SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

NOVEMBER 2, 2002 PAGES 273-288 VOL. 162, NO. 18

ancient inland ocean

herbicide alters frog sex organs

a star from the beginning?

new painkiller headache

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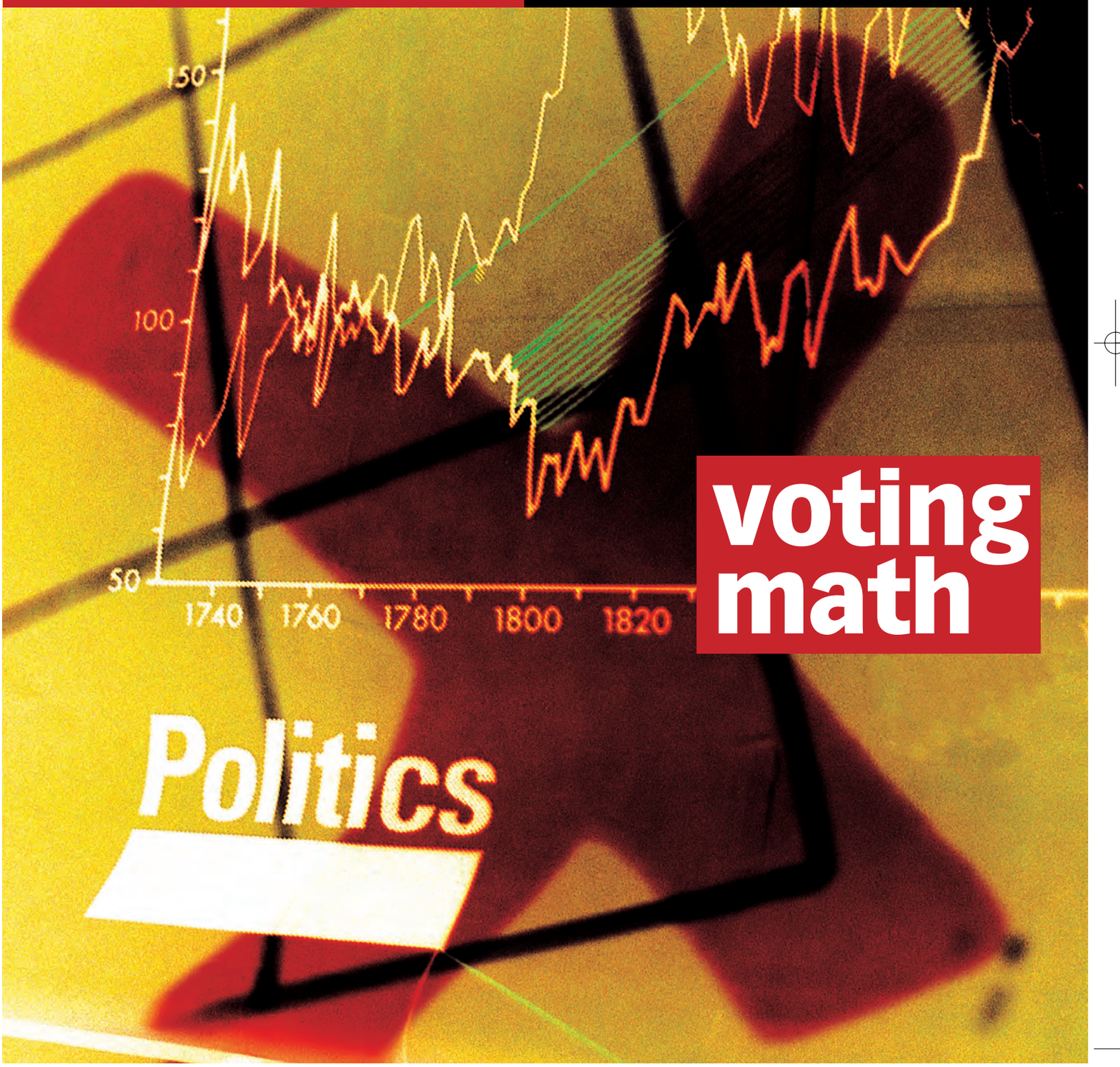

voting math

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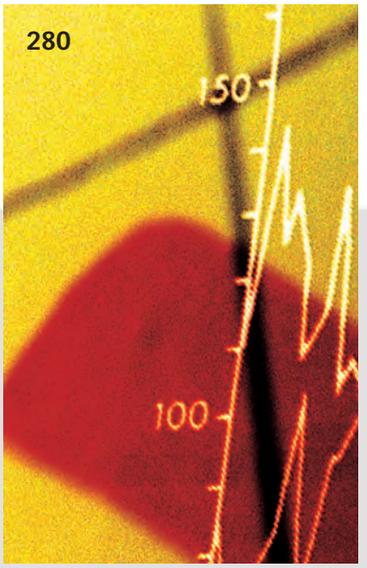

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Cover While news reports may highlight problems with voting equipment and counting procedures, mathematics is shedding light on more basic questions about how well different systems of election capture the political will of the voters.
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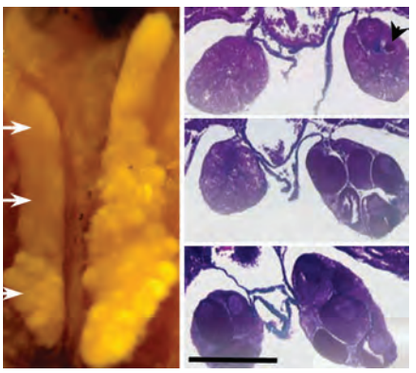
More Frog Trouble

Herbicides may emasculate wild males

New studies of male frogs in the wild link trace exposures to common weed killers with partial sex reversal. The findings suggest one possible factor behind declining amphibian populations worldwide.

Atrazine, the nation's most widely used herbicide, is nearly ubiquitous. Some U.S. rainwater carries up to 0.4 part per billion of the chemical. Earlier this year, scientists at the University of California, Berkeley reported bending the gender of male frogs by incubating tadpoles in as little as 0.1 ppb atrazine (*SN: 4/20/02, p. 243*). Affected animals grew extra testes and sometimes, ovaries.

Those researchers used the amphibian equivalent of a lab mouse, a frog native to South Africa. The Berkeley team now reports similar laboratory results in two U.S. species, the leopard frog (*Rana pipiens*) and the Pacific tree frog (*Hyla regilla*). It also studied wild leopard frogs from eight sites in the Midwest and West. Half came from areas of high atrazine use, but all sites had measurable concentrations in streams. Concentrations at the most heavily exposed site fluctuated over the year between 0.7 and 15.2 ppb.



ADAPTED FROM HAYES ET AL., ENVIRON. HEALTH PERSPECT. 2002; MURRAY AND D. KERSTEN

DAD'S EGGS Ordinarily, a frog testis pinches during development, and the lower two-thirds disappears. However, atrazine-exposed males can retain this lower portion, which can produce eggs (bumps in the left photo). Cross-sections of the gonads at arrow-marked levels appear at right. They show dense, immature tissue (top image) and heavy loads of eggs (middle and bottom images). Scale bar at bottom right indicates 250 micrometers for cross-section images.

At seven of those sites, 10 to 92 percent of the males had underdeveloped testes, Tyrone Hayes and his colleagues report in the Oct. 31 *Nature*. Furthermore, portions of some of the frogs' testes produced eggs, the researchers show in a more detailed report slated to appear in *Environmental Health Perspectives*. The scientists didn't detect any effects of atrazine on female frogs.

The males' malformations—where a testis appears male at the top but becomes increasingly female toward the bottom—have been witnessed only in frogs exposed to atrazine, Hayes told *Science News*.

"It's impossible that those gonads are functioning normally," herpetologist James Hanken of Harvard University's Museum of Comparative Zoology concluded after seeing photos from the new study.

At a symposium hosted by Tulane and Xavier Universities last month in New Orleans, Hayes described lab studies of tadpoles exposed to a blend of atrazine and metolachlor, another common herbicide. When exposed to concentrations seen in runoff from Nebraska cornfields, each, by itself, appeared to prolong metamorphosis very slightly. However, when delivered together, the pair increased the tadpoles' metamorphosis time—normally 60 days from egg to frog—by 10 days.

Hayes points out that prolonging metamorphosis increases an amphibian's exposure to atrazine while the animal is most vulnerable—during development. In fact, he's found that the most dramatic emasculating effects occur in atrazine-exposed lab frogs that develop most slowly. Hayes is now studying whether the affected frogs are even fertile.

What Hanken finds "especially worrisome" in Hayes' findings is that trace concentrations of atrazine affect frogs' testes. That's troubling, says Hanken, because "rainfall virtually everywhere now has atrazine."

Joseph Kiesecker of Pennsylvania State University in State College also worries that these herbicides "can serve as a stressor that interacts with disease outbreaks in [fostering] amphibian declines."

However, toxicologist Tim Pastoor, with the atrazine maker Syngenta in Greensboro, N.C., remains unpersuaded. He's particularly troubled by a surprising finding by the Berkeley group: that 25 ppb exposures of atrazine in the lab produced only one-third as many hermaphrodites as 0.1 ppb did. "It doesn't appeal to common sense," Pastoor says.

Hayes disagrees. Atrazine's impacts in frogs appear to stem from its stimulation of aromatase, an enzyme that converts testosterone to estrogen, he says. Normally, when gonads make too much estrogen, some of the excess enters the blood and signals the pituitary gland to shut down aromatase. However, Hayes speculates, low concentrations of atrazine probably stimulate the testes to make enough estrogen to feminize them but not enough to engage the pituitary's shutdown switch.

The big question, he and others maintain, is why atrazine appears to trigger excessive aromatase activity in the first place. —J. RALOFF

Neural Shape-Up

Brain anticipates object perception

Many neuroscientists suspect that in order to see, a person first sorts through edges, contours, and other basic visual features using a brain area called the primary visual cortex. Then so-called higher visual areas of the brain assemble these features into perceptions of shapes and objects.

However, according to a new investigation, at least one of these higher areas shapes what we see from the get-go, and it does it by actually suppressing activity in the primary visual cortex.

This give and take of higher and lower parts of the visual system allows the brain to use predictions about the world, generated from experience and presumably stored in neural structures, to perceive objects under often ambiguous circumstances, propose neuroscientist Scott O. Murray of the University of California, Davis and his coworkers.

"Higher visual areas anticipate the struc-

DOUBLE VISION In one experiment, volunteers watched this diamond with obscured corners move back and forth. The four visible segments sometimes appeared to move independently and sometimes as a group.

ture of incoming visual information, and if the input matches what's expected, neural activity declines in the primary visual cortex," Murray says.

This is surprising, he adds, because feedback from one brain region to another is typically thought to enhance, rather than inhibit, neural activity. The new findings will appear in the *Proceedings of the National Academy of Sciences*.

Murray's group used functional magnetic resonance imaging to measure blood-flow changes in the lateral occipital complex (LOC), a higher visual area involved in object recognition, and in the primary visual cortex. Jumps and dips in blood flow provide indirect markers of neural activity.

In three experiments, a total of 18 adults viewed lines and dots that were perceived as either meaningless jumbles or geometric shapes. Jumbles elicited substantially more activity in the primary visual cortex than in the LOC. In contrast, coherent shapes—especially three-dimensional ones—yielded much stronger LOC responses accompanied by diminished blood flow in the primary visual cortex.

In the first experiment, volunteers saw haphazard lines and drawings of two-dimensional and three-dimensional shapes.

In the second experiment, participants saw three computer displays: a set of stationary, randomly arrayed dots; randomly arrayed dots rotating on an axis around drawings of cubes and other shapes to create three-dimensional perceptions; and dots moving at random.

The third experimental stimulus consisted of a moving diamond on a computer screen, with the diamond's four corners invisible to different degrees. The diamond's four visible segments then moved from side to side on the screen. Volunteers sometimes perceived segments as moving haphazardly and at other times, as moving together as a diamond. All experimental stimuli can be seen at http://www.demos.kersten.org.

The new findings suggest that the primary visual cortex sifts through basic visual elements until the LOC recognizes an object and terminates most low-level activity, remarks neuroscientist Michael S. Beauchamp of the National Institute of Mental Health in Bethesda, Md. Still, he says, other researchers need to confirm the results and see whether a similar pattern of electrical responses occurs in visual areas. —B. BOWER

Echoes of Icequakes

Simple probe could measure Europa's ocean and icy shell

A football-size space probe could provide a low-cost way to determine whether there's a liquid ocean on the Jovian moon Europa. The ice-sheathed, nearly airless world is just a bit smaller than our own moon, and it stands as one of the solar system's prime candidates for hosting life beyond Earth. Discussions among scientists about small, discount probes to be sent to Europa have intensified since funds earmarked for a full-scale orbiter were dropped from the President's 2003 budget proposal.

The probe would act as an electronic ear, detecting sound waves traveling through Europa's icy crust, says Nicholas C. Makris, an acoustical oceanographer at the Massachusetts Institute of Technology. Those reverberations could be generated by a variety of sources, including the occasional impacts of objects falling from space. However, Makris contends that if there is a liquid ocean within Europa's thick shell of ice, its tidal motions could provide a nearly continuous source of seismic shivers.

Europa orbits Jupiter, its massive parent planet, once every 3.5 days at an average distance of about 671,000 kilometers, or roughly twice the distance from Earth to our moon. Forces that would cause tides on Europa arise because the moon wobbles slightly as it sweeps through its oblong path. Scientists estimate that tides in Europa's underground ocean, if one is present, could heave the moon's icy surface up and down through a range of about 30 meters during each orbit.

All that flexing would generate cracks, and measurements of the seismic waves generated by the fracturing ice would provide a wealth of information. Scientists could calculate the thickness of Europa's crust by using the time lag between the arrival of seismic waves that traveled directly to the instrument and those that first bounced off the lower surface of the crust. The time it takes for subsequent echoes to reach the sensor could provide information about the depth of the moon's liquid ocean and might even enable researchers to map the ocean bottom under the probe. Makris described the techniques this week at a Geological Society of America meeting in Denver.

These depth-sounding methods are similar to ones that oceanographers use to map the seafloor on Earth, says Makris. Geologists also use such seismic analyses to infer Earth's inner structure. Tests on pack ice floating in the Arctic Ocean show that the proposed techniques can be used to map the thickness of ice, determine ocean depth, and even detect layers of different temperature or density within the ocean.

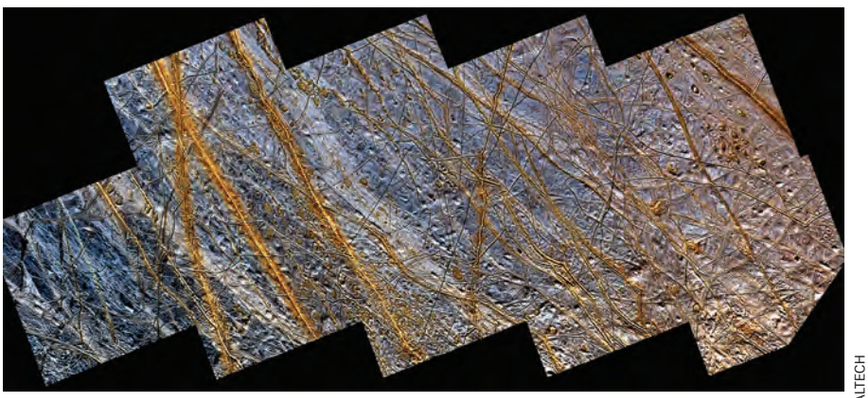
Makris and his colleagues next intend to test their echo-sounding methods on the ice shelves that fringe Antarctica. Those ice masses often stretch dozens of kilometers from the continent's coast and undergo tidal flexing just as Europa's crust does.

A probe like the one Makris envisions could put an end to debates about the thickness of Europa's ice and whether the moon indeed has a liquid ocean, says Paul M. Schenk, a geologist at the Lunar and Planetary Institute in Houston. —S. PERKINS

Metal Manipulation

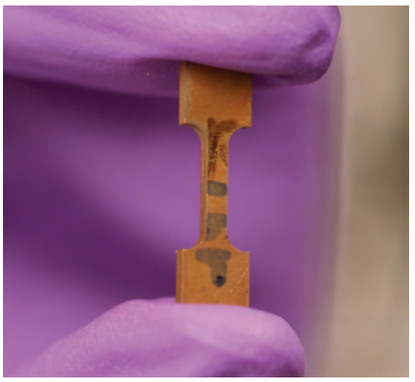
Technique yields hard but stretchy materials

Metalworking is an ancient craft, with time-tested practices that go back thousands of years. But now, working within the



NASA/JPL/CALTECH

EUROPA CRACKS A proposed probe's analysis of the sound waves generated by cracking in Europa's icy shell could help scientists estimate the thickness of the moon's crust and confirm the suspected presence of a liquid ocean there.



METAL MAGIC A new process gave this copper strength and ductility.

modern context of nanotechnology, researchers have found a way to make strong yet stretchy metals. Metallurgists might eventually incorporate such improved materials into countless applications, from micromechanical machines to biomedical implants.

In the Oct. 31 *Nature*, En (Evan) Ma and his colleagues at Johns Hopkins University in Baltimore report that they've combined a standard metalworking technology—rolling—with a programmed sequence of cooling and heating steps to process copper into a form that contains both nanoscale and microscale crystal grains. The resulting material has six times the strength of unprocessed copper yet retains most of the metal's characteristic ductility, or stretchiness.

In the 1980s, materials scientists discovered that solid metals are stronger when their crystalline grains are on the order of 100 nanometers or so in diameter. Unfortunately, nanocrystalline materials' superlative strength is usually accompanied by very low ductility.

Instead of accepting this apparent tradeoff, Ma and his colleagues sought a compromise. About 75 percent of their material's grains are just a couple of hundred nanometers wide, enhancing the metal's strength. The rest of the copper's crystals grow into larger, microscale grains. This combination gives the copper good ductility, says Ma.

The results are "really great," comments Julia Weertman of Northwestern University in Evanston, Ill. "You have a good increase in strength without having to sacrifice the ductility."

To give their material its unusual internal structure, the researchers first cooled a 1-inch cube of copper to nearly –200°C and then passed the frigid cube between heavy rollers, flattening it to about 1 millimeter in thickness. Then they heated the resulting sheet to 200°C for 3 minutes before returning it to room temperature.

This procedure is much easier than many methods for making nanocrystalline materials, which rely on compacting powders of nanoscale particles, says Ma. He and his coworkers now plan to repeat their experiments with other pure metals and with alloys.

The new process ought to be applicable to these materials, comments Ruslan Valiev of the Institute of Physics of Advanced Materials at Ufa State Aviation Technical University in Russia. "It is important to check this experimentally, and I hope it will be done soon," he says.

A strong, pure metal processed with the new technique might even replace alloys for some applications, suggests Ma. In biomedical implants, for instance, a pure metal might reduce the likelihood of corrosion or adverse reactions to a metal mixture, he says. —J. GORMAN

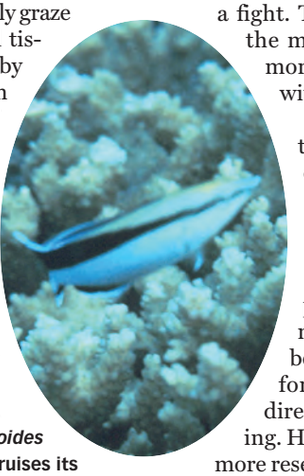
Fish Fraud

Cleaners show off before biting clients

Some of the reef fish that make their living by nibbling parasites off other fish may be luring clients into scams by offering free massages.

Widespread fish called cleaner wrasses (*Labroides dimidiatus*) normally graze on the parasites and diseased tissue of other species that stop by for grooming, explains Redouan Bshary of the University of Cambridge in England. However, some of the cleaner wrasses cheat now and then by taking a bite of healthy flesh out of a client.

Now Bshary proposes new twists to this scam. Client fish seem to keep track of the reputation of specific cleaner wrasses, preferentially visiting those previously seen with an unruffled customer, he reports in the Oct. 22 *Proceedings of the Royal Society of London B*. Also, some devious cleaners take advantage of this so-called image scoring by clients, says Bshary. They give extra-special treatment to one client, even stroking it with their fins in a fish version of a massage. When the next client settles in, perhaps lured by the apparent four-star service, the cleaner wrasse bites.



CLEANER A wrasse, *Labroides dimidiatus*, cruises its reef home between sessions of grooming other fish.

Other work has shown that people also decide whether to cooperate based on the image of their potential partners. "This is the first study of image-scoring in animals other than humans," Bshary says.

"Some cleaners have found a way to exploit image scorers," he says. "Contrary to the predictions of models, image scoring does not lead to pure cooperation" between cleaners and clients.

Bshary observed the cleaner wrasses in a sheltered bay opening into the Gulf of Aqaba at Mersa Bareika, Egypt. Some cleaner wrasses nipped their clients, which gave a visible jerk, about five times more often than typical cleaner wrasses did. The biting cleaners mostly nipped nonpredatory species, not fish that could bite them back.

Bshary monitored this fishy business for an hour at each of 28 cleaning stations. He reports that a potential client was significantly more likely to stop for a cleaning if the previous cleaning had just ended well than if it ended in an aggressive chase or spat. He scored as positive those endings in which the previous client swam away serenely in the 5 seconds before a new cleaning session started.

Bshary also noticed that about half of the biting cleaners' interactions with their littler clients consisted of fin contact only. The cleaner fish, riding on the back of the client, brushes its pelvic and pectoral fins against the client and "provides a massage," says Bshary. The fish generally do this at the end of an apparently aggressive encounter, as if making peace after a fight. The next cleaning after the massage, Bshary found, more often than not ended with biting.

Manfred Milinski of the Max-Planck Institute of Limnology in Plön, Germany, cautions that the case for calling these behaviors image scoring is "not a watertight proof" because Bshary merely observed the behaviors and hasn't performed experiments that directly test for image scoring. However, he predicts that more research would confirm the hypothesis. —S. MILIUS

Iron-Poor Star

Closing in on the birth of the first stars

For decades, astronomers have been searching for stars born soon after the Big Bang, around the time the Milky Way began forming. Researchers now report that they've found one of these ancient stars.

According to a widely accepted theory, the Big Bang forged nearly all of the hydrogen and helium in the universe but only trace amounts of a few other heavier elements. In time, as star formation

W. KIRK; NOAA

began, the gas that condensed to form galaxies became increasingly enriched with heavier elements. All stars synthesize heavy elements, but the largest supply has come from massive stars exploding as supernovas. The very oldest stars, born before most supernova explosions had a chance to pop off, should therefore contain only a minuscule supply of iron and other metals.

In the Oct. 31 *Nature*, astronomers report finding a Milky Way star that has just one-two-hundred-thousandth the iron content of the sun, an amount that's just one-twentieth that of the previous record holder among iron-poor stars. The discovery team includes Norbert Christlieb of Hamburg University in Germany and Timothy C. Beers of Michigan State University in East Lansing.

"This is the closest astronomers have come to having direct knowledge of the chemistry of the universe shortly after the Big Bang," says Beers.

That's not to say that the star, which lies within the galaxy's ancient halo, belongs to the very first generation of stars, adds Beers. That the star contains small amounts of iron and other metals, rather than none at all, is evidence that it must have been preceded by a generation of yet older, massive stars that exploded as supernovas, he notes. Dubbed HE01017-5240, the star "may be the first example of a truly second-generation star," Beers says.

Several theorists have calculated that the very first stars were 50 to 300 times more massive than the sun *(SN: 6/8/02, p. 362)*. These behemoths would have died in supernova explosions just a few million years after their birth.

In contrast, the newly discovered star, which lies 36,000 light-years from Earth, is about four-fifths the mass of the sun. Such low-mass stars not only live far longer than heavier stars but are much more common. By measuring the chemical composition of HE0107-5240, "we're starting to get the recipe for how [the more typical] low-mass stars formed," says Beers.

"When I first heard about these results, I was jumping up and down," says Tom Abel of Pennsylvania State University in State College, whose research focuses on simulating the birth of the first stars. He speculates that the star might have formed as long as 200 million years after the Big Bang.

Like several other iron-deficient stars, HE0101-5240 has an abnormally high abundance of carbon and nitrogen. Beers and his colleagues say that the presence of those heavy elements doesn't negate the star being ancient. They suggest that the star wasn't born with these elements but produced them over its lifetime. Alternatively, the star may have been born with a more massive partner that transferred the two heavier elements to it, suggests Beers.

The variations in the abundance of elements heavier than helium, which astronomers sweepingly refer to as metals, is further evidence that HE0101-5240 formed at a time so early in the universe that heavy elements weren't yet evenly distributed, says Abel.

The discovery team analyzed millions of stellar spectra in search of the most ancient stars, narrowing the candidates to about 8,000 metal-poor stars. The scientists then took high-resolution spectra of several stars, including HE0101-5240, with one of the quartet of 8-meter telescopes collectively known as the Very Large Telescope, in Paranal, Chile. If more such stars are found, it could lead to a more refined estimate for the age of the universe. —R. COWEN

Hidden Effect?

Hypertension risk linked to common, over-the-counter pain relievers

Women who take over-the-counter medicines for headaches and inflammation boost their chances of developing high blood pressure, a long-term epidemiological study suggests. Among the drugs are acetaminophen and ibuprofen, but not aspirin, researchers report in the Oct. 28 *Archives of Internal Medicine*.

Scientists analyzed medical and lifestyle data from questionnaires filled out by 80,020 female nurses aged 31 to 50. The surveys, completed by women in 15 states in 1995 and again in 1997, revealed how often the women used these analgesics and whether they had been diagnosed with high blood pressure during that time.

About half the women took aspirin at least once a month, and three-fourths used acetaminophen or nonsteroidal anti-inflammatory drugs (NSAIDs), such as ibuprofen or naproxen, that often.

Women taking acetaminophen or NSAIDs in any amount had about a one-sixth greater incidence of high blood pressure than did women who didn't take any of the analgesics. Moreover, compared with the no-analgesics group, women who took acetaminophen or NSAIDs at least 22 days per month had roughly twice the rate of high blood pressure, and women who took aspirin, whether seldom or frequently, were no more likely to have high blood pressure, the researchers found.

Acetaminophen is sold as Tylenol; ibuprofen, as Advil or Motrin. Both drugs are also marketed generically.

To eliminate any differences among the women that might skew the results, the scientists took into account age, weight, and other physical and lifestyle factors, says study coauthor Gary C. Curhan, an epidemiologist and nephrologist at Harvard Medical School in Boston.

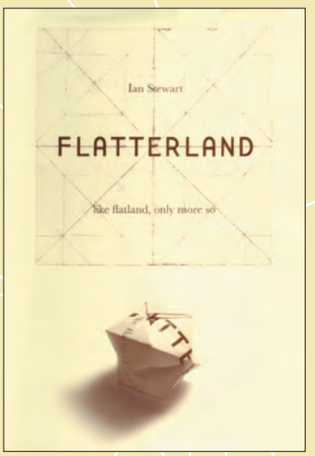
It's possible that women taking acetaminophen and NSAIDs have more aches and pains and therefore visit doctors more often than women not taking analgesics, he says. Such women might get their blood pressure checked more frequently and hence be diagnosed with hypertension more often. However, such "detection bias" seems unlikely here, Curhan says, because the women routinely taking aspirin, another analgesic, presumably would fall into the same group. Yet they were no more likely to have hypertension than women not taking the pain relievers.

Any biological link between having high blood pressure and taking pain relievers remains obscure, Curhan says. But there are points at which the phenomena cross paths. For example, natural hormonelike compounds called prostaglandins influence blood pressure, inflammation, and muscle contraction. NSAIDs inhibit prostaglandin production in the body, which is how the drugs reduce inflammation. Acetaminophen apparently does so in the brain (*SN: 9/21/02, p. 180*).

Even so, precisely how the drugs' influence on prostaglandins—or other compounds in the body—might increase blood pressure has yet to be determined, Curhan says.

Mahendr S. Kochar, an internist at the Medical College of Wisconsin in Milwaukee, agrees. "This work is provocative," he says. It raises a question about connections between high blood pressure and NSAIDs and acetaminophen, "but I don't think it answers it." To do that, researchers need to conduct a blood pressure study in which some participants get placebos instead of acetaminophen or NSAIDs, Kochar says, and that might help establish a cause and effect. —N. SEPPA

SPACE, TIME, MATTER, AND... MODERN GEOMETRIES



Perseus Publishing, 2002, 301 pages
5" x 8", paperback, $14..00

First there was Edwin A. Abbott's remarkable *Flatland*, published in 1884 and one of the all-time classics of popular mathematics. Now, from mathematician and accomplished science writer Ian Stewart, comes a dazzling, modern sequel.

Flatterland provides an engaging, completely accessible guide to some of the trickiest concepts in contemporary mathematics. Through larger-than-life characters and an inspired story line, Flatterland explores our present understanding of the shape and origins of the universe, the nature of space, time, and matter, as well as modern geometries and their applications.

The journey begins when our heroine, Victoria Line, comes upon her great-great-grandfather A. Square's diary, hidden in the attic. The writings help her to contact the Space Hopper, who tempts her away from her home and family in Flatland and becomes her guide and mentor through 10 dimensions.

Informed by Stewart's ingenious stream of wordplay and crackling dialogue, *Flatterland* is the story of Vikki's fantastic voyage through the Mathiverse. From the Charming Construction Entity to Moobius, the one-sided cow, from the Hawk King to the Space Girls, her encounters grow ever stranger. She watches two Parallel Lions meet and sees the Doughmouse change a doughnut into a teapot without breaking any mathematical rules. She experiences the universe expanding from the outside and survives a harrowing trip through a black hole. Finally, armed with a clearer vision of the world beyond, Vikki makes her way home to two-dimensional Flatland—and starts to spread the word.

In the tradition of *Alice in Wonderland* and *The Phantom Tollbooth*, this magnificent investigation into the nature of reality is destined to become a modern classic.

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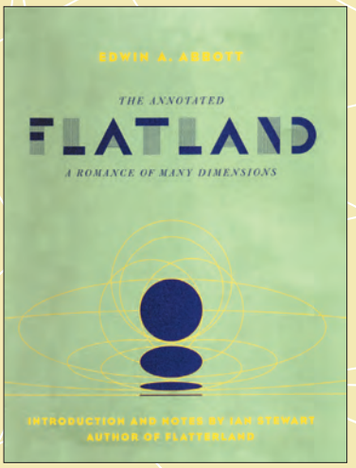

Perseus Publishing, 2002, 239 pages
7 ⅛" x 9 ½", hardcover, $30.00

Flatland is a unique, delightful satire that has charmed readers for over a century. Published in 1884 by the English clergyman and headmaster Edwin A. Abbott, it is the fanciful tale of A. Square, a two-dimensional being who is whisked away by a mysterious visitor to The Land of Three Dimensions, an experience that forever alters his worldview. By contemplating the notion of dimensions beyond their own, Abbott's Victorian readers were exposed to the then-radical idea of a fourth dimension—preparing them for Einstein's spectacular theories of relativity.

Like the original, Ian Stewart's commentary takes readers on a strange and wonderful journey. With clarity and wit, Stewart illuminates Abbott's numerous Victorian references, weaves in little-known biographical information about Abbott and his intellectual circle—elucidating Abbott's remarkable connections to H.G. Wells and the mathematician George Boole—and traces the scientific evolution of geometric forms and dimensions.

Further, Stewart provides an extensive bibliography of Abbott's work and that of Charles Howard Hinton, whose wild but ingenious speculations about the fourth dimension undoubtedly inspired Abbott's fable.

Touching on such diverse topics as ancient Babylon, Karl Marx, the Indian Mutiny of 1857, Mary Shelley's *Frankenstein*, the Gregorian calendar, Mt. Everest, and phrenology, Stewart makes fascinating connections between Flatland and Edwin A. Abbott's life and times. The result is a book that will inspire and delight curious readers for generations to come.

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ELECTION SELECTION

Are we using the worst voting procedure?

BY ERICA KLARREICH

As Election Day approaches, voters must be feeling a sense of déjà vu. With recent reports of malfunctioning voter machines and uncounted votes during primaries in Florida, Maryland, and elsewhere, reformers are once again clamoring for extensive changes. But while attention is focused on these familiar irregularities, a much more serious problem is being neglected: the fundamental flaws of the voting procedure itself, say various researchers who study voting.

Nearly all political elections in the United States are plurality votes, in which each voter selects a single candidate, and the candidate with the most votes wins. Yet voting theorists argue that plurality voting is one of the worst of all possible choices. "It's a terrible system," says Alexander Tabarrok, an economist at George Mason University in Fairfax, Va., and director of research for the Independent Institute in Oakland, Calif. "Almost anything looks good compared to it."

Other voting systems abound. One alternative is the instant runoff, a procedure used in Australia and Ireland that eliminates candidates one at a time from rankings provided by each voter. Another is the Borda count, a point system devised by the 18th-century French mathematician Jean Charles Borda, which is now used to rank college football and basketball teams. A third is approval voting, used by several scientific societies, in which participants may cast votes for as many of the candidates as they choose.

Unlike these procedures, the plurality system looks only at a voter's top choice. By ignoring how voters might rank the other candidates, it opens the floodgates to unsettling, paradoxical results.

In races with two strong candidates, plurality voting is vulnerable to the third-party spoiler—a weaker candidate who splits some of the vote with one of the major candidates. For instance, in the hotly contested 2000 U.S. presidential race, Republican George W. Bush won the state of Florida—and, consequently, the presidency—by just a few hundred votes over Al Gore, the Democratic candidate. Green Party candidate Ralph Nader won 95,000 votes in Florida, and polls suggest that for most Nader voters, Gore was their second choice. Thus, if the race had been a head-to-head contest between Bush and Gore, Florida voters probably would have chosen Gore by a substantial margin. Should Nader have withdrawn from the race, as many angry Democrats asserted? Certainly not, says mathematician Donald Saari of the University of California, Irvine. "We live in a democracy, and anyone should be able to run for any office," he says. "The problem was the bad design of the election."

Mathematics can shed light on questions about how well different voting procedures capture the will of the voters, Saari says. In ongoing work, he has been using tools from chaos theory to identify just which scenarios of voter preferences will give rise to disturbing election outcomes. "With the muscle power of mathematics, we can address these questions and finally get some results," he says.

SINGULAR PLURALITY In elections with only two candidates, plurality voting works just fine, since the winner is guaranteed to have been the top choice of more than half the voters. But as soon as three or more candidates are on the ballot, the system can run into trouble.

In races with a large slate of candidates, plurality voting dilutes voter preferences, creating the possibility of electing a leader whom the vast majority of voters despise. In the French election last April, with 16 candidates on the ballot, extreme right-wing candidate Jean-Marie le Pen—widely accused of racism and anti-Semitism—managed to place second with just 17 percent of the vote. He then advanced to a runoff against the top candidate, incumbent President Jacques Chirac. Political analysts scrambled to explain le Pen's success, putting it down to voter disenchantment and a surge in right-wing fervor across Europe. But the real reason, voting theorists say, is that the plurality vote distorted the preferences of the voters.

"The fact that le Pen was in the runoff had nothing to do with what the people wanted," Saari says. The runoff election, in which Chirac trounced le Pen with 82 percent of the vote, suggests that while le Pen was at the top of a few voters' lists, he was near the bottom of many more. "There is no question that under almost any other system, le Pen would not have made it to the runoff," says Steven Brams, a political scientist at New York University.

> "I don't think any voting theorist would choose plurality rule today."
>
> —ALEXANDER TABARROK

If it weren't for the plurality system, Abraham Lincoln might never have become president, Tabarrok says. In the four-candidate 1860 election, Lincoln was a polarizing figure, popular with many Northerners but abhorred by many Southerners. Stephen Douglas, Lincoln's closest competitor, was more broadly popular, and although he didn't get as many first-place rankings as Lincoln did, he was nearly everyone's second choice, historians hold. In 1999, Tabarrok and Lee Spector, an economist at Ball State University in Muncie, Ind., calculated that if almost any other voting system had been used, history books would refer to President Douglas, not President Lincoln. "On paper, Lincoln's victory looks overwhelming, but he actually didn't have broad-based support," Tabarrok says. With Lincoln now a folk hero, the result of that election might seem good in retrospect. But that's a separate matter from whether the voters actually preferred Lincoln on Election Day, 1860.

History is full of similar situations, Tabarrok says. "One thing we've discovered is how radically the outcome of an election can change by even a small change in the voting system," he says.

In some elections, in fact, any one of the candidates can be the winner, depending on what voting system is being used (see box, page 281). Saari has calculated that in three-candidate elections, depending on the voting system, more than two-thirds of all possible configurations of voters' preferences will yield different outcomes.

NO ONE'S PERFECT Is there a best voting procedure? In 1952, Kenneth Arrow, a professor emeritus of economics at Stanford University in Palo Alto, Calif., proved that no voting system is completely free from counterintuitive outcomes. Arrow looked at voting systems that satisfy two harmless-sounding properties. First, if everyone prefers candidate A to candidate B, then A should be ranked higher than B. Second, voters' opinions about candidate C shouldn't affect whether A beats B—after all, if you prefer coffee to tea, finding out that hot chocolate is available shouldn't suddenly make you prefer tea to coffee. These sound like reasonable restrictions, yet Arrow proved that the only voting system that always satisfies them is a dictatorship, where a single person's preferences determine the outcome.

The paradoxical behavior Arrow studied crops up all the time. Saari points to the 2000 Bush-Gore-Nader race in Florida. "It's a beautiful example of Arrow's theorem at work," Saari says.

While Arrow's theorem shows that no system is flawless, many capture voter preferences more effectively than plurality voting does. For instance, the paradoxical outcome of the Florida race might have been avoided under the instant runoff, which is advocated by the Center for Voting and Democracy in Takoma Park, Md. In that system, voters rank the candidates, then the candidate with the fewest first-place votes is dropped. That candidate is erased from the voters' preference lists, and ballots of voters who had placed him first are converted into votes for their second choice. From the remaining candidates, once again the one with the fewest first-place votes is dropped. When only two candidates remain, the one with more top votes wins. Since voters communicate their entire ranking when they vote, there's no need to hold repeated elections. In Florida, Nader would probably have been eliminated in an instant runoff, most of his votes converted into votes for Gore.

An instant runoff also reduces the dangers inherent in an election with many candidates. In the French election, most of the voters who selected one of the weaker candidates probably preferred Chirac or the then–prime minister, Socialist Lionel Jospin, to le Pen. Then in an instant runoff, as candidates were eliminated, their votes would have gone to Chirac and Jospin.

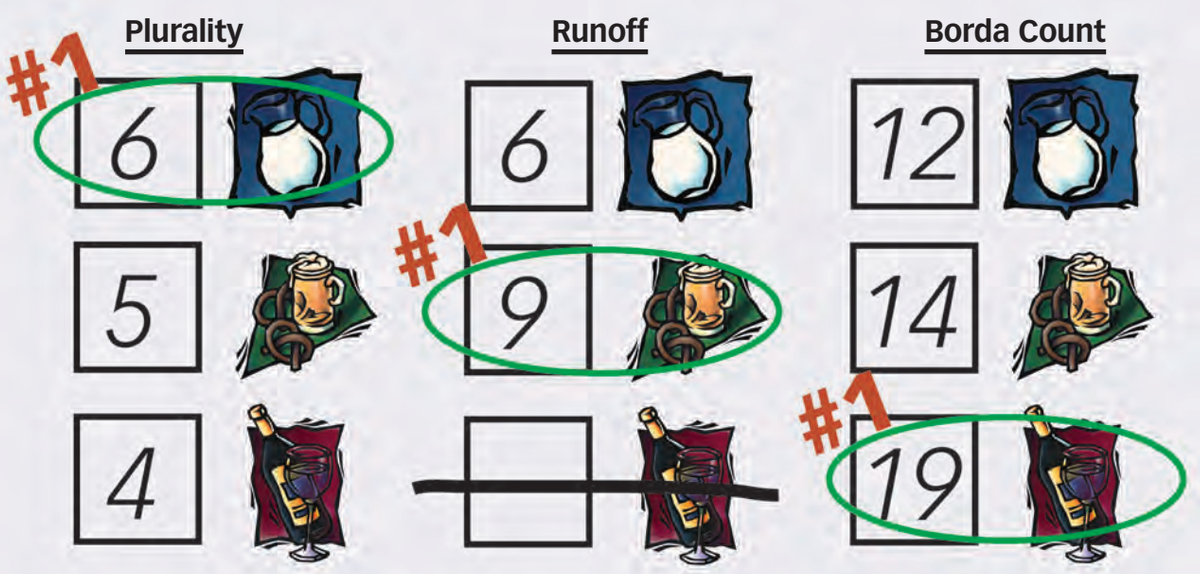
Instant-runoff voting could make campaigns both more civil and more issue oriented, suggests Terry Bouricius, New England regional director for the Center for Voting and Democracy. "To win, you have to be highly ranked by a majority of voters, and you also have to appeal to a bunch of voters strongly enough to get their first-place votes," he says. "So, you have to distinguish yourself from the other candidates but also build coalitions."

CHAOS IN THE POLLING PLACE Whatever its potential benefits, instant-runoff voting is prone to one of voting theory's most bewildering paradoxes. If a candidate is in the lead during an election season, making a great speech that attracts even more supporters to his cause shouldn't make him lose. But in the instant-runoff system, it can. Suppose, for example, that 35 percent of voters prefer A first, B second, and C third; 33 percent prefer B first, C second, and A third; and 32 percent prefer C first, A second, and B third. In an instant runoff, C will be eliminated, leaving A and B to face each other. A scoops up C's first-place votes, winning a resounding 67 percent to 33 percent victory over B. But suppose A makes such an inspiring speech that some voters who liked B best move A into first place, so now 37 percent rank the candidates as A-B-C, 31 percent as B-C-A, and 32 percent as C-A-B. Now, A faces C in the runoff, not B. The votes that ranked B first become votes for C, and C beats A, 63 percent to 37 percent.

And the winner is?

Different voting methods can produce very different results

In some elections, any candidate can win, depending on which voting system is used, says Donald Saari of the University of California, Irvine. Consider 15 people deciding what beverage to serve at a party. Six prefer milk first, wine second, and beer third; five prefer beer first, wine second, and milk third; and four prefer wine first, beer second, and milk third. In a plurality vote, milk is the clear winner. But if the group decides instead to hold a runoff election between the two top contenders—milk and beer—then beer wins, since nine people prefer it over milk. And if the group awards two points to a drink each time a voter ranks it first and one point each time a voter ranks it second, suddenly wine is the winner. Although this is a concocted example, it's not an anomaly, Saari insists. —E.K.



In an article to be published early next year in the *Journal of Economic Theory*, Saari has catalogued scenarios that give rise to this type of paradox. It can occur in any voting procedure with more than one round, he has found, but never in one-round procedures.

Saari's result draws on a seemingly unrelated field of mathematics: chaos theory, which studies physical systems, such as the weather, in which tiny changes in the starting conditions can have drastic repercussions. Chaos researchers look for points at which the systems' parameters stabilize momentarily and then change direction, since only near those points can a small change produce dramatic effects. Saari realized that in voting theory, only when an election is nearly tied does a small change in voter preferences swing the election in a new direction. By looking at arrangements of ties, Saari has classified the possible paradoxical outcomes for a wide range of procedures.

Saari argues that the way to identify the best voting procedure is to consider which scenarios should result in ties. If three voters have what researchers call cyclic preferences—one prefers A-B-C, one B-C-A, one C-A-B—there should be a tie, he says. Likewise, if two voters have exactly opposite preferences—one prefers A-B-C, say, and the other, C-B-A—their votes should cancel. The only common voting procedure that would give a tie to both of these cases is the Borda count, which gives two points to a voter's top choice and one point to his second choice in a three-candidate election.

Like the instant runoff, the Borda count gives weight to a voter's entire preference ranking. If the Borda count had been used, second-place votes would probably have tipped the 2000 race in Gore's favor, Saari and Brams say. And in France, it's highly unlikely that le Pen would have come in second, Saari says.

Saari has shown that the Borda count is much less prone to the kinds of paradoxes that Arrow studied than most other systems are. Using ideas from chaos theory, Saari has found, for instance, that plurality voting in a six-candidate election gives rise to 10^{50} times as many paradoxical situations as the Borda count does.

APPROVE OR DISAPPROVE Not all the researchers are fans of the Borda count, however. Brams objects that it forces voters to rank all the candidates, even when there are some about whom they have no strong opinion, potentially leading to outcomes that don't really reflect voter preferences.

Brams prefers approval voting, in which people vote for as many candidates as they like. Approval voting, Brams says, gives voters more sovereignty by enabling them to express the intensity of their preferences: a voter who strongly favors one candidate can vote for just that candidate, while a voter who can't stand one candidate can vote for everyone else. A voter with more- moderate views can vote for any number of candidates between these two extremes.

It's hard to predict the outcome of an approval vote since voters' choices depend on where they draw the line between approval and disapproval. But Brams argues that approval voting would significantly alter voter behavior in many elections. In the 2000 presidential race, for instance, approval voting would have enabled Nader supporters to vote for him and also for one of the two stronger contenders.

While the instant runoff, Borda count, and approval voting each has drawbacks, most voting theorists would be happy to replace plurality voting with any one of them. "All methods that allow voters to express their views fully rather than to single out one candidate convey a much more nuanced message to the political machine," says Hannu Nurmi, a political scientist at the University of Turku in Finland.

The fact that U.S. elections have always been plurality votes is no reason to resist change, Tabarrok says. "We chose our voting systems before voting theory existed," he says. "I don't think any voting theorist would choose plurality rule today."

The real lesson to draw from recent election anomalies, voting theorists say, is that citizens should think carefully not just about how well the election machinery counts up the votes but also about how they want the votes to count. ■

ONCE UPON A LAKE

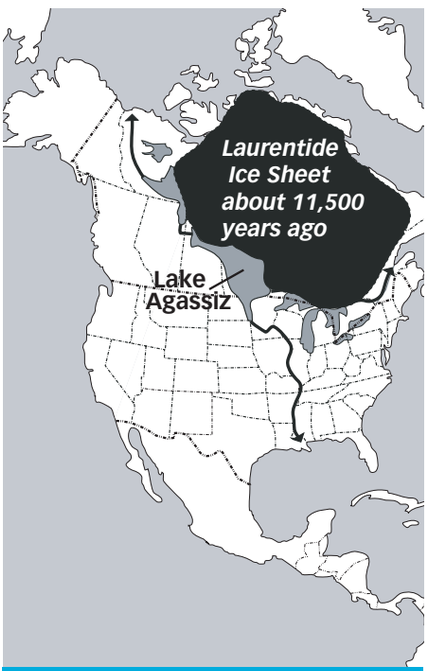
The life, times, and demise of the world's largest lake

BY SID PERKINS

During the last ice age, sea levels fell more than 100 meters. The ocean water didn't disappear, of course. It just ended up someplace else. A significant decrease in global temperatures permitted snow in some places to accumulate faster than it melted. Glaciers formed at high altitudes and scoured mountain valleys. Existing ice masses, like those in Greenland and Antarctica, thickened. In the higher latitudes of Asia, North America, and Europe, ice sheets hundreds of meters thick grew to smother vast regions.

When Earth's average temperature began to rise and the ice started to melt, the water long sequestered on continents once again sought the sea. Along many edges of the ice sheets, meltwater could flow directly into the ocean. In the interiors of continents, however, the ice sheet itself blocked the water's downhill progress. Immense lakes formed, deepened, and spread across the landscape until they reached a spillway or broke through a weak spot along the ice sheet's edge to scour a new route to the ocean.

During the waning days of the ice age, North America's Lake Agassiz was the largest body of fresh water in the world. At times it held more water than that in all the world's lakes today. Lake Agassiz strongly influenced North American climate, but scientists have also linked several major surges of fresh water from the lake to sudden global climate changes. The last and largest of these discharges was associated with a 400-year-long cold spell and raised sea levels about a half-meter. It also may have been the source of the flood stories included in the Bible and the Babylonian Epic of Gilgamesh.



THREE EXITS — At various times, Lake Agassiz drained northwest through the Mackenzie River, south through the Mississippi River, and eastward through the St. Lawrence River. Arrows show drainage routes for those outlets.

FISHER

A LAKE IS BORN Between 18,000 and 20,000 years ago, at the height of the last ice age, the Laurentide Ice Sheet covered Canada east of the Rockies. At its highest point, over what is now Hudson Bay, the ice was nearly 5 kilometers thick and weighed so much that it depressed the underlying terrain more than 1 km. Tonguelike lobes of ice spilled into the Midwest as far south as Iowa and central Illinois, and their meltwater fed tributaries of the Mississippi River and ultimately flowed into the Gulf of Mexico.

Then, about 13,000 years ago, the southern edge of the ice sheet retreated past the divide that separates the Mississippi watershed from areas that drain northward. After that time, meltwater pooled against the ice sheet on the northern slope of the divide. Thus, Lake Agassiz was born. The lake was named after Louis Agassiz, the 19th-century Swiss geologist who first proposed that massive ice sheets once covered large areas of continents.

The size, shape, and depth of the lake changed significantly—and sometimes rapidly—over its lifetime, says David W. Leverington, a geologist at the Smithsonian Institution's Center for Earth and Planetary Studies in Washington, D.C. Scattered remnants of Lake Agassiz' ancient beaches stretch across the Canadian landscape like partially scrubbed bathtub rings.

The northern edge of Lake Agassiz followed the fluctuating position of the ice sheet. The locations and altitudes of spillways largely determined the depth of the lake, Leverington explains. The water would rise until it reached an outlet, at which point the lake would overflow. By carbon-dating sediments deposited in the lake's spillways or in marshes left high and dry by sudden drops in water, scientists can now chronicle the lake's changing profile.

In its earliest stages about 13,000 years ago, Lake Agassiz' overflow spilled down the Mississippi River. Some of the oldest beaches stretched along the lake's southern and western shores, from an outlet in North Dakota northward into Manitoba. Leverington and his colleagues at the University of Manitoba in Winnipeg estimate that the lake then covered more than 134,000 square kilometers. At that time, the researchers say, what is now Winnipeg was submerged beneath about 200 m of icy water.

Then, a new spillway opened along the eastern edge of the lake. A sudden 100-m drop in lake level sent 9,500 cubic kilometers of fresh water—about 85 percent of Lake Agassiz' volume at the time—flowing through the Great Lakes and the St. Lawrence River into the North Atlantic. This abrupt change in the routing of meltwater coincided with the onset of a 1,600-year worldwide cold spell known as the Younger Dryas, says Peter U. Clark, a geophysicist at Oregon State University in Corvallis.

The period's cooler temperatures are recorded in ice cores in Greenland, lake sediments in Japan, deposits drilled from the ocean floor off the northern coast of South America, and elsewhere. Many of these climate indicators suggest that the Atlantic's influx of fresh water from Lake Agassiz interrupted the ocean's transport of heat from the equator to high latitudes. Many researchers suggest that this heat transport, called the thermohaline circulation, drives Earth's climate.

OF NOTE

TECHNOLOGY

Triggering genes in a flash

Flicking a switch can now turn on much more than just the lights. Thanks to a technique developed by a team of biologists in California, a light pulse can activate or deactivate selected genes in cells.

Sae Shimizu-Sato of the University of California, Berkeley and the U.S. Department of Agriculture in Albany, Calif., and her colleagues rendered a yeast gene light-triggerable by splicing plant genes into yeast cells. Those genes included one for a light-sensitive plant protein called a phytochrome, which changes shape upon absorbing certain wavelengths of red light.

In one configuration, the phytochrome joins with other proteins to turn on the selected yeast gene. Switched to another shape by a dose of different red light, the phytochrome releases those partner proteins, shutting off the gene.

The team described its new technique in the October *Nature Biotechnology*. In a commentary in the same issue, Andrew R. Mendelsohn of the Molecular Sciences Institute in Berkeley, Calif., says the method may give researchers unprecedented control over biological processes such as cell communication and some enzyme functions. If so, Mendelsohn declares, "this report would seem to signal the dawn of the age of light-based biological engineering." —P.W.

ASTRONOMY

Enlarging a Mars photo album

A new set of more than 18,000 images of Mars, posted online in early October, features the sharpest picture of the Red Planet ever taken by an orbiting spacecraft. That image, a view of gullies in a crater in the Newton Basin, allows planetary scientists to study features as small as a school bus.

The newly archived planetary images (http://www.msss.com/moc_gallery/e07_e12/globalmaps.html) were recorded by the Mars Global Surveyor spacecraft between August 2001 and January 2002. Surveyor, which arrived at the Red Planet in 1997 and continues to map the Martian surface and climate, has returned more data on Mars than all other Mars missions combined.

Other images in the new series show planetwide dust storms and the springtime retreat of the south polar ice cap. Scientists are using some of the pictures to help choose a landing site for the Mars Exploration Rover mission, which is scheduled for launch next year. —R.C.

BIOLOGY

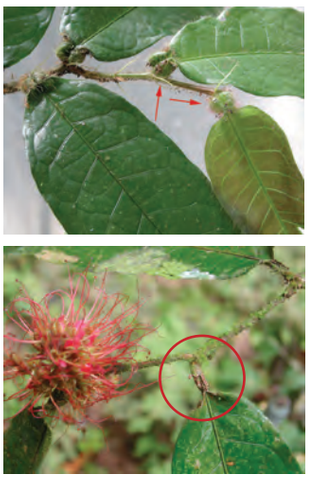
Ant cheats plant; plant cheats back

A tropical tree acts as a fickle but pragmatic landlord, report researchers in Brazil.

This small tree of the central Amazon, *Hirtella myrmecophila*, grows a pair of little pouches at the base of young leaves. Two-millimeter-long ants of the species *Allomerus octoarticulatus* move into the pouches.

Plenty of plants offer ants special shelters in exchange for protection from other insects, says Heraldo L. Vasconcelos of Universidade Federal de Uberlândia in Brazil. Sometimes, however, ants exploit the trees' good will by not doing their part. In the case of *H. myrmecophila*, the trees take an unusual countermeasure, report Vasconcelos and Thiago J. Izzo of the Instituto Nacional de Pesquisas da Amazônia in Manaus, Brazil. In a preserve north of Manaus, they found that as leaves age, they shed their little ant pockets.

To figure out why, the researchers excluded ants from some branches. Those branches lost about half their new growth to pests. But the antfree branches also kept about eight times as many flowers as ant-laden counterparts did. In the October *Oecologia*, the researchers propose that the tree benefits from ant security guards when foliage is young but then drops its cozy pouches from branches of mature leaves, preventing the ants from damaging too many flowers. —S.M.



INVITATION DROPPED Young leaves of an Amazonian tree (top) grow pairs of pockets at their base, perfect for ant shelters (arrows). As the tree matures and opens vulnerable blooms (bottom), leaves lose their pockets (circle).

BEHAVIOR

Brain trait fosters stress disorder

Several studies have noted that an inner brain structure, the hippocampus, is unusually small in individuals who, after surviving extraordinary threats, experience flashbacks, nightmares, and other symptoms of post-traumatic stress disorder (PTSD). A new investigation, in the Nov. 1 *Nature Neuroscience*, indicates that some of these people possess an undersized hippocampus before they ever develop PTSD.

This finding challenges the theory that hormonal responses to traumatic events shrink the hippocampus, a brain area implicated in memory and in the learning of fear responses (*SN: 6/3/95, p. 340*).

Psychiatrist Mark W. Gilbertson of Harvard Medical School in Boston and his colleagues studied 40 pairs of identical twins in which one brother had been a Vietnam combat veteran and the other had stayed at home. After the war, PTSD afflicted 17 combat veterans. None of the veterans' brothers developed PTSD.

Magnetic resonance imaging scans identified a smaller hippocampus, relative to total brain size, in those with PTSD than in other combat veterans. In the PTSD group, the hippocampus reached its lowest relative size in men with the most severe psychiatric symptoms. A comparably small hippocampus appeared in the twin brothers of men with PTSD, but not in brothers of other veterans.

A small hippocampus may predispose a person to form intense, long-lasting emotional responses to sights, smells, and other stimuli associated with traumatic events, the scientists theorize.

Trauma-induced atrophy of the hippocampus may still occur and perhaps contribute to PTSD, comments Stanford University biologist Robert M. Sapolsky. For instance, he notes an earlier study of different Vietnam veterans by Gilbertson

OECOLOGIA

OF NOTE

and his team. They found a small hippocampus in those who survived severe combat trauma, whether or not PTSD later occurred. —B.B.

PHYSICS

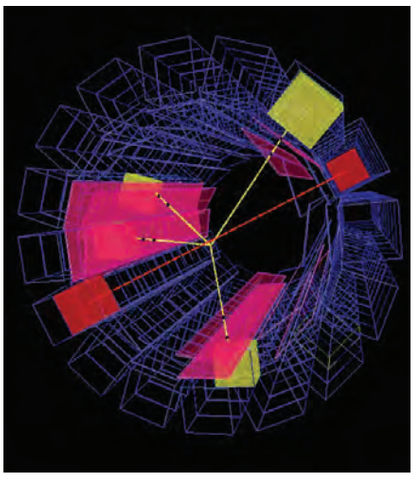
Putting the brakes on antihydrogen

Scientists have long wondered why so little antimatter is found today in the universe. Presumably, both matter and antimatter were created in equal amounts in the Big Bang.

Researchers at the European Organization for Nuclear Research (CERN) in Geneva have now made the first slow-moving atoms of antimatter. By studying them, scientists may more closely compare matter and antimatter and possibly explain the latter's glaring absence.

Well-tested theory holds that every type of particle in matter has an antiparticle with identical mass and spin but opposite electric charge. When such particles meet, the two vanish in a burst of energy.

In the mid-1990s, physicists pieced together the first few atoms of antihydrogen (*SN: 1/13/96, p. 20*), each of which consists of a negatively charged antiproton orbited by one positively charged antielectron, or positron. Scientists couldn't study their properties, however, because the antiatoms were traveling at nearly light speed and were almost instantly annihilated by contact with matter.



SELF-DESTRUCT A tiny fireball, triggered when a drifting antihydrogen atom struck some ordinary matter, unleashes pions (yellow tracks) and gamma rays (red tracks) into surrounding detectors.

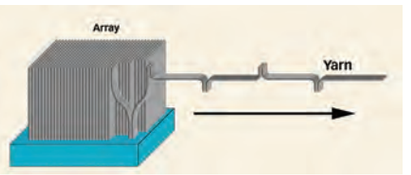
In the new experiment, known as ATHENA, researchers trapped antiprotons in electric and magnetic fields and then mixed them with positrons in an ultracold, jar-size cylinder. In the Oct. 3 *Nature,* the scientists estimate that they've produced about 50,000 atoms of antihydrogen, which last a few microseconds until they drift into the cylinder's walls and are destroyed, says CERN's Rolf Landua. The ATHENA team now expects to modify its setup in the next year or two to begin laser studies of the antiatoms' properties. —P.W.

MATERIALS SCIENCE

Knitting with nanotubes

As if pulling threads from a silkworm's cocoon, researchers in China have drawn fine yarns of carbon nanotubes from a reservoir of the microscopic carbon cylinders.

The resulting nanotube yarns, which can reach lengths of more than 30 centimeters, might eventually be woven into super-strong materials such as bullet-stopping fabrics, suggest Kaili Jiang, Qunqing Li, and Shoushan Fan of the Nanotechnology Research Center at Tsinghua University in Beijing. Carbon nanotubes are hollow tubes of carbon atoms just nanometers in diameter. Despite their size, they're incredibly strong, and they hold promise for future generations of microelectronic chips.



FANCY THREADS A model of the formation of a carbon nanotube yarn.

The scientists stumbled upon their discovery while trying to pull nanotubes from an array. Instead of removing a bundle, the researchers reeled out a continuous length of nanotube yarn. The component threads are each several hundred nanometers wide. Weak forces called van der Waals interactions hold the threads together end-to-end.

The researchers suggest in the Oct. 24 *Nature* that a carbon nanotube array just 1 square centimeter in area can make about 10 meters of yarn.

Unlike other methods of making threads from nanotubes, the new one doesn't require a solvent or some other additive, so the yarn contains pure nanotubes, and after heating, may maintain its superlative mechanical, thermal, and electrical properties, the researchers say (*SN: 12/16/00, p. 398*). In one experiment, the researchers formed the yarn into a lightbulb filament and found that its strength and conductivity increased after it heated up. —J.G.

PHYSICS

Motor design flouts physical law

For centuries, optimistic inventors have proposed perpetual-motion machines. These would defy scientific law, of course, and none has ever worked as advertised. Now, a blueprint for a minuscule perpetual-motion machine has been found convincing enough by other scientists to get published in the October *Foundations of Physics.*

In the report, Daniel P. Sheehan of the University of San Diego and his colleagues describe their design: a square silicon doughnut about the size of a red blood cell. A narrow gap in the doughnut ring would harbor a strong electric field. This would develop, presumably, because ambient heat and the structure's electronic properties would separate charges. By driving a tiny silicon piston within the gap, the device would perform work.

A desktop array of such devices could power an entire office "without plugging any appliances into wall sockets," Sheehan's group projects.

However, the second law of thermodynamics requires that heat-driven machines receive energy that raises their temperatures above that of the surroundings—so that the flow of heat from hot to cold can run the machines (*SN: 10/7/00, p. 234*). By directly converting the heat-generated motion of particles into mechanical power, the proposed device would break that law, Sheehan contends.

Not so, counters Denis J. Evans of the Australian National University in Canberra, who rates the San Diego scheme "impossible." He and his coworkers recently demonstrated that light-guided microspheres in water can briefly violate the second law but obey it over the long run (*SN: 7/27/02, p. 51*). While the San Diego team has done "good work," says Daniel C. Cole of Boston University, the more likely benefit from it will be "qualifications on normal statements of the second law," rather than practical payoffs. —P.W.

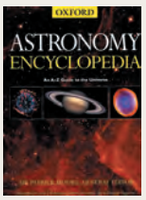
ATHENA COLLABORATION; JIANG, LI, AND FAN

Books

A selection of new and notable books of scientific interest

ASTRONOMY ENCYCLOPEDIA: An A–Z Guide to the Universe

PATRICK MOORE, ED.



More than 3,000 entries pack this oversized, richly illustrated volume that also features colorful photos, descriptive diagrams, and star maps. Virtually every aspect of astronomy, from adaptive optics to cold dark matter, is defined clearly and succinctly. Where needed, entries are quite substantive, carrying on for several paragraphs. The text spans the history of astronomy, from the field's origins to the present era of orbiting telescopes. ***OUP, 2002, 456 p., color/b&w photos/illus., hardcover, $50.00.***

DANGEROUS TASTES: The Story of Spices

ANDREW DALBY

The quest for spices is inexorably linked to the development of global trade and exploration. Dalby profiles individual spices and aromatic botanicals, including the contribution of each to human history. Readers learn, for example, how Greeks and Romans came to crave ginger, which originated in southeast China. Dalby provides background information for each spice, including where it was first used, how it initially fit into that region's culture, and how it came to be exported to other lands. Originally published in hardcover in 2000. ***U CA Pr, 2002, 184 p., paperback, $16.95.***

THE MILLENNIUM PROBLEMS: The Seven Greatest Unsolved Mathematical Puzzles of Our Time

KEITH DEVLIN

Just over 100 years ago in Paris, German mathematician David Hilbert challenged his colleagues to conquer the most significant unsolved math problems of the day. There were 23 on Hilbert's list, which shaped the course of mathematics and brought fame to those who solved them. By 2000, all but one had been cracked. That set the stage for a new challenge brought by the Clay Mathematics Institute. This group announced a prize of $1 million to be awarded for each solution of seven new problems now known as the Millennium Problems. Specifically, they are the Riemann hypothesis, which lingers from Hilbert's list, Yang-Mills theory and the mass gap hypothesis, the P Versus NP problem, the Navier-Stokes equations, the Poincairé conjecture, the Birch and Swinnerton-Dyer conjecture, and the Hodge conjecture. Devlin profiles each problem and offers insight into how it came about and its significance. ***Basic, 2002, 237 p., b&w illus., hardcover, $26.00.***

ENTANGLEMENT: The Greatest Mystery in Physics

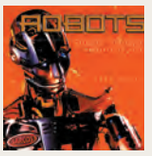
AMIR D. ACZEL

Entanglement is one of science's most provocative ideas. It stems from the realm of quantum mechanics and holds that two particles may be very far apart—conceivably millions of miles away from each other—yet may be inexorably linked. If so, whatever happens to one particle immediately causes a change in the other. Albert Einstein was deeply troubled by entanglement, feeling that it was an incomplete and "spooky" idea. After all, if entanglement were a property of the universe and could be harnessed, then teleportation and other seemingly impossible processes could become realities. Aczel explains how entanglement came of age and was proved through physical experiments once considered undoable. He summons the work and words of physicists at the forefront of this field who aim both to understand how entanglement operates and to manipulate it to advance fields such as cryptography and computing. ***FWEW, 2002, 284 p., b&w plates, hardcover, $25.00.***

ROBOTS: Bringing Intelligent Machines to Life?

RUTH AYLETT

Although robots are inherently mechanical things, Aylett explains that researchers find themselves drawing on nature's own biomechanical innovations to change the way robots move, sense their environments, think, learn, and make decisions. She explains this through illustrated two-page spreads, each devoted to a robotics topic—such as smelling the world or determining locations. She also discusses obstacles confronting the robotics community, including the need for better energy sources and the fear that robots will supercede people. Recommended for age 12 and up. ***Barrons, 2002, 144 p., color photos/illus., hardcover, $23.95.***



STORM WATCHERS: The Turbulent History of Weather Prediction from Franklin's Kite to El Niño

JOHN D. COX

Through profiles of 30 pioneers in the field, Cox unravels the history of meteorology before the advent of high-tech machines that make highly accurate prediction possible. Readers learn about Benjamin Franklin's research on the Gulf Stream and the effects of volcanoes on atmospheric cooling and how expansion-minded government officials ignored John Finley's 19th-century warnings about of the wrath of tornadoes in the U.S. frontier. In the process of telling these individual stories, Cox relates tales of some of the most devastating weather events ever. He also discusses how the weather has influenced history, including how conflicting weather reports may have delayed the launch of D-Day during World War II. ***Wiley, 2002, 252 p., hardcover, $24.95.***

LETTERS

Hot mail

Regarding the article "What the mail must go through" (*SN: 8/31/02, p. 142*), I was shocked. Not by the findings but the resources that were wasted. I have been involved in the radiation sterilization of medical devices for 30 years. Yellowing and brittleness of cellulose materials is well known, as are discoloration and damage to many plastics. Computer chips, CDs, film, and video and audiotapes are usually rendered useless.
JAMES M. GIBSON JR., ODESSA, FLA.

As a former member of the Viking Meteorology Science Team, to me the concept of using irradiation to sterilize the mail, an expensive process, and allowing it to heat mail to more than 130°C appears ridiculous. I suggest that sterilization be discussed with some of my Viking colleagues to see if baking will suffice for this application.
JAMES E. TILLMAN, UNIVERSITY OF WASHINGTON, SEATTLE, WASH.

Pet theory

Rather than early exposure to pets preventing allergies ("Pet exposure may reduce allergies," *SN: 9/7/02, p. 157*), I suspect that families who have allergies may generally tend to avoid having pets in the home because they cause physical discomfort to allergy sufferers.
TERRY LEE, YERINGTON, NEV.

Arctic sneeze

Concerning "Arctic Sneeze: Greenlanders' allergies are increasing" (*SN: 9/7/02, p. 150*), why not explore the connection to much greater use of antibiotics, particularly in recent years, including by expectant mothers and very young children? Could not this factor negatively affect immature immune systems, leading to increases in allergic disorders in otherwise healthy people?
ROBERT C. WAGGONER, MOUNTAIN LAKES, N.J.

CORRECTION *As several scuba divers have informed us, exposure to 2 to 3 atmospheres of pressure, as described in "Into the Tank: Pressurized oxygen is best at countering carbon monoxide exposure"* (SN: 10/5/02, p. 214)*, isn't akin to being under 6 feet of water. Two atmospheres feels like submersion under 33 feet of water, and 3 atm, 66 ft.*

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