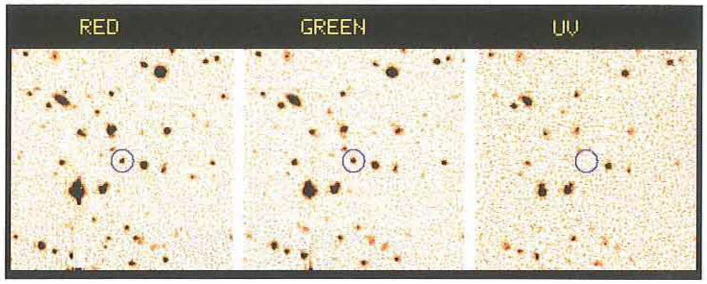
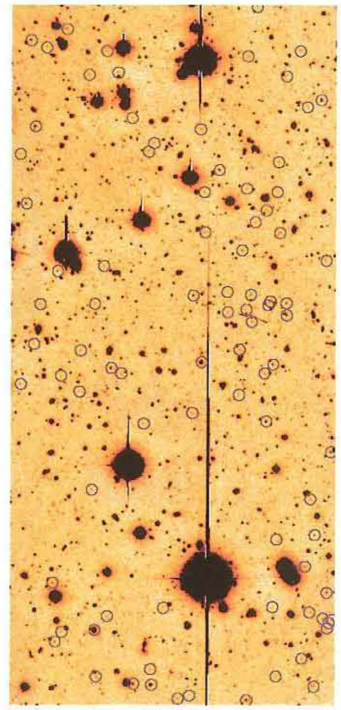
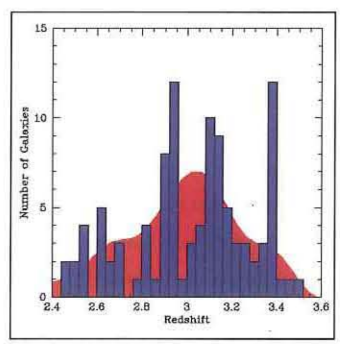
That Was a Quick Decade

The January 1998 broadcast of *AirTalk: The Caltech Edition* on KPCC (89.3 FM) marks the 10th anniversary of that monthly live radio program. The *Caltech Edition* is a special installment of the regular *AirTalk* series, which is hosted every weekday evening by Larry Mantle. Mantle devotes *AirTalk* to interviews of political figures, celebrities, academic personalities, authors, and others from a wide variety of backgrounds. Listeners have the opportunity during the show to call in and talk to Mantle or the guests directly. KPCC, licensed to Pasadena City College, has the strongest signal of any NPR-affiliated station in Los Angeles and Orange Counties, and, in general, can be heard from Santa Barbara to San Diego.

Caltech President David Baltimore and Robert O'Rourke, Caltech's associate vice president for institute relations and the originator of the idea for the series, are the 10th-anniversary guests. Past *Caltech Edition* guests have included Kip Thorne, an expert on gravitation and a longtime collaborator with Stephen Hawking; Ed Stone, who holds a joint appointment as director of Caltech's Jet Propulsion Laboratory (JPL) and as vice president at Caltech; Donna Shirley, the head of JPL's Mars exploration program; Christof Koch, an expert on neural networks and computers who has spoken on the cloning controversy; seismologists Kate Hutton and Lucy Jones; and planetary scientist Andy Ingersoll, who is an expert on global warming and the El Niño phenomenon. □







Associate Professor of Astronomy Charles Steidel (PhD '90) and colleagues have found several large clusters of galaxies that had begun to aggregate when the universe was only about one-tenth of its present age, long before gravity would have had time enough to pull them together. These clusters therefore reflect the distribution of matter in the universe soon after the Big Bang. Since a galaxy's redshift is a proxy for its age, the astronomers used the 200-inch Hale Telescope at Caltech's Palomar Observatory to search for galaxies whose light has been shifted so far to the red that they are invisible at ultraviolet wavelengths (top). This portion of a typical field from the Hale Telescope (middle) contains some 2,000 galaxies and about 75 "ultraviolet dropouts" (circled). The redshifts of these dropouts were then measured at the twin 10-meter telescopes at Caltech's W. M. Keck Observatory in Hawaii. The blue bars (bottom) show the clumpiness of the dropout galaxies' measured distribution; the red curve in the background shows how the data would look if the galaxies were distributed randomly in space.

Caltech senior Rowena Lohman, geology major, flutist, actress (seen here as Eva in last fall's production of *Thieves' Carnival*), and rock climber, has been named one of *Glamour* magazine's Top Ten College Women for 1997. The award includes a trip to New York City, where honorees are introduced to professionals in their field.

Caltech Beats the Big 10, Big 12, Big West, Big East, SEC, Ivy League. . .

No, it's not the fantasy of a frustrated football coach, but the results of a very different nationwide sporting event—the Fourth Annual Collegiate Championship of Amateur Radio Clubs. The Caltech Amateur Radio Club (CITARC) took first place, winning by commanding margins the two lesser events that make up the championship. In both events, the club, which holds the call sign W6UE, attempted to contact other amateur radio operators. Scoring is based on the number of contacts completed times the number of sections contacted. (For these contests, Canada and the United States—including Alaska, Hawaii, Puerto Rico, the U.S. Virgin Islands, and the Pacific Territories—are divided into 79 sections, some of which are quite difficult to contact because of their distance or sparse population. The idea is to reward the stations that reach the widest areas; otherwise stations in densely populated regions could win on purely local contacts.) The first event, held on the first weekend of November, was conducted in Morse code; the other, on the third weekend of November, was in voice mode. In both events, Caltech made a clean sweep of all 79 sections. (For more information about CITARC, check their Web site at http://www.cco.caltech.edu/~w6ue/)

There's a serious side to all this—in the aftermath of an earthquake or other natural disaster that brings down telephone lines and computer networks, amateur radio provides a vital communications link. Contests such as these hone operators' technical skills and test the station's equipment, much like emergency-preparedness excercises.

Some two dozen colleges participated, including Penn State, the University of Texas, the University of Nevada–Reno, Virginia Tech, the University of Arkansas, and Harvard. Oh, and That Other Institute of Technology? We beat them, too. □—*DS*

Hudson Bay Bounces Back

While Earth's gravitational field is commonly thought of as constant, in reality there are small variations in the field as one moves around the surface of the planet.

These variations have typical magnitudes of about one ten-thousandth of the average gravitational attraction, which is approximately 9.8 meters per second per second. A global map of these variations shows large undulations at a variety of length scales. These undulations are known as gravity anomalies.

There are many such anomalies in Earth's gravity field, but one of the largest negative gravity anomalies (implying the attraction of gravity being a little less than average, or in other words, a mass deficit) is centered on Hudson Bay, Canada.

Using a new approach to analyzing planetary gravity fields, Assistant Professor of Geophysics Mark Simons at Caltech and Bradford Hager at MIT have shown that incomplete glacial rebound can account for a substantial portion of the Hudson Bay gravity anomaly.

With this new information, Simons and Hager were able to place new constraints on the variations in strength of the materials that constitute the outer layers of Earth's interior (the crust and mantle). Their work appeared in the December 4 issue of the journal *Nature*.

About 18,000 years ago, Hudson Bay was at the center of a continental-sized glacier. Known as the Laurentide ice sheet, this glacier had a thickness of several kilometers. The weight of the ice bowed Earth's surface down. The vast majority of the ice eventually melted at the end the Ice Age, leaving a depression in its wake.

While this depression has endured for thousands of years, it has been gradually recovering, flattening itself out like a vacated sofa cushion. (The term "glacial rebound" refers to this tendency of land in formerly glaciated areas to rise after the ice load has disappeared.) The coastlines located near the center of the former ice sheet have already risen several hundred meters, and will continue to rebound.

"The rate at which the area rebounds is a function of the viscosity of Earth," says Simons. "By looking at the rate of rebound going on, it's possible to learn about the planet's viscosity."

Simons says that geophysicists have known for some time about the Hudson Bay gravity anomaly, but have hitherto been uncertain how much of the gravity anomaly is a result of glacial rebound and how much is due to mantle convection or other processes.

The gravity anomaly is

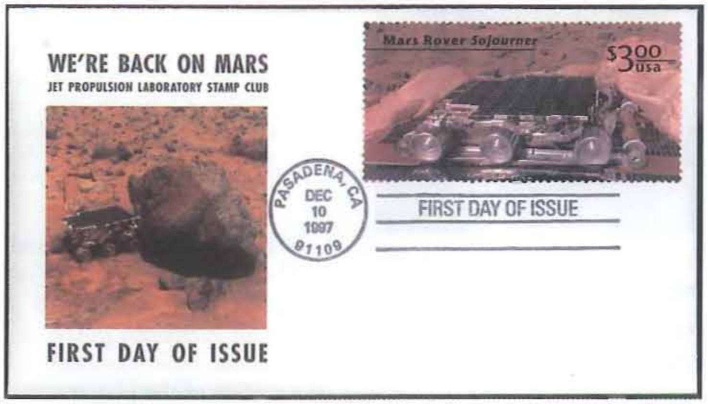
measured from both the ground and from space. Simons and Hager use a gravity data set developed by researchers at NASA's Goddard Space Flight Center.

However, knowing how much of an anomaly exists at a certain site on Earth is not sufficient to determine the pliability of the materials beneath it. For this, Simons and Hager developed a new mathematical tool that looks at spatial variations of the spectrum of the gravity field.

In many instances, this approach allows one to separate the signatures of geologic processes that occur at different locations on Earth. In particular, Simons and Hager were able to isolate the glacial-rebound signature from the signatures of other processes, such as manifestations of plate tectonics, that dominate that gravity field but are concentrated at other geographic locations.

Having an estimate of incomplete postglacial rebound allowed Simons and Hager to derive a model of how the viscosity of the mantle changes with depth. Simons and Hager proposed one such model that explains both the gravity anomaly as well as the uplift rates estimated from the coastlines.

Their favored model suggests that underneath the oldest parts of continents (some of which are over 4 billion years old), the viscosity of the outer 400 kilometers of Earth's interior is much stiffer than it is under the oceans. Therefore, these continental keels can resist the erosion by the convective flow that drives plate tectonics. □—*RT*



On December 10, the Mars Pathfinder mission was honored by the U.S. Postal Service with the issuance of a $3 priority-mail stamp. Fifteen million of the stamps, which bear a portion of the first panoramic image returned after the July 4 landing, have been printed.

The Cartoon Guide to Geophysics

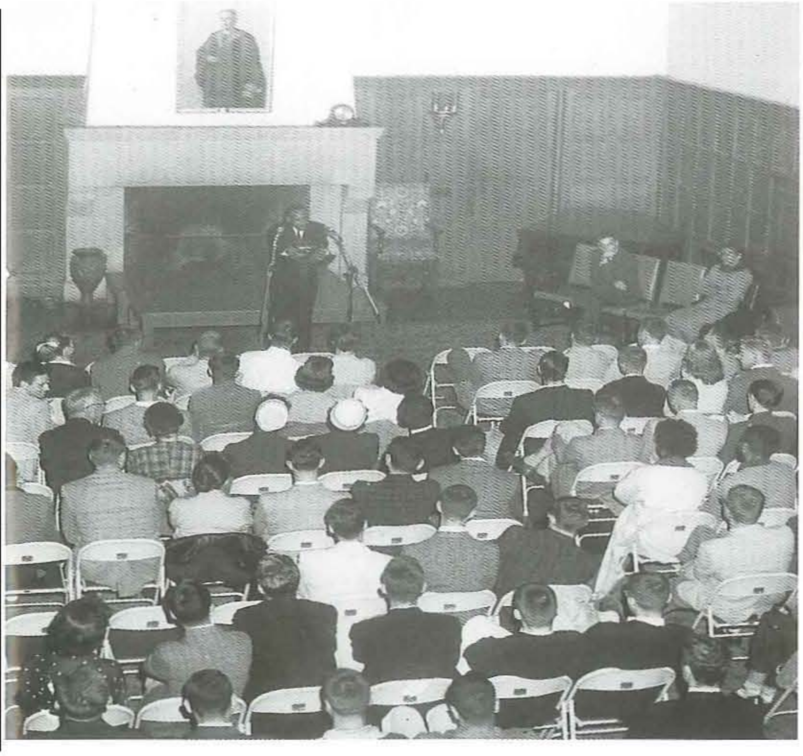
As every Bugs Bunny fan knows, the laws of physics in the cartoon universe are rather different than in our own. But can cartoon physics inspire real discoveries? The "Feedback" section of the October 11, 1997, issue of *New Scientist* noted, "Where do scientific ideas first appear? Looking back 35 years reveals one possibility. In the early 1960s, American TV aired a popular weekly cartoon called the *Rocky and Bullwinkle Show*. In one sequence, the dimwitted hero, Bullwinkle J. Moose, notices that his normally frozen home town of Frostbite Falls, Minnesota, is starting to thaw much earlier than usual.

"No, it isn't global warming arriving early. Our hero discovers that the North Pole has become so top-heavy with ice that it is slipping toward the equator, taking Frostbite Falls into sunnier climes and wreaking general environmental havoc..." (This polar deep freeze was caused by arch-nogoodnik Boris Badenov's scheme to displace the North Pole, and with it Santa Claus, into the Pacific Ocean. Boris, operating from the new North Pole, planned to take over Christmas, carrying gifts up the chimney instead of down.)

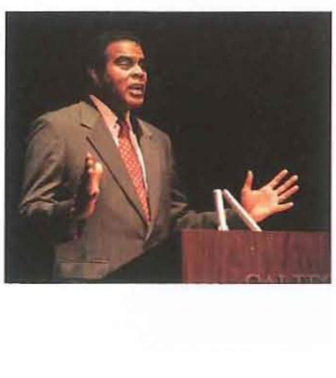
The article went on to compare this plot line to recent speculations by Professor of Geobiology Joseph Kirschvink (BS, MS '75) that some 534 million years ago, a mass imbalance in the mantle beneath the supercontinent of Gondwanaland (which had formed from the fusion of several lesser land masses only 20–30 million years earlier) caused Earth to become rotationally unstable. Gondwanaland, which was straddling the South Pole at the time, suddenly lurched 90 degrees northward as a result, shifting the excess mass to a more stable equatorial location. (See "Atlas Shrugged" in the Random Walk section of the last *E&S*.)

The item concluded, "Kirschvink's proposal earned him considerable ink in the science press... Nowhere, however, was there any recognition of the key contribution to the theory made by Bullwinkle J. Moose."

Kirschvink, who loved *Rocky and Bullwinkle* as a kid, has a more prosaic explanation. "The theoretical possibility of true polar wander has been known for over 50 years. Then, back in the early '60s, a bunch of papers came out saying that Earth's moment of inertia is about half a degree off from its spin axis, and is moving back toward it. This was presumed to be due to deglaciation [see Hudson's Bay Bounces Back]. Some writer for the show probably saw it in the newspaper somewhere and said, 'Hey, cool. I can use that!'" □—*DS*



The Reverend Martin Luther King, Jr., was on campus February 25–27, 1958, as the second visitor in the Caltech Y's Leaders of America program. He arrived in Los Angeles with his wife, Coretta Scott King, and the two were driven to campus from the Beverly Hilton by then-sophomore Kent Frewing (BS '61). For three days, King met informally with a large number of students, faculty, and staff, and presented formal lectures at the Athenaeum and Dabney Hall (above). He was also the guest of honor at several meals in the undergraduate residential houses. Forty years later, basketball-star-turned-media-star Tommy Hawkins, vice president of communications for the Los Angeles Dodgers, was the keynote speaker at Caltech's King Day observances (below). In a moving speech, Hawkins described his experiences as the first black player on the University of Notre Dame's basketball team, crediting King, Jackie Robinson, and Notre Dame president Rev. Theodore Hesburgh, C.S.C., for making it possible.



10-4, Copy That

Caltech biologists have pinpointed the sequence of reactions that triggers the duplication of DNA in cells.

In companion papers appearing in recent issues of the journals *Science* and *Cell*, Assistant Professor of Biology Raymond Deshaies and his colleagues describe the chain of events that lead to the copying of chromosomes in a baker's yeast cell. Baker's yeast is often used as a model for human cells, so the research could have implications for technology aimed at controlling cell reproduction, such as cancer treatments.

"We've provided a bird's-eye view of how a cell switches on the machinery that copies DNA," says Deshaies. "These principles can now be translated into a better understanding of how human cells proliferate."

The group's research keys primarily on how cells copy and segregate their chromosomes during the process of duplicating one cell into two. The new papers are concerned with how cells enter the DNA synthesis phase, during which the chromosomes are copied.

For years, cell biologists have tried to determine precisely which chemical events set off these reactions. The cell cycle is fundamental to the growth and division of all cells, but the process is somehow ramped down once the organism reaches maturity.

The paper appearing in *Science* describes how DNA synthesis is turned on. In the preceding stage (known as G_1), proteins named G_1 cyclins trigger the destruction of an inhibitor that keeps DNA synthesis from beginning.

This inhibitor sequesters an enzyme referred to as S-CDK (for DNA synthesis-promoting cyclin-dependent kinase), thereby blocking its action. Once the S-CDK is released, it switches on DNA synthesis. The S-CDK is present before the copying of DNA begins, but the DNA copying is not turned on until the S-CDK is freed of its inhibitor.

The Deshaies group has shown that several phosphates are attached to the S-CDK inhibitor. These phosphates act as a molecular Velcro, sticking the inhibitor to yet another set of proteins called SCF.

The *Cell* paper essentially picks up the description of the cell cycle at this point. The SCF, which acts like a molecular "hit man," promotes the attachment of another protein, ubiquitin. (See *E&S*, Spring 1995.) Ubiquitin in turn attracts the cellular garbage pail, prote-asome. The inhibitor is dis-posed of in the prote-asome, thereby freeing the S-CDK, which goes on to stimulate DNA duplication.

The process described above is quite complicated even in this condensed form, and actually is considerably more complicated in its technical details. But the detailed description that Deshaies and his colleagues have achieved is important fundamental science that could have technological implications in the future, Deshaies says.

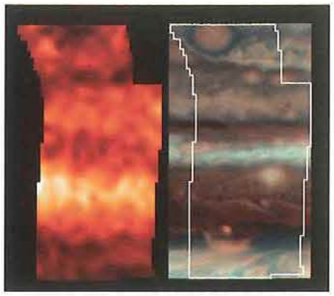
"This traces the ignition of DNA synthesis down to a relatively small set of proteins," he says. "Any time you figure out how a part of the cell division machinery works, you can start thinking about devising new strategies to turn it on and off."

It is a precise turning on and off of DNA replication, many researchers think, that will someday be the key to better and more specific cancer-fighting drugs. Because a tumor is a group of cells that literally never stops the cell duplication cycle, a greater understanding of the cycle itself is almost certain to be a factor in further medical advances in cancer treatment.

"It could be five to 10 years, but this work could point the way to new cancer-fighting drugs," Deshaies says. "It is much easier to begin a rational approach to developing new treatments for cancer if you are armed with fundamental insights into how the cellular machinery works."

The other authors on the paper in the October 17 issue of *Cell* are Caltech grad student R. M. Renny Feldman, postdoc Craig C. Correll, and Kenneth B. Kaplan, a postdoc at M.I.T.

The other authors of the *Science* paper from the October 17 issue are Rati Verma, a senior research fellow at Caltech; Gregory Reynard, a Caltech technician; and R. S. Annan, M. J. Huddleston, and S. A. Carr, all of the Research Mass Spectrometry Laboratory at SmithKline Beecham Pharmaceuticals in King of Prussia, PA. □—*RT*



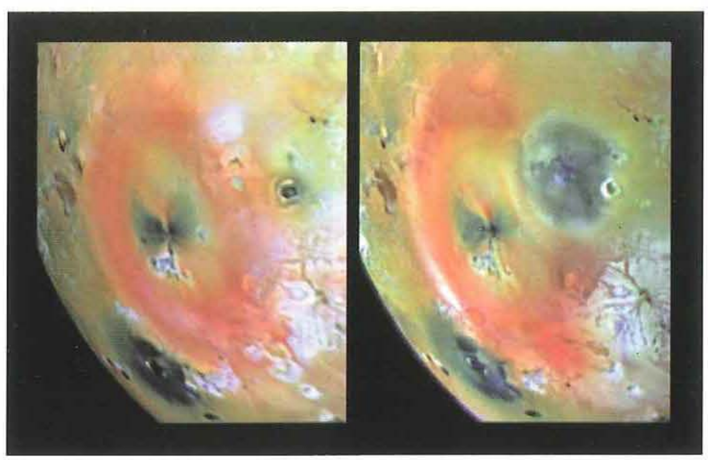
Above: A high-resolution map of Jupiter's temperatures (left) and a Hubble Space Telescope view of the same area (right), taken within 10 hours of the Galileo map. The visually bright spots are generally colder than their surroundings, indicating that rising gas is cooling and forming reflective condensates.

Above: This one-minute exposure of a piece of Jupiter's night side, which was taken in the moonlight of Io, has been colored red for dramatic effect. The white patches near the top are lightning storms, made visible by multiple bolts during the exposure. As befits the king of the gods, Jove's lightning bolts are hundreds of times more powerful than terrestrial ones.

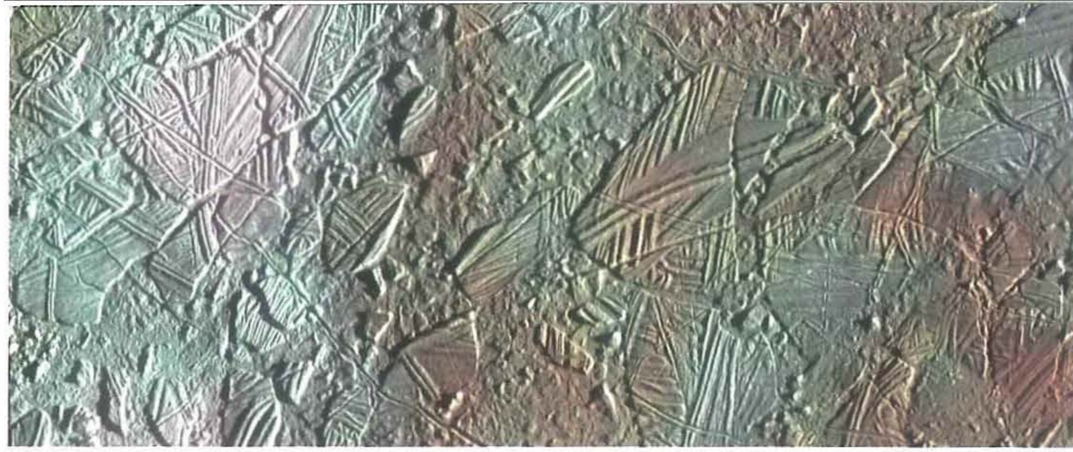
GALILEO: PRIMARY MISSION ACCOMPLISHED

JPL's Galileo spacecraft ended its two-year, 11-orbit primary mission to Jupiter on December 7, 1997. The program will henceforth be known as the Galileo Europa Mission, or GEM. Galileo will swoop past Europa eight times in the next two years, looking for hints as to whether a liquid ocean lurks under Europa's fractured, icy crust. Four loops by Callisto will follow, which will slow the spacecraft and alter its course for Io. If the intense radiation in Io's neighborhood doesn't prove fatal, Galileo will then make two close passes by Jupiter's pizza-faced moon for a detailed look at its volcanic surface.

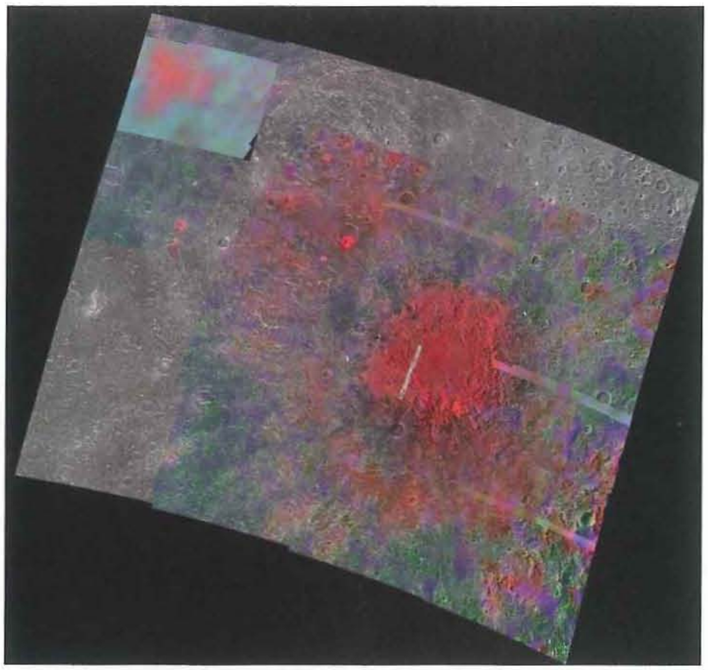
During its primary mission, Galileo beamed back roughly a billion bytes of data, enabling such nonphotogenic discoveries as the tenuous atmospheres around Ganymede, Callisto, and Europa; the metallic cores within Io, Europa, and Ganymede; and Ganymede's magnetic field. The spacecraft also returned more than 1,800 pictures of Jupiter and these four moons. Here are some recent highlights.

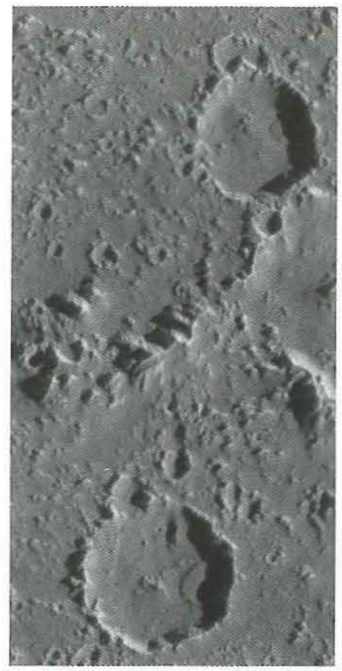


Above: Between April (left) and September (right), 1997, an Arizona-sized dark spot formed on Io around a caldera, or volcanic depression, called Pillan Patera. (The red ring is deposits from Pele, another volcano.)



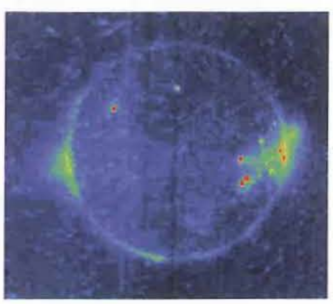
Above: In this color-enhanced view of Europa, the blues and whites come from a dusting of fine ice particles ejected by the impact that formed a 26-kilometer-diameter crater some 1,000 kilometers to the south. The rest of the surface has been painted reddish-brown by mineral contaminants that escaped from beneath the crust when it fractured. Europa's original color was probably the deep blue seen elsewhere over large areas of its surface.

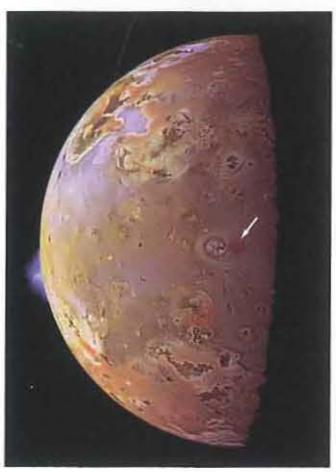




Right: This false-color image of part of Callisto's southern hemisphere combines visible and infrared data. Red indicates icy areas, while regions with less ice are blue. The big red blotch in the center is an unnamed, 200-kilometer-diameter impact crater; several of the other red blotches correlate with lesser craters, suggesting that an icy subsurface underlies a thin coating of darker material.

Far right: The pancake-shaped deposits on the floors of these two craters are landslides from the crater walls. Each landslide is about 3–3.5 kilometers long. The fact that they traveled such large distances may indicate that Callisto's surface material is very fine-grained.





Far left: Io glows in the dark. This false-color image was taken in visible light when Io was in Jupiter's shadow. Red marks the most intensely glowing regions (lakes and flows of hot lava), with dimmer areas trailing off through yellow and green into blue. Like our moon, Io always keeps the same side facing its planet. The point closest to Jupiter is at the right-hand edge of this image, where a field of hot spots can be seen. Jupiter's tidal influence pulls Io's surface some 50 meters out of round at this point, squeezing and heating the magma. The diffuse glow on Io's left limb hangs over a volcanic vent named Prometheus, and extends some 800 kilometers into space, although the visible plume is only about 75 kilometers tall.

Left: In this true-color image, the plume on Io's limb is the first one ever seen emitted by Pillan Patera. The reddish-brown shadow of Prometheus's plume is marked by the arrow. (The vent itself is in the center of the adjoining dark ring.) Prometheus, which was discovered by Voyager 2 in 1979, may have been continously active for more than 18 years.