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SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

another pesticide threat
fighting spreads devils' cancer
better treatment for lupus
antarctic land o' lakes

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microbial power plant

THE WEEKLY NEWSMAGAZINE OF SCIENCE

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FEBRUARY 4, 2006 VOL. 169, NO. 5

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Of Note

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Cover Bacteria that release electrons during their metabolism are the workers in microbial fuel cells, devices that could someday power remote sensors, wastewater-treatment plants, and portable devices. (Dean MacAdam) Page 72

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Poor Devils

Critters' fights transmit cancer

A fatal cancer afflicting Tasmanian devils passes from one of the small marsupials to another when they bite each other, rather than being transmitted via a virus, a new study suggests. The disease is the first cancer known to spread directly from scratch to scratch.

The whirling cartoon version of a Tasmanian devil may not look much like the furry reality, but it does capture the creature's legendary fierceness.

"They're always squabbling and fighting. They don't share food, and their [mating] foreplay isn't much better," says cytogeneticist Anne-Maree Pearse of Tasmania's Department of Primary Industries, Water and Environment in Kings Meadows. "They bite each other around the face and mouth."

That behavior may have deadly consequences, Pearse says. The disease appeared in the 1990s and by 2004 had spread across more than half the Australian island. It produces lesions that soon develop into large tumors on the face and neck, preventing the animal from eating. Within 6 months of the lesions' appearance, most devils die of starvation.

Pearse and her colleagues searched for a virus that might transmit the disease, but they came up empty. "It occurred to me that there didn't necessarily have to be a virus if the [cancer] cells themselves could be transmitted," Pearse says.

To learn more about the tumor cells, she and her colleagues investigated the animals' chromosomes. They found identical complex chromosomal anomalies in the cancer cells of all of the 11 afflicted animals studied. That uniformity wouldn't occur if the disease were caused by a virus, Pearse says. In virus-induced cancers, chromosomes begin mutating from a common point and then evolve through several stages, resulting in many different complex chromosomal rearrangements.

But rearrangements in the devils' tumors, though highly complex, were identical, suggesting that all the tumors are the work of a single rogue cell line grafted onto the animals, the team reports in the Feb. 2 *Nature*.

The clincher, Pearse adds, was that the researchers found an abnormal chromosome in one animal's nontumorous cells but not in its tumor cells. "That meant the tumor couldn't have arisen from [the animal's] own tissues," she says.

Since Pearse and her colleagues finished the original study, they've analyzed chromosomes in 15 more animals, and all the tumors have shown the same distinctive anomalies. This result bolsters the theory that one rogue cell line was the original infective agent, Pearse says.

Though this is the first documented instance of trauma-transmitted cancer cells, scientists know of one similar case: a nonlethal venereal sarcoma that passes between dogs during genital contact. In that example, too, the tumors' chromosomal defects are similar from dog to dog.

Wildlife biologist Menna Jones of the University of Tasmania in Hobart says the new paper presents "sound, plausible, impeccable science." If direct contact transmits the cancer between devils, she says, the most effective strategy to control the disease may be to quarantine infected animals. As part of Tasmania's Devil Disease Project, Jones and several collaborators are already testing this strategy on parts of the island. Results so far are encouraging, she says. —C. GRAMLING

ROUGH PATCH Tasmanian devils can spread fatal facial tumors (inset) when they fight.

Self Help

Stem cells rescue lupus patients

By rebuilding a patient's immune system using his or her own stem cells, doctors can reverse the course of lupus in severely ill patients for whom medication no longer works, a new study shows.

In this autoimmune disease, white blood cells go awry and create antibodies that target the person's cells and tissues. The tissue damage results in rashes, swollen joints, fever, and fatigue. Lupus can also turn deadly and attack vital organs, especially the kidneys, lungs, and nervous system.

Immune-suppressing drugs can alleviate symptoms, but they sometimes have debilitating side effects. In many patients, the drugs eventually stop working.

The experimental therapy uses stem cells to make new, healthy white blood cells to replace the tissue-targeting ones. Doctors first administer a drug that coaxes those cells out of a patient's bone marrow into the bloodstream. The researchers isolate these stem cells from the patient's blood.

The patients then receive drugs that wipe out the remaining defective white blood cells. This treatment leaves the patient temporarily without an immune system. Finally, the doctors return to the patient's bloodstream the stem cells that had been isolated. Being in blood expedites their transformation into working immune cells.

These stem cells—sometimes called adult stem cells rather than embryonic stem cells—form a fresh army of white blood cells that's less likely to make rogue antibodies.

"We kind of reboot the computer," says Richard K. Burt, a physician and immunologist at Northwestern University School of Medicine in Chicago, who pioneered the therapy.

Since 1997, when Burt performed the first stem cell therapy for lupus, he and his colleagues have treated 48 people at Northwestern Memorial Hospital in Chicago. The patients all had life-threatening disease or impending organ damage and weren't expected to improve.

No patient died from the therapy, Burt and his team report in the Feb. 1 *Journal of the American Medical Association (JAMA)*. As of 6 months ago, after an average follow-up of 29 months, 42 of the patients were still alive. Lupus was in remission in 33 of these patients, Burt says. One patient has survived nearly 8 years.

Roughly 1.5 million people in the United States have lupus. "About 15 to 20 percent of them [become] seriously ill," says Joan Merrill, medical director of the Lupus Foundation of America and a rheumatologist at the Oklahoma Medical Research Foundation in Oklahoma City.

STATS

1.5 million

People in the United States with lupus

Although preliminary, she says, "these new data are very exciting."

While a stem cell transplant doesn't necessarily represent a cure, "the therapy offered substantial benefit ... to the majority of patients," say lupus specialist Michelle Petri and hematologist Robert A. Brodsky of Johns Hopkins Medical Institutions in Baltimore in the same issue of *JAMA*.

Burt's team has received Food and Drug Administration clearance to begin a large-scale trial in which randomly selected volunteers will get either the stem cell treatment or the best medication currently available. —N. SEPPA

Smashing Success

Accelerator gets cool upgrade

A novel scheme for increasing the number of collisions in particle accelerators has boosted the performance of the world's highest-energy collider and promises to rev up others.

This scheme, called high-energy electron cooling, helped the Tevatron collider at Fermi National Accelerator Laboratory (Fermilab) in Batavia, Ill., last October to shatter the 23-year-old world record for particle-collision rates.

For decades, particle physicists have used electron cooling to control the properties of particles in low-energy accelerators, but they were daunted by the difficulty of high-energy cooling, comments beam-cooling specialist Fritz Caspers of the European Organization for Nuclear Research in Geneva. To finally develop and implement such a system is "a really great achievement," he says.

Accelerators must generate vast numbers of collisions to produce even a few of the exceedingly rare elementary particles sought by high-energy-physics researchers. In the Tevatron accelerator, discrete bunches of protons and antiprotons circulate in opposite directions around a 6-kilometer ring. They travel at nearly the speed of light. When these bunches cross paths at two locations in the ring, particles smash into each other and spawn sprays of other elementary particles that are recorded by huge detectors.

However, most protons and antiprotons zoom right past each other, explains physicist Sergei Nagaitsev, leader of electron cooling at Fermilab. That's largely because the antiproton bunches tend to be hot and therefore spread out. To pack antiprotons more tightly in each bunch, Nagaitsev and his colleagues created a separate electron accelerator that serves as the heart of the electron-cooling system. That accelerator ramps up electrons to the same velocity as that of the antiprotons and then injects the electrons into a ring. There, the two types of particles interact before the antiprotons enter the main ring and encounter the protons.

Because each electron weighs only a fraction of what an antiproton weighs, jostling among the particles tends to transfer energy to the electrons. Those energy transfers decrease random vibrations of the antiprotons, in effect cooling them, Nagaitsev explains. That, in turn, makes it possible to have more antiprotons in each bunch, increasing its density and the subsequent collision rate.

HOT HOOPS High-voltage tubes shown encircling this electron accelerator drive cooling electrons downward to join with antiprotons in the world's highest-energy particle collider.

"The Fermilab work is particularly significant for us," says Ilan Ben-Zvi of Brookhaven National Laboratory in Upton, N.Y. He and his team plan to build upon it to equip a giant accelerator there with even higher-energy electron cooling.

The Tevatron's surging collision rate increases the chances that the machine will yield important discoveries in coming years, Nagaitsev says. In the debris of future smashups, physicists will search for such long-hunted prizes as the Higgs boson, thought to bestow mass on other particles, and supersymmetric particles, which are hypothetical sister particles to the particles already known (*SN: 6/12/04, p. 371*).

Many other tweaks to the Tevatron have contributed incrementally to its collision rate. However, electron cooling by itself has so far resulted in a roughly 50 percent increase in the Tevatron's instantaneous collision rate, Nagaitsev says. Another 50 percent boost might be possible with further improvements, he adds.

Nagaitsev and his colleagues describe their system in the Feb. 3 *Physical Review Letters*. —P. WEISS

Good for Something

Prion protein maintains stem cells

The same protein that, in an altered shape, causes mad cow disease and other neurodegenerative disorders maintains the body's cache of blood-producing stem cells, a new study suggests.

Called the prion protein, or PrP, it's scattered throughout the body in mammals. When, in rare occurrences, PrP becomes misshapen, it causes neurodegenerative diseases in cows (*SN: 1/10/04, p. 19*), deer (*SN: 1/28/06, p. 52*), people (*SN: 10/4/97, p. 212*), and other species. However, researchers haven't been sure what function the normal protein performs.

"For years, we've wondered why evolution has preserved this protein, what positive role it could possibly be playing," says Susan Lindquist of the Whitehead Institute for Biomedical Research in Cambridge, Mass.

While studying blood-producing stem cells in mouse fetal tissue, Lindquist's colleague Cheng Cheng Zhang noticed that PrP was present on the cells' surfaces. To determine whether the protein plays a part in how stem cells operate, Zhang, Lindquist, and their Whitehead colleagues Andrew Steele

and Harvey Lodish compared the blood and the blood-producing stem cells found in bone marrow in normal mice and in mice missing the gene for PrP. They observed no differences between the two sets of samples.

However, the researchers quickly noticed a distinction when they subjected stem cells to the stress of bone marrow transplants. The scientists moved bone marrow from normal and PrP-deficient mice into similar mice that had been irradiated to kill off their blood-producing stem cells. After the stem cells in the transplanted bone marrow became established and reproduced, the scientists repeated their procedure, transferring bone marrow from these recipients into new irradiated mice.

In normal mice, the researchers found that each new bone marrow transplant was as effective as the previous one, and all the recipients thrived. However, in the mice without PrP, the stem cells gradually lost their capacity to reconstitute themselves with each subsequent transplant.

When the researchers inserted the gene for PrP into stem cells in the bone marrow taken from mice without PrP, the marrow became as hardy as that from normal mice. The scientists report their results in an upcoming *Proceedings of the National Academy of Sciences*.

Lodish notes that previous studies investigating PrP's function may have missed this role because they didn't provide the extreme stress that puts blood-producing stem cells to the test. "When there's loss of blood, a massive infection, or a bone marrow transplant, that's where these stem cells spring into action," he says.

The results are "interesting and novel, because no one had studied the role of prion protein in this type of cell," notes Andréa LeBlanc of McGill University in Montreal, who investigates these proteins.

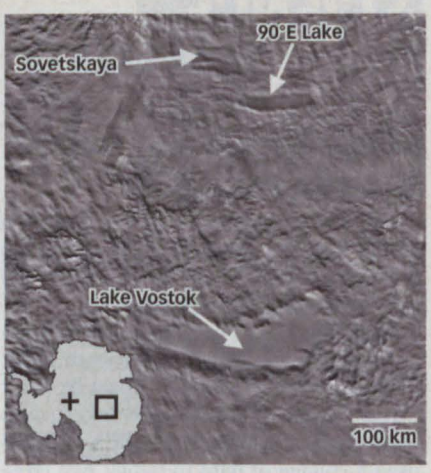
However, she says, the experiments don't explain why mice without the PrP gene can survive to old age, given that blood-producing stem cells wear out over a lifetime of normal stress. "If these mice had an incapacity to proliferate cells and were prone to stress," LeBlanc argues, "you'd assume that they would die or have problems in late life, and they don't." —C. BROWNLEE

Cold and Deep

Antarctica's Lake Vostok has two big neighbors

Trapped beneath Antarctica's kilometers-thick ice sheet are two bodies of water that rival North America's Great Lakes, new analyses suggest. The geological setting of these huge, unfrozen lakes hints that they may harbor ecosystems that have been isolated for millions of years.

More than 140 lakes lie buried beneath varying thicknesses of Antarctic ice, but most of them are small and shallow, says Michael Studinger, a geophysicist at the Lamont-Doherty Earth Observatory in Palisades, N.Y. Lake Vostok, discovered decades ago, is the largest. It's the size of Connecticut and holds 5,400 cubic kilometers of water, enough to fill Lake Michigan.



GREAT LAKES Lake Vostok and the newly described 90°E and Sovetskaya Lakes lie beneath a kilometers-thick blanket of ice. The black square in the inset shows the outline of this satellite image on a map of Antarctica; the cross indicates the South Pole.

Scientists who've drilled through Lake Vostok's overlying ice sheet to within 120 meters of the lake's upper surface have found microbes trapped in the ice (*SN:*

Protecting People from a Terrifying Toxin

Vaccine stimulates immune response against ricin

In its first test in people, a vaccine against the toxin ricin appears safe and generates antibodies that are expected to be protective against the potential bioterrorism agent.

Ricin comes from castor seeds and can cause lethal damage to the gut if swallowed or to the lungs if inhaled. Murderers and assassins have used it for centuries.

The vaccine might be used to protect soldiers and first responders in advance of possible ricin exposure, says immunologist and study leader Ellen S. Vitetta of the University of Texas Southwestern Medical Center in Dallas.

However, widespread vaccination "is going to be hard to justify," argues Gary Nabel, director of the Vaccine Research Center at the National Institutes of Health in Bethesda, Md. Ricin poisonings are rare in people—fewer than 1,000 cases have ever been reported—and they usually result from accidental ingestion of castor seeds.

The Dallas researchers' study is more interesting for its science than for its potential to mitigate ricin attacks, says Nabel. The "proof of concept" that the study represents could lead to new vaccines against numerous toxins, including those produced by staph and strep bacteria, he says.

For a mutant toxin to safely generate immunity, "you have to preserve the structures of the molecule that are seen by the immune system ... at the same time that you modify specific amino acids that are responsible for its toxicity," says Nabel. "This study shows that you can, in fact, do that."

Vitetta and her colleagues developed the vaccine, called RiVax, by modifying the plant gene that makes part of the toxin. Like the natural ricin toxin, the altered protein stimulates the body to make antibodies. But it doesn't kill cells. Antibodies against ricin can stop a poisoning only if they're present before ricin exposure.

The researchers detected immune responses after giving three injections of the altered toxin to each of 15 healthy young adults. The team had previously shown that a similar response protects laboratory mice and rabbits against death after subsequent contact with ricin.

"The present study takes the research a step further by showing that humans can tolerate a dose that leads to the production of ricin-neutralizing antibodies," says molecular cell biologist J. Michael Lord of the University of Warwick in England.

The vaccine produced, at worst, side effects that were mild and temporary, Vitetta and her collaborators report in an upcoming *Proceedings of the National Academy of Sciences*.

The antibody response observed should protect people, just as it protects animals, says Lord, who worked on a different experimental ricin vaccine until the British military stopped funding the research. The U.S. military is studying a third ricin-vaccine candidate. —B. HARDER

10/9/99, p. 230). The researchers view that finding as a tantalizing clue that the lake may hold a thriving ecosystem.

Lake Vostok sits in a basin that formed as Earth's crust stretched thin, a feature that had set this body of water apart from all other subglacial Antarctic lakes, says Studinger. Now, he and his colleagues have used a collage of data to depict two large subglacial lakes near Lake Vostok and to determine that they also sit in basins formed by a thinning tectonic plate.

One of the lakes is dubbed 90°E because it stretches along that longitude. The other is called Sovetskaya, after the Russian research station atop it. Although scientists knew of these two lakes, they had no notion of their sizes until they saw recent satellite images of the region, says Studinger.

90°E Lake has a surface area of about 2,000 square kilometers, about half the size of Rhode Island, which makes it the second-largest known subglacial lake in Antarctica. It probably holds about 1,800 km^3 of water, more than enough to fill Lake Ontario. Sovetskaya Lake covers about 1,600 km^2. Studinger's team describes the lakes in the Jan. 28 *Geophysical Research Letters*.

Ice-penetrating-radar data gathered during aerial surveys indicate that the upper surfaces of these lakes lie beneath 4 km of ice. A new analysis of measurements of Earth's gravitational field suggests that the lakes in some places are about 900 m deep.

The lakes remain unfrozen because heat seeps up from Earth's interior and insulating blankets of ice lie above them, says Studinger. Any ecosystems now in the lakes would have been isolated from Earth's surface for 35 million years, the estimated age of the ice sheet in that region.

Because of their great sizes, the covered lakes probably have always contained at least some liquid water, says David M. Karl, an oceanographer at the University of Hawaii in Honolulu.

"This is an important discovery," says Karl. "It shows how little we know about the Earth around us." —S. PERKINS

Bird-Safe Rx

Alternative drug won't kill India's vultures

An international research team says that it has found a substitute for the livestock drug that has accidentally poisoned most of the vultures of India and neighboring countries.

SURVIVOR This oriental white-backed vulture is a member of one of the three species that have dwindled dramatically on the Indian subcontinent since the early 1990s.

Last March, India announced that it intended to ban the vulture-killing drug, but no alternative had been identified.

The now-proposed substitute is meloxicam, a nonsteroidal anti-inflammatory drug (NSAID). It didn't harm several species of *Gyps* vultures in tests, report Gerry Swan of the University of Pretoria in South Africa and his colleagues. In the March *PLoS Biology*, they propose that farmers use it, instead of the older NSAID diclofenac, to treat swelling and pain in cattle and water buffalo.

About 2 years ago, a different research team fingered diclofenac as the killer responsible for a population drop in three vulture species. Counts had fallen more than 95 percent since the early 1990s. In the past 2 decades, diclofenac had become popular, and vultures eating carcasses died of kidney failure.

The new study "is likely to prove quite important," says veterinarian J. Lindsay Oaks of Washington State University in Pullman. Oaks led the effort that identified diclofenac's role in the vulture disappearances (*SN: 1/31/04, p. 69*).

The population crash occurred among the oriental white-backed (*Gyps bengalensis*), long-billed (*Gyps indicus*), and slender-billed (*Gyps tenuirostris*) vultures. The vultures had thrived on dead animals left in carcass dumps. The vultures' decline fueled rising populations of feral dogs, says Rhys Green of the Royal Society for the Protection of Birds in Bedfordshire, England.

In an effort to save the vultures by finding a safer livestock drug, he and other conservationists sent out questionnaires asking zoo veterinarians and animal keepers around the world what NSAIDs they'd used on vultures and what the effects were. In some 30 detailed accounts of vulture medicine, meloxicam stood out as never having been seen to damage the birds' kidneys. Common NSAIDs typically affect blood flow to animals' kidneys, and several of the drugs have caused kidney damage in birds.

To test meloxicam, Green and his colleagues started with the African white-backed vulture (*Gyps africanus*), which is closely related to the declining Indian species but isn't threatened as a population.

The team administered increasing doses of meloxicam in successive rounds of tests. The birds didn't show ill effects, and tests of the vultures' blood failed to show uric acid buildup, which typically precedes kidney problems.

Next, the researchers tested meloxicam on a few vultures of two of the threatened Asian species in a captive-breeding center.

"Meloxicam is already a drug used in cattle, and it appears to be just as effective and safe as diclofenac," says Oaks. "But currently it is more expensive, and this is always an issue for farmers, and it remains to be seen if the price can be made comparable."

Green says that he's optimistic. Over the past several years, the price of meloxicam has dropped in India to just twice the price of diclofenac or less. The patent on meloxicam is expired, and Green hopes that many companies will jump in to manufacture it. —S. MILIUS

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MICROBIAL MOXIE

Bacteria-based fuel cells provide power

BY AIMEE CUNNINGHAM

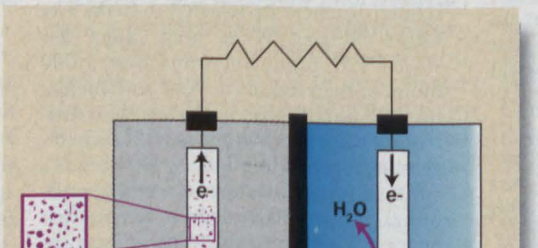
Anglers casting their lines last September into a Montana creek may not have noticed, but a diminutive power plant was churning away in a shallow spot by the shore. The device generated electricity—with the aid of river-dwelling bacteria—to power a sensor system that wirelessly transmitted data to a receiver about 10 miles away. The underwater device, small enough to fit in a person's hand, was the first attempt to power such a system with a microbial fuel cell.

Microbial fuel cells take advantage of the long-known fact that some microbes produce electricity when they break down organic matter. Only recently, however, have scientists discovered that they could tap into this energy in a practical manner and use it as an alternative energy source.

Today, microbial fuel cells are being explored primarily as a power source for remote sensors and for wastewater treatment, in which the bacteria that break down sewage generate sufficient electricity to run the treatment plant. But the role that the fuel cells could eventually play will depend on whether certain limitations can be overcome.

For starters, the prototype fuel cells don't produce power fast enough to do much more than juice up a clock. "These systems can be very efficient, but they are slow, in terms of the rate that organic matter is converted to electricity," says microbiologist Derek Lovley of the University of Massachusetts at Amherst.

Still, the potential payoff is too good to pass up. "Once the device is constructed, it's basically working for free," says Zbigniew Lewandowski of Montana State University in Bozeman, whose group set up the Montana-stream system.



POWER BASICS — Microbes on the anode (in left chamber) deposit electrons (e-), which travel along a wire to the cathode (in right chamber). Protons (H+) move through a selective membrane from anode's chamber to cathode's chamber, where they combine with electrons and oxygen to form water.

ELECTRIFYING EVENTS Among the entities zipping along a microbe's metabolic pathways are electrons, which hop from molecule to molecule in the course of various biochemical reactions. When microbes metabolize organic matter in aerobic conditions, they tend to deposit these electrons onto oxygen, an exchange that provides the microbes with chemical energy.

By putting the bacteria in a microbial fuel cell under anaerobic conditions—that is, with no oxygen present—researchers "are stealing some of the energy and harvesting it as electricity," says Lovley.

A basic microbial fuel cell has two chambers, one containing an anode and the other a cathode. The microbes reside under anaerobic conditions on the anode. There, they break down their food, such as glucose, acetate, or the organic compounds in wastewater. Lacking oxygen, these microbes transfer their electrons to the anode. This exchange gives the microbes a small amount of energy to fuel their growth.

A wire connects the anode to the cathode. The cathode chamber harbors oxygen dissolved in water. The electrons travel to the oxygen, generating a current as they move from one chamber to the other.

There is also a selective membrane between the two chambers that enables protons, another product of the microbe's biochemical reactions, to travel from the anode to the cathode. In the cathode chamber, the electrons and protons combine with oxygen to form water.

A different type of fuel cell can operate in a river or a lake. Local microbes colonize an anode stuck into the oxygen-poor sediment. Their electrons travel along a wire connected to a cathode suspended in the overlying water, which contains oxygen (*SN: 7/13/2002, p. 21*).

While electrifying, all this microbial activity doesn't yet translate into much power. There may be room for improvement in both the materials and the microbes.

For the anode, many researchers use a form of carbon called graphite, which conducts electrons. But "that may not be the best material to interact with whatever protein it is that's transferring electrons to the [anode] surface," says Lovley.

At the cathode, meanwhile, the transfer of the electrons to oxygen is slow. Researchers have used various catalysts and electron shuttles to improve cathode performance, but they tend to be expensive or toxic.

The microbes themselves are another limiting factor. Although some microbes, when deprived of oxygen, will ferry their electrons to an anode, says Lovley, they "aren't optimized for electricity production—they've had no evolutionary pressure to do this."

To speed electron transfer, Lovley's group is studying bacteria from the family Geobacteraceae, originally discovered in the sediment of the Potomac River in Washington, D.C. When these com-

mon microbes break down organic matter, they transfer their electrons to iron oxides, which makes them adept at using an electrode as their final electron acceptor.

By comparing electrode-dwelling and natural colonies of Geobacteraceae, Lovley's group has identified genes that are more active in the electrode-dwellers and thus likely to be important for transferring electrons to an electrode. In an attempt to increase energy production, the team is now genetically engineering Geobacteraceae to produce more of their electron-transferring proteins.

WASTEWATER WATTAGE Researchers with an eye toward a self-sustaining wastewater-treatment plant are moving forward with prototype microbial fuel cells, says Korneel Rabaey of Ghent University in Belgium.

About 5 percent of U.S. electricity production goes into water and wastewater treatment, says Bruce Logan of Pennsylvania State University in University Park. His team was the first to demonstrate that a microbial fuel cell could produce electricity as it cleans household wastewater (*SN: 3/13/2004, p. 165*).

Along with providing energy savings for developed countries, microbial fuel cells could "revolutionize how we do wastewater treatment" worldwide, Logan says. He points out that 2 billion people live in areas without wastewater-treatment plants.

An inherent difficulty with using domestic wastewater as a raw material, however, is that it contains a lot of matter that biodegrades slowly, says Rabaey. This decreases the rate at which the microbes can pass along their electrons, so it reduces the power they produce. Also, the systems need to deal with a continuous stream of wastewater because it would be impractical to hold wastewater in a tank, notes Largus T. Angenent of Washington University in St. Louis.

BUG TIME — Microbes from the family Geobacteraceae, living in sediments collected from the Boston Harbor, provide power to a digital laboratory clock.

In the July 15, 2005 *Environmental Science & Technology* (*ES&T*), Angenent and his colleagues described a microbial fuel cell in which the wastewater flows from the bottom to the top of a tubular system. The team fed the fuel cell continuously with artificial wastewater—a sucrose solution spiked with nutrients and metals—for 5 months.

Rabaey and his colleagues reported another tubular-fuel cell design in the Oct. 15, 2005 *ES&T*. The anode chamber contains porous, graphite granules that are 1.5 to 5 millimeters in diameter and packed to permit liquid to flow through channels among them. Microbial biofilms cover the granules, which serve as the anode surface.

The researchers tested three such fuel cells, each fed continuously for about a year with a solution of a different raw material: acetate, glucose, or household wastewater. The acetate-fed fuel cell generated 90 watts per cubic meter (W/m^3), while the glucose consumer put out 66 W/m^3. The wastewater-fed fuel cell achieved a maximum of 48 W/m^3.

Neither Rabaey's laboratory system nor Angenent's system is self-sustaining. Both rely on a regular supply of a toxic electron shuttle, which gets used up as it acts in the cathode. Logan's systems use an expensive platinum catalyst to speed the final transfer of electrons to oxygen. In the Jan. 1 *ES&T*, his team describes much cheaper metal catalysts containing little or no platinum.

All the researchers report that as they make adjustments to their designs, they continue to increase the power outputs of their laboratory systems. But much work needs to be done to make such systems economically feasible, increase the amount of electricity harvested from the organic matter, and prove that the systems can handle the volumes of a large treatment plant.

Currently, Logan's laboratory system generates 16 W/m^3 as it breaks down wastewater. His goal is 100 W/m^3 in a sustainable system, which he estimates could produce 0.5 megawatt of energy, enough to power a treatment plant for a town of 100,000.

SENSOR SUCCESS Powering a remote temperature sensor also requires technical advances to boost the meek wattage now generated by the microbes.

Microbial fuel cells are an ideal solution for remote sensors, says Lewandowski, because they avoid the logistical difficulty of changing batteries in dense wilderness areas or at the bottom of the ocean. Future microbial fuel cells might chug along for years, opening the way to a "drop-it-and-forget-it type of probe," he says.

When Lewandowski's group set up its microbial fuel cell in Hyalite Creek near Bozeman, Mont., the scientists adopted a fuel cell design that differs from the basic approach. The anode is not stuck in the sediment, and the microbes reside on the cathode instead of on the anode. The electrons carrying the current come not from the microbes but directly from the anode, a slab of magnesium alloy, as it slowly corrodes in the water and releases magnesium ions and electrons.

The microbes, which settle on the stainless steel cathode, capture manganese ions present in the water and oxidize them to form encrustations of manganese oxide on the cathode's surface. The electrons then reduce some of the manganese oxides, switching them back to manganese ions, and the cycle continues.

To demonstrate that the fuel cell could power a wireless system, Lewandowski's group housed electric components in a nearby shed. The creek-based fuel cell supplied the entire system with electricity.

By the team's design, energy generated by the fuel cell built up in a capacitor and discharged in short bursts when needed, as a camera flash does. The team also included a component called a DC-DC converter to increase the voltage potential. The converter relayed power to a transmitter, which sent the sensor's water temperature readings wirelessly to a receiver roughly 10 miles away. In the July 1, 2005 *ES&T*, the researchers described the scheme, which ran in the field until September of last year.

Lewandowski's group plans to incorporate into its system a longer-lasting, traditional anode—one that uses electricity-producing microbes on a noncorroding surface—and the researchers say they'd like to scale up the system to power multiple sensors.

WHERE TO? While researchers say that microbial fuel cells hold great promise, they don't expect them to become major power producers. "You're not going to run an entire city" with them, says Angenent.

But the technology could become a convenient power source for portable electronics, says Lovley. He notes that powering a cell phone during continuous talk mode would require a power-production rate 10 to 100 times as great as that of current microbial fuel cell technology, but he thinks that increase is feasible. With such a system, "10 grams of sugar could theoretically produce power for nearly 2 days of talk time," he says.

Lovley also suggests that the technology could be beneficial for developing countries that don't have well-established power grids.

"There are probably a lot of new opportunities to use this technology—we're still trying to figure out what those are," says Logan. "As it develops and we understand the economics, we will be able to find and define systems. ... I see a future with lots of [energy] technologies, and there is room for this technology." ■

A LITTLE LESS GREEN?

Studies challenge the benign image of pyrethroid insecticides

BY JANET RALOFF

Rachel Carson turned the pest-control world upside down in 1962. In *Silent Spring* (Mariner), she documented how long-lived organochlorine pesticides, most notoriously DDT, were not only ridding croplands of insects, streets of mosquitoes, and homes of spiders but also exacting a high toll on songbirds and other nontargeted species. The chemicals' broad-spectrum potency and resistance to breakdown, advantages in their use against pests, emerged as hazards.

Shortly after the publication of Carson's book, industrialized countries began phasing out such persistent organic pollutants, or POPs. There's now a United Nations treaty aiming at their global elimination (*SN: 11/8/03, p. 301*).

In the wake of organochlorine pesticides came organophosphate agents. Although these agents are highly effective, their toxicity to nontarget animals—including people—echoed the perils of DDT. Regulators responded, and by the middle 1990s, once-popular members of this class of agents—such as dursban, malathion, and chlorpyrifos—were being phased out or severely restricted in their uses.

In recent years, farmers and others have increasingly turned to products based on pyrethrins, chemicals made by certain members of the chrysanthemum family. Farmers in various parts of the world have for millennia used preparations from these flowers to protect crops from insects. Since the 1960s, manufacturers have produced synthetic analogs—called pyrethroids—of the herbal products' active ingredients.

TOXIC DRAINAGE — Excess irrigation water running off California farm fields enters this creek through a discharge pipe, thereby introducing pyrethroids and other pesticides.

Although pyrethroids have greater toxicity to insects and somewhat more resistance to breakdown than their natural counterparts do, studies have demonstrated that these synthetic chemicals pose little risk to most vertebrates, from songbirds to people.

Pyrethroids stand poised to overtake organophosphate insecticides for farm use and are already the leading insecticides sold to homeowners. However, emerging data show that even pyrethroids can pose serious environmental hazards. At concentrations found in streams, the chemicals can kill beneficial insects and crustaceans and may even be acting—below the radar screen—to poison fish and lizards.

Most of these findings came to light in some dozen presentations in Baltimore last November at the Society of Environmental Toxicology and Chemistry (SETAC) annual meeting. The research described there suggests that, at least where the mumbased pesticides might enter streams, these compounds should be used sparingly.

"The Environmental Protection Agency needs to take a closer look at pyrethroids" with an eye toward changing how the 22 such compounds that it has registered are marketed and used, argues Michael J. Lydy, an environmental toxicologist at Southern Illinois University in Carbondale. Ample and growing data, he says, challenge "the suggestion that in the environment, pyrethroids will be innocuous."

HUNTING *THRINS* "Walk down the pesticide aisle of your local hardware store and read the active ingredients in insecticides. Nearly every one ends in 'thrin,'" a dead giveaway that it is a pyrethroid, observes Donald P. Weston, an environmental toxicologist at the University of California, Berkeley. Only a few pyrethroids—most notably esfenvalerate—lack that suffix.

Although many of these compounds have been used for decades, especially on farms, "no one had looked for them in the environment," Weston notes. In the past few years, he and his colleagues launched several surveys to check whether pyrethroids were causing harm in streams. Because these pesticides don't readily dissolve, but instead glom on to particles and quickly settle out of water, his team focused its analyses on sediments.

Their findings proved eye-opening, Weston told *Science News*.

In one study of creeks adjacent to farmlands across a 10-county area in California's Central Valley, researchers looked for five pyrethroids and found one or more in at least three-quarters of the 70 sediments sampled.

The researchers then tested two stream dwellers: the amphipod *Hyalella azteca*, which is a small, shrimplike crustacean, and a larval midge of the species *Chironomus tentans*. Ecologists use these tiny "lab rats of the sediment-testing world" for toxicity assessments, Weston explains.

At 42 percent of the sampled sites, the sediment proved deadly to at least one of two species, his group reported 2 years ago.

In a follow-up study, the scientists spiked sediment samples from clean sites with six common pyrethroids to compare their toxic effects on *H. azteca*. They measured each compound's LC_{50}—the concentration lethal to 50 percent of animals exposed in a test.

In the April 2005 *Environmental Toxicology and Chemistry* (*ET&C*), the team reported that permethrin's LC_{50} was 60 to 110 parts per billion (ppb), depending on how much organic carbon the sediment contained. The LC_{50} for the remaining pyrethroids was far lower, indicating greater toxicity. The most toxic: lambda-cyhalothrin and bifenthrin, which have an LC_{50} of 2 to 6 ppb.

The crustaceans' growth was significantly retarded at concentrations just one-third of a pyrethroid's LC_{50}.

LAWN POLLUTION Farm runoff isn't the only—or perhaps even the most important—way in which these agents get into streams. Weston and his Berkeley colleague Erin L. Amweg reported data at the SETAC meeting showing that pyrethroids are washed into waterways from suburban yards by rain and lawn watering.

In one recent study, Weston, Lydy, and others surveyed streams in Roseville, a suburb of Sacramento, Calif. Only a decade earlier, land along these creeks had been arid grassland. Since then, much of it has been converted to subdivisions sporting four homes per acre, most with manicured lawns.

Roughly 90 percent of the stream sediments sampled contained bifenthrin, and the majority of them had bifenthrin concentrations toxic to *Hyalella*, the scientists report in the Dec. 15, 2005, *Environmental Science & Technology*. Often, one to five more pyrethroids were present.

In contrast, the pesticides didn't show up in waters draining Roseville sites free of residential development.

In toxicity, bifenthrin dominated the suburban sediments. Indeed, Lydy told *Science News*, "80 percent of our samples had enough toxicity due to bifenthrin alone to cause at least half of our [amphipods] to die." The team recorded pesticide concentrations as high as 437 ppb—that's about 100 times as great as its LC_{50} for *H. azteca* and 15 times the highest bifenthrin concentration seen in sediments of creeks running through Central Valley croplands.

This indicates, Weston says, that the highest concentrations of pyrethroids in creek sediments trace to "classic suburbia—we're talking Mom, Dad, two kids, and a dog."

Although pesticides applied by professional exterminators around the perimeters of homes are a possible source of the creek contamination, the research group strongly suspects that much of the bifenthrin comes from lawn-care products. Some fertilizers even include bifenthrin, so that homeowners can feed their grass and kill bugs in one pass.

In the Roseville study, the pesticides didn't appear to travel far once they reached a creek, with the high concentrations appearing only within 100 yards or so of storm-drain outfalls.

What's not clear, Weston and others observe, is whether the California data reflect what's occurring nationally or might instead represent a worst-case scenario. For instance, Amweg presented data at the SETAC meeting indicating that creeks near Sacramento and San Francisco showed substantial sediment contamination but streams in Nashville didn't.

The California sites, unlike Nashville, get little summer rainfall to dilute stream pollutants. Moreover, many of California's urban areas rely on concrete storm drains to channel lawn runoff directly into streams, whereas the Nashville sites were separated from waterways by a corridor of greenery.

RUNAWAY RUNOFF — Lawn-watering runoff at this home in Roseville, Calif., illustrates how pyrethroids used on the yard would be washed into storm drains, which are a direct conduit to neighborhood streams.

TOO EXCITED Joel R. Coats of Iowa State University in Ames and his colleagues have been probing why pyrethroids "are as nasty as DDT [is] to a lot of aquatic life—including fish."

Pyrethroids poison pests by wreaking havoc on their nervous systems, as most insecticides do. When nerves transmit an impulse, Coats explains, "there's an electrical ripple that's triggered by sodium gates in [each cell] opening in sequence." Pyrethroids perturb the nerve cells' sodium gates, however, so that once open, they never fully close, Coats says. The resulting sodium leaks maintain nerve cells in a state of overexcitation that kills the insects.

Because the nervous systems of crustaceans and many other soft-bodied aquatic animals resemble those of insects, these nontargeted animals are also vulnerable to pyrethroids.

Coats observes that mammals and birds gain some protection from pyrethroid poisoning by two mechanisms: production of esterase enzymes that inactivate the poisons by splitting them in half, and another metabolic process that employs oxidation. He reported at the SETAC meeting that although rainbow trout, bluegill, and fathead minnows can all oxidize pyrethroids, their esterase enzyme activity doesn't break apart the pesticides.

Although these pesticides may induce ill effects that fall short of lethality, toxicologists have generally been forced to focus on their deadliness, Weston says, because fatal concentrations tend to be at or near the minimum value at which current technology can detect the pesticides. If the pesticides cause sickness, therefore, it's likely to happen at concentrations too low to measure, he says. To get around this difficulty, some scientists have added minute amounts of the compounds to tanks of water containing aquatic animals.

At Oregon State University (OSU) in Corvallis, Katherine R. Johnson and her colleagues administered esfenvalerate to aquatic nymphs of the caddis fly (*Brachycentrus americanus*)—an insect eaten by many fish.

For protection from predators, these nymphs enshroud themselves in hard cases. As the OSU researchers increased pyrethroid concentrations above 0.05 ppb, formerly resting animals began fleeing their cases in increasing numbers, notes coauthor Jeffrey J. Jenkins. Among nymphs that fled, three-quarters of those exposed to as little as 0.2 ppb esfenvalerate didn't rebuild their cases. Rebuilt cases were disordered and much weaker than the originals, the scientists reported at the SETAC meeting.

CONDITIONAL TOXICITY Environmental stressors can sabotage pesticide-detoxification systems, even in animals that would otherwise withstand the chemicals, notes Larry G. Talent. At Oklahoma State University in Stillwater, he studied adult green anole lizards (*Anolis carolinensis*), 6 to 8 inches long, exposed to a pyrethroid product used to treat birds for mites and lice.

When he doused the lizards with a solution of the pesticide and then maintained the reptiles at a comfortable 95°F, none died. However, 70 percent of treated lizards died within 2 days when they were instead housed at a cool 68°F. Without pesticide exposure, the lizards showed no mortality at the lower temperature, Talent reports in the December 2005 *ET&C*.

Low temperatures, which might mimic night or winter environments, pose a double whammy for pyrethroid effects: Not only is the lizard's nervous system more vulnerable to poisoning but its metabolic breakdown of pollutants also slows.

Mark A. Clifford last year reported a similar synergy between

two environmental stressors—pyrethroid exposure and a viral infection—in young salmon. The University of California, Davis fish pathologist exposed 2-month-old chinook salmon for 4 days to either esfenvalerate or chlorpyrifos, an organophosphate pesticide. He then seeded some of the aquariums holding the fish with infectious hematopoietic necrosis virus, which can kill juveniles.

Fish exposed to low doses of the virus survived, as did those exposed to either pesticide alone, Clifford's team reported in the July 2005 *ET&C*. Deaths occurred only in fish exposed to high concentrations of the virus or to both the pyrethroid and virus. Within 3 days of being exposed to either dose of virus, roughly 70 percent of the pesticide-exposed salmon fry were dead.

The pyrethroid's impact "was totally unexpected," Clifford says. Two follow-up trials confirmed that the initial observation was not a fluke.

HOW NEAT? — Aquatic caddis fly nymphs build protective cases from plant debris. Ordinarily, a nymph cuts and stacks materials, log-cabin style, into an orderly, well-aerated covering (top inset). Pyrethroid-exposed nymphs, however, make chaotically structured dwellings from uncut parts (bottom inset) or forgo such protection altogether.

WINDS OF CHANGE? EPA considers new data when it periodically reviews its approvals of pesticides registered before 1984. Reevaluations for permethrin, resmethrin, and cypermethrin are slated for completion this year, and three other pyrethroids are to be reviewed by 2008.

Because bifenthrin was registered in late 1985, it's not scheduled for such a reevaluation. In a statement to *Science News*, however, EPA's Office of Pesticide Programs (OPP) notes that this pesticide's manifestation of "certain toxic properties at the level of detection [makes it] challenging for the agency to determine whether risks from the use of this pesticide are acceptable."

In fact, the statement says, to better understand pyrethroids' toxicity and bioavailability to nontarget organisms, OPP is "reviewing the sediment toxicity studies on bifenthrin, cypermethrin, cyfluthrin, and esfenvalerate that were recently submitted [by Weston's group and others]." These pesticides were chosen as "surrogates," the statement says, for assessing the exposures and toxicity of other pyrethroids.

Indeed, OPP notes, despite their use on some 50 agricultural crops, some pyrethroids have only "conditional" approval from EPA, pending future evaluation of their sediment toxicity and of the value of buffer zones in keeping treated areas from tainting streams.

OPP says that it anticipates completing a "comparative assessment for pyrethroids" by December.

Pyrethroid manufacturers are already bracing for change.

Jim Fitzwater, a spokesman for bifenthrin-maker FMC Corp. of Philadelphia, says that homeowners need to be educated about how and when to apply lawn-care products containing pyrethroids. He notes that his company sells to consumer-products companies rather than consumers and says, "We're looking at working with [these] end-use manufacturers to do a better stewardship job." ■

OF NOTE

BIOMEDICINE

Diabetes most often begins in March

A person's likelihood of developing type 2 diabetes varies seasonally and is about 50 percent higher in March than in August, according to a 6-year study.

Led by Péter Doró, researchers at the University of Szeged in Hungary analyzed 26,695 cases of the disease that arose in one Hungarian county between 1999 and 2004. The scientists recorded diabetes onset as the date on which each patient first received drugs to reduce blood glucose.

Type 2 diabetes onset peaked in March, at about 10 cases per 10,000 county residents, and fell in subsequent months to a low of 6.8 cases per 10,000 residents in August. Onset rose after August, the researchers report in the January *Diabetes Care*.

A study published last year of U.S. veterans suggested that people with type 2 diabetes have the greatest difficulty maintaining healthy concentrations of blood glucose in March and April, Doró's team notes. The researchers speculate that the preceding months of cold weather, inactivity, and overeating may contribute to the seasonal patterns. —B.H.

ZOOLOGY

New candidates for smallest vertebrate

Two recent scientific papers have described fish species that could—depending on the definition—be the world's smallest vertebrate.

A specimen of a mature female minnow, now named *Paedocypris progenetica*, from peat swamps in Sumatra measures only 7.9 millimeters long, report Ralf Britz of the Natural History Museum in London and his colleagues. They found *P. progenetica* females from 5.3 to 10.3 mm long, the group says in an upcoming *Proceedings of the Royal Society B*. The 7.9-mm fish, though, was the smallest carrying ripe eggs.

Britz says that's shorter than the previous record-holder, the stout infantfish (*Schindleria brevipinguis*) from the Great Barrier Reef. The only adult female *S. brevipinguis* that was measured was 8.4 mm in length. If the smallest-vertebrate title can go to a male that must attach parasitically to a female, then the winner would be a *Photocorynus spiniceps* anglerfish, says Ted Pietsch of the University of Washington in Seattle. A mature male of this species can be as small as 6.2 mm in length, he and his colleagues reported last year. Regardless of who wins the title, these are remarkable fish, says Britz.

In *P. progenetica*, the bones of the skull fail to cover the brain. Also, the adult males have flanges on their pelvic fins and a hard knob of skin nearby. These might be tools for gripping a female during mating or handling eggs, the researchers speculate.

MINI FISH A newly named species of minnow from peat swamps in Southeast Asia is shorter than the width of a fingertip.

Sorting out such details could be a race against habitat destruction. Southeast Asia's peat swamps are disappearing as oil palm plantations and shrimp farms take over the land. Many of the peat swamps that Britz and his colleagues surveyed in the 1990s for this work have already vanished. —S.M.

OCEANOGRAPHY

Warming climate will slow ocean circulation

Later this century, rising concentrations of greenhouse gases in Earth's atmosphere will slow the ocean currents that bring warm waters to the North Atlantic, thereby affecting that region's climate, computer simulations suggest.

When the waters of the Gulf Stream and other warm currents of the North Atlantic reach an area just south of Greenland, they cool, become denser, and sink. That, in turn, pulls more surface water northward, says Thomas L. Delworth, a climate scientist at Princeton University. The rate of this so-called thermohaline circulation depends on the temperature and salinity of the surface waters. The warmer and fresher those North Atlantic surface waters are, compared with underlying layers, the more buoyant they are and the slower the circulation becomes.

Using a new computer model, Delworth and his colleague Keith W. Dixon simulated various scenarios for ocean circulation in the North Atlantic from now until 2100. They calibrated the model using weather and ocean-circulation data gathered since 1860.

Throughout the 20th century, rising concentrations of greenhouse gases such as carbon dioxide warmed the atmosphere and ocean surface, but not enough to slow the thermohaline circulation. That's because large amounts of air pollutants known as aerosols have scattered sunlight back into space and counteracted the greenhouse effect somewhat, says Delworth.

In the remaining years of the 21st century, however, growing concentrations of greenhouse gases will begin to overwhelm the cooling effect of aerosols, Delworth and Dixon suggest. By the year 2040, thermohaline circulation could carry only 80 percent as much warm water to the North Atlantic as it does now. The researchers report their findings in the Jan. 28 *Geophysical Research Letters*. —S.P.

BIOMEDICINE

Tumor's border cells told to leave

Cells on a tumor's outer layer that touch healthy tissue receive a chemical signal that sends them wandering away, according to new research. The finding could eventually lead to new ways to stop metastasis, the process by which cancers spread.

Scientists traditionally study metastasis by observing tumors cultured in a lab dish. According to Ross Cagan, a developmental biologist at Washington University School of Medicine in St. Louis, these cultured cells may not truly represent how tumors behave in the body.

To study metastasis in an organism, Cagan and his colleagues created tumors in fruit flies by turning on a cancer-promoting gene called *Src*.

Once the tumors began to grow, the researchers found that cancerous cells touching healthy cells gradually lost surface proteins that kept them anchored. When they detached, the tumor cells "literally walked around the body," says Cagan.

Most of these motile cells died after moving away from the tumor. However, Cagan suggests that if additional mutations were to keep the cells alive, they could multiply and form tumors elsewhere in the body.

The team's preliminary investigations suggest that the chemical that sends tumor

cells on their way is a protein called cadherin, which is secreted by healthy cells.

"Knowing what this signal is could give us a big step up on stopping the signal," says Cagan. He and his team report their findings in the January *Developmental Cell*. —C.B.

INFECTIOUS DISEASES

Rotavirus vaccines pass big safety tests

The largest corporate-funded medical trials in history indicate that two new vaccines against rotavirus, a leading cause of childhood mortality worldwide, are both effective and safe.

Rotavirus causes childhood diarrhea and is responsible for several hundred thousand deaths each year, mostly in developing countries.

Merck & Co. of Whitehouse Station, N.J., calls its vaccine RotaTeq, and London-based GlaxoSmithKline calls its product Rotarix. Smaller trials had already shown that both vaccines prevent illness, and Rotarix has been in use in Mexico since 2004.

In the late 1990s, a separate rotavirus vaccine was abandoned after researchers determined that it occasionally caused a dangerous intestinal blockage (*SN: 9/27/03, p. 204*). To reduce the possibility of such side effects, the manufacturer of the new vaccines launched separate clinical trials, each one including some 60,000 children.

Neither new vaccine is associated with intestinal blockages or other problems, according to reports of the trials in the Jan. 5 *New England Journal of Medicine*. Rotarix prevented 85 percent of severe illnesses, and RotaTeq prevented 98 percent. —B.H.

ENVIRONMENT

Manganese can make water toxic

Water contaminated with manganese not only tastes vile but also can limit the intellectual development of children drinking it, a new study finds.

While studying the arsenic-tainted wells of Bangladesh several years ago, scientists turned up another natural pollutant there: manganese. The World Health Organization's pollutant standard for the metal is 500 micrograms per liter (μg/l) of drinking water, and contamination in some Bangladesh wells far exceeded that amount.

To assess manganese's independent threat, researchers identified low-arsenic wells contaminated with various amounts of manganese. They grouped the wells into four categories. The least-tainted wells had less than 200 μg/l of manganese, and the most-contaminated wells all carried more than 1,000 μg/l of the metal.

The researchers then administered IQ tests to 142 local 10-year-olds who routinely drank from the various wells.

The higher the concentration of manganese in a child's drinking water, the lower his or her IQ score, the scientists report in the January *Environmental Health Perspectives*.

Amounts of waterborne manganese in the new study were within safe limits set for food, says study leader Gail A. Wasserman of Columbia University's College of Physicians and Surgeons. However, because manganese in water is more readily absorbed in the body than is manganese in food, limits for water are set far lower than those for food. She says that more studies are needed to evaluate how early in life manganese's poisoning can affect children and test the metal's toxicity relative to that of arsenic.

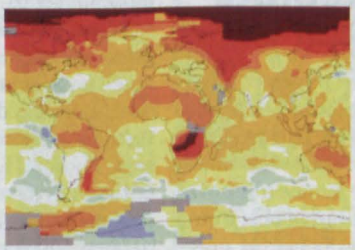
Although some U.S. well water exceeds manganese concentrations that triggered effects in this study, Wasserman points out that people in developed countries typically avoid such tainted water because it smells nasty and stains porcelain. —J.R.

CLIMATE

2005 was warmest year on record

Last year's global average temperature of 14.6°C (58.3°F) was the warmest recorded since scientists began compiling records in the late 1800s.

The previous record for global warmth was set in the El Niño year of 1998, when high sea-surface temperatures in the equatorial Pacific pushed up the global average, says James Hansen, director of NASA's Goddard Institute for Space Studies in New York. This year's record warmth is notable because temperatures didn't get a boost from El Niño, he notes. Hansen and his colleagues announced results of their analyses on Jan. 24.



HOT, HOT, HOT Last year's average temperature in large portions of the Northern Hemisphere was more than 1.5°C above normal (red and dark red areas).

Global average temperatures have risen 0.6°C in the past 30 years and 0.8°C in the past century. Recent warming coincides with rapid growth in the atmospheric concentrations of greenhouse gases such as carbon dioxide and is consistent with predictions from climate models based on industrial emissions of those gases, says Hansen.

During the past half-century, the largest increases in temperature have occurred in high-latitude regions such as Alaska, Siberia, and the Antarctic Peninsula. Last year, the average temperature across large swaths of Alaska, Canada, Scandinavia, and Russia was more than 1.5°C higher than the average recorded for those areas between 1951 and 1980. —S.P.

ASTRONOMY

Galactic cannibalism

The Milky Way has been at it again. Astronomers have found evidence that our home galaxy is tearing apart and swallowing a nearby collection of stars—most likely the remains of a dwarf galaxy. The galactic violence would be the latest confirmed act of cannibalism by the Milky Way (*SN: 4/22/00, p. 261*). Galaxies commonly grow by eating each other.

Some 30,000 light-years from Earth, the collection of stars lies within the Milky Way but differs in velocity and shape from that of other known galaxy components. Containing several hundred thousand stars, the group spans a swath of sky larger than any galaxy beyond the Milky Way.

Astronomers found the group by combing through distance measurements of 48 million stars recorded by the Sloan Digital Sky Survey. The data enabled the team to build a three-dimensional map of the Milky Way in which faint star groupings "snapped into view," says Robert Lupton of Princeton University. He reported the findings in January at a meeting of the American Astronomical Society in Washington, D.C.

Another team, reporting in the Jan. 10 *Astrophysical Journal Letters*, already had evidence that a subset of stars in the same region moves in concert and is probably the remains of a dwarf galaxy. But the Sloan study revealed the breadth of the newfound collection of stars.

Because the former galaxy lies considerably closer to the center of the Milky Way than do any other known dwarf-galaxy remains, "it is likely to have been chewed up more by the interactions with the Milky Way's gravitational field," says Heather Morrison of Case Western Reserve University in Cleveland. —R.C.

Books

A selection of new and notable books of scientific interest

CITIES OF THE WORLD: A History in Maps

PETER WHITFIELD

With the birth of agriculture around 10,000 years ago, humankind formed settlements and abandoned its nomadic ways. These settlements became villages, then cities, and finally fonts of civilization as we know it. Indeed, the rise of cities is directly linked to the development of written records, religious association, law, and government. This book celebrates urban planning as it has developed over millennia and reveals the history of cities worldwide through exquisite maps and artwork. Map historian Whitfield examines more than 60 cities, including New Orleans, London, and the ancient Mediterranean ports of Alexandria and Constantinople. Each entry includes details of a city's founding, development, and rulers, as well as maps, photos, and illustrations. ***Univ. Calif. Press, 2005, 208 p., hardcover, $39.95.***

DON'T KNOW MUCH ABOUT MYTHOLOGY: Everything You Need to Know about the Greatest Stories in Human History but Never Learned

KENNETH C. DAVIS

Before science, people used myths to explain the mysteries of life and nature, from the world's creation to a person's death. Davis offers a glimpse at myths that pervade the world's civilizations and ponders what these stories reveal about human nature. In an engaging question-and-answer format, Davis presents a primer on the mythology of Egypt, Greece, Mesopotamia, the British Isles, India, and a few other places. He examines how tales of gods and other spiritual beings, from Zeus to Odin to Indra, evolved into modern-day religions. He reveals some of the recurring themes in various myths, such as great floods and trickster gods, and considers which myths might be based in historical fact. Each chapter includes a who's who of gods in a particular myth-making society and includes passages from famous myths, bringing the stories to life for modern readers. ***HarperCollins, 2005, 545 p., hardcover, $26.95.***

THE DEVIL'S TEETH: A True Story of Obsession and Survival among America's Great White Sharks

SUSAN CASEY

Thirty miles west of San Francisco's Golden Gate Bridge lie the Farallon Islands, with some of the most forbidding terrain in America. They're the only dry land on Earth where one can observe great white sharks in their natural element, untouched by human influence. Each year, the normally solitary sharks mysteriously converge on the islands to feast on a bounty of seals—and anything else foolish enough to enter the water. Journalist Casey takes the reader along as she follows her curiosity about researchers Scot Anderson and Peter Pyle, whom she learned about in a documentary on sharks. Casey's initial interest, she writes, turned into an obsession with the sharks and the barren islands known as "the Devil's teeth." She documents her experience on the islands, where she holed up with the scientists in the only habitable building there and accompanied them on forays, by boat, into shark-infested waters. There, the author and the researchers witnessed firsthand the incredible size and awesome killing power of these creatures. ***Holt, 2005, 304 p., color plates, hardcover, $25.00.***

FREAKS OF THE STORM: From Flying Cows to Stealing Thunder: The World's Strangest True Weather Stories

RANDY CERVENY

We've all heard the tales: The tornado that plucked the feathers from a coop full of chickens, or the wind that lifted a baby and carriage hundreds of yards safely into a tree or the heat wave that literally melted the asphalt. These and other stories fill this entertaining look at the history of freak weather events. Weather researcher Cerveny examines the popularity of these tales, some of which have been published in prestigious scientific journals, and introduces people who made their livings documenting these events. He includes stories of such phenomena as massive hailstones, ball lightning, devastating hurricanes, and snowfall in unexpected places, and he goes on to explain how such events occur. Cerveny includes the weirdest weather extremes and a state-by-state list of weather oddities. The book is not simply a tale of the weird and woeful, however, as it also offers helpful tips for surviving severe weather. ***Avalon, 2006, 304 p., b&w images, paperback, $15.95.***

BEATING THE BLUES: New Approaches to Overcoming Dysthymia and Chronic Mild Depression

MICHAEL E. THASE AND SUSAN S. LANG

Mild depression or, as it's clinically known, dysthymia affects up to 35 million people in the United States, but only a fraction of them seeks treatment. Instead, most people with dysthymia cope without anyone's help, viewing the pessimism and feelings of unhappiness that accompany their condition as an unalterable personality trait. Depression researcher Thase and science writer Lang seek to dispel this myth and offer numerous ways in which mild depression can be overcome. They offer tips for determining whether you have depression, list common medications that can have depressive side effects, identify who's at risk of developing dysthymia, and offer readers advice on talking to a physician about their symptoms. The authors highlight the patterns of negative thinking that can lead to depressive feelings and offer ways to avoid falling into these traps. They also suggest treatments, ranging from psychotherapy and medication to exercise, and social support. ***Oxford, 2006, 208 p., paperback, $13.95.***

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LETTERS

DOUBLE TROUBLE?

"Sleep apnea could signal greater danger" (*SN: 11/26/05, p. 349*) says that "twice as many ... with sleep apnea had a stroke or died of that or another cause. ..." This sounds serious, but your readers can't correctly assign importance to "twice as many" because you omit numbers of deaths.

DAVID KOLLAS, TOLLAND, CONN.

Among the 697 people with sleep apnea, 22 suffered strokes and 50 other people died of that or another cause during the study. Among the 325 people without sleep apnea, there were 2 strokes and 14 deaths from strokes or other causes. —N. SEPPA

What a dino might be

The picture caption in "Ancient Grazers: Find adds grass to dinosaur menu" (*SN: 11/19/05, p. 323*) states, "This phytolith, which was extracted from fossilized dinosaur dung unearthed in India, indicates that the reptiles dined on grasses." I do believe that dinosaurs aren't classified as reptiles.

PATRICIA GRIFFITH,
AMERICAN CANYON, CALIF.

Confusion in this area stems from the fact that not all ancient reptiles were dinosaurs. But dinosaurs were a class of reptiles, set apart from others by their postures and their hip structures. —S. PERKINS

Buzz bomb

The evidence at best is fuzzy for bee recognition of faces ("Face Time: Bees can tell apart human portraits," *SN: 12/3/05, p. 360*). Both sugar water and quinine have unique odors that are probably readily recognizable by bees. And what do the feeders look like in the bee spectral range?

JACQUES M. DULIN, SEQUIM, WASH.

For the test of bees' face recognition, the researchers used empty, identical feeders to avoid just such clues. —S. MILIUS

Wayward worms

While it is extraordinary that an unprotected insect larva survives gut passage ("When Worms Fly: Insect larvae can survive bird guts," *SN: 12/10/05, p. 373*), it is not the first demonstration that insects may be carried inside of birds. The larvae of phytophagous wasps living inside the seeds of the multiflora rose pass unharmed through the guts of mockingbirds.

C.A. NALEPA, RALEIGH, N.C.

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Never run out of batteries

Many digital cameras require expensive, hard to find batteries. This camera works on ordinary alkaline AAA batteries, rechargeable AAA batteries or AAA lithium ion batteries. So it's easy to keep extra batteries on hand and easy to find replacements if you should run out.

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