The April 2 dedication of the Powell-Booth Laboratory for Computational Sciences showcased, among other things, the Immersadesk large-screen 3-D projector. Virtual passengers included (from left) President Baltimore, the Powell Foundation's Larry Cox, and Professor of Civil Engineering and Applied Mechanics Paul Jennings. The lab also contains a Hewlett-Packard Exemplar, the world's largest cache-coherent shared-memory computer.

The Whittier Foundation Expresses Itself at Caltech

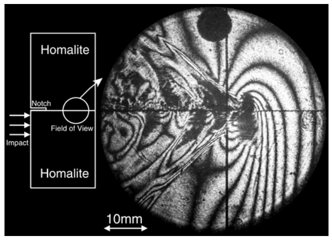
Caltech has received a $1,444,000 grant from the L. K. Whittier Foundation to found the L. K. Whittier Gene Expression Center. Led by Professor of Biology Barbara Wold (PhD '78), the center will use Caltech's unique resources to begin large-scale human gene expression analysis. Mel Simon, chair of the biology division and the Biaggini Professor of Biological Sciences, has produced probes for 40,000 known human genes, and for many of the genes characterized in the mouse. By combining this information with what scientists have already learned from the Human Genome Project, the center is expected to produce wide-ranging discoveries in both the medical and biological sciences. "We hope to make the center a useful tool for all of the biologists on campus, and ultimately for scientists around the world, through our accumulated database of gene-expression information," says Stephen Quake, associate professor of applied physics and another collaborating scientist at the center. "Gene arrays provide more data than any one person can analyze, and the aggregate sum of the data provides a powerful resource to answer a number of questions about gene function." □—*SMcH*

Self-Awareness Neurons

Clusters of large neurons found exclusively in the brains of humans and other primates closely related to humans may provide these species with enhanced capacities for solving hard problems, as well as for self-control and self-awareness. In the April 27 issue of the *Proceedings of the National Academy of Science*, neurobiologists Patrick Hof from Mount Sinai Medical Center and Caltech's John Allman, Hixon Professor of Psychobiology and professor of biology, and their colleagues have found an unusual type of neuron that is likely to be a recent evolutionary acquisition. The neurons in question are spindle-shaped cells that are almost large enough to be seen with the naked eye and are located in the frontal lobe near the corpus callosum, which connects the two halves of the brain.

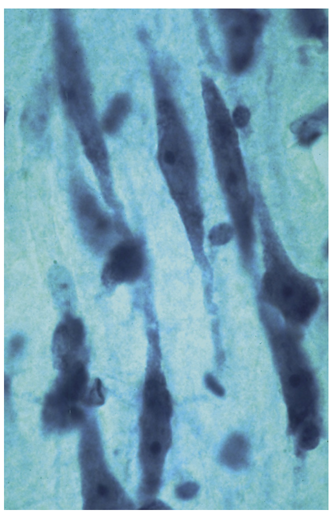
Allman, Hof, and their team studied 28 different species of primates and found the spindle neurons only in humans and very closely related apes. The concentration of spindle neurons was greatest in humans, somewhat less in chimpanzees, still less in gorillas, and rare in orangutans. According to Allman, "This declining concentration matches the degree of relatedness of these apes to humans." There were no spindle cells in gibbons, which are small apes, or in any of the other 22 species of monkey or prosimian primates they examined. The spindle cells were also absent in 20 nonprimate species examined, including various marsupials, bats, carnivores, and whales.

The cells are found in an area of the brain already linked to psychiatric diseases. Says Allman, "In brain-imaging studies of depressed patients, there is less neuronal

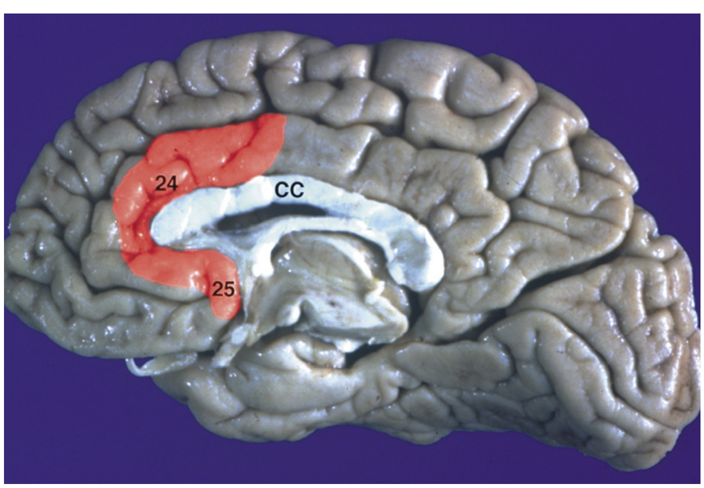


When a brittle material breaks, the cracks spread like lightning, as anyone who has inadvertently subjected a favorite vase to “floor stress” knows. But how fast is fast? In the May 21 issue of *Science*, Professor of Aeronautics and Applied Mechanics Ares Rosakis and grad students Omprakash Samudrala and Demirkan Coker used an ultrafast camera running at two million frames per second to show that for cracks resulting from shear stresses traveling along weak planes, the speed of the crack can exceed the speed of sound in the material, creating angled shock waves (the > shape) that closely resemble photographs of a supersonic bullet breaking the sound barrier. This crack is moving at about 2,200 meters per second, or 5,000 miles per hour. Rosakis hopes that studying how such cracks get going will help seismologists understand how earthquakes begin along shear faults, such as California’s notorious San Andreas.

activity in the region and the volume of the area is smaller. The activity of the area is increased in manic and obsessive-compulsive patients.” The area’s activity has been shown to increase with the difficulty of the cognitive task being performed, suggesting that the area enhances the capacity to do hard thinking. Activity also increased when a subject withheld a response or focused its attention, suggesting the area is involved in self-control. Furthermore, the spindle neurons themselves are especially vulnerable to degeneration in Alzheimer’s disease, which is characterized by diminished self-awareness. From this Allman suggests, “Part of the neuronal susceptibility that occurs in the brain in the course of age-related dementing illnesses may have appeared only recently during primate evolution.” ☐—*RT,*



Left: The spindle cells.
Below: The cells live in the anterior cingulate cortex, shown in red in this view of the bisected human brain.



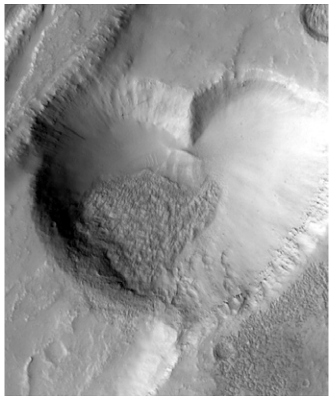
The CENIC Route to Mexico

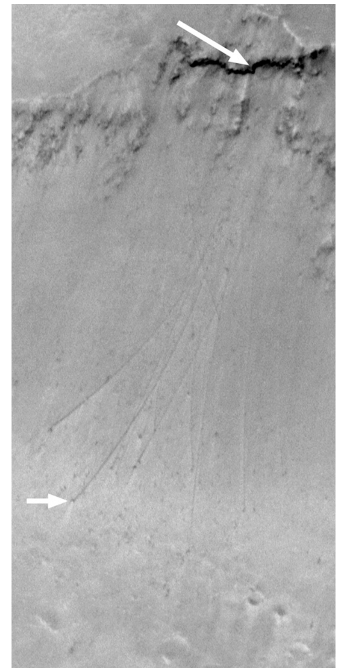
Plans for a new high-speed Internet2 linkage between California and Mexico were unveiled in San Diego on May 19, when Governor Gray Davis and President Ernesto Zedillo endorsed a joint memorandum of understanding. The memorandum establishes an agreement for the linkage between California’s Corporation for Education Network Initiatives in California (CENIC), of which Caltech is a member, and Mexico’s Corporacion Universitaria para el Desarrollo de Internet (CUDI). “Linking together Mexico’s and California’s advanced networks will enable our universities to share powerful instruments and supercomputers, enrich learning through real-time interactions, share medical research and diagnostic capabilities, and reach into each others’ libraries,” said M. Stuart Lynn, Chairman of the CENIC Board. “Together, we can solve important educational, social, and research problems to improve the lives of people everywhere.” ☐

The Planetary Travel Report

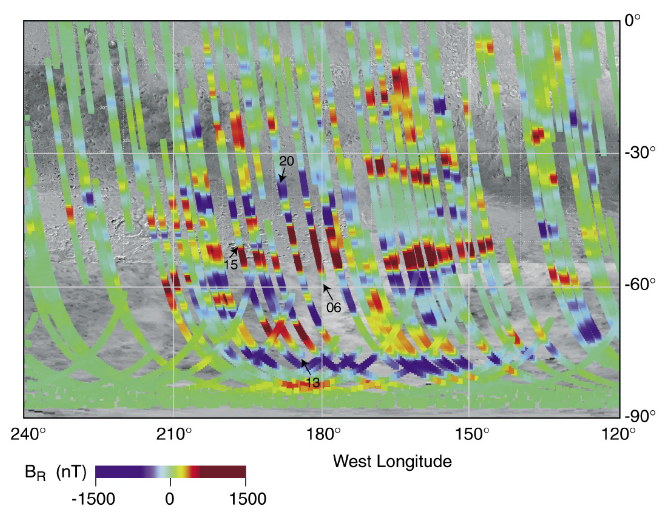
Mars is the solar system's happenin' tourist destination these days. There's the Mars Global Surveyor, which settled into its final mapping orbit on February 19, deployed its high-gain antenna on March 28, and began its somewhat deferred primary mission on April 4. The Mars Climate Orbiter and the Mars Polar Lander are well on their way, having lifted off on December 11 and January 3 respectively. The former is set to slip into orbit on September 23; the latter to land near the south pole on December 3. The lander is actually two missions in one, as it carries two microprobes collectively known as Deep Space 2 that will hit the Martian surface at some 200 meters per second (400 miles per hour) and bury themselves as much as a meter deep in search of water ice.

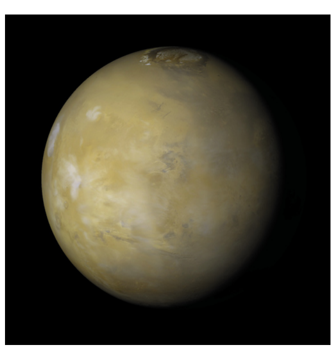
By the way, it's no longer the Red Planet—in the 575-page compendium of results from the Mars Pathfinder mission published as a special section of the April 25 issue of the *Journal of Geophysical Research*, one conclusion was that the planet is actually various shades of yellowish brown. (Our eyes don't perceive these hues well from afar and so see them as red, which has colored our thinking.) Whether "The Butterscotch Planet" will catch on with the Martian Board of Tourism remains to be seen.

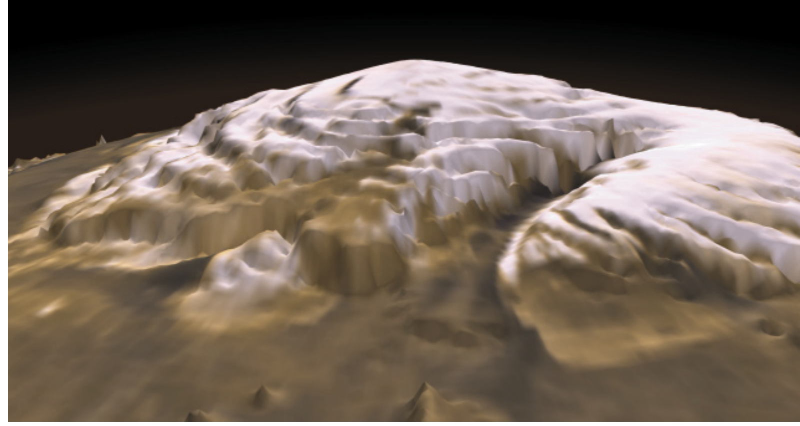




Aboard the Mars Global Surveyor, the Mars Orbiter Camera (MOC), built and operated by Michael Malin (PhD '76) and Malin Space Science Systems, continues to be a workhorse, but other instruments are cranking out data as well. Clockwise, from the top left: (1) This Martian valentine is actually a pit about a mile and a half wide, formed by the collapse of subsurface material. (2) The "Happy Face Crater," officially known as Galle, is about 134 miles across and lies on the east flank of Argyre Planitia. (3) The large arrow points to a steep cliff of dark rock from which several boulders appear to have broken off, leaving a fan of trails down the soft, dusty slope. The small arrow points to one such boulder, approximately 18 meters in diameter—bigger than a two-story house. (The MOC can actually see boulders as small as 1.5 meters, or five feet, in diameter—the size of Yogi rock at the Pathfinder landing site.) (4) Data from the Mars Orbiter Laser Altimeter provide a global relief map—see page 33 for another view. (5) Global nighttime (2:00 a.m.) surface temperatures from the first 500 mapping orbits, as measured by the Thermal Emission Spectrometer. It's winter in the southern hemisphere, and the coldest temperatures mark the polar ice cap. Along the equator the coldest areas are very fine dust; warmer regions, such as the Valles Marineris (10° S, 30–90° W), are coarse sand, gravel, and rocks. The north pole gets full sunlight, and is relatively warm. (6) The discovery of these magnetic stripes, which may be the signature of long-extinct plate tectonic processes, was a bonus from the aerobraking orbit's dipping below the ionosphere—at mapping altitude, the magnetometer would not have been able to see them. (7) Mars—the butterscotch planet.

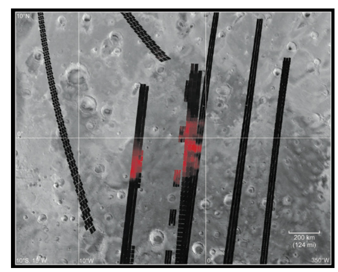


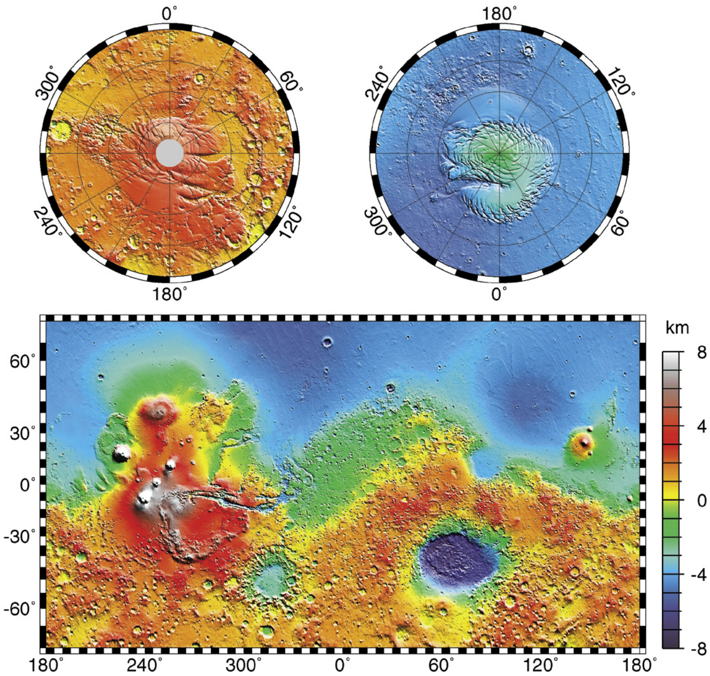


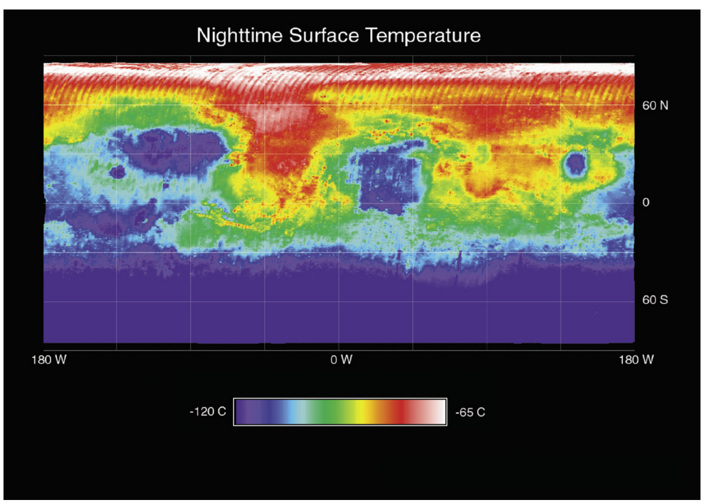


Above: The first ever 3-D picture of Mars's north pole (vertical scale exaggerated), as measured by NASA/Goddard's Mars Observer Laser Altimeter. The elevation data is accurate to 5–30 meters over a spatial resolution of one kilometer, and will allow scientists to better estimate the volume of water in the polar ice cap.

Below: The Thermal Emission Spectrometer, run by Arizona State, also maps surface mineralogy by their spectral fingerprints. Here hematite concentrations are shown in red—black pixels mean no detectable hematite was found. The data is superimposed on a Viking image.



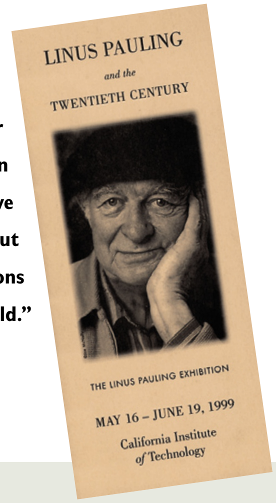




Meanwhile, beyond the asteroid belt, Galileo continues exploring the Jovian system, particularly the moon Europa. The latest news there is that Europa's nighttime temperatures show puzzling variations from place to place—patterns that don't correlate with either the surface's geology or reflectivity. (The daytime temps are as expected.) The spacecraft has also detected hydrogen peroxide, a powerful chemical perhaps best known on Earth as "blonde in a bottle," on Europa's icy surface. Hydrogen peroxide reacts with pretty much everything and so doesn't hang around long (it's not found naturally on Earth), so it appears to be forming continually as energetic particles from Jupiter's radiation belts smash into Europa and break down other molecules. On other moons, Galileo has discovered a cloud of microscopic dust grains, believed to be from meteoroid impacts, around Ganymede, and a thin atmosphere of carbon dioxide—so thin that the molecules literally drift around without colliding with one another—on Callisto. This latter finding means that all four of Jupiter's largest moons have some sort of atmosphere, no matter how tenuous.

And from the "If it's Tuesday, it Must be Belgium" department, Cassini hit another milestone on its roundabout, gravity-assisted trajectory to Saturn by buzzing Venus for the second time on June 24th. Next stop is Earth on August 18.

During the month that the exhibition *Linus Pauling and the Twentieth Century* occupied the Winnett Center, a total of 16,000 people visited it, 3,300 of them students from local schools. Sponsored by the Pauling family with Oregon State University, Caltech, and Soka Gakkai International, the exhibition, subtitled "A Quest for Humanity," celebrated Pauling's life—his work in peace as well as in science—through photos, historical artifacts, papers, and interactive workstations. Part of its mission was "to teach today's youth about the role of scientists in creating conditions for a secure and peaceful world."



Watson Lectures Set

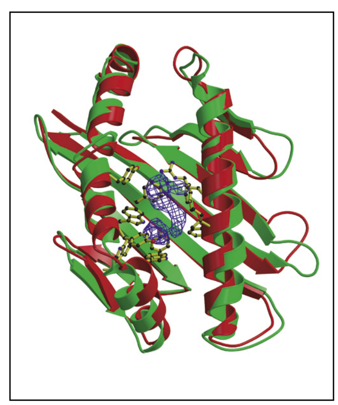
Next fall's Watson lecture lineup has been announced. Opening the season on October 6 will be "Grocery Bags to Baseball Bats: Polymers and Us" by Robert Grubbs, the Atkins Professor of Chemistry. Next comes "Stem Cells to the Rescue" by David Anderson, professor of biology and investigator at the Howard Hughes Medical Institute, on October 20. On November 3, Professor of Finance Peter Bossaerts will speak "Of Bulls, Bears, and Crystal Balls." And as the 1900s draw to a close, Robert Neary, Caltech's chief administrative information officer, will attempt to answer the question "The Y2K Problem: Solved?" on November 17. Then, shortly after we find out if he was right, Fred Culick, Hayman Professor of Mechanical Engineering and professor of jet propulsion, will tell us "What Happened in Aeronautics After the Wright Brothers?" on January 12, 2000. All Watson lectures are at 8:00 p.m. in Beckman Auditorium and, as always, are free and open to the public. □

ZAG and Chicken Soup

Caltech biologists have determined the three-dimensional structure of a protein that causes fat loss in some cancer patients. The discovery could lead to new strategies for controlling weight loss in patients with cancer or AIDS—and conversely, perhaps new strategies for fighting obesity. The protein is commonly known as ZAG and is found in most bodily fluids. Researchers have been aware for some time that the protein is particularly abundant in some breast cancers. More recently, researchers have discovered that the protein is involved in the wasting syndrome known as cachexia, which is associated with both cancer and AIDS. "This protein has something to do with fat metabolism," says Pamela Bjorkman, professor of biology and associate investigator at the Howard Hughes Medical Institute. Bjorkman and senior research fellows Luis Sanchez Perez and Arthur Chirino (who is also an associate at the Howard Hughes Medical Institute) published ZAG's structure in the March 19 issue of *Science*.

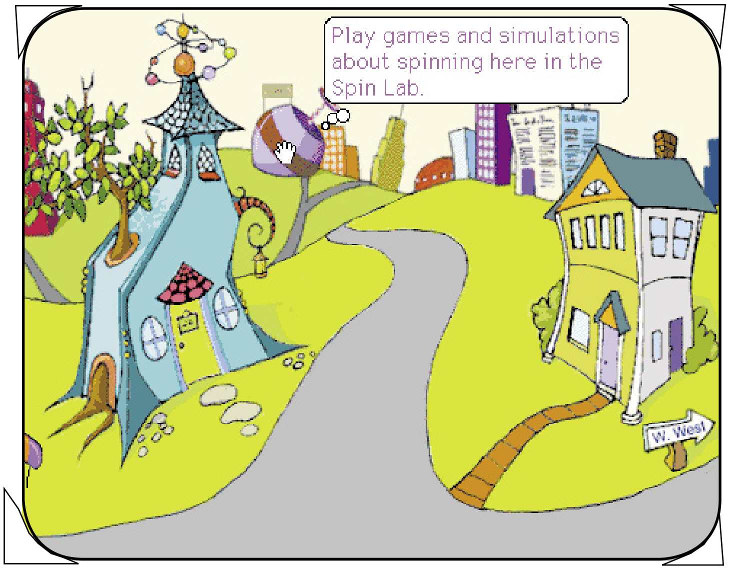
It turns out that ZAG resembles a family of proteins known as class I major histocompatibility complex (MHC) molecules. "MHC proteins have a large groove that binds a peptide derived from a pathogen," says Bjorkman, adding that their picture of the ZAG crystal shows an unexpected blob in ZAG's counterpart of the MHC peptide-binding groove. The blob is "not a peptide, but some organic molecule," she says. "We suspect that it is involved in the function of ZAG. If this compound is involved in breaking down lipids, that is, fats, then maybe you could design a drug that replaces it and interfere with lipid breakdown."

According to Bjorkman, other research has shown that tumor cells seem to stimulate the body to overproduce ZAG, which in turn leads to the breakdown of body fat. Thus, people suffering from cachexia lose body weight not because they don't eat, but because the fat in their bodies is ultimately destroyed by an interaction involving ZAG. Thus if the overexpression of ZAG were disrupted, perhaps by monoclonal antibodies or small molecules that bind to ZAG, the wasting might be stopped, she says. □—*RT*



This rendering superimposes the ZAG structure (red) and the MHC class I structure (green) to show how similar they are. The blue chicken-wire sculpture in the binding groove represents the electron-density outline of the as-yet unidentified organic molecule that binds to ZAG. The ball-and-stick structures sticking into the groove are the amino acids that make up ZAG's binding site.

The Whos, Whats, and Hows of Whyville



Above: Whyville Square is the heart of Whyville, containing the site's four original buildings. Clockwise from bottom left-hand corner: Dr. Leila's House, the Spin Lab, the Times Building (in white), and the CAPSI House. (Whyville artwork by Ann Pickard)

Who can forget the Whos? Residents of Whoville in Dr. Seuss's *How the Grinch Stole Christmas*, the Whos were a close-knit community who loved nothing more than the opportunity to frolic about in celebration.

With that spirit in mind, welcome to Whyville, an interactive Web site that celebrates science education. Based on more than 15 years of science education research by the Caltech Precollege Science Initiative, the Whyville community—located on the Web at www.whyville.net—is designed by CAPSI in conjunction with NuMedeon LLC. The production team includes Whyville founder Jim Bower, professor of biology; and alums Mark Dinan '91 and Jen Sun, PhD '96.

Like CAPSI's own approach to science education, the site's concept follows the idea that kids learn science best by doing it. To this end, the site uses games and activities linked to Dr. Leila's (Leila Gonzalez '79) weekly column in the *Los Angeles Times*, "Caltech Connections for Kids," which appears every Thursday during the academic year in the *Times* Living section's "Kid's Reading Room."

For each topic, Dr. Leila gives background information, interesting facts, and experiments and activities that children (and others) can do at home. Each topic is housed in a separate building within Whyville. The first such building, the Spin Lab, contains activities related to such things as momentum, resistance, and rotational velocity and inertia.

Other buildings include the House of Illusions, constructed for April Fools' Day to show how one's eyes can be fooled by certain three-dimensional images; the *Times* building, which contains current and past "Connections" articles; Dr. Leila's House, where members can look at other members' questions and submit their own; and the CAPSI house, a building for educators that includes links to other educational Web sites. And recently the site added the residential suburb of Myville, where registered citizens can claim a plot of land and build a house that then gets rendered in 3-D.

Citizenship in Whyville is open to anybody. Once registered, members may use all of the site's features and can even win prizes to be used within Whyville.

Whyville and the articles are connected to a set of 10-week science curriculum units developed at CAPSI for grades 7–12. Together they link chemistry, biology, physics, and the history of science. □—*RP*

In other science-education-journalism news, Caltech and the Foundation for American Communications (FACS) have launched a national initiative to improve the quality of news reporting on science and technology. The initiative's first program is the Jack R. Howard Science Institute for Journalists, being held at Caltech as *E&S* goes to press.

Caltech–Huntington Seminar Founded

Caltech has received a $90,000 grant from the Andrew W. Mellon Foundation in support of the newly created Mellon Seminar in Interpretation. The seminar, to be taught jointly by William Deverell, associate professor of history, and Amy Meyers, curator of American art at the Huntington Library, will address the intersection between documentary and visual records in American history. Eight graduate students from across the United States will come to Pasadena in the winter or spring quarter of the upcoming academic year (the dates have not yet been fixed) to take part in the eight-week program. "This is an important step in drawing the intellectual resources of Caltech and the Huntington Library ever closer," says Deverell. "This partnership, which was envisioned by George Ellery Hale 80 years ago, offers exciting opportunities to Caltech students and faculty, Huntington curators and fellows, and scholars from other universities." The program will be overseen by the newly established Caltech–Huntington Committee for the Humanities, which is designed to foster collaborative intellectual and pedagogical exchange between the humanities faculty at Caltech and the curators and readers at the Huntington. □—*DT*

Electrons of a Different Stripe

It may be that Eisenstein's electrons have accumulated into long ribbons, somewhat like lines of billiard balls lying in parallel rows on a pool table.

Caltech physicists have succeeded in forcing electrons to flow in a way never previously observed in nature or in the lab. Professor of Physics Jim Eisenstein and his collaborators have observed electrons that, when confined to a two-dimensional plane within a layered semiconductor crystal and subjected to an intense perpendicular magnetic field, can apparently tell the difference between "north-south" and "east-west" directions in their otherwise featureless environment. As such, the electrons are in a state very different from that of conventional solids, liquids, and gases.

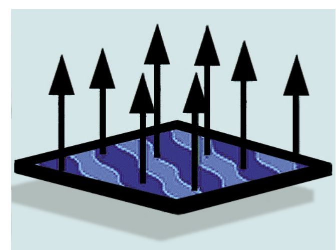
Research on exotic states of electrons is relatively new, but its theoretical history goes back to the 1930s, when Eugene Wigner speculated that electrons in certain circumstances could actually form a sort of crystallized solid. It turns out that forcing electrons to lie in a two-dimensional plane increases the chances for such exotic configurations. "They cannot get out of one another's way into the third dimension, and this actually increases the likelihood of unusual 'correlated' phases," Eisenstein says. Adding a magnetic field has a similar effect by forcing the electrons to move in tiny circular orbits rather than running unimpeded across the plane.

Eisenstein's group has found that a current sent one way through the plane of electrons tends to encounter much greater resistance than an equal current sent at a perpendicular angle. This "anisotropy" only sets in when the temperature of the electrons is reduced to within one-tenth of one degree above absolute zero, which is the lowest temperature a system can approach. Normally, a current flowing at any angle experiences the same resistance as a current flowing at any other angle, because the electrons are dispersed more or less evenly across the plane.

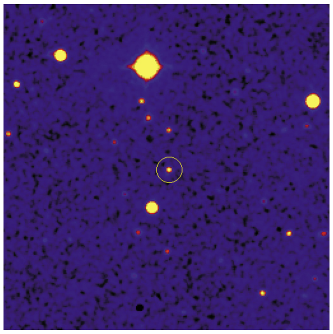
One of the best-known examples of the strange behavior of two-dimensional electron systems is the fractional quantum Hall effect, for which three American scientists won the Nobel Prize in physics last year. (Electrons in such a system essentially act as a liquid that exhibits some unusual properties.) Owing to the laws of quantum mechanics, the electrons' circular orbits exist only at discrete energies, called Landau levels. For the fractional quantum Hall effect, all of the electrons are in the lowest such level. Eisenstein's results appear when higher energy levels are also populated with electrons. While it appears that a minimum of three levels must be occupied, Eisenstein has seen the effects in many higher Landau levels. "This generic aspect makes the new findings all the more interesting," remarks Eisenstein.

It may be that Eisenstein's electrons have accumulated into long ribbons, somewhat like lines of billiard balls lying in parallel rows on a pool table. Something in the ribbon structure overwhelms the electrons' mutual repulsion, allowing them to cram more closely together, while the number of electrons in the spaces between the ribbons is reduced. "There's not a good theoretical understanding of what's going on," Eisenstein says. "Some think such a 'charge-density wave' is at the heart; others think a more appropriate analogy might be the liquid-crystal displays in a digital watch." Another interesting question that could have deep underpinnings is how and why the system "chooses" its particular alignments. The alignment could have to do with the crystal substrate in the wafer, but Eisenstein says this is not clear.

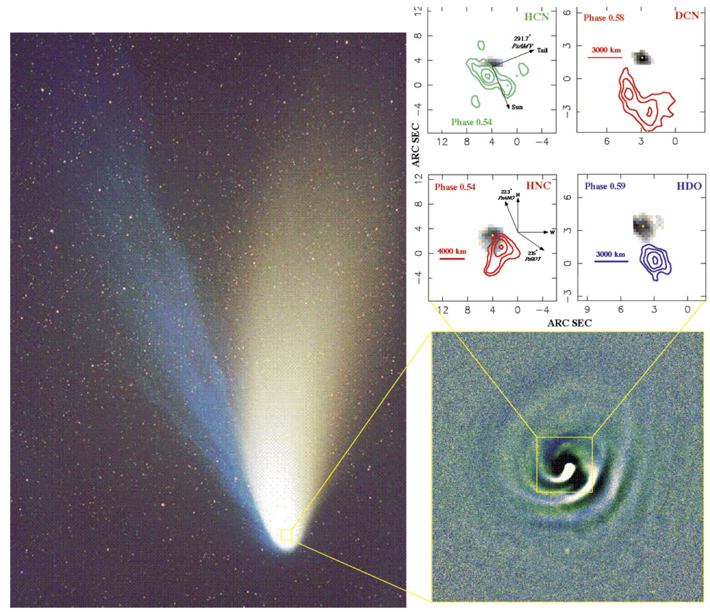
The Caltech group includes postdoc Mike Lilly and grad student Ken Cooper. Loren Pfeiffer and Ken West of Bell Laboratories, Lucent Technologies in Murray Hill, New Jersey, provided the high-purity semiconductor wafers essential to the experiments. □—*RT*



Above: In this view of the semiconductor layer, the hypothesized ribbons of alternating high and low electron density are shown in different colors. An electric current traveling in the direction of the ribbons would meet considerably less resistance than one flowing across the ribbons. The direction of the applied magnetic field is shown by the arrows.



You ain't seen nothin' yet: The circled object, which has a spectrum unlike anything ever observed before, is just one of the first fruits of the Digital Palomar Observatory Sky Survey (DPOSS), now nearing completion. The survey, which covers the entire northern sky in three colors of visible light, will contain information on over 50 million galaxies and about 2 billion stars and will be made available to astronomers worldwide as the Palomar-Norris Sky Catalog. Caltech and JPL are also performing data analysis for the University of Massachusetts' 2MASS (for Two-Micron All-Sky Survey), which is producing comparable amounts of data at infrared wavelengths. Both databases will be available on-line; the first release of 2MASS images (about 6 percent of the final database) went up on the Web in May. For more on DPOSS, see http://phobos.caltech.edu/~george/dposs/. For 2MASS, see http://www.ipac.caltech.edu/2mass.



Zooming in on Hale-Bopp. Left, as seen by H. Mikuz and B. Kambic at the Cnri Vrh Observatory in Slovenia. Bottom right, a computer-enhanced look at the nucleus and its jets, by B. E. Mueller of the National Optical Astronomical Observatory. Top right, OVRO maps of the concentrations of several molecules. The gray blob in the center of each frame shows the nucleus's location.

Comets, Comets Everywhere, But Not a Drop in the Ocean

A new study of comet Hale-Bopp suggests that long-period comets did not give Earth most of its water, buttressing other recent studies but contrary to the longstanding belief of many planetary scientists. In the March 18 issue of *Nature*, Professor of Cosmochemistry and Planetary Sciences and Professor of Chemistry Geoffrey Blake (PhD '86) and his team showed that Hale-Bopp contains sizable amounts of "heavy water," which contains a heavier isotope of hydrogen called deuterium. Thus, if Hale-Bopp is a typical comet, and if comets indeed gave Earth its water supply billions of years ago, then the oceans should have roughly the same amount of deuterium as Hale-Bopp. In fact, the oceans have significantly less.

The team, which included grad student Charles Chun-hua Qi, Michiel Hogerheijde of UC Berkeley, Mark Gurwell of the Harvard-Smithsonian Center for Astrophysics, and Professor Emeritus of Planetary Science Duane Muhleman, looked at a form of heavy water called HDO, which can be measured in Earth's oceans using mass spectrometers and in comets with Caltech's Owens Valley Radio Observatory (OVRO) Millimeter Array. Just as radio waves go through clouds, millimeter waves easily penetrate the comet's obscuring coma to see jets of water and organic molecules emitted from the surface of the nucleus within.

The jets are quite small, so OVRO's image clarity was crucial. "Hale-Bopp came along at just the right time for our work," Blake said. "We didn't have all six telescopes in the array when Halley's comet passed by, and Hyakutake was a very small comet. Hale-Bopp was quite large and quite bright, and so it was the first comet that could be imaged at high spatial and spectral resolution at millimeter wavelengths."

The study also showed that Hale-Bopp is composed of 15 to 40 percent primordial material that existed before the sun formed. □—*RT*