and his colleagues.

The scientists have already laid the groundwork for a test that could catch the disease in time for potential treatments to be effective. They've found a pattern of proteins in the blood of mice with precancerous pancreatic lesions.

How pancreatic cancer arises has remained obscure because it's typically detected at an advanced stage. "We have never known what the precursor lesion is in people," says Tuveson.

He and his colleagues created mice in which the cells that give rise to the pancreas contain the most common mutation found in human pancreatic cancer. The mutation occurs in a gene called *KRAS*, which is defective in more than 90 percent of people with pancreatic cancer.

Within months of birth, the mutant rodents developed lesions in pancreatic ductal cells that are similar to lesions that physicians have seen in the pancreases of people with and without cancer, Tuveson and his colleagues report in an upcoming *Cancer Cell*. Scientists have speculated that these lesions are comparable to the polyps that presage colon cancer. Indeed, more-severe lesions appeared as the mice aged, and, in a few old mice, the lesions gave rise to highly malignant tumors.

A team headed by Ronald DePinho of Dana-Farber Cancer Institute in Boston has crossed the *KRAS*-mutant mice with mice lacking a tumor-suppressor gene implicated in pancreatic cancer. The offspring developed invasive pancreatic tumors even more quickly than Tuveson's mice did, DePinho's team reports in the Dec. 15 *Genes & Development*.

By studying the pancreatic lesions in mice, Tuveson and his colleagues have identified cellular molecules that could be targeted by anticancer drugs. They're also developing tests to reveal the lesions. "What we're hoping is that the mouse will be a springboard to new ways of finding these lesions in people," says Tuveson.

Investigators at the Food and Drug Administration–National Cancer Institute Clinical Proteomics Program in Bethesda, Md., have already analyzed blood samples from the *KRAS*-mutant mice. They found a pattern of protein abundances that clearly distinguishes healthy mice from those with pancreatic lesions. "What's fascinating now is that we actually have a premalignant pancreatic cancer signature," says Emanuel Petricoin of the FDA, codirector of the program.

Investigators have begun looking for this signature in people diagnosed with pan-

creatic cancer. "The results are promising," says Lance Liotta of the NCI, the program's other codirector.

Liotta and Petricoin contend that people at high risk of the disease could benefit from such a diagnostic tool. Pancreatic cancer is so rare that it's unlikely that a screening test for the general population would be accurate enough to be useful, they say. —J. TRAVIS

Breach of the Shield

Magnetic links between sun and Earth last hours

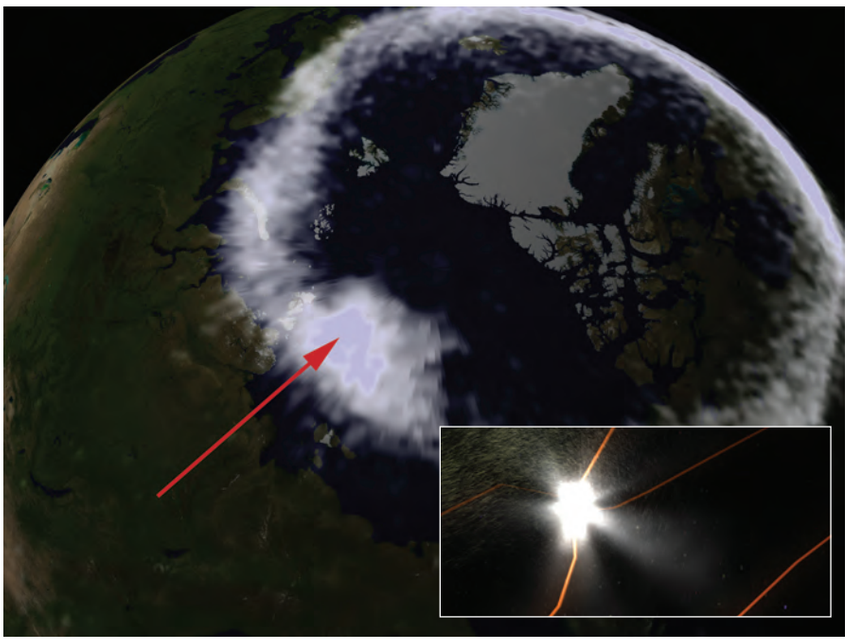
Each time the sun hurls a planet-size cloud of charged particles toward Earth, there's a potential for power outages and satellite damage. But it's when the magnetic field carried by these billion-ton clouds points opposite to Earth's magnetic field that geomagnetic storms are most severe. In that configuration, our planet's field, which usually shields Earth from the sun's outbursts, connects directly to the field accompanying the cloud. That magnetic handshake opens up a hole in Earth's shield, permitting energetic ions and electrons from the sun to gush through and induce large electrical currents in and around the planet.

A report in the Dec. 4 *Nature* reveals that once such breaches are created, they can persist for hours, rather than closing up soon after they've formed. The finding ends a 2-decades-long debate about the duration of holes in Earth's magnetic shield, says Ron Zwickl of the National Oceanic and Atmospheric Administration's Space Environment Center in Boulder, Colo. The results, he adds, should be incorporated into models of geomagnetic storms and could be crucial for placing regional hot spots—places where solar ions most easily punch through—on global space-weather maps.

In the study, a NASA satellite called IMAGE (Imager for Magnetopause to Aurora Global Exploration) observed two powerful proton auroras in the arctic portion of Earth's upper atmosphere, or ionosphere. Proton auroras are generated by ions in the solar wind, the stream of charged particles blown out by the sun. Unlike the colorful northern and southern lights, proton auroras shine only in ultraviolet light.

During the proton aurora on Feb. 18, 2002, a constellation of four spacecraft known as Cluster was perfectly situated for recording solar-wind ions streaming through a breach in Earth's magnetosphere. The breach occurred along magnetic field lines that traced down to a bright spot in the proton aurora, which IMAGE observed for 4 hours.

Although Cluster's orbit enabled the spacecraft to observe the breach for only 5 minutes, IMAGE's observations of the aurora indicate that the breach lasted for at least 4 hours, assert study coauthor Harald U. Frey of the University of California, Berkeley and his colleagues.



STORMY WEATHER Ultraviolet image shows a proton aurora (ring). Brightest spot (arrow) is about the size of California. Inset: Simulation of a breach (white spot) in Earth's magnetic shield. NASA

At the boundary of Earth's magnetic shield, about 60,000 kilometers above the planet's surface, the breach's diameter was greater than that of Earth.

Other scientists recently got a taste of just how powerful geomagnetic storms can be when the magnetic field carried by a cloud of solar material opposes that of Earth. Soon after a recent eruption on the sun, dubbed the Halloween solar storm, a high-altitude belt of energetic electrons that cradles Earth was pushed inward and the radiation it emitted greatly increased.

From Nov. 1 to Nov. 10, the center of the belt, normally 19,000 to 25,000 km above Earth's equator, descended to an altitude of about 9,600 km. "We have never seen such a powerful enhancement and distortion" of the belt during 11 years of observations, notes Daniel Baker of the University of Colorado at Boulder. He reported the findings this week at the fall meeting of the American Geophysical Union in San Francisco. —R. COWEN

Slowing Puberty?

Pesticide may hinder development in boys

Chronic exposure to a widely used pesticide may delay sexual maturity in boys, according to a new study in India.

Endosulfan is an organochlorine used around the world to protect squash, melons, strawberries, and other produce. A 2001 report by the U.S. Environmental Protection Agency estimated that 1.4 million pounds of the pesticide are used annually on U.S. crops. It's also the third most commonly used pesticide in India, where concerns about endosulfan have surfaced.

For example, for irrigation water and fish, the southern Indian town of Padre relies on streams that run through a cashew plantation where the trees had been sprayed with endosulfan a few times a year for 2 decades until December 2000. Residents then demanded that the spraying stop because they suspected it was increasing the local rates of several cancers and neurological diseases.

"Because of the particular topography, people were exposed to high concentrations of endosulfan," says Habibullah Saiyed of the National Institute of Occupational Health in Ahmedabad, India. Even though endosulfan doesn't last long in the body, it can linger in the food chain by contaminating soil and accumulating in fish.

Saiyed and his colleagues collected blood from Padre residents and village-water samples 10 months after the last spray. "They were still showing endosulfan,"

Saiyed says.

Since previous experiments in laboratory rats had linked high endosulfan exposure during development to defects in sperm quality, the researchers investigated possible effects of the compound on human male-reproductive development. The team examined 117 Padre schoolboys between 10 and 19 years old and a comparable group of boys from a town 20 kilometers away, where there had been no endosulfan spraying.

Blood tests indicated the pesticide's presence in more than three-quarters of the boys in the Padre group, whereas less than a third of the control group's blood samples showed endosulfan. The results demonstrate the overall environmental prevalence of this pesticide, Saiyed says.

Reproductive development of each boy was evaluated using a sexual-maturity rating based on the size of the penis and testes and the development of pubic hair. After taking age into account, the researchers found that boys in Padre scored significantly lower on all three measurements than boys from the other village did. The scientists report their findings in the December *Environmental Health Perspectives*.

They also found that the blood concentration of testosterone was lower in the Padre boys, even though they had higher concentrations of luteinizing hormone than the other boys did. Luteinizing hormone normally pumps up production of testosterone, so the results imply that something is impeding testosterone synthesis and therefore the progression of puberty, the researchers say.

"The findings really suggest that we should use [endosulfan] cautiously or not use it at all," says Saiyed, adding that this is one of the first studies to link an environmental pollutant to delayed puberty in boys.

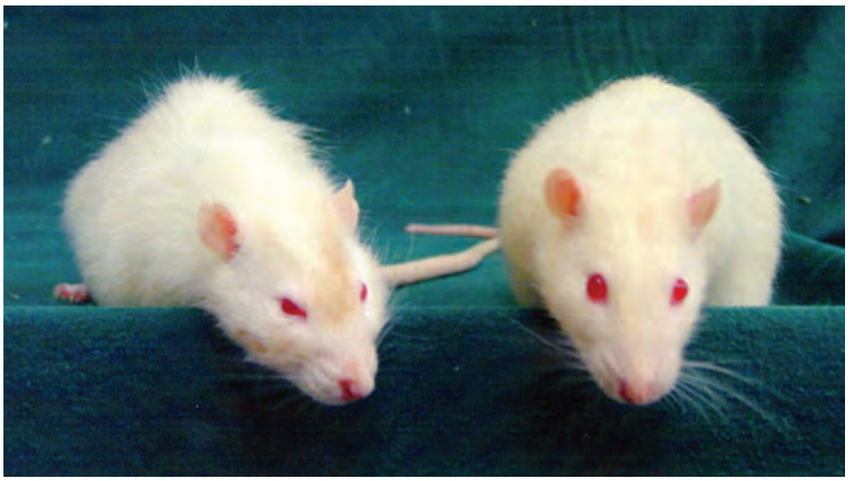
Richard Sharpe of the Medical Research Council's Centre for Reproductive Biology in Edinburgh says the study ought to raise concerns, but because it looked at only a small number of children, the results may simply represent natural variations in the onset of puberty. —K. RAMSAYER

Worried to Death

Lifelong inhibitions hasten rodents' deaths

Some animals shy away from novel settings all their lives, preferring the predictability of familiar surroundings. Although this can be a safe strategy in the short run, it may have a fatal drawback down the line.

A new study finds that novelty-averse laboratory rats, after reaching maturity, died at markedly younger ages than did their more adventurous comrades. Heightened hormone responses to mildly stressful events throughout life ultimately undermined the capacity of the inhibited rats to resist tumors and other health threats, contend Sonia A. Cavigelli and Martha K. McClintock, both psychologists at the University of Chicago.



CAVIGELLI, MCCLINTOCK

STRESSED OUT The rat on the left exhibits fear and caution in a novel environment while its brother (right) displays boldness and curiosity in the same setting.

In essence, stress responses cause the inhibited rats to age prematurely, the researchers conclude in an upcoming *Proceedings of the National Academy of Sciences*. These animals exhibit a 20 percent reduction in maximum life span compared with that of their bolder brethren.

"This is the first study to show that a psychological trait present from infancy can have life span consequences," McClintock says. "I suspect this finding applies to people as well as to rats."

An initial experiment with male rats confirmed that the tendency of animals either to avoid or explore new environments persisted into adulthood. Twelve animals that, when placed in an unfamiliar chamber at age 4 months, avoided contact with items there, were equally cautious 4 months later. Likewise, 16 rats that readily touched and climbed on objects in a novel setting at 4 months retained their curiosity.

Blood tests revealed comparable baseline concentrations of the stress hormone corticosterone in cautious and bold rats. However, after being placed in and 5 minutes later removed from a novel setting, the reserved animals displayed elevated corticosterone concentrations for at least 40 minutes, while the bolder group's corticosterone readings rose transiently before dipping back to baseline.

In another experiment, the scientists studied 14 pairs of brothers. In each pair, tested at around 20 days of age, one rat exhibited a fear of novelty and the other a willingness to explore. These traits remained stable through adulthood.

When briefly restrained in a tube at age 15 months, inhibited rats mounted a much larger corticosterone response than the bold rats did. This disparity lasted for at least 2.5 hours after removal from the tube.

The novelty-averse rats commonly lived about 600 days, compared with 700-day lifetimes for the bolder rats. The strain of rats used in the study are genetically predisposed to developing pituitary gland tumors, and many of the deaths were due to this condition. However, the reserved rats died more often than their bolder brothers did from relatively small tumors.

An inhibited lifestyle comes with a health trade-off, McClintock theorizes. Cautious rats avoid predators and other dangers in their prime, but accumulated exposure to high levels of stress hormones renders them vulnerable to disease later in life.

"These are potentially important findings, but I'm cautious about accepting them," remarks psychologist Jerome Kagan of Harvard University, who studies inhibited children. The results need to be confirmed in other strains of rats and with different measures of inhibition, he says.

Moreover, Kagan notes, risky behavior, rather than inhibition, causes people to die young. —B. BOWER

Risk Profile

C-reactive protein may presage hypertension

A protein that shows up in inflammation may signal risk of high blood pressure, researchers report in the first large-scale trial to link the two disorders.

The compound, called C-reactive protein (CRP), has already been implicated in heart disease and stroke. In light of that, some doctors have begun routinely testing patients' blood for elevated concentrations of the compound. Many studies have indi-

cated that low-level inflammation triggers blood vessel damage.

While CRP's role in either inflammation or heart disease is far from clear, high blood pressure is a well-recognized danger sign for heart attacks and strokes.

To investigate a link between CRP and hypertension, epidemiologist Howard D. Sesso of Harvard Medical School in Boston and his colleagues tapped into a database of 20,525 women who had donated blood samples during the early 1990s as part of a wide-ranging health study called the Women's Health Study. The women entered the study at age 45 or older with no history of high blood pressure, heart disease, stroke, or cancer. But after roughly 8 years, one-fourth of them showed high blood pressure.

The scientists measured CRP in the initial blood samples and then divided the volunteers into roughly equal-size high-, medium-, and low-CRP categories. They found that women in the low-CRP group were about 50 percent as likely to have developed hypertension during the study as were those in the high-CRP category. The report appears in the Dec. 10 *Journal of the American Medical Association*.

Next, the researchers set aside the data from women who smoked, were overweight, had diabetes, were using hormone therapy, or had high cholesterol. Of the 6,795 women who remained, those with low CRP at the start of the study were still only about 60 percent as likely to have developed high blood pressure as were the high-CRP women.

The study shows a "potential relationship between hypertension and inflammation," says Daniel Jones, an internist at the University of Mississippi Medical Center in Jackson. But scientists still need to determine whether inflammation can incite high blood pressure in lab animals, he says. Until then, "there are too many gaps in our knowledge" to suggest that CRP causes high blood pressure, Jones says.

The largest gap lies in the absence of a recognized biological mechanism for the link, but basic research has turned up some possibilities. For example, studies show that vessel-lining cells exposed to CRP produce abundant surface molecules that activate angiotensin, a compound that causes blood pressure to rise. Other research suggests that CRP depresses production of nitric oxide, a vessel dilator.

However, since the role of CRP in inflammation remains unclear and its link to hypertension unproved, doctors should be careful about prescribing anti-inflammatory drugs—which can have side effects—on the basis of a high CRP reading, says physician Marvin Moser of Yale University School of Medicine. —N. SEPPA

RED START In sun, young cacao leaves begin crimson but later turn green and pick up fungi.

Sweet Lurkers

Cryptic fungi protect chocolate-tree leaves

A hidden world of fungi abounds inside healthy leaves, and scientists are beginning to learn what it's doing there. A research team reports that in tree leaves, these fungi, called endophytes, can limit damage from attacking disease agents.

In tests on chocolate trees in Panama, leaves colonized with endophytes that don't cause disease coped better with a vicious pathogen than fungusfree leaves did, report A. Elizabeth Arnold of Duke University in Durham, N.C., and her colleagues. "Here's a major role for broad-leaved-tree [endophytes] that's never been noticed," she says.

The endophytes in grasses fight pathogens, explains Keith Clay of Indiana University in Bloomington. He welcomes the similar result in these trees as "pretty dramatic." He adds, "I'm sure it's going to get a lot of attention."

Clay predicts that ecologists will look for similar effects in other broad-leaved trees and muses that cacao growers might find ways to harness the endophytes' disease-fighting power.

Endophytes have turned up in every plant tested, from Douglas firs and grasses to mosses and liverworts, says Arnold. Clay and other grass researchers have demonstrated fungal benefits that include reduced appeal to grazing animals, for temperate-zone grasses.

Grasses and tropical trees have very different fungal tenants, says Arnold. Unlike the grass inhabitants, the tree endophytes are quite diverse and colonize emerging leaves instead of passing from one generation to the next.

Arnold and her colleagues surveyed fungi in cacao leaves at five sites in Panama. The similarity in fungal residents decreased as the sites grew more distant, the researchers report in an upcoming *Proceedings of the National Academy of Sciences*.

Yet the pattern of endophytes isn't merely geographical, the researchers conclude. Different tree species at the same site tend to have different mixes of colonizers. In lab experiments, extracts of leaves from different tree species influenced the growth rates of various fungal types and even altered the outcomes of fungus-versus-fungus growth competitions.

Arnold and her colleagues chose seven kinds of fungi that showed up frequently in leaves of the local trees and won laboratory growth competitions. The researchers introduced these fungi to both young and old leaves on cacao seedlings that had been kept free of fungi. Then, the scientists inoculated some of the leaves with a strain of *Phytophthora*, one of the three major pathogens in commercial cacao and a relative of the organism behind Irish potato blight. Compared with leaves without endophytes, the leaves housing the friendly colonizers lost about half as much area to invaders and were more likely to survive.

The bonus turned out to be biggest for the older leaves. The fungi may compensate for the waning of defensive chemicals as leaves age, says Arnold.

Plant pathologist Christopher Schardl of the University of Kentucky in Lexington welcomes the work as a "very important advance." Aside from grass studies, he says, "there has been very little evidence of defensive mutualisms between fungi and plants." —S. MILIUS

ARNOLD

KETONES TO THE RESCUE

Fashioning therapies from an adaptation to starvation

BY BEN HARDER

In times of plenty, both the mind and the body thrive. But deprived of basic sustenance, the mind perishes before the body does. That's not New Age philosophy; it's basic metabolic chemistry. While most of the body manages food shortages with relative ease, the tissues of the brain are vulnerable during periods of scarcity. So when blood sugar dips, the brain must fall back on special biochemistry to meet its energy needs. From studying that metabolic back-up system, a coterie of scientists has drawn inspiration that could lead to a new treatment for conditions as diverse as epilepsy, diabetes, Alzheimer's disease, and heart failure.

Most of the time, the body makes its fundamental fuel, glucose, from ingested carbohydrates. With each meal, the bloodstream gets replenished with glucose to replace the blood sugar that hungry cells have consumed to satisfy their metabolic needs. The body can't store glucose well, yet cells must be fed continually. So the body puts away extra energy in the form of fat, which it can break down into energy-supplying fatty acids when needed. A starving animal or a person with normal fat stores can thus sustain most of the body's cells for weeks or months without eating.

But brain cells, even hungry ones, can't avail themselves of these emergency stores. A physiological barrier that blocks toxins in the bloodstream so they can't enter the delicate brain also keeps out fat and fatty acids. As a consequence, when glucose in the blood runs low, brain cells can run into trouble.

People are uniquely vulnerable to such glucose starvation because of their disproportionate braininess. Although the brain makes up about 2 percent of a normal adult's weight, it commands roughly 20 percent of the body's resting metabolic budget.

A condition found only in people and a few ruminants can protect against this Achilles' heel. The state, known to followers of the popular Atkins diet, is called ketosis. When blood-glucose concentrations get low, the liver converts a portion of fatty acids into acids called ketone bodies or ketones. These substances can substitute for glucose and fatty acids as cellular fuel. However, unlike fatty acids, ketones can penetrate the blood-brain barrier.

While ketosis may guard the brain in times of starvation, Richard L. Veech has additional applications in mind. Veech, who works at the National Institutes of Health in Rockville, Md., argues that ketones might be therapeutic any time cells are threatened by energy deprivation. Such threats could arise both from a lack of fuels and from cells' failure to properly metabolize the fuels at their disposal. The latter category covers a broad array of diseases.

Veech and others have been suggesting for several years that ketosis could help treat, among other conditions, Alzheimer's and Parkinson's diseases, certain insulin disorders such as type 1 diabetes, and several metabolic disorders caused by rare mutations.

"These diseases appear wildly different," Veech says. Treating "all these different things with some magic substance sounds improbable," he adds. Yet across a wide range of specialties, doctors who've dabbled with ketone-based therapies are warming to that seemingly outlandish idea, and a vanguard of research on ketone therapies is appearing in scientific journals. At NIH earlier this fall, Veech hosted a gathering of researchers who have studied ketones.

KETONE CUISINE There is one medical condition in which ketones find proven, if limited, application. Since the 1920s, a ketosis-inducing diet has been used to treat some cases of severe childhood epilepsy. This high-fat, low-protein, low-carb regimen shifts the body's main fuel supply from glucose to ketones and fatty acids. This ketogenic diet is more extreme than the high-protein Atkins diet, which produces ketones in urine but not necessarily in the blood, says Veech.

Whereas most people consume less than a third of their calories in the form of fat and the rest as carbohydrates or protein, people on the medical ketogenic diet obtain at least two-thirds of their calories from fat.

Since the 1920s, a ketosis-inducing diet has been used to treat some cases of severe childhood epilepsy

"It's a hideous diet," says Kieran Clarke of the University of Oxford in England, who attended Veech's summit. "Think of eating pounds of butter at a time, and eating cream on top of that," she says. Not surprisingly, many children find the diet unpalatable. In studies, refusal to eat has been a primary cause for the treatment's failure. Implementing the diet, furthermore, usually requires a hospital stay and the involvement of numerous dietitians and pediatricians. Enforcing it requires parents to weigh foods and calculate ratios of calories from different sources.

With the widespread introduction in the 1960s of more effective drugs for epilepsy, the unwieldy diet's use declined. Its reputation has recently enjoyed a resurgence, however, because some seizures that had been resistant to the drugs were observed to stop during ketosis. The well-publicized case of one boy, whom doctors at Johns Hopkins Medical Institutions in Baltimore successfully treated with the ketogenic diet, inspired the 1997 movie *First Do No Harm*.

Even so, no more than a few hundred people in the United States are on the medical ketogenic diet at any one time, estimates Eileen P.G. Vining, a pediatric neurologist at Johns Hopkins. For one thing, she says, it's prescribed almost exclusively for children because doctors are concerned about the heart attack risk that adults might face from chowing down on so much fat.

To get a feel for how serious the side effects of the ketogenic diet might be, Vining, Peter O. Kwiterovich, and their colleagues studied 141 epileptic children they'd treated for at least 6 months at Johns Hopkins since 1994. The children's blood concentrations of

total cholesterol, triglycerides, and other markers associated with cardiovascular disease had jumped by as much as 60 percent during the ketogenic treatment. Meanwhile, blood concentrations of high-density lipoproteins, or good cholesterol, fell by an average of 13 percent, the researchers reported in the Aug. 20 *Journal of the American Medical Association*.

Even if those numbers translate into a health risk for children on a ketogenic diet, which is far from certain, "it's a price worth paying" when children are wracked by drug-resistant seizures, Vining contends.

Nevertheless, there could be a better way. Studies suggest that certain ketones are directly involved in inhibiting seizures. That raises the possibility of supplanting the ketogenic diet with pure ketones as drugs.

RESCUE MISSION Limited quantities of ketones are produced for research purposes, but they are expensive and difficult to test because the body breaks them down quickly. Nevertheless, neurologist Serge Przedborski of Columbia University is experimenting with ketones. Przedborski's main research interest is Parkinson's disease (*SN: 5/3/03, p. 285*), the symptoms of which include tremors, muscle stiffness, and loss of balance and coordination. The physiological hallmark of Parkinson's is the loss of certain neurons that respond to the brain chemical dopamine.

Ketones might be therapeutic anytime cells are threatened by energy deprivation

The degeneration of those neurons and of similar brain cells in Alzheimer's disease has been linked to defects in the cells' energy-producing machinery, or mitochondria. In both diseases, mitochondria in some neurons are inefficient at metabolizing glucose. But the process by which mitochondria metabolize ketones isn't necessarily impaired in the two diseases.

Veech, Clarke, and four of their colleagues from Japan demonstrated 3 years ago that, in test tubes, the ketone D-beta-hydroxybutyrate protects neurons that have the mitochondrial defects associated with Parkinson's and Alzheimer's.

To test the effectiveness of the approach in animals, Przedborski and his colleagues implanted into some laboratory mice a pump that gradually released D-beta-hydroxybutyrate, and into other mice a dummy pump. A day later, the researchers gave the animals a neurotoxin that inhibits glucose metabolism in the critical neurons. That procedure is commonly used in the lab to induce a condition similar to Parkinson's disease.

After a week, the researchers counted surviving neurons. While mice given dummy pumps had lost about two-thirds of a certain neuron type associated with Parkinson's, mice treated with 160 milligrams of D-beta-hydroxybutyrate per kilogram of body weight per day appeared to have lost only one-third of those cells. Mice receiving lower doses of the ketone didn't fare noticeably better than the animals that had gotten the dummy pumps.

"It's not a dramatic effect," Przedborski acknowledges. "But, sure enough, we were able to recover some of the function of the mitochondria." Most important, the scientists report in the September *Journal of Clinical Investigation*, the high dose of the ketone prevented the mice from developing Parkinson's-like movement problems.

To confirm that defective mitochondria use ketones to detour around their obstructed metabolic pathway, Przedborski's team administered a second toxin, which interferes with ketone metabolism. In mice with both metabolic pathways blocked, the ketone therapy didn't rescue any neurons.

The Columbia researchers' findings support the idea that ketones could help people with Parkinson's disease, says Theodore B. VanItallie of St. Luke's-Roosevelt Hospital Center in New York City. "There's enough evidence available now to encourage people to test the hypothesis," he says. "There's at least a reasonable possibility that these things [ketones] will work."

VanItallie and his colleagues recently put several people with Parkinson's disease on a ketogenic diet, but the researchers haven't yet gathered enough data to draw conclusions. VanItallie is looking for funding to mount a full-size trial.

Diabetes, too, can affect the brain. Children with type-1 diabetes lose some mental acuity when their glucose metabolism slows, says Jullie W. Pan of the Albert Einstein College of Medicine in New York. That can eventually affect their academic performance.

In type 1 diabetes, the body doesn't have enough insulin to do its normal job of transporting glucose into cells that would metabolize it. In fact, ketosis is a symptom of diabetic shock because it arises when glucose metabolism is suppressed. Insulin injections can boost glucose metabolism, but blood insulin can vary considerably between injections.

Pan is now studying the effect of ketone infusions in diabetic children to see whether the therapy might compensate for the effects of glucose-metabolism fluctuations on the brain.

PUTTING HEART INTO IT Brain effects of low glucose availability aren't the only problems that ketones could conceivably fight. An international team of doctors recently reported successes in using ketones to treat three children with the rare genetic disease known as multiple acyl-CoA dehydrogenase deficiency, or MADD. The metabolic defect renders the body unable to process certain fatty acids. A low-fat diet and other interventions sometimes help affected children, but weakened muscles, particularly heart muscles, and damage to other tissues can lead to early death.

The first child the researchers treated with ketones was a 2-year-old boy receiving standard treatment for MADD who suddenly developed quadriplegia and could no longer speak. To supply energy to poorly functioning cells, doctors gave the boy oral doses of ketones every 4 hours. The boy recovered gradually until, after 19 months of the ketone therapy, he could again walk unassisted, a development that NIH's Veech hails as remarkable.

The researchers subsequently gave the same treatment to two other children with MADD, both of whom had suffered heart failure. These patients showed substantial recovery, pediatrician Johan L.K. Van Hove, now at the University of Colorado Health Sciences Center in Denver, and his colleagues reported in the April 26 *Lancet*.

Oxford's Clarke suggests that ketones could treat heart failure from other muscle-weakening causes, as well. One hypothesis of heart disease suggests that a heart can gradually fail after a nonfatal heart attack because the organ's muscle cells become inefficient at both taking up glucose and metabolizing fatty acids, says Clarke. Ketones could provide heart muscle with an alternative energy source. Clarke is experimenting on failure-prone rat hearts to test this idea.

If this treatment is ever to be practical, an abundant and reasonably inexpensive source of purified ketones will be needed, she says. "The only way now we can produce ketones in the body is a high-fat diet," she says. "You couldn't feed a high-fat diet to a heart-failure patient. That would be a disaster."

Even in the small amounts needed by the children that Van Hove and his colleagues treated, purified ketones could cost $20,000 per patient per year, says Veech. The higher quantity of ketones that an adult would require would lead to even more expense.

That's only a temporary obstacle, according to Veech. In the lab, scientists can already use bacteria to manufacture a compound that can be processed into ketones. If researchers can improve on the current method for refining the precursor, then ketones could be inexpensively produced, he says, and his theories about their broad medical effectiveness could be put to the test. ■

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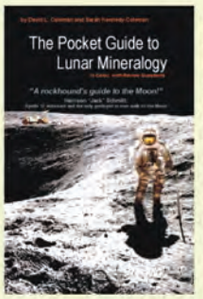

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WARM-BLOODED PLANTS?

OK, there's no blood, but they do make their own heat

BY SUSAN MILIUS

"The dead-horse arum of Corsica looks and smells like the south end of a horse that died going north," says Roger Seymour. He's actually talking about a plant, and a more prosaic soul might add that it belongs to the same family as calla lilies and jack-in-the-pulpits. Seymour is a zoologist, and the plants he studies show an animalistic feature: They can generate body heat. Most plants, including calla lilies and jack-in-the-pulpits, simply assume the ambient temperature because their metabolic reactions hum along so gently that they don't give off bursts of heat. The dead-horse arum, however, belongs to the group of several hundred plant species scattered among some 10 families that can rev up their own furnaces. That heat can launch strong odors, like those of a dumpster in August. In winter, warm flowers can melt snow.

The dead-horse arum outdoes all the others, says Seymour, who's at the University of Adelaide in Australia. The plant's flesh-pink blooms produce more heat than does any other known plant or any animal considered in its entirety. Scientists have measured higher rates of bodily heat production only in the flight muscles of some insects and, possibly, the brown fat of hamsters.

Descriptions of remarkable heat-making plant species date back more than 200 years, but scientists are still discovering new facets of the phenomenon, sometimes hidden in plain sight. Current research about the biochemistry behind plant heat may someday change the way people deal with heat. The pattern of heating power in the botanical family tree intrigues evolutionists searching for traits of ancient flowering plants. And, this winter, two research teams have presented new research on what good this heating does for a plant.

DEAD GIVEAWAY — The dead-horse arum exudes such a carcasslike fragrance that female blowflies arrive and lay eggs as if the flower were an inviting hunk of carrion. The eggs are doomed, though.

GIBERNAU

KIDNAPPERS All the plant tissues so far found to warm themselves have reproductive functions, and Seymour sees common themes among the hot species' sex lives. They tend toward large blooms, which have a low surface-to-volume ratio favoring heat retention. In many of these blooms, the female organs mature before the male parts, requiring the plant to briefly kidnap pollinators to make its pollination system work.

Consider the dead-horse arum, *Helicodiceros muscivorus*. In spring on islands in the Mediterranean, these plants send up blooms with a central, fingerlike projection in front of a rounded dish of tissue, or spathe, several inches wide. When the plant first blooms, the finger radiates heat, which sends out strong aromas. Female blowflies soon swarm over the bloom.

Botanists have speculated that the stench represents step 1 in an entrapment scheme, attracting blowflies under the false pretense that there's nice dead flesh available as a nursery for their eggs. Tests bear that out, reported Marcus C. Stensmyr of the Swedish University of Agricultural Sciences in Alnarp and his colleagues in the Dec. 12, 2002 *Nature*. Several dominant compounds, called oligosulfides, showed up in both the stink of the flower and in that of a dead seagull. A study of nerve responses of blowfly antennae showed that the flies respond similarly to the composites of compounds that make up the scents, so they don't seem to be able to tell a flower from a dead gull on the basis of smell alone.

In nature, once flies buzz in to explore the dead-horse–arum bloom, many crawl down into the pocket where the spathe narrows to surround the base of the finger. That pocket contains a band of male florets above a band of female florets. Spines and filaments at the entrance to the pocket imprison the flies.

During the first day that a dead-horse arum blooms, female florets have matured enough to receive pollen, but male florets aren't releasing it. The flies, however, may carry pollen they picked up from a previous adventure in another, earlier-blooming plant. As the flies scramble around in the pocket, trying to escape, they dust that pollen onto female florets.

By the next day, the female organs have lost their receptivity, but the male parts have matured. The trapped insects then pick up pollen. The blockade of spines withers, so the flies can at last squeeze up out of the pocket. They then carry the new pollen to the next arum, should they fall for the same trick again.

SELF-CONTROL Seymour reminisces that he first learned about heat-generating flowers several decades ago, when a friend brought the large fingerlike projection of a self-heating flower, *Philodendron selloum*, as a conversation piece to a California party. The structure was warm to the touch and looked more like a mammal's reproductive organ than a plant's.

Seymour was so taken with the structure that he savaged philodendron blooms in his mother's garden to get specimens for measuring heat generation. Thus began the project that first documented a new twist in a few self-warming plants.

While the dead-horse arum and most other self-heating plants produce heat on a preset schedule, regardless of the air temperature, *P. selloum* manages something more sophisticated: It regulates its heat generation to keep its flower temperature approximately steady, Seymour and his colleagues reported in 1972.

Growing outdoors, *P. selloum* keeps its blooms between about 30°C and 36°C. In lab tests, the flowers manage to stay in this range even when experimenters chill the air to 4°C.

Those experiments also revealed that most of the plant's heat comes from a band of tiny, sterile male flowers located between the fertile male and female flowers on the bloom's fingerlike projection. The sterile blooms shut down heat production when air temperature reaches about 37°C.

Like the dead-horse arum, this philodendron in its native Brazil lures insects inside. The philodendron's spathe closes over scarab beetles for only 12 hours. Yet the beetles remain for some 22 hours. While in the bloom, they mate, feed, and brush pollen onto female flowers. At the end of the beetles' stay, they pick up pollen from just-matured male flowers and fly off to another bloom.

The eastern skunk cabbage (*Symplocarpus foetidus*) in North America and Asia also keeps warm, independent of air temperature, Roger Knutson reported in 1974. The insect-pollinated plant flowers early in the year, sometimes by New Year's Day in mid-Atlantic states. Its bloom, a thick-walled, teardrop-shaped spathe surrounding a fat stub covered with florets, can melt holes in the snow cover (*SN: 8/21/99, p. 123*).

Skunk cabbages can bloom inside a snowbank and create their own ice caves. "You can break through the snow and look into these fantastic spaces," Seymour says.

HOT STUFF — The skunk cabbages in Japan melt snow and show the most-precise temperature regulation yet recorded in a plant.

In experiments at air temperatures around 15°C, the inner core averaged some 9° higher. When the air temperature dropped to –15°C though, the fingerlike projections reached temperatures 30° higher than the air. "Some mammals can't even do that well," says Seymour.

In 1996, Seymour and his University of Adelaide colleague Paul Schultze-Motel reported that the Asian sacred lotus (*Nelumbo nucifera*) could also regulate its flower temperature. The species is hardly rare or unfamiliar. It grows widely on both sides of the Atlantic Ocean, but no one had previously tested it for temperature regulation. The Adelaide team found that as environmental temperatures dropped as low as 10°C, flower temperatures stayed between 30°C and 36°C.

The researchers decided to see whether day-night cycling influences the lotus' temperature control, as it does in some other plants. The team covered individual lotus blooms with translucent jackets made from inverted wine-bottle coolers and reversed the normal temperature pattern for night and day. The flowers tracked the temperature instead of the light, Seymour and his colleagues reported in 1998.

The dead-horse arum maintains a relatively stable bloom temperature, but the plant isn't a true temperature regulator, says Marc Gibernau of Paul Sabatier University in Toulouse, France. He, Seymour, and Kikukatsu Ito of Iwate University in Morioka, Japan, found that heating related more to time than air temperature, they report in the December 2003 *Functional Ecology*.

There's only one other plant that's been identified as regulating heat production. It's a South American species, *Xanthosoma robustum*, that's related to the dead-horse arum, philodendron, and skunk cabbage. *X. robustum* has received less attention so far.

FURNACE DESIGN The past 5 years have shaken up the study of the chemistry of hot plants by adding a new heat-generating pathway for scientists to probe. Since 1932, physiologists have known about one heat-making pathway, which is a secondary process for respiration (*SN: 6/24/89, p. 392*). By the 1970s, physiologists had linked the slow-heat burns of arums with a jump in activity in this pathway. An enzyme in the pathway, alternative oxidase or AOX, occurs only in plant cells, where it's located in the cell powerhouses called mitochondria.

Mammal mitochondria can blast out heat, too, but they rely on what's called uncoupling proteins, UCPs. In 1997, a European research team reported similar chemistry in potatoes. Cold prompted activity of a gene making what looked like a version of a mammalian UCP rather than an AOX, said Maryse Laloi of the Max Planck Institute for Molecular Plant Physiology in Golm, Germany.

Ito then began searching for UCPs in skunk cabbages. In 1999, he reported finding genes encoding two UCPs. A temperature drop activated these genes only in the floret-holding stub. The UCPs and AOX seem to function for heat generation simultaneously, he and his colleagues reported at the Plant Biology 2003 meeting in Hawaii in June. "Now, we have to reconsider the functions of two different thermogenic reactions," says Ito.

Since 2001, Ito and his Iwate colleagues—with support from the Japanese government—have been searching for the temperature sensor and other compounds that operate in the skunk cabbage's heat production. The researchers have figured out the basic protocol that the plant follows, says Ito. "We call it 'the skunk cabbage algorithm.'"

Ito has applied for a patent on this protocol and isn't releasing the details. "This sort of biological algorithm could be used as a new brain to control nonbiological devices, such as air conditioners," he says. The standard program controlling an air conditioner was invented more than 60 years ago. The system used by a skunk cabbage, "which is a typical chaotic system, is totally different," he says. Ito's team has recently succeeded in operating an artificial heater with this algorithm. "I really think we can learn a lot from skunk cabbages," he says.

WHAT'S HOT The majority of the hundreds of plants known to generate heat sprout from ancient lineages at the base of the botanical family tree, observes Leonard Thien of Tulane University in New Orleans. Self heating may have been an early innovation that arose soon after the invention of flowering.

Evolutionists are looking at thermogenesis as they reevaluate traits in these old lines. "At the moment, a great deal of discussion is under way to decide upon the state of various characters," says Thien.

For example, heat generation has turned up in certain plants of these ancient lineages of flowering plants: the magnolias, Dutchman's pipes, star anises, custard apples, and water lilies. Heat-generating flowers include the darling of 19th-century aquatic gardens, the Amazon water lily (*Victoria amazonica*).

Thien says that preliminary results suggest that at least one

ITO

other ancient family includes a self heater, but he won't say which one until he double-checks his results next spring.

The most ancient family that Thien has tested is *Amborellaceae*. Only one member remains, a scrub in New Caledonia, and it shows no sign of heat generation, he and his team report.

Moreover, there's no sharp boundary for the evolutionary disappearance of thermogenesis. The trait does show up in a few lineages of moderately recent origin, such as the arums, the palms, and a related family sometimes called the Panama-hat palms. The Asian sacred lotus represents the highest branch on the botanical family tree that shows heat generation.

THE BOTTOM LINE Study of the evolution of heat generation raises questions about what benefits it might bring, or once brought, to a plant. The trait's absence among the newest plant families suggests that its value has declined as modern plants developed.

Biologists first proposed that heat helps spread the plants' insect-attracting odors. In contrast, one recent finding suggests that heat might make a plant more closely resemble a dead animal because microbial processes in a carcass raise its temperature.

Heating an artificially scented plant restored a fading bloom's capacity to lure insects into its pocket. "This is the first time it has been proved that this heating function of the plant is important, with scent, for guiding the pollinators," says Anna Maria Angioy of the University of Cagliari in Monserrato, Italy. She and her colleagues report their findings in an upcoming *Proceedings of the Royal Society of London B: Biology Letters*.

However, Seymour suggests another scenario. He points out that some plants keep the heat on after trapping insects in their chambers, so heat itself might serve as a reward for certain pollinators.

To test that idea, he and his colleagues studied *Cyclocephala colasi* beetles pollinating *Philodendron solimoesense* in French Guiana. As many beetles do, these produce heat to keep their body temperatures high enough for activity. Beetles active in a warm flower during the evening are using less than half the energy they would have used if they had stayed active out in the open, the researchers report in the Nov. 20 *Nature*.

The heat-generating flowers "are like nightclubs for beetles," Seymour says. The warm, alluring environment draws an insect in.

During evolution, a floral innovation may have supplanted the nightclub concept. A flower that offers just a sip of nectar or a pollen snack and then sends the pollinator on its way will probably spread its pollen over many more partners than will a plant that traps insects for a whole night. Seymour's take on why heat rewards died out is that "nightclubs were replaced by fast food." ■

JUNGLE TRAP — A *Philodendron solimoesense* in French Guiana on the first day of blooming (left) starts emitting odors that attract insects. The bloom heats up, and beetles cluster around, saving energy by drawing on the plant's warmth for their nighttime activities. The next evening, when the bloom cools, the beetles fly off.

GIBERNAU

OF NOTE

PHYSICS

Hints emerge of a four-quark particle

Physicists at accelerators in Japan and the United States have detected a subatomic particle that may be unlike any seen before.

Some evidence suggests that the particle contains two pairs of more fundamental particles—quarks and antiquarks—bound together. If that's verified, then the new find would be the first four-quark particle known.

Until recently, quarks and antiquarks were observed only in groups of twos or threes. However, twice this year, researchers have reported possible five-quark particles (*SN: 10/18/03, p. 245*).

The discovery of yet other combinations of quarks and antiquarks could illuminate the force that binds quarks and antiquarks together. Physicists call this the strong force.

Experimenters at the High Energy Accelerator Research Organization (KEK) laboratory in Tsukuba, Japan, noted the first signs of the new particle while examining the aftermaths of hundreds of millions of electron-positron collisions. When the KEK investigators stumbled upon the intriguing new particle, they were seeking a previously undiscovered but mundane quark-antiquark duo—that remains unobserved.

A team at Fermi National Accelerator Laboratory (Fermilab) in Batavia, Ill., confirmed the KEK results, which are chronicled in an upcoming *Physical Review Letters*.

Some theorists suspect the new find may be deceptive. The calculations that guided the KEK team might have been inadequate for predicting the properties of the duo particle the team was seeking, proposes Fermilab theorist Estia J. Eichten. In that case, the newfound particle could actually be the duo, but with characteristics that only seem unexpected. On the other hand, Eichten notes, the large mass of the new particle closely matches that expected if two quark-antiquark D-mesons got hitched. —P.W.

BIOMEDICINE

Nanoparticles hunt down and kill tumors

An innovative therapy that uses gold nanoparticles to destroy tumors could someday offer patients a new weapon against cancer, recent animal studies suggest. Researchers at Rice University in Houston injected gold-coated silica spheres into mouse tumors. Light shined onto the particles triggered the release of heat that destroyed the cancer cells. Because this phototherapy would be less invasive than surgery, it could offer an alternative to typical cancer treatments, the team says.

Each particle, which the researchers call a nanoshell, measures about 130 nanometers in diameter. The team designed the nanoshells to absorb near-infrared light,

OF NOTE

which can penetrate tissue without damaging it.

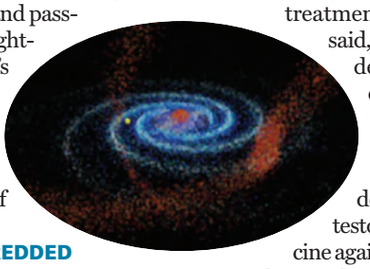
After injecting the nanoshells into the mouse tumors, Jennifer West and her colleagues shined near-infrared light over the tumor site for several minutes. The resulting temperature rise of nearly 40°C was enough to cause irreversible tissue damage. Untreated tissues near the tumors, however, remained unharmed. The Rice team reports its results in the Nov. 11 *Proceedings of the National Academy of Sciences*.

The nanoshells might work against tumors in places where surgery is difficult, such as the brain, or for cancers that have spread in the body, say the researchers. To show that potential, the Rice team injected nanoshells into the bloodstreams of mice with cancer. Because tumors are surrounded by leaky blood vessels, the tiny particles slipped out of the vessels predominantly at the cancer sites and accumulated there, says coinvestigator Leon Hirsch. —A.G.

ASTRONOMY

Alien stars pass close to home

Stars from an alien galaxy are raining down on our own Milky Way and passing just a few hundred light-years from Earth. That's the conclusion of astronomers who have mapped the extent of the Sagittarius dwarf galaxy, one of two dwarf galaxies that the Milky Way's gravity is ripping apart (*SN: 11/15/03, p. 307*).



SHREDDED GALAXY Map of stars in the Sagittarius dwarf galaxy (red streams) orbiting the Milky Way (blue pinwheel). Yellow dot marks the sun.

When a dwarf galaxy passes close to the Milky Way, its leading edge gets pulled more strongly by our galaxy's gravity than its trailing edge does. The unequal tugs stretch the dwarf, pulling stars out in spaghetti-like streams.

A veil of dust in the Milky Way blocks visible light emanating from these streams, but infrared light punches through. Steven R. Majewski of the University of Virginia in Charlottesville and his colleagues mapped Sagittarius by selecting a group of infrared-bright stars. These M stars are rare in the outskirts of our galaxy but plentiful in the dwarf.

The new map reveals that thousands of stars from Sagittarius are now passing through the region of the Milky Way in which the sun resides, the team reports in the Dec. 20 *Astrophysical Journal*. That's something of a cosmic coincidence because the sun and its environs take 240 million years to orbit the center of the Milky Way and intersect the Sagittarius stream for only a small fraction of that time. —R.C.

SCIENCE AND SOCIETY

Panel turns critical eye on testosterone

Existing scientific evidence does not justify claims that testosterone treatments can relieve or prevent certain age-related problems in men, a panel of specialists has concluded. On Nov. 12, the panel, formed by the Institute of Medicine (IOM) in Washington, D.C., called for more-rigorous study of the therapy's putative health benefits and risks.

A rapidly growing legion of men is using testosterone supplements to combat problems such as frail bones, depression, and loss of muscle, mental focus, and libido. But research has not forcefully demonstrated that the treatment is effective. Moreover, the panel notes, the long-term safety of testosterone therapy is even less well understood (*SN: 5/10/03, p. 296*).

After reviewing available data, the IOM committee concluded that researchers should first attempt to establish more carefully whether testosterone is an effective treatment. If it is, the committee said, then further studies could determine whether it also carries risks such as exacerbating prostate cancer and clogging blood vessels.

For now, men and their doctors shouldn't consider testosterone preventive medicine against age-related symptoms, says the panel's chair, Dan Blazer of Duke University in Durham, N.C. —B.H.

ASTRONOMY

Spying a planet in star's dusty veil

To examine the dust disk encircling a young star 330 light-years away, scientists at the University of Arizona in Tucson used an emerging technique called nulling interferometry to block out the star's light. When they looked further, they found clues suggesting that a large gaseous planet was forming near the star, designated HD 100546.

Astronomers are eager to study the disruptions in dust disks to determine how our own planetary system evolved. However, the star's brightness overwhelms the thermal emissions from surrounding dust, making it all but invisible.

Wilson M. Liu and his colleagues adjusted the Magellan I telescope in La Serena, Chile, to record two sets of wavelengths from HD 100546—one offset by exactly one-half a wavelength from the other. This caused the crests and the troughs of the emissions from the star to negate each other, dimming the star's light and giving the astronomers a relatively unobstructed view of infrared emissions from the surrounding dust disk.

In the Dec. 1 *Astrophysical Journal Letters*, the investigators report that there appears to be a gap between the star and the dust disk. They attribute the gap to a Jupiter-like planet sucking up debris. If that interpretation is correct, the 10-million-year-old HD 100546 would be one of the youngest stars to have an orbiting planet. —K.R.

GENETICS

Genome made quickly from scratch

Scientists have found a way to rapidly synthesize the entire genome of a virus. To construct the sequence, which consists of 5,386 DNA building blocks, or base pairs, strung into a single chromosome, J. Craig Venter of the Institute for Biological Energy Alternatives in Rockville, Md., and his colleagues first ordered 259 smaller segments of the genome from a commercial supplier.

Using a cocktail of enzymes and extra DNA pieces, the scientists bound the snippets together and filled in gaps. This created a full-length, synthetic version of the chromosome for a virus known as bacteriophage phiX174, which is harmless to people.

The researchers then infected bacteria with their synthetic bacteriophage genome. Although most of the viruses contained errors, some were able to multiply within the bacteria as effectively as their natural counterparts do. Venter and his coworkers announced their findings at a press conference in Washington, D.C., on Nov. 13 and will publish them in an upcoming *Proceedings of the National Academy of Sciences*.

Last year, scientists announced that they had synthesized the poliovirus genome. That accomplishment took 3 years (*SN: 7/13/02, p. 22*), whereas it took Venter's team only 14 days to replicate the bacteriophage genome.

The next step, says Venter, is to synthesize the shortest-possible functional microbial genome. A microbe made in this way could potentially consume pollutants or churn out hydrogen for fuel cells, the scientists say. At the press conference, they acknowledged that this technique could be combined with others to create harmful viruses such as smallpox. —K.R.

S. MAJEWSKI ET AL.

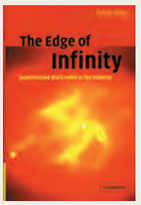
Books

A selection of new and notable books of scientific interest

THE EDGE OF INFINITY: Supermassive Black Holes in the Universe

FULVIO MELIA

At one time, supermassive black holes were viewed as the most destructive force in nature. Now, astronomers view these phenomena as critical tools that built the early universe. Black holes may have spawned bursts of stars, planets, and even life, as



well as contributing as much as half of all the radiation produced after the Big Bang. As many as 200 million black holes could be lurking in the observable cosmos today. Melia, a professor of astronomy and a researcher in the field, outlines what these giant distortions in the fabric of space-time can tell us about our origins and destiny. ***CUP, 2003, 148 p., color plates, hardcover, $30.00.***

EMPIRE STATE BUILDING: When New York Reached for the Skies

ELIZABETH MANN

Built in just 18 months at the hands of more than 3,500 workers, the Empire State Building became

the tallest building in the world and one of New York City's most prominent icons. Mann details its rise, from its inception in the late 1920s to its completion in 1931. Geared toward youngsters, this volume explains how tall buildings are erected and chronicles the people who built this one. *Empire State Building* is the latest addition to a highly acclaimed series of books detailing the construction and history the world's most notable structures. A blend of illustrations and photographs—many taken during construction—includes a centerfold of the building that shows unique facets of its structure. Recommended for ages 8-12. ***Mikaya Pr, 2003, 48 p., color/b&w photos/illus., hardcover, $19.95.***

EVERYTHING'S RELATIVE: And Other Fables from Science and Technology

TONY ROTHMAN

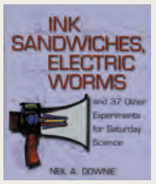
Rothman charges scientists with being self-aggrandizing at the expense of the sometimes scores of others who contribute in some way to each discovery or advance. He turns away from the currently

popular approach of taking a whole book to tell the story of a single scientific milestone. Instead, Rothman presents 20 "anti-anecdotes," each providing a short background to a landmark, such as the discoveries of penicillin and the telegraph, while paying tribute to the lesser-known individuals important to those stories. For instance, he declares that Thomas Savary built the first prototype of the steam engine in 1698, long before James Watt or Robert Fulton tried their hands at similar pursuits. ***Wiley, 2003, 272 p., hardcover, $24.95.***

INK SANDWICHES, ELECTRIC WORMS: And 37 Other Experiments for Saturday Science

NEIL A. DOWNIE

The author of *Vacuum Bazookas, Electric Rainbow Jelly* follows up with another set of fun yet informative science demonstrations. Rather than just listing the necessary tools and instructions for performing an experiment, Downie provides much detail about the science behind each project, including analysis of how each one works and details of the underlying mathematics. Each chapter describes an activity and ends with an advanced challenge. Among the projects is making an hourglass that never has to be turned by hand and creating a clock with an ice cube at its core. Downie also explores the chemistry of solar cells and the fluid mechanics of a coffee-cup revolution counter. Science teachers and inveterate tinkerers will find this book a joy. ***Johns Hopkins, 2003, 334 p., b&w illus., paperback, $18.95.***



SUPERVISION: A New View of Nature

IVAN AMATO

From start to finish, this stunning celebration of science imagery shows how scientific instrumentation has helped us transcend our own sensory limitations, revealing aspects of nature to which our unassisted senses are blind. The book's more than 200 images—each with a detailed caption—sweep across more than 40 orders of spatial magnitude, ranging from the realm of subatomic particles to the entire universe. The result is a visually luscious portrait of the entire scientific enterprise. Amato, who

is the associate editor of *Science News*, says he wrote and assembled this book to make the appealing, visual aspects of science available to an audience beyond scientists themselves. Physician and author Oliver Sacks encapsulates *Super Vision* this way: "A whole history of science and technology, of seeing and imaging, is contained in this extraordinary book." ***Abrams, 2003, 232 p., color/b&w photos, hardcover, $40.00.***

THIS IS NOT A WEASEL: A Close Look at Nature's Most Confusing Terms

PHILIP B. MORTENSON

Homonyms, such as their and there and our and hour, are easily discernable. However, we can be perplexed as to whether quite dissimilar words mean the same thing—especially when it comes to plants and animals. Sweet potato versus yam is one example. Shrimp-prawn and scallion-shallot are others. Mortenson meticulously spells out the distinctions between these items and scores of others by presenting scientific information or taxonomy. He also sorts out the history of the terminology and how various cultures regard the items. As it turns out, yams aren't especially tasty to people—it is the sweet potato that graces our holiday tables. And, it is the British who favor prawn, while Americans eat shrimps of different varieties. ***Wiley, 2004, 272 p., paperback, $16.95.***

HOW TO ORDER To order these books, please contact your favorite bookstore. *Science News* regrets that at this time it can't provide books by mail.

LETTERS

Edgy approach

I feel that there is a major factor that nobody takes into account when modern people set out to replicate possible ancient voyages ("Erectus Ahoy," *SN: 10/18/03, p. 248*). It is that they're attempting to get from point A to point B, which they know exists, but ancient seafarers weren't. Setting off from Timor on a 600-mile voyage without knowing whether there is any land out there seems like a terrific leap of faith. Even sailors in the Middle Ages were scared that they were going to sail off the edge of the world. Surely, *Homo erectus* would be.

PHIL BUGLASS, WAYNESBORO, PA.

Researcher Robert G. Bednarik says that from Bali to Timor, Stone Age seafarers could see across each sea barrier to the next island's shore by climbing volcanic outcrops. He suggests that these experienced mariners also recognized indirect evidence of Australia, such as bushfire smoke carried on prevailing winds and the movement of birds and sea creatures. —B. BOWER

Damned if it doesn't

The proposed Policy Market Analysis (PAM) project might be useful if it sparks interest in market limitations ("Best Guess: Economists explore betting markets as prediction tools," *SN: 10/18/03, p. 251*). The stock market may have quickly determined who was to blame for the Challenger disaster, but it didn't predict the disaster. An unexamined problem with the PAM plan is the presence of a superpower that can game the system. Example: Will the Egyptian government be taken over by fundamentalists? If the market says yes, the United States may send troops. Traders know this, so predicted probability decreases, U.S. decision makers relax, resulting in a fundamentalist takeover. The market can make an effective prediction only if the superpower doesn't act on the information.

LYLE LOFGREN, MINNEAPOLIS, MINN.

Correction *Because of an error in the referenced research article, "Chicken Little? Study cites arsenic in poultry"* (SN: 10/25/03, p. 259) *overstated the tolerable intake of inorganic arsenic. A United Nations committee recommends consumption of no more than 15 micrograms per kilogram of body weight per week.*

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