SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

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Cover An infestation of frogs no longer than your thumb has Hawaiians and federal wildlife officials poised to wage war. Locals object to the critters' loud crooning, while biologists worry that the invasive species will upset ecosystems that evolved in the absence of amphibians. (Rex Cauldwell) Page 11

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SCIENCE NEWS
This Week

Fracture Protection

Nanotubes toughen up ceramics

Ceramics are famous for being hard but easy to break. Now, researchers have demonstrated that adding carbon nanotubes to a ceramic material can nearly triple its resistance to fracturing.

Since carbon nanotubes were discovered a decade ago, ceramics researchers have tried to exploit the tiny tubes' extraordinary strength and flexibility to make much more fracture-resistant materials.

Such durable materials could eventually replace conventional ceramics or even metals in countless products, says Joshua D. Kuntz of the University of California, Davis. For instance, engineers might use the toughened ceramic to make gears, bearings, or other parts for everything from racecars to industrial food-processing equipment.

In the new research, Kuntz, Amiya K. Mukherjee, and their UC-Davis coworkers aimed to toughen a ceramic made of alumina crystals only nanometers wide. Such nanocrystalline ceramics are particularly hard, but they're brittle and fracture easily.

In previous work, other researchers had added carbon nanotubes to alumina during processing. The best of these attempts improved the resulting composite's fracture resistance, or toughness, by only 24 percent. That experiment used multiwall carbon nanotubes, which resemble a set of nested straws.

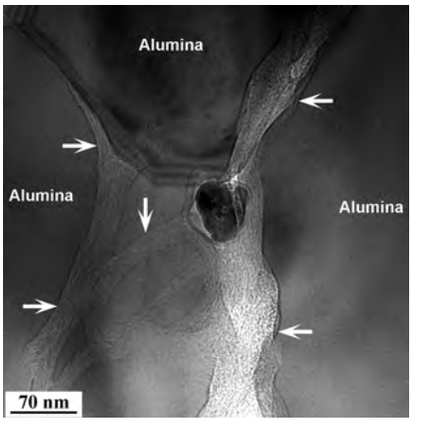
The UC-Davis researchers suspected that high processing temperatures damaged many of the added nanotubes. They also predicted that single-wall carbon nanotubes would work better than the multiwall kind.

In their recent experiments, the scientists mixed alumina powder with single-wall carbon nanotubes and then forced the particles together with a combination of heat, pressure, and pulses of electric current. Called spark-plasma sintering, the method operates at lower temperatures than the conventional sintering technique used in previous attempts to make nanotube-reinforced composites.

When the researchers made a ceramic with nanotubes as 5.7 percent of its material, the product's fracture toughness was more than twice that of a pure-alumina ceramic. With carbon nanotubes at 10 percent of the volume, the ceramic's toughness nearly tripled. The researchers report their results in the January *Nature Materials*.

"It's a very nice piece of work," says Richard W. Siegel of Rensselaer Polytechnic Institute in Troy, N.Y., who had worked with other researchers to produce the toughest previous alumina-nanotube ceramic. Says Siegel, "Combining single-wall carbon nanotubes . . . with the rapid sintering technique that they used seems to be the key, and it's exciting."

Siegel also points out that single-wall carbon nanotubes aren't cheap. The earliest uses of ceramics made with these materials would probably be applications in which cost is a secondary concern, such as in space vehicles and medical devices, he says. —J. GORMAN



NANOTUBE NETWORK Several carbon-nanotube bundles (arrows) wind their way through a mostly alumina ceramic.

KUNTZ AND C. NELSON/LAWRENCE BERKELEY NATIONAL LABORATORY

Sulfur Studies

Early Earth's air was oxygen-poor

Analyses of ancient sulfide minerals and the modern organisms that create sulfides are giving scientists a better idea of what Earth's atmosphere and oceans may have been like billions of years ago. The findings may also explain a paradox that has long puzzled solar astronomers.

In one of the new studies, scientists looked at the ratio of isotopes in sulfide particles trapped in diamonds unearthed from a mine in Botswana. Radioactive dating shows that those gems formed about 2.9 billion years ago, says Mark H. Thiemens, a chemist at the University of California, San Diego.

In the Dec. 20, 2002 *Science*, Thiemens and his colleagues argue that their data—in particular, a higher-than-normal proportion of sulfur-33 in the inclusions—can only be explained by certain atmospheric chemical reactions that are stimulated by specific wavelengths of ultraviolet light. Today, those wavelengths are screened from most of Earth's atmosphere by ozone (O_3) and oxygen (O_2). If there had been more than a trace of oxygen in the atmosphere 2.9 billion years ago, the sulfide inclusions would have contained isotope ratios typical of today's compounds.

Coauthor Kevin D. McKeegan says that it's "rather surprising" that a diamond formed deep within the planet contains information about Earth's ancient atmosphere.

In another report in the same issue of *Science*, other researchers infer the composition of the early atmosphere in a different way—from the isotope ratios in sulfides produced by aquatic microorganisms that feed on dissolved sulfates.

Donald E. Canfield of the University of Southern Denmark in Odense and his coworkers studied living microbes taken from both freshwater lake sediments and coastal marine sediments. They also measured isotope ratios in sulfides produced by *Archaeoglobus fulgidus*, a single-celled organism that thrives around deep-sea hydrothermal vents.

When dissolved sulfates were plentiful in the experiment, the microbes produced sulfide compounds with isotope ratios that differed significantly from those in the sulfates. However, when the scientists provided concentrations of dissolved sulfates of less than 20 parts per million, the sulfur-isotope ratios in the microbe-generated sulfides didn't vary markedly from those in the sulfates.

That's telling because sediments deposited more than 2.5 billion years ago don't show large differences between the isotope ratios of their sulfates and sulfide minerals produced by primordial microbes, says Canfield.

The new lab results suggest that ancient oceans had only low concentrations of dissolved sulfates—a sign that there probably wasn't much oxygen in the air to react with the abundant sulfur dioxide that was being spewed into the sky by volcanoes.

The early scarcity of dissolved sulfates and atmospheric oxygen has big implications. For one, says Canfield, microbial communities were probably dominated by organisms that produced methane, a planet-warming greenhouse gas that traps heat more than 20 times as effectively as carbon dioxide does.

A methane-rich atmosphere on early Earth, in turn, could explain the so-called faint-young-sun paradox, says Uwe H. Wiechert of the Institute for Isotope Geology and Mineral Resources in Zurich. Current models of solar evolution suggest that when

our planet first formed 4.5 billion years ago, the sun produced only about 70 percent as much radiation as it does now. Without a large greenhouse effect, solar luminosity at that time wouldn't have been enough to keep the oceans from freezing solid. —S. PERKINS

Homing Lobsters

Fancy navigation, for an invertebrate

Scientists willing to drive boats and cars in convoluted patterns say that spiny lobsters are the first animals without backbones to pass tests for the orienteering power called true navigation.

This capability lets homing pigeons and a few other animals figure out not just compass orientation—which way is north—but also their current address on the planet, explains Larry Boles of the University of North Carolina at Chapel Hill. Some birds, turtles, and salamanders can get back on track even after researchers enclose them in windowless containers and move them by a twisted route to an unfamiliar place. Bees and ants, however, get lost. People generally succeed at similar challenges only with the help of maps, compasses, and informative bystanders.

Experts on the Caribbean spiny lobster (*Panulirus argus*) have recorded occasional tales of its superior navigation, and now systematic tests have confirmed them, says Boles. The new experiments also suggest that the lobsters manage their remarkable feat by sensing their location within the magnetic field of Earth. Circuitous driving didn't fool animals transported to a new spot, but altering the magnetic field of the destination did, report Boles and his North Carolina colleague Kenneth Lohmann in the Jan. 2 *Nature*.

"A lot of people, even scientists, tend to think of invertebrates as lower animals," says Boles. "We now have an example in an invertebrate of the most sophisticated navigation an animal can do."

The Caribbean spiny lobsters dwell in the western Atlantic Ocean from Bermuda to Brazil. To see whether they have a homing ability, Boles caught more than 100 lobsters in different locations and transported them for about an hour in various deceptive ways to a test site. He kept the lobsters in opaque, rope-suspended compartments, and for some, he dangled magnets inside the travel containers.

While transporting the lobsters, he followed routes with "ridiculous contortions," he says. "I was worried about attracting attention from the marine patrol looking for drunken boaters."

When Boles finally reached one of his two test sites, he blindfolded each lobster by applying removable caps molded out of dental amalgam to fit over the eye stalks and tethered the animal in a tank with a slippery floor. It then trudged in a direction close to its homeward bearing. For example, lobsters dislocated 250° from north oriented themselves, on average, at an angle of 222°. The magnetic conditions during transport didn't influence this behavior.

KIDNAP ME A Caribbean spiny lobster's extraordinary navigation system points the creature homeward even after tortuous transport to an unfamiliar location.

LOHMANN

To explore what cues the lobsters might be using, Boles and Lohmann settled each animal into a device that recreates the magnetic field of another place. Lobsters in a false field mimicking conditions 400 kilometers north of their home walked south, and counterparts in a false southern field walked north.

A specialist in animal navigation, John Phillips of Virginia Tech in Blacksburg calls the findings "very exciting." Recent work suggests that vertebrates can use two separate systems for detecting their magnetic environment. Phillips suspects that the lobster system evolved independently and will make an interesting comparison. —S. MILIUS

Secrets of Memory All-Stars

Brain reflects superior recollection strategy

Some people have flypaper memories. Bits and pieces of information stick in their minds, enabling them to remember a dizzying array of stuff.

These memory all-stars aren't smarter than the rest of us. Nor do they possess brains equipped with beefed-up memory centers. According to a report in the January *Nature Neuroscience*, their advantage lies in a propensity to use a learning strategy that engages brain areas important for spatial memory.

This particular memory-boosting strategy, described almost 2,500 years ago by a Greek poet, requires visualizing a pathway along which items to be remembered are situated at different points. A person later recalls the items by mentally retracing the route.

Neuroscientist Eleanor A. Maguire of University College London and her colleagues studied 20 adults, half having exceptional memories and half having average memories. The two groups scored comparably on tests of verbal intelligence and nonverbal reasoning. During memory trials, a functional magnetic resonance imaging scanner measured blood flow—a marker of neural activity—in their brains.

Each volunteer viewed six items presented briefly, one at a time, and tried to remember the order. Each sequence was presented five times. One test consisted of three-digit numbers, another displayed black-and-white photos of men's faces, and a third showed snowflake patterns.

After seeing, say, the sequence of six faces shown five times, participants viewed pairs of the faces and indicated by pressing a key which of the two had appeared first.

Exceptional memorizers showed pre-

dictable superiority on this task. In 9 of 10 cases, they reported having relied on the route-visualization strategy to remember items in sequence. None of the average-memory volunteers said that they had used a special memory strategy.

Compared with the run-of-the-mill rememberers, exceptional memorizers displayed greater activity in three brain areas linked to spatial memory and navigation. Neural bustle in these spatial sites remained apparent in the scans after the researchers screened out the responses of regions that had been activated by visual processing alone.

Intriguingly, the critical spatial areas were no larger in exceptional memorizers than in average memorizers.

"These brain findings confirm what memory experts have long said about using this [spatial] strategy," comments memory researcher Larry R. Squire of the Veterans Affairs Medical Center in San Diego. —B. BOWER

Coffee Jitters

Caffeine boosts predictor of heart problems

Whether it comes from coffee or another source, caffeine gives a troubling boost to one biological indicator of poor heart health, a new study suggests. Moreover, other ingredients in coffee appear to at least double the effect of caffeine alone.

Past studies have shown that drinking coffee can increase blood concentrations of the amino acid homocysteine, which has been associated with an elevated risk of heart attacks (*SN: 1/11/97, p. 22*). Meanwhile, quitting coffee can reduce blood concentrations of both homocysteine and artery-dam aging cholesterol (*SN: 9/22/01, p. 180*).

Petra Verhoef of Wageningen University in the Netherlands and her colleagues set out to test whether caffeine is responsible for coffee's homocysteine-raising effect. For each 11-day study period, the researchers gave volunteers one of three daily treatments: 0.9 liters of filtered coffee, six pills containing an equivalent amount of caffeine, or six caffeinefree pills. During the trial, every volunteer received a course of each treatment and was asked to refrain from consuming other items that contain caffeine.

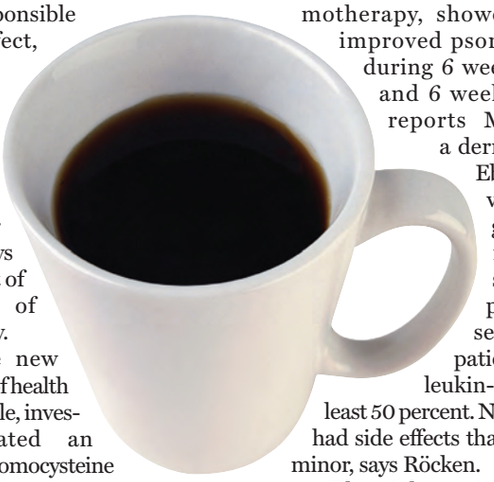
Twice during each treatment period, the researchers collected blood samples from the volunteers before and after they ate breakfast and consumed half their daily coffee or pills. People who weren't consuming caffeine had an average prebreakfast homocysteine concentration of 9.6 micromoles per liter (µmol/l), compared with 10.0 µmol/l for volunteers taking caffeine pills and 10.5 µmol/l for people on the coffee treatment. Although these differences are small, they indicate statistically significant rises in homocysteine during treatments featuring caffeine, Verhoef and her team report in the December 2002 *American Journal of Clinical Nutrition*.

In general, volunteers' homocysteine concentrations fell nearly 1 µmol/l after breakfast, even when caffeine pills were part of the meal. However, drinking coffee with breakfast canceled the meal's usual homocysteine-lowering effect.

The study confirms researchers' suspicion that caffeine contributes to coffee's homocysteine-raising effect, says Paul F. Jacques of the Jean Mayer USDA Human Nutrition Research Center on Aging at Tufts University in Boston. It also indicates that caffeine isn't responsible for the entire effect, he says.

Given the modest homocysteine increases shown in the new study, it shouldn't cause much concern for coffee drinkers, says Stein Emil Vollset of the University of Bergen in Norway.

In a separate new nationwide study of health data on 7,103 people, investigators correlated an increase in blood homocysteine with a rise in blood pressure and risk of heart and artery problems. Women with the highest homocysteine concentrations were three times as likely to have hypertension as were women whose concentrations measured about 5 µmol/l lower. Men showed a smaller correlation, Unhee Lim and Patricia A. Cassano of Cornell University report in the Dec. 15, 2002 *American Journal of Epidemiology*. —B. HARDER



JAVA WORRY
Drinking coffee may make matters worse for the heart.

Clear Skin

Injections counteract psoriasis in patients

Injections of an immune system protein can alleviate skin problems in people with psoriasis, a German-Dutch research team reports. The well-tolerated protein, called interleukin-4, works as well as a powerful standard therapy known to cause severe side effects. If the results are confirmed in larger studies, interleukin-4 could offer an alternative therapy for this difficult-to-treat disease.

Psoriasis is marked by an overproduction of skin cells. The scaly skin that results causes itching, burning, and pain. Scientists consider the disease an autoimmune disorder, in which the immune system attacks a person's own tissues.

The researchers instructed 22 patients with moderate-to-severe psoriasis to inject themselves with interleukin-4 three times a day for 6 weeks. Eight other patients received photochemotherapy, the most potent therapy currently in use. In this treatment, patients expose their skin to ultraviolet light and take the immune-suppressing drug methotrexate. All the people in this study hadn't responded adequately to other psoriasis therapies.

All the volunteers, whether they had received interleukin-4 or photochemotherapy, showed significantly improved psoriasis symptoms during 6 weeks of treatment and 6 weeks of follow-up, reports Martin Röcken, a dermatologist at the Eberhard Karls University in Tübingen, Germany. For instance, on a standard scale of psoriasis-symptom severity, 19 of 22 patients taking interleukin-4 improved by at least 50 percent. None of the patients had side effects that were more than minor, says Röcken.

The eight patients getting photochemotherapy achieved similar responses during the study, Röcken and his colleagues report in the January *Nature Medicine*.

The ultraviolet-light therapy is inconvenient and boosts the risk of skin cancer, says dermatologist Gerald Krueger of the University of Utah in Salt Lake City. Methotrexate carries a risk of liver damage. Other psoriasis medications can leave patients vulnerable to side effects that include infections, headaches, fever, and nausea.

"Without a doubt, a new approach is needed" for psoriasis care, Krueger says. Previous studies in people have shown that interleukin-4 causes few side effects. Whether interleukin-4 will be a successful treatment will depend on further testing and whether patients would be willing to put up with repeated injections, he says.

In the body, immune cells called CD4 T helper cells produce a host of proteins, including interleukin-4, that orchestrate the response to invaders. In psoriasis, these cells overproduce a damaging protein called interferon-gamma. Röcken found that interleukin-4 treatment reduced the proportion of interferon-making cells in patients' skin lesions and boosted the proportion of cells making interleukin-4. The healing scores for patients correlated closely with the extent of this change, Röcken says. —N. SEPPA

MAPPING WITH GRACE

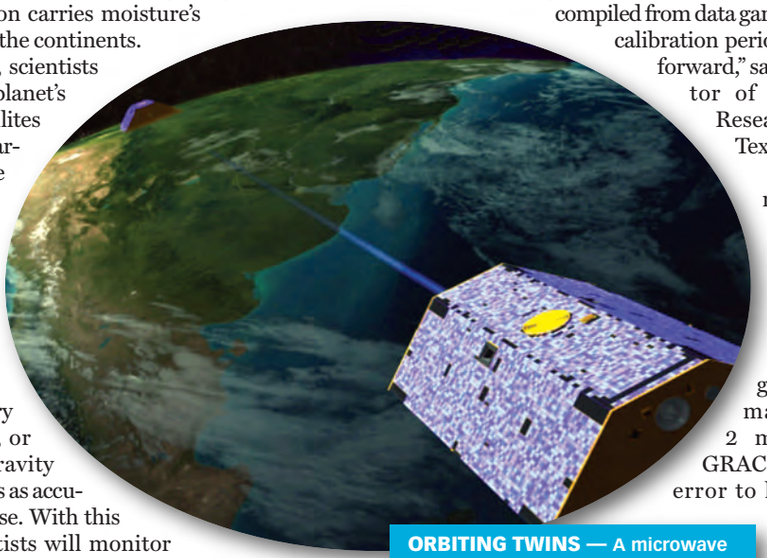
Twin satellites chart changes in Earth's gravitational field

BY SID PERKINS

Concerned about your weight? Don't go to the North Pole, where you're about 20 km closer to the center of Earth—and therefore a pound or so heavier—than at the equator. Head, instead, for India. There, you'd be standing over a less-dense landscape with a gentler gravitational pull. Yes, what you weigh depends on where you are. Your body doesn't change from place to place, but the gravitational field does. Topography, crust composition, and the planet's rotation-induced equatorial bulging are among the factors that influence Earth's gravitational pull at different locations. Furthermore, this uneven gravitational field changes slightly with the seasons, as precipitation carries moisture's mass from the oceans onto the continents.

For more than 30 years, scientists have been monitoring the planet's tug with several dozen satellites and sensitive instruments carried into the field. But the global gravitational model that they've compiled from that data has just been rendered obsolete by a pair of satellites that were launched last March.

Over their 5-year lifespan, the two spacecraft—dubbed the Gravity Recovery and Climate Experiment, or GRACE—will produce gravity maps more than 1,000 times as accurate as those currently in use. With this enhanced accuracy, scientists will monitor subtle seasonal shifts in ocean currents, the changing mass of ice sheets, and the movement of water over and beneath Earth's surface.



ORBITING TWINS — A microwave relay between the GRACE satellites measures their separation, which varies as the craft pass over gravitational anomalies on Earth's surface.

NASA

ORBIT FOR TWO The twin GRACE craft—each about the size of a car and weighing half a ton—will orbit Earth at an altitude of nearly 500 kilometers, says Michael M. Watkins, a project scientist at NASA's Jet Propulsion Laboratory in Pasadena, Calif. They'll zip along a single trajectory, with one satellite leading the other by about 200 km. A microwave relay between the two craft will enable scientists to measure the distance between the satellites within a few millionths of a meter—about the width of a red blood cell or a particle of smoke. That accuracy is the key to constructing detailed maps of the planet's gravitational field, says Watkins.

Here's how the process works: As the first GRACE craft approaches a massive object on Earth's surface—a mountain, for example—it's pulled slightly forward in its orbit, away from its partner. After it passes over the mountain, it's pulled backward while the second satellite is pulled ahead, thus decreasing the distance between the two craft. Finally, after the second satellite crosses the mountain, it's pulled backward. Eventually, the distance between the two craft returns to normal. The changes in separation between the two satellites indicate the size of the gravitational anomaly that the mountain creates.

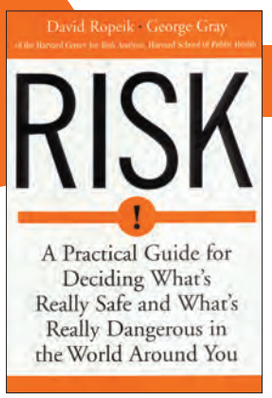
Those anomalies, representing local distributions of mass, are then used to map Earth's so-called geoid—the height that sea level would be at any point on the planet without the effects of ocean currents, weather, or tides.

BETTER BY FAR The first geoid maps derived from GRACE data were unveiled last month at the American Geophysical Union's fall meeting in San Francisco. Even though those maps were compiled from data garnered during the satellites' calibration period, they're "already a step forward," says Byron D. Tapley, director of the Center for Space Research at the University of Texas at Austin.

Updates to old gravity maps are largest in South America, Africa, the Himalayas, and other areas where scientists had previously collected only limited field data. In some places, errors in geoid height on the old maps were as much as 2 meters, says Watkins. GRACE data has reduced that error to less than 1 centimeter. "Now, we're ready to look at how the geoid varies over short periods of time," he adds.

What scientists hope to see in GRACE data are month-to-month changes in Earth's geoid, says John M. Wahr of the University of Colorado at Boulder. For example, GRACE will soon detect to accuracies of about 4 mm any rises or falls in water stored in a snow pack or in soil over areas about the size of the Mississippi River basin, an area of 3.2 million square km. When the satellites are fully operational in a few months, GRACE will detect monthly changes of 4 mm or more in water level over areas as small as 250,000 square km.

That sort of accuracy could help scientists watching arctic ice sheets determine whether the ice masses are shrinking and enable farmers to monitor soil-moisture levels, says Wahr. Monthly updates to Earth's geoid should be available beginning in about a year. ■



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We have become a fearful nation. Every day, we hear reports about hazards to our health and safety—from air travel to air bags, cell phones to salmonella—that leave us feeling frightened and insecure. But our fears often don't match the facts, according to David Ropeik and George Gray, analysts from the Harvard Center for Risk Analysis at the Harvard School of Public Health.

Fears of relatively low risks often run high, while concern about some larger risks is lower than it should be. To help people make more informed decisions about just what is dangerous and what isn't,Ropeik and Gray have produced a scientifically accurate and balanced guide to many of the major risks we face. In *Risk*, the authors explain hazardous materials and processes, describe ranges of consequences and exposures, and tell us what we can do to reduce our risk.

Topics include driving while talking on a cell phone, genetically modified food, biological weapons, environmental hormones, and obesity.

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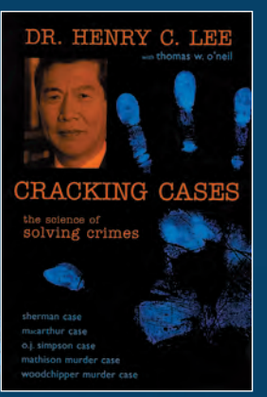
A SERVICE OF SCIENCE NEWS BOOKS

Cracking Cases takes the reader through the entire investigative process of five murder cases, with world-renowned forensic expert Henry C. Lee as guide. These engaging cases include the infamous O.J. Simpson case, in which Lee's analysis of blood evidence at the crime scene revealed that the Los Angeles Police Department had missed several blood drops on Nicole Simpson's back, a footprint belonging to a second assailant, and the physical improbability of O.J. Simpson's climbing a fence to return to his home. Also included are the Woodchipper murder, in which an airline pilot killed his wife and then ground up her body; the Mathison murder, in which a veteran Hawaiian police sergeant claimed he accidentally ran over his wife after she fled the family van during a dispute; a murder in which a college English professor tried to disguise the time of his wife's death by turning up the air conditioning; and the case of a police officer who killed his wife but tried to make it look like suicide.

In each case, Lee presents an easily understood, detailed scientific explanation of how he investigated the murder, analyzed the evidence, and used forensic techniques to bring the criminals to justice. The reader learns how forensic experts examine blood-splatter evidence and use blood identification, DNA analysis, and other scientific technologies.

—from Prometheus Books



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BREATHTAKING SCIENCE

Biologists home in on the brain area that drives respiration

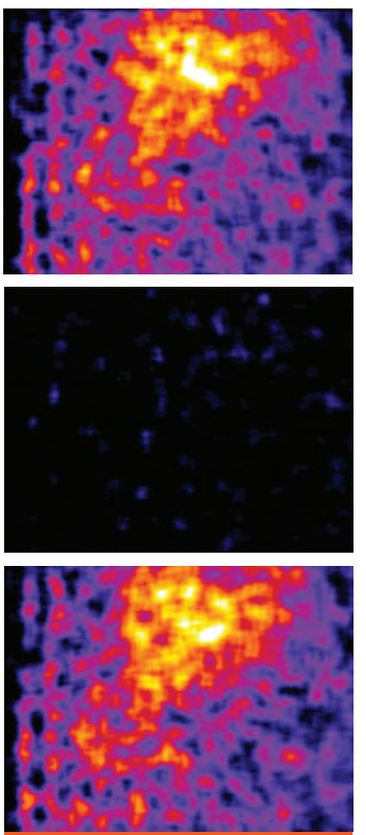
BY JOHN TRAVIS

Nearly 2,400 years ago in a treatise aptly titled "On Breath," Aristotle posed a question that continues to captivate scientists today: "How can we account for the maintenance of the breath inherent in us, and for its increase?" In a suburb just outside Washington, D.C., Jeffrey C. Smith shows just how close modern researchers are to answering that question. With the aid of a powerful microscope, a computer monitor, a loudspeaker, and an array of other devices, he and a colleague use a minuscule electrode to listen in on the electrical activity of a paper-thin disc of living brain tissue. Every few seconds, the speaker crackles with sound.

That recurring noise is compelling evidence that biologists have finally identified what French physiologist Jean Pierre Marie Flourens more than a century ago called the *noeud vital*—the vital node. It's the source of a body's natural breathing rhythm.

Over the past decade, Smith and other neuroscientists have homed in on this rhythm-generating kernel of nerve cells. They've located it within a well-defined region of the brainstem, the part of the brain that sits at the top of the spinal cord and controls most of the body's automatic functions. This brainstem area, called the pre-Bötzinger complex, appears to drive both the normal, quiet breathing pattern and more complicated breathing actions such as sighs and gasps.

"We're very far along the road of solving the basic problem of how we breathe," says Smith, who works at the National Institute of Neurological Disorders and Stroke in Bethesda, Md. That solution is of more than academic interest. Understanding how the brain controls breathing could suggest new ways to prevent sudden infant death syndrome (SIDS), point toward safer anesthetics, and lead to better treatments for respiratory conditions such as sleep apnea, in which people have difficulty breathing while asleep. "There's considerable clinical relevance," says Smith.



LIGHTS ON — This series of lab-plate images, taken at 5-second intervals, shows rhythmic activity of a cluster of brain cells that drives respiration. A calcium-sensitive dye fluoresces (yellow) when the cells have a burst of electrical activity.

J. SMITH ET AL.

THE VITAL NODE With two treatises on the topic, Aristotle was among the first to record his thoughts on the role of breathing. "A few of the earlier natural philosophers have dealt with respiration; some of them have offered no explanation why this phenomenon occurs in living creatures; other have discussed it without much insight, and with insufficient experience of the facts," he dismissively noted. Aristotle, of course, had his own theory. He argued that breathing cools the body heat generated by the "fiery nature of the soul which exists in the heart."

It was another 2,000 years before scientists began to recognize that breathing's core function is to draw in oxygen from the air and expel carbon dioxide. Although people can hold their breaths for a while and sometimes exert great control over breathing, the process usually is on autopilot. And for good reason. "From birth until death, you can't go too long without breathing," Jack Feldman of the University of California, Los Angeles wryly noted in a lecture at the Society for Neuroscience meeting in Orlando last November.

A person's heart can beat on its own, but it takes brainpower to drive even the automatic inhaling and exhaling of air. Galen, a Greek physician who lived a few generations after Aristotle, may have been the first to realize that. He noted that gladiators and animals could usually still breathe if injured below the neck but sometimes stopped breathing immediately when suffering neck and head injuries.

That observation points to the brain as the breathing center, but it doesn't indicate a specific part of the brain. When investigators in the 18th century showed that rabbits continue to breathe after their cerebrum and cerebellum are removed, researchers began to concentrate on the brainstem. In the 1840s, Flourens narrowed the field's focus to a specific brainstem region within an area called the medulla. Lesions in this area, his *noeud vital*, stopped respiration in animals.

Over the next century or so, researchers tried to better define the boundaries of the *noeud vital*. Initially, they mostly performed lesion experiments, and then later they began recording the electrical activity of the brains of sedated cats. "Breathing is the only movement that continues to be generated spontaneously by the brain in the deeply anesthetized animal," notes Smith.

In the 1980s, researchers found that the neural basis of respiration could be studied in brainstems—attached to spinal cords—surgically removed from newborn rodents and kept alive in laboratory dishes. This tissue contains brainstem nerves that control muscles involved in breathing, such as the tongue and diaphragm muscles. Even in a lab dish, these nerves continue to show peri-

odic bursts of electrical activity that the scientists concluded reflect a basic respiratory rhythm. The bursts occur at a slower frequency than the normal breathing rate, says Smith, because the tissue is kept in oxygen-rich, lower-than-body-temperature conditions that reduce the typical bursting rate.

In the mid-1980s, Smith joined Feldman's group and began an effort to further pinpoint the *noeud vital*. He painstakingly carved out pieces of the newborn rat brainstem and documented whether the respiratory rhythm persisted. In 1991, Smith, Feldman, and their colleagues reported that this rhythm could be traced to an area of the medulla near another brain region that controls breathing out. The region involved in exhaling had been named the Bötzinger complex after a German wine that scientists were drinking when they announced its discovery, so Smith and Feldman dubbed the newly recognized area the pre-Bötzinger complex (PBC).

The investigators also reported that nerve cells within this complex exhibit periodic bursts of electrical activity. Calling these cells "pacemaker neurons," they proposed that a network of these cells is responsible for the rhythmic electrical activity observed in the nerves controlling respiratory muscles.

More recently, neuroscientists have sought a more molecular way to identify which nerve cells in the PBC generate the respiratory rhythm. In 1999, Feldman's group reported rhythmic electrical activity in a set of about 600 PBC neurons that display a cell-surface protein that responds to a brain chemical called substance P.

Two years later, the scientists established the importance of those cells. They injected the PBC of live rats with a toxin that gradually destroys nerve cells bearing the substance P receptor. For a few days after the injections, the rats breathed normally. But after the toxin had killed more than 75 percent of the targeted nerve cells, the rodents began to breath so irregularly that they could not regulate the carbon dioxide and oxygen in their blood. Some of the rats died.

At the Society for Neuroscience meeting, Boston researchers investigating the origin of SIDS reported that the receptor for substance P may have led them to the human *noeud vital*. "We look at sites in the brainstem that are critical for the control of things like respiratory function, heart rate, and temperature control," explains David Paterson of Children's Hospital in Boston. "There's a body of evidence suggesting that respiratory failure is part of the underlying cause of SIDS."

The investigators studied the brainstems of five infants who had died of natural causes other than SIDS. Using an antibody marker that binds to the substance P receptor, the researchers found nerve cells that carry the receptor and are in a location in the infant brains roughly corresponding to that of the PBC in rodents.

"We still have a lot of work to prove that it's the same region that we see in animals," cautions Patterson. If it is, however, his team plans to investigate whether this brain region is abnormal in infants who died of SIDS or other respiratory disorders.

A SIGH IN A DISH Does the PBC control all types of breathing? Yes, says Jan Marino Ramirez of the University of Chicago. He studies sighs and gasps, in addition to the typical, resting breathing pattern that scientists call eupnea.

A sigh is a breath with an extended period of inspiration, according to Ramirez. Most people think of a sigh as the loud exhaling that follows this intake of air, he notes. Infants tend to sigh about every 10 minutes, but this frequency goes down as a person grows up.

"The sigh is an arousal mechanism. Ninety percent of the time when you wake up at night, [it's] due to a sigh or starts with a sigh," notes Ramirez.

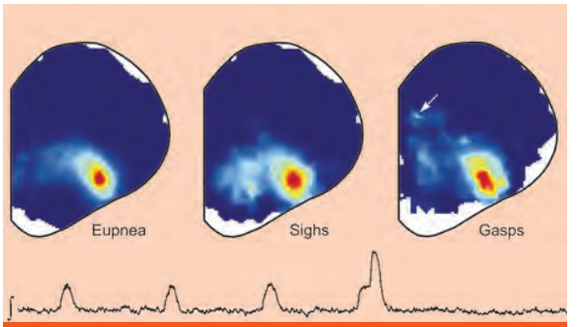
On the other hand, a gasp is a much more rapid, dramatic intake of air. The gasp, says Ramirez, is largely a last-ditch effort to bring in air when the body is starved for oxygen.

> "The same network can generate normal breathing, gasping and sighing."
>
> —JAN MARINO RAMIREZ

There's evidence that infants who die of SIDS don't sigh or gasp normally. "Basically, the two emergency mechanisms, the sigh and the gasp, are reduced [in SIDS babies]," says Ramirez.

About 2 years ago, he and his colleagues reported that sighs and gasps can be discerned within the respiratory rhythm recorded with electrodes from rodent brainstem tissue. Whereas eupnea shows up as single bursts of electrical activity, occasionally a second, larger burst immediately follows this regular burst. Ramirez considers this a sigh. Moreover, if the rodent brainstem is subjected to low oxygen availability, the respiratory rhythm occasionally exhibits spasms of electrical activity that are briefer but much stronger than a typical burst. Ramirez interprets those powerful surges as the equivalent of gasps.

When the investigators looked to see where each of these different bursting patterns originated in the brainstem, they found that the electrical activity always centered within the PBC. These findings stunned Ramirez. He had long thought that sighs and gasps were triggered by networks of nerve cells distinct from the one that controls normal breathing. Now, he argues that a single neural network simply reconfigures itself to produce different kinds of respiration. "The same network can generate normal breathing, gasping and sighing," he says.



BREATHE IN — These three maps of nerve cell activity indicate that the rhythmic electrical pulses that drive normal breathing, gasps, and sighs all occur in the same area of the rodent brainstem, the pre-Bötzinger complex. A recording of the electrical activity within this complex shows three pulses typical of the normal breathing rhythm followed by a double pulse that signifies a sigh.

S.P. LIESKE ET AL./NATURE NEUROSCIENCE

FINDING THE RHYTHM Not everyone is convinced by the current evidence pointing to the PBC as the neural locus of breathing. Some scientists still argue that a much larger network of nerve cells drives the respiratory rhythm. Even Smith and Feldman acknowledge that there's much more to the neural control of breathing than the PBC.

"The evidence is pretty unequivocal that this is a key element for the generation of respiratory rhythm. But in an intact animal, there are other things going on" that influence this rhythm, Feldman says. "You might need an engine in a car, but you can't drive down the street with just the engine."

Donald McCrimmon of Northwestern University in Evanston, Ill., says that few scientists question that the rhythmic activity of the PBC in a laboratory dish reflects some aspect of breathing. "But how you really build a robust respiratory-control system—on top of this [complex] that generates a rhythm—is the really big question," he adds.

An equally big question for McCrimmon and others who embrace the PBC as the *noeud vital* is how the basic respira-

tory rhythm of eupnea arises, seemingly from fewer than 1,000 nerve cells. More than a decade ago, when Feldman and Smith first proposed that the periodic electrical bursts seen in pacemaker neurons could drive that rhythm, that model made sense to many scientists. Recently, however, Feldman has developed reservations about it.

"It was such a compelling and straightforward explanation that it rose from hypothesis to paradigm before one had the chance to do the experiments needed to test it," he says.

In the May 30, 2002 *Neuron*, Feldman's group offered data reinforcing his doubts. The investigators reported that treating the PBC in rodent brainstems with a drug called riluzole didn't alter the recorded respiratory rhythm. That surprised Feldman because riluzole blocks the periodic electrical bursts of pacemaker neurons by inhibiting cellular pores known as ion channels. He and his colleagues concluded that the pacemaker bursting isn't at the heart of the respiratory rhythm.

However, that result hasn't been confirmed. Smith's group recently conducted similar experiments and found that riluzole treatments do indeed interrupt the respiratory rhythm recorded from rodent brain tissue. And Ramirez has evidence that riluzole can block the gasping rhythm, but not the normal breathing rhythm. His studies suggest that there may be different kinds of pacemaker neurons within the PBC.

These discrepancies may be related to the way the brain tissues are sliced and exposed to the drug, suggests Smith. "It's certainly something that's going to be resolved over the next few months," McCrimmon says.

ONE NODE OR TWO It may take longer to address the tantalizing question of whether there's a more primitive *noeud vital* within the mammalian brain, an issue Feldman broached at the Society for Neuroscience meeting.

He noted that opiates slow a person's breathing rate, which can be a considerable problem for physicians administering opioid-based narcotics. In still unpublished work, Feldman's group found that rats don't respond to opiates by gradually breathing slower but instead by skipping breaths.

> "We're very far along the road of solving the basic problem of how we breathe."
>
> —JEFFREY C. SMITH

Feldman interprets his group's data as evidence for two sources of respiratory rhythm within the brainstem, an opioid-insensitive one with a naturally slow breathing rate and the PBC, which is opioid-sensitive and generates a faster respiratory rhythm.

Japanese researchers have recently identified a brainstem region near the PBC that exhibits a respiratory rhythm and is insensitive to opioids, Feldman notes. "Our current thinking is that the PBC in mammals is the dominant rhythm generator, but one has to consider the role of this second group of cells," he says.

Feldman speculates that this newfound area appeared early in vertebrate evolution to drive the slower respiratory rhythm of fish, amphibians, reptiles, and other animals that don't have a diaphragm. But the faster-paced PBC arose in mammals as they evolved a bellows-like diaphragm and had a greater demand for oxygen, he suggests.

A second *noeud vital* would add a new dimension to studies of the neural control of breathing. Still, with the PBC in hand, researchers remain confident that they are close to explaining one of the most fundamental examples of how the brain generates a behavior.

"There's a reason to hope that in the not too distant future, we'll be able to say that this is the basic [brain] circuitry for generating the respiratory rhythm," says McCrimmon. ■

HAWAII'S HATED FROGS

Tiny invaders raise a big ruckus

BY JANET RALOFF

Puerto Rico's beloved mascot is a miniature tree frog named for its distinctive call: ko-KEE. All night long, choirs of love-starved males serenade would-be mates, who respond with quiet guttural chuckles. "To me, it's pleasant—just like birds singing," says Bryan Brunner, a University of Puerto Rico plant breeder in Mayaguez. "Here, everybody loves the coquies." And legend has it, he says, that coquies—native only to Puerto Rico—die of sadness when removed from their island.

Hawaiians are lamenting that that fable isn't true.

In the mid-1980s, potted plants from the Caribbean began arriving in Honolulu carrying frogs. Some were 5-centimeter-long coquies (*Eleutherodactylus coqui*), and others, a quieter and even tinier cousin, the greenhouse frog (*Eleutherodactylus planirostris*). These stowaways reveled in their new setting: a largely amphibian-free land with a bountiful smorgasbord of insects, tiny spiders, mites, and other delectables—and no snakes, tarantulas, or other natural predators.

TINY IMMIGRANTS— Adult coqui (left) and greenhouse frog (right) may be small, but their arrival in Hawaii has unleashed a big furor.

USGS/HEAR PROJECT

By the end of 1998, seven populations of coquies had established themselves on the Big Island of Hawaii, recalls Earl Campbell of the Fish and Wildlife Service (FWS) in Honolulu. And the number has rocketed. "We now have over 400 populations on the Big Island," reports Campbell, the FWS Pacific Basin coordinator for invasive-species issues. He also notes a few coqui outposts on Maui, Kauai, and Oahu.

Local wildlife-protection officials have no trouble recognizing new coqui populations. On the Big Island, public officials receive about 10 complaints a day from homeowners who, unlike Puerto Rican residents, get fed up with the racket, notes Tim J. Ohashi of the Department of Agriculture's Wildlife Services Branch in Honolulu.

A backyard full of the frogs can reach 70 to 90 decibels—the volume of moderate-to-heavy street traffic or the din in neighborhoods along aircraft takeoff and landing corridors. Indeed, 75 decibels is the maximum sound volume that people can encounter at work throughout their careers without risking hearing loss (*SN: 5/22/82, p. 347*).

Hawaiians aren't used to such nighttime noise. "Because we don't have lots of calling insects, if you go to where the frogs aren't at night, it's dead quiet," observes herpetologist William J. Mautz of the University of Hawaii at Hilo. "Then enter an area with a big infestation, and you hit this wall of sound."

But it's not only the noise that has federal officials up in arms. The proliferating coqui and greenhouse frog populations on islands that evolved in the absence of amphibians threaten to overwhelm native ecosystems. That's why USDA has teamed up with the State of Hawaii and FWS to control—and, if possible, eradicate—the tiny hoppers.

The scientists are developing tools, including caffeinated sprays and scalding showers, for holding back what they see as an advancing plague of frogs.

HOPPING HATCHLINGS For the many frogs and toads that spend their youths as tadpoles, early survival and development depend on access to water in which they can swim and feed. But for members of *Eleutherodactylus*, the world's largest genus of vertebrates, young emerge from the egg or from Mom as tiny, fully formed frogs. This opens up a broader range of habitats than is available to tadpoles. Water-soaked moss decorating a potted plant will do, as will the humid packaging around plants, or a spoonful of water cupped in the leaf of an ornamental bromeliad.

Eggs, which coquies and greenhouse frogs lay on the soil, are hard to detect. Normally, male coquies guard their eggs for 2 to 3 weeks—not to fend off predators so much as to keep them moist, explains ecologist Larry Woolbright of Siena College in Loudonville, N.Y. Like a sponge, Dad's underbelly efficiently absorbs water and then releases it onto the eggs. But fatherless eggs could survive transit to Hawaii if they're attached to damp plant material, he says.

At hatching, baby coquies are green and only 5 millimeters long, about the size of a rice grain. Because they're nocturnal and don't begin bellowing their telltale serenades until they're about a year old, the youngsters tend to remain undetected, Woolbright says.

The frogs' catholic tastes facilitate their integration into the Hawaiian environment. After sleeping under leaf litter all day, the tiny amphibians come out after dark to dine. Some stay near the ground, while others ascend into a tree's canopy. Then they sit patiently and await the arrival of the evening's entrees—insects or any other small creature that crawls within pouncing range.

Hawaii's other Caribbean intruders, the greenhouse frogs, also concern scientists. So far, they've conducted relatively few studies of those quiet immigrants, which have proved difficult to find and count.

Though coquies invaded Florida roughly a century ago, they haven't spread far there, Campbell notes, probably because they had plenty of competitors for food and shelter.

But in Hawaii, he observes, "we don't have as many creatures as do ecosystems on the mainland, so we still have a lot of what people might term open niches." When the coquies and greenhouse frogs arrived, they set claim to one such niche.

BEYOND THE RACKET During mating season—which can run year round, depending on the climate—crooning males from ground to treetops produce a three-dimensional fog of sound. To drown it out at bedtime, many Hawaiians run air conditioners as a source of white noise. Others don earplugs.

It's gotten so bad, Ohashi notes, that realtors have been forced to disclose the presence of coquies on listed properties, much as they would evidence of termites, water damage, or structural flaws.

But of even bigger concern to USDA and Hawaii's Department of Agriculture is the frogs' economic threat to Hawaiian plant growers, notes Ohashi's colleague Will Pitt at USDA's Wildlife Services research center in Hilo. Sales of orchids and other tropical plants amount to a huge export industry. Buyers on the Hawaiian islands that are still free of coquies and greenhouse frogs are now rejecting some potted plants grown on the Big Island. It may not be long, Pitt speculates, before the frog scare affects foreign trade or plant shipments to the U.S. mainland. Any impact on Hawaii's $80-million-per-year cut-flower-export industry would be especially troublesome.

GOTCHA! — Fairly indiscriminate diners, coquies will eat almost anything, like this bug, that enters their range.

R. CAULDWELL

Rather than simply imposing a quarantine on plants in frog-infested areas of Hawaii, Pitt says, government agencies want to offer growers tools for coping with the problem. The proposed arsenal is remarkably low-tech.

"We started, about 2 years ago, looking at trapping—hand captures—but it was not at all effective," says Pitt.

So, Campbell, who was then with USDA, began screening off-the-shelf agents that might poison the frogs without harming their environment. "I started by looking at insecticides for use on ornamentals, probably 20 to 25 compounds," he says. None killed frogs at permitted application rates.

Then Campbell heard that acetaminophen—the active ingredient in Tylenol—works as a poison to control the invasive brown tree snake on Guam (*SN: 8/10/02, p. 85*). He redirected his attention to over-the-counter drugs and food additives. Again, the results were abysmal—until he tested a popular formulation for staying awake that contains caffeine. In Campbell's lab, coqui and greenhouse frogs died quickly after being sprayed with a 2-percent-caffeine solution, which contains a far higher concentration of caffeine than coffee does.

KILLING THEM SOFTLY Because caffeine has never been federally approved as a pesticide, the State of Hawaii had to petition the Environmental Protection Agency for permission to experiment outdoors with the antifrog stimulant. The agency granted the state permission to try a 2-percent-caffeine solution as an experimental pesticide spray for 1 year.

Pitt says that tests on small plots of infested greenery proved that the spray is indeed "an effective frogicide, if you will." Best of all, he says, caffeine exhibited "very few impacts on other, nontarget organisms." For instance, insect populations in sprayed plots declined a bit, but within a week had returned to normal. The tests turned up another potential benefit. Garden slugs, the bane of the orchid industry, rose to the surface of treated soils and died (*http://sciencenews.org/20020706/food.asp*).

In September, the temporary EPA permission for testing expired. USDA has now applied for a 3-year extension to conduct further research that might eventually lead to caffeine's federal approval as a frog-control agent.

"But we don't want to limit ourselves to one tool," Pitt says, so his laboratory has continued testing other unusual candidate frogicides. It recently uncovered one that's so safe a food product that EPA doesn't regulate it. It's citric acid, the primary constituent of lemon juice.

Preliminary tests, begun in August, used a citric-acid formulation roughly comparable to double-strength lemon juice. The spray isn't quite as potent as caffeine for killing frogs, Pitt told *Science News*. Nevertheless, early data on citric acid "look very promising," he says, "and we see very little impact on plants."

In July, the *Honolulu Star Bulletin* reported that the Hawaii Department of Agriculture had found that hydrated lime, the powder used to reduce the acidity of soil, also kills frogs. Ohashi confirms this, but he points out that hydrated lime couldn't legally be used against frogs unless it were to receive federal approval as a pesticide. And that's unlikely, he adds. Manufacturers don't view as worthwhile the prospect of carrying out the necessary safety and efficacy testing, he explains, "because they make enough money selling it for its currently labeled use."

Pitt says that plant growers might also resist lime because it can leave a white residue on treated plants. "If you're an orchid grower selling $200 or $300 plants, a little leaf spotting may not be acceptable," he says.

Finally, several research centers are investigating an experimental nursery technique to prevent the spread of frogs in potted plants. Ed Brodie of Hawaii's Division of Forestry and Wildlife in Hilo, for instance, has fine-tuned an $11,000 computer-controlled device that sprays hot water onto a few potted plants at a time to kill pests. A 3-minute spray of 46.5°C (116°F) water kills any coquies and greenhouse frogs present. As a bonus, he says, the treatment kills geckos, centipedes, and about everything else in the soil except ants.

Brodie's lab includes a nursery for endangered and native plants. Over the past 3 years, workers there have treated up to 1,000 plants a day with the hot-water spray. The only downside so far is that orchid blooms wilt, but the rest of the plant remains healthy.

CLOCK IS TICKING Other than noise pollution, the frogs' effect on Hawaii is hard to characterize, Campbell says. Ordinarily, scientists gauge environmental impacts by comparing before-and-after data on species in a region invaded by an alien. In Hawaii, however, there's little pre-invasion data for most areas now infested with coquies and greenhouse frogs.

However, the overwhelming numbers of frogs in those areas

convince Mautz that "there will be impacts," he says. He's particularly concerned about the frogs' consuming insects now available to birds.

Woolbright agrees. His surveys of 20-m-square forest plots in Puerto Rico have turned up an average coqui concentration of about 2 per square meter. But more important, he says, is the number of reproductively mature adults. Typically, a 4-night survey logs 40 adults in a 20-by-20-m plot.

This summer, he set up similar plots in Hawaii. During one 4-night census, "we got 200 adults in one plot," he told *Science News*.

The abundance of coquies in Hawaii probably traces to a lack of predators. Woolbright says that Puerto Rican coquies are a dietary staple of rats, screech owls, cuckoos, snakes, tarantulas, and many others. During a typical night's survey of his plots in Puerto Rico, six to eight coqui predators show up. "In our plots in Hawaii, we found none," he says.

In Hawaii, "I estimate that about 200 kilograms of arthropods [such as insects and spiders] per hectare per year go to feed the frogs," Mautz says. "So, you now have an invader that's suddenly commanding a huge piece of the whole food chain." The open question is, he says, Whose dinner are coquies stealing?

The greenhouse frogs raise additional concerns. They frequently turn up where coquies have settled, although their numbers appear relatively small. Campbell notes that this quiet species could be amassing big colonies without anyone knowing it.

"But what actually scares me the most about the frogs being here," Mautz says," is that they'll be food for other invading animals. . . . If we have this huge food base of frogs, it will be a paradise found for invading snakes." Hawaiian ecologists have long scouted for invading brown tree snakes, which occasionally stow away on planes landing in Honolulu.

LARRY WOOLBRIGHT

FROG LOVER — In their native Puerto Rico, coqui populations are held in check by a broad range of predators—including this whip scorpion, which has a body the size of a quarter, an arm span the diameter of a salad plate, and no tail.

In theory, it's not too late to think about eradicating coquies, Mautz contends. They could easily be hunted down. Even now, there are only several hundred reported populations, some with just a few isolated animals. He estimates that the frogs cover only about 1,000 acres statewide.

"If true," he maintains, "you could apply a scorched-earth policy to [routing] them" with caffeine or citric acid. Then again, he concedes, getting the political will to cut through the environmental red tape for such dramatic action would be difficult.

Stall too long, Mautz warns, and it may be too late to do anything but learn to live with the noisy immigrants. "The way I see it," he says, "we've only got 5 years, maybe 10."

Indeed, Woolbright says, "I see no quick, clean, and easy way to remove these frogs from sensitive island habitats like Hawaii." Start unleashing poisons, even one as mild as caffeine, and things could get ecologically messy, he worries.

In the end, he suspects, "this just might turn out to be a situation where [Hawaiians] will have to grin and bear it." ■

MEETINGS

The American Society of Hematology
Philadelphia, Pa.
December 6–10

CANCER

Protein vaccine slows leukemia

By injecting leukemia patients with part of a protein found in greater abundance on cancerous cells than on healthy ones, researchers have been able to induce some patients' immune systems to fight this blood cancer.

Jeffrey J. Molldrem of the University of Texas M.D. Anderson Cancer Center in Houston and his colleagues fashioned the cancer vaccine from a piece of proteinase 3, a compound overproduced by malignant blood cells in leukemia patients. Earlier research suggested that the piece, called PRI, stimulates production of immune system T cells that specifically target proteinase 3.

Molldrem's group identified 15 patients with leukemia that had resisted other treatment. Each patient received three PRI injections, each separated by 3 weeks. In five people, the leukemia went into remission and their T cells showed a strong attraction to the leukemia cells. Three other patients in the group showed partial responses.

Molldrem and his colleagues are now testing the vaccine in 60 more leukemia patients. —N.S.

ANEMIA

Getting the iron out

While transfusions are lifesavers for many anemia patients, they introduce excess iron into recipients. This overload can damage the liver, pancreas, and heart. A new pill that reverses this process may vastly improve the lives of anemia patients, a new study shows.

The standard drug for removing iron from the body is deferoxamine mesylate. It chemically captures, or chelates, excess iron but must be given intravenously or by injection. The chief problem with deferoxamine mesylate therapy is that patients sometimes skip treatments, notes Stanley L. Schrier of Stanford University. A pill-based alternative would presumably be easier for patients to follow.

The new medication, now designated as ICL670, binds to excess iron, and these complexes ultimately leave the body in the feces. Researchers in Italy compared deferoxamine mesylate with ICL670 in 71 patients with an average age of 25. The participants had a hereditary form of anemia called thalassemia that required them to get transfusions every 3 weeks. They had been receiving deferoxamine mesylate via a needle drip placed under the skin for 8 hours a night, 5 nights a week.

Periodic testing of iron content in the patients' blood and liver over a year showed that ICL670 cleared transfusion-caused iron overload as well as deferoxamine mesylate did, says study coauthor Antonio Piga of Turin University.

If the work is confirmed, ICL670 "would represent a major clinical advance for patients with sickle-cell [anemia]" and others who need regular blood transfusions, says Ronald Hoffman of the University of Illinois Medical Center in Chicago. —N.S.

OF NOTE

MATERIALS SCIENCE

Carbon nanotubes beam electrons

The scientists who work with carbon nanotubes have big dreams for the tiny objects, including superfast electronics and hard spaceship materials. To date, however, few applications using the nanoscale carbon cylinders have been realized.

Now, a team from the Netherlands and France has taken a step toward making carbon nanotubes the electron sources for machines such as high-resolution electron microscopes.

Beams of electrons in microscopes are generally produced by heating or applying an electric field to a metal tip. The new work, reported in the Nov. 28, 2002 *Nature*, shows that carbon nanotubes could be superior electron sources.

In their experiments, the scientists mounted a single, 10-nanometer-wide carbon nanotube on the end of an electron microscope's tungsten tip, applied an electric field, and studied the nanotube's electron emission.

The electron beam was 10 times as bright as that from a conventional source, the researchers report. The nanotube also emitted a stable beam of electrons with uniform speeds, or energies, says team member Niels de Jonge of Philips Research Laboratories in Eindhoven, the Netherlands. Increasing a beam's brightness and its uniformity in electron energies are two ways of improving the resolution of electron microscopes, he says. —J.G.

BIOMEDICINE

Double cord-blood transplant helps cancer patients

For patients with blood diseases who need a stem cell transplant, doctors often turn to umbilical cord blood. But the small supply of blood in each cord is often inadequate to meet the needs of an adult patient (*SN: 10/26/02, p. 261*).

To up the stem cell dose in each transplant, researchers gave 32 adults with lethal blood cancers stem cell transplants from two cord-blood donors. Double cord-blood transplants have rarely been used because of fears that immune cells from two donors might attack each other and derail the treatment.

In all but three of the cases receiving double transplants, however, the stem cells successfully grafted into the patient's bone marrow, says Juliet N. Barker of the University of Minnesota, Twin Cities.

In all the engrafted transplants, cells from one of the cords completely displaced the other within 100 days, Barker reported last month in Philadelphia at a meeting of the American Society of Hematology. The "winning" cord blood wasn't necessarily the closest match with the patient's blood and wasn't always the larger of the two transplants, she notes.

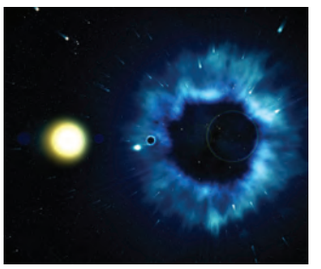
Barker doesn't know why one transplant wins out over the other, but the mere presence of the losing transplant seems to facilitate engraftment of the winner, she says. Although all of the patients in the study were extremely ill, 12 are still alive. —N.S.

ASTRONOMY

Runaway black hole

Observing a black hole and a companion star caroming through our galaxy, astronomers say they've found the best evidence to date that small black holes are born during supernova explosions.

The black hole and its partner, collectively known as GRO J1655-40, are streaking across the galaxy at 400,000 kilometers per hour, four times the average speed of neighboring stars. The duo's speed and elliptical orbit about the galaxy's core suggest the bodies were kicked out of their presumed birthplace within the Milky Way's inner disk, where most stars are formed.



KICKED AROUND Illustration of a black hole and a companion star (yellow) bumped across the sky by a supernova explosion.

EUROPEAN SPACE AGENCY/ NASA, MIRABEL

The gargantuan power required to set GRO J1655-40 into motion most likely came from a supernova that created the pair, asserts I. Felix Mirabel of the French Atomic Energy Commission in Gif-sur-Yvette, France, and the Institute for Astronomy and Space Physics in Conicet, Argentina.

In such an explosion, the core of a massive star implodes, sending out shock waves that eject the star's outer layers. If the core has a mass greater than three times that of the sun, gravity crunches it down into a black hole. If the explosion isn't perfectly spherical, it can impart a kick to the black hole it created.

"GRO J1655-40 is the first black hole [system] for which there is evidence for a runaway motion imparted by a natal kick in a supernova explosion," Mirabel and his colleagues report in the Nov. 19, 2002 *Astronomy and Astrophysics*. —R.C.

NEUROSCIENCE

Brain learns to sharpen its focus

Practicing a perceptual skill dramatically alters the way the visual system works, according to a study that will appear in the *Proceedings of the National Academy of Sciences*. For people tested on their ability to spot subtle visual distinctions, practice on the task beforehand results in intensified activity in the neural gateway for information from the eyes, say Sophie Schwartz of University College London and her colleagues.

In a single session, Schwartz's group trained 16 adults to make visual discriminations using only one eye. Volunteers had to identify a central letter—either L or T, each rotated into various positions—as well as the orientation of three solid, parallel lines embedded within an array of dashed lines. Each display, flashed briefly on a computer screen, appeared in the upper left part of the visual field and, thus, was always projected to the same small region of the primary visual cortex.

The next day, volunteers were tested on the same two-part task while a functional magnetic resonance imaging scanner measured blood flow—an indirect marker of neural activity—throughout their brains. Earlier studies had established that improvement on the task occurs only for the trained eye.

The brain scans revealed greater blood flow in the key section of the primary visual cortex as participants used their trained eyes, compared with their untrained eyes. Structures elsewhere in the brain ramped up their activity along with that of the primary visual cortex only when volunteers used their untrained eyes, probably because of the greater demands of having to perform a task without training. These data support the theory that learning translates into more efficient localized brain activity. —B.B.

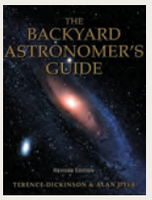
Books

A selection of new and notable books of scientific interest

THE BACKYARD ASTRONOMER'S GUIDE

TERENCE DICKINSON AND ALAN DYER

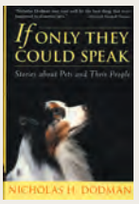
Completely revised from its previous edition 10 years ago, this all-encompassing reference provides practical advice about buying one of the latest telescopes, setting it up, and learning how to use it. Once armed with knowledge about equipment, including accessories and binoculars, the reader receives basic information about how to navigate the sky. Dickinson and Dyer explain how to read star charts and star atlases and how to track the movement of Earth and the sun. Hundreds of color photos depict equipment and provide examples of sky photographs by the authors, along with tips about photography. ***Firefly, 2002, 336 p., color photos/illus., hardcover, $49.95.***



IF ONLY THEY COULD SPEAK: Stories About Pets and Their People

NICHOLAS H. DODMAN

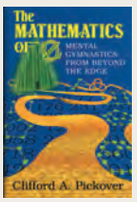
As the founder of the Animal Behavior Clinic at Tufts Veterinary School, Dodman has seen just about every outlandish and disturbing habit a pet could exhibit, from a dog that always arranges exactly six pieces of kibble in the buttonhole depressions in a couch to a cat that exhibits stress by pulling its hair out in clumps. An advocate of both behavior modification and medication for changing undesirable cat and dog activities, Dodman shares these and other stories and describes how he successfully treated the animals. He explains that the roots of animal and human behavior aren't very different and how various environmental factors affect both groups. ***Norton, 2002, 262 p., hardcover, $24.95.***



THE MATHEMATICS OF OZ: Mental Gymnastics from Beyond the Edge

CLIFFORD A. PICKOVER

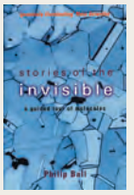
The prodigious Pickover challenges fans of recreational mathematics and the like with this astounding collection of more than 100 puzzles. Each is based on one or more mathematical topics: geometry and mazes, sequences, series, sets, arrangements, probability and misdirection, number theory, arithmetic. Using the characters of Oz, including Dorothy and the Wizard, to introduce each puzzle adds a witty flare. The characters face several hurdles, the most challenging of which are zebra numbers, circular primes, and legion's number. Each puzzle is rated for difficulty, and complete answers close the volume. *The Mathematics of Oz* is a stimulating romp through often mind-bending terrain. ***Cambridge U Pr, 2002, 351 p., b&w illus., hardcover, $29.00.***



STORIES OF THE INVISIBLE: A Guided Tour of Molecules

PHILIP BALL

Most people don't think much about molecules or how they interact. Yet molecular chemistry drives some of the most thrilling breakthroughs of modern science. Ball's inspiring tour of this small world illustrates how molecules assemble and function and how that action influences myriad aspects of the macro world. For instance, Kevlar fibers in bulletproof vests have a molecular alignment that imitates that in the silk threads of a spider's web. Ball reveals a host of such facts about synthetic molecules and their predecessors in nature. Originally published in 2001. ***OUP, 2002, 204 p., b&w photos/illus., paperback, $14.95.***



STRANGE MATTERS: Undiscovered Ideas at the Frontiers of Space and Time

TOM SIEGFRIED

What's the universe made of? How does it work? These are the two questions that stoke the creative and intellectual fires of physicists. The answers that they offer nowadays seem counterintuitive and sometimes downright crazy. Siegfried, the science editor at The Dallas Morning News, provides a highly accessible and engaging look at mind-bending theories that could, for instance, explain the so-called dark matter in the universe or reconcile Albert Einstein's general theory of relativity with quantum mechanics. He dubs such ideas prediscoveries—things imagined but not yet proven. For one prediscovery, Siegfried introduces Vic Teplitz, who suggests that "strange quark nuggets" might be silently raining onto or even zipping through Earth. For another, Cumrun Vafa suggests that space might not be the only multidimensional realm—time might have several dimensions, as well. ***Joseph Henry Pr, 2002, 307 p., hardcover, $24.95.***

A THIN COSMIC RAIN: Particles from Outer Space

MICHAEL W. FRIEDLANDER

Earth's atmosphere is regularly bombarded by cosmic rays, a thin rain of particles generated largely by supernovas, with some particles coming from the sun. This rain is mostly high-speed protons, with about 9 percent of it being the nuclei of helium and a few heavier atoms. In this expanded and revised edition of his earlier book *Cosmic Rays*, Friedlander incorporates new data amassed over the past decade. The result is a compelling account of our understanding of cosmic rays. He considers the many ways these rays have an impact on our planet and its inhabitants. For instance, some measurable traces of cosmic rays come in the form of carbon-14, an invaluable tool for dating archeological specimens. Friedlander also considers the place of cosmic rays in several continuing mysteries of astrophysics. Originally published in hardcover in 2000. ***HUP, 2002, 241 p., b&w photos/illus., paperback, $17.95.***

LETTERS

Wonderful world of color

In response to ("Why turn Red?" *SN: 10/26/02, p. 264*), I'd like to ask why is it that on our campus, native swamp maples growing within 30 feet of one another display totally different leaf color? While I appreciate them aesthetically, I'd also like to understand why their anthocyanin production is different.

MARCIA WALSH, NORTH ANDOVER, MASS.

According to David Lee of Florida International University in Miami, the answer could lie in small genetic or habitat differences among the trees. He adds, "Actually, we know little about the patterns of such variation in nature. . . . Often, we take for granted such phenomena so close to us when, in fact, they are poorly studied." —S. MILIUS

What's in a lake?

"Once Upon A Lake" (*SN: 11/2/02, p. 283*), claims that Lake Agassiz became the world's largest lake. It seems to me that the same conditions should have occurred in Asia. Shouldn't you compare Lake Agassiz to glacier-dam-produced lakes in Asia and contemporary freshwater versions of the Black Sea and the Caspian Sea?

ROBERT W. DAVIS, MILLBURN, N.J.

According to Martin Jakobsson of the University of New Hampshire in Durham, the three largest Eurasian glacial lakes at the end of the last ice age together covered a total of 907,000 square kilometers, an area about 8 percent larger than Lake Agassiz at its largest. But those shallower bodies held only one-fifth the water that Lake Agassiz did. Freshwater Lake Agassiz covered more than twice the area of the Black or Caspian Sea, but it didn't hold as much water as the Black Sea. —S. PERKINS

Was it pills or pain?

"Hidden Effect? Hypertension risk linked to common, over-the-counter pain relievers" (*SN: 11/2/02, p. 278*) says that women taking some kinds of over-the-counter painkillers are more likely than others to have high blood pressure. The conclusion that the painkiller "boosts their chance of developing high blood pressure," however, is unfounded. It's also plausible that whatever causes the women to take the pain medication raises blood pressure.

GEOFFREY A. LANDIS, BEREA, OHIO

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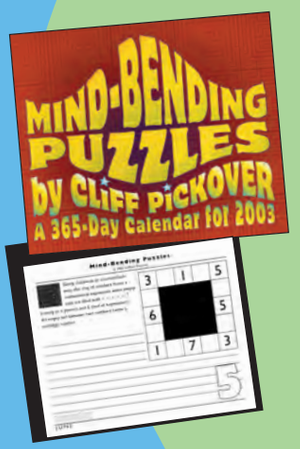
2003 Calendars



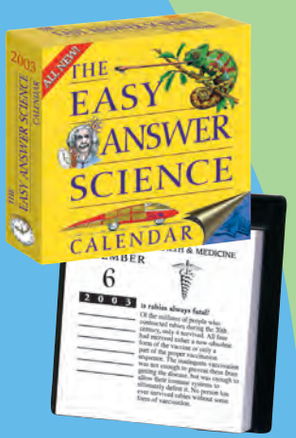
Mind-Bending Puzzles Page-a-Day Calendar 2003

BY CLIFFORD PICKOVER

Wake your brain up each day with one of these fiendishly difficult, totally satisfying puzzles! This assortment of visual puzzles, mazes, cryptograms, mathematical hairpullers, anagrams, and other sources of perplexity and pleasures come complete with answers that appear on the flip side of each page. *Pomegrante, 6"x 5", $11.95*

Easy Origami Page-a-Day Calendar 2003

Don't throw yesterday away, just fold it. Who needs a Zen garden when you can create hundreds of figures including animals, flowers, insects, birds, and miscellaneous objets d'art throughout the years. Step-by-step illustrated instructions make origami—the art of paper folding—easy and fun every day! On weekends, enjoy fun facts and folding tips. *Accord Publishing, 6 1/2" x 6", $12.95*



The Easy Answer Science Page-a-Day Calendar 2003

Imagine starting every day just a little smarter and discovering something that you always wanted to know, but had never looked up. That's what this handy calendar can do for you. For instance, get answers for: How thick was the coat on a woolly mammoth? Why does iron in the blood drop suddenly when we have a fever? What are the largest animals eaten by carnivorous plants?
Accord Publishing, 5" x 5", $10.95

Latin for the Illiterati Page-a-Day Calendar 2003

BY JON R. STONE

This entertaining desk calendar raises Latin from the dead, dusts it off, and sets it speaking. It presents catchy Latin toasts and useful maledictions, exposes the Latin roots of English words and phrases, and offers proverbs and observations that are still cogent millennia after they were coined. *Pomegrante, 5 ¼" x 4 ¼" , $10.95*

All Purpose Yiddish Page-a-Day Calendar 2003

BY IRA STEINGROOT

In this enjoyable translation of the *mama-loshen* (mother tongue) of the Jews of Eastern Europe, this desk calendar presents a fact-filled treasure trove of cultural and historical tidbits about Yiddish. No matter what your yichus (ancestry), you'll appreciate the information presented throughout the chadoshim (months). A pronunciation guide is included. *Promegrante, 5 ¼" x 4 ¼" , $10.95*

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