SCIENCE NEWS

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SEMIANNUAL INDEX

NEWS OF THE YEAR

THE WEEKLY NEWSMAGAZINE OF SCIENCE

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Cover With sprightly wit, several recent dramas have delved into the world of mathematicians and their abstruse concerns. (Dean MacAdam) Page 392

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SCIENCE NEWS This Week

Chinese Roots

Skull may complicate human-origins debate

In 1958, farm workers digging in a cave in southern China's Liujiang County discovered several human bones including a skull. Relying on its resemblance to securely dated human fossils in Japan, scientists assigned this *Homo sapiens* skull an age of 20,000 to 30,000 years.

However, the Liujiang finds may be much older than that, according to a report in the December *Journal of Human Evolution*.

The fossils probably came from sediment dating to 111,000 to 139,000 years ago, says a team led by geologist Guanjun Shen of Nanjing (China) Normal University. He and his coworkers add that it's still possible that the Liujiang discoveries came either from a cave deposit dating from around 68,000 years ago or from one dating to more than 153,000 years ago.

If any of these estimates pans out, "the Liujiang [specimen] is revealed as one of the earliest modern humans in East Asia," the team concludes. The presence of modern humans in this part of the world 100,000 years ago or more would roughly coincide with their earliest fossil dates in Africa and the Middle East.

Evidence of such ancient roots for *H. sapiens* in China creates problems for the influential out-of-Africa theory of human evolution, Shen's group says. That theory holds that modern humanity originated in Africa between 100,000 and 200,000 years ago and then spread elsewhere, replacing other *Homo* species. If the Liujiang dates were confirmed, out-of-Africa adherents would need to find older African *H. sapiens* fossils than they now have or show that modern humans migrated extremely quickly from Africa to eastern Asia.

The new dates also suggest that other, more-primitive-looking Chinese *Homo* fossils that date to 150,000 to 100,000 years ago represent a lineage that coexisted with modern humans, Shen proposes.

Scientific accounts from 1959 and 1965 of the Liujiang discoveries guided the new determination of the fossils' likely burial site. Shen's team mapped various soil deposits in the cave and calculated the age of crystallized limestone samples by using the rate of uranium decay.

Uranium analyses at other sites support an ancient origin of modern humans in southern China, Shen says. *H. sapiens* teeth found at two other caves in this region come from sediment that his group dates to at least 94,000 years ago.

Anthropologists with divergent views about human evolution say that the new age estimate for the Liujiang skull remains preliminary. It's still uncertain how the skull got in the cave and where it was originally buried, remarks Christopher B. Stringer of the Natural History Museum in London. Stringer, an out-of-Africa proponent, says that Shen's team members need to date either the skull itself or the calcite clinging to its surface to make their case.

Milford H. Wolpoff of the University of Michigan in Ann Arbor agrees. "I'd love for the Liujiang skull to be as old as Shen proposes, but we'll never know for sure without directly dating the specimen," Wolpoff holds. In his view, modern humanity evolved simultaneously in Africa, Asia, and Europe over the past 2 million years.

Shen says he hopes to work out an agreement with Chinese officials in charge of the Liujiang skull to date the specimen directly. —B. BOWER

W. WANG

ASIAN CONNECTION **If southern China's Liujiang skull is really more than 100,000 years old, this modern *Homo sapiens* fossil will shake up theories of human evolution.**

Life at the Frigid Edge

Microbes turn up deep in Antarctic lake ice

A pocket of cold, concentrated saltwater at the bottom of Antarctica's Lake Vida has been sealed off from the world for at least 2,800 years. Yet it could still harbor life, say researchers who found microbes in the ice right above the briny layer.

Peter T. Doran of the University of Illinois in Chicago and his team started studying the frozen 5-kilometer-long lake after learning that it contains liquid.

Previously, researchers thought that Lake Vida—one of the largest lakes in the McMurdo Dry Valleys desert—was just a "big chunk of ice," says Doran. However, in 1995 ice-penetrating radar revealed saltwater 19 meters down. "This brine pocket in the center of the lake popped up like a sore thumb," says Doran.

The next year, Doran and his colleagues returned to Lake Vida to obtain cores as deep as 15.8 m. However, fearing that they might contaminate the buried pocket of liquid with contemporary microbes, they stopped their drilling short of it.

Instead, the researchers sampled the top of an overlying 3-m-thick layer of slushy saltwater. They also left probes at the bottom of the boreholes to monitor the temperature there for 4 years. The water is so salty—seven times the salt concentration of seawater—that it can remain liquid even at –10°C.

Lake Vida differs from other nearby, perennially ice-covered lakes. In those bodies, meltwater enters by flowing under a 3-to-6-m ice cover. In contrast, meltwater and sediments carrying microorganisms don't enter Lake Vida but instead freeze on top of it in a bubble-pocked layer thick enough to block sunlight from reaching the bottom. The resulting 19-m cover—the thickest lake ice ever recorded—is an "ice museum" recording biological history, says John C. Priscu of Montana State University–Bozeman.

The researchers were surprised to discover that 12-m-deep ice samples dated to 2,800 years ago contained viable microbial life. Some icebound microbes, such as cyanobacteria, became active and grew when the researchers thawed them.

The scientists, who report their findings in an upcoming *Proceedings of the National Academy of Sciences,* plan to sample Lake Vida's brine in a few years. A similar challenge also faces scientists pining to sample Antarctica's Lake Vostok, which receives meltwater from the 4-km-thick glacier that covers it (*SN: 10/2/99, p. 216*).

Charles R. Bentley of the University of Wisconsin–Madison is eager to learn more about life in such an extreme environment. "The idea that the lake water has been isolated for at least 2,800 years is fascinating," he says.

Lake Vida is unique, agrees Diane M. McKnight of the University of Colorado in Boulder. It's the first example of an ice-sealed lake that has no contact with overlying glacial ice, new meltwater, or the atmosphere.

Priscu says that finding viable life in seemingly inhospitable places, such as deep in Lake Vida's ice, supports his view that Earth's biosphere is much larger than previously imagined. "The microbial world has few limits on our planet," he says. —C. MARZUOLA

SEALED BY ICE **Supersalty water that lies at the bottom of Lake Vida may support life.**

DORAN

Ant Traffic Flow

Raiding swarms with few rules avoid gridlock

A novel analysis shows how individual ants' behavior keeps the traffic flowing as 200,000 virtually blind army ants use a single trail to swarm out to a raid and return home with the booty.

The South American army ant *Eciton burchelli* avoids epic gridlock by forming traffic lanes on its trail, explains Iain D. Couzin of Princeton University. The ants don't follow people's simple stay-to-the-right (or left) paradigm. Instead, they create three lanes—the outer two carrying raiders to the job and the middle one returning them to the nest. This pattern can develop from just the basic behavioral tendencies of individual ants, say Couzin and Nigel Franks of the University of Bristol in England in an upcoming *Proceedings of the Royal Society of London B.*

This work is the first to examine individual ants' traffic rules, Couzin says. He finds that the system is innately different from the human-traffic patterns that he has modeled. The crucial difference: "Ants are not selfish," he says.

Couzin began his army ant analysis by formulating a mathematical model to describe an individual rushing along a chemically marked trail until it detects a possible obstacle and chooses whether to turn aside. Next, he tuned the model by observing the behavior of real raiders.

In the jungle at Soberania National Park at the Smithsonian Tropical Research Institute in Panama, Couzin and Franks filmed ant raids. During its 10-hour workday, an ant colony flows across the forest floor catching some 3,000 invertebrates each hour. The swarms flow so densely that the ants' feet make an audible rustle, Couzin says. "I think it's one of the wonders of the natural world," he says.

Plugging measurements of ant movement into the computer model, the researchers found that ants have optimized their tendency to turn aside when encountering a possible obstacle, such as another ant. More sensitivity to collisions would have made the ants cringe and defer so much that they'd never get anywhere, but too little sensitivity would have created hundred-ant pileups.

The scientists also discovered that army ants carrying home their prey don't turn aside as much as ants on the way to work do. The computer model showed that this factor could enable ants to initiate a return lane by pushing into and deflecting the arriving ants.

The ants' three-lane system probably works better for them than a two-lane system would, speculates Couzin. A two-lane system would require a tendency to turn one way more often than another, he says. Such a bias could easily have undesirable effects, such as reducing the raiding party's tendency to forage in certain directions from its nest.

Another ant biologist, Neil Tsutsui of the University of California, Davis, speculates that a three-lane trail provides better defense for the booty lane than two lanes would. Tsutsui praises Couzin and Franks for their "unique and valuable" insights in showing how simple individual behavior can add up to a complex pattern for a whole group. —S. MILIUS

Gold Deposits

Scientists design nanoparticle films

In a step toward a cheaper, easier way to connect computer chips to computers, scientists have patterned semiconductors with a film of extremely small gold particles. The nanoscale detailing might also lead to other applications: new sensors for detecting chemical weapons, novel chemical catalysts, and better ways of delivering medicines.

The contacts that connect tiny components of a computer chip to a much larger wire are often made of gold because it doesn't react with air easily. The metal is expensive, however.

In the new work, Jillian Buriak, Lon Porter Jr., and their colleagues at Purdue University in West Lafayette, Ind., use gold leftovers from coin-making factories. This so-called gold salt is inexpensive and can be converted into relatively pure gold particles, says Buriak.

In simple bench-top experiments, the researchers dipped pieces of semiconductor materials, such as germanium or gallium arsenide, into a solution containing gold salt. A gold layer spontaneously formed on the semiconductors' surfaces. "You take a test tube [of gold salt] that's worth pennies, and you're able to get a very high-purity gold layer on top of your chip," says Porter.

Scanning electron microscopy and atomic force microscopy revealed that the film is actually made of nanoscale gold particles. The same process worked for palladium and platinum, precious metals well known for catalyzing chemical reactions.

Simply forming nanoparticle films is just a start. To move toward practical applications, the researchers used several chip-patterning techniques to deposit the nanoparticle films as lines or grids. The team also learned to control the size of the films' particles—from about 10 nanometers to 1 micrometer—by adjusting the temperature, deposition times, and gold-salt concentrations, says Porter, who with his coworkers reports the work in the Dec. 11 *Nano Letters*.

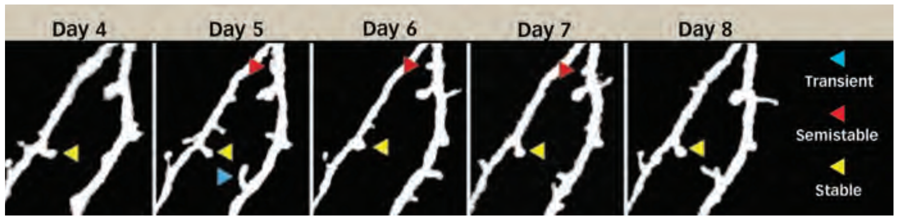
This work is "a very good example . . . of a generalizable method to fabricate nanoscale structures," comments Jie Liu of Duke University in Durham, N.C.

The scientists also bonded a dense layer of organic molecules to the large surface area created by the films' nanostructure, says Buriak. Researchers might be able to tailor such a top layer to detect certain molecules—say, those of a chemical warfare agent—to create a portable chemical sensor the size of a PalmPilot, adds Porter.

The new precious-metal films might also find use as catalysts since their nooks and crannies could promote chemical reactions, Porter suggests. Or, the small pockets could hold molecules for drug delivery. —J. GORMAN

Showing Some Spine

Imaging of nerve cell branches stirs debate



TWIGGING OUT **This series of images from the brain of a live mouse provides evidence for a brief lifespan of many spines—the stubby bulges (distinguished by colored arrowheads) from nerve cell branches known as dendrites.**

ADAPTED FROM J.T. TRACHTENBERG ET AL./NATURE

Two research groups have taken unprece-dented, high-resolution images of nerve cells inside the brains of live mice—and come to seemingly contradictory views. Resolving their conflict about the stability of cell projections called dendritic spines could illuminate how the adult brain adapts to experience and stores information, say neuroscientists.

The research teams, which both report their work in the Dec. 19/26 *Nature*, studied different areas of the mouse cortex, the brain's outer layer. The group led by Karel Svoboda, a Howard Hughes Medical Institute investigator at Cold Spring Harbor (N.Y.) Laboratory, examined a cortical region that processes sensory information from a mouse's whiskers. The team led by Wen-Biao Gan of New York University School of Medicine investigated cortical cells that respond to visual information.

Both groups worked with mice genetically engineered to incorporate fluorescent proteins into the targeted nerve cells. Svoboda and his colleagues studied the green-glowing cells of their mice by implanting viewing windows in the rodents' skull. Gan's team instead thinned the skulls of their mice until they could image the nerve cells that glowed yellow.

Rafael Yuste of Columbia University, coauthor of a manual on imaging nerve cells, calls the experiments a "tour de force" that will set the stage for many similar studies in live animals.

Over days, weeks, and even months, the neuroscientists recorded images of the same rodent brains, focusing on the nerve cell branches known as dendrites. In particular, the groups studied each dendrite's many stubby projections, or spines. Nerve cells communicate with each other through specialized junctions called synapses, and a dendritic spine provides the receiving end of a synapse, according to many neuroscientists.

In studies of 1-to-2-month-old mice, Svoboda and his colleagues found that although the dendrites of the mouse cortex remain stable, many of their spines quickly appear and vanish. The investigators report that about 50 percent of spines persist for more than a month, but the rest show up for only a few days or less. Trimming the whiskers of a mouse increases the percentage of spines that exist only briefly.

Svoboda's team considers its data as evidence for a dynamic adult brain in which synapse-based circuits are constantly remodeled by the formation and elimination of dendritic spines, especially in response to new experiences.

Yuste, however, cautions that not every spine contains a synapse, and synapses don't have to be on spines.

Gan's group envisions a more stable adult brain. Even in their 1-month-old mice, more than 70 percent of dendritic spines persisted for more than a month. And in mice 4 to 10 months old, around 96 percent of spines were stable for at least a month, many of them enduring much longer.

Some spines "can even be maintained over the lifetime of an animal," says Gan's colleague Jaime Grutzendler. The researchers suggest that such long-term spines may offer a way for the brain to store information such as memories.

Grutzendler questions whether Svoboda's team was really studying the adult brain because that group's mice were all young. The different brain regions examined may also partly account for the two groups' clashing data, he adds.

"The two papers are showing opposite results, something that doesn't happen too often in science. It draws the skepticism of all the people in the field," says a puzzled Yuste. "I find it hard to believe that one part of the cortex is very dynamic and the other is not." —J. TRAVIS

Sea Sickness

Despite cleaner cruises, diarrhea outbreaks persist

Cruise ships are cleaner than they used to be, but their standard sanitation practices don't reliably wipe out the viruses behind a recent wave of diarrheal outbreaks, according to new reports from the Centers for Disease Control and Prevention (CDC) in Atlanta. Halting viral epidemics on ships may require unusually rigorous measures, such as docking stricken vessels for extreme scrub downs.

Noroviruses, or Norwalk-like viruses, spread easily through casual contact and can survive outside the body for days. In the confined spaces of ships, military camps, and overcrowded institutions, these hardy viruses often set off epidemics of diarrhea and violent vomiting. Noroviruses cause an estimated 23 million illnesses each year in the United States.

Cruise ships hosted at least 23 outbreaks of gastrointestinal illness during 2002, and noroviruses triggered more than three-quarters of those linked to a specific pathogen, says Elaine H. Cramer, a CDC consultant in Vancouver, Canada. In the Dec. 13 *Morbidity and Mortality Weekly Report*, Cramer, Marc-Alain Widdowson, and other CDC investigators describe norovirus outbreaks on five ships operated by four different companies. More than 2,000 people were sickened in these epidemics.

On three of the ships, epidemics affected several consecutive voyages, probably because viruses survived onboard despite the recommended post-outbreak procedures that were carried out between scheduled cruises. These measures range from scrubbing public spaces to sterilizing poker chips. Outbreaks caused by a norovirus struck Holland America's *Amsterdam* on four separate voyages; the epidemic abated only after the ship was sidelined for 10 days and subjected to even more aggressive cleaning.

The spate of outbreaks in 2002 departs from an overall downward trend in gastrointestinal infections at sea. In a separate study, Cramer and two of her colleagues reviewed a trove of CDC data on cleanliness and the occurrence of stomach ailments aboard cruise ships. CDC inspectors periodically board vessels and score them on hygiene.

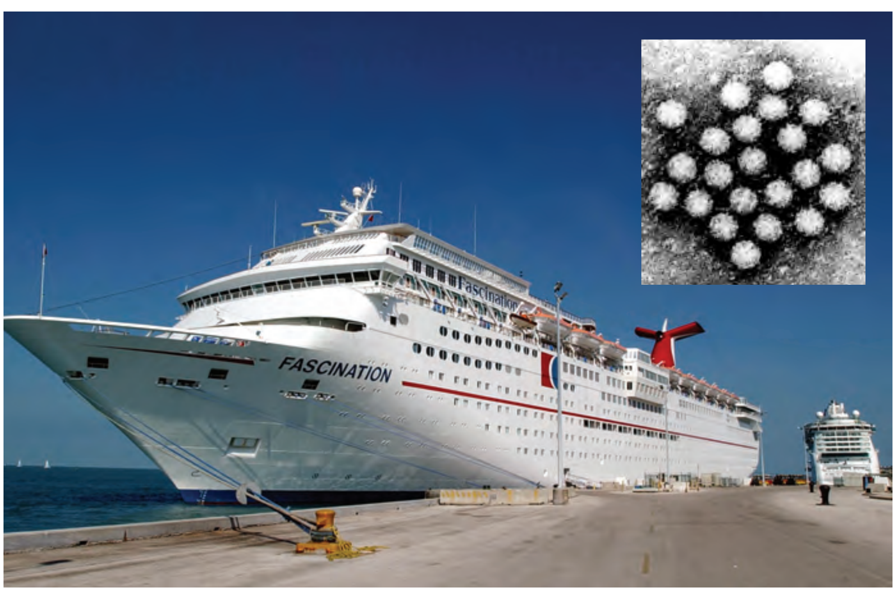
During the 1990s, inspectors reported improper handling of water on 55 percent of inspections and of food on 62 percent. They noted violations in equipment maintenance and dishwashing procedures in 95 percent of assessments. Half of all cruise lines nevertheless received scores deemed as passing for at least four-fifths of their inspections.

A rising percentage of cruise ships passed muster toward the end of the decade. Meanwhile, outbreak-related cases of diarrheal diseases declined from 42 per million passenger-days between 1990 and 1995 to 35 per million passenger-days later in the decade, the researchers will report in the April 2003 *American Journal of Preventive Medicine.*

Megan Murray, an epidemiologist at Harvard University, cautions that general public health efforts, for example the reduction of salmonella bacteria in eggs, may explain the 1990s decline of intestinal ills on ships.

Since most of the recent outbreaks haven't been associated with food or water, proper handling of provisions may not avoid norovirus infections, says Cramer.

Once the viruses sneak on board, they don't require lapses in hygiene to spread, so "even ships with extremely high sanitation scores are going to be susceptible to norovirus [outbreaks]," says the CDC's Widdowson. —B. HARDER



HARBORING VIRUSES **Stomach illnesses affected passengers on the *Fascination* and other ships during recent voyages. Small, round noroviruses (inset) cause many shipboard outbreaks.**

AP/WIDEWORLD; NATIONAL CENTER FOR BIOTECHNOLOGY INFORMATION

News of the Early Universe

Findings from the cosmic microwave background

The most detailed snapshots so far of the infant universe are confirming that the cosmos consists mostly of mystery material, called dark energy, that accelerates the universe's expansion.

The new evidence comes from the Arcminute Cosmology Bolometer Array Receiver (ACBAR), a South Pole network of 16 detectors that probes the temperature of the Big Bang's remnant radiation, known as the cosmic microwave background. That radiation provides an image of what the universe looked like about 400,000 years after the Big Bang, when photons first streamed into space.

Although the radiation has cooled to an average temperature of 2.73 kelvins, the remnant light emanating from some patches of sky is slightly cooler or hotter. These tiny hot and cold spots reveal the earliest phases of gravitational clumping of matter and radiation, the seeds of galaxy formation.

The clumping also caused the early universe to ring like a bell. As gravity forced photons to bunch together, the photons resisted by exerting an outward pressure. That push and pull set up acoustic oscillations that remain imprinted in the cosmic microwave background today.

It's the peaks and valleys in those oscillations that cosmologists analyze to measure such cosmic traits as the overall curvature of the universe and the density of matter. ACBAR's sensitivity to temperature variations over a wide range of spatial scales enabled the array to measure both these traits. The results confirm that "we live in a bizarre universe" where dark energy reigns, says ACBAR researcher Jeffrey B. Peterson of the Carnegie Mellon University in Pittsburgh.

The study also provides a new hint of how photons of the microwave background interacted with hot gas in galaxy clusters in the 14 billion years that followed the Big Bang. Peterson and his colleagues recently posted their initial results online (*http://xxx.lanl.gov/abs/astro-ph/0212289*).

If further analyses uphold these findings, it could mean that galaxy clusters "are much more abundant than they appear from other observations," says Wayne Hu of the University of Chicago. That would indicate that cosmological models are incomplete.

Cosmologists are eagerly awaiting the findings from another device, the Microwave Anisotropy Probe (MAP) satellite. Unlike the ground-based ACBAR, the satellite has examined the microwave background over the entire sky. But MAP's resolution is less than that of ACBAR, so it can't discern as much detail.

"MAP will see the big picture, while ACBAR's high-resolution data enable it to zoom in on a small patch of sky," says MAP theorist David N. Spergel of Princeton University. ACBAR probes the detailed physics during the time that photons from the microwave background were beginning to be set free from matter and that acoustic oscillations were starting to be damped out, he notes.

Together, ACBAR and another high-resolution, ground-based device, the Cosmic Background Imager in Chile, "have started a new chapter in microwave-background research," says Max Tegmark of the University of Pennsylvania in Philadelphia. "The best is yet to come." —R. COWEN

DRAMA IN NUMBERS

Putting a passion for mathematics on stage

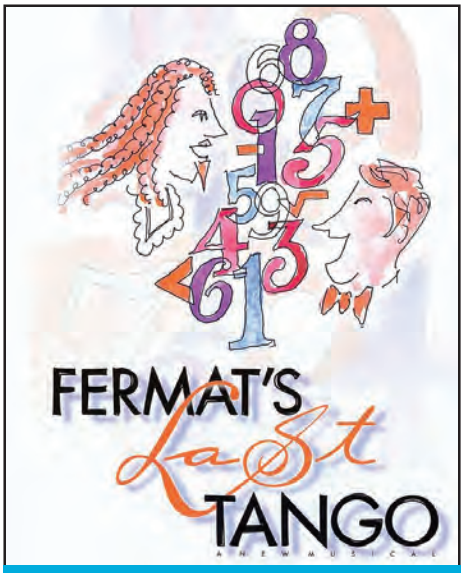
BY IVARS PETERSON

As the curtain rises, an illuminated mathematical expression dominates the scene. "Do you see that theorem?" the narrator asks. "In 1637, Pierre de Fermat . . . wrote it down in the margin of a book. Then he added this tantalizing note." A spotlight suddenly reveals a bearded, bewigged, flashily dressed Fermat, who promptly sings, "I have discovered a truly marvelous proof, a truly marvelous proof of this, which this margin is not large enough to contain."

Next, a quick succession of vignettes portraying centuries of immense mathematical frustration spawned by Fermat's never-recorded proof—known as Fermat's last theorem—unfolds across the checkerboard floor of a sparsely furnished stage.

The musical number that closes this prologue introduces the play's hero—Daniel Keane, a modestly dressed, mildly bewildered, Princeton mathematician who is claiming to have proved Fermat's last theorem. Pursued by a gaggle of reporters, Keane fumbles to explain what he has done. One reporter inquires, "What is a proof, and who cares?"

"Fermat's Last Tango" is billed as a musical fantasy inspired by real-life Princeton mathematician Andrew Wiles and his encounters with Fermat's last theorem (*SN: 11/5/94, p. 295*). It's one of several mathematics-rich stage productions of the past few years. Although these plays, with their overtly mathematical themes and number-enthralled characters, have especially captivated mathematicians, they have also attracted remarkably diverse and enthusiastic audiences.



FERMAT SINGS — This musical fantasy was inspired by Princeton mathematician Andrew Wiles' 7-year quest to prove Fermat's last theorem.

COURTESY OF THE CLAY MATHEMATICS INSTITUTE

David Auburn's "Proof," which hinges on the disputed authorship of a mathematical work, won the 2001 Pulitzer Prize for drama and is still running on Broadway. Tom Stoppard's 1993 play "Arcadia," which brings fractal geometry and chaos theory into a 19th-century setting, continues to thrive in a variety of venues.

"Each of these plays gave me considerable pleasure, albeit in very different ways," says Robert Osserman of the Mathematical Sciences Research Institute in Berkeley, Calif. He has interviewed the playwrights of "Proof" and "Arcadia" as part of public programs including excerpts from the stage productions.

These three plays depict the pursuit of mathematics as a painful joy—an intense endeavor that can unveil an alluring beauty in ideal objects or bare mathematical symbols. In "Fermat's Last Tango," Keane lauds the power and purity of mathematics. The beauty of numbers is everywhere, he tunefully proclaims.

At the same time, the pursuit of mathematics can humble or even crush a practitioner who fails to measure up to the field's exacting demands. The plays bring to mind people's powerful needs for recognition and connection with others doing similar work. The scripts explore the counterpoint between pure logic and the emotional complexities of everyday life, and they elucidate the meaning of *proof* in different settings.

BEAUTIFUL PROOF Auburn's play "Proof," first produced in 2000, centers on the younger daughter of a brilliant mathematician. The father, Robert, had become mentally unstable in his later years. Emotionally drained after years of taking care of him and neglecting her own education, 25-year-old Catherine must face her father's death, deal with her manipulative, estranged sister, and cope with the amorous attentions of a former student of her father.

The plot centers on the authorship of a potentially outstanding mathematical proof in number theory, which was found among notebooks filled with Robert's less-than-lucid scribbles. At first glance, the play appears to be both a mystery and a romantic comedy. On a deeper level, it raises questions about proof in human relationships as well as in math and about the stereotype that links youth and creativity.

"Auburn's script is well-crafted, fast moving, and marked by sparkling dialog," Donald J. Albers of the Mathematical Association of America remarked in a review of the play. "The mathematicians portrayed in 'Proof' come off as delightfully human and rather attractive people with whom you would probably enjoy having dinner."

Auburn himself has stated that he did not set out to write a play about mathematicians. He was interested in exploring the question of whether mental illness, as well as talent, can be inherited. And he was attracted to the idea of sisters fighting over an item of ambiguous significance found after their parents had died. The mathematical connections came later.

Auburn ended up immersing himself in works depicting the mathematical mind. He read popular books about mathematicians such as Paul Erdős, Srinivasa Ramanujan, and John Forbes Nash, whose biography became the basis of the 2001 film *A Beautiful Mind*. The example of Wiles working in his attic for 7 years to prove Fermat's last theorem gave Auburn a sense of the romance of mathematical work.

Members of the mathematics department at New York University offered Auburn advice and visited rehearsals. Auburn also sent copies of the play to other mathematicians, including Jean E. Taylor of Rutgers University. "I was surprised to find myself quite captivated by it," Taylor says.

In "Proof," Catherine's spiritual mentor is the 19th-century mathematician Sophie Germain, who sent her own highly original mathematical results to Carl Friedrich Gauss under a man's name because women then had no credibility in mathematics. Her work centered on certain numbers that are now known as Germain primes. Taylor pointed out that the example of a Germain prime given in the preliminary text was missing the term "+ 1."

"When I first went to see 'Proof' and that moment came up in the play, I was happy to hear the 'plus one' clearly spoken," Taylor says.

When the play opened just over 2 years ago, the Courant Institute in New York City hosted a daylong symposium that addressed some of the issues raised in the play, including the role of women in mathematics.

In Taylor's view, the play accurately portrays some of the barriers that women still face as professional mathematicians. A man, for example, wouldn't be expected to forego his education to take care of an ailing parent. His claim to have authored a proof would also be considered more credible. "Try to imagine the play with the sex of the characters [Catherine and her father's student] reversed," Taylor says.

In "Proof," Auburn found a witty, engrossing way to explore the notion of proof in several different senses—in the idea of a mathematical proof with its particular ironclad inevitability, the notion of establishing the authorship of an intellectual work, and the daily proof that people seek to reassure themselves of the stability of reality and of their personal relationships.

ARCADIAN CHAOS Like "Proof," the play "Arcadia" features a very clever young woman who has remarkable mathematical insights yet faces the skepticism of well-trained scholars who are less original in their thinking.

Thomasina Coverly is a mathematically precocious teenager of the early 19th century. Noting the irregular or branched nature of natural forms such as mountains and trees, she sets out to invent by trial and error the first mathematical framework to portray such structures.

FRACTAL FERN — In "Arcadia," Thomasina Coverly invents a simple mathematical recipe that yields branched forms resembling ferns.

Later, she playfully writes in her notebook, "I, Thomasina Coverly, have found a truly wonderful method whereby all the forms of nature must give up their numerical secrets and draw themselves through number alone." Then she slyly adds, "This margin being too mean for my purpose, the reader must look elsewhere for the New Geometry of Irregular Forms discovered by Thomasina Coverly."

The play nimbly switches back and forth between the early 19th century and modern scenes that take place in the same house. One of the contemporary characters is mathematician and biologist Valentine Coverly, who discovers Thomasina's notebook and marvels at her insights. As it happens, Valentine himself is modeling population changes among grouse on his family's estate. Valentine tries to explain iteration, algorithm, chaos, and other mathematical terms to a best-selling author and garden historian who's visiting.

Stoppard's play delves into the unsettling experience of facing new ideas, the interplay of hypothesis and evidence, and the role of human character in discovery. Yet the conversation remains sprightly and amusing, and the often-befuddled characters are engaging.

"I consider ['Arcadia'] one of the outstanding plays of the last couple of decades, with or without the math," Osserman says. "Stoppard is one of our greatest playwrights, and 'Arcadia' is one of his best—if not the best—of his plays. . . . Apart from that, the amount of serious mathematics he fits in—in a totally natural way—is just amazing. And unlike most plays that touch on mathematics, he really gets it right."

"Arcadia" serves as an antidote to the common impression that mathematics putters along in inscrutable increments and hasn't changed much since Euclid's time. The play also brings mathematics to, as Valentine puts it, ". . . the ordinary-sized stuff which is our lives, the things people write poetry about—clouds—daffodils—waterfalls—and what happens in a cup of coffee when the cream goes in."

Mathematician Robert L. Devaney of Boston University originally learned about "Arcadia" from his son, an actor in New York City. When the play was scheduled to be performed at Boston's Huntington Theater, Devaney became an informal advisor. "I spoke several times to the director as he was putting the play together and eventually he had me talking to the cast about the mathematical ideas in the play, showing them fractals, and so on," he says. "I became the 'chaos consultant' for the production."

"Since my original involvement, I have helped out a number of school productions by getting together the math, humanities, and science teachers and students to understand the different aspects of the play," Devaney adds. "I can't imagine a better way to get liberal arts students involved in some contemporary mathematics."

Devaney has developed an informative Web site describing and animating some of the mathematical ideas lurking in Stoppard's play (*see http://math.bu.edu/DYSYS/arcadia/*).

SONG-AND-DANCE NUMBERS "Fermat's Last Tango" is a rare foray of mathematics-inclined playwrights into the arena of musicals. Written by Joshua Rosenblum and Joanne Sidney Lessner, "Fermat's Last Tango" revels in the drama and passion associated with the centuries-long quest to elucidate Fermat's tantalizing marginal hint.

"As a musical fantasy on the subject of wrestling with the mysterious process of discovering a proof, 'Fermat's Last Tango' is in a class by itself," Osserman says.

The musical focuses on the traumatic period between the 1993 discovery of a flaw in the proof Wiles originally presented of Fermat's last theorem and Wiles' circumventing of that deficiency a year later. Keane, the character standing in for Wiles, must confront the possibility of failure. Riddled with doubt, taunted by a mean-spirited Fermat, and haunted by a ghostly chorus of Pythagoras, Euclid, Isaac Newton, and Gauss, Keane returns to his singular, possibly ill-fated pursuit. He retreats to the attic, again leaving his wife as the "math widow" she had been for so many years before.

"This drama is so powerful because it describes the clash between frail humanity on the one hand and intellectual destiny on the other," says mathematician Arthur Jaffe of Harvard University. "And it all rings true."

The musical is also cheerful, clever, and appealing. The extraordinarily inventive lyrics of its wide-ranging score are laced with numerous mathematical and historical references. Indeed, the play's mathematical vocabulary is surprisingly sophisticated. Imagine a song in which the phrase "Taniyama-Shimura conjecture" is heard not just once but several times.

"Of all popular portrayals of mathematics in the media, I believe that only this play contains real mathematical content," Jaffe contends. "The authors had real insight. The characters think about mathematics just the way a real mathematician would."

"Fermat's Last Tango" was originally performed by the York Theater Company in New York City in December 2000. Fascinated by the play and encouraged by Wiles, Jaffe went to considerable trouble to have the production videotaped on behalf of the Clay Mathematics Institute in Cambridge, Mass., where he worked until recently. The institute continues to sell the tape. A London production of the play is now is the works.

Mathematics on stage is a scarce commodity. The recent spate of successful productions may be just the start of a beautiful marriage between mathematics and the theater. ■

GETTING WARPED

A new exhibit on Albert Einstein dissects his slippery science

BY PETER WEISS

Science exhibits don't often come with a warning sign. But there's one at the entrance to a sprawling, new exhibit on Albert Einstein's life and science at the American Museum of Natural History in New York City. The sign has no words. It's a video screen whose center is dominated by a dark blob. Around the blob yawn strangely bloated, bowed, stretched, and sometimes doubled images of museum visitors. That's how they might appear if light from them were distorted by a black hole—an unimaginably dense package of matter whose existence follows from Einstein's theories (*SN: 9/29/01, p. 203*).

What's the message of this cryptic warning? Astrophysicist Michael M. Shara, curator of the exhibit, translates it this way: "From the minute you step through the front door, we will twist your view of space and time and what your entire vision of the universe is like."

The exhibit delivers just that. Using computer simulations of warped space, time-manipulating soundscapes, and sparkling light sculptures, the displays immerse visitors in Einstein's counterintuitive science. In the exhibit's quieter, less flashy galleries, Einstein himself is minutely scrutinized. With artifacts, film footage, handwritten letters, and other documents, the exhibit probes Einstein's often-tumultuous life—his friendships, loves, and political pursuits. The museum bills the new displays as "the most comprehensive exhibition ever on the life and theories of one of the greatest scientists of all time."

TIME TRAVEL — Animations of clocks that tick when a light pulse hits a mirror demonstrate time's slowdown for a moving object (bottom) relative to a stationary one. Because light's speed is constant and a diagonal path is longer than a vertical one, the orange clock ticks more slowly than the yellow clock.

AMERICAN MUSEUM OF NATURAL HISTORY

FOLLOW THE LIGHT Albert Einstein is best known for a handful of monumental achievements. They include his iconic equation, $E=mc^2$, which led ultimately to nuclear weapons, nuclear power, and enhanced understanding of the sun and other stars. Perhaps even more famous are his theories of relativity, which radically changed notions of time, space, and gravity.

Although most people are aware that Einstein fomented a revolution in physics, few are acquainted with the specific ideas behind that upheaval, notes physics educator Gretchen Walker, who helped coordinate the exhibit for the museum. In the new exhibit, about half the display space is devoted to conveying the gist of Einstein's most renowned revelations about light, time, energy, and gravity.

"It's the first attempt to explain the essence of Einstein's scientific contribution in a museum exhibition," says physicist Hanoch Gutfreund of the Hebrew University in Jerusalem at the recent launch of the exhibit.

The starting point for those explanations is the nature of light. Is it just a wave—as most turn-of-the-century physicists had viewed it—or also a stream of particles—as Einstein ultimately concluded? If it's a wave, then what medium does it undulate through? Is it like an ocean wave advancing through the water?

Einstein already had begun pondering such questions as a teenager in the 1890s. The exhibit includes a sheet from a six-page handwritten letter—billed as Einstein's first scientific paper—which the 16-year-old boy mailed to his uncle. In it, the budding theorist imagines what it would be like to ride on a light wave.

Scientists at that time considered light to be moving ripples in a tenuous, uniform medium, called the aether. They presumed that the aether filled all of space. To test for its presence, scientists observed light beams propagating simultaneously in perpendicular directions and looked for a speed difference. The idea was this: Because Earth plows through the aether as it traces its orbit, light should appear to move slowest along the direction in which the planet pushes into the aether, quickest along the opposite direction, and at intermediate speeds along other directions. Yet the experiments detected no deviation in light's speed, regardless of direction.

This result deeply disturbed most physicists of the day.

Einstein took the findings at face value, rejected the idea that light travels through an aether, and went on to explore other logical consequences of light's apparently constant speed. One deduction is that nothing can move faster than light.

His cogitations eventually led him to develop the so-called special theory of relativity, which he first published in 1905. The theory's name connotes that it is limited to bodies that are moving at a constant speed rather than extending to objects in any type of motion. In his theory of relativity, Einstein deduced that time and space themselves must fluctuate. “He accepted a nonsensical universe,” says Shara. With simple animations, the exhibit demonstrates how Einstein came to that view.

TIME RULES Numerous recent experiments, such as comparisons of clocks aboard planes and on the ground, have demonstrated that moving clocks tick more slowly than stationary ones. Einstein reached this conclusion theoretically from the premise that the speed of light is constant. The exhibit illustrates this logic. Adding eerie ambiance to those time-dilation displays, a staccato soundtrack of ticking clocks—some speeding up, others slowing down—plays in the background.

“It’s a wonderful exhibit,” comments Princeton University astrophysicist J. Richard Gott III, author of *Time Travel and Einstein’s Universe* (2001, Houghton Mifflin). Says Gott: “They picked out a key item—moving clocks tick slowly—and explained it three different ways.” If one explanation doesn’t get through to a museum visitor, he notes, then another probably will.

On display also are six original sheets—neatly hand-written by Einstein in German—from a 72-page, 1912 manuscript on special relativity. Einstein’s relativity investigations included calculations describing what happens to a body when it emits light. The results revealed that mass (m) would be transformed into energy (E) by a conversion factor, the speed of light (c) squared. One of the displayed pages includes the earliest remaining inscription by Einstein of $E=mc^2$.

To calculate just how subtly or dramatically time will slow down for a given moving object, it’s critical to know how fast the object is moving. To illustrate that aspect of time dilation, a wall-sized bank of digital clocks in the exhibit invites the visitor to suppose that Einstein had boarded a space ship on the day of his birth—March 14, 1879—and zoomed off at various speeds.

For a half-dozen speeds ranging from that of today’s spaceships—essentially 0 percent of light speed—to 99.99999999 percent of light speed, the clocks indicate today’s date as it would be for the space-faring Einstein. For example, in the slowest ship, Einstein would have aged 123 years, right along with his friends and family on Earth. At the fastest speed, however, nearly 20 hours of Earth time would have elapsed for each second that would have ticked by for Einstein. That means that the baby Einstein who rocketed away on the day he was born would now be only 1 day old.

Having found a cosmic speed limit—the speed of light, which is almost 300,000 kilometers per second—Einstein also exposed a profound flaw in the theory of gravity handed down by Isaac Newton centuries before. Newton had proposed that the force of gravity acts instantaneously to attract two distant masses to each other. Einstein realized that this couldn’t be. His cosmic speed limit required that nothing, including gravity, could act instantaneously over a distance.

Developing an alternative explanation for gravity took Einstein a decade. He published that alternative, the general theory of relativity, in 1915. The exhibit includes original pages of a hand-written draft of that seminal report, which extends the unexpected consequences of motion to accelerating objects.

Ultimately, Einstein showed that gravity’s effects result not from instantaneous action across distances but from a warping of space-time itself. The sun’s mass, for instance, distorts space-time in its own vicinity. That warping confines Earth and other planets to their elliptical orbits.

Even people’s puny bodies bend space and time, albeit to a negligible degree. To give exhibit visitors a feel for this usually unperceived fact of their lives, a computer instantaneously calculates and amplifies their bodies’ gravitation effects on surrounding space. As people approach a wall-sized monitor, it shows richly colored swells and dips in space-time. The biggest people and those closest to the wall trigger the most elaborate images. The display gives weight-consciousness a whole new meaning.

UNFINISHED BUSINESS Einstein’s revolution remains a work in progress. In many ways, researchers continue to explore, exploit, and test Einstein’s theories. Today’s physicists are observing black holes in deep space (*SN: 11/09/02, p. 299*), tuning in to hypo-

The Human Equation

Taking a comprehensive look at Einstein, the man

Besides being a great scientist, Albert Einstein was a father of the atomic age, a passionate defender of civil liberties, an ardent pacifist, and a champion of Jewish causes. Many papers, photos, films, and other artifacts that illustrate his multiple facets are on display in the new exhibit at the American Museum of Natural History in New York.

Included is his final high school report card, which dispels the myth that Einstein was a poor student. In fact, he received good-to-excellent grades in all subjects, and the highest possible marks—all 6s—in math and physics.

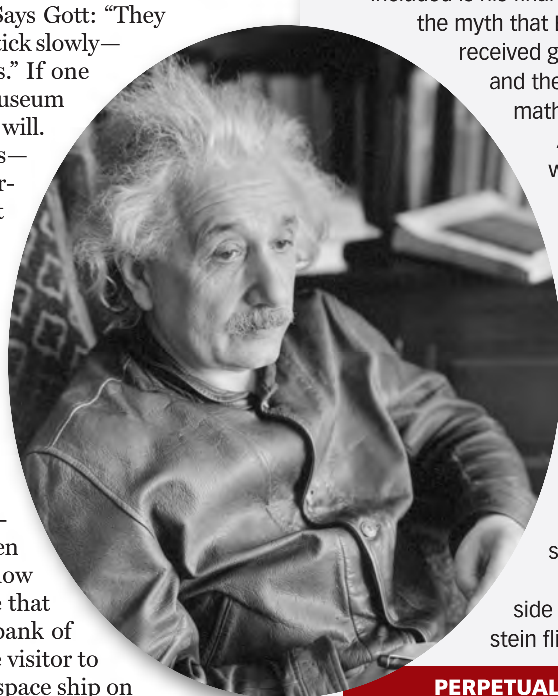
A letter from Einstein side-by-side with a response from Franklin Delano Roosevelt Jr. illuminates Einstein’s role in prompting the United States to develop the first atomic bombs. In those letters, Einstein encourages research into such weapons, and President Roosevelt confirms that he has set in motion the machinery to pursue that goal.

Other memorabilia depict Einstein promoting socialism, fighting against Sen. Joseph McCarthy’s anti-Communist witch-hunt of the early 1950s, and supporting the fledgling State of Israel.

From the collected mementos, a seamy side of Einstein also emerges. In a letter, Einstein flirts with one of the many women with whom he—a married man—had romantic affairs.

“We don’t want to whitewash him,” says exhibit curator Michael M. Shara. “Some of his family relationships were rocky, to say the least.”

The Einstein exhibit, organized by the museum, the Hebrew University of Jerusalem, and the Skirball Cultural Center in Los Angeles, runs in New York until Aug. 10, 2003. It’s scheduled to travel to Los Angeles in 2004 and Jerusalem in 2005. —P.W.

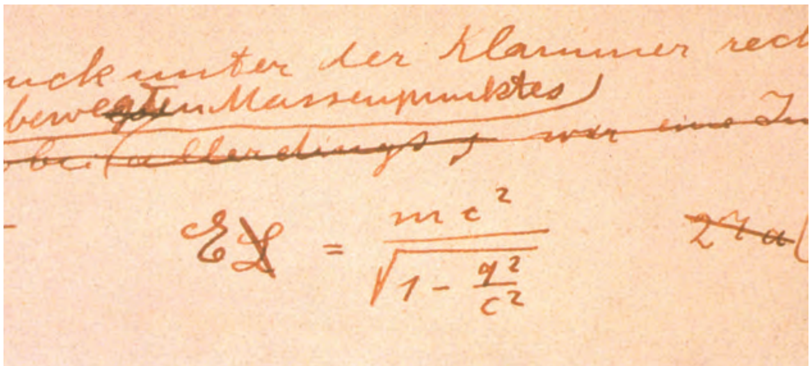


PERPETUAL PONDERER — After early theoretical triumphs, Einstein tried unsuccessfully to explain within one, unifying theory the fundamental forces then known: gravity and electromagnetism.

LOTTE JACOBI COLLECTION/UNIV. OF NEW HAMPSHIRE thetical ripples in space-time known as gravitational waves (*SN: 5/6/00, p. 303*), and fielding ultrasensitive space-time experiments, such those on the upcoming Gravity Probe B satellite (*SN: 11/15/97, p. 308*).

Curiously, all these pursuits stem from work Einstein had done before 1920. Although he continued to work diligently in physics until his death in 1955 at the age of 76, he produced no further landmark theories.

That's partly because Einstein was caught up during his later decades fighting a futile, rear-guard action against quantum physics, whose laws govern the realm of the very small. In particular, he objected to the randomness in particle behavior that the new approach predicted. Quantum physics proved to be, like relativity theory, a great 20th-century revolution in modern physics, but it left Einstein behind.



FORMULA E — Einstein wrote this version of his famous equation in a 1912 special-relativity manuscript—the oldest surviving document with the equation in Einstein's hand. Whereas the simpler form $E=mc^2$ applies to an object at rest, the version shown here applies also to moving objects.

ISRAEL MUSEUM, JERUSALEM

Ironically, Einstein initially helped build the foundations of quantum physics. Indeed, he won the 1921 Nobel Prize in Physics for a 1905 advance in which he established a theoretical grounding for the particle-like aspect of light. The exhibit includes the medal and certificate that he received with that award.

Also, by continuing to be an astute skeptic, Einstein prodded quantum physics' developers to improve their theory.

In the latter part of his life, Einstein was also preoccupied with another theoretical quest. Having already clarified the nature of electromagnetism and reformulated gravity, the aging Einstein sought to unite those two phenomena within a single, comprehensive theory.

At the time, "many physicists thought it was a fool's errand," notes Shara. Yet today many top theorists are striving to develop similarly overarching theories, such as string theory (*SN: 9/22/01, p. 184*). Their goal is to create a single theoretical framework that accounts for all the fundamental forces and particles in nature.

Rather than considering the last 30 years of Einstein's life a waste, Columbia University string theorist Brian R. Greene says that the period "was really what launched the current generation of work in the physical sciences." In one of the exhibit's galleries, Greene and other scientists discuss Einstein's scientific legacy in continuously running video clips.

Einstein never stopped his search for a unified theory. The day before his death on April 18, 1955, from a ruptured aortic aneurysm, Einstein asked his secretary to bring to the hospital a pad of paper on which he had been working. That very sheaf of papers, which Einstein smothered with calculations, serves as send-off as visitors leave the exhibit. ■

COLD COMFORT

A futuristic play of cryogenic proportions

BY BRUCE BOWER

ACT ONE, "DIE ANOTHER DAY"

Overhead lights cast a sterile glow over a conference room dominated by a rectangular, polished wood table. A woman wearing a business suit sits at the head of the table. Three other people slump in chairs. Each wears a white smock that extends to just above bare feet. Wisps of steam waft from the heads and exposed lower arms of the sprawled forms. Behind each misting body stands a gleaming chrome cylinder.

Woman: Wake up. Come on, wake up, sleepyheads.

The hunched bodies groan, mumble, and begin to move.

Woman: Yes, sit up, that's it. Shall we have some wine and cheese? I'll bet you're hungry. Let's take roll call first and make sure the gang's all here. I'll start with the Splendid Splinter, the greatest hitter in baseball history—Ted Williams. (*No response*) Step up to the plate, slugger.

Ted: Oh my lord, how did I get here? Last I remember, my son told me to drink a special milkshake he'd whipped up for me. I took a swig and then everything went hazy. (*Pause*) I'm gonna take batting practice on that boy's behind!

Woman: Now, now. He was acting in your best interests. Next we have Carl Sagan—astronomer, author, skeptic, and the last known scientist to have appeared on a late-night television talk show without putting both the host and the audience to sleep.

Carl: Why yes, I'm here. Have I made contact with the great cosmic hereafter? You're not . . . no, that's impossible. It *would* be thoroughly ironic, though, given the unwillingness of modern religious systems to conceive of a female God. But, of course, the whole idea is irrational.

Woman: Indeed. Now, let's hear from Richard Feynman, physicist extraordinaire and all-purpose supersmart individual.

Dick: Hello. I love surprises, and I'm certainly surprised to be here. But don't call me supersmart. Just think of me as a curious dude and a wise guy.

Carl: That's not how your scientific colleagues referred to you, as I recall.

Dick: Oh, they called me much worse names—usually while I was giving lectures. But I was never boring. How many of those stick-in-the-muds still get talked about today? Say, what day *is* it?

Woman: It's the first day of the rest of your lives in the year 2102. You are now wards of the Martha Stewart Living Foundation.

Ted: 2102? That would mean I'm, gee, 183 years old. By God, the Red Sox should have won a World Series by now.

Woman: Don't be silly. Something far less preposterous has happened. Our scientists finally figured out how to revive people from cryogenic sleep. None of you actually died. You just took metabolic time-outs while hanging upside-down in chrome cylinders (*She points to each of the containers.*), your bodies frozen solid in liquid nitrogen.

Carl: Lucky I wear turtleneck sweaters, even in the summer. At least, I used to wear them. (*He looks at his smock with disgust.*)

Woman: Oh, you're all lucky. First, Martha had the foresight to acquire this company back in 2005. She had made a lot of money improving the quality of people's lives, but her firm hit a rough patch. So, she took her remaining resources and invested them in the business of improving the quantity of people's lives.

Carl: Whoever corners the market on extending human life is going to enter a financial universe of, well, billions and billions of dollars.

Woman: I like your style. Of course, money has lost some of its value over the past century. The 7-11 down the block charges $200 for a hot dog and a soda.

Dick: Ouch.

Woman: But let's look on the bright side. You're the first group to come out of the deep freeze, and we're all so happy about it here at the MSL Foundation. It means that our scientists have succeeded in regenerating frozen biological cells. It's sort of like jump-starting a dead car battery on a winter morning. I can't reveal the complex details of our discovery. Competition is fierce out there.

Dick: Tell me anyway. I could care less about the blood sport among business types trying to squeeze big bucks out of crying medics.

Woman: That's cry-o-gen-ics. (*She emphasizes each syllable.*)

Dick: (*Grinning*) Whatever. You don't have to worry about me having a yard sale with your trade secrets. I'm just like every other retired Nobel laureate—I want to devote my spare time to solving the mystery of consciousness and explaining how the brain works.

JIM PAILLOT

CARL: You're forgetting the big questions, Dick. What are we doing here, and what do these people plan to do with us? I never put a down payment on a cryogenics capsule, yet here I sit, steam coming out of my armpits.

TED: I didn't know I was cooling my cleats in this cryogenic on-deck circle, either.

WOMAN: None of you did. We recruited you through confidential family and professional contacts. As elite members of the scientific community, you'll serve as cryogenic ambassadors to the world now that regeneration technology is a reality.

TED: You've got to be kidding. Me, a scientist? And I suppose you think Dick here can hit a curve ball and Carl can throw overhand.

WOMAN: You wrote a book called *The Science of Hitting*, didn't you? Let's not overstate the importance of academic degrees. Consider yourself just as much of a scientist as these gentlemen. (*Pause*) Now, we're waiting for Monroe. He runs the MSL Foundation, and he'll fill you in on what we have in store for you.

A waiter enters the room carrying a tray that holds wedges of cheese, a bottle of wine, and three glasses. He puts the tray on the table and hands a card to the woman.

WOMAN: Ah, it's from Monroe. He's ready to see you. But first, eat, drink, and be merry.

TED: Wine and cheese? Who put this Little League menu together, Bud Selig? Let's go fishing and fry us up some real food.

WOMAN: No one goes anywhere until you meet Monroe.

CARL: Martha Stewart runs a tight ship. Where's that free-spirited Julia Child, now that we need her?

Lights dim.

ACT TWO, "BODIES POLITIC"

Ted, Carl, and Dick stand in a plush executive suite. A large window looks out on a city skyline. Oak-paneled walls accentuate an array of art deco furniture. A beefy man in a business suit smiles from behind a mahogany desk.

MAN: Hello. Welcome to the future. (*He laughs casually.*) My name is Monroe. I've taken hold of the reins here at the MSL Foundation, or Martha's place, as we call it. And I believe the company's about to gallop into a position of industry leadership now that our thoroughbreds are showing some life. (*He waits for a response and gets none.*) Ah, by thoroughbreds I mean all of you.

CARL: We get it, sir. What we'd like to know is why we're on this ride and where it's taking us.

DICK: Yes. This situation has already gotten weirder than quantum physics.

MONROE: Please, everyone, call me Monroe. Let's get down to business, shall we? You are our first cryogenic success stories, and success creates responsibilities.

DICK: I know what your game is, Monroe. You put me in the big chill so I could be regenerated as your director of research operations. You sly duck.

MONROE: An intriguing but inaccurate inference. Science has far surpassed anything you could imagine from your 21st century perspective. So has technology. We need all of you to attend a globally broadcast press conference tomorrow where you'll announce that MSL cryogenics extended your lives, it's the real deal. Heck, you didn't feel a thing, did you? It was like taking a long, restful nap and then, pow! You came, you thawed, you conquered death. Put it in your own words.

TED: Well, spray paint me in pinstripes and call me a Yankee. That's it? Just tell those scribblers and microphone jockeys that we're tickled to have been pickled?

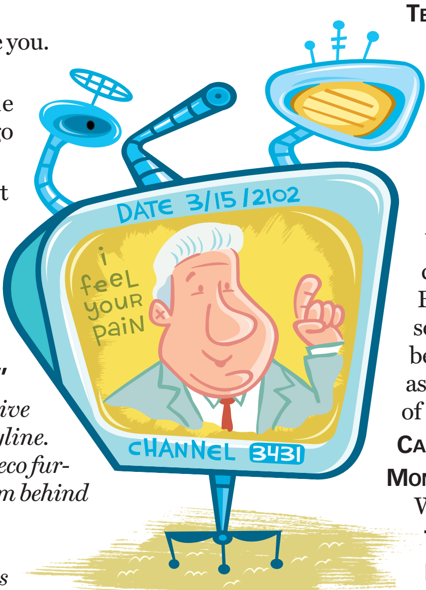
MONROE: Good one. You're a natural. We'd also like you all to serve as MSL Foundation spokespersons on television shows.

CARL: It's not that I'm averse to chatting up the media, mind you. But what a waste! You're putting us out to pasture when we're still in our intellectual prime.

DICK: Not to mention the good deeds that can be accomplished with these . . . what should I call them, cold capsules? Think of the many endangered wild animal species that Martha's place can save from extinction.

MONROE: We're saving a wild animal species, all right—politicians. (*He leans back in his leather chair.*) Remember, you come from a time when there were only a few hundred television channels. Wireless transmission advances since then have spawned 5,000 television channels, and that number is growing as we speak. And do you know what three-quarters of those channels broadcast?

CARL: (*With a downcast look*) Infomercials.



TED: Hey, they're not all so bad. I bought one of those singing fish you hang on the wall. I call him Gil Hodges.

MONROE: No, Carl, not infomercials—news and public affairs shows. Nearly 4,000 channels serve up headline news and commentary, all the time, day and night. Those shows are cheap to produce and highly profitable, believe you me. I think we have more people covering news than making news these days. But there aren't enough political analysts and social pundits to go around. That's why we've been cryogenically canning as many politicians as we can. Now, we can regenerate a whole army of talking heads for hire.

CARL: Which politicians are you talking about?

MONROE: Oh, let's see, there's Bill, Hillary, George W., Al, Colin . . . you get the picture.

TED: How about Strom Thurmond?

MONROE: No, he's still alive. But we have an impressive stable of ready-for-prime-time pontificators waiting to come in from the cold. And each of you has led the way in making their political comebacks possible.

DICK: So, you used us to get regeneration technology up and running, and now you're going to have us sell freeze-dried blowhards for the boob tube.

MONROE: It's the natural cycle of scientific enterprise. Remember the Human Genome Project? It started out as a great DNA-dissection adventure, stimulated a raft of research into the genetics of disease, and after a few decades, morphed into a bunch of secretive DNA firms that sell medical breakthroughs directly to people who have enough money or insurance.

TED: Whew. I think we all just got knocked on our keisters by a high, hard one under the chin.

CARL: Baseball is truly a metaphor for life, even among formerly frozen folk. I think it's time to dust myself off, crawl back into my cryogenic clubhouse, and ice myself down for another 100 years or so. Maybe then I can be put to better use. Want to join me, fellas?

Dick and Ted nod their heads in approval.

MONROE: If that's what you really want. Personal choice means so much here at Martha's place. As our motto says, it's a good thing.

Lights dim. ■

JIM PAILLOT

OF NOTE

PALEONTOLOGY

New fossil weighs in on primate origins

Excavations in Wyoming have yielded the partial skeleton of a 55-million-year-old primate that probably was a close relative of the ancestor of modern monkeys, apes, and people. The creature was built for hanging tightly onto tree branches, not for leaping from tree to tree, as some scientists had speculated, based on earlier fragmentary finds. Also, despite expectations, the ancient primate didn't have eyes specialized for spotting insects and other prey.

Jonathan I. Bloch and Doug M. Boyer, both of the University of Michigan in Ann Arbor, unearthed the new specimen. It belonged to a group of small, long-tailed primates that lived just before the evolution of creatures with traits characteristic of modern primates—relatively large brains, grasping hands and feet with nails instead of claws, forward-facing eyes to enhance vision, and limbs capable of prodigious leaping.

GET A GRIP Illustration depicts 55-million-year-old primate, based on its newly discovered skeleton.

The new find, in the genus *Carpolestes*, had long hands and feet with opposable digits, Bloch and Boyer report in the Nov. 22 *Science*. The animal grew nails on its opposable digits, and claws on its other fingers and toes. Unlike later primates, *Carpolestes* had side-facing eyes and lacked hind limbs designed for leaping. —B.B.

IMMUNOLOGY

Herpes vaccine progresses

A vaccine against the herpes-simplex-2 virus, which causes genital herpes, protects some women, provided they haven't had a genital or oral herpes infection before.

The vaccine consists of a molecule patterned after a protein that sits on the surface of the herpes-2 virus and a natural immune boosting substance called 3-*O*-deacylated monophosphoryl lipid A, says Lawrence Stanberry of the University of Texas Medical Branch in Galveston.

He and his colleagues identified 2,714 people in five countries whose regular sex partners have genital herpes. About one-third of the volunteers had no sign of oral or genital herpes at the start of the study. The rest had antibodies to herpes-simplex-1 virus, which causes cold sores.

The researchers gave half the volunteers three vaccine injections over 6 months. The others got inert injections as a placebo.

Of women who had no herpes at the start of the 19-month study, 22 percent of those getting a placebo subsequently acquired a genital herpes infection. In contrast, only 12 percent of vaccinated women developed such an infection, the researchers report in the Nov. 21 *New England Journal of Medicine.*

Women who had had oral herpes before the study gained little protection from the vaccine. This suggests that oral herpes might interfere with the vaccine's building a reservoir of immune cells and antibodies against genital herpes, Stanberry says.

The vaccine didn't protect men, regardless of whether they had oral herpes. Vaccine-stimulated immune proteins and cells may be more potent against herpes viruses contracted on the vaginal lining than on the skin of the penis, Stanberry says. —N.S.

PHYSICS

Prying apart antimatter

Physicists in Switzerland have taken the first peek inside atoms of antimatter. The new experiments, which probed antihydrogen atoms, show no sign that physical laws differ between this exotic matter and ordinary matter. The new observations set the stage for far more precise comparisons that researchers say will test the foundations of modern physics.

Prevailing theories hold that antihydrogen and hydrogen are identical except for having constituents with opposite electrical charges. An atom of antihydrogen comprises a positively charged positron—the antimatter twin of the electron—orbiting a negatively charged antiproton. Scientists made the first atoms of antihydrogen in the mid-1990s within an accelerator, but those particles moved too quickly to be closely studied.

In October, a team of researchers at the European Organization for Nuclear Research (CERN) in Geneva reported making the first slow-moving antihydrogen atoms (*SN: 11/2/02, p. 286*)—a step toward high-precision measurements of the atoms' properties.

Now, a second CERN group, known by the acronym ATRAP, has independently made slow-paced antihydrogen atoms. Plus, the ATRAP team took another step: They used an electric field to pry apart the exotic atoms' positrons and antiprotons. "That gives us a peek inside," says ATRAP spokesman Gerald Gabrielse of Harvard University.

By revealing how tightly joined those components were, the prying provided a measure of the so-called ionization energies of antihydrogen atoms at different levels of excitation.

That's the kind of data physicists need for even more precise comparisons between matter and antimatter. Gabrielse and his colleagues describe their findings in the Nov. 18 and Dec. 2 issues of *Physical Review Letters.* —P.W.

ANTHROPOLOGY

Ethiopians reveal high-altitude twist

There's more than one way for people living at extremely high altitudes to adapt to so-called thin air. Biologically, there must be at least three ways, according to a report in an upcoming *Proceedings of the National Academy of Sciences.*

A team led by Cynthia M. Beall of Case Western Reserve University in Cleveland obtained blood samples and medical data from 236 Ethiopian villagers living more than 2 miles above sea level. The villagers displayed an average blood concentration of oxygen-rich hemoglobin comparable to that already reported for sea-level populations. Oxygen saturation of hemoglobin among the Ethiopians also roughly equaled measurements made in lowland groups. The researchers now plan to look for a biological mechanism to explain how these people survive at their high altitude.

Previous research directed by Beall had found a high blood-hemoglobin concentration but low hemoglobin-oxygen saturation among Andean highlanders. Beall also reported that high-altitude Tibetans possess a blood-hemoglobin concentration similar to sea-level folk combined with low oxygen saturation. —B.B.

MEETINGS

American Geophysical Union
San Francisco
December 6–10

PLANETARY SCIENCE

Fresh crater found on lunar images

Scientists analyzing images of the moon's surface taken from lunar orbit believe they've identified the crater that formed when a small asteroid slammed into the moon almost 5 decades ago.

Early in the evening of Nov. 14, 1953, an amateur astronomer in Oklahoma observed and photographed a bright flash—believed to be the impact of an extraterrestrial object—on the moon's surface. Although the camera's exposure was set for 0.5 seconds, the flash probably lasted about 1 s, says Bonnie J. Buratti, a planetary astronomer at NASA's Jet Propulsion Laboratory in Pasadena, Calif.

Using the brightness of the flash and its estimated duration, she and Lane L. Johnson of Pomona College in Claremont, Calif., estimate that the energy of the impact was equivalent to that released by exploding 500,000 tons of TNT. Only about 0.3 percent of the kinetic energy was converted into visible light, Buratti notes. Much of the remainder vaporized rocks, generated huge seismic waves, and blasted a crater.

The pockmark formed by the 1953 impact isn't large enough to be resolved by earthbound telescopes. Images of the impact's area garnered by Clementine, a Department of Defense–designed probe that mapped the moon in 1994, show a bright, bluish halo about 1.5 kilometers across. The images don't show a crater inside the halo because the photos were snapped when the sun was high in the lunar sky and shadows were minimal. Nevertheless, the blue tinge suggests its material is freshly excavated, says Buratti.

The researchers estimate the crater to be about 300 meters across and 60 m deep. The stony asteroid that smacked the moon was therefore probably about 20 m in diameter. Objects that size probably strike Earth or the moon once every decade or so. —S.P.

EARTH SCIENCE

Warm arctic summer melted much ice

Satellite observations of the Arctic Ocean show that the amount of sea ice there this year was the lowest it's been in more than 20 years.

In September, the extent of the sea ice—defined as the area in which ice covers at least 15 percent of the ocean's surface—was 5.27 million square kilometers, says Julienne C. Stroeve, a climatologist at the National Snow and Ice Data Center in Boulder, Colo. Of that area, sea ice actually covered about 3.6 million square kilometers, a figure 17 percent lower than normal for that time of year and 9 percent below the previous minimum for a September. The earlier record low was set in 1998, during the late stages of the strongest El Niño ever seen and when the global average temperature had been much higher than normal for several months.

Satellites have been monitoring arctic sea ice since 1978. Since then, annual ice coverage has dropped about 3 percent per decade, and September ice coverage has declined 8 percent per decade.

Several factors contributed to the low ice cover this year, says Stroeve. From March through May, southerly winds pushed ice away from the northern shores of Eurasia and North America. Because the open water absorbed more radiation than snow-covered ice would have, the near-shore waters warmed and accelerated melting at the edges of the ice packs. From June through August, unusually warm and persistently stormy conditions blanketed the Arctic Ocean, fracturing the and further fostering melting.

Unlike earlier years with low ice coverage, this year the sea northeast of Greenland was relatively free of ice. —S.P.

ATMOSPHERIC SCIENCE

Contrails forecast on the horizon

Studies of the contrails generated by jets flying high over Alaska may lead to improved techniques for predicting the formation of these artificial clouds, which some scientists suggest have a warming effect on Earth's climate.

The skies over Fairbanks, Alaska, are busy because the city lies beneath air routes between North America and the Far East, as well as the flight paths between nearby Anchorage and cities in Europe. Between March 2000 and July 2002, more than 2,500 jets passed within 80 kilometers of Fairbanks International Airport, says Martha Shulski, an atmospheric scientist at the University of Alaska in Fairbanks.

Of those aircraft, about 10 percent flew past during daylight hours with good visibility and within 4 hours of when weather instruments were lofted from the airport. The scientists observed contrails in 223 instances, and the clouds' lifespans varied from a few seconds to several hours, says Shulski. In 20 cases, researchers spotted an aircraft that didn't produce a contrail.

About 97 percent of the contrails that lasted more than 10 minutes formed in air with a relative humidity greater than 25 percent. On the other hand, most of the aircraft that didn't produce contrails were flying through air with a relative humidity less than 25 percent.

Shulski and her colleagues have used their observations to develop a mathematical model for predicting whether or not contrails will form behind an aircraft. The new model is correct 92 percent of the time but doesn't do a good job at predicting how long contrails will persist, a factor needed for scientists to estimate the clouds' effect on global climate. Future analyses will investigate the effect of wind speed and wind shear on the spread and lifetime of contrails. —S.P.

EARTH SCIENCE

Toppling icebergs sped breakup of Larsen B ice shelf

Early this year, most of Antarctica's Larsen B ice shelf fell apart during the region's warmest summer on record (*SN: 3/30/02, p. 197*). Now, scientists think they know what accelerated that rapid disintegration.

In just 5 weeks, a 3,200-square-kilometer, Rhode Island–size section of the ice shelf collapsed and spread into a 6,750-square-kilometer mélange of icebergs, says Douglas R. MacAyeal of the University of Chicago. However, only about 1,600 square kilometers of that area appeared white and covered with snow, as the ice shelf had. The rest of the exposed ice was riddled with rocks and showed the distinct blue color of ice that's been compressed in glaciers. On satellite images, the sea "looked like a big blue Slurpee," says MacAyeal.

That exposed glacial ice provides a big clue about why the ice shelf disintegrated so quickly. MacAyeal and his colleagues speculate that much of the shelf had been fractured into tall, thin bits that resembled dominos standing on end—a configuration that would become unstable if the fragments weren't tightly packed. Once the outer edge of the ice shelf gave way, individual domino-bergs began to wedge each other apart as they fell over. —S.P.

Books

A selection of new and notable books of scientific interest

BROTHERHOOD OF THE BOMB: The Tangled Lives and Loyalties of Robert Oppenheimer, Ernest Lawrence, and Edward Teller

GREGG HERKEN

Ten years in the making, Herken's book blends information from private papers, interviews with Manhattan Project survivors, recently released documents, coded intercepts obtained from FBI and KGB archives, and other sources. Together, this wealth of data tells a fascinating tale about three legendary scientists. Herken's story of the collaboration of Robert Oppenheimer, Ernest Lawrence, and Edward Teller is rife with intrigue and the effects of massive egos. The author tells how Oppenheimer hid his radical past during the developing years of the Manhattan Project and how it caught up with him during the reign of McCarthyism years later. Teller's agenda to make larger and larger hydrogen bombs also comes to light, as well as his will to get his way. A most fascinating twist is the spy-versus-counterspy, United States–versus–Soviet Union game that touched these men. Herken blends all these aspects to provide a complete and compelling narrative of the advent of weapons of mass destruction. ***H. Holt, 2002, 448 p., hardcover, $30.00.***

MEASURING AMERICA: How an Untamed Wilderness Shaped the United States and Fulfilled the Promise of Democracy

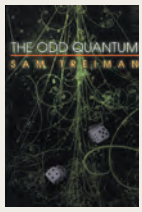
ANDRO LINKLATER

On the banks of the Ohio River—in East Liverpool, Ohio—stands a marker that reads, "The Point of the Beginning." Few people today take note of the words, or understand the significance of the land survey that originated at this spot on Sept. 30, 1785. Linklater presents a stirring account of the work that surveyors did from East Liverpool to the Pacific Ocean and north-to-south from the Canadian border to Mexico. The author illustrates how the effort created a pattern of land ownership unique in history. As that story unfolds, so does the tale of the system of measurement used to chart 3 million square miles of territory. This choice kept this country's dimensions in acres and miles instead of hectares and kilometers. Linklater paints fascinating portraits of men from Ferdinand Hassler, who introduced the American Customary System of measurement used today, to Edward Gunter, who in the sixteenth century invented the surveyor's chain that was central to the survey and this country's way of measuring land since its beginnings. ***Walker, 2002, 310 p., hardcover, $26.00.***

THE ODD QUANTUM

SAM TREIMAN

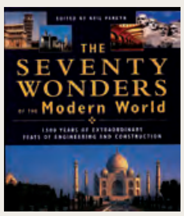
The principles of quantum mechanics seem to fly in the face of common sense, frustrating nonspecialists. Princeton physics professor Treiman's introduction seeks to overcome this problem. Although he writes for a general audience, he strives to convey the substance, methods, and oddities of quantum mechanics without abandoning the basic mathematics. Beginning with the accomplishments of the founding fathers of the field—Niels Bohr, Erwin Schrödinger, Werner Heisenberg—he explains the intrinsically probabilistic nature of quantum mechanics, explores the strictly identical nature of quantum particles, and tells how such particles can move through barriers and in regions of space forbidden by classical mechanics. Emphasizing the wave aspects of the subject, Treiman concludes by delving into the intricacies of quantum field theory. Originally published in hardcover in 1999. ***Princeton U Pr, 2002, 262 p., paperback, $16.95.***



THE SEVENTY WONDERS OF THE MODERN WORLD: 1,500 Years of Extraordinary Feats of Engineering and Construction

NEIL PARKYN, ED.

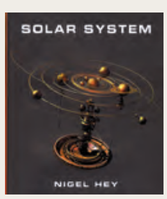
How was the Empire State Building constructed? Why doesn't' the Leaning Tower of Pisa fall over? How can the Akashi Kaikyo suspension bridge in Japan span 1.4 miles yet withstand earthquakes and typhoons? These questions are answered in profiles of some of the most famous structures ever built. Chosen by virtue of not only a structure's impressiveness, but also by its aesthetic power and durability, these bridges, buildings, statues, and dams include structures built using traditional methods and materials. Others represent the latest in computer-aided design and space-age technology, such as the Guggenheim Museum in Bilbao, Spain, and Kansai Airport in Japan. Brilliant color photographs and diagrams bring each specimen to life. ***Thames Hudson, 2002, 304 p., color photos/illus., hardcover, $40.00.***



SOLAR SYSTEM

NIGEL HEY

Drawing on the most recent data retrieved by spacecraft such as Galileo and Cassini, Hey offers a vibrant introduction to the sun, the nine primary planets in our solar system, and the asteroids and comets that accompany them. He gives attention to technology, as well as astronomers' theories about planets and whether they might harbor life. Essays written by luminaries such as Arthur C. Clarke and Donald Gray offer insiders' analyses that enhance profiles of individual planets and provide a solid introduction to space studies. Originally published in the United Kingdom in 2002. ***Weidenfeld & Nicolson, 2002, 272 p., color photos, hardcover, $24.95.***



LETTERS

Critical concern

I am concerned about the article "Neptunium Nukes? Little-studied metal goes critical" (*SN: 10/26/02, p. 259*). It addresses the mass of fissile materials needed to "make a bomb," yet it's clear that the critical masses given—10 kilograms for plutonium-239, 50 kg for uranium-235, and 60 kg for neptunium-237—are for bare spheres with no neutron moderation, reflection, or other factors contributing to going critical. Consider that the International Atomic Energy Agency controls quantities of 8 kg of ^{239}Pu and 25 kg for ^{235}U and that these quantities probably relate to masses needed for crude "bombs." Further, in some processing plants, a mass of about one-half a kilogram is used as a guideline for the minimum quantity of ^{239}Pu or ^{235}U, which can, given optimum conditions, go critical. I think the article could mislead people on what quantities need protection.

ROBERT MARSHALL, SANTA FE, N.M.

The old bawl game

Your readers need not wait to do less crying in the kitchen ("Less Crying in the Kitchen: Tasty, tearfree onions on the horizon," *SN: 10/19/02, p. 244*). All you have to do is put the onions in the refrigerator for a half hour or in the freezer for 10 minutes.

DANIEL F. BARIGHT, LEBANON, MO.

Another solution is to do the chopping outside. I have found that more turbulent, outside air reduces onion-chopping stress.

CHRISTOPHER BILTOFT, SALT LAKE CITY, UTAH

The last line says these so-called improved onions may be "more prone to attack by insects and microorganisms." That ought to keep the scientists busy developing insecticides, fungicides, and so on—all to solve the inconvenience of cooking with healthful onions.

BARBARA CUSHING, KILLINGWORTH, CONN.

It is rocket science

In "News flash: Earth still has only one moon" (*SN: 10/26/02, p. 269*) concerning the Apollo rocket's third stage returning to Earth orbit, how did the researchers determine the source to be Apollo 12, since there were six other Apollo moon missions? Did they use some fancy orbital mechanics along with statistical probability?

GEORGE RICHESON, BRENHAM, TEXAS

Yes, they did, and the orbit matched. Also, the researchers found no evidence of the object in images that had been taken before the launch of Apollo 12. —R. COWEN

SCIENCE NEWS
Of the year
THE WEEKLY NEWSMAGAZINE OF SCIENCE

A year of twists and turns

What the world needs, say some people, is more one-handed scientists. That way, reports would have fewer sentences starting, "On the other hand. . . ."

Actually, scientists need all the hands they can muster. Most of the phenomena they investigate are so complex that even carefully designed experiments can't take into account all possible influences on the results. Change one condition—a chemical concentration, a nutritional state—and an experiment can yield dramatically different data. Or worse, factors that scientists haven't even considered can turn out to be the main drivers. What scientists know for sure is that today's conclusions may well be overturned by tomorrow's data.

This frustrating aspect of science was magnificently demonstrated this year with the surprising findings of two trials of hormone-replacement therapy. Previous studies had convinced doctors to prescribe estrogen and progestin supplements to millions of women, primarily to prevent heart disease. But in large, rigorously designed U.S. studies, women receiving the treatment experienced more blood clots and either more or the same amount of heart disease and strokes than did the women who didn't get the supplement (*SN: 7/27/02, p. 61*).

Luckily, not every follow-up study contradicts earlier work. The longest follow-up studies on breast cancer surgery confirmed that the breast-sparing surgery called lumpectomy benefits women just as much as having an entire breast removed (*SN: 10/19/02, p. 243*).

Yet many of the 2002 scientific findings that we list below challenge earlier results. Mars may not have had a continuously warm, wet past. Neutrinos have mass after all. Diamond isn't the sturdiest material.

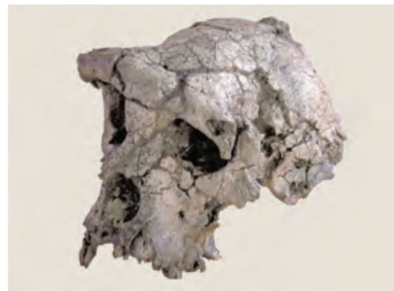
So, what you learned in school years ago—or what you read just last year—doesn't necessarily correspond with today's scientific conclusions. To keep current, you'll want to follow the twists and turns as researchers apply new technologies and carry out larger, longer, and smarter studies. At *Science News*, now in its 80th year of publication, all hands are devoted to keeping you up-to-date with timely, concise reports. —*Julie Ann Miller, Editor*

* An asterisk indicates that the text of the item is available free on **SCIENCE NEWS ONLINE (http://www.sciencenews.org)**.

HOW TO OBTAIN FULL ARTICLES This review lists important science stories of 2002 reported in the pages of SCIENCE NEWS. The reference after each item gives the volume and page number on which the main article appeared (vol. 161 is January–June; vol. 162 is July–December). Full text of any article can be obtained free by **SCIENCE NEWS** subscribers who register at **SCIENCENEWS ONLINE** or for $2.50 from ProQuest **(http://pqasb.pqarchiver.com/sciencenews).** Back issues are available for $3 each (prepaid). Send orders to **SCIENCE NEWS,** 1719 N Street, N.W., Washington, D.C. 20036.

Anthropology & Archaeology

Fair enough People everywhere divvy up food and make other deals based on social concepts of fairness, not individual self-interest, a cross-cultural project found (161: 104).



Researchers announced the discovery of a fossil skull representing the earliest known member of the human evolutionary family, which lived in central Africa nearly 7 million years ago (162: 19*). Other scientists argued that the skull instead comes from an ancient ape (162: 253).

Erectus set A newly found fossil skull entered an ongoing debate about whether the human ancestor *Homo erectus* was a single species or several (161: 179*).

Genetic divide Investigators reported that the distinctive looks and thinking styles of people and chimpanzees derive from contrasting actions of their similar DNA sequences (161: 227).

Early writers Excavators of an ancient site in southeastern Mexico stirred controversy with the announcement that they had

Archaeological discoveries indicated that ancient groups in Mexico and Central America believed in a sacred landscape and held key rituals in natural and human-made caves (161: 314*).

BRUNET/NATURE; J. BRADY

found examples of the earliest known writing in the Americas (162: 355).

Neander-tot An anthropologist recovered the 40,000-year-old skeleton of a Neandertal baby from a French museum, where it had been stored and forgotten for nearly 90 years (162: 148).

Cracking up Scientists unearthed the first chimpanzee archaeological site, which included stone nut-cracking implements (161: 195*). Another dig yielded evidence that hard-shelled nuts were a dietary staple of human ancestors living in the Middle East 780,000 years ago (161: 117).

DNA diaspora A controversial genetic analysis concluded that *Homo sapiens* evolved by leaving Africa in multiple waves beginning at least 600,000 years ago and then interbreeding with Neandertals and other close relatives (161: 149).

Lake likers Chilean excavations revealed that, starting around 13,000 years ago, people lived at extremely high altitudes during rainy periods, when they could set up hunting camps on the shores of mountain lakes (162: 259*).

Ancient care A nearly toothless fossil jaw found in France reignited scientific debate over whether skeletal remains of physically disabled individuals show that our Stone Age ancestors provided life-saving aid to the ill and infirm (162: 328).

Astronomy

Cosmic age Setting their sights on the galaxy's faintest stars, scientists calculated the universe's age to be between 13 billion and 14 billion years (161: 277).

Sharper vision A newly installed camera on the Hubble Space Telescope produced a picture of the distant universe that ranks as the sharpest and most detailed ever recorded (161: 278). Other Hubble images demonstrated that the craft's infrared vision has been restored after 3 years of blindness (161: 358).

Galactic birth Observing a tiny galaxy still in the process of being born, astronomers got a rare glimpse of how larger galaxies formed early in the history of the universe (162: 164).

Cosmic evidence New observations of the cosmic microwave background provided additional support for the Big Bang (162: 195*). The most detailed snapshots of the infant universe ever recorded are providing additional evidence that a mystery material makes up the bulk of the cosmos' energy and is accelerating the rate at which the universe expands (162: 390).

Q. DANIEL WANG, UNIV. OF MASS.; V. BROMM, P. COPPI, AND R. LARSON

PENETRATING VIEW
Sensitive X-ray, infrared, and radio telescopes are providing an extraordinarily clear view of the dust-shrouded center of our galaxy (161: 122*). This mosaic of X-ray images reveals hundreds of point sources at the Milky Way's core, including white dwarf stars, neutron stars, and stellar-mass black holes. All are bathed in a fog of multimillion-degree gas that surrounds a supermassive black hole.

Early starbirth Using new computer models, astronomers explored the birth of the first stars in unprecedented detail (161: 362*).

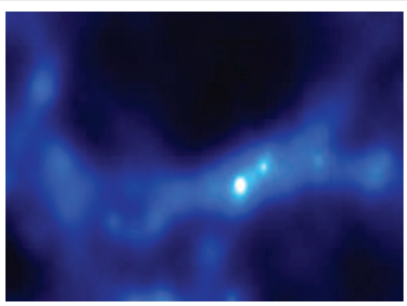
Celestial divide Analyzing data from a mammoth sky survey, astronomers found that there are two distinct families of galaxies, according to stellar mass (162: 244).

Stellar relic Astronomers found a star so old and chemically primitive that it carries vestiges of the origin of our galaxy (162: 277*).

Galactic brush up A vast, invisible halo of hot gas envelops the Milky Way and could be brushing up against our nearest galactic neighbors (161: 21).

First structures Researchers uncovered new details about the earliest galaxies and galaxy clusters in the universe (161: 196).

Superwinds New measurements revealed that some of the earliest galaxies in the universe produced winds so powerful and persistent that they profoundly influenced the evolution of future generations of galaxies (161: 244).



Using new computer models, astronomers explored the birth of the first stars in unprecedented detail (161: 362*).

Super findings Astronomers welcomed the discovery of two supermassive black holes in one galaxy (162: 339*). Other researchers found the best evidence to date that a supermassive black hole lies at the Milky Way's core (162: 301).

Middle class Two teams of astronomers reported that they had confirmed the existence of a new, midsize class of black hole (162: 180*).

Burst findings New evidence supports the notion that gamma-ray bursts, the most violent explosions in the universe, are the primal calling cards of newborn black holes (161: 228). A sizable minority of gamma-ray bursts may originate in relatively nearby galaxies (161: 37).

Martian water A catastrophic outpouring of water—in a volume four times that of Lake Tahoe—may have gushed from fissures near the equator on Mars as recently as 10 million years ago (161: 157). Yet contrary to a popular model in which ancient Mars was warm, wet, and hospitable to life, the Red Planet may have been cold and dry for most of its history, with only brief episodes of scalding rain and flash flooding (162: 372).

Rays from Mars Astronomers obtained the first X-ray image of the Red Planet (162: 342).

Howdy neighbors! Astronomers discovered 12 previously unknown stars that lie within a mere 33 light-years of Earth (161: 77).

Stormy weather Two titanic storms in Jupiter's upper atmosphere collided (161: 85*).

SCIENCE NEWS
Of the year

Planetary milestone Extrasolar-planet hunters came up with a landmark finding: a Jupiterlike planet orbiting a sunlike star at a Jupiterlike distance (161: 371*).

Hints of planets Images of gaps, rings, arcs, warps, and clumps in disks of dusty debris surrounding nearby stars provided new clues to the nature of planets beyond the solar system (161: 280*).

Weighing in Astronomers measured the mass of a planet outside the solar system (162: 358).

Belt of its own Astronomers reported the first evidence that a young star has an orbiting belt of asteroids held in place by a massive, unseen planet (161: 388).

Big breakup A comet split into 19 fragments strung out along a million-kilometer-long chain (162: 69).

Smashing study Planetary scientists have for the first time precisely dated a collision that smashed an asteroid into fragments (162: 30).

Seeing Pluto Astronomers were given two rare opportunities to peer through the atmosphere of Pluto (162: 148).

Sunspot mystery The sharpest visible-light images of the sun ever recorded revealed puzzling new features of sunspots (162: 310).

Volcanic record holder Pointing a ground-based telescope at Jupiter's moon Io, astronomers reported finding the most powerful volcano ever observed in the solar system (162: 326).

Behavior

Attention loss Imaging data indicated that the brains of children diagnosed with attention-deficit hyperactivity disorder are slightly smaller than those of their peers without psychiatric disorders (162: 227*).

Abused kids A long-term study found that a genetic variant linked to high concentrations of certain brain chemicals protects abused children from becoming violent and impulsive later in life (162: 68). Another study suggested that physical abuse at home tunes a child's perceptual system to pick up facial signs of anger (161: 389).

Psychotic biology Two genes involved in transmission of glutamate, a key chemical messenger in the brain, were implicated in the severe mental disorder schizophrenia (162: 195).

Evo-upstarts Researchers presented theoretical alternatives to the influential notion that genetic competition during the Stone Age yielded human brains prewired for specific types of thinking (162: 186).

Good grief In a 2-year study, bereaved spouses who often talked with others and briefly wrote in diaries about their emotions fared no better psychologically than their tight-lipped, unexpressive counterparts did (161: 131*).

Social net A variety of studies explored the nature of social interactions on the Internet, from the factors that make for efficient online corporate work groups to the motivations for joining white supremacist chat rooms (161: 282*).

Face time Babies studied between ages 6 and 9 months lost their ability to distinguish individual faces in animal species but started to develop an expertise in discerning human faces (161: 307*).

Inner me Experiments with a split-brain patient suggested that left-hemisphere structures contribute to the conscious understanding of oneself (162: 118*).

CALCULATING KIDS
Reports of babies' basic counting capabilities inspired a wave of new research and a spirited debate about infants' number knowledge (161: 392*).

Conscious brain A reanalysis of brain-imaging data linked conscious visual experience to activity throughout the brain, challenging the popular view that only a few specific brain areas coordinate this mental state (162: 251).

Drug ranks Male monkeys' social position influenced their brains' chemical susceptibility to cocaine's addictive pull (161: 53*).

Cigarette smokers In a surprising finding with implications for understanding nicotine addiction, cigarette smokers monitored for 1 week reported feeling no different just before they lit up than at other times when they weren't smoking (162: 340).

Disorder dip A controversial report concluded that far fewer people suffer from mental disorders requiring treatment than earlier surveys had indicated (161: 102).

Snooze power Scientists found that a brief daytime nap may block or even reverse learning declines that occur during extended practice of a perceptual task (161: 341*).

War torn A substantial and largely unnoticed minority of war reporters and photographers told investigators that they had developed symptoms of a severe stress disorder as a result of their jobs (162: 165).

Biomedicine

Anthrax advances Spurred by threats of bioterrorism, researchers unveiled the anthrax bacterium's genome (161: 317*) and reported possible ways of blocking its deadly effects (162: 115*).

New vaccines In women, vaccines stopped human papillomavirus, the cause of cervical cancer (162: 323); 10 common bacteria that cause bladder infections (161: 5); and the virus that causes genital herpes (162: 399). Another vaccine protected kidney-dialysis patients from common blood infections (161: 99). In the lab, a malaria vaccine showed promise (162: 99), and a vaccine fashioned from pieces of the viruses that cause dengue fever and West Nile fever protected mice against West Nile infections (161: 164).

Estrogen redux Several studies indicated that the health risks associated with estrogen therapy for postmenopausal women outweigh its benefits (162: 61*).

Cancer therapies Among women who harbor mutations in the *BRCA* genes, ovary removal reduced the risk of ovarian, peritoneal, and breast cancers (161: 323*). Three new drugs stopped acute myeloid leukemia in mice, suggesting new treatments against this deadly blood cancer in people (161: 371*).

Inflammation and disease Researchers gathered evidence that inflammation precedes and predicts diabetes (162: 136*) and showed that people who died suddenly of heart attacks had an abundance of C-reactive protein, an indicator of inflammation, in their blood (161: 244).

The age of Alzheimer's A pharmaceutical company halted tests of vaccine against Alzheimer's (161: 109), but a drug showed it can interfere with deposits of amyloid, like those in the brains of people with Alzheimer's disease (161: 307).

Smallpox scourge Government scientists found that stockpiled smallpox vaccine doses can be diluted to one-tenth their original concentration and still be effective (161: 238). And researchers calculated that vaccinating an entire city in response to a smallpox attack would save thousands more lives than would quarantining infected people and vaccinating their contacts (162: 21).

Mammograms on trial New controversy about old data had physicians, women, and policy analysts struggling to decide whether mammography reduces deaths from breast cancer (161: 264).

Targeted therapies Tailoring prescriptions according to a person's genes may help reduce side effects and enable doctors to deliver more personalized medicine (162: 171*). Another approach to individualizing therapy is to monitor molecular and cellular changes in cancer cells as people respond to cancer therapies (161: 139).

Healing hormone A hormone called erythropoietin, long used to treat anemia, also seems to protect against nerve damage and holds promise as a new therapy for stroke and spinal cord injury (162: 296).

Acetaminophen action The discovery of an enzyme that scientists are calling cyclooxygenase-3, which is disabled by acetaminophen, might explain why this over-the-counter drug can stop pain and fever but not inflammation (162: 180). Another study showed that women who take acetaminophen or ibuprofen for headaches boost their chances of developing high blood pressure (162: 278).

NASA; RAMBUKKANA/SCIENCE

STAND UP FOR SCIENCE
Understanding the dizziness that astronauts often feel after space flight may help explain orthostatic intolerance, a disorder in which patients get faint or dizzy while standing. Here, one astronaut monitors a test in which another astronaut (foreground, beneath tubes) lies in a device that produces negative pressure on the lower half of his body, mimicking the effects of gravity on blood flow. (161: 376).

Activating AIDS New studies suggested that a natural alerting of immune cells to foreign invaders could explain why infection with HIV progresses to AIDS more quickly in some people than in others (161: 360).

Diabetes drug A drug fashioned from a mouse antibody halted the progression of diabetes in children and young adults newly diagnosed with the disease (161: 339*).

Chill out Icing down patients whose hearts had stopped boosted their chances of survival and prevent brain damage (161: 115).

Resistant bacteria Viruses that destroy bacteria protected mice from antibiotic-resistant bacteria (161: 23).

Fat chance Research showed that drugs being tested against cancer because they thwart new blood vessel growth might also be a treatment for obesity (162: 67*).

MS cause? A decade-long study bolstered the link between the Epstein-Barr virus and multiple sclerosis by showing that the common infection is more active in people who later develop the nerve disease (161: 4).

Firefighter health Relatively few of the New York firefighters involved in rescue and recovery after the terrorist attack on Sept. 11, 2001 developed chronic coughs and respiratory problems, but among those who did, the problems seem unusually severe (162: 222).

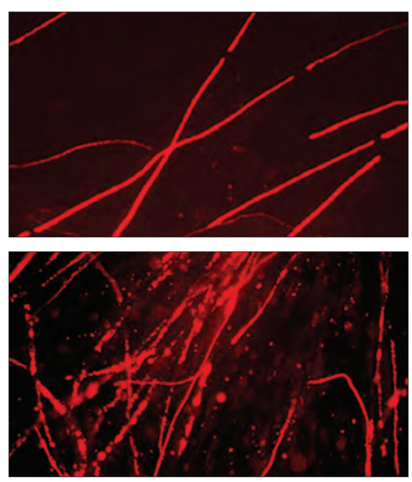
Nerve signals A study showed that Parkinson's disease damages nerve endings in the heart, kidneys, and thyroid gland, which may explain dizziness and fainting in people with this neuromuscular disease (161: 293). In a lab test, alcohol made some pain-generating nerves trigger more easily than normal (161: 294).

Breathe deeply Ten years after the discovery of the gene that, when mutated, causes cystic fibrosis, researchers still struggled to understand why deadly lung infections are so common in people with the disease (161: 59).

Slim pickings A new compound mimicked the effects of an extremely low-calorie diet and lowered the incidence of diabetes and heart disease in monkeys (161: 77). Severely restricting their calorie consumption kept some dogs living about 22 months longer than nondieting canines (161: 291).

Snooze and lose? Sleeping 8 to 10 hours a night doesn't necessarily translate into a longer life (161: 173). However, new evidence suggested that chronic lack of sleep might be as damaging as poor nutrition and physical inactivity in the development of chronic illnesses such as obesity, diabetes, and cardiovascular disease (162: 152*).

***In silico* medicine** To design better drugs and medical care, researchers are increasingly turning to computer simulations of patients and treatments (162: 378*).



New images revealed that the bacterium that causes leprosy directly attacks the fatty sheath that coats healthy nerve fibers (top), leaving them irreversibly damaged (bottom) (161: 365).

SCIENCE NEWS Of the year

Biking problem Men who maintained grueling mountain bicycling programs were apt to have lower sperm counts and more testicular damage than nonbikers were (162: 355*).

Risky genes Researchers found genes linked to prostate cancer (161: 51*; 162: 205), aggressive breast cancers (161: 68; 161: 259), and lung cancer (161: 254). They also found a mutation that can predispose women to uterine growths called fibroids (161: 149).

Gross medicine Research on probiotic bacteria—living microbes that confer health benefits when intentionally introduced into the body—offered growing medical promise (161: 72*).

Kiss and tell A kiss can trigger allergic reactions to molecules carried on a person's lips (162: 40*).

Help against herpes Scientists identified a new class of compounds that stops herpes simplex virus from replicating (161: 227*).

Smoke and SIDS Nicotine impairs a molecule that's necessary for arousing people and other animals from sleep, an effect that could account for the heightened risk of sudden infant death syndrome in babies born to women who smoked during pregnancy (162: 163).

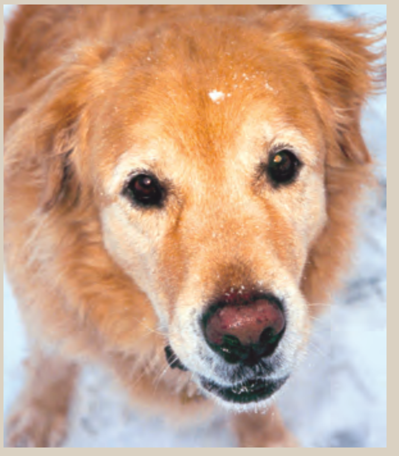
Salty story Researchers found that babies who tolerate a salty flavor have higher blood pressure on average than do their less tolerant counterparts (162: 101).

Botany & Zoology

Mad deer disease? A wildlife brain ailment, once limited to a small part of the West and some game farms, turned up in wild deer in new areas, such as Wisconsin (162: 346*).

Upside way down The first video of the deep-ocean dwellers called whipnose anglerfish showed that scientists have had it wrong and the fish actually swim "upside down" (162: 262).

Species splits Researchers found that a walking stick insect may be evolving into two species by adapting to different environments (161: 350), and reef corals that spawn in great, churning, multispecies soups may be maintaining diversity because hybrids are nearly sterile (161: 374).



DOG WORLD
Genetic studies suggested that people domesticated dogs in East Asia and brought them along when first venturing into the Americas (162: 324*). Other tests indicated that dogs have an innate sensitivity to humans' body language as a legacy of domestication (162: 324*).

Lamprey allure An unusual sex attractant—male bile acid—turned up in an analysis of sea lampreys, and it may inspire new ways to defend the Great Lakes against this invasive species (61: 213).

Altruistic sperm Microscopy revealed that the sperm of wood mice hook together by the thousands to form high-speed teams racing toward an egg, even though only one of each pack can win the prize (162: 20).

Glow-in-the-dark bird A budgerigar's head literally fluoresces, and both males and females prefer to court partners with a glow, a study found (161: 40).

Ant peace and war The largest ant supercolony yet found stretched in a network of cooperating nests from Italy to the Atlantic (161: 245).

Gecko toes Scientists pinned down the molecular basis of the gecko's prowess at scampering up polished walls and hanging from ceilings (162: 133).

Cryptic invasion A mild-mannered reed native to the United States was found innocent; it was being blamed for the environmental damage caused by an evil twin from abroad (161: 118).

Bleeding trees A microbe related to the one that caused the Irish potato famine was tentatively identified as the long-sought culprit killing majestic beech trees in the northeastern United States (162: 70).

Cell & Molecular Biology

Malaria milestones Biologists deciphered the DNA sequences of a key malaria-causing parasite and of the mosquito that usually carries it, findings that suggest new ways to combat the deadly disease (162: 211*).

Hunger hormone The stomach makes a hormone called ghrelin that, in the brain, triggers hunger. Dieting, gastric-bypass surgery, and genetic mutations appeared to disturb the hormone's production (161: 107*, 366; 162: 14).

Rice twice Two research groups independently described the entire genetic sequence of rice, a first for a crop plant (161: 211*).

Cloning consensus A national advisory panel recommended outlawing cloning aimed at creating a child but suggested allowing medical experiments with cloned human cells (161: 52).

Stem cell stir Generating controversy over the potential of similar work in people, scientists showed that stem cells derived from cloned mouse and cow embryos can cure some animal diseases and create organs such as kidneys (161: 163*, 356*). Offering an alternative source for similar human cells, researchers showed that bone marrow from adults contains cells that can mature into many specialized types (161: 390).

Monkey business Scientists obtained long-lived stem cells from monkey eggs stimulated to develop without being fertilized by sperm (161: 94).

Showing off a growing ability to guide the growth of lab-grown tissues, Salt Lake City scientists created this image of the Olympic rings from live nerve cells (161: 61).

E. ROELL; UNIVERSITY OF UTAH

Viral threat Stoking bioterrorism fears, scientists proved they could build the poliovirus from scratch, using the widely known genetic sequence and available chemicals (162: 22).

RNA world An unexpectedly large number of genes encode RNA strands instead of proteins (161: 24*). Scientists started using short RNA strands to inhibit viruses and cancer growth (162: 93, 189).

Small wonder A microbe plucked from a volcanically heated ocean bed has the smallest number of genes of any living organism studied (161: 275).

Sleepy head Two common general anesthetics produce their sedative effects by triggering the brain's natural sleep circuits (162: 132*).

Gender gap Parasites infect male mammals more often than females, possibly contributing to the tendency for male mammals to die earlier than females (162: 182).

Spark of life Biologists identified the enzyme in mammalian sperm that triggers development of a fertilized egg (162: 189) and found that sperm contain an unexpected payload of RNA (162: 216).

Longevity gene Variations in a gene called *klotho* may influence the length of a person's life (161: 36*).

Muscled out A study in worms suggested that during aging, the nervous system stays intact but muscles degenerate (162: 260).

Chemistry

Hydrogen generation Researchers experimented with more sustainable ways to generate hydrogen, which burns cleanly but is typically made from fossil fuel (162: 235*).

Self-sutures Surgical sutures made from a new biodegradable material tie themselves into a knot and tighten as the material warms to body temperature (161: 262).

Nanotech concerns Scientists explored nanomaterials' possible negative consequences in the human body and the environment (161: 200*).

Better batteries A new material could make rechargeable lithium-ion batteries smaller, cheaper, and safer (162: 196*).

STEEL COLOSSUS
Unlike the stainless steel that caps New York's Chrysler Building, cheap grades of the rust-resistant alloy are prone to pit corrosion, in which small spots on the metal's surface erode at accelerated rates. British researchers who analyzed various grades of stainless steel discovered that pit corrosion results from a dearth of chromium in the material that surrounds sulfide-rich inclusions in the metal (161: 99*).

Money allergies Some of the new two-alloy European Union coins release large amounts of nickel, a common skin irritant (162: 163*).

Viral parts Researchers transformed viruses into potential building blocks for electronic circuits and tools for biomedical therapies (161: 68).

Minimotor A single molecule performed mechanical work—pulling and releasing a cantilever tip—when exposed to light (161: 292).

Macro costs A new analysis revealed that the production of a single 2-gram microchip requires nearly 2 kilograms of chemicals and fossil fuels (162: 309).

Questions of origin Two studies of inks and paper renewed controversy about the authenticity of a map that some scholars claim is the first depiction of North America (162: 109).

Mimicking nature's binders A new technique made artificial receptors that differentiate among molecules that are similar to each other (162: 53).

Icy birth Two experiments simulating the environment of interstellar space produced amino acids, the building blocks of proteins (161: 195*).

Molecular sorting A novel modification of polymer membranes gave researchers a means to tune certain filters to be more selective yet faster (161: 245). Other experiments suggested that a new membrane would make it easier to separate mixtures of the right-hand and left-hand versions of drug molecules (161: 388). A recently devised, metal-laced organic solid proved that it can act as a sieve for nanosize molecules (162: 213).

Earth Science

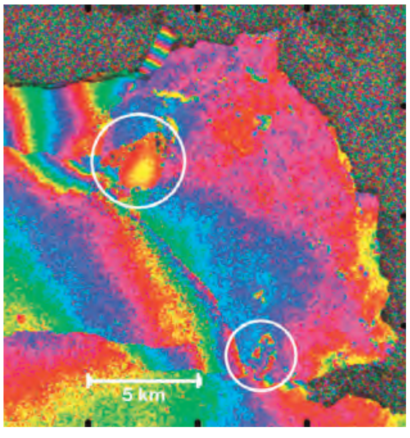
September's science Weather data gathered during the 3-day shutdown of commercial aviation within the United States after Sept. 11, 2001, suggest that the contrails from high-flying jets have a significant effect on Earth's climate (161: 291*).

It's baaaack Early in the year, scientists analyzed rainfall patterns in the Indian Ocean and predicted the late-summer return of El Niño, the worldwide weather maker marked by sea-surface warming in the tropical Pacific (161: 142). In July, NOAA researchers confirmed the phenomenon's arrival (162: 110).

Outside-in A fresh look at old experimental data suggests that water droplets in clouds freeze from their surface inward, a finding that would overturn a theory in place for more than 6 decades. (162: 340*)

Bottoms up Seafloor sediments suggest that the plankton-nourishing iron that's in surface waters surrounding Antarctica comes from upwelling deepwater currents, not from dust blowing off the continents (161: 6).

Cracked ice A Rhode Island–size section of the Antarctic's Larsen B ice shelf splintered into thousands of icebergs in a mere



Researchers analyzing satellite images of a remote island (large circle) off the northeastern coast of Greenland stumbled upon an undiscovered group of nearby small islands (small circle) (161: 222).

MOHR AND FORSBERG/NATURE

5-week period during the area's warmest summer on record (161: 197).

Demo job An analysis of trace elements in meteorites suggested that most of the heavenly objects that rained hell on the inner solar system about 3.9 billion years ago were asteroids, not comets (161: 147).

Global impact Sediments laid down on Earth about 3.47 billion years ago contain remnants of what may have been an extraterrestrial object large enough to disperse collision debris over the entire planet (162: 115).

Twister risk A new model found that the bull's-eye in Tornado Alley lies over southeastern Oklahoma, where any particular spot can expect to get damaged once every 4,000 years (161: 296*). As of Aug. 1, barely half the usual number of tornadoes had struck the lower 48 U.S. states (162: 125).

Deep sea Analysis of lab-made minerals suggested that the zone of rocks just outside Earth's core could hold enough water to fill the oceans five times (161: 205).

Ice museum Super-concentrated salt water at the bottom of Antarctica's Lake Vida has been sealed off from the world for at least 2,800 years and may support life (162: 387) .

Both sides now Scientists can map the size and distribution of ice particles in a cirrus cloud by combining simultaneous observations from satellites and ground-based instruments (161: 342).

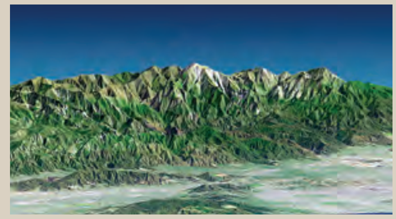
Paved paradise Rose Garden, one of the first undersea hydrothermal vents to be discovered nearly 25 years ago near the Galápagos Islands, may have been covered by a recent volcanic eruption (161: 382).

Tiny signs Mangled microfossils may become a new diagnostic tool for identifying the sites of ancient, hidden extraterrestrial-object impacts (161: 382).

Jelly alert Scientists refined a technique for calculating the probability of encountering stinging jellyfish in Chesapeake Bay (162: 52).

Storm warning Data from Arabian Sea sediments suggest that Asian monsoons have been intensifying over the past 400 years, and scientists predict that these storms are slated to get worse (162: 54*).

A FINE MAP
Defense Department mapmakers and NASA scientists are assembling billions of radar measurements made from the space shuttle Endeavour to produce what will be the world's best topographic map (161: 126).



Environment & Ecology

Frog woes At water concentrations found in the environment, the weed killer atrazine stripped male frogs of their masculinity, suggesting that the chemical is partly responsible for global amphibian declines (161: 243*; 162: 275*).

Troubled waters Several dozen organic contaminants were quantified in U.S. streams, and the chemicals' combined effects may be killing aquatic organisms (161: 181).

Fish beware *Pfiesteria* microbes, implicated in fish kills and human illness along the mid-Atlantic U.S. coast, turned up in Norway (161: 39). Another study suggested that some types of *Pfiesteria* don't produce a toxin but kill by eating holes in a fish's skin (162: 84).

Polluting seas Chemical analyses of seawater provided the first direct evidence that the ocean may be a significant source of atmospheric gases—alkyl nitrates—that scientists had assumed trace mainly to industrial activity (162: 102).

Legal steroids Farm-field runoff containing hormones excreted by steroid-treated livestock appeared capable of harming aquatic life (161: 10*).

Light blight Researchers found reason to suspect that artificial lighting at night disrupts the physiology and behavior of nocturnal animals (161: 248*).

Teenage hold up A study of adolescents suggested that widespread environmental pollutants, such as polychlorinated biphenyls and dioxins, might be delaying young people's sexual development (162: 3).

Tougher weeds Tests on sunflowers showed that a lab-engineered gene from a crop plant, if introduced into its wild relative, can give the native plant a survival edge over other wild plants (162: 99*).

Wasteful harvest New research and policy developments aimed to curb the practice of killing sharks solely for their fins, an Asian delicacy (162: 232*).

Drugs afield Researchers found that antibiotics excreted by people and animals have the potential to poison plants and end up in food (161: 406*).

Clay slays Scientists experimented with sprays of dirt particles to kill toxic algae in seawater (162: 344).

Mercurial foliage A study discovered that fallen leaves that collect in stagnant water can release toxic mercury, which can eventually accumulate in fish far downstream (161: 148).

Embryonic losses Minuscule amounts of over-the-counter weed killers impaired reproduction in mice (162: 228).

Dioxin's new target Scientists found indications that dioxin, a hormonelike pollu-

FIRED UP
Set alight by wildfires, thick beds of decaying tropical-plant matter can spew massive amounts of carbon, which researchers calculated could rival global emissions from fossil fuels (162: 291*).

NASA/JPL/CALTECH; PAGE AND J. RIELEY

tant, can trigger breast cancer in heavily exposed women (162: 77).

Killer cocktails Trace amounts of human-excreted drugs in waterways appeared to work together to deform and kill native microscopic organisms (162: 101).

Smoking gun Living with a smoker at least doubled a cat's risk of developing the feline analog of the cancer non-Hodgkin's lymphoma (162: 125).

Cold war Algae fight over nutrients, and one Swedish combatant under frozen lakes apparently prevails by poisoning its adversaries (161: 61).

Pollution magnet Atmospheric scientists learned that the Mediterranean Sea is a crossroads for pollution-laden air currents from Europe, Asia, and North America (162: 261).

Food Science & Nutrition

Vegetarians' vitamins Vegetarians' low intake of vitamin B_{12} may cause an overabundance of the amino acid homocysteine and thus increase their risk of heart disease (161: 100).

Cancer-fighting folate Even a little supplemental folate during a mother's pregnancy appeared to reduce the risk that her child will develop acute lymphoblastic leukemia (161: 8). Dietary folate also helped avert colon cancer in women (161: 253).

Wholesome grains Diets rich in whole rather than processed grains may help protect overweight people from diabetes and heart disease by improving their management of blood sugar concentrations (161: 308).

Fat of the sea A diet containing fish oil that's rich in omega-3 fatty acid cut inflammation of the colon in rats, so it might benefit people with colitis (161: 53).

To life! People fighting high blood pressure benefited from drinking cocoa (161: 142) and red wine (161: 8), thanks to the actions of plant polyphenols, which both beverages contain in abundance.

Big red Lycopene, which makes tomatoes red and in people's diets might help guard against prostate cancer, was found more abundant in watermelons than in tomatoes (162: 29).

The discovery that cooking and frying laces starchy foods with the animal carcinogen acrylamide (161: 277) launched an international effort to investigate how the poison forms (162: 120) and whether people's current exposures pose risks (162: 213*).

Not too sweet Honey can contain traces of potent liver-damaging compounds produced naturally by many flowering plants (161: 317).

Soy excess Large doses of the estrogen-like hormones in soybeans and soy-based infant formulas weakened the immune systems of mice (161: 325*).

Corn conundrum Although cooking sweet corn reduced its concentration of the antioxidant vitamin C, the process increases corn's overall disease-fighting antioxidant activity (162: 141).

A twist Moderate alcohol consumption appeared to reduced a drinker's risk of developing Alzheimer's disease and other forms of age-related dementia (161: 67*).

Stomach stalker A chemical abundant in broccoli killed ulcer-causing *Helicobacter pylori* bacteria in the laboratory and inhibited stomach cancer in mice (161: 340).

Garlic and HIV Garlic supplements interfered with one of the drugs people take to fight an HIV infection (161: 8).

Mathematics & Computers

Prime pursuit A novel approach for identifying prime numbers provided a long-sought improvement in the theoretical efficiency of algorithms for that task (162: 266*).

Powerful proof A mathematician proved Catalan's conjecture, a venerable problem in number theory concerning relationships among powers of whole numbers (161: 324).

Guessing secrets Analyzing a variant of the familiar game of 20 questions offered insights into Internet communication (161: 216*).

Filling in blanks Researchers developed speedy automated methods, based on differential equations, to repair or modify digital images (161: 299*).

Block logic Analyses of sliding-block puzzles led to a novel theoretical model of computer logic (162: 106*).

Molecular factoring For the first time, a simple, molecule-based quantum computer carried out Shor's algorithm for factoring a whole number (161: 31).

Nuclear blast In a classified U.S.–government experiment, what was then the world's fastest computer simulated a thermonuclear blast in three dimensions (161: 189).

Big bucks A government report estimated that software errors in industrial computer programs cost the United States about $60 billion per year (162: 45).

Peer pressure Researchers used a mathematical model of peer-influenced behavior to explain unexpected patterns in financial data and bird populations (162: 116).

Gaze control Researchers introduced a new method for gaze-operated, hands-free text entry that's faster and more accurate than using an on-screen keyboard (162: 141).

Paleobiology

Veggie bites Fossil remains of a creature that had rodentlike incisors and a hefty overbite provided the first distinct dental evidence for plant-eating habits among theropod dinosaurs (162: 179*).

No Olympian A biomechanical analysis of *Tyrannosaurus rex* hinted that the creature ran only slowly, if at all (161: 131*).

Moist heat Fossil leaves unearthed in central Colorado suggested that the region contained one of the world's first tropical rain forests just 1.4 million years after the demise of the dinosaurs (161: 403*).

Gap-filler A fossil originally misidentified as an ancient fish turned out to be the nearly intact remains of a four-limbed creature that lived during a period that left few fossils of land animals (162: 5).

SCIENCE NEWS Of the year

Leonardo, a mummified dinosaur unearthed in Montana, gave scientists a rare peek at what the creature's muscles, beak, skin, and other soft tissues may have looked like (162: 243*).

Swoop-n-scoop Fossils unearthed in Brazil strengthened the notion that some species of ancient flying reptiles swooped low over the water's surface and snapped up fish (162: 35).

Only traces Scientists found the birdlike footprints of a yet undiscovered creature in rocks more than 60 million years older than *Archaeopteryx*, the first bird to leave fossil remains (162: 62).

Say cheese Paleontologists unearthed fossils of a tiny, duck-billed crocodile that boasted a smile like no other: The animal had no front teeth (161: 142).

Marine mamas Newly discovered fossils of aquatic reptiles known as mosasaurs suggested that the creatures gave birth in mid-ocean rather than in near-shore sanctuaries, as previously suspected (162: 270).

On the go Scientists said that a sediment-filled, bathtub-shape depression at one of North America's largest dinosaur trackway sites is the first recognized evidence of dinosaur urination (162: 270).

Physics

Quick-change artists Observations of ghostly neutrinos from the sun and from nuclear-power reactors suggested that all neutrino types violate the prevailing theory of particle physics by frequently changing their identities (161: 301; 162: 371).

Wiring atoms Scientists demonstrated transistor action by a single atom (162: 88*).

Muon-go-round A deviation from theoretical predictions of the magnetic strengths of subatomic muons hinted at an undiscovered realm of elementary particles (162: 158).

Yin yang Electron bombardment of neutrons revealed that the nominally neutral particles contain regions of positive and negative charge (161: 262).

All in the family Exotic cousins of protons and neutrons known as doubly charmed baryons made their laboratory debut (162: 14).

False physics Two prominent physicists lost their jobs following allegations that they had fabricated data in landmark experiments (162: 37, 214).

Wee black holes Theorists proposed that ultradense specks of matter—microscopic black holes—might fleetingly appear in Earth's atmosphere and in a powerful particle accelerator soon to be built (161: 187*).

Bubble power In a controversial claim, researchers presented evidence of nuclear fusion in bubbles imploding in a liquid bombarded by sound waves (161: 147*). Other scientists reported that a cooling process in such bubbles makes fusion unlikely (162: 125).

Bright palette Researchers unveiled a novel microchip that's a laser that emits a band of infrared light rather than the single, pure wavelength of a typical laser (161: 115*).

Hard to beat In ultrahigh-compression experiments, the rare metal osmium outperformed diamond for sturdiness (161: 211*). Meanwhile, scientists continued to improve synthetic diamonds (162: 165*).

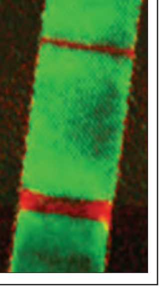
Technology

Pocket power For cell phones and other portable electronics, researchers field-tested prototypes of tiny, refillable fuel cells expected to last much longer than today's batteries (162: 155*).

Biomed structures Chemists synthesized new gelatinous and rubbery polymers that may serve as superior dressings for wounds (162: 20) and as scaffolds for artificial organs and tissues (161: 323, 408; 162: 93).

Attractively cool A compact cooler incorporating a permanent magnet showed that it could give rise to household refrigerators and air conditioners that depend on magnetism instead of volatile liquids (161: 4*).

Scientists unveiled new building blocks for ultrasmall electronic circuits including striped nanowires (right), embossed silicon, and welded nanotubes (161: 83*, 390*; 162: 222) and a novel magnetic microcircuit (161: 373).



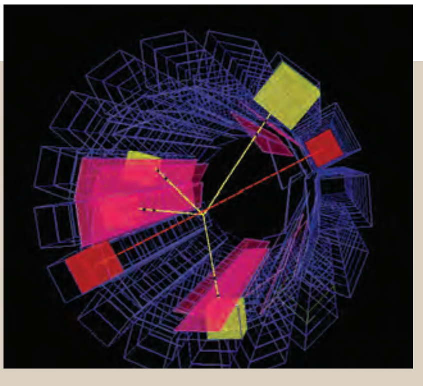
Microplumbing Researchers packed thousands of microscopic pipes and chambers onto fluid-manipulating microchips of unprecedented power (162: 198).

Hot cross beams Novel microstructures of crisscrossed tungsten rods filtered various wavelengths of radiated heat—a talent that someday might boost the efficiency of lightbulbs (161: 334).

Billowy billboards? An electronic display capped by a transparent polymer membrane applied as a liquid and then solidified may be a step toward paint-on displays for walls and fabrics (161: 349).

SLOW WINNERS

To make the first antimatter atoms that move slowly enough to be studied, physicists combined ultracold antiprotons and antielectrons into atoms of antihydrogen. Such atoms annihilate (right) when they hit ordinary matter (162: 286). Researchers also took a first, cursory peek inside antihydrogen and found matter and antimatter to be fundamentally alike, as expected (162: 399).



M. THOMPSON/PHILLIPS COUNTY MUSEUM; ATHENA COLLABORATION; BJÖRK ET AL./NANO LETTERS

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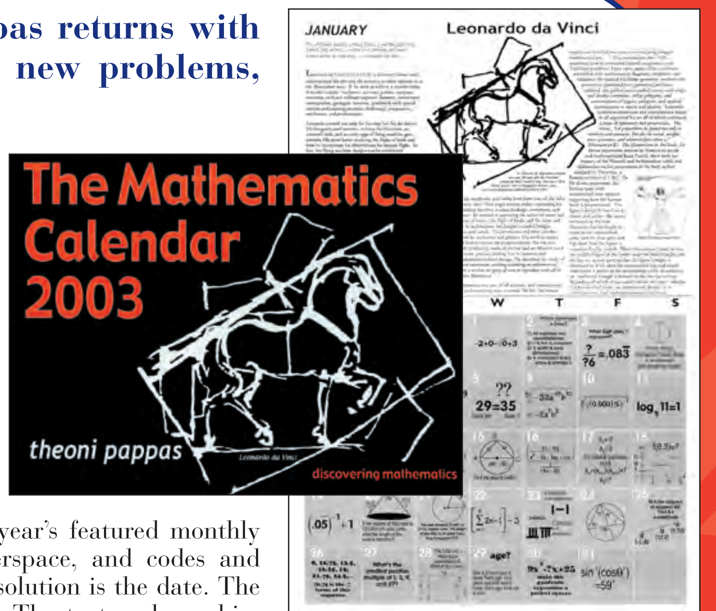
Math Calendars are back! ALL NEW FOR 2003

After a one-year hiatus, Theoni Pappas returns with these calendars for 2003 featuring all new problems, puzzles, and mathematical profiles!

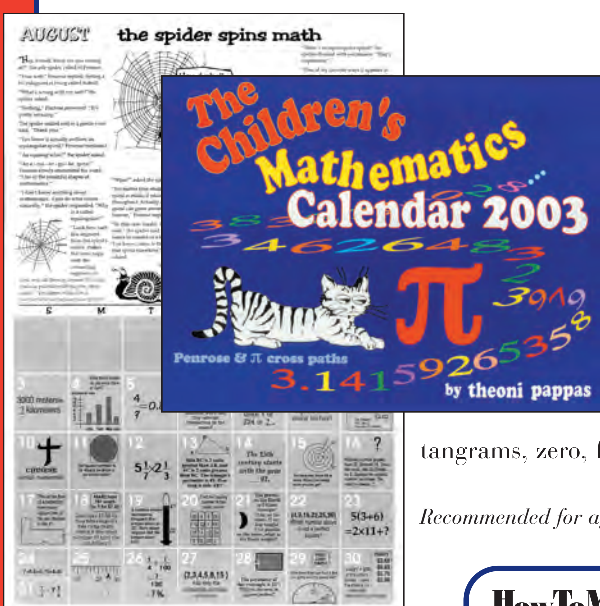


Wide World Publishing/Tetra 2003, 12" x 18", $10.95

These calendars allow you to unlock a fascinating world of mathematical challenges and learning. Both wall calendars feature math problems for every day of the year; in each case, the solution is the date. An informative essay, mathematical curiosity, or intriguing problem—plus handsome graphic—accompanies each month. Problems cover the spectrum from basic arithmetic to calculus. The answer is only one small part in the process of solving a problem. The challenge is discovering how to arrive at the solution and possibly discovering more than one method of solving it.

The Mathematics Calendar 2003 is loaded with challenging puzzles and problems and short essays on the ways in which math integrates other fields. Among this year's featured monthly topics are chaos theory, mathematics and cubism, hyperspace, and codes and ciphers. There is a problem for every day of the year; the solution is the date. The problems range in difficulty from arithmetic to calculus. The text and graphics accompanying each month have a wealth of information and even a bit of humor.

—from Wide World Publishing/Tetra



The Children's Mathematics Calendar makes math fun, as well as educational. Mathematics comes alive with the characters and ideas in the stories and concepts presented each month. This calendar is designed so that the answer to each day's problem is the date. The varied and unique graphics are designed to intrigue, motivate, and inform. Problems and text range in difficulty and will develop skills, introduce new concepts, stimulate curiosity, and present challenges for students in grades 1 through 8. In addition to stimulating a young person's thinking and helping in the discovery of new ideas in mathematics, this calendar offers a unique opportunity for young people to work with each other, their parents, and their teachers in determining how the solution to each problem is reached. This anniversary edition's featured topics include: tangrams, zero, fractals, and prime numbers.

—from Wide World Publishing/Tetra

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