SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

FEBRUARY 1, 2003 PAGES 65-80 VOL. 163, NO. 5

olde english milkmaids

getting under a shark's skin

deep-diving drones

temperature guides sperm

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mercury hot spots

SOME ARE VERY COLD

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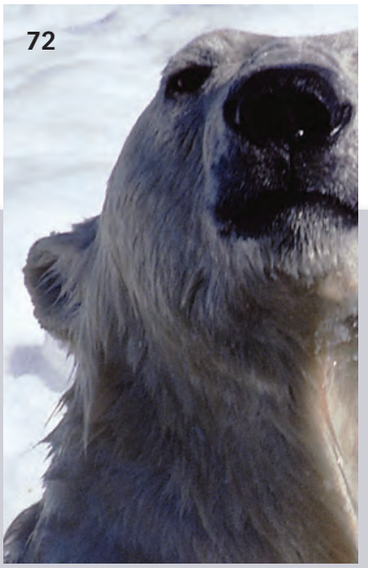

Features

This Week

Of Note

Departments

Cover The atmosphere is full of mercury. Studies are finding that where this toxic metal falls can depend on other air pollutants. Polar coasts can be seasonal hot spots of mercury fallout—perhaps explaining the tainting of polar bears. Page 72

THIS WEEK ONLINE
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Portion inflation Food portions at meals are getting supersized even at home. See Janet Raloff's Food for Thought.

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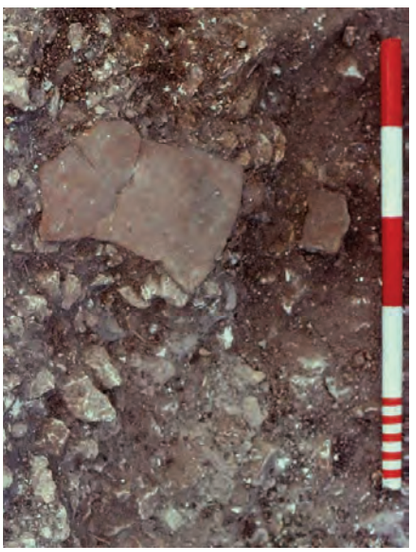
Dairying Pioneers

Milk ran deep in prehistoric England

Farmers who settled in England around 6,000 years ago literally milked cattle and other grazing animals for all they were worth. A chemical analysis of broken pots found at 14 ancient British sites confirms archaeological evidence suggesting that early farmers raised livestock for dairy products as well as for meat.

The new study, directed by chemist Richard P. Evershed of the University of Bristol in England, employed a recently developed mass spectrometric technique to identify milk fats on pots from the ancient sites, which range from about 1,500 to 6,000 years old.

"This is the first direct evidence of milk use at the time farming began in Britain, 6,000 years ago," says archaeologist and study coauthor Sebastian Payne of English Heritage in London, a public agency that supports archaeological work.



COPLEY, EVERSHED, ET AL.; AYASSE

MILKY WAYS Chemical analyses of this pottery fragment and many others reveal widespread dairying in prehistoric England.

These findings, described in an upcoming *Proceedings of the National Academy of Sciences*, reveal only that many pots once contained milk or milk products. "We don't know the extent to which prehistoric people drank milk or converted it into products such as cheese and butter," he says.

Some archaeologists suspect that only after several thousand years of farming did milk make its way into people's diets because lactose, a sugar in milk, commonly elicits allergic reactions. In accordance with that view, Payne speculates that early farmers in England primarily used milk to make lower-lactose dairy products, at least until widespread biological tolerance for the sugar had evolved.

Evershed and his colleagues studied more than 950 pot fragments found among the remains of villages spanning England's Neolithic, Bronze, and Iron ages. Small samples taken from each fragment were ground to a powder and chemically treated using a method that identifies the amounts of different carbon isotopes. Milk fats display a signature ratio of carbon isotopes, distinctive from that for meat fats.

"Evershed's chemical technique is the breakthrough we've been waiting for to investigate prehistoric nutrition," comments archaeologist Andrew Sherratt of the University of Oxford in England.

Many pottery pieces from each site that Evershed's team investigated—including the three oldest sites—contained milk-fat residue, the scientists say. Even the earliest English farmers seem to have employed a variety of agricultural practices, such as domesticating animals, cultivating crops, and dairying, Payne notes.

The new chemical data set the stage for researchers to look for milk-fat residues on pottery from comparably ancient sites in central Europe, adds archaeologist Peter Bogucki of Princeton University. Clues to dairying at these locations consist of large numbers of adult female cattle bones and ceramic strainers possibly used in cheese production, Bogucki says.

Evershed and Payne, with Sherratt, are now searching for milk-fat residues on pottery from about a dozen prehistoric sites in southeastern Europe, Turkey, and the Middle East. Payne suspects that Middle Eastern villagers milked farm animals at least 7,000 years ago. Various farming practices developed slowly there and then spread into Europe as a "package," he speculates.

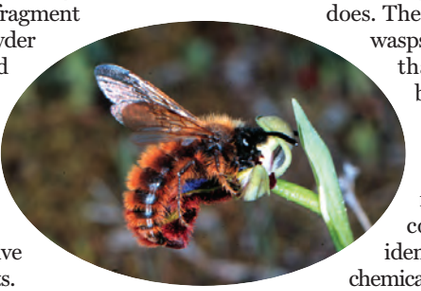
At this point, it's hard to know precisely where dairying and milk consumption began and how they spread from those origins, Sherratt notes. "The milk story is getting fuzzier and more interesting," he says. —B. BOWER

Better Than Real

Males prefer flower's scent to female wasp's

In an extreme case of sex fakery, an orchid produces oddball chemicals that mimic a female wasp's allure so well that males prefer the floral scents to the real thing, scientists say. This plant's come-on is different from that of a related orchid that flirts with bees.

The Mediterranean orchid *Ophrys speculum* manufactures whiffs of the same scent that the female wasp *Campsoscolia ciliata* does. The flower misleads male wasps into mating attempts that benefit the plant by spreading pollen, explains Manfred Ayasse of the University of Ulm in Germany. He and his colleagues have now identified the attractants as chemicals not previously known in plants. The orchids produce them more abundantly than female wasps do, and males prefer the stronger bouquet, the researchers say in an upcoming *Proceedings of the Royal Society of London B.*



OOPS A male wasp is discovering something not quite right about his newest mate, despite the plant's red hair and lovely scent.

This finding adds to the growing respect for the powers of deceptive orchids, according to Ayasse. Biologists had previously concluded that the plants make only mild attractants that males neglect once females appear. Last year, however, scientists found that an Australian orchid releases a scent that attracts inexperienced male bees as well as the actual female scent does (*SN: 7/27/02, p. 56*).

Several hundred orchids have been identified worldwide that use sexual deception to attract pollinators, says coauthor Florian P. Schiestl of the Geobotanical Institute ETH in Zurich.

With brushy red hairs, the *O. speculum* blooms look vaguely like the wasps that pollinate them. The flower produces 100 to 150 volatile compounds, but tests by several scientists had failed to figure out which ones matter, says Ayasse. He and his colleagues hitched a gas chromatograph, which separates scent components, to equipment that measures nerve impulses in insect antennae. With this setup, the researchers identified the 10 compounds that the male antennae detect.

When the researchers offered whiffs of these substances to the wasps, only a few related compounds inspired males to start attempting to mate. One chemical, 9-hydroxydecanoic acid, had been previously described only in honeybees.

The scientists next set out pairs of dead females, one with the scent from a flower blown over it and the other with the scent from a real female wasp. Males responded to the floral scent with more than twice as many attempts to mate as they did to the true sex lure.

This orchid's chemical seduction takes the opposite strategy from that of a species in the same genus that the team had analyzed earlier (*SN: 7/3/99, p. 11*). That study had found that *Ophrys spegodes* relies on a specific blend of more than a dozen common chemicals rather than a mix of a few rare compounds. Finding sister species that take such different approaches indicates that "the [orchid] system is very flexible," Schiestl says.

Says pollination biologist Elizabeth Elle of Simon Fraser University in Burnaby, British Columbia: "Think of it as an arms race. At the moment, the plants are ahead." —S. MILIUS

SENSITIVE GUY Sharks rely on gel under their skin to detect ocean temperatures.

Shark Sense

Gel helps animals detect thermal fluctuations

Sharks possess uncanny skill at tracking down prey, but it's unclear how the animals sense their surroundings so acutely. New studies suggest that a clear jelly under a shark's skin keeps the animal informed about minute changes in seawater temperature that may serve as signposts to feeding grounds.

Brandon R. Brown, a physicist at the University of San Francisco, set out to characterize this mysterious gel. The salty brew of glycoproteins fills hundreds of electrosensory canals, called ampullae, that connect skin pores to subsurface nerve cells in sharks, skates, and rays.

After collecting gel from black-tip reef sharks and white sharks that had recently died at aquariums, Brown placed each sample in a tube and warmed one end. He then measured any voltage produced by the temperature difference along the gel's length. To his surprise, Brown found that a variation as small as 1°C would produce a voltage as large as 300 microvolts. From these data, reported in the Jan. 30 *Nature*, he concluded that a temperature change in seawater of less than a thousandth of a degree Celsius would induce a voltage in the gel filling the ampullae large enough for the shark to detect.

Brown wondered why a shark would require such exquisitely fine temperature detection. Sensitivity to one-thousandth of a degree could be a distraction to the animal unless it served a purpose, he says.

Scientists have known for years that sharks can home in on prey that congregate at thermal boundaries, where the ocean's temperature varies by a couple degrees over a kilometer or so. Brown conjectured that sharks use their supersensitive gel to detect these subtle boundaries.

"My guess is that sensing temperature is a pretty good strategy for finding food," agrees David W. Sims of the Marine Biological Association in Plymouth, England, who has studied sharks and their prey at thermal boundaries. Sharks may use these boundaries as "foraging corridors," he says.

Over the years, researchers have proposed that sharks use their ampullae to find their way and that the sensory canals play a role in detecting temperature. However, the questions of how and how well the canals might do so haven't been answered entirely, Sims notes.

Now, Brown's work indicates that "sharks seem to have the equipment to detect very small temperature changes," says Sims. —J. GORMAN

Rackets and Radicals

Noise may cause gene damage in heart

Exposure to loud, continuous sound can pepper free radicals throughout heart tissue and cause injury to cells' DNA that persists after the din subsides. This new finding from animal research adds to evidence that too much noise may be bad for the heart, but some scientists suggest that the changes may be no more than part of the body's general response to stress.

Research over the past 2 decades has suggested that in addition to causing hearing loss, excessive noise exposure contributes to high blood pressure (*SN: 3/28/81, p. 198*) and elevated death rates from diseases of the heart and arteries (*SN: 5/7/83, p. 294*). Researchers at the University of Pisa in Italy and elsewhere recently reported that noise exposure can damage cells' power-generating structures, or mitochondria.

According to Pisa geneticist Giada Frenzilli, loud sound sensed by the auditory system can trigger a surge in blood concentrations of the hormone norepinephrine, which stimulates heart cells to absorb too much calcium. That can weaken the membranes of the mitochondria and cause them to release free radicals.

To investigate whether free-radical activity induced by noise might damage DNA in cells' nuclei, Frenzilli and her colleagues blasted 10 male lab rats with white noise at 100 decibels, a volume heard in some dance clubs and loud industrial workplaces. Meanwhile, the scientists kept a similar group of rats in relative quiet.

Immediately after 12 hours of these regimens, the researchers removed heart cells from half the rats in each group. The remaining animals got another 24 hours of quiet before Frenzilli's team analyzed their cells.

Under microscopes, mitochondria from the noise-blasted rats had more broken membranes than did those from animals that had experienced quieter conditions. Mitochondria from rats given a day to recover from the din were no better off than those from the other animals exposed to loud noise.

The researchers then examined DNA in the cells' nuclei. Again, the sound-exposed animals displayed damage not suffered by

the other rats and not lessened by a recovery day, the team reports in an upcoming *Environmental Health Perspectives*.

The persistence of the observed effects for at least a day is interesting, says Sandra L. McFadden of the State University of New York at Buffalo. Future research should determine how long the changes last, she says, since damaged DNA can often repair itself, even though cells meanwhile may be more susceptible to other threats. Studies could also test whether subsequent exposure to noise causes more damage or less, she says.

Other researchers note that shorter exposures or less earsplitting volumes might not have similar effects. They also note that the study doesn't address how sound stacks up against other sources of physiological stress.

Kevin K. Ohlemiller of the Central Institute for the Deaf in St. Louis suspects that a general stress response to the deafening noise, rather than any quality unique to sound-induced injury, fully accounts for the activity of the free radicals. —B. HARDER

Heat-Seeking Missiles

Sperm may follow rising temperature to egg

As a blast of Arctic air chills much of the United States this winter, many people travel long distances seeking warmth. Much like sperm, apparently.

A new study suggests that rabbit sperm find their way toward an unfertilized egg by heading toward higher temperatures within the animal's fallopian tubes. The egg rests at a spot slightly warmer than the site where sperm begin the final leg of their journey, and sperm can sense that temperature difference, report Michael Eisenbach of the Weizmann Institute of Science in Rehovot, Israel, and his colleagues in the February *Nature Medicine*.

About a decade ago, Eisenbach's team found that mammalian sperm cells can move toward chemicals secreted by unfertilized eggs, a phenomenon called chemotaxis. That led the investigators to argue that mammalian eggs lure sperm by using attractants. The finding challenged the dogma that the egg is a passive partner in the fertilization process.

Yet Eisenbach wasn't convinced that sperm chemotaxis could occur over the full 2 to 3 centimeters of the mammalian fallopian tube. The tube's natural pulsing prevents a gradient of the attractant from being stable except near the egg, he says.

Recently, Eisenbach read about experiments performed more than a decade ago that showed temperatures varying within female mammals' genital tracts. In one example, English reproductive biologist Ronald Hunter had found that during ovulation, the isthmus—a site in the fallopian tube where sperm rest and mature before moving on—is slightly cooler than the site where fertilization occurs. Hunter had even raised the notion that sperm perceive this temperature difference.

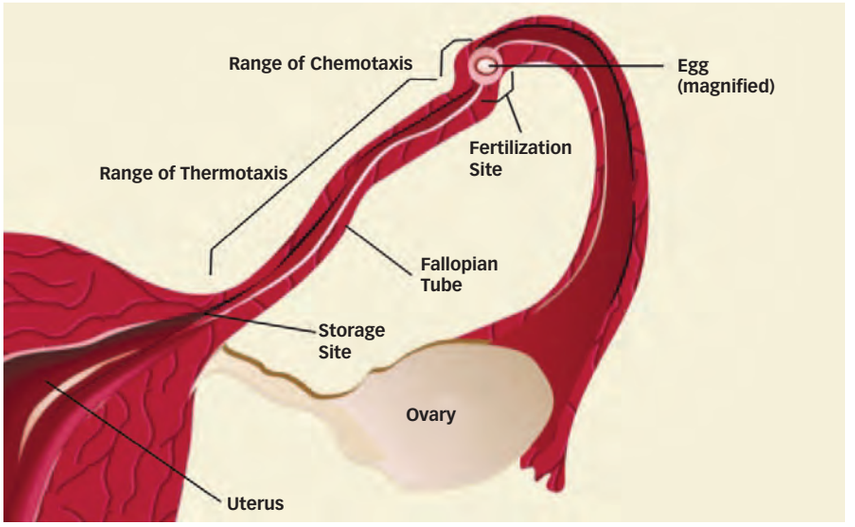
Intrigued, Eisenbach and his colleagues designed a chamber mimicking a fallopian tube. It contains two liquid-filled wells, one held at 39°C—about the body temperature of rabbits—and one at 37°C. After videotaping the swimming of rabbit sperm placed in this chamber, Eisenbach's team concluded that a small share of rabbit sperm, 7 to 17 percent, exhibit a clear preference for moving toward the warmer well, a process called thermotaxis.

The researchers obtained similar results when the wells had only a half-degree temperature difference between them. They also found evidence of thermotaxis with human sperm. Eisenbach and his team determined that the isthmus of live rabbits is nearly 2°C cooler than the fertilization site—a result similar to Hunter's.

"The evidence for thermotaxis is, in my opinion, as good as the evidence for chemotaxis," says Eisenbach. His group's experiments indicate that only the small percentage of sperm that are fully mature can sense the temperature gradient and chemical cues needed to reach an egg.

While finding the new work "intriguing," sperm researcher Susan Suarez of Cornell University calls for more studies. "I would stop short of concluding that the data provide strong proof for the existence of thermotaxis in rabbit sperm," she says. "The problem with [the] studies is that so few sperm appear to respond."

Assuming that human sperm navigate by temperature, Eisenbach envisions physicians' using a thermotaxis assay to evaluate the fitness of a man's sperm. An unusually large number of sperm unresponsive to temperature differences might explain some cases of male infertility. —J. TRAVIS



EISENBACH

SPERM LIKE IT HOT **In a process called thermotaxis, sperm cells may use a temperature gradient to find their way from a storage and maturation site, the isthmus, to the fertilization site. Nearer the egg, chemotaxis takes over as egg chemicals lure the sperm.**

Putting Whales to Work

Cetaceans provide cheap labor in the icy deep

Polar scientists have recruited an unlikely pair to aid their exploration of freezing Arctic waters: two wild white whales. The data gathered by these cetacean assistants promise to bolster scientists' understanding of environmental conditions in the Arctic region, which climate modelers predict will be hard hit by global warming.

White whales, also known as belugas, live primarily in the Arctic Ocean and adjoining seas. In winter, the 3-to-5-meter-long whales frequent waters topped by ice. "The whales enabled us to get data from an area that would be more or less impossible to explore any other way," says oceanographer Ole Anders Nøst of the Norwegian Polar Institute in Tromsø.

Nøst and his colleagues captured the whales—residents of the Storfjorden, Svalbard, Arctic fjord—and outfitted them with sensors designed to track their movements and relay the information via satellite. To measure ocean conditions, the team added temperature and salinity sensors to the devices. After the whales were released, the sensors sampled the water

once per second each time the animals ascended from a dive. Researchers on shore received the data when the whales surfaced for air.

"We couldn't plan where the whales were going to go," Nøst says. "It was lucky for us that they swam where the data was interesting."

Marine mammals naturally seek out temperature boundaries because they are prime feeding spots. That inclination led to a surprising discovery: Beneath the Arctic Ocean's ice-covered surface lies a tongue of warmer North Atlantic water. Scientists had thought that the entire water column is at or near the freezing point. The inflow of higher-temperature water could be part of a complex equation governing ice formation, the researchers report in an upcoming *Geophysical Research Letters*.

Information gathered by whales and other marine mammals could lead to improved climate models and enable researchers to separate natural short-term cycles in ocean conditions from longer-term change driven by global warming, the researchers suggest.

"It's fine data and a really novel approach," says physical oceanographer James H. Swift of the Scripps Institution of Oceanography in La Jolla, Calif. However, robotic underwater vehicles now under development (*see page 75*) will also be able to access arctic waters, he notes, so the use of marine mammals as data collectors might be short-lived.

Or maybe not, says George W. Boehlert, an oceanographer at the Oregon State University Hatfield Marine Science Center in Newport. The oceans are vast, and a diverse set of approaches—including use of sensor-carrying animals—may be needed to understand changing conditions. —K. MORGAN

HARDWORKING WHALE Researchers equip a wild beluga whale with an environmental sensor before sending him off to explore arctic waters.

NØST

Talent Found

Top science students chosen in 62nd annual competition

Forty wunderkinder from 14 states and the District of Columbia have been named as finalists in the 2003 Intel Science Talent Search. The competitors, announced on Jan. 29, represent the cream of more than 1,500 high school seniors who submitted their original research in biochemistry, mathematics, physics, behavioral sciences, and other scientific fields.

"These remarkable students, with their solid grounding in science and math, are poised to become tomorrow's leaders and innovators," says Craig Barrett, chief executive officer of Intel Corp. of Santa Clara, Calif., the contest's sponsor. Past finalists number more than 2,000 and include winners of the Nobel prize, the National Medal of Science, and other esteemed science and math honors.

Science Service, which publishes *Science News*, has run the contest each year since its inception in 1942. Intel replaced the program's original corporate sponsor, the Westinghouse Foundation, in 1998.

Apart from science, the talents of this year's finalists include competitive ballroom dancing, opera singing, and jazz piano. One finalist is a sign-language interpreter, and 24 are fluent in a language other than English.

In March, the students will travel to Washington, D.C., to compete for $530,000 in college scholarships. The top winner will receive $100,000 toward college, and all finalists will take home a high-performance computer and a scholarship of at least $5,000.

In addition to the finalists, 260 other entrants in the Intel Science Talent Search were chosen as semifinalists. They and their high schools will each receive $1,000 for the honor.

Here are this year's finalists:

CALIFORNIA: Peter Michal Pawlowski, Troy H.S., Fullerton; Michelle Rengarajan, Westridge School, Pasadena.

CONNECTICUT: Alexander Chow Mittal, Greenwich H.S., Greenwich; Michael Herbert Nyberg, Lyme–Old Lyme H.S., Old Lyme.

DISTRICT OF COLUMBIA: Sabrina Curie Snell, School Without Walls, Washington.

FLORIDA: Jamie Elyce Rubin, Canterbury School, Fort Myers; Bryan A. Lemus, Dr. Michael M. Krop H.S., Miami; Ibraheem Maqsood Mohammed, Niceville Senior H.S., Niceville; Anupama Kotha, C. Leon King H.S., Tampa; Anant Ramesh Patel, Astronaut H.S., Titusville.

HAWAII: Matthew Douglas Apau Jachowski, Maui H.S., Kahului.

MARYLAND: Anatoly Preygel, Montgomery Blair H.S., Silver Spring.

MASSACHUSETTS: Steven J.F. Byrnes, Roxbury Latin School, West Roxbury.

MICHIGAN: Ethan James Street, Winston Churchill H.S., Livonia.

MINNESOTA: Emma Rose Schmidgall, Robbinsdale Cooper H.S., New Hope.

NORTH CAROLINA: Edward Joseph Su, William G. Enloe H.S., Raleigh.

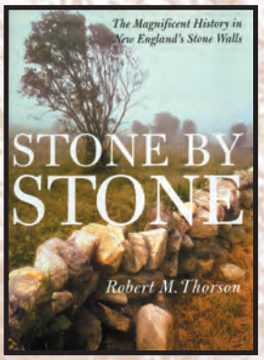
NEW MEXICO: Naveen Neil Sinha, Los Alamos H.S., Los Alamos.

NEW YORK: Matthew Jay Kroll and Alison Kimberly Yee, both of Byram Hills H.S., Armonk; Casey Ann Vaughn, Lawrence H.S., Cedarhurst; Carolyn Morgan Tewksbury, Clinton Senior H.S., Clinton; Brandon Stuart Imber, Commack H.S., Commack; Hyeyeon Choi, Half Hollow Hills H.S. East, Dix Hills; Lester Wayne Mackey, Half Hollow Hills H.S. West, Dix Hills; Zachary Daniel Wissner-Gross, Great Neck South H.S., Great Neck; Julian A. Gingold, New Rochelle H.S., New Rochelle; Yi-Chen Zhang, Bronx H.S. of Science, New York; Anna Gekker, Brooklyn Technical H.S., New York; Alex Levin, Joel Brewster Lewis, and Varun Kumar Narendra, all of Stuyvesant H.S., New York; Phoebe Robeson Rounds, Irondequoit H.S., Rochester; Hilary Caren Fleischer and Alex Kardon, both of South Side H.S., Rockville Centre; Jeffrey Lawrence Licitra, Blind Brook H.S., Rye Brook; Adam Mikah Malin and Daniel Jacob Ketover, both of Syosset H.S., Syosset.

OKLAHOMA: Vera Louise te Velde, Oklahoma School of Science and Mathematics, Oklahoma City.

OREGON: Tianhui Li, Oregon Episcopal School, Portland.

TEXAS: Scott Bailey Zeglin, Oak Ridge H.S., Conroe. —B. HARDER



Walker & Company, 2002
5 ¾" x 8", 288 p., hardcover, $26.00

There once may have been 240,000 miles of stone walls in America's northeast, more than the distance to the moon. They took 3 billion man-hours to build. And even though most of them are crumbling today, they contain within them a magnificent scientific and human story—if you know what to look for.

Stone walls tell nothing less than the story of how New England was formed, and in Robert Thorson's *Stone by Stone*, they live and breathe. "The stone wall is the key that links the natural history and human history of New England," Thorson writes. Millions of years ago, New England's stones were parts of ancient mountains thrust up by prehistoric collisions between continents. During the Ice Age, pieces were cleaved off by glaciers and deposited—sometimes hundreds of miles away—when the glaciers melted. Buried over centuries by forest and soil buildup, the stones gradually worked their way back to the surface during the Little Ice Age, only to become impediments to farmers cultivating the land in the 18th and 19th centuries, who piled them into walls. Thorson shows that while the walls were often useful as boundaries or fences, they were primarily "linear landfills" constructed simply to hold the stones. Usually the biggest investment on a farm, often exceeding that of the land and buildings combined, stone walls became a defining element of the northeast's landscape and a symbol of the shift to an agricultural economy.

Stone walls hold time like Russian dolls, their smallest elements reflecting the longest spans, and Thorson inspires us to study them, for each stone has its own story. Linking geological history to the early American experience, *Stone by Stone* presents the fascinating history of the land the Pilgrims settled and allows us all to see and understand it with new eyes.

—from Walker & Company

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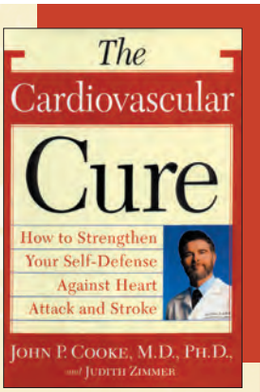

The Cardiovascular Cure offers a new approach to preventing heart attack and stroke by enhancing your body's own natural defenses. John Cooke, head of Stanford Medical School's vascular unit, has devised a plan for fighting cardiovascular disease without bypass surgery or angioplasty. Drawing on his own investigations, as well as Nobel prize–winning research, Cooke provides heart patients with a diet, supplement, and exercise program that he says will help them feel better in as little as 2 weeks. He holds that his program also works to prevent heart disease in those at high risk.

In 1998, a team of American scientists won the Nobel prize for the discovery of EDRF (endothelium-derived relaxing factor), a chemical produced in the lining of the blood vessels that keeps them free of plaque. Cooke and other scientists have reported that specific nutrients can enhance EDRF production and improve blood flow in people with high cholesterol, high blood pressure, diabetes, or other risk factors for heart disease.

Cooke offers a 2-week menu plan featuring recipes that emphasize EDRF-enhancing foods. He also provides detailed information on supplemental nutrients and vitamins that are useful in strengthening the cardiovascular system. And he outlines an exercise program beneficial for people already suffering heart disease. It includes aerobic workouts designed for more active patients. Cooke also provides pros and cons on conventional drugs—from aspirin to beta blockers—and medical tests and procedures designed to further combat cardiovascular disease. —from Broadway Books

Broadway Books, 2002, 6 ½" x 9 ½", hardcover, 310 pages, $25.00.

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WHY THE MERCURY FALLS

Heavy-metal rains may trace to oxidants, including smog

BY JANET RALOFF

In the mid-1980s, some researchers in the northern Midwest, Canada, and Scandinavia began reporting alarming concentrations of mercury in freshwater fish. Curious about Florida's largemouth bass and other finned delicacies, state scientists there began assaying lake fish. Thomas Atkeson, then a Florida state wildlife biologist, recalls that most of the fish he examined fell just under the limit then recommended by the Food and Drug Administration. "We were scratching our heads as to whether this was a big deal," he recalls, until his team reached the Everglades. In these wetlands, mercury contamination of fish routinely averaged more than twice the concentrations seen elsewhere in the state. Indeed, their mercury values were among the highest ever reported for U.S. freshwater fish.

"There was no quibbling that these levels were high and a potential health concern to humans and wildlife," Atkeson says. Eating mercury-tainted fish can trigger a variety of problems, ranging from hair loss and chronic fatigue in adults to nervous system impairment of fetuses and children (*http://www.sciencenews.org/20021221/food.asp*).

When a study of water entering the Everglades showed that feeder streams weren't responsible for the mercury excess, "we realized, astonishingly, this was an air-pollution problem," says Atkeson, now the coordinator of mercury research for the Florida Department of Environmental Protection in Tallahassee. Subsequent data confirmed that 95 to 99 percent of the mercury entering the Everglades each year comes from the air, so Florida called in atmospheric scientists to determine why the Everglades had become a mercury hot spot.

Efforts by those researchers are finally paying off in explaining Florida's problem and, ironically, mercury pollution as far away as the ice and water at Earth's poles.

Mercury taints the atmosphere worldwide, but there are large variations in how much of it drops onto land or water at any location. Recent experiments have begun identifying oxidizing gases, such as ozone and molecules containing the halogens bromine and chlorine, as triggers for that mercury fallout. Which oxidants dominate that process appears to depend on the environment, the season, the altitude of the airborne mercury, and even the amount of daylight.

Only in the past 5 years have scientists seriously considered that such gaseous oxidants might affect mercury fallout. Previously, they knew that this metal was spewed largely from smokestacks but were puzzled by why it fell out of the atmosphere where it did. Although the magnitude of atmospheric mercury oxidation and fallout is still hard to quantify, the recent findings suggest its control could prove difficult and politically thorny—because limiting mercury's fallout may hinge on better controlling regional or even international emissions of not just that metal but also sulfates, nitrates, and other air pollutants.

For instance, mercury fallout in some areas may turn out to depend on smog as much as on how much of the metal is being released, says Douglas J. Steding, a geochemist who's now studying law at the University of Washington in Seattle. Indeed, the skies already hold so much mercury that even if industrial emissions of the metal ended tomorrow, significant fallout of the pollutant might persist for decades, he notes.

IN COLD LIGHT — The melting of Barrow's annual polar ice and snow can release huge quantities of pent-up halogens. In sunshine, these chemicals transform mercury—found throughout the atmosphere—into a form that readily falls onto land and water.

K. J. SCOTT/U. MANITOBA

QUICKSILVER SKIES Mercury enters the air easily. It's released when coal is burned, gold is mined, some chlorine is manufactured, and even when a fluorescent lightbulb breaks. Some 99 percent of the airborne metal is elemental. Fairly insoluble and unreactive in this form, it can circumnavigate the globe for up to 2 years. What's contaminating the Everglades, therefore, may have originated in Miami, India, or Siberia.

However, atmospheric chemists have discovered that when elemental mercury encounters certain oxidants, it changes into so-called reactive gaseous mercury. Unlike the element, this form is both highly reactive and water soluble, so it remains airborne only hours to days and falls—in rain or snow or attached to dust—near where it's formed. In a lake or ocean, bacteria transform it into methylmercury, the harmful form of the metal that fish and, in turn, people and other predators accumulate in their tissues.

When it comes to triggering the transformation of elemental mercury, all oxidants are not equal. Anthony Hynes of the University of Miami (Fla.) recently found that the hydroxyl radical—abundant in the atmosphere and normally considered a strong oxidant—is a poor oxidizer of mercury except perhaps in extremely cold conditions, such as high in Earth's lower atmosphere.

On the other hand, observes Steve Lindberg of Oak Ridge (Tenn.) National Laboratory, certain halogen radicals—reactive compounds containing bromine or chlorine—rapidly and efficiently transform elemental mercury to the reactive gaseous form. It so happens that

sea spray and melting polar ice release especially large quantities of these halogen radicals.

Working in Barrow, on the north-central coast of Alaska, Lindberg and his colleagues correlated the buildup of these halogens during the Arctic spring with a dramatic, localized depletion of elemental mercury in the air. In the March 15, 2002 *Environmental Science & Technology*, they showed that the missing elemental mercury had been oxidized; roughly 35 percent remained airborne, and the rest fell onto the ground. In fact, the surface snow proved so rich in oxidized mercury "that we initially had a hard time believing the data," he recalls.

Peak readings of reactive gaseous mercury in the air at this remote site ran to 1,000 picograms per cubic meter, says Lindberg, "or up to 100 times what we typically find in industrial areas of the eastern United States."

POLAR EXTREMES Such findings demonstrate the natural vulnerability of polar sites to mercury fallout. During the many weeks of total darkness at Barrow, chemical precursors to the oxidants appear to build up in the air, Lindberg says. Reactive gaseous mercury remains undetectable until Arctic sunrise occurs in late January. Then, he says, "Boom!"—the light triggers mercury oxidation at a skyrocketing pace. Production of reactive gaseous mercury "is just screaming as you go from January through May," when Barrow begins experiencing 24-hour sunlight, says Lindberg.

Measurements by other researchers at Arctic sites further inland show less mercury pollution, indicating that the heavy fallout may be restricted to the near-coastal environment and parcels of open ocean where floes of annual ice melt. Halogen impurities concentrate on the surface of ice crystals and vaporize before the snow or ice begins to melt, Lindberg explains.

Ralf Ebinghaus of the GKSS Research Center in Geesthacht, Germany, and his colleagues have observed similar fallout of reactive gaseous mercury at the Neumayer Research Station in Antarctica. Again, it begins with the polar sunrise and continues through the austral spring when generation of airborne halogens is high.

In the Jan. 1 *Environmental Science & Technology*, Ebinghaus' international team offers the first report of a second, Antarctic-summertime peak in mercury fallout. Beginning after much coastal sea ice has melted, this peak probably results from mercury-oxidizing pollution drifting in from industrial areas to the north, he says.

Even as a coastal phenomenon, Lindberg estimates that fallout of oxidized mercury could still amount to "hundreds of tons per year" in the Arctic and Antarctica. In large areas of the polar seas, bacteria probably start the metal on its way up the food chain, he says. Indeed, Lindberg notes, such events could account for the high concentrations of methylmercury that naturalists have measured in polar bears.

TEMPERATE FALLOUT Recently, scientists collected oxidized mercury over the temperate Atlantic Ocean. There, they encountered substantial concentrations of reactive gaseous mercury—not predominantly at low altitudes typical of polar regions, but mostly in the lower atmosphere's upper reaches, at heights up to 3,000 meters, report Robert K. Stevens, who works with Atkeson at the Florida Department of Environmental Protection, and Matthew S. Landis of the Environmental Protection Agency in Research Triangle Park, N.C.

They have since turned to measuring elemental and oxidized mercury at a ground station on Hawaii's Mauna Loa, where they can sample air at 4,000 m above sea level. Over the past year, they've seen wide swings in air concentrations of oxidized mercury there. Much of it appears to be attached to dustlike particles, which may foster the metal's fallout.

"The elemental mercury completely disappears for long peri-

Mercury Retirement

The ultimate solution may be to store the metal, not sell it

To limit mercury's fallout, society must reduce the metal's release. Environmentalists have proposed limits on mercury use, but another idea gaining interest is the collection of excess or recovered mercury for long-term—potentially permanent—storage.

Indeed, at a United Nations–sponsored meeting on mercury in Geneva last September, the U.S. State Department supported a proposal asking nations to formally consider "retiring excess mercury through long-term waste management (terminal storage)."

Not so long ago, mercury was mined throughout the world to meet a growing demand for the metal. What little was retired from use often ended up in landfills, from which it can escape into the atmosphere (*SN: 7/7/01, p. 4*).

But in the 1980s, biologists recognized the toxic impact of chronic, low-level mercury exposure. Now, landfills frequently prohibit products containing mercury. Moreover, use of the metal is falling as recovery programs mushroom. For instance, U.S. mercury demand has decreased to 20 percent of its 1980 level at the same time that recycling of the metal has nearly tripled, notes Michael T. Bender, director of the Mercury Policy Project in Montpelier, Vt. Today, industrial countries—including the United States—usually end up with more mercury than they need.

At issue is what to do with the excess.

A Department of Defense-strategic stockpile of almost 5,000 metric tons of mercury—holdings no longer deemed essential—constitutes the nation's largest store. Another 3,000 metric tons of mercury is employed in aging chlorine-production facilities using a so-called chlor-alkali process. These plants are expected to shut down in the coming decades, says Art Dungan of the Chlorine Institute in Rosslyn, Va., an industry group.

Until recently, the Defense Department and the owners of retiring chlor-alkali plants had expected to sell their mercury. Buyers of such low-cost recycled mercury tend to be in the developing world, where few regulations exist to encourage only essential uses and careful management of the toxic material, observes John Gilkeson of the Minnesota Office of Environmental Assistance in St. Paul.

To keep mercury from re-entering the atmosphere, such sales must be prohibited, he argues. Indeed, Bender advocates that the United States halt mercury recycling and trade—"and provide options for long-term, monitored storage."

The Chlorine Institute agrees, in part. "It may be prudent for the United States to consider a national policy to identify which worldwide outlets are acceptable," Dungan says, and halt mercury trading with unacceptable ones. Last May, his institute said that the chlor-alkali industry is willing to work with federal officials on "how [it] can best ensure that any surplus mercury from idled or converted sites is placed into . . . permanent storage." However, Dungan says his industry wants Uncle Sam to take possession—and responsibility for—its mercury.

The states want that, too. The Quicksilver Caucus—a consortium of state officials—has begun lobbying for centralized storage of excess mercury. For legal and financial reasons, Gilkeson says, "the states believe this must be at the federal level."

To date, Bender notes, the only step toward retiring mercury is storage, last year, of 80 metric tons of the metal from a shutdown Maine chlor-alkali plant. Environmental groups convinced the plant's owner not to sell the mercury but to ship it to a private company for safekeeping for at least 5 years. —J.R.

ods," Stevens finds. When that happens, he says, "reactions are going on that are producing a water-soluble form of mercury that can contaminate the oceans of the world.

In smog-chamber experiments, he and Landis showed that sunlight activates certain airborne halogen compounds to convert elemental mercury to reactive gaseous mercury. If the main source of the halogens reacting with elemental mercury is sea spray, Stevens says, this mechanism might increase concentrations of the metal in the water of warm coastal areas, such as Florida.

However, he points out that halogen oxidants also form during the sunlight-triggered breakdown of industrial chemicals such as chlorofluorocarbon refrigerants. What would be the source of such industrial oxidants at Mauna Loa? Plumes of pollution from Asia, Stevens suspects.

OZONE, TOO California researchers have been examining the impact of Asian air masses that travel to the U.S. mainland. In this case, ozone and several other compounds carried in that air appear to directly oxidize elemental mercury.

Steding and A. Russell Flegal of the University of California, Santa Cruz, measured mercury in coastal rains and compared events when the air had been relatively clean with storms when plumes of ozone-rich Asian pollution were present. In the Dec. 19, 2002 *Journal of Geophysical Research*, they report that when pollution from China coincides with a California rainstorm, up to nine times as much mercury rains out of the atmosphere as it does during other storms.

MERCURIAL RAINS — Downpours, like this one crossing the Everglades, effectively scrub water-soluble mercury from the air, thus contaminating the food chain.

D. SCHEIDT

Eight years ago, when Lindberg reported data suggesting that ozone might be oxidizing elemental mercury in ambient air, "nobody believed me," he recalls. Now, he observes, a growing number of scientists are indicting ozone pollution as a potentially important factor in creating reactive gaseous mercury.

After years of study, the Everglades' high mercury fallout appears to have resulted from many unusual factors, such as its shallow waters and South Florida's especially large number of municipal- and medical-waste incinerators, which emitted mercury at a relatively low height. In recent years, new controls on their emissions cut mercury releases to 1 percent of those in the mid-1980s. "Largemouth bass are now carrying around one-third of the mercury that they had in 1990," says Atkeson.

As it turns out, for the Everglades, "everything was in the right juxtaposition to create an exaggerated response," he observes. However, because of the wetlands' heavy mercury contribution from local emitters. cleaning up their releases "allowed these waters to clean up more rapidly than you would expect with other water bodies. So, the Everglades is not a good example of how much success you could have with lakes elsewhere in North America," Atkeson says. "But it does show there is hope for them." The newly recognized role of other pollutants in mercury's fallout increases the challenge. Indeed, Steding says, that task will likely require political and diplomatic solutions that transcend national borders. ■

ELECTRONIC JETSAM

Ocean rovers explore the depths and monitor the environment

BY SID PERKINS

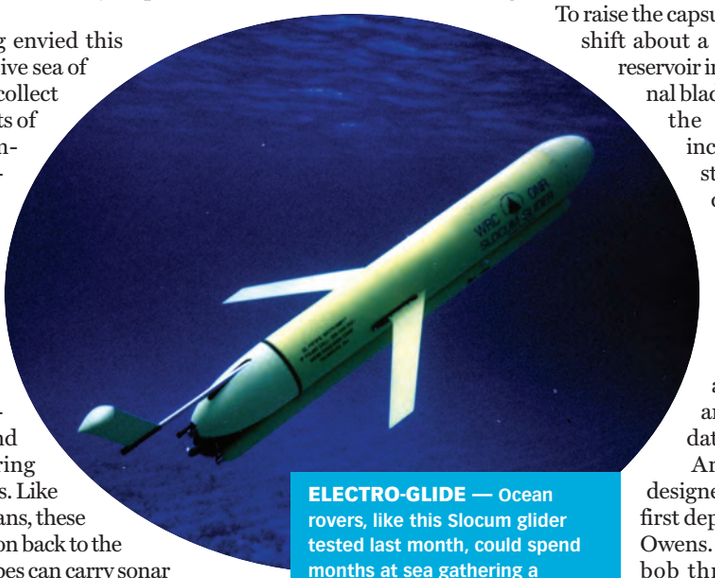
Twice each day at more than 1,100 sites around the world, scientists simultaneously loft weather balloons to collect data about Earth's atmosphere. During each balloon's ascent, which lasts a couple of hours or so, instruments garner information about air temperature, humidity, barometric pressure, wind speed, and wind direction. Meteorologists feed all of these data into their computer models to forecast rain for next Tuesday or predict the weather for next year.

Oceanographers have long envied this wealth of data about the massive sea of air above them. If they could collect millions of daily measurements of currents, salinity, water temperature, chemical composition, plankton populations, and other features of the oceans, which cover 70 percent of Earth's surface, scientists could begin to model the vast, underwater world with finesse.

To alleviate their envy of meteorologists, oceanographers have been developing and deploying a variety of seafaring probes in ever-greater numbers. Like an array of remote sensory organs, these probes would report information back to the scientists on dry land. The probes can carry sonar systems for mapping the thickness of arctic ice, charting the seafloor around a roiling hydrothermal vent or searching for explosive mines in hostile waters. They also carry sensors to measure pressure, temperature, salinity, and other ocean traits. The probes pause intermittently to use their antennas to transmit data back to a home base via satellites or to receive revised instructions.

Such instrument-crammed ocean rovers will free scientists from sea duty, says Daniel J. Fornari, a senior scientist at the Woods Hole (Mass.) Oceanographic Institute (WHOI). In the past, he notes, oceanographers' observations have been "snapshots in time" limited by the availability of funding, personnel, ships, and time at sea. The coming era of drifters, gliders, and scientific torpedoes is poised to greatly enhance oceanographers' power to gather data, thereby transforming isolated snapshots into full-length feature films.

BOB, BOB BOBBIN' A global fleet of drifting probes that monitor conditions in the top layers of the ocean is giving ocean scientists a taste of what's to come.



WHOI

ELECTRO-GLIDE — Ocean rovers, like this Slocum glider tested last month, could spend months at sea gathering a wealth of oceanographic data.

Each float in this array, called Argo, looks like an oxygen cylinder. It's full of instruments and capped with a 70-centimeter-tall antenna. Sensors measure water temperature, electrical conductivity, and pressure, which tells the probe its depth in the ocean, says W. Brechner Owens of WHOI. With data from these sensors, scientists calculate the water's density and salinity, two of the driving forces for ocean currents.

Argo floats can be dropped into the ocean from research vessels, commercial ships, or even low-flying aircraft. Once deployed, the 26-kilogram probes at first drift with the currents about 2 kilometers below the surface. Then they pop back to the surface, collecting data en route.

To raise the capsule through the water, pumps shift about a cup of hydraulic oil from a reservoir in the cylinder to a small external bladder. As the bladder expands, the probe's overall volume increases slightly while its mass stays the same, so its density declines and the probe rises.

When the float reaches the surface, it beams data to researchers via satellites. That done, the pumps pull the hydraulic oil back inside the cylinder, and the probe again sinks and drifts for another 10 days before its next data-gathering ascent.

Argo probes, which are designed to last about 5 years, were first deployed in the year 2000, says Owens. More than 600 of them now bob through the world's oceans. Oceanographers from a dozen or so nations plan to launch an armada of 3,000 Argo probes by 2006. In such a fleet, floats would be spaced, on average, 300 km apart.

Scientists are using Argo data to calibrate ocean measurements made remotely from Earth-orbiting satellites, as well as to directly inform ocean-current and climate models.

SEA WINGS Not having motors, the Argo armada drifts along at the mercy of currents. To overcome this constraint, scientists have designed ocean gliders that are propelled by the same buoyancy-change technique used in the Argo probes.

Admittedly, such gliders are slow. They slip through the water at speeds of only around 1 knot—that's about 0.5 meter per second. On the other hand, their gravity-assisted trajectory doesn't require much electric power. Nevertheless, the lifetime of the batteries that power the oil movement within the glider limits its range.

That's why scientists such as WHOI oceanographer David M. Fratantoni are now developing a more energy-efficient way to

pump oil back and forth. The new system will tap a source of energy readily available in most temperate-latitude oceans—the temperature difference between the warm water at the ocean's surface and the cold water thousands of meters below. The heart of the thermal engine is a tube filled with a wax that solidifies at about 10°C. The substance shrinks significantly when it solidifies.

The test bed for this novel engine is the Slocum glider, a craft that looks like a 2-m-long torpedo with slim wings. The wings ensure that the probe glides forward, plowing a sawtooth path through the ocean. The glider is named after Joshua Slocum, a New England captain who in 1898 became the first man to sail solo around the world.

Like the Argo float, the Slocum glider has an external bladder that changes volume as oil is pumped to and from an internal reservoir. When the glider is first placed in warm waters at the ocean's surface, some of that oil is pumped into the glider, increasing its overall density and causing it to sink. As the probe descends into colder water, the wax freezes and contracts, creating a vacuum that pulls yet more oil from the external bladder into the probe's interior. This action gives the pump battery a break.

When the glider reaches a depth of about 1,500 m, an onboard computer opens a valve so that compressed nitrogen can push oil back to the external bladder, increasing buoyancy. As the probe glides upward to warmer water, the wax melts and expands, ready for another cycle.

Fratantoni and his colleagues field-tested this propulsion system about 2 weeks ago in an ocean basin in the Bahamas that's more than 2 km deep. Preliminary analyses of the data downloaded from the probe after each of eight dives shows the propulsion system worked as expected. On a ninth dive, the glider encountered a problem unrelated to the propulsion system. Rough topography on steep terrain trapped the glider. "During field tests, you expect this sort of thing," says Fratantoni.

Scientists left the glider behind, but all is not lost. The probe, equipped with an acoustical beacon that can broadcast pings for the next 2 months awaits rescue in about 450 m of water.

CIRCUITS OVERBOARD — Battery-powered torpedoes such as this REMUS can map the ocean floor, measure the salinity or speed of ocean currents, or sniff the water for particular chemicals.

FULL SPEED AHEAD To explore the ocean at speeds greater than 1 knot, investigators turn to autonomous underwater vehicles, or AUVs. Essentially battery-powered torpedoes for research, the probes can carry a host of sensors as they dive deep and travel several dozen kilometers.

AUVs are already routinely used by companies surveying the ocean bottom, for example, to identify optimal routes for pipelines or fiber-optic cables. In May 2001, an AUV surveying a pipeline route in the Gulf of Mexico discovered wreckage of the German World War II submarine U-166. The only sub sunk in the Gulf during the war, that U-boat went down on July 30, 1942, and now lies in about 1,500 m of water.

The Department of Defense, too, is finding AUVs useful. They can be sent into hostile areas to map the ocean bottom, look for mines, and assess environmental conditions. The U.S. Navy now has several Remote Environmental Monitoring Units—nicknamed REMUS—that can be programmed via laptop, dumped overboard by two sailors, and sent into harm's way in the stead of frogmen.

Now, more scientists are getting in on the AUV action. Consider the ALTEX (Atlantic Layer Tracking Experiment), which includes an AUV designed to monitor a layer of relatively warm water that flows from the Atlantic into the Arctic Ocean. Oceanographers put the probe through its first arctic field trials in October 2001, says James G. Bellingham, director of engineering at the Monterey Bay Aquarium Research Institute in Moss Landing, Calif. Last December at the American Geophysical Union's meeting in San Francisco, he and his colleagues described results of those tests.

Researchers deployed the ALTEX AUV from a Coast Guard icebreaker several times, says Bellingham. During the probe's first excursions under the ice, it ranged dozens of kilometers and traveled as deep as 500 m. All the while, it measured the temperature, salinity, and nitrate concentrations in the water and used sonar to determine the thickness of the icepack overhead.

The current version of the AUV is powered by metal-hydride batteries and has a range of about 50 km, but future models driven by longer-lasting fuel cells could cruise about 1,000 km. Other improvements on the drawing board include a mechanism by which the probe releases buoys that melt their way through surface ice and then broadcast data and information about the AUV's position back to the home base.

Other arctic AUVs could serve as roving seafloor seismometers. WHOI engineer Rob Sohn is dreaming up missions for the Autonomous Polar Geophysical Explorer, or APOGEE. In one scenario, the 2.5-m-long, 200-kg APOGEE would rest on the ocean floor, monitor and record earthquake activity for a certain period, and then make its way to the edge of the icepack or to a hole cut into the ice by a recovery team.

This AUV's modular design will let scientists outfit it any way they like, says Sohn. One option might include sonar equipment to map the ocean bottom and the layers of sediment beneath; another might have the sensors tuned to look for the thermal and chemical anomalies associated with undersea hydrothermal vents.

Albert M. Bradley of WHOI says that AUVs are particularly suited to search for such vents. Compared with manned submersibles, AUVs can carry out longer, more systematic searches close to the ocean bottom. Once a probe's sensors detect signs of a hydrothermal plume, on-board computers could send the AUV into a three-dimensional flight plan to map the plume, take its temperature, measure its mineral content, and estimate its flow rate.

AUVs equipped with side-scan sonar equipment can map the ocean floor in great detail in a cost and time-efficient manner, agrees Fornari. In a single dive, for example, an AUV could map a square several kilometers on a side with enough resolution to pick out features just 1 m across. That economy makes AUVs ideal for the initial exploration of a certain area of seabed, for example, but it also enables scientists to make repeated visits and watch how features around midocean ridges or hydrothermal vents evolve.

In conjunction with other oceanographic equipment, AUVs can be particularly useful in so-called nested surveys, says Fornari. For instance, surface ships can map the ocean bottom on a broad scale and identify areas of interest, AUVs can then home in on those areas and map or photograph them in finer detail, and then scientists can descend in submersibles to investigate personally.

Or scientists could send forth fleets of AUVs to discover phenomena that merit further study. Permanent ocean observatories may be the home bases for such probes (*SN: 12/7/02, p. 362*), which could locate underwater electrical outlets, recharge batteries, download data, and perform self-diagnostic checks before receiving new marching orders and zipping back to duty.

Fornari says that these intelligent vehicles have the potential to "revolutionize" oceanography. Sohn agrees: "There's a place in oceanography for all types of vehicles, and there will be for decades to come." ■

WHOI

OF NOTE

BEHAVIOR

Psychiatric drugs surge among kids

During the early 1990s, the numbers of children and teenagers in the United States receiving prescriptions for psychiatric drugs rose markedly, a new study finds.

Julie M. Zito of the University of Maryland, Baltimore and her coworkers analyzed medical data on nearly 900,000 youngsters enrolled in Medicaid programs—in an unnamed mid-Atlantic or midwestern state—or in a large health maintenance organization (HMO) in the Pacific Northwest. Psychiatric-drug use tripled at the HMO and in the midwestern state, while it doubled in the mid-Atlantic state.

The overall proportion of kids and teens taking at least one psychiatric drug rose from 2.5 percent in 1987 to 6.2 percent in 1996, the scientists report in the January *Archives of Pediatric and Adolescent Medicine*. This new rate of psychiatric medicine use nearly matches that of adults.

Ritalin and other stimulants for treating attention-deficit hyperactivity disorder were the most commonly prescribed psychiatric drugs for children in 1996, followed by antidepressants and anticonvulsants used for mood disorders.

The researchers say it's unclear whether the rising use of psychiatric medications among children reflects mainly a growing emphasis on comprehensive mental-health care at early ages or an increasing reliance on drugs alone, without any talk or behavior therapy. —B.B.

BIOMEDICINE

Clot promoter cuts surgical bleeding

Blood banks face a perpetual supply shortage, but a clot-promoting agent known as recombinant activated factor VII (FVIIa) might offer a new means to staunch the demand for blood. When administered during surgery, the lab-generated enzyme can reduce a patient's bleeding and need for transfusions, a new study indicates.

Dutch surgeons tested the drug or a placebo in 36 men undergoing removal of cancerous or seriously enlarged prostate glands. The surgery often causes substantial bleeding. Early in their operations, 24 of the patients received injections loaded with either of two amounts of FVIIa. The other 12 volunteers got a sham injection. Neither the patients nor their surgeons knew which treatment went to whom.

The patients who got FVIIa lost less blood during surgery and needed fewer transfusions than their placebo-treated counterparts. None of those receiving the higher dose of FVIIa needed a blood transfusion, while 38 percent of those receiving the lower dose and 58 percent of those getting the placebo required extra blood to get through their operations.

There were no negative consequences from the treatment, Marcel Levi of the University of Amsterdam and his colleagues report in the Jan. 18 *Lancet*. FVIIa is considered safe for patients with blood clotting disorders, but it hasn't been widely tested in other people. —B.H.

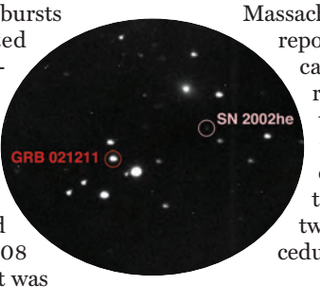
ASTRONOMY

Gamma-ray burst leaves ephemeral afterglow

A ground-based telescope on automatic pilot has recorded the visible-light afterglow of a gamma-ray burst less than 2 minutes after the eruption. One of the most energetic flashes of radiation known in the universe, gamma-ray bursts seem to be generated when a massive star collapses on itself and becomes a black hole or when a black hole merges with a superdense neutron star.

The telescope started taking pictures just 108 seconds after the burst was detected by the High Energy Transient Explorer (HETE)-2 spacecraft. The ground-based device, the Katzman Automatic Imaging Telescope in Santa Cruz, Calif., traced the afterglow for more than 2.5 hours, until dawn halted observations.

"For the first time, we have really good data showing the early time afterglow from a gamma-ray burst and the transition to late-time decline," says Alex Filippenko of the University of California, Berkeley. His team reported the findings Jan. 9 at a meeting of the American Astronomical Society in Seattle.



GLOWING IMAGE Visible-light afterglow just 108 seconds after a gamma-ray burst. Red circle indicates afterglow. This image is actually a double exposure including a supernova (pink circle) in a different patch of sky that the robotic telescope had been observing.

FILIPPENKO, S. JHAN, ET AL./UC-BERKELEY

HETE-2 detected the 2.5-second gamma-ray burst on Dec. 11, 2002. Just 34 seconds later, the craft put out an e-mail alert. Although another ground-based telescope, dubbed RAPTOR (Rapid Telescopes for Optical Response), recorded the afterglow 43 seconds earlier than the Katzman telescope did, RAPTOR acquired only a single, short exposure.

Because this afterglow was so transient, it may shed light on so-called dark gamma-ray bursts, which don't seem to have visible-light components, Filippenko says. Perhaps visible emanations fade away before most telescopes have a chance to record them, he suggests. —R.C.

PHYSICS

Quantum computers to keep an eye on

Among schemes to build extraordinarily powerful computers whose calculations depend on quantum properties of particles, an approach using molecules in liquids as information bits has consistently attained a higher level of computing complexity than other designs. Now, a competing method, in which ultracold ions serve as bits, is moving up the problem-solving ladder.

In the Jan. 2 *Nature*, Stephan Gulde of the University of Innsbruck in Austria and his colleagues there and at the Massachusetts Institute of Technology report carrying out a computation called the Deutsch-Jozsa algorithm. This quantum calculation evaluates certain mathematical functions in one operation, although a conventional computer would require two. To execute the simple procedure, the researchers used laser pulses, which can control the quantum state of a lone calcium ion.

Liquid-based systems have already mastered algorithms such as Deutsch-Jozsa and others that are more complicated (*SN: 1/12/02, p. 31*). However, Innsbruck's Jürgen Eschner, a member of the research team, says it's important that an ion-based system has reached the Deutsch-Jozsa rung because liquid systems aren't expected to work in quantum-computer designs that include more than a handful of bits. In contrast, Eschner notes, ion-based approaches are

OF NOTE

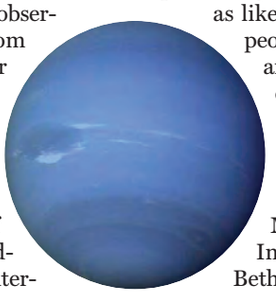
more likely to accommodate the tens to hundreds of bits required for building practical computers. —P.W.

ASTRONOMY

New moons for Neptune?

Astronomers say they have discovered three additional moons circling Neptune. If confirmed, the findings would bring to 11 the planet's retinue and would be the first Neptunian moons found since Voyager 2 flew past the planet in 1989 and the first discovered with ground-based telescopes since 1949.

Only 30 to 40 kilometers in diameter, the newly discovered bodies are too dim by a factor of 100 million to be discerned by the naked eye. Also complicating their observation is their great distance from Neptune—roughly 60 times as far as Triton, the planet's largest moon. A team led by Matthew J. Holman of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., and J.J. Kavelaars of the National Research Council of Canada in Ottawa reported the findings in a Jan. 13 circular of the International Astronomical Union.



NEPTUNE NEWS With three newly discovered moons, the planet may have a retinue of 11.

Each of the bodies orbits in a plane different from that of most of the solar system's planets. According to the astronomers, one of the objects orbits Neptune in the direction opposite to the planet's rotation. Their findings suggest the purported moons arose from collisions or were captured by the planet shortly after the solar system formed.

But planetary scientist Brian G. Marsden of Harvard-Smithsonian cautions that it's not certain that the objects are in fact satellites of Neptune. New observations, based on the predicted positions of these objects a few months from now, should determine whether these denizens of the solar system belong to Neptune, he notes. —R.C.

EPIDEMIOLOGY

As population ages, flu takes deadly turn

The annual toll of influenza has risen dramatically since the late 1970s, according to an analysis of U.S. death statistics. One major factor is the advancing average age of the population. Another is the increasing prevalence of virulent strains of the flu virus.

Influenza is typically not a direct cause of death, but researchers at the Centers for Disease Control and Prevention in Atlanta, estimated the disease's contribution to mortality by noting seasonal fluctuations in deaths that might have resulted from underlying flu infections. Bacterial pneumonia, for example, can be a fatal consequence of severe flu.

Such calculations suggest that influenza claimed more than 68,000 lives on average during each of the last three flu seasons of the 1990s, William W. Thompson and his colleagues report in the Jan. 8 *Journal of the American Medical Association* (*JAMA*). That's well up from about 16,000 annual deaths attributable to flu during a similar period 2 decades earlier.

People over age 65 are nearly 100 times as likely to die from flu than people 5 to 50 years old are, and the efficacy of flu vaccinations wanes in older adults.

Responding to the new findings in the same issue of *JAMA*, David M. Morens of the National Institutes of Health in Bethesda, Md., urges physicians to get annual flu shots, in order to avoid transmitting the virus to patients. They should also encourage their patients, especially older ones, to get the shots, he says. "Even an imperfect vaccine, used optimally, can prevent many thousands of deaths," says Morens. —B.H.

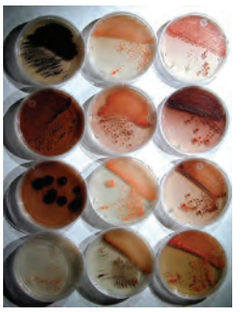
CHEMISTRY

Sea bacteria may be new anticancer resource

Many drugs, including the antibiotic streptomycin, are derived from soil microbes called actinomycetes. Lately, however, scientists have been wondering whether they have wrung out all of the drugs possible from these bacteria.

Now, William Fenical and his colleagues at the Scripps Institution of Oceanography in La Jolla, Calif., have found a large source of previously unknown strains of actinomycetes that may make chemicals with antibiotic or cancer-fighting properties.

Fenical discovered the new bacteria, which he dubs *Salinospora*, in deep ocean sediments collected from all over the globe. In preliminary benchtop tests, many of the 2,500 *Salinospora* strains identified by Fenical produced potentially therapeutic chemicals.



MICROBE MEDICINE? These lab dishes contain a dozen new strains of bacteria that may harbor medicinal chemicals.

In additional studies, Fenical and his coworkers determined the chemical structure of one such molecule—salinosporamide A. In test tubes, the molecule strongly inhibited the growth of some cancer cells from human colon, lung, and breast tissues. The researchers describe their results in the Jan. 20 *Angewandte Chemie International Edition*.

"This is the tip of an iceberg," says Fenical. Salinosporamide A and molecules from other strains of *Salinospora* might serve as new tools for studying cancer or even as therapeutic drugs themselves one day, he says. —J.G.

EARTH SCIENCE

Kilauea: 20 years on, it's still erupting

As of Jan. 3, Hawaii's Kilauea volcano has been erupting continuously for 2 decades. During that period, this Energizer Bunny of volcanic activity has repaved more than 110 square kilometers of mountainside, as well as 13 km of local highways.

Lava that has flowed 10 km or more to reach the Pacific has created about 2.2 km^2 of new oceanfront property and black-sand beaches. At some spots along the coast, hardened lava is 25 meters thick. In all, Kilauea has coughed up more than 2.3 cubic kilometers of molten rock since 1983.

Despite the longevity of Kilauea's eruption, lava output remains high, says Don Swanson of the U.S. Geological Survey's Hawaiian Volcano Observatory near Hilo. Each day, the volcano produces nearly 350,000 cubic meters of lava—that's about 45,000 dump truck loads—and emits 1,800 tons of sulfur dioxide gas. This noxious gas reacts with water vapor, sea spray, dust, and other atmospheric constituents to form volcanic smog, also known as vog.

In the past 20 years, Kilauea has destroyed nearly 200 homes and other structures, causing $61 million in damage. The ongoing eruption is one of the volcano's lengthiest in the past 600 years, Swanson notes. The USGS released statistics about Kilauea late last year. —S.P.

NASA/JPL; CMBB, SCRIPPS INSTITUTION OF OCEANOGRAPHY

Books

A selection of new and notable books of scientific interest

DREAMING: An Introduction to the Science of Sleep

J. ALLAN HOBSON

Drawing on basic brain research, sleep-lab studies, and his own dream journal, Harvard psychiatrist and sleep researcher Hobson explains how and why the brain creates dreams. He and his team are focusing less on what dreams mean and more on what mental characteristics of dreaming distinguish it from waking mental activity. With recent innovations in brain imaging, this type of mental activity can be monitored. These images show that when we dream, the brain's visual and auditory centers are very active and other areas shut down. Thus, our dreams are vivid but not memorable, unless we awaken in the midst of them. Hobson also explores how this research is illuminating phenomena ranging from mental illness to the way we regulate body temperature. ***OUP, 2002, 170 p., b&w illus., hardcover, $22.00.***

FLOODS, DROUGHTS, AND CLIMATE CHANGE

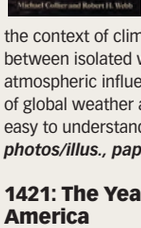
MICHAEL COLLIER AND ROBERT H. WEBB

The year 2002 was the second-worst wildfire season in 50 years, scorching more than 6.7 million acres of U.S. land. Almost half of the United States has experienced drought for several years. Despite these dry conditions, floods were the most frequent of disasters in the past decade. For a public increasingly interested in weather phenomena, Collier and Webb analyze the nature of floods and droughts in the context of climate change. They explain the link between isolated weather events and human and atmospheric influences. They make the mechanics of global weather and patterns of climate change easy to understand. ***U AZ Pr, 2002, 153 p., b&w photos/illus., paperback, $17.95.***

1421: The Year China Discovered America

GAVIN MENZIES

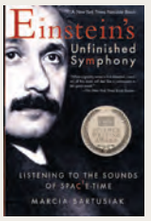
While pursuing his passion for medieval history, Menzies came across an intriguing item—a chart dated from 1424 that appeared to portray islands of the western Atlantic. After prolonged and intense research, he concluded that someone had reached the Caribbean and established a colony there 7 decades before Christopher Columbus sailed. Menzies believes it was the Chinese who departed on this epic voyage in 1421 under the command of Emperor Zhu Di's admirals. In this stirring book, the author claims that maps of the world existed before Europeans set sail and that only the Chinese had the ships and expertise to have provided them. Moreover, he presents evidence that Europeans found Chinese people, ships, artifacts, plants, and animals when they arrived in the Americas. He documents Chinese voyages to Antarctica and Australia, which support the 15th-century Asian sailors' navigational expertise. Whether or not readers will believe that this evidence is enough to rewrite history, Menzies takes a fascinating look at a world of 500-foot long wooden ships, survival at sea, emperors, cannibals, and a time when parts of the world were waiting to be discovered. Originally published in Great Britain in 2002. ***Morrow, 2003, 552 p., color plates/b&w illus., hardcover, $27.95.***



EINSTEIN'S UNFINISHED SYMPHONY Listening to the Sounds of Space-Time

MARCIA BARTUSIAK

Gravity waves—tremors in the fabric of space-time caused by massive cosmic events—define the great remaining mystery of Einstein's general theory of relativity. Physicist and veteran science writer Bartusiak spins this complicated technical subject into a riveting narrative. By using the metaphor of music to explain our still-developing understanding of relativity, she illuminates the theories and thinkers behind this area of cosmology. Observing these waves, which Einstein predicted but no one has ever found, would open a broad window onto the workings of the universe, black holes, and the Big Bang itself. Bartusiak likens current astronomy to a silent movie and suggests that the discovery and observation of gravity waves will suddenly add sound to that picture. Her clear writing and thorough understanding of the science and personalities behind her topic make her book as absorbing as any film. Originally published in hardcover in 2000. ***Berkley, 2003, 256 p., b&w plates, paperback, $14.00.***



STATE OF THE WORLD 2003

CHRIS BRIGHT, CHRISTOPHER FLAVIN, ET AL.

This annual from the environmental watchdog group the Worldwatch Institute celebrates its 20th anniversary of tracking economic trends that imperil ecosystems and touting ways to foster an environmentally sustainable society. In this year's volume, the authors reflect on the positive changes that have occurred over the past few decades, including the eradication of smallpox and the encouraging drop in birth rates in many countries. Looking toward the future, they focus on the outcome of the Johannesburg World Summit on Sustainable Development that took place last year. A focus, therefore, is South Africa, and the book documents poor living conditions—little improved since the end of apartheid—and environmentally damaging gold mining. In examining global trends, the authors address the spread of West Nile virus, progress in organic farming, and advances in renewable energy. ***Norton, 2003, 241 p., paperback, $16.95.***

HOW TO ORDER To order these books or any other book in print, call **1-800-370-3010.** Visa, MasterCard, and American Express accepted. Send checks or money orders plus $5.95 shipping and handling ($2.50 for each additional item) to **How To Media, 28 Slocum Place, Long Branch, NJ 07740**. Or see our Web site at **www.sciencenewsbooks.org.** This service is provided in conjunction with Science News Books.

LETTERS

Picture this

"Photography at a Crossroads" (*SN: 11/23/02, p. 331*) asserts that the earliest photographic image was taken in 1826. In fact, the earliest photographic image may date to much earlier. Using silver nitrate on linen (1992) and later silver sulfate (1994), Nicholas P.L. Allen was able to reproduce, in large part, the unique visual and chemical properties of the Shroud of Turin. The best one can say is that the 1826 photograph is *possibly* the earliest.

PATRICK GILLESPIE, SOUTH STRAFFORD, VT.

Oldies but goodies

What is reported in "Loony Tunes: Bugs blare in software set to music" (*SN: 11/30/02, p. 339*) is a new application of an old idea. In the 1950s and early 1960s, engineers would check a computer by setting a radio beside the central processing unit to pick up the electromagnetic signals put out by switching vacuum tubes and, later, transistors. By programming so that the switching played a familiar tune, the engineer could detect instantly where bugs were. Some of us from those years can recall standing around a $6 million computer listening to it play "Rudolph the Red-nosed Reindeer" for a Christmas party at Cape Canaveral.

WAYNE MCCOY, POOLESVILLE, MD.

I worked for Control Data Corp. from 1962 to 1964. I distinctly remember being impressed by a snappy version of a polka that the programmers used to quickly isolate defective cards plugged into the first mainframe computers. This was done by tuning a portable radio near the frame.

JOHN D. SHOTZBARGER, MINNEAPOLIS, MINN.

Vaccine query

Many people who are exploring the possible connection between childhood vaccines and autism claim that the culprit is not the vaccines themselves, but the mercury-containing preservative thimerosal ("Study exonerates childhood vaccine," *SN: 11/30/02, p. 349*). Does the Danish MMR vaccine contain it?

ANNE SEALS, SUMNER, WASH.

Thimerosal has never been used in the MMR vaccine, either in the United States or in Denmark. —B. HARDER

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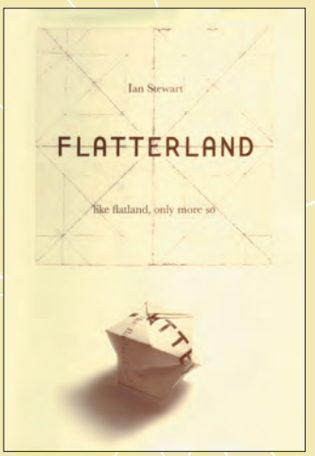
SPACE, TIME, MATTER, AND... MODERN GEOMETRIES



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.

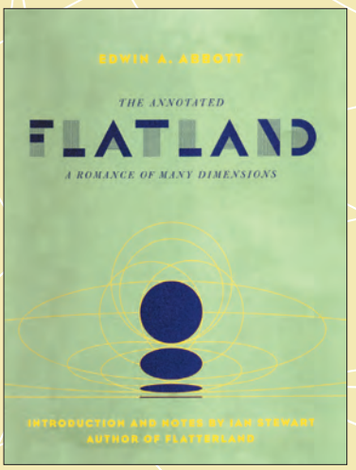
Flatterland provides an engaging, completely accessible guide to some of the trickiest concepts in contemporary mathematics. Through larger-than-life characters and an inspired story line, Flatterland explores our present understanding of the shape and origins of the universe, the nature of space, time,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

—from Perseus Publishing



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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