SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

MARCH 10, 2007 PAGES 145-160 VOL. 171, NO. 10

getting estrogen out of water

kids beat cancer, still face risk

dieting rejuvenates human cells

mafioso cowbirds

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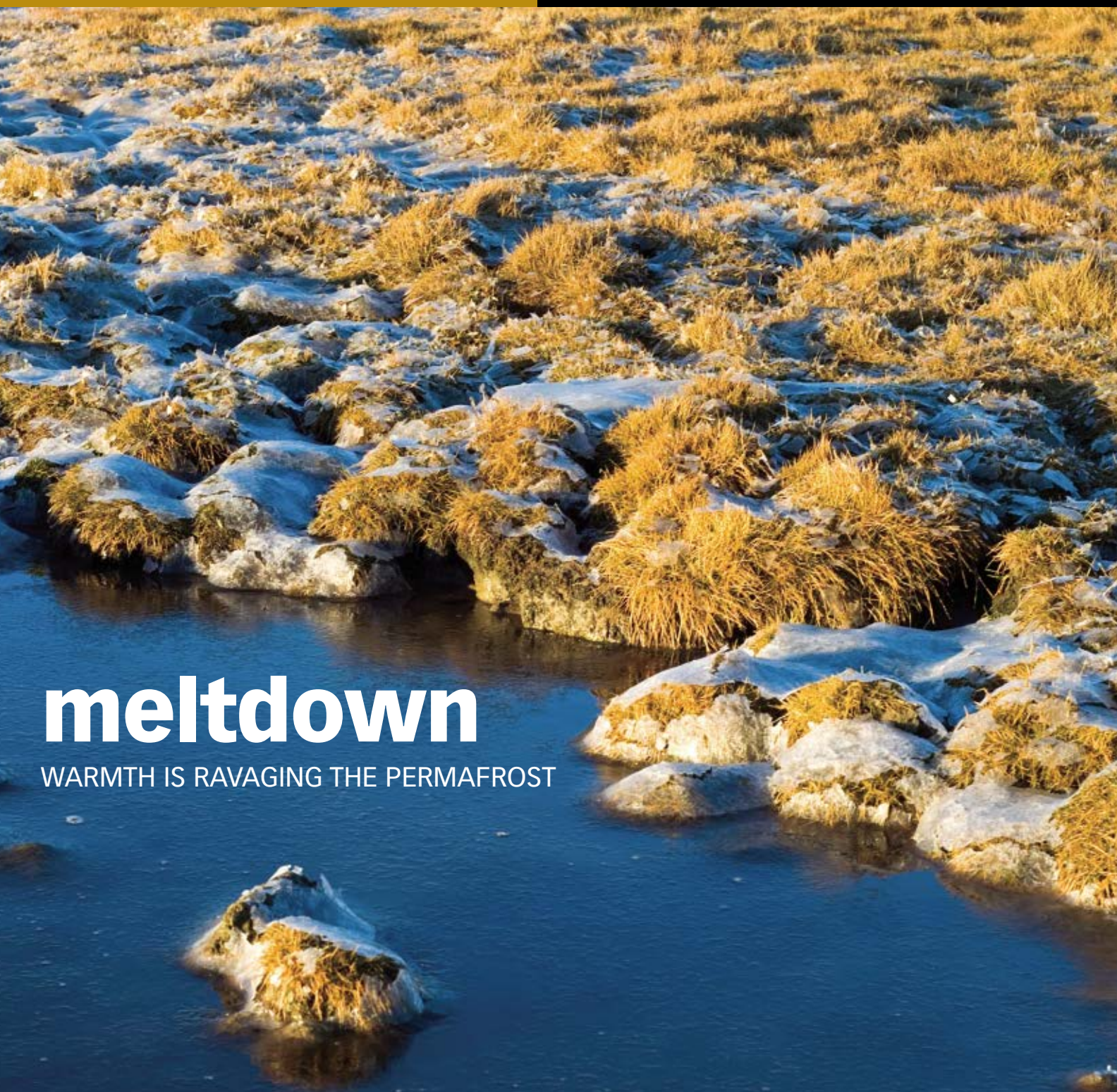

meltdown

WARMTH IS RAVAGING THE PERMAFROST

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Features

This Week

Of Note

Departments

Cover Earth's warming climate is taking its toll on the permafrost that lies beneath about one-fourth of the Northern Hemisphere's land area. In many parts of the Arctic, changing patterns of precipitation and wildfires are accelerating that loss. (iStockphoto)
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Living Long on Less?

Mouse and human cells respond to slim diets

Scientists have known since the 1930s that mice and other animals live 30 to 50 percent longer when placed on a diet that's low in calories yet nutritionally complete. The unanswered question has been whether calorie restriction has the same life-extending effect on people.

Direct proof of a payoff for human longevity would take decades. But scientists have now shown that people on a calorie-restricted diet experience many of the cellular changes reported in mouse studies.

"The experimental results [in mice] mirror the results we found," says Anthony E. Civitarese of the Pennington Biomedical Research Center in Baton Rouge, La. Whether those changes would extend a person's life remains uncertain, he notes.

As people get older, energy-converting organelles called mitochondria decrease in number and generate greater amounts of harmful by-products called free radicals. Many scientists hypothesize that DNA damage from these by-products can cause chronic diseases of old age such as cancer.

Civitarese and his colleagues randomly assigned 36 overweight people to one of three groups. The first group was instructed to follow a diet with 25 percent fewer calories than the individuals' initial energy expenditures. Each participant in the second group followed a diet with 12.5 percent fewer calories than he or she had initially expended, while exercising to burn another 12.5 percent. Both diets contained adequate nutrition. People in the third group ate a weight-maintenance diet, the researchers report in the March *PLoS Medicine*.

During the 6-month study, participants in both calorie-restricted groups showed a 20 to 35 percent increase in the number of mitochondria in their muscle cells and a 60 percent decrease in DNA damage. The mitochondria appeared to become more youthful and efficient.

People in the calorie-restricted groups also showed increased activity of several genes related to mitochondrial function. Scientists have long considered one of these genes, *SIRT1*, to be crucial for animals' responses to calorie restriction.

"Not only is it a good study, but it's the only kind that we can do" practically, comments David Sinclair of Harvard Medical School in Boston. Several companies, including one cofounded by Sinclair, are developing drugs to activate *SIRT1*.

"It's exciting to see *SIRT1* in the middle of this," says Leonard Guarente of the Massachusetts Institute of Technology, a cofounder of a competing company. However, he says that interpretation of the results of the Baton Rouge study is limited because the participants were overweight, a condition that can accelerate tissue aging.

The researchers enrolled overweight people in part because they would be motivated to follow a strict diet, Civitarese says. His team is planning a test that will focus on people of normal body weight and last 2 years. —P. BARRY

Mafia Cowbirds

Do they muscle birds that don't play ball?

Cowbirds in Illinois that sneak their eggs into other birds' nests retaliate violently if their scam gets foiled, researchers say.

The brown-headed cowbirds of North America outsource nest building and chick raising. Female cowbirds dart into other birds' nests, quickly lay eggs, and rush away. The nest owners are left to care for big, demanding cowbird chicks.

Why don't the dupes throw out the odd eggs? When scientists removed cowbird eggs from warbler nests, more warbler eggs later got smashed or carried off than did eggs in nests with cowbird eggs in place. It was cowbird retaliation, conclude Jeffrey P. Hoover of the Illinois Natural History Survey in Champaign and Scott K. Robinson of the Florida Museum of Natural History in Gainesville.

That's the first evidence of gangsterlike behavior in cowbirds, says Hoover.

A decade of monitoring prothonotary warblers in nest boxes in southern-Illinois swamps gave Hoover the idea for the new experiment. The nest boxes sit on poles coated with axle grease to thwart raccoons, snakes, and most other raiders. Egg-laying cowbirds still strike, and Hoover had for years left the cowbird eggs alone. In 2002, he and other researchers removed cowbird eggs. Nest vandalism suddenly increased.

No one saw the vandals, but Hoover and Robinson turned to an idea put forward in 1979 by Israeli biologist Amotz Zahavi. He'd suggested that by tending the weird-looking eggs and chicks, the foster parents protect their own progeny. In a rare test of the idea, cuckoos retaliated against magpies in Spain that rejected cuckoo eggs, scientists reported in 1995.

In the new experiment, the researchers recorded egg damage in only 6 percent of the warbler nests where cowbird eggs remained unmolested. In contrast, 56 per-

DRIVE-BY MOM A female brown-headed cowbird will dart into another bird's nest to lay an egg and leave it to the care of the nest owners. A warbler nest in Illinois has three of the oversize, brown-speckled cowbird eggs (inset).

C. YOUNG; (INSET) HOOVER

cent of nests were vandalized after the researchers removed the cowbird eggs. When the scientists removed the cowbird eggs but added new fronts to the nest boxes with holes too small for cowbirds, there was no damage.

So, the nest trashers are cowbirds, Hoover and Robinson conclude in a paper now online for an upcoming *Proceedings of the National Academy of Sciences*.

When the cowbird eggs stayed in the nest, some warbler chicks starved because the pushy cowbird nestlings took so much of the food. Yet with the retaliation attacks, the nests where cowbird eggs had been removed produced, on average, only 40 percent as many warblers as the cowbird-fostering nests did, says Hoover.

"This is a surprising result," says Stephen Rothstein of the University of California, Santa Barbara.

Rothstein hasn't tested whether cowbirds retaliate, but he says, "My bet, before this paper, would have been definitely no." He's now reconsidering but says, "I'd like to see more direct evidence," such as video.

So would Naomi Langmore of the Australian National University in Canberra. Still, she describes the evidence as "compelling."

"Best evidence to date," says Rebecca Kilner of the University of Cambridge in England. —S. MILIUS

Schizophrenia Plus and Minus

Cognitive course nudges patients into workforce

Two approaches to treating schizophrenia, a severe mental disorder that affects an estimated 1 in 100 adults worldwide, receive contrasting evaluations in new studies.

On the disappointing side, patients with schizophrenia who took any of five highly touted antipsychotic drugs for 1 year experienced only modest gains in holding down jobs, sustaining friendships, and otherwise functioning well in daily life. These drugs, the second generation of such medications, achieved no better results in improving patients' quality of life than an older antipsychotic medication did.

On the encouraging side, people with schizophrenia who had completed a computerized training program in cognitive skills as part of a vocational program worked more and made more money over the next 2 to 3 years than did patients in the same program who received no cognitive training.

These results underscore the need for studies of various drugs in combination with psychological and social interventions for schizophrenia, remarks psychiatrist John Lauriello of the University of New Mexico in Albuquerque. "Improving quality of life does not come prepackaged in a medication bottle," he says.

QUOTE

"Improving quality of life does not come prepackaged in a medication bottle."
JOHN LAURIELLO, University of New Mexico

Both new reports appear in the March *American Journal of Psychiatry*.

In the first study, a team led by psychiatrist Marvin S. Swartz of Duke University School of Medicine in Durham, N.C., tracked 455 patients with schizophrenia who took randomly assigned antipsychotic medications for 1 year. They also received a mix of rehabilitation and vocational services. As part of a larger study (*SN: 9/24/05, p. 195*), the patients had been recruited at facilities throughout the United States.

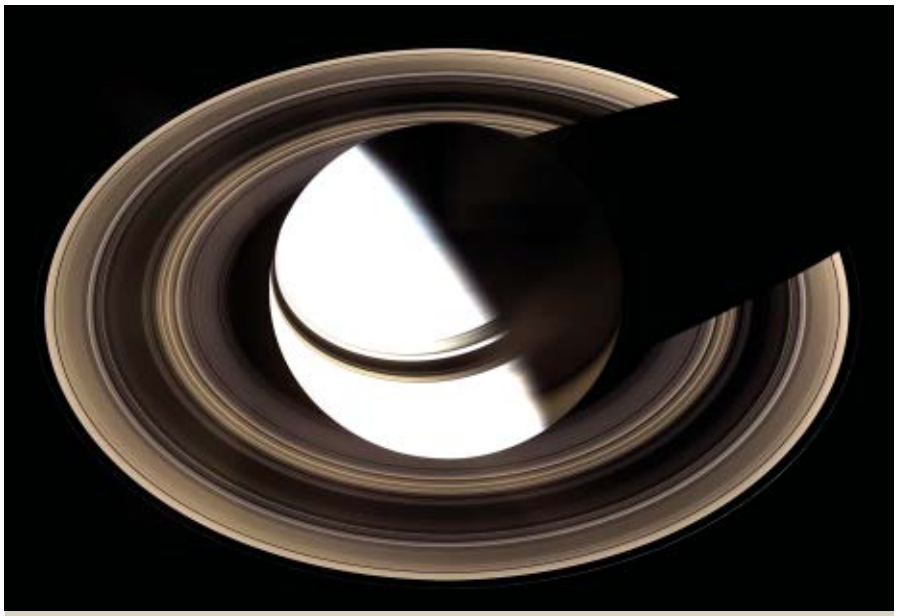
No matter which drug a participant took, after a year he or she still displayed severe impairments. Participants who scored lowest on a quality-of-life measure at the start of the study reported the most gains.

The second study, directed by psychologist Susan R. McGurk of Dartmouth Medical School in Hanover, N.H., focused on 44 people with schizophrenia or related psychotic disorders who were enrolled in either of two employment programs at mental-health clinics in New York City. Of those patients, 38 were taking an antipsychotic medication.

For 2 to 3 years, all the participants met with an employment specialist who assisted them in finding and keeping jobs. Twenty-three of the study participants were randomly assigned to receive computer-based cognitive training in 24 roughly hour-long sessions. That training lasted for about 3 months and included practice on mental tasks that demanded attention, concentration, memory, reasoning, and fast responses.

Depression and social isolation declined after the cognitive training. The employment rate for those who completed cognitive training fluctuated but peaked at 40 percent, compared with a peak of 13 percent for patients in the regular employment programs. Still, cognitive-training graduates worked an average of only 6 months during the 2-to-3-year follow-up.

It's not clear whether the apparent benefits of cognitive training stemmed from increased hopefulness, self-esteem, or other



SPACE SCIENCE INSTITUTE, JPL/NASA

Saturn's rings: A panoramic perspective

Sailing high above Saturn, NASA's Cassini spacecraft recently made this sweeping portrait of the icy rings that girdle the planet. "It's a view that no human has had before, nor a spacecraft," says Cassini scientist Carolyn Porco of the Space Science Institute in Boulder, Colo. From a vantage point 40° above the equator, Cassini captured the rings' full breadth as well as Saturn's shadow across them. By combining the views from several perspectives, Cassini is indicating the ring particles' texture and density. The craft has toured Saturn for nearly 3 years. Released by NASA on March 1, this mosaic of 36 images was recorded on Jan. 29, when the craft was 1.23 million kilometers from the planet. —R. COWEN

positive effects of receiving trainers' attention, comments Boston University psychologist Courtenay Harding. She recommends that researchers also examine training programs tailored to specific cognitive impairments, which vary among people with schizophrenia. —B. BOWER

Bad Influence

TV, movies linked to adolescent smoking

White adolescents who watch a lot of R-rated movies are nearly three times as likely to try smoking as are their peers who watch little of such fare, a new study finds. Those who have televisions in their bedrooms are twice as likely to take a puff.

In contrast, black teens' smoking isn't associated with how many R-rated movies or hours of television they watched, researchers report in the March *Archives of Pediatrics and Adolescent Medicine*.

While it might seem unsurprising that television shows and movies—with characters often puffing away—would influence youth smoking, few studies had recorded the effects of such media exposure over time, says study coauthor Christine Jackson, a social ecologist at the Pacific Institute for Research and Evaluation in Chapel Hill, N.C.

In 2001 and 2002, Jackson and her colleagues interviewed 735 children ages 12 to 14 in their homes. Roughly equal numbers of blacks and whites participated, and all said that they had never smoked. The team gauged the children's exposure to 93 films, including 23 R-rated movies, playing in theaters during the study. Previous research had shown that R-rated movies show two to three times as much smoking as PG-13 movies do. The kids also averaged 4.7 hours of television a day.

At follow-up 2 years later, 30 percent of the teens reported having tried cigarettes. When the researchers adjusted the data to offset differences such as grades, having friends who smoke, and parents' rules about television and movie viewing, the link between smoking and viewing more R-rated films and unsupervised television persisted in white teens.

Some research suggests that movies increasingly put smoking in a bad light (*SN: 9/3/05, p. 158*). But children may still emulate a character who's a villain or an antihero, says epidemiologist Madeline A. Dalton of Dartmouth Medical School in Hanover, N.H.

"Think of James Dean," Dalton says. Smoking can be "a rebellious expression more than anything else," and tough movie characters who smoke might look attractive to teens. "They have an edge," she adds.

Stanton A. Glantz, a cardiovascular researcher at the University of California, San Francisco, notes that the new work bolsters earlier data linking excessive television viewing to teen smoking. Even though there's less smoking per hour on television than in R-rated movies, children see many more hours of television.

None of the scientists could explain why black teens in this study, who smoked just as much as the white teens, showed less influence from films and television. Since more movies and television programs have white leading actors rather than black ones, black teens may identify less with these characters than white teens do, Jackson surmises. —N. SEPPA

High and Dry

Pollution may stifle mountain precipitation

Trends seen in meteorological data gathered on a Chinese mountaintop suggest that air pollution reduces the amount of precipitation that falls at high-altitude sites.

NO UMBRELLAS TODAY **Hazy conditions atop China's Mount Hua may stifle precipitation there as much as 30 percent, a new study of long-term weather data suggests.**

When winds force moisture-laden air masses up a mountainside, the air cools, its water vapor condenses, and precipitation often results. Therefore, many mountainous locales receive more rainfall and snow than do sites on the plains just upwind, says Daniel Rosenfeld, an atmospheric scientist at the Hebrew University of Jerusalem.

This moisture-squeezing effect seems to be faltering in some areas, Rosenfeld notes. Many mountainous areas in the western United States, especially those downwind of major urban areas, have experienced as much as a 25 percent drop in precipitation in recent years.

Some scientists suspect that air pollution wafting from those industrialized regions may be triggering the downturn in rainfall. However, because of a lack of long-term atmospheric data in affected areas, "there's been no smoking gun," says Rosenfeld.

Now, he and his colleagues have analyzed weather data gathered atop Mount Hua, a 2,060-meter-tall peak about 120 kilometers east of Xi'an, China. Meteorologists there have made detailed measurements, including rainfall, atmospheric visibility, and humidity, since 1954, he notes.

First, Rosenfeld and his team adjusted the data by removing the contribution of relative humidity to haze, thereby isolating the role of aerosols—particles suspended in the air—in reducing visibility. Then, they calculated the ratio of rainfall measured on Mount Hua to that collected at Huayin, the closest city on the plains nearby.

On days when the adjusted visibility was more than 20 km, Mount Hua received, on average, about 65 percent more precipitation than did Huayin. When aerosols reduced visibility to below 8 km, rainfall on Mount Hua measured only 20 percent more than that at Huayin. The researchers describe the findings in the March 9 *Science*.

Although the team's findings bolster the notion that pollution stifles precipitation, they're not conclusive, says Randolph D. Borys, an atmospheric scientist with the Desert Research Institute's Storm Peak Laboratory in Steamboat Springs, Colo. For instance, the visibility data don't distinguish between industrial pollutants and natural aerosols, which may have dissimilar influences on the formation of raindrops.

Wei-Kuo Tao, a meteorologist at NASA's Goddard Space Flight Center in Greenbelt, Md., calls the new report the first to look at the connection between atmospheric visibility and precipitation. Nevertheless, he, too, points out a potentially confounding variable. While an abundance of tiny particles tends to produce small droplets that don't coalesce, thereby stifling precipitation, a smaller number of large particles—which may also block long-distance visibility—may have no effect whatsoever on precipitation. —S. PERKINS

Functional Family

Mock theta mystery solved

A pair of mathematicians has solved a problem that had tantalized number-theory researchers for more than 8 decades. It is the so-called final prob-

lem of the legendary Indian mathematical genius Srinivasa Ramanujan.

In the years before his death in 1920, Ramanujan studied theta functions, which are numerical relationships that show special symmetries. On his deathbed, Ramanujan wrote a letter to his British collaborator G. H. Hardy, in which he listed 17 complicated formulas for new functions. He called them mock theta functions because they had some properties similar to those of theta functions.

The first few pages of Ramanujan's letter were lost, and the surviving portion gives little indication of why Ramanujan grouped these functions. Since that time, the mock theta functions have cropped up in a surprising array of fields, including number theory, probability theory, and statistical mechanics. Yet mathematicians have puzzled over just what the 17 mock theta functions have in common.

"The mock theta functions are like beautiful butterflies that Ramanujan happened to find," says Freeman Dyson, an emeritus professor at the Institute for Advanced Study in Princeton, N.J. "But if you're a scientist, you want more—you want a theory of evolution, a framework of ideas to fit the butterflies in."

Now, Ken Ono and Kathrin Bringmann, mathematicians at the University of Wisconsin–Madison, have supplied that theory. They figured out a definition of mock theta functions that covers all of Ramanujan's examples and shows how to build infinitely more such functions.

"I didn't really hope to see someone actually do this," says George Andrews of Pennsylvania State University in University Park, who had called the description of the mock theta functions one of the hardest math problems for the new millennium. Ono and Bringmann's accomplishment is "absolutely stunning," he concludes.

The reason that mathematicians have had trouble figuring out what the mock theta functions are, Ono says, is that in a certain sense, the functions are missing a piece. Building on 2002 work by Dutch mathematician Sander Zwegers, then at Utrecht University, Ono and Bringmann have shown that when certain functions are added to each of the mock theta functions, the results are highly symmetric expressions known as harmonic Maass forms.

The researchers report their findings in the March 6 *Proceedings of the National Academy of Sciences*. In two additional papers, they use their theory to prove long-standing conjectures about properties of the mock theta functions.

The new theory is likely to be valuable in many fields, Andrews says. "Whenever a mathematical subject is developed deeply, applications seem to crawl out of the woodwork," he notes.

The new work relies on contemporary mathematics that could not have been known to Ramanujan, says Bruce Berndt of the University of Illinois at Urbana-Champaign. "The task still remains to figure out what Ramanujan's ideas were," he says. "He had a viewpoint which we are still missing." —E. KLARREICH

QUOTE

"The mock theta functions are like beautiful butterflies that Ramanujan happened to find."
FREEMAN DYSON, Institute for Advanced Study

Unlocking the Gaits

Robot tests locomotion switch

A blocky, bright-yellow robot that would look at home in a toy chest moves like a salamander, as its inventors intended. The robot and the mathematical model behind it provide insights into how vertebrates transitioned from swimming to walking, the researchers say.

Computer scientist Auke Jan Ijspeert of the Swiss Federal Institute of Technology in Lausanne and his colleagues chose to model the salamander because it resembles the first terrestrial vertebrates. Salamanders can both swim and walk. A network of neurons located in the spinal cords of salamanders and other vertebrates triggers motion in the body's musculature that leads to the swimming gait. Another such network in the limbs produces a walking gait.

Each of these body and limb networks generates regular patterns of nerve cell activity that cause muscles to contract and relax in a rhythmic fashion. Ijspeert and his coworkers propose that the limb network appeared later in the salamander's evolutionary development than the body network. Coordination between the two networks enables salamanders to sometimes swim and sometimes walk.

The researchers also hypothesize that nerve cells within the limb network switch between muscle-contracting and muscle-relaxing states more slowly than cells in the body network do. When the brain sends out signals in rapid succession, the limb network can't keep up, leaving the body network in command. At low frequencies of stimulation, the limb network overrides the body network and the animal walks.

QUICK DIP **A salamanderlike robot strolls on the beach after a swim in the waters of Lake Geneva in Switzerland.**

A. HERZOG/SWISS FEDERAL INST. TECHNOLOGY

To test their theories, the researchers first produced a mathematical model based on data on nerve and muscle function in salamanders and limbless animals. However, "we wanted to test our model with a real body," Ijspeert says.

So, the researchers used their model to create software representing the limb and body networks and installed it in an 85-centimeter-long robot.

The robot's software resides in a microprocessor that's controlled wirelessly. The operator of the robot acts as its brain, sending higher- or lower-frequency signals to the microprocessor, which in turn controls the robot's motors. In response, the robot either swims or walks.

In the March 9 *Science*, the team reports that its programmed robot mimics a salamander's two gaits, albeit slowly, especially when swimming. The team also presents biological evidence that the neurons in the salamander's limb network indeed switch states more slowly than those in the body network do.

By bringing together biology, engineering, and mathematics, the work is "a wonderful example of how different disciplines are necessary and are coming together" to solve problems such as how animals move, comments Robert J. Full, an integrative biologist at the University of California, Berkeley.

He adds that while the salamander model is an "outstanding first step," it takes only the motion of the body parts into consideration. A full understanding of locomotion, he says, requires that scientists also consider forces, such as how an animal pushes on the ground. —A. CUNNINGHAM

Are We Conscious or Merely Zombies?

Explore the mysteries of the mind in 12 thought-provoking lectures

It's as essential to human existence as water is to a fish, and yet every night we surrender it gratefully. As human beings, we recognize that we have it, but we can never be sure anyone else does. It has been the subject of debate for philosophers and scientists for millennia, but we've yet to understand its true essence and purpose.

It's *consciousness*, and if you think you grasp the nuances of this unique mental state, then take a moment to consider … the zombie.

Most of us are familiar with this wretched star of B-grade horror films: a once-human creature dead but not truly dead. In its state of suspended life, it performs many of the tasks we do every day. It can move, it can carry things, it finds its way around.

But can we say, therefore, that a zombie has consciousness? Does a zombie feel empathy? Is it aware of its existence? Of course not, we are inclined to answer. And yet, if a zombie acts like a conscious human being, do we have any ground for denying it a consciousness very much like our own?

Join distinguished philosopher and psychologist Daniel N. Robinson as we explore these and other fascinating questions in **Consciousness and Its Implications.** Over the course of 12 thought-provoking lectures, you'll probe the depths of this mysterious mental state from the perspective of the philosopher, the psychologist, the scientist, and the doctor.

Can a Computer Play Chess?

A master storyteller, Dr. Robinson brings this riveting topic vividly to life with real-world examples and striking anecdotes.

You'll review the case of Deep Blue, the IBM computer that in 1997 shocked the world by defeating grand chess master Garry Kasparov. Does Deep Blue's ability to "outsmart" a human being constitute a kind of consciousness?

You'll also look at the lives of real people and explore what happens when normal human consciousness seems to slip away.

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When we daydream are we conscious?

Consider the case of the sleepwalker who mimics behaviors we see in everyday life, but upon awakening, remembers nothing of her nighttime activities.

Professor Robinson will also introduce you to poignant tales of lives lived between consciousness and unconsciousness. For example, a comatose patient, who upon regaining consciousness, claims to have heard her doctor say she'd never awaken.? Or the autistic child, who can perform complicated mental tasks, but lacks the most basic human attribute: empathy.

Using compelling examples such as these, Professor Robinson will change the way you think about your own mind.

About Your Professor

Dr. Daniel N. Robinson is a member of the Philosophy faculty at Oxford University, where he has lectured annually since 1991. He is also Distinguished Professor, Emeritus, at Georgetown University, on whose faculty he served for 30 years. He was formerly Adjunct Professor of Psychology at Columbia University. Professor Robinson earned his Ph.D. in neuropsychology from City University of New York. Prior to taking his position at Georgetown, he held positions at Amherst College, Princeton University, and Columbia University.

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TRACES OF TROUBLE

Removing the small but potent quantities of estrogens from waterways

BY AIMEE CUNNINGHAM

In 1978, during a routine ecological assessment of several British waterways, wildlife biologists discovered an unusually high number of abnormal fish living downstream of two sewage-treatment plants. The fish were considered intersexual because their gonads contained both ovarian and testicular tissue. Nearly 2 decades later, after the development of more-sensitive analytical techniques, researchers provided an explanation. They traced the animals' reproductive problems to low concentrations of estrogens, known as the female-sex hormones, that had entered the environment in waters released by the sewage plants.

Researchers had found that concentrations as low as a few parts per trillion lead to reproductive abnormalities in fish. "This changed the whole thinking about chemicals in the environment," says John P. Sumpter, an ecotoxicologist at Brunel University in Uxbridge, England. Having generally focused on chemical pollution at higher concentrations, researchers began to consider that perhaps biologically active chemicals at low concentrations "are the things we should be more concerned about," he says.

Evidence of reproductive harm to aquatic life chronically exposed to estrogens continues to accumulate, and affected fish have now been found in the United States, Italy, and elsewhere.

Naturally occurring estrogens, a family of closely related molecules, can enter the environment from livestock urine and feces. The hormones in feces and urine of people reach sewage-treatment plants. Synthetic estrogen from birth control pills also turns up in sewage. Small amounts of the chemicals often exit sewage-treatment plants with the treated water. Those plants "are not designed to remove trace pollution," says Jörg E. Drewes, an environmental engineer at the Colorado School of Mines in Golden.

Recently, scientists and engineers have been investigating how to stem the flow of estrogens into the environment. The researchers are considering fixes both inside and outside the treatment plants.

"There's a certain optimism that we can control the problem," says David L. Sedlak, an environmental chemist at the University of California, Berkeley. "I think there are cost-effective solutions out there."

CLEANSING POWER — Researchers are working to improve estrogen removal in wastewater treatment plants. This plant in is Las Vegas.

CORBIS

PRIMING PLANTS Federal and state governments regulate what substances a treatment plant must remove. The size of the population that a plant serves, the body of water into which it discharges, and other local environmental factors influence treatment processes, explains Drewes.

The main task of sewage-treatment plants is to remove organic matter from wastewater. Large amounts of decomposing organic matter rob water of oxygen and endanger aquatic life. Some treatment plants also remove nitrogen and phosphorus, nutrients that encourage growth of oxygen-depleting algae. Finally, treatment plants kill pathogens in the water before discharging it.

Research groups have assessed estrogen removal at various facilities. Between 2002 and 2004, Drewes and his colleagues surveyed seven conventional U.S. treatment plants. The group focused on a treatment step during which microbes digest waste from the water.

The water exiting this step had, on average, only 4 percent of the estrogenic activity measured in the water entering this step. However, even that level of activity could cause adverse effects in fish, notes Drewes.

As a first approach to increasing estrogen removal, many scientists and engineers are focusing on treatment steps in today's plants. "There's a lot of investment in the current infrastructure," says Drewes. "That's why research is ongoing to see whether you can fine-tune existing plants."

A few trends have emerged. For example, the longer a plant retains waste for bacterial digestion, the better the estrogen removal. During the retention time, the food available to the microbes changes and different types flourish, increasing the chance that the waste will encounter estrogen degraders. Treatment plants with the longest sludge retention times, sometimes several weeks, are typically those designed to remove nitrogen from their wastes. These plants depend on slow-growing bacteria that convert ammonia to nitrate.

Kung-Hui Chu, an environmental engineer at Texas A&M University in College Station, went in search of strains capable of breaking down estrogens. She and her colleagues sampled degrading waste from a treatment plant in Knoxville, Tenn. For 6 months, they grew the microbes in a flask with estrogen as the only food source.

The researchers isolated 11 bacterial strains that break down 17-beta estradiol, the main form of naturally occurring estrogen, to a form called estrone. That degradation continued for at least 7 days.

However, getting rid of estrone proved more difficult. Two other strains reduced the concentration of estrone measurably in 5 days but couldn't finish the job. The researchers found just one strain that completely degraded 17-beta estradiol to compounds free of estrogenic activity, and it took 5 days to do so. The team reports its results in the Jan. 15 *Environmental Science & Technology*.

Now that they've identified specific strains, Chu and her colleagues are investigating how abundant the estrogen-degrading microbes are in treatment plants. They would like to figure out the operating conditions that are most favorable to these bacteria, so that the microbes can "do the degradation work for us," says Chu.

Later stages of water treatment can also remove estrogens. Studies have shown that chlorine, commonly used to disinfect treated water, reacts with and removes estrogen. But those studies also reported the formation of by-products that may cause cancers.

Ozonation, a disinfection process used principally in drinking-water treatment, also removes estrogen, but concerns over cost make its use rare among wastewater-treatment plants, notes Sedlak.

More-advanced treatment options could be added to plants, but they'd be expensive, notes Chu. "From an economic point of view," she says, engineers are initially focusing on improving the microbial degradation of estrogen.

WETLAND WAGER Estrogen-removal strategies are also being considered outside treatment plants. Sedlak and his colleagues have investigated wetlands engineered to remove contaminants. Some municipalities, such as the Orange County Water District in California, already use engineered wetlands to aid in nitrogen removal.

Characterized by their dense plant growth, wetlands support many bacteria and can be designed so that water moves slowly through their channels. An engineered wetland, put in place at a treatment plant's discharge point, would provide an additional microbial-degradation step that might also break down estrogens.

In 2002, Sedlak's group measured the removal of estrogens from a test wetland thick with cattails and bulrushes. The researchers tracked changes in hormonal concentration as estrogen-spiked water moved through the site for 3.5 days. The researchers found evidence of microbial degradation of the hormone along with some adsorption to plant surfaces. When the water exited the wetlands, its estrogen concentration had fallen by almost 40 percent from the initial value.

Sedlak says that engineered wetlands with longer water-retention times would probably remove even more estrogen. And other designs might provide more opportunity for degradation. Subsurface wetlands, for example, force the water to travel underground through gravel or sediments that harbor microbial colonies.

Researchers are also investigating whether engineered wetlands—in combination with the lagoon systems that farmers often use to handle manure—can protect watersheds near livestock operations. Nancy W. Shappell of the U.S. Department of Agriculture's Agricultural Research Service in Fargo, N.D., and her colleagues examined barns housing more than 100 pigs at North Carolina Agricultural and Technical State University in Greensboro.

During the study, water flushed manure out of the barns into a pit. The resulting slurry next entered a lagoon, and then continued into test wetlands. Finally, the water moved to a storage pond before being used to flush the barns again. The water remained in the wetlands between 20 and 50 days, depending on the time of year.

In the Jan. 15 *Environmental Science & Technology*, the researchers report that the wetlands decreased the estrogenic activity of the water by 83 to 93 percent. Researchers haven't yet examined how well lagoon-wetland systems would handle larger livestock operations, which can house thousands of animals.

Sedlak says, "One of the challenges associated with wetlands is understanding their reliability." There's little known about the effects of seasonal changes or about what wetland configurations are most successful for hormone removal. "The science there is in its infancy," he notes.

TAKING ACTION With the continuing development of low-cost approaches to removing estrogen from wastewater—and the availability of more-expensive, advanced treatments usually reserved for drinking water—"the scientific community is now trying to provide a toolbox for water utilities," Sedlak says. Without regulations requiring estrogen removal, however, it's unclear whether water utilities will use these options.

"You can design plants that take care of these problems," notes Drewes. "The question is, Is the community willing to spend that money?" Moving beyond current federal and state standards would require widespread community support.

Estrogen is not the only compound traveling through water systems that raises concern (see sidebar). "I think we need to focus on determining which chemicals put our environment most at risk," says Shappell. That would entail investigating which compounds persist in treated wastewater at concentrations that have biological activity.

Adds Sumpter, "There are some very interesting questions to ask about how you decide what to focus on and whether the decisions you make are in the best interest of conserving your biodiversity." ■

Dealing With Drugs

Are pharmaceuticals a problem in wastewater?

With the discovery that small concentrations of naturally occurring and synthetic estrogens can adversely affect aquatic wildlife, "there's now a lot of interest across the whole suite of pharmaceuticals," says John P. Sumpter, an ecotoxicologist at Brunel University in Uxbridge, England. "These chemicals are by definition biologically active. If not, you shouldn't be taking them."

Optimizing operations at sewage-treatment-plants could reduce pharmaceuticals as well as hormones. Diana S. Aga, an analytical chemist at the State University of New York in Buffalo, and her colleagues studied the removal rate of two medical compounds—an X-ray–contrast agent and an antibacterial drug—that frequently turn up in treated water.

In the Dec. 1, 2006 *Environmental Science & Technology*, the researchers reported that slow-growing microbes called nitrifying bacteria, which convert ammonia to nitrate, can also degrade those two pharmaceuticals. The group studied a sewage-treatment plant in Amherst, N.Y., that relies on a two-stage microbial process. The first stage retains the waste for 6 days. The second, which encourages the growth of nitrifying bacteria, keeps the waste for 49 days. While the removal of the two compounds was negligible in the first process, the second took care of 61 percent of the contrast agent and 50 percent of the drug.

"If you make the sludge-retention time appropriate for growing these nitrifying bacteria, you may solve a lot of these problems," says Aga.

Considering the precedent of natural and synthetic estrogens, concern over other pharmaceuticals is legitimate, but there is little evidence yet that they are affecting aquatic wildlife, says Sumpter. And with the vast differences among classes of drugs, "the trick is, How do you go about selecting the few that are going to be the ones you're concerned about?" He adds that researchers are in the "very early stages" of determining the best way to categorize the compounds. —A.C.

NOT-SO-PERMA FROST

Warming climate is taking its toll on subterranean ice

BY SID PERKINS

Daniel Fortier spends his summers studying the permafrost on Bylot Island, high in the eastern Canadian Arctic. While hiking there early in the 1999 field season, he distinctly heard the sound of running water yet saw no streams nearby. "I thought to myself, 'Where is this sound coming from?'" says Fortier. "So, like a good researcher, I started to dig."

Excavating the soil, known as permafrost because its temperature is below 0°C year-round, Fortier tapped into a torrent-filled tunnel a meter or so below the surface. By tracking the water course uphill, he found its source: Large volumes of snowmelt had flowed into open fissures in the ground and had then melted a passage through a network of subterranean ice wedges that had formed over millennia (*SN: 5/17/03, p. 314*).

Eventually, the surprising tunnel grew so wide that its roof caved in, creating a gully that erosion then widened, says Fortier, a geomorphologist at the University of Alaska in Fairbanks. By the end of the summer, that gully was about 250 m long and 4 m wide. During the next 4 years, the network of underground tunnels at the site turned into a 750-m-long system of gullies that drained an area about the size of four soccer fields. Since then, Fortier and his colleagues have observed the same phenomenon at other sites on Bylot Island.

SCOUR POWER — If large amounts of snowmelt flow into surface fissures, they can melt tunnels through masses of subterranean ice. That, in turn, leads to the tunnels' collapse and further erosion, which forms extensive networks of gullies.

FORTIER

Several teams of scientists had previously described similar networks of gullies at various sites in the Arctic, but those highly eroded features had been deemed as much as several thousand years old. "No one had ever seen one of these things forming," says Fortier. "We were in the right place at the right time."

Researchers are observing many new phenomena in the Arctic—most of them related to the world's changing climate. Globally, 11 of the 12 years from 1995 to 2006 are among the dozen warmest since the mid-1800s, scientists of the Intergovernmental Panel on Climate Change reported last month (*SN: 2/10/07, p. 83*). Average temperatures worldwide have risen about 0.7°C in the past 100 years, but those in the Arctic have risen even more. In high-latitude portions of Alaska and western Canada, average summer temperatures have increased by about 1.4°C just since 1961 (*SN: 11/12/05, p. 312*).

Those warmer air temperatures are significantly boosting soil temperatures in many regions, new studies show. Because the average annual temperature at many Arctic sites sits at or just below water's freezing point, even a small increase in local warming can have big consequences. Besides rendering underground ice wedges more susceptible to melting, the hike in temperatures threatens near-surface permafrost that has been in place since the height of the last ice age, about 25,000 years ago. Ecological changes, such as shifts in the patterns and timing of forest fires, further endanger near-surface permafrost. But researchers are still working out whether the permafrost will disappear over decades or millennia.

Permafrost serves as a stable foundation for much of the Arctic's infrastructure, including pipelines, roads, buildings, and bridges. In many areas, that frozen ground also contains huge amounts of organic material, which could readily decompose and send carbon dioxide, a greenhouse gas, into the atmosphere if the permafrost thaws (*SN: 11/12/05, p. 312*).

BALANCING ACT When most people think of permafrost, they envision the coldest Arctic landscapes, where layers of ground hundreds of meters thick have remained deep-frozen since the last ice age, maybe even longer. However, permafrost need not be either long-lived or icy. Geologists consider any soil or rock that's been colder than 0°C for more than 2 years to be permafrost.

Permafrost lies beneath as much as 25 percent of the land area of the Northern Hemisphere. Although much of the frozen ground occurs in high-latitude regions, the rocky summits of many high-altitude peaks in temperate and tropical latitudes also consist of permafrost, says Margareta Johansson, a physical geographer at the Abisko Scientific Research Station in Abisko, Sweden. She and her colleagues have conducted long-term permafrost studies in the region surrounding Abisko, which is about 200 kilometers north of the Arctic Circle. They reviewed their findings in the June 2006 *Ambio*.

The presence or absence of permafrost at any particular spot depends on the balance between geothermal heat making its way up from Earth's interior and the average annual air temperature

at the site, says Johansson. "The lower a site's average air temperature is, the more heat the air pulls from the ground," she notes, leaving the soil colder and the permafrost thicker.

The slope of the terrain has a significant effect as well. South-facing slopes usually receive more direct sunlight and therefore are warmer than flat terrain would be. By contrast, northern slopes spend much of the day in shade, so soil temperatures there are chillier than the region's average and more conducive to the formation of permafrost.

Although permafrost can form in any climate where the average annual air temperature is below freezing, it doesn't normally occur or persist widely until temperatures are substantially lower, says Johansson. When an area's average temperature lies between 0°C and –1.5°C, permafrost is patchy and typically underlies no more than 10 percent of the region. At sites with average air temperatures below –6°C, few spots if any are free of permafrost.

"The amount of snowfall at a site significantly affects the permafrost there, but in a counterintuitive way," says Johansson. When snow forms a thick blanket that lasts all winter, it insulates the ground from the most frigid air of the year. Near Abisko, which receives only about 30 centimeters of snow each year, the permafrost is about 16 meters thick, the deepest in the region, she notes. At similarly cold sites that receive as little as 1 m of snowfall each winter, permafrost is patchier and only a few meters thick.

In experiments at several sites in the Abisko region, Johansson and her colleagues piled up extra snow at some sites, artificially doubling or tripling the snowfall that the spot would normally receive over a winter. As a result, average ground temperatures rose as much as 2.2°C. That large a change can melt underlying permafrost.

Scientists elsewhere have noted that winter snow cover can keep the average ground temperature as much as 10°C higher than the average air temperature, Johansson notes.

It's often difficult for scientists to accurately predict how vegetation will affect ground temperatures, says Johansson. Evergreen trees and shrubs cast shadows that cool the ground during the summer. However, the vegetation forms a windbreak that tends to trap snow in winter, creating drifts that warm the soil. Computer simulations suggest that shrubby sites in northern Alaska accumulate as much as 20 percent more snow than bare ones do, and scientists have found that the soil in shrubby areas is about 2°C warmer than soil in shrub free spots nearby.

FIRE AND ICE The wildfires that intermittently ravage Arctic forests can exact a harsh toll from permafrost. It's not the heat of the conflagration that does the damage but the changes that take place after the fire dies down.

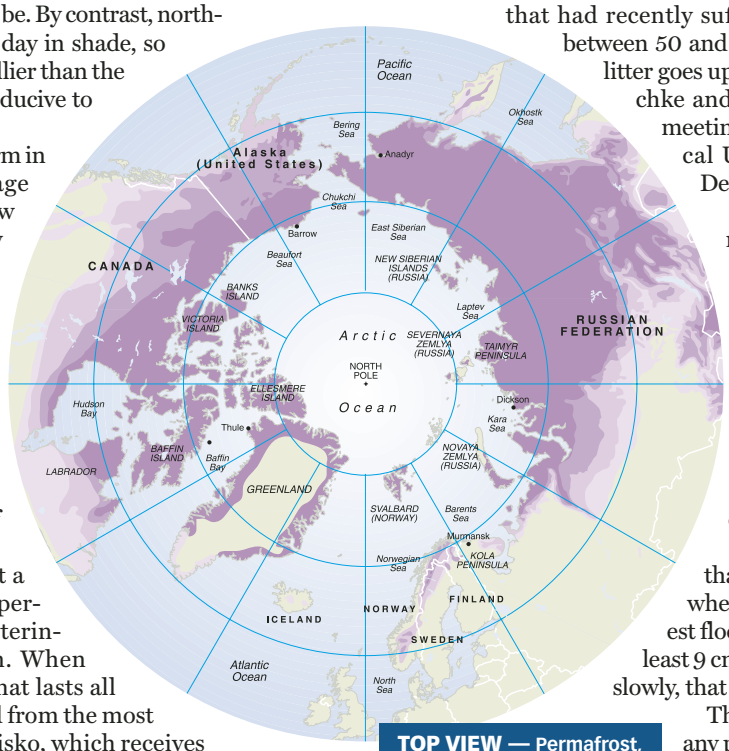
A severe fire strips away the foliage that shades the forest floor. The resulting increase in sunlight reaching the ground boosts soil temperature, says Eric S. Kasischke, a fire ecologist at the University of Maryland, College Park.

An even greater warming effect stems from the fire's consumption of the limbs, twigs, needles, and leaves that had fallen to the ground and insulated it. Unlike a blanket of snow, forest litter insulates the ground year-round. It keeps the ground warmer in winter and cooler in summer. On balance, the insulation favors permafrost formation and retention.

Consider what happens in a black spruce forest, the type that makes up more than half of North America's boreal forests. Scientists have gathered data at more than 200 central-Alaska sites that had recently suffered wildfires. On average, between 50 and 60 percent of the forest-floor litter goes up in smoke during a fire, Kasischke and his colleagues reported at a meeting of the American Geophysical Union in San Francisco last December.

After a fire has destroyed so much litter, a much thicker surface layer of soil thaws each summer, says Kasischke. During the growing season, seedlings quickly become established in that thawed soil. Then, as trees mature, they shade the ground more effectively and drop limbs and needles to reestablish the forest floor's veneer of insulation. Computer models suggest that permafrost begins to recover when organic material on the forest floor accumulates to a depth of at least 9 cm. In a region where trees grow slowly, that could take decades.

The interval between wildfires in any particular patch of boreal forest ranges between 30 and 300 years, Kasischke notes. But, the postfire recuperation of a forest's permafrost isn't a sure bet. Because today's climate in a region may be substantially warmer than it was the last time fire swept through, conditions may not be conducive to permafrost recovery.



TOP VIEW — Permafrost, depicted in various shades of purple, underlies about one-fourth of the Northern Hemisphere's land area. The darker the purple, the greater the percentage of local landscape that permafrost underlies.

HANGING ON When the centuries-long cold spell called the Little Ice Age ended about 150 years ago, glaciers and permafrost reached their maximum extent of the past few millennia. Deep remnants of that permafrost will probably persist for millennia to come. However, in a world that's warming, it's only a matter of time until much of that ice melts. Most permafrost loss will take place at shallow depths, where it will have the greatest effect on ecosystems and people.

In many regions, permafrost temperatures, like air temperatures, have been climbing steadily for decades, says Sergei Marchenko, a permafrost researcher at the University of Alaska in Fairbanks. Data gathered in field studies since the early 1970s indicate that permafrost temperatures in the Altai region of Mongolia and the Tian Shan mountains of central Asia have risen as much as 0.2°C per decade, he notes. Similar rates of warming have been observed on the Tibetan Plateau since 1985.

In the Tian Shan mountains, the thickness of the seasonally thawed layer has increased 23 percent since the early 1970s. It's now 5 m thick, says Marchenko. Climate simulations suggest that since the end of the Little Ice Age, the lowest altitude at which permafrost could persist has climbed about 200 m. During that time, about 16 percent of the region's permafrost would have disappeared, according to the model that Marchenko and his University of Alaska colleague Vladimir Romanovsky described at the American Geophysical Union meeting.

Measurements taken inside three boreholes, each at least

INTL. PERMAFROST ASSN. AND P. REKACEWICZ/UNEP/GRID-ARENDAL

400 m deep, at a mine in the barren terrain of northern Quebec also chronicle modern-day warming, says Christian Chouinard, a paleoclimatologist at McGill University in Montreal. The data suggest that surface soil has heated up about 2.75°C in the past 150 years, he and his colleagues reported at the meeting.

A slight cooling trend in the region from the 1940s to the early 1990s has since been replaced by extremely rapid warming—more than 1°C in the past 15 years or so, the researchers note.

Permafrost can be quick to warm to its melting point but then slow to melt. The energy needed to melt a block of ice at 0°C is about 80 times the amount that's needed to raise its temperature from –1°C to 0°C, says Sharon L. Smith, a permafrost researcher at the Geological Survey of Canada in Ottawa.

Data gathered throughout Canada show that permafrost in the coldest regions of the country is steadily warming, as are soils in areas free of permafrost. However, in the areas where permafrost sits at its melting point, ground temperatures aren't changing significantly. Much of the air's thermal energy goes into melting the permafrost rather than into warming it.

About 42 percent of Canada's land area, or about 4 million square kilometers, overlies permafrost, says Smith. In about half that area, the permafrost is patchy and thin, with a temperature above –2°C. If many scientists' climate-warming scenarios come to pass, Smith says, "permafrost in those regions could ultimately disappear."

When it will disappear is another issue. Research published in 2005 sparked a major debate. In that report, climate scientists David M. Lawrence of the National Center for Atmospheric Research in Boulder, Colo., and Andrew G. Slater of the University of Colorado at Boulder suggested that climate warming will wipe out more than 90 percent of the world's near-surface permafrost by the year 2100.

That dramatic claim is almost certainly wrong, says Christopher Burn, a permafrost researcher at Carleton University in Ottawa. Burn says that although he doesn't dispute the predictions of climate warming, he does question Lawrence and Slater's predictions concerning the pace and extent of the permafrost's demise.

Burn says that the Colorado scientists' estimate requires that permafrost melt almost instantaneously. Instead, the time lag between the climate warming and the permafrost melting will probably be hundreds of years, he suggests.

STATS

42%

Percentage of Canadian land area that overlies permafrost

Lawrence agrees that the computer model that he and Slater used for their study had some limitations—for instance, it included only the top 3.4 m of the ground and didn't account for conditions associated with some soil types. The pair has now modified its model to look 50 m into the ground, says Lawrence. Preliminary results suggest that this deeper permafrost will indeed last longer than they'd previously predicted—but only a couple of decades longer at most—he reports.

Nevertheless, Burn says that the model doesn't take into account the cooling effect of permafrost that lies deeper. For example, permafrost in Alaska and western Canada extends as much as 600 m into the ground, and in Siberia it's more than 1.5 km thick. "The persistence of permafrost increases with its thickness," Burn adds. So, deep soil will stay cold for millennia, thereby putting brakes on the warming of the higher layers.

Whatever the rate of permafrost loss, Earth's rapidly warming climate will continue to gnaw at the long-frozen soil that serves as the bedrock of the Arctic. The carbon dioxide that will probably be released in the process will only tend to accelerate the permafrost's disappearance. ■

LONG-TERM THREAT

Young cancer survivors face risks later

BY NATHAN SEPPA

Childhood-cancer treatment is one of the success stories of the late 20th century. A child diagnosed with cancer in the 1970s had a 56 percent chance of surviving for 5 years. Today, that likelihood is nearly 80 percent. With that gain, however, doctors have noticed that cancer survivors seem prone to other life-threatening medical problems later. Recent studies confirm that survivors face a heightened danger of heart problems or another bout with cancer. In a cruel twist, the youngest cancer patients often face the greatest risk.

Up to 5 percent of childhood-cancer survivors get second cancers. That's several times the cancer risk that people in the general population face, National Cancer Institute data show.

While some subsequent tumors are recurrences of the primary cancer, many are new tumors biologically unrelated to the first one. Such a change suggests to scientists that either a child's original treatment contributed to the second cancer or that the person had a genetic predisposition that led to cancer twice.

The newly recognized dangers are the flip side of progress, says Elaine Ron, an epidemiologist at the National Cancer Institute in Bethesda, Md. "We wouldn't be worried about second cancers if we hadn't been so successful with the first ones," she says.

REAL RISKS A recent study revealed that survivors of the cancer called Hodgkin's disease, diagnosed between 1967 and 2000, subsequently had at least twice the incidence of deaths from heart attack as other people had. Children and teens treated for the cancer had 19 times the rate of deadly heart attack later in life that their contemporaries did, epidemiologist Anthony J. Swerdlow of the Institute of Cancer Research in Sutton, England, and his colleagues report in the Feb. 7 *Journal of the National Cancer Institute* (*JNCI*).

The incidence of heart attacks in survivors of the childhood cancer is still much lower than that of a general population of elderly people, but the findings raise concerns about the cancer treatments, says Swerdlow.

The chance of developing a cancer called a sarcoma within a decade of a childhood cancer is nine times as great among survivors as in other people, pediatric oncologist Tara O. Henderson of the University of Chicago School of Medicine and her colleagues report in the Feb. 21 *JNCI*. Sarcomas are cancers of muscle, bone, and tissues surrounding nerves. No screening test exists for these cancers. Doctors often find them when a patient reports having pain or an unusual mass, says Henderson.

"The only way to screen for sarcomas is for the clinician to have a high index of suspicion," she says. The new study may make doctors especially attentive to survivors of childhood cancers.

Unusually high numbers of brain tumors crop up in survivors of childhood cancers, particularly leukemia. A recent study showed that people who had had childhood cancers experience brain tumors called gliomas within the next decade at a rate nine times the population average. Pediatric oncologist Joseph P. Neglia and his team the University of Minnesota in Minneapolis described those findings in the Nov. 1, 2006 *JNCI*.

WHAT'S THE PROBLEM? Radiation therapy stands out as the leading culprit in heart problems and second cancers. Past work showed that radiation therapy of the chest may damage coronary arteries, which increases the risk of heart problems.

In the studies of sarcomas and brain tumors, survivors who got radiation were three and seven times, respectively, as likely to develop second cancers as were other survivors who didn't get radiation.

Although radiation "is still incredibly important for treating pediatric cancers, it can cause a whole host of problems," says Kevin Oeffinger, a physician at the Memorial Sloan-Kettering Cancer Center in New York. Second cancers often appear in the radiation field, that part of the body getting irradiated.

> "We wouldn't be worried about second cancers if we hadn't been so successful with the first ones."
>
> — ELAINE RON, NATIONAL CANCER INSTITUTE

"Radiation is very good at breaking DNA strands," says radiobiologist David J. Brenner of the Columbia University Medical Center. That can stop cancer. Unfortunately, radiation "occasionally will mutate a gene that [normally] prevents a cell from overdividing," he says. "That's where radiation can be carcinogenic."

Over the past 2 decades, engineers and physicists have learned to focus therapeutic radiation into small beams, Brenner says. That enables doctors to boost the dosage while decreasing the size of the radiation field. While the higher doses cure more primary cancers, he says, only future studies will reveal whether the focused beams limit second-cancer risk.

Chemotherapy can also damage DNA. In the sarcoma study, chemotherapy that included high doses of anthracyclines or alkylating agents doubled the risk of having a second cancer, Henderson says. But research into the risks of chemotherapy in second cancers has lagged behind radiation studies, says Brenner.

Swerdlow's team attributed the increased heart attack risk in Hodgkin's disease survivors to both radiation and chemotherapy.

The role of genetics in second cancers remains murky. "We don't know [why] one child gets a secondary brain tumor and another, with almost identical treatment, doesn't," Neglia says. Genetic mutations reducing cells' production of enzymes needed to repair radiation damage might predispose a person to a second cancer, he says.

The good news is that the paradigm of childhood cancer has shifted, Henderson says. "A generation ago, pediatric cancer was almost a death sentence." Now, part of the challenge is to ensure that the cure carries as little risk as possible. ■

OF NOTE

PLANETARY SCIENCE

A crack at life

New images of ancient cracks on Mars suggest that liquid may have percolated through underground rock, providing a possible habitat for primitive life.

NASA's Mars Reconnaissance Orbiter, which carries the most powerful magnifying camera yet sent to the Red Planet, captured the images in September 2006 as it flew over a Martian canyon called Candor Chasma.

While analyzing the images, geologist Chris Okubo of the University of Arizona in Tucson and his colleagues noticed that faults and fractures appeared to be lighter in color than surrounding rock. That's an indication that the flow of a fluid made minerals leach from and react chemically with material along cracks, the team reported last month in San Francisco at the annual meeting of the American Association for the Advancement of Science.

ROCKY HABITAT? Light-colored areas of fractures in exposed rock at the Martian canyon Candor Chasma suggest the flow of fluid millions of years ago.

The researchers estimate that millions of years ago, the minerals were deposited about a kilometer underground. Signs of their activity became visible only after overlying layers of rock eroded.

If organisms arose within an underground water flow, the rock layers could have sheltered them from the harsh environment at the surface, Okubo says.

The data suggest new places to search for signs of past life on Mars, says Dave Des Marais of NASA's Ames Research Center in Mountain View, Calif. —R.C.

ENVIRONMENT

DNA pinpoints poached ivory tusks

Poaching of elephants in Africa has surged in recent years, driven by ivory prices that have more than quadrupled since 2004. Bans on killing elephants are difficult to enforce, partly because authorities don't often know where on the vast continent the poaching is happening.

Scientists had previously attempted using DNA analysis to trace the origins of confiscated tusks, but the information was too imprecise to aid law enforcement. Now, scientists have demonstrated that they can trace the ivory to a single country.

In 2002, police seized more than 6.5 tons of illegal ivory in Singapore. Interpol, an organization that coordinates international police forces, asked Samuel K. Wasser of the University of Washington in Seattle to investigate the source of the ivory.

Wasser and his colleagues adapted the existing technique to work for batches of ivory rather than for single tusks. They compared DNA from each of 37 seized tusks with that from the other samples.

The genetic similarities among the tusks suggested how far apart the elephants lived. When the researchers referred to a reference map of DNA taken from elephant tissue or dung at locations throughout central Africa, the new technique revealed that nearly all the poaching occurred in Zambia. The team confirmed the approach by testing fecal samples of known origin.

The researchers report their findings in the March 6 *Proceedings of the National Academy of Sciences*.

"We're pretty struck by how much better [the new technique] does," Wasser says. "When we showed that it all came from Zambia, it changed the entire scope of [Interpol's] investigation."

So far, though, the organized-crime network behind the poaching and illegal trade remains intact, Wasser says. —P.B.

ARCHAEOLOGY

Spicy finds from before Columbus

People living in areas extending from the Bahamas to southern Peru cultivated and consumed chili peppers at least 6,100 years ago, a new study finds. Only after Columbus' voyages to the New World did the spicy condiments reach other parts of the world, say Linda Perry of the Smithsonian Institution in Washington, D.C., and her colleagues.

Perry's team identified distinctively shaped microscopic starch grains from domesticated chili peppers on grinding stones, inside charred pots, and in sediment from seven ancient villages in Central and South America, as well as at a Bahamian settlement. Estimated radiocarbon ages for the sites range from 1,000 to 6,100 years.

Artifacts from each of the ancient New World locations also yielded starch grains from maize and root crops, including arrowroot and squash. Sophisticated agricultural practices and complex cuisines had begun to spread throughout the Americas before the introduction of pottery approximately 3,000 years ago, the scientists conclude in the Feb. 16 *Science*. —B.B.

PHYSIOLOGY

Body clock affects racing prowess

When it comes to athletic performance, everyone's a night owl, a new study suggests.

Shawn D. Youngstedt and his colleagues at the University of South Carolina in Columbia erased time-of-day cues in 25 trained collegiate swimmers by keeping them perpetually in low lighting for 2 days at the school's fitness center. Throughout the study, each athlete adhered to a short sleep-wake cycle: 1 hour of rest followed by 2 hours of sedentary activity. The starting time of the cycle differed among the participants.

Core body temperature, on average, ebbs near 5 a.m. The lowest daily temperature varied slightly throughout the test.

Once every 9 hours, each volunteer was instructed to swim a 200-meter freestyle race at peak speed. Start times varied between 2 a.m. and 11 p.m.

A swimmer typically racked up his or her worst time about 5 a.m., which was within a few hours of his or her daily body-temperature minimum, the researchers report in the February *Journal of Applied Physiology*. From then on, times improved—peaking at 11 p.m. Differences between an individual's performance extremes varied by almost 6 seconds and proved independent of whether the swimmer initially had been an early bird or a night owl, according to his or her previous sleep schedule, Youngstedt notes.

Although time-of-day effects might make little difference for well-rested athletes competing close to home, Youngstedt says that they could significantly handicap jet-lagged athletes performing in global competitions. In those instances, the Carolina team concludes, athletes might consider using tricks—such as exposure to bright light (*SN: 5/27/06, p. 330*)—to reset their body clocks to coordinate with competition times. —J.R.

UNIV. OF ARIZONA, JPL/NASA

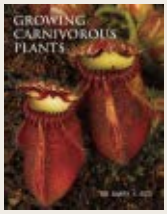
Books

A selection of new and notable books of scientific interest

GROWING CARNIVOROUS PLANTS

BARRY A. RICE

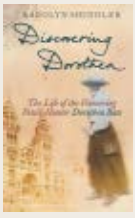
Among the plant world's most fascinating specimens are those that feed on animal flesh. For the more-adventurous gardener, Rice provides this comprehensive guide to growing carnivorous plants, from the well-known Venus flytrap to the group of plants bearing such imaginative names as the bellies of blood and ladies in waiting. Rice's introduction scrutinizes people's fascination with plant monsters, citing their occasional appearance in legend and cinema, and he reviews the carnivores' natural history. A chapter describes how carnivorous plants trap their prey. Section two of the book is an alphabetical list of carnivorous-plant genera. Each listing includes a description of the plants within that genus, their methods of reproduction, their food-trapping mechanisms, and their native ranges. Rice also includes guidelines for the cultivation of plant of each genus. Section three provides further advice for cultivation of these plants and tips for viewing them in the wild. ***Timber Press, 2006, 224 p., color images, hardcover, $39.95.***



DISCOVERING DOROTHEA: The Life of the Pioneering Fossil-Hunter Dorothea Bate

KAROLYN SHINDLER

One day in 1898, a young woman from South Kensington, England, did the unthinkable: She demanded a job as a scientist at the new Natural History Museum in London. Successful in that effort, Dorothea Bate set off to Cyprus on an arduous expedition to collect animal specimens. In her impressive career, she would put to use both her great intellect and her sense of adventure. Shindler, a producer and an editor for the BBC, tells the story of this remarkable but little-known paleontologist. During her expedition to Cyprus, Bate discovered and described the fossilized remains of such beasts as dwarf hippos and elephants. Further travels to Crete, Majorca, and Menorca yielded even more fossils for the museum and garnered Bate official recognition from the Royal Society. Drawing from Bate's extensive work diaries and papers at the museum, Shindler pieces together the picture of this woman's impressive 50-year association with the institution. ***HarperCollins, 2005, 390 p., b&w plates, hardcover, $45.00.***



IWOZ

STEVE WOZNIAK AND GINA SMITH

Thanks in large part to Steve Wozniak, computers that were once loud, room-size behemoths have been transformed into the desktop and portable tools that nearly everyone uses today. For the first time, Wozniak, with journalist Smith's aid, explains how he combined his talent for engineering with his humanistic spirit to create Apple Computer and the first personal computer. As a young man, Wozniak's self-described "geeky" interest in technology led him to create clubs of like-minded individuals, such as the Electronics Kids and Homebrew Computer Club. It was at this time that Wozniak developed his idea for what would become Apple 1, a television screen combined with a keyboard and a basic microprocessor. To expand his vision, Wozniak and his friend Steve Jobs formed the company Apple Computer. The rest is history, still in the making. Wozniak explains how his life's experiences—including a near-fatal plane crash, attending music festivals, and fatherhood—have fed his inventive spirit. ***W.W. Norton, 2006, 313 p., b&w plates, hardcover, $25.95.***

KENNEDY SPACE CENTER: Gateway to Space

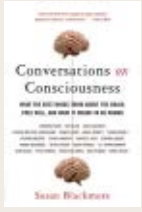
DAVID WEST REYNOLDS

Marshy Cape Canaveral, jutting into the Atlantic, has been the launching point for the dreams of scientists, astronauts, and ordinary citizens. In this first complete history of the Kennedy Space Center, Reynolds, an author of several space books, chronicles how the Truman administration selected the site and completes the story with accounts of a half-century's worth of missions begun there. Reynolds explains the entire process up to and including launch. In 1950, the cape launched its first rocket, which flew east over the Atlantic to avoid any threat to populated areas. Soon, pressure from the Soviets led to the pursuit of a human mission to space from the Cape. NASA initiated Project Mercury in 1958, and in 1961, Alan Shepard took off from the Florida site as the United States' first astronaut. Reynolds chronicles the Apollo moon missions and the development of the space shuttle, and he provides an overview of space missions still planned to launch from this historic site. ***Firefly, 2006, 248 p., color photos, hardcover, $40.00.***

CONVERSATIONS ON CONSCIOUSNESS

SUSAN BLACKMORE

Consciousness. Where does it come from? Is it somehow separate from the human brain? Can the brain itself comprehend it? Inspired by a conference on consciousness in 2000, Blackmore, a lecturer in psychology at the University of the West of England, poses these and other intriguing questions to some of the top thinkers in philosophy and brain studies. In each interview, the author gets to the heart of the struggle to explain subjective experience in objective, scientific terms. Francis Crick, Daniel Dennett, John Searle, David Chalmers, and others describe the ideas behind their assertions about and study of consciousness, including free will, the separation of mind and body, artificial intelligence, and conscious versus unconscious experience. ***Oxford, 2006, 274 p., b&w illus., paperback, $15.95.***



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LETTERS

Cosmic cling

At least on Earth, rock impacts result in charging of the particles ("Rocky Finding: Evidence of extrasolar asteroid belt," *SN: 1/6/07, p. 5*). In space, wouldn't this have a great effect on the motion of the rocks?

STUART HOENIG, TUCSON, ARIZ.

According to researchers, it's true that the electrostatic charging of space dust and rocks may affect the motions of small particles. However, little is known about the influence of this on dust clumping or on the formation of molecular hydrogen. —R. COWEN

Double dose?

Regarding "Folic Acid Dilemma: One vitamin may impair cognition if another is lacking" (*SN: 1/13/07, p.19*), would it be feasible for the government to require both folate and vitamin B_{12} in grain products?

NANCY POWER, ALTADENA, CALIF.

Researchers say that such double fortification is theoretically possible. However, vitamin B_{12} is more expensive than folate, and it turns flour pink. —B. HARDER

Watch your fingers

Regarding "Digital Fingerprints: Tiny behavioral differences can reveal your identity online," *SN: 1/13/07, p. 26*), Morse code "fist" analysis can easily be defeated by a software buffer that conforms the intervals between all types of strokes. Actual Morse buffers are already in regular use among ham operators. "Writeprints" can also be defeated. "Clickprints" aren't as easy to conceal, perhaps, but some clever software designer will devise a foil for them too.

PAUL SCHLUETER III, DALLAS, PA.

Half empty

Although "almost half" of the individuals came to agree that coerced eating-disorders treatment was justified, I find it irresponsible that the study seemingly ignored the identification of potentially long-lasting negative effects on more than half of coerced clients ("Starved for Assistance: Coercion finds a place in the treatment of two eating disorders," *SN: 1/20/07 p. 38*). Those people may come away with less hope that such treatment can ever be of help to them.

ROBERT C. JOHNSON, BEND, ORE.

Correction *"Suburb of Stonehenge: Ritual village found near famed rock site"* (SN: 2/3/07, p. 67) *referred to unearthed houses measuring "16 square feet" but should have described them as 16 feet by 16 feet.*

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