SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

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she-bee he-bees

artificial intelligence takes off

dyslexia genetics

possible plastic transistors

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approaching infinity

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AUGUST 30, 2003 VOL. 164, NO. 9

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Of Note

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Cover For mathematicians, there are many infinities, and some infinities are larger than others. A new approach may shed light on a long-standing question, known as the continuum hypothesis, about infinite sets of numbers. Artist Helaman Ferguson presents his own visualization of an infinite set in his work "Hyperbolic 5." (Helaman Ferguson) Page 139

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Hyperbolic 5 For more information about the Helaman Ferguson artwork featured on this week's cover, see Ivars Peterson's MathTrek.

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Dyslexia's DNA Clue

Gene takes stage in learning disorder

For the first time, scientists have identified a gene that appears to influence the development of at least some cases of dyslexia.

This learning disorder is characterized by difficulties in perceiving sounds within words, spelling and reading problems, and troubles with written and oral expression. It's estimated that dyslexia affects at least 1 in 25 people. Although scientists are investigating dyslexia's suspected neural roots (*SN: 5/24/03, p. 324*), the condition's causes remain unknown.

If confirmed in further studies, the new genetic finding represents a major step forward for dyslexia researchers. Until now, investigators have only been able to link dyslexia to alterations along stretches of DNA containing tens or hundreds of genes. The most prominent of these genetic segments are located on chromosomes 6 and 15.

A team led by geneticist Juha Kere of the Karolinska Institute in Huddinge, Sweden, narrowed the search to a gene called *DYXC1* on chromosome 15. Two disruptions of this gene substantially raise the odds of developing dyslexia, the scientists report in an upcoming *Proceedings of the National Academy of Sciences*.

"Certainly, there are other genes involved in dyslexia," Kere says. Even so, he adds, "our research may [eventually] help doctors to diagnose dyslexia more accurately."

He and his colleagues first determined that a break had occurred at a specific location on the *DYXC1* gene in the three dyslexic members of a Finnish family—the father and two daughters—as well as in a son without the condition. Molecular analyses indicated that the genetic break prevented the production of the protein encoded by the *DYXC1* gene.

The researchers then probed the same gene in 109 children and adults diagnosed with dyslexia and in 195 others who had no learning disorder. The previously observed *DYXC1* break appeared in nearly 9 percent of those with dyslexia, compared with fewer than 3 percent of the comparison group.

Another *DYXC1* disruption, which yields an altered version of the gene's protein, occurred in about 12 percent of the dyslexic group, compared with roughly 5 percent of the others.

Evidence of the gene's activity appears in the brain, the scientists say. Their analyses of preserved human brains indicate that only certain brain cells respond to the DYXC1 protein. The neural function of the protein remains unknown, Kere says.

The DYXC1 protein's molecular makeup in people differs to a surprising extent from that of corresponding proteins in chimpanzees and other apes, Kere notes. "This gene may reveal important evolutionary differences in how our brains and those of other primates work," he says.

Geneticist Shelley D. Smith of the University of Nebraska Medical Center in Omaha calls the new report "a really neat finding." The challenge is to confirm the results in larger samples of people with dyslexia and then determine how the gene and its protein work, Smith says.

Her team is looking for genetic alterations on chromosome 6 that influence dyslexia.

Further work needs to establish whether the *DYXC1* gene influences other developmental disorders, such as speech problems and attention-deficit hyperactivity disorder, adds psychologist and geneticist Elena L. Grigorenko of Yale University, in a comment slated to appear with the new report. Still, Grigorenko dubs Kere's study "an exciting beginning of a new stage of research into genetic pathways of dyslexia." —B. BOWER

Long Ride West

Many western sediments came from Appalachians

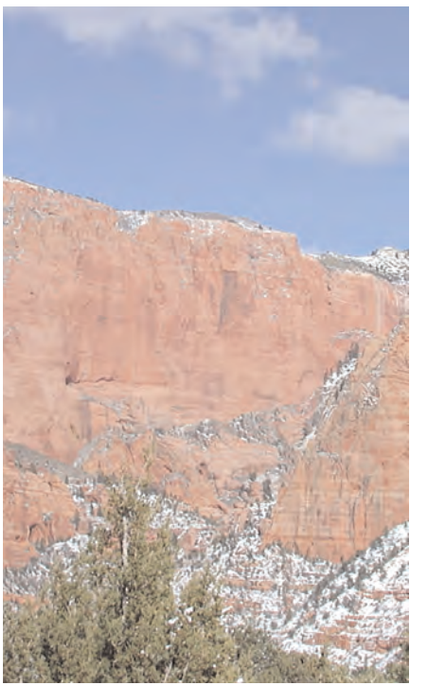
North America may once have hosted a continent-crossing river system as grand as today's Amazon, two new studies suggest. That notion is bolstered by the discovery that material in several thick layers of sandstone in the western United States originated in the Appalachians.

About 190 million years ago, what is now southwestern Utah was covered with sand dunes. The so-called Navajo Sandstone of today is the preserved remnant of dunes that covered as many as 660,000 square kilometers, an area almost the size of Texas. In some Utah locations, that rock formation is up to 750 meters thick.

Scientists have long debated where all that sand came from, says Peter W. Reiners, a geochemist at Yale University. In an effort to end the debate, he and his colleagues used two radioactive dating techniques on small mineral grains called zircons that they harvested from the sandstone. First, the researchers zapped a zircon with a laser and chemically parsed the vapor to estimate when the mineral crystallized. Then, they analyzed what was left of the mineral grain to determine when in the past the zircon had cooled below 180°C, the temperature at which a zircon starts trapping the helium being produced by the radioactive decay of other atoms. Rocks cool below that temperature as they approach Earth's surface during episodes of mountain growth.

The researchers found that about two-thirds of the zircons they analyzed had cooled between 400 million and 250 million years ago. Of that fraction, most had originally crystallized between 1.2 billion and 950 million years ago. Those periods correspond with the uplift of the Appalachians and the formation of the rocks from which they grew. Because no other large-scale mountain growth took place on the continent during that time, it's a safe bet that most of those zircons came from the Appalachians, Reiners asserts. He and his colleagues report their findings in the September *Geology*.

If this conclusion is correct, the Appalachian zircons took a long, circuitous route to reach Utah. After eroding from exposed rocks, the zircons—and presumably many of the sandstone's other mineral grains—were carried to a region north and



M. BRANDON

CHANGES IN LONGITUDE **Many zircons in some of southern Utah's sandstone (cliffs in background) eroded from the Appalachians of eastern North America.**

northwest of Utah. The pattern of ripple marks and other features locked in southwestern Utah's sandstone indicates that the mineral grains had been blown in from those directions.

The most likely transportation system across the continent, says Reiners, would have been a river system capable of moving massive amounts of sediment.

Similar analyses of sandstone at several western sites back this scenario. In a study to be published in an upcoming *Sedimentary Geology*, William R. Dickinson and George E. Gehrels of the University of Arizona in Tucson report that about half the zircons they analyzed came from the Appalachians, and about one-fourth had eroded from ancient rocks in central Canada. "We didn't expect that many of [these zircons] would have come from so far away," Dickinson says. The team's research suggests that a westward-flowing transcontinental river system was in place several times between 275 million and 150 million years ago. —S. PERKINS

Black Hole Life Preserver

Don't get sucked in without one

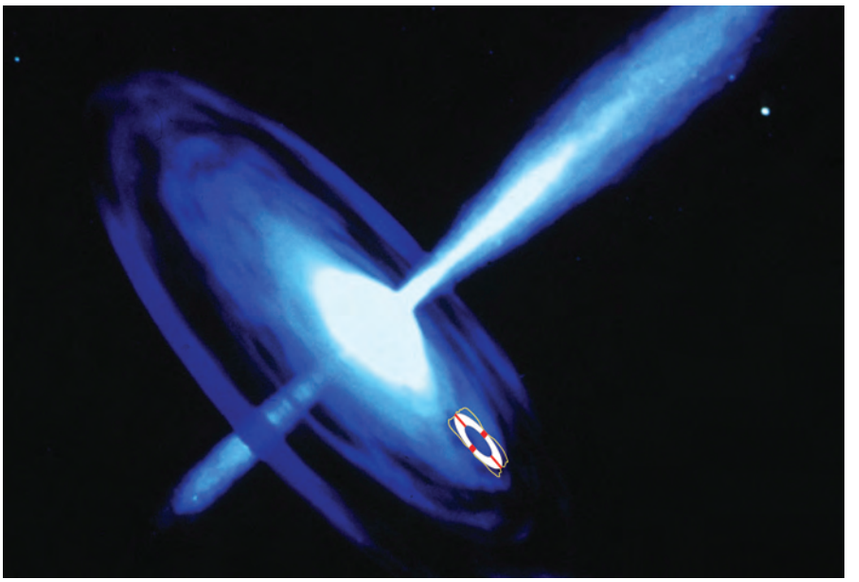
As anyone falling into a black hole would tell you—if only they could—the trip ends badly.

Actually, for all but the last moment, things would be fine. As you began approaching the great abyss, you'd be in free fall, experiencing weightlessness. But as you got very close or ventured inside the hole, watch out.

If you fell in feet first, the hole would pull harder on your toes than your head, because the top of your body would lie farther from the hole's center. Similarly, the uneven tug exerted by the hole would compress your shoulders as though they were in a vise. Because of these differences in gravity, you'd be simultaneously ripped apart vertically and squeezed horizontally. From the instant these tidal forces became too much to bear, death would occur in just under a tenth of a second.

Although death is unavoidable, is there any way to delay it and shorten the agony?

According to two researchers who actually took the time to contemplate the problem, the answer is yes. But you have to take along the right equipment, assert Princeton University cosmologist J. Richard Gott and Deborah L. Freedman of Harvard University. The essential item resembles a life preserver—a thin ring massive enough to counteract the black hole's tidal forces. The ring would have to be as heavy as a large asteroid and could be as large as one of the rings of Saturn, says Gott. The researchers have posted their whimsical analysis online (*http://xxx.lanl.gov/abs/astro-ph/0308325*).



LIFE PROLONGER A "life preserver" of charged matter would allow an object to venture further inside a black hole than otherwise possible before being ripped apart.

Kept at waist level, the ring would exert an upward tug on your feet and a downward pull on your head, counterbalancing the black hole's uneven tug on different parts of your body. As the traveler approached the black hole and the tidal forces from it increased, the ring would shrink and exert correspondingly larger countertidal forces. The massive ring would have to be electrically charged to keep it from collapsing.

The ring counters the black hole's tidal forces up to a whopping 6,760 g's—676 times the gravity a human body can withstand. That would give a black hole diver an extra 0.09 second to remain in one piece. It also means that tidal forces would begin to overwhelm the explorer only during the last 0.00346 second of the journey, a time so short "you'd never know what hit you," says Gott.

The notion that it's possible to even temporarily prevent tidal dismemberment of any object that gets too close to a black hole is "something no one had shown before," says Freedman.

This intellectual exercise could have a practical application. In venturing near a dense star called a neutron star, or touring the outskirts of a small black hole, such a life preserver would enable a space traveler to "venture closer than would otherwise have been the case and still return safely home from the adventure," the researchers note.

"This idea could make a nice problem in a textbook . . . but will not have much wider implications," says Avi Loeb of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass. —R. COWEN

To Bee He or She

Honeybees use novel sex-setting switch

After more than a decade of searching, an international team of scientists has found the main gene that separates the girls from the boys among honeybees.

Called *csd*, it's the first sex-determining switch sequenced in an animal in which females typically grow from fertilized eggs and males from unfertilized eggs, according to Robert Page Jr. of the University of California, Davis. Called haplodiploidy, this arrangement governs sex determination in some 20 percent of animals, including ants, bees, thrips, white flies, ticks, and mites.

The *csd* gene has many versions, and a honeybee's gender depends on whether it inherits only one version or two different ones, the researchers report in the Aug. 22 *Cell*.

Another investigator of honeybee genetics, Ross Crozier of James Cook University in Townsville, Australia, says that bee researchers have been searching for a sex-switch gene such as *csd* for years. "We're disappointed that we didn't get it, but—

D. BERRY/STSCI, S. NORCROSS

congratulations—it's really wonderful that it's been done," Crozier says.

He points out that this match-mismatch system of *csd* differs fundamentally from the few other sex-determination systems decoded so far. He predicts the new gene will spark some interesting new investigations into the genetics underlying sex, as well as help for the notoriously difficult task of breeding honeybee varieties.

The rough hypothesis for how the genetic switch works goes back to attempts to inbreed honeybees. During these attempts, under artificial conditions, researchers found that sterile males arose from fertilized eggs. In a hive, those larvae usually don't mature because the female bees quickly detect and eat them. Geneticists in the mid-20th century proposed that one gene determines sex. If a bee receives only one version of that gene—as an unfertilized egg does—or if inbreeding provides identical copies from mom and dad, then junior ends up a male. However, if a bee inherits different versions of that gene from mom and dad, she's female.

Page says that by the late 1980s, advancing genetic technologies inspired him, his lab colleagues, and Martin Beye, now of Martin Luther University in Halle, Germany, to start chasing the proposed gene. Together, the researchers found markers defining the area of the gene on a specific bee chromosome and then painstakingly mapped the area in increasing detail to reveal *csd*. The researchers speculate that two versions of the gene's product—two versions of the same protein—bind together to start female development.

To confirm that the gene's protein products are involved in gender determination, the U.S.–German team joined Stig Omholt of the Agricultural University of Norway in Ås to construct RNA that interferes with the activity of a specific version of the gene. When they injected the RNA into fertilized eggs and this version of *csd* ceased working effectively, the lone functioning version made the bee a male. —S. MILIUS

USDA; ANGEWANDTE CHEMIE INTNL ED

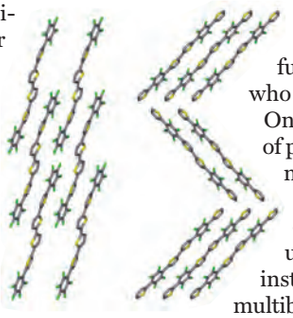
WHY HER? The gene that throws the switch to make a honeybee embryo female or male has been found and sequenced.

Plastic Chips

New materials boost organic electronics

Over the past decade, research groups in academia and industry have been racing to fabricate electronic devices—integrated circuits, displays for handheld computers, and solar cells—not from silicon but from semiconducting polymers (*SN: 5/17/03, p. 312*). Components made from such organic materials could be flexible, as well as cheaper and easier to manufacture than their silicon counterparts.

Now researchers at Northwestern University in Evanston, Ill., and Lucent Technologies in Murray Hill, N.J., have devised a new class of organic semiconductor materials that could hasten the arrival of what could be the electronics revolution's next big wave.



BUILDING BLOCKS A new class of organic molecules yields both n-type (left) and p-type (right) semiconductors for plastic electronic devices.

Until recently, the fabrication of plastic electronics has been limited by the number of molecular building blocks suitable for making semiconducting polymers. Transistors—which are the switches in an integrated circuit—require two types of semiconductor materials: n-type and p-type. In n-type materials, charge flows through the material via electrons. P-type materials transport charge through "holes," places where electrons are missing.

"Yet, most of the organic materials examined so far have all been p-type," says lead investigator Tobin Marks at Northwestern. Existing n-type organics are rare and unstable. "So there's a real need for n-type materials," he says.

His team's new class of molecules assembles into semiconductors of both p- and n-type. A rod-shaped organic molecule made of six thiophene units forms the basis for each type of material. Each thiophene, in turn, is a ring of five carbons and one sulfur. When the researchers replaced the rod's two end thiophenes with a perfluoroarene group (a ring of six carbons decorated with fluorines), the organic molecule behaved like an n-type semiconductor. When the researchers instead replaced the next two thiophenes from the ends, the molecule behaved as a p-type semiconductor.

The researchers describe their molecular constructions in the Aug. 25 *Angewandte Chemie International Edition*.

"It turns out, the way we move the perfluoroarenes around also allows us to control the packing between the molecules," says Marks. The closer the molecules are to each other, the faster a charge can hop from one molecule to another in either type of semiconductor.

So far, the team has fabricated prototype transistors from the materials, which performed just as well as existing organic semiconductors do, as measured by the mobility of the electrons and holes. But Marks says his lab expects to increase the n-type material's electron mobility by at least a factor of 5, an advance that would boost the switching speed of the material.

The pantry of organic materials for making n-type semiconductors has been particularly sparse, says Ananth Dodabalapur of the University of Texas at Austin. "This will be very useful for people like myself who make organic circuits."

One of the biggest appeals of plastic electronics is that manufacturers could spray liquid polymer circuits onto a surface using ink-jet printers, instead of resorting to the multibillion-dollar fabrication equipment used to etch circuitry on silicon wafers.

Marks predicts that low-cost, even disposable plastic electronic devices, such as smart cards, electronic tags for tracking inventory, and chemical sensors, will emerge in the next couple of years. —A. GOHO

Better Bones

Women benefit from low dose of estrogen

Even as evidence accumulates that hormone-replacement therapy increases the risk of breast cancer and heart attack, stroke, and other vascular problems, one benefit of giving estrogen to older women has remained untainted: bone preservation.

Scientists now report that even a tiny dose of estrogen can boost bone density in elderly women significantly better than no dose at all. Moreover, the small dose apparently doesn't cause an increase in the kinds of adverse effects that have driven women away from hormone therapy. On the other hand, aside from fewer headaches, this dose of estrogen didn't

provide relief from postmenopausal symptoms, such as bloating and breast tenderness. The new findings appear in the Aug. 27 *Journal of the American Medical Association*.

The researchers enlisted 167 healthy women over age 65 and randomly assigned 83 of them to get a pill containing one-quarter the typical dose of estrogen and 84 to receive an inert pill. All participants also took vitamin D and calcium daily.

In addition, except for women who had previously undergone a hysterectomy, the study volunteers received the female hormone progesterone for 2 weeks every 6 months. Although this results in a dose of progesterone considerably smaller than that typically given in combined progesterone-estrogen therapy, it prevented the abnormal thickening of the uterine lining that can arise from estrogen-only therapy, says Karen M. Prestwood of the University of Connecticut Health Center in Farmington.

Over 3 years, the women getting the inert pill had a 1 percent increase in bone density, while women taking estrogen averaged a 2.3 percent increase, a significant difference.

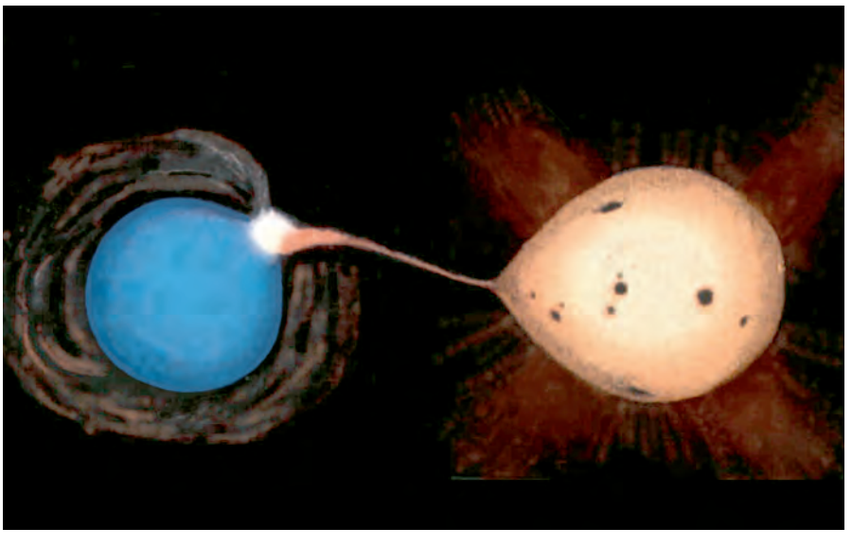
Blood and urine samples revealed that the women on estrogen had lower amounts of two chemicals associated with bone degradation.

Meanwhile, adverse effects from the estrogen therapy were minimal over the 3 years. For example, the women receiving the hormone and those receiving the inert pills had roughly the same incidence of abnormal mammograms.

"There's been a wave of discontinuation of estrogen [therapy] across the country," says Robert P. Heaney of Creighton University in Omaha, Neb. These and other findings may cast the hormone in a new light, he says. "I'm quite sure the pendulum is going to swing back."

Heaney suspects that taking estrogen orally is part of the problem. Whereas naturally produced estrogen spreads gradually throughout the body, a pill produces a hormone surge that has strong effects on the liver. The surge might induce the organ to make blood-coagulation factors, he says, which contribute to vessel blockages, heart attack, and stroke. Estrogen delivered by a skin patch largely bypasses the liver, Heaney says. In the Aug. 9 *Lancet*, French scientists report that postmenopausal women taking estrogen by patch have less clogging in their veins than those taking the hormone orally do.

Oral estrogen also seems to enhance the liver's synthesis of C-reactive protein, a compound implicated in heart disease, Prestwood says. Further tests should investigate ultralow-dose estrogen delivered by patch and should compare bone-fracture rates in women on estrogen versus those on a placebo, she says. —N. SEPPA



TWO TO TANGO In this artist's rendition, gravity keeps a pair of stars in orbit around each other so closely that the hot blue star pulls gas from its cooler orange companion.

Stellar Tantrums

Tracking the flaring cycles of other stars

During each iteration of its fierce and familiar 11-year cycle of activity, the turbulent surface of the sun reaches a crescendo, shooting jets of scalding gas and magnetic energy into space at a markedly increased rate. For the first time, astronomers have made continuous, long-term observations of such flare activity on stars outside the solar system, and they've found that the stars have cycles of activity and quiescence similar to those of the sun.

At the National Radio Astronomy Observatory in Green Bank, W. Va., Mercedes Richards and her colleagues from Pennsylvania State University in State College recorded radio waves from flares spewing from two nearby star systems, Beta Persei and V711 Tauri. Both include binary pairs—two stars orbiting one another. These systems are close by, which makes them easy to observe, and they're known to have strong flaring activity. With observations made up to six times a day for 5 years, the team built up a far more comprehensive picture of the stars' behavior patterns than previous studies had.

In an upcoming *Astrophysical Journal*, the astronomers report heightened flare activity in the two star systems every 50 to 120 days. Moreover, Richards suspects that a broader pattern of activity and quiescence might be at work in Beta Persei and V711 Tauri. In both cases, the overall cycle seems to be about 500 days long.

The orbiting pair in Beta Persei consists of a star that is a younger version of our sun, along with a hotter companion. In the V711 Tauri orbiting pair, both stars resemble a young sun. Because the paired stars in each system tug on one another, the magnetic fields that drive flare activity are more complex than they are for individual stars.

"When two stars are next to each other, the tidal forces on them are very significant, so that changes the internal dynamics of the stars," comments Craig DeForest, a solar physicist at the Southwest Research Institute in Boulder, Colo. For one thing, the proximity causes the stars to spin more quickly: The sunlike stars in Beta Persei and V711 Tauri are spinning 10 times as fast as the sun. This means that compared with the sun, they have a more powerful magnetic field and are 10 times more active.

"It's exactly the way we expect the sun behaved when it was younger" and spinning faster, Richards says. "It was flaring far more often."

With this in mind, DeForest says that rather than provide a window into the sun's present or future, the new study can help illuminate the sun's past, perhaps even at a time when the first molecular glimmers of life on Earth were emerging. Says DeForest: "Studying the patterns of flares around these newer stars could conceivably help us understand more about the conditions under which life evolved on Earth." —S. MCDONAGH

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MIND-EXPANDING MACHINES

Artificial intelligence meets good old-fashioned human thought

BY BRUCE BOWER

When Kenneth M. Ford considers the future of artificial intelligence, he doesn't envision legions of cunning robots running the world. Nor does he have high hopes for other much-touted AI prospects—among them, machines with the mental moxie to ponder their own existence and tiny computer-linked devices implanted in people's bodies. When Ford thinks of the future of artificial intelligence, two words come to his mind: cognitive prostheses.

It's not a term that trips off the tongue. However, the concept behind the words inspires the work of the more than 50 scientists affiliated with the Institute for Human and Machine Cognition (IHMC) that Ford directs at the University of West Florida in Pensacola. In short, a cognitive prosthesis is a computational tool that amplifies or extends a person's thought and perception, much as eyeglasses are prostheses that improve vision. The difference, says Ford, is that a cognitive prosthesis magnifies strengths in human intellect rather than corrects presumed deficiencies in it. Cognitive prostheses, therefore, are more like binoculars than eyeglasses.

IN PLANE VIEW — A typical cockpit setup, left, contrasts with that of the OZ system, right. OZ combines data from dials and gauges into a visual depiction of the aircraft and external conditions. Here, the aircraft approaches a runway, represented by three green dots.

Current IHMC projects include an airplane-cockpit display that shows critical information in a visually intuitive format rather than on standard gauges; software that enables people to construct maps of what's known about various topics, for use in teaching, business, and Web site design; and a computer system that identifies people's daily behavior patterns as they go about their jobs and simulates ways to organize those practices more effectively.

Such efforts, part of a wider discipline called human-centered computing, attempt to mold computer systems to accommodate how humans behave rather than build computers to which people have to adapt. Human-centered projects bear little relationship to the traditional goal of artificial intelligence—to create machines that think as people do.

As a nontraditional AI scientist, Ford dismisses the influential Turing Test as a guiding principle for AI research. Named for mathematician Alan M. Turing, the 53-year-old test declares that machine intelligence will be achieved only when a computer behaves or interacts so much like a person that it's impossible to tell the difference.

Not only does this test rely on a judge's subjective impressions of what it means to be intelligent, but it fails to account for weaker, different, or even stronger forms of intelligence than those deemed human, Ford asserts.

Just as it proved too difficult for early flight enthusiasts to discover the principles of aerodynamics by trying to build aircraft modeled on bird wings, Ford argues, it may be too hard to unravel the computational principles of intelligence by trying to build computers modeled on the processes of human thought.

That's a controversial stand in the artificial intelligence community. Although stung by criticism of their failure to create the insightful computers envisioned by the field's founders nearly 50 years ago, investigators have seen their computational advances adapted to a variety of uses. These range from Internet search engines and video games to cinematic special effects and decision-making systems in medicine and the military. And regardless of skeptics, such as Ford, many researchers now have their sights set on building robots that pass the Turing Test with flying colors.

"I'm skeptical of people who are skeptical" of AI research, says Rodney Brooks, who directs the Massachusetts Institute of Technology's artificial intelligence laboratory. He heads a "hard-core AI" venture aimed at creating intelligent, socially adept robots with emotionally expressive faces. Brooks also participates in a human-centered project focused on building voice-controlled, handheld computers connected to larger systems. The goal is for people to effectively tell the portable devices to retrieve information, set up business meetings, and conduct myriad other activities (*SN: 5/3/03, p. 279*).

Cognitive prostheses represent a more active, mind-expanding approach to human-centered computing than Brooks' project does, Ford argues. "This line of work will help us formulate what we really want from computers and what roles we wish to retain for ourselves," he says.

FLIGHT VISION In the land of OZ, which lies entirely within a cockpit mock-up at IHMC, aircraft pilots simulate flight with unaccustomed ease because they see their surroundings in a new light.

IHMC's David L. Still has directed work on the OZ cockpit-display system over the past decade. The movie-inspired name comes from early tests in which researchers stood behind a large screen to run demonstrations for visitors, much as the cinematic Wizard of Oz controlled a fearsome display from behind a curtain.

For its part, Still's creation taps into the wizardry of the human visual system. In a single image spread across a standard computer screen, OZ shows all the information needed to control an

STILL

aircraft. An OZ display taps into both a person's central and peripheral vision. The pilot's eyes need not move from one gauge to another, says Still.

A former U.S. Navy optometrist who flies private planes, Still participated in research a decade ago that demonstrated people's capacity to detect far more detail in peripheral vision than had been assumed.

"OZ decreases the time it takes for a pilot to understand what the aircraft is doing from several seconds to a fraction of a second," Still says. That's a world of difference to pilots of combat aircraft and to any pilot dealing with a complex or emergency situation.

The system computes key information about the state of the aircraft for immediate visual inspection. The data on the six or more gauges in traditional cockpits are translated by OZ software into a single image with two main elements. On a dark background, a pilot sees a "star field," lines of bright dots that by their spacing provide pitch, roll, altitude, and drift information. A schematic diagram of an airplane's wings and nose appears within the star field and conveys updates on how to handle the craft, such as providing flight path options and specifying the amount of engine power needed for each option. Other colored dots and lines deliver additional data used in controlling the aircraft.

In standard training, pilots learn less-intuitive rules of thumb for estimating the proper relationship of airspeed, lift, drag, and attitude from separate gauges and dials. With the OZ system, a pilot need only keep certain lines aligned on the display to maintain the correct relationship.

Because OZ spreads simple lines and shapes across the visual field, pilots could still read the display even if their vision suddenly blurred or if bright lights from, say, exploding antiaircraft flak, temporarily dulled their central vision or left blind spots.

Experienced pilots quickly take a shine to OZ, Still says. In his most recent study, 27 military flight instructors who received several hours training on OZ reported that they liked the system better than standard cockpit displays and found it easier to use. In desktop flight simulations, the pilots maintained superior control over altitude, heading, and airspeed using OZ versus traditional gauges.

OZ provides "a great example" of a human-centered display organized around what the user needs to know, remarks Mica Endsley, an industrial engineer and president of SA Technologies in Marietta, Ga. The company's primary service is to help clients in aviation and other industries improve how they use computer systems.

If all goes well, OZ will undergo further testing with veteran pilots as well as with individuals receiving their initial flight training. The system will then be installed in an aircraft for test flights.

WHAT A CONCEPT In an age of information overload, it would be nice for people to have a simple, concise way to tease out the information they really want from, say, the World Wide Web. Today's search engines usually drag along a vast amount of irrelevant data, says Alberto Canas, IHMC's associate director.

Enter concept maps.

Concept-mapping software developed by Canas and his colleagues provides a way for people to portray, share, and elaborate on what they know about a particular subject. Concept maps consist of nodes—boxes or circles with verbal labels—connected by lines with brief descriptions of relationships between pairs of nodes. Clicking on icons that appear below the nodes opens related concept maps or a link to a relevant Web site.

For instance, scientists at NASA's Center for Mars Exploration created a Mars concept map. A red box at the top contains the words "Exploring Mars" and connects to boxes arrayed below it, with labels such as "Search for Evidence of Life" and "Human Missions." Icons positioned below the boxes link to a variety of Mars-related Web sites.

A concept-map maker needs to possess a thorough grasp of his or her subject, says Canas. Such a map draws connections between essential principles in a particular realm of knowledge. IHMC researcher Joseph Novak invented a paper-and-pencil version of concept maps nearly 30 years ago.

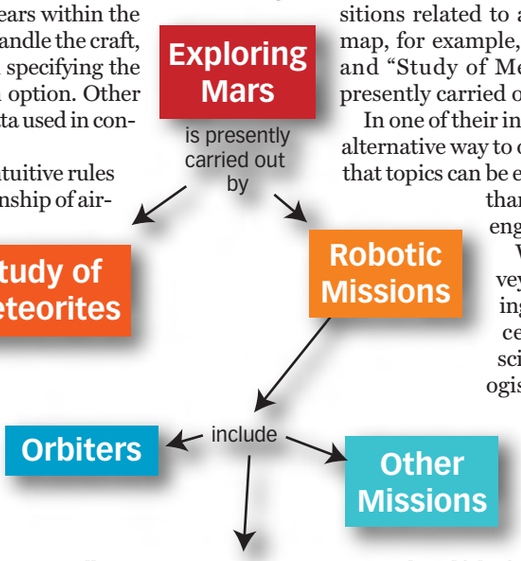
These tools aren't just jazzed-up outlines of topics within a story. In a concept map, nodes contain nouns and the connecting lines are associated with verbs, thus forming a web of propositions related to a central idea. In the Mars concept map, for example, the line between "Exploring Mars" and "Study of Meteorites" brackets the phrase "is presently carried out by."

In one of their incarnations, concept maps provide an alternative way to organize information on Web sites so that topics can be explored quickly and efficiently rather than through haphazard hunts on search engines, Canas notes.

With this technology, people can convey their expert knowledge and reasoning strategies to others. In one case, concept maps developed by IHMC scientists working with Navy meteorologists plumb the knowledge of experienced Gulf Coast weather forecasters and are now used to train new Navy forecasters.

Perhaps the greatest potential for concept maps lies in education. Elementary and high school students in a handful of countries now use a software system developed at IHMC to build their own concept maps about academic topics and then share them over the Internet with distant classes. The computer system ferrets out and displays related claims from different maps. It also poses questions to provoke further thought about the topic. Students then critique each other's maps and, if necessary, revise them.

"It's hard work to learn enough to build a good concept map," Canas says, "but it leads to far more understanding about a topic than simply memorizing information, as so often happens."



LINES ON MARS — The boxes and lines on concept maps, such as this section of a NASA concept map on Mars exploration, form simple sentences. General concepts appear in boxes at the top and connect to progressively more specific concepts in lower boxes.

NASA

BRAHMS AT WORK In the workplace, computers are virtuosos of information storage. However, a computer system known as Brahms sings a different tune. It discerns revealing patterns in people's work behaviors and simulates ways to get their jobs done more effectively.

The Brahms system illuminates the informal practices and collaborations that occur during the workday, according to IHMC computer scientist William J. Clancey. "A Brahms model is a kind of theatrical play intended to provoke conversation and stimulate insights in groups seeking to analyze or redesign their work," he says.

Clancey and other scientists began working on Brahms in 1993. The system builds on social science theories that regard each person's behaviors as being structured by broad pursuits, which researchers often call activities. In an office, common activities

include coffee meetings with a supervisor, reading mail, taking a break, and answering phone messages. Activities provide a forum for addressing specific job tasks. A morning coffee meeting, for example, may determine who will make an important sales call later in the day.

Brahms creates a computerized cartoon of how a work group's members perform their activities and tasks. The system's software is based on simulations of interactions among virtual individuals.

Brahms got its first tryout with workers at a New York telecommunications firm in 1995. Since then, Clancey has imported the system to NASA, where he helps six-person crews practice for future Mars-exploration missions. Brahms portrays how a crew's members go about their daily business so that mission-support planners can evaluate the procedures for critical activities, such as maintaining automated life-support systems and conducting scientific experiments.

After a crew in training spent 12 days in 2002 working out of a research station in the Utah desert, Brahms translated extensive data on crew behavior into a portrayal of how each person divvied up his or her time and moved from one place to another during each day. Ensuing simulations indicated that simple scheduling changes—eating lunch and dinner at slightly earlier times and eliminating afternoon crew meetings—would markedly boost the time available for scientific work and other critical duties.

Brahms remains a work in progress, Clancey notes. He wants to use the system to study how pairs of scientists on the Mars crews collaboratively adjust their plans in the field as they make unexpected discoveries.

David Woods of Ohio State University in Columbus welcomes that prospect. Traditional artificial intelligence programs treat plans as rigid specifications for a series of actions, says Woods, who studies how people use computers in air-traffic control and other complex jobs. In such difficult endeavors, however, plans often get modified as circumstances change and surprises crop up.

"Researchers are just beginning to look at plans as ways in which people prepare themselves to be surprised," Woods says. In other words, the best-laid plans are those that are loose enough to allow for innovation.

WIDE-OPEN SPACE — Geologists participating in a simulated Mars exploration in Utah investigate a site and transmit data back to home base through units in their backpacks.

CLANCEY

BIG SYSTEMS The sprawling IHMC facility in downtown Pensacola has witnessed its own surprising transformation. Before Ford and his computer-savvy colleagues arrived in 1990, the building housed the local sheriff's department and a jail.

IHMC now represents freedom, at least of the academic sort. People trained in computer science, the social sciences, philosophy, engineering, and medicine mingle and collaborate. The only requirement: Treat computers not as isolated systems of chips and codes, but as parts of larger systems also characterized by how individuals think, the type of organizations in which they work, and the settings in which labor occurs.

It's this big-system perspective that informs OZ, concept maps, and Brahms. "Building cognitive prostheses keeps human thought at the center of our science," Ford says. ■

INFINITE WISDOM

A new approach to one of mathematics' most notorious problems

BY ERICA KLARREICH

How many numbers are there? For children, the answer might be a million—that is, until they discover a billion, or a trillion, or a googol. Then, maybe they notice that a googol plus one is also a number, and they realize that although the names for numbers run out, the numbers themselves never do. Yet to mathematicians, the idea that there are infinitely many numbers is just the beginning of an answer. Counterintuitive as it seems, there are many infinities—infinitely many, in fact. And some are bigger than others.

In the late 19th century, mathematicians showed that most familiar infinite collections of numbers are the same size. This group includes the counting numbers (1, 2, 3, . . .), the even numbers, and the rational numbers (quotients of counting numbers, such as 3/4 and 101/763). However, in work that astonished the mathematicians of his day, the Russian-born Georg Cantor proved in 1873 that the real numbers (all the numbers that make up the number line) form a bigger infinity than the counting numbers do.

If that's the case, how much bigger is that infinity? This innocent-sounding question has stumped mathematicians from Cantor's time to the present. More than that, the question has exposed a gaping hole in the foundations of mathematics and has led mathematicians to reexamine the very nature of mathematical truth.

Now, Hugh Woodin, a mathematician at the University of California, Berkeley, may finally have found a way to resolve the issue, long considered one of the most fundamental in mathematics.

INFINITE REGRESS — Architectural features, such as a ceiling that consists of stacked polygons of diminishing size, can create an illusion of infinite extent.

"It's a remarkable piece of mathematics," says Patrick Dehornoy of the University of Caen in France. He presented a lecture on Woodin's work last March at the Bourbaki seminar in Paris, one of the most famous and long-standing seminars in mathematics.

A PARADISE OF INFINITIES At first glance, it might seem obvious that the real numbers form a bigger infinity than the counting numbers do. After all, the real number line is an infinitely long, continuous expanse, while the counting numbers are just isolated milestones along this line.

However, little is obvious when it comes to infinite sets. For one thing, there's no way to simply count the elements of two infinite sets and determine which set has more. Instead, mathematicians say two infinite sets are the same size if there's a way to pair their elements, one to one, with no elements of either set left over.

Oddly enough, by this measure, the infinite set of counting numbers {1, 2, 3, . . . } is the same size as the infinite set of even numbers {2, 4, 6, . . . }, despite the fact that the even numbers make up precisely half of the counting numbers. The pairing procedure here works by hooking up 1 with 2, 2 with 4, 3 with 6, 4 with 8, and so on to make a perfect one-to-one correspondence between the two sets.

At first, mathematicians thought that all infinite sets could be paired with the counting numbers in this way. However, Cantor came up with an ingenious argument to show that there is no way to match the real numbers with the counting numbers without having real numbers left over. Because of this, mathematicians now refer to the infinite set of real numbers as uncountable.

Once Cantor had shown that the real numbers make up a bigger infinity than the counting numbers do, he saw no reason to stop there. He realized that there's an entire hierarchy of infinities—a "paradise of infinities," in the words of the great German mathematician David Hilbert, one of Cantor's contemporaries.

Cantor studied many infinite sets of numbers, but he never found one whose size fell between that of the counting numbers and the real numbers. So in 1877, he speculated that the real numbers, often called the continuum, form the smallest possible infinite set that is bigger than the counting numbers. In other words, there should be no set of numbers larger than the set of counting numbers but smaller than the set of real numbers. In a famous lecture presented in 1900 at the International Congress of Mathematicians in Paris, Hilbert placed this assertion, called the continuum hypothesis, at the top of a list of the 23 most important mathematics problems of the new century.

Proving the truth or falsehood of Cantor's continuum hypothesis boils down to answering this: Where does the set of real numbers sit in the hierarchy of infinite sets? Is it really the very first uncountable set? Cantor, for one, suspected the answer was no, but he couldn't prove it.

Cantor's hierarchy of infinities was such a revolutionary concept that many of his contemporaries rejected it out of hand. Their derision, coupled with Cantor's inability to prove the continuum hypothesis, sent him into several nervous breakdowns. At times,

I. PETERSON

he gave up mathematics temporarily, opting to pursue instead another passion: trying to prove that the English philosopher Francis Bacon was the real author of William Shakespeare's plays. In 1917, Cantor died, unhappy and depressed, in a sanatorium.

DECLARATION OF INDEPENDENCE While Cantor was struggling with the continuum hypothesis, other mathematicians were exploring the implications of Cantor's dramatically broad vision of sets. British mathematician Bertrand Russell demonstrated that if mathematicians were careless about how they defined sets, baffling paradoxes would result.

The elements of a set can be numbers, mathematical functions, or even sets themselves. Russell observed that a set conceivably could even contain itself, like a picture that includes a picture of itself, which includes a picture of itself, and so on. Russell asked mathematicians to consider a set—call it S—that contains all sets that do not contain themselves. Then he asked, Does S contain itself? Chase the cycle of implications around, and you'll find that an answer of either yes or no leads to a logical contradiction.

To deal with this problem, mathematicians in the first quarter of the 20th century developed basic principles, or axioms, spelling out how sets behave and ruling out paradoxical sets such as Russell's set S. These axioms are statements so natural and intuitive that mathematicians are willing to accept them without proof. One such axiom, for instance, states that given two sets, their elements can be collected together to make a new set. Another states that infinite sets exist. Despite their simplicity, these axioms—called the standard axioms of set theory—have enabled mathematicians to set up a rigorous framework for proving results in all mathematical fields, from fractals to differential equations.

The continuum hypothesis, however, exposed a glaring incompleteness in these axioms. In 1938, logician Kurt Gödel proved that the continuum hypothesis is consistent with the standard axioms of set theory. Then in 1963, Paul Cohen, now at Stanford University, proved that the opposite of the continuum hypothesis—the assertion that there is actually an infinite set that is bigger than the set of counting numbers but smaller than the set of real numbers—is also consistent with the axioms.

Put together, those two results indicate that it's impossible either to prove or to disprove the continuum hypothesis using the standard axioms. This made many mathematicians conclude that it might never be possible to develop a satisfying sense of whether the hypothesis is true or false.

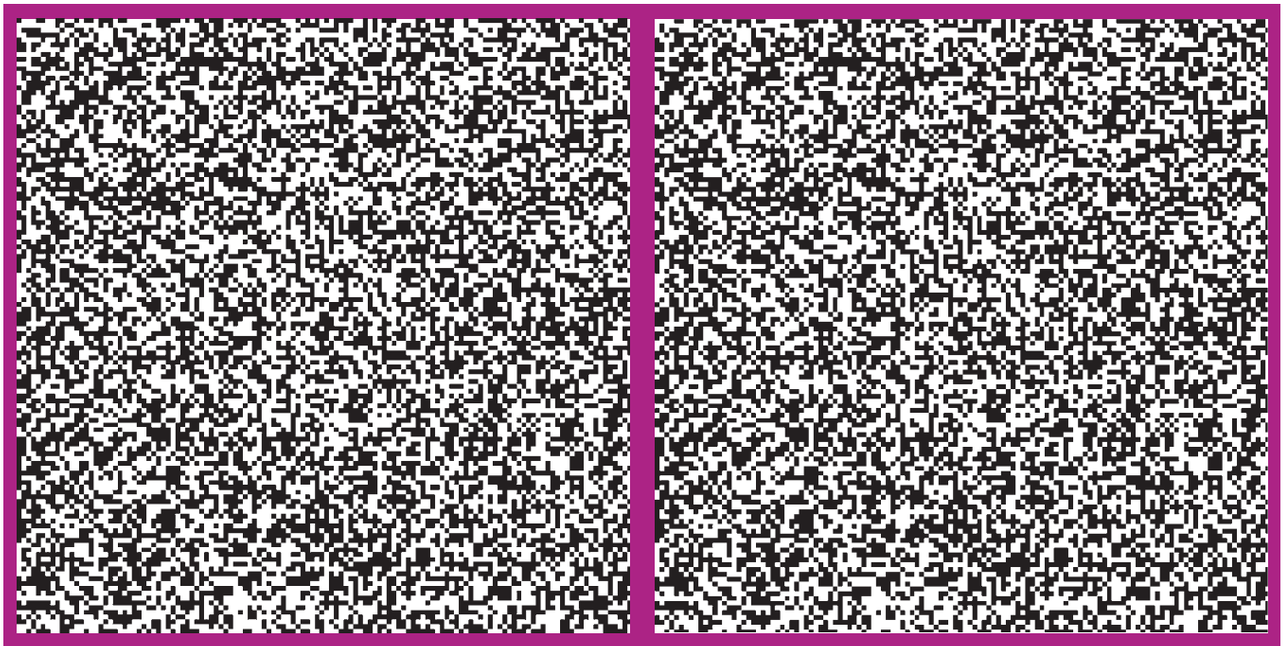
> "Here, we had a question which should have an answer, but it had been proven that there were no means of answering it."
>
> —HUGH WOODIN

Cohen's demonstration that the continuum hypothesis could be neither proved nor disproved "caused a foundational crisis," Woodin says. "Here, we had a question which should have an answer, but it had been proven that there were no means of answering it." This left mathematicians with a fundamental question: Does it even make sense to say the continuum hypothesis is true or false?

When it comes to the philosophical issue of the nature of truth, most mathematicians fall into one of two camps called formalism and Platonism. Formalists take the position that mathematical statements don't have an intrinsic truth or falsity—that the only thing that can ever be said about a statement is whether it can be proved in a given axiom system.

To formalists, it makes no sense to talk about whether the continuum hypothesis is true or false. They hold that, if the continuum hypothesis can't be resolved within the standard framework of mathematics, then the hypothesis must be inherently vague. "Some people think it's as intractable as asking how many angels can dance on the head of a pin, or what color is the number pi," Woodin says.

To Platonists, mathematical objects such as sets exist in an ideal mathematical world, and axiomatic systems are merely useful tools for illuminating which statements about those objects are true in that world. To Platonists, the continuum hypothesis feels

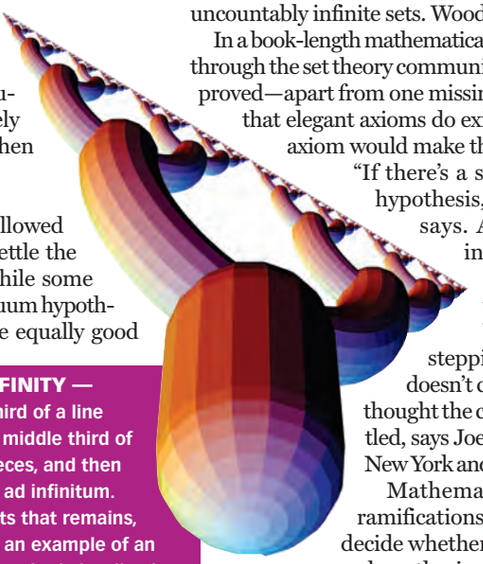


FLICKERING FIGURES — To prove that real numbers are uncountable, Georg Cantor invented his diagonal argument. He started with a square array of numbers where each row is different and then changed each number that falls on the diagonal. Reading the diagonal as a new row gives a number that's not in the original array, so if there had been infinite rows, there would still be an additional possible row. Artist and mathematician Helaman Ferguson has created a visualization of that argument in this stereoscopic pair of images. The two square arrays of pixels are identical except for the diagonals (running from top left to bottom right), where a black pixel in one is a white pixel in the other. When viewed stereoscopically, the images combine, and the diagonal stands out from the background array, appearing to flicker.

H. FERGUSON

like a concrete statement that should be true or false. To them, if the standard axioms can't settle the continuum hypothesis, it's not that the hypothesis is a meaningless question, but rather that the axioms are insufficient.

From this point of view, Cohen's result indicates that mathematicians need to add to their roster of axioms about infinite sets. There is a problem, however. An axiom should be so intuitively obvious that everyone agrees immediately that it's true. Yet intuition quickly evaporates when confronted with questions about infinity.



BRANCHING TO INFINITY — Remove the middle third of a line segment, remove the middle third of the two remaining pieces, and then continue this process ad infinitum. The collection of points that remains, called a Cantor set, is an example of an infinite set. Here, a branched visualization of the process as a binary tree appears in the work of art "Infinite Cactus."

H. FERGUSON

INFINITE ELEGANCE In the decades that followed Cohen's 1963 result, mathematicians trying to settle the continuum hypothesis ran into a roadblock: While some people proposed new axioms indicating the continuum hypothesis was true, others proposed what seemed like equally good axioms indicating the it false, Woodin says.

Woodin decided to try a different tack. Instead of looking for the missing axiom, he gathered circumstantial evidence about what the implications of that axiom would be. To do this without knowing what the axiom was, Woodin tried to figure out whether some axioms are somehow better than others. A good axiom, he felt, should help mathematicians settle not only the continuum hypothesis but also many other questions about Cantor's hierarchy of infinite sets.

Mathematicians have long known that there is no all-powerful axiom that can answer every question about Cantor's hierarchy. However, Woodin suspected a compromise is possible: There might be axioms that answer all questions up to the level of the hierarchy that the continuum hypothesis concerns—the realm of the smallest uncountably infinite sets. Woodin called such an axiom "elegant."

In a book-length mathematical argument that has been percolating through the set theory community for the last few years, Woodin has proved—apart from one missing piece that must still be filled in—that elegant axioms do exist and, crucially, that every elegant axiom would make the continuum hypothesis false.

"If there's a simple solution to the continuum hypothesis, it must be that it is false," Woodin says. And if it is false, then there are indeed infinite sets bigger than the counting numbers and smaller than the real numbers.

Woodin's novel approach of sidestepping the search for the right axiom doesn't conform to the way mathematicians thought the continuum hypothesis would be settled, says Joel Hamkins of the City University of New York and Georgia State University in Atlanta.

Mathematicians haven't yet absorbed the ramifications of Woodin's work fully enough to decide whether it settles the matter of the continuum hypothesis, says Akihiro Kanamori of Boston University (Mass.). "[It's] considered a very impressive achievement, but very few people understand the higher reaches [of Woodin's framework]," he says.

Does Woodin himself believe that the continuum hypothesis is false? "If anyone should have an opinion on this, I should, but even I'm not sure," he answers. "What I can say is that 10 years ago, I wouldn't have believed there was a chance the continuum hypothesis was solvable. Now, I really think it has an answer." ■

OF NOTE

PALEOBIOLOGY

Oh, what a sticky web they wove

A look inside a piece of 130-million-year-old amber found in Lebanon has revealed a gossamer treasure: a filament of spider silk laced with sticky droplets that look just like those from modern spiders.

The 4-millimeter-long strand of viscid silk—the glue-covered type that some web-spinning spiders use to capture prey—is more than 90 million years older than any known sample of spider silk.

Despite its age, the strand has hallmarks of modern spider silk, says Samuel Zschokke, a biologist at the University of Basel in Switzerland. For example, most of the filament's glue droplets range from 7 to 29 micrometers in diameter and are arranged in an alternating sequence of small and large. Zschokke describes the delicate fossil in the Aug. 7 *Nature*.

Both modern orb-weaver spiders and comb-footed spiders spin this type of silk. If the fossil filament came from an ancestor of one of those varieties, it was probably a comb-footed spider, says Zschokke. Today, those arachnids are the only ones that spin webs bearing viscid silk near tree trunks, where seeping resin would be likely to trap a stray strand of silk. —S.P.

BEHAVIOR

Meditation changes

People who meditate say that the practice calms them and improves their performance on everyday tasks. There may be foundations of these benefits in the brain and immune system, a new study finds.

Psychologist Richard J. Davidson of the University of Wisconsin–Madison and his colleagues studied 41 employees of a biotechnology company, 25 of whom completed an 8-week meditation program. The scientists measured brain wave activity in all participants before, immediately following, and 4 months after the meditation program. Volunteers also received an influenza vaccination at the end of the program and gave blood samples 1 month and 2 months later, enabling the researchers to assess the volunteers' immune responses to the vaccine.

Only the meditators exhibited increases in brain wave activity across the front of the left hemisphere, Davidson's group reports in the July/August *Psychosomatic Medicine*. Earlier studies had suggested that this neural response accompanies both reductions in negative emotions and surges in positive emotions. The employees who took the course reported subsequent drops in negative feelings but no change in pleasant feelings.

Meditators displayed more-vigorous antibody responses to the vaccine than their nonmeditating peers did. —B.B.

TOXICOLOGY

Big worries about little tubes

Carbon nanotubes could carry the same dangers to human lungs that asbestos does, says an Environmental Protection Agency researcher. Philip M. Cook of the EPA's Duluth, Minn., research laboratory and other scientists had previously linked the toxic potential of various needlelike fibers to their length, width, and shape. Fibers that damage lungs tend to fall into a size range comparable to some carbon nanotubes, an emerging family of synthetic fibers with a variety of potential industrial applications.

Cook and his colleagues have shown that short, thin mineral fibers are retained longer in the lungs than larger fibers are and that the short fibers can trigger cancer. Some commercially produced carbon nanotubes are 0.1 micrometer wide and 5 to 20 μm long, just about "the asbestos-fiber size that everyone believes is toxic," notes Cook.

In some industrial applications, carbon nanotubes are being commingled with zeolites, which are natural and synthetic silica-based minerals. Cook's research has shown that at least one type of zeolite fiber is even more toxic to the lungs than is asbestos. A separate study last year found that the zeolite fibers' size and the minerals' chemistry contributed independently to toxicity, providing a double whammy.

Cook recommends caution. Until research demonstrates that nanotubes aren't toxic to people, he says, manufacturers shouldn't be commercializing them in sizes that can be readily inhaled. —J.R.

CHEMISTRY

Testing computers' hazardous potential

The standard test to evaluate whether metal-laden products are hazardous fails to flag high concentrations of lead in some discarded electronics equipment, new studies show.

"It was a surprise," says Timothy Townsend of the University of Florida in Gainesville. On the other hand, the data are consistent with findings by others for certain metal-foundry wastes, he says.

Under the acidic conditions in many landfills, electronic gadgetry can leach lead and other toxic metals. To test an object's potential to leach metal, federal guidelines require that it be crushed into pieces smaller than 1 cubic centimeter and soaked for 18 hours in a vinegar-strength acid bath. Products that leach at least 5 milligrams of any toxic metal per liter of solution must be designated as hazardous waste when discarded. That usually requires keeping them out of municipal landfills.

When Townsend's team conducted this standard test on seven shredded computer central-processing units (CPUs), none leached enough lead to be deemed hazardous. However, when the group tested dismantled but unshredded CPUs, 9 of 10 failed the acid test. Nine of 30 cathode ray tubes from color computer monitors passed the standard shredded-parts test even though separate tests have shown that most of these tubes contain huge amounts of lead (*SN: 11/4/00, p. 303*).

Why didn't the standard test find hazardous amounts of lead in these computer parts? Townsend says it appears to be the products' steel content, which, when shredded, alters the acid bath's chemistry so that it pulls less lead from the shredded parts.

Laptop computers contain much less lead than cathode ray tubes do. Nevertheless, six of eight shredded laptops failed the standard test, as did all eight samples of dismantled but unshredded laptops. The laptops' low steel content had little effect on the acid bath, says Townsend. Results for cell phones were similar to those for the laptops.

Townsend concludes that for steel-laden electronics, a direct measurement of lead content may be more reliable than the standard leaching test for determining whether the products, when thrown away, should be designated as hazardous waste. —J.R.

TOXICOLOGY

Nonstick but not nontoxic

A growing number of products designed to shun both water and oil rely on fluorine-based compounds. The nonstick chemicals also serve in stain-resistant coatings and as surfactants in fire-fighting foams, floor polishes, and insecticides. What these fluorine compounds don't do is fully degrade.

In the environment, many break down only to perfluorooctane sulfonate (PFOS), a remarkably persistent pollutant that has started showing up in the blood of people and animals. Fetal exposures to this proliferating pollutant can harm newborn mice and rats, a new study shows.

Christopher Lau of the Environmental Protection Agency in Research Triangle Park, N.C., and his colleagues exposed female rodents to a range of PFOS doses throughout pregnancy. Though high doses of the compounds were tested, the study included exposures yielding blood concentrations of PFOS similar to those in some people exposed to the chemicals at factories that make the fluorine-based precursors of PFOS. Those amounts can be hundreds of times higher than those to which the general population is exposed.

The higher exposures in the new study proved toxic to pregnant rodents, which failed to gain much weight during gestation. Yet at birth, all pups looked normal, Lau notes. Only those pregnant rodents getting the highest doses in the study were a little more likely to bear with birth defects, such as cleft palate.

If the experiments had ended there, Lau says, PFOS wouldn't look like much of a reproductive hazard. However, his team observed the pups for several days after birth, and that's when PFOS' more-devastating effects emerged.

All pups in the highest-exposure groups were born active and pink, but within an hour turned sickly and soon died. Nearly all rat pups from mothers getting the next-highest exposure to PFOS died within 8 to 12 hours. Even half of pups from the middle-exposure group eventually succumbed.

The exposed pups that managed to survive showed various problems. For example, they grew more slowly than unexposed newborns did. And the activity of their choline acetyltransferase, an important brain enzyme, was subtly but significantly impaired. Lau and his colleagues detail their new findings in the August *Toxicological Sciences*.

Although puzzled by the high mortality of newborns that had initially appeared healthy, the scientists suspect that those deaths trace to impaired lung development. At the workshop, Lau unveiled photos showing that as fetal exposure to PFOS climbs, the lungs don't expand as fully after birth. He speculates that the effect might reflect the reduction in PFOS-exposed moms and newborns of certain thyroid hormones that are pivotal to the development of the lungs and other organs. —J.R.

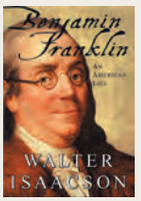
Books

A selection of new and notable books of scientific interest

BENJAMIN FRANKLIN: An American Life

WALTER ISAACSON

This biography of one of the country's most recognized founding fathers traverses all aspects of Franklin's contributions as a scientist, inventor, media mogul, diplomat, writer, and business strategist. As Isaacson portrays Franklin's life, it was the model for the American way. In reviewing Franklin's myriad scientific contributions, Isaacson notes that his subject was "celebrated as the most famous scientist alive" during the late 1700s. Franklin's pursuits and interests ranged from meteorology to epidemiology. He was a practical experimenter who not only figured out ways to harness electricity but also invented the urinary catheter and a wood-burning stove for placement in fireplaces. A quintessential member of what would now be the U.S. middle class, Franklin was a thrifty, hard-working, self-made businessman. Beyond that, he was a champion of a social philosophy that melded liberal, populist, and conservative ideas. Franklin was an influential diplomat who made possible the breakaway colonies' alliance with France. Isaacson allots many pages to Franklin's role in the Continental Congress and his contributions to the Declaration of Independence. Finally, the author considers how Franklin's legacy has evolved. ***S&S, 2003, 590 p., hardcover, $30.00.***



CITY BIRDING: True Tales of Birds and Birdwatching in Unexpected Places

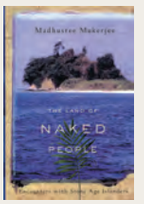
KENN KAUFMANN ET AL.

Most people perceive bird-watching as a rural, or at least suburban, pursuit. The cadre of bird-watchers that wrote this book challenges urbanites to open their eyes and focus their binoculars. Vignettes in this collection feature songbirds that hang out in parking lots, ravens that cavort on airport tarmacs, and a rare spotted redshank visiting Brooklyn. It turns out that some interesting specimens are denizens of areas around sewage ponds. This is an entertaining and enlightening guide to birding in unusual locales. ***Stackpole Bks, 2003,181 p., hardcover, $18.95.***

THE LAND OF NAKED PEOPLE: Encounters with Stone Age Islanders

MADHUSREE MUKERJEE

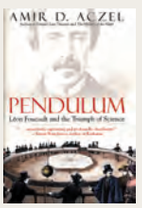
The Andaman Islands, located in the Bay of Bengal lie along a busy trade route between India and China. However, due to the historically savage reputation of the islands' inhabitants, outsiders were scarce for millennia. Stories from around 850 painted the Andamanese people as cannibals who roasted hapless sailors who wandered ashore. Not until after World War II did many non-natives venture to the islands. Even now, the 100 or so inhabitants of tiny North Sentinel Island ward off all boats that approach. Scientists believe that the Andamanese directly descended from early humans who colonized central and southeastern Asia 50,000 years ago. These people essentially live in a prehistoric time capsule. Mukerjee presents a thorough investigation of the Andaman Islands and the late introduction of its people to modern civilization. She chronicles the experiences of four Andamanese groups that encountered outsiders at different times. These stories are an encapsulated version of what has happened to every culture that has ever had to adapt to the encroachment of another. As in many cases elsewhere, these people have been driven almost to extinction by disease and pollution, and the habitat that sustains them has been damaged. Now, activists and anthropologists are trying to preserve what is left of the Andamanese and their culture. ***HM, 2003, 268 p., b&w photos, hardcover, $24.00.***



PENDULUM: Léon Foucault and the Triumph of Science

AMIR D. ACZEL

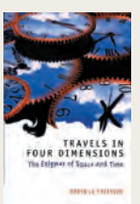
Before 1851, no one had ever proved Copernicus' claim that Earth isn't the center of the universe. Then, Léon Foucault set up a pendulum in the basement of his mother's house and verified that Earth spins on an axis and rotates around the sun. Today, pendulums are ubiquitous. Small ones swing in clocks in our homes, and big ones sway slowly in great halls of museums. But Foucault is generally forgotten. Aczel, author of *The Riddle of the Compass,* details the life and times of this French physicist. Foucault was a medical school dropout, yet he had a keen mind and an unwavering interest in science. He gave us the modern compass, measured the speed of light, and invented the gyroscope. However, because of his lack of formal training, his peers at the French Academy of Sciences denied him recognition for many years, until Napoléon III took notice of him. In telling Foucault's story, Aczel also paints a portrait of life during France's Second Empire, when the Catholic church didn't look kindly on unorthodox views. ***Atria Bks, 2003, 275 p., hardcover, $25.00.***



TRAVELS IN FOUR DIMENSIONS: The Enigmas of Space and Time

ROBIN LE POIDEVIN

Metaphysics professor Le Poidevin considers some of the most perplexing questions we face about space and time. Among them: Does time really flow, or is that simply an illusion? Did time have a beginning? Does space have boundaries? Is change really possible? Are our space and time unique, or could there be other, parallel worlds? The author provides his own thoughts on such matters, as well as answers postulated by others. Le Poidevin believes that time doesn't actually flow and that it is possible for space and time to be both finite and yet without boundaries. He challenges readers to consider these and other ideas and draw their own conclusions. ***OUP, 2003, 275 p., b&w illus., hardcover, $25.00.***



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LETTERS

Courting trouble

In "Ideal Justice: Mathematicians judge the Supreme Court" (*SN: 6/28/03, p. 405*), Lawrence Sirovich assumes that the degree of unpredictability shown in Supreme Court decisions results from judicial independence, with the implication that this is a good thing. That unpredictability could easily result instead from confusion caused by absent or conflicting principles in the justices' political and juridical doctrines, a not-so-good thing.

ALAN ESWORTHY, APEX, N.C.

Crazy pursuit

Yes, trying to pin an actual date and time of the day to van Gogh's painting is an intellectual exercise, but no one should believe this is possible ("Timing a Moonrise: Van Gogh painting put on the calendar," *SN: 7/5/03, p. 6*). An artist plays with what's seen. One only need look at van Gogh's painting. Does the sky really have white streaks in it? No. So what makes the group who relied on this picture so positive that the moon is in exactly the right position? More likely than not, van Gogh painted something that gave the scene feeling and depth, but it's hardly scientifically accurate.

KIRK RYAN, EAST WINDSOR, N.J.

Van Gogh's own letters say that he painted what he saw around him. —R. COWEN

Pass the doughnuts

Lowered melatonin secretion was an implied factor in the 35 percent increase in colon cancer among night shift nurses, compared with their daytime counterparts ("Second cancer type linked to shift work," *SN: 7/5/03, p. 13*). A couple of altered lifestyle factors may contribute, as well: The night shift is often occasion for a sedentary work style, and decreased alertness might even affect daytime activity. Also, there may be the tendency during the night toward eating low-fiber, oily, salty, and sugary snack foods.

CLYDE ROGGENKAMP, LOMA LINDA, CALIF.

Did Eva S. Schernhammer's research team control for diet? Caffeine? Nicotine?

M. WOOD, WAIANAE, HAWAII

The researchers controlled for such variables and daily hours of sleep. —J. RALOFF

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