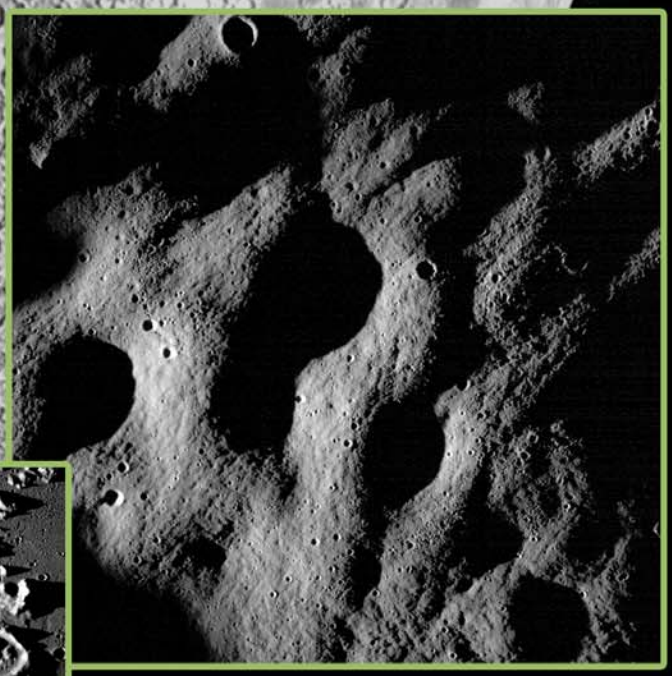
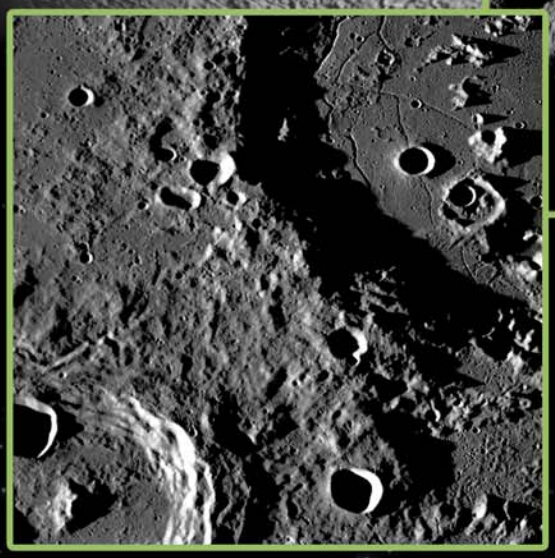
New Views of the Moon: A Photo Essay





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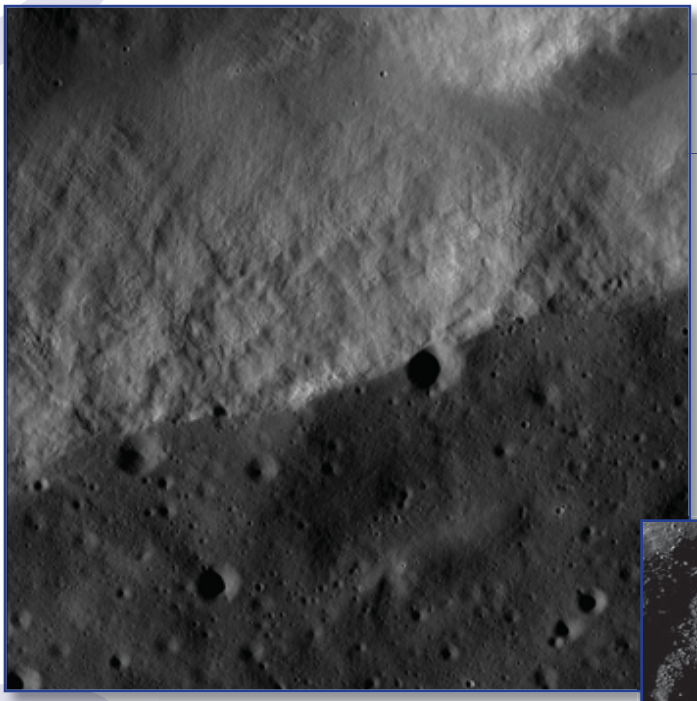
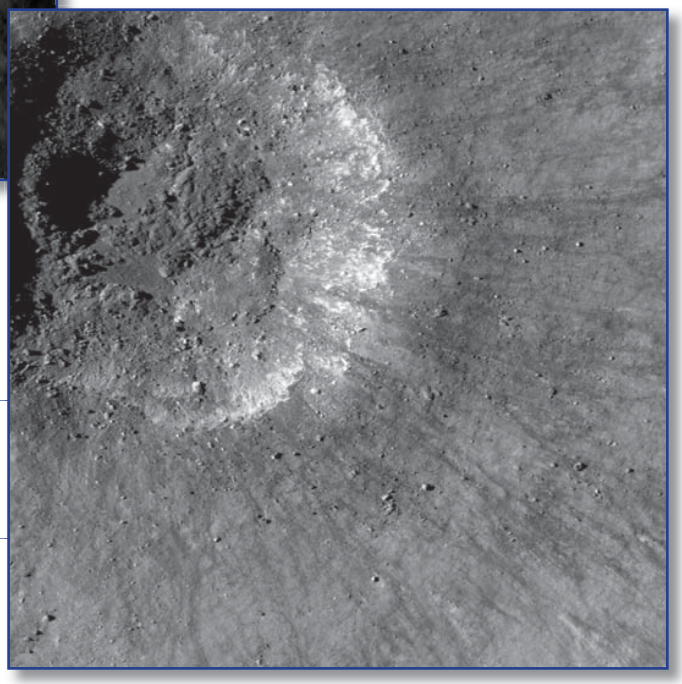
New Views of the Moon: A Photo Essay

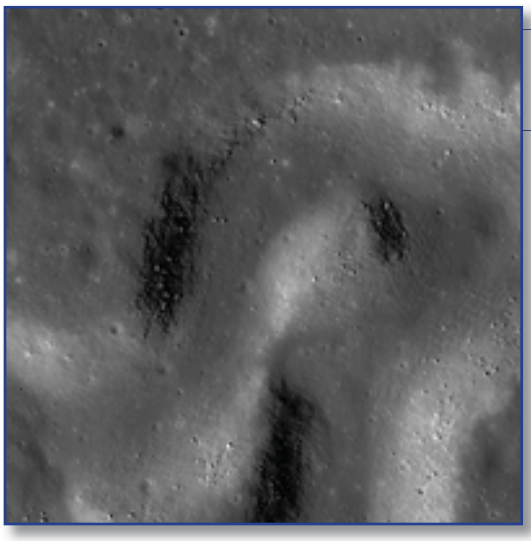
The Lunar Reconnaissance Orbiter (LRO) mission, launched on June 18, entered its validation orbit in August. In late September it reached the final mapping orbit, a nearly circular orbit approximately 31 miles above the lunar surface. Among its suite of instruments are two cameras: a low-resolution Wide Angle Camera and a high-resolution Narrow Angle Camera. Known collectively as the Lunar Reconnaissance Orbiter Camera (LROC), the cameras have already returned stunning photographs taken as the Moon rotates beneath the spacecraft. The LROC is designed to address two of the prime LRO mission requirements: (1) to assess meter-scale features to facilitate selection of future landing sites, and (2) to acquire images of the poles every orbit to characterize the polar illumination environment (100-meter scale), identifying regions of permanent shadow and permanent or near-permanent illumination over a full lunar year. The details seen in the LROC images are remarkable; not only do the images of the Apollo landing sites show the lunar module descent stages sitting on the lunar surface, waiting for the next generation of explorers to visit them, but the footpaths of the astronauts are visible as well (perhaps this will provide food for thought for the "Moon hoax" believers . . .). Featured here are just some of the images that have been captured by LRO; more images and information about the mission are available at *www.nasa.gov/lro*, *lro.gsfc.nasa.gov*, and *lroc.sese.asu.edu*. All images are courtesy of NASA/Goddard Space Flight Center/Arizona State University. So sit back, relax, and enjoy an armchair visit to the Moon!



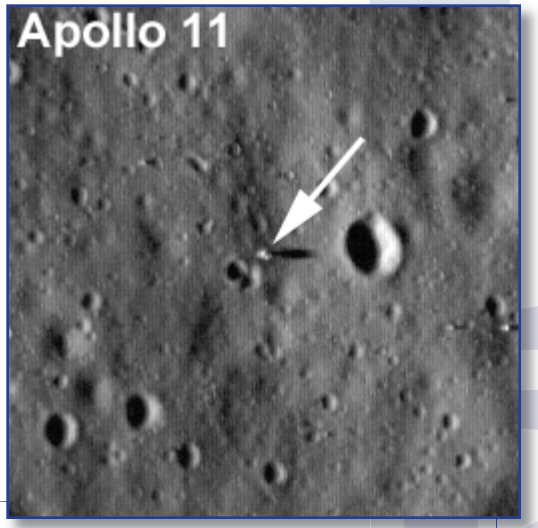
Ejecta blanket and rim of Timocharis Crater in southeastern Mare Imbrium.



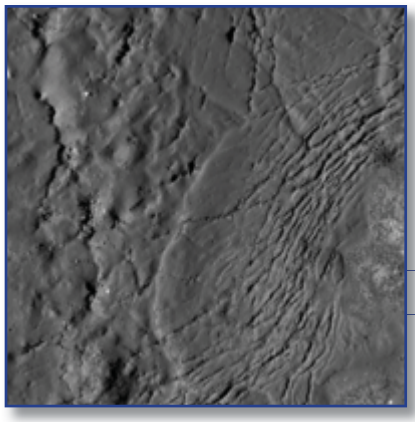
A very young impact crater in the Moon's Balmer basin. The dark streamers are impact melt splashes thrown out during crater formation. The entire image is 1302 meters (0.8 miles) wide.



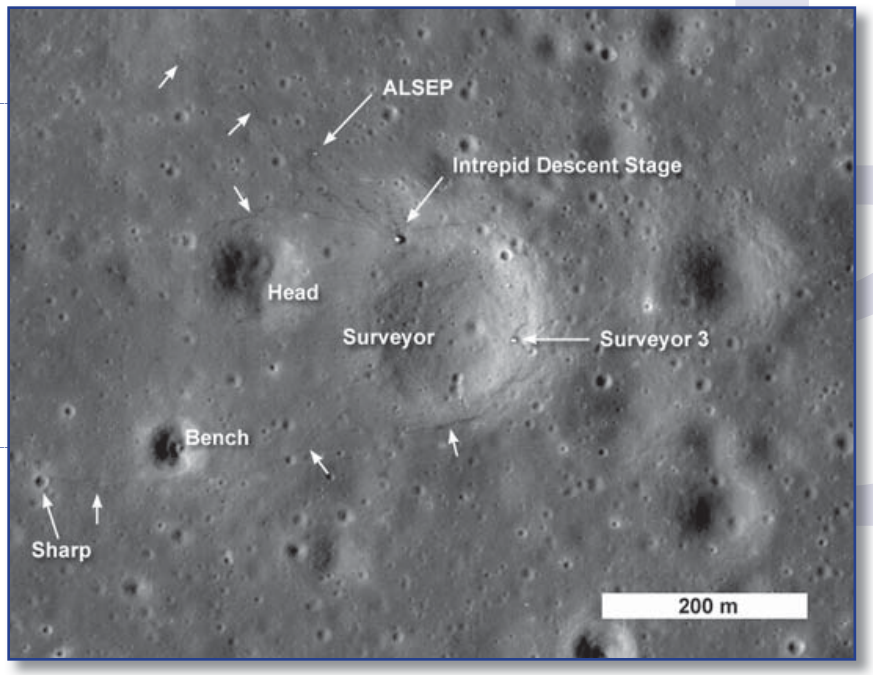
The Aristarchus Plateau contains many geologic wonders, such as the channels seen here, and has long been a prime target for a human return to the Moon.



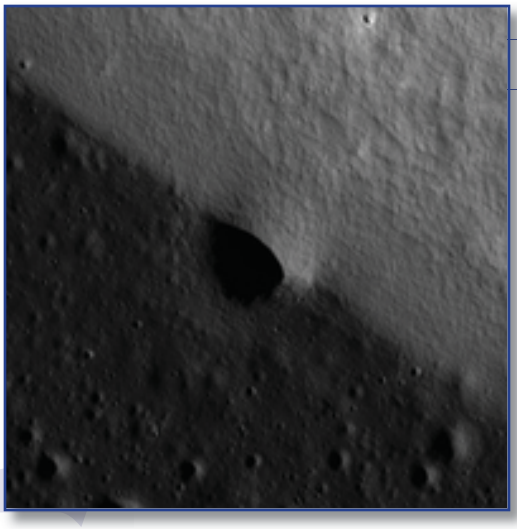
This labeled image shows the Apollo 11 lunar module, Eagle. The width of the image is 282 meters (about 925 feet).



Floor deposits of Necho Crater.



Nearly 40 years after the launch of Apollo 12 in November 1969, LRO captures its first look of the Apollo 12 landing site. The Intrepid lunar module descent stage, experiment package (ALSEP), and Surveyor 3 spacecraft are all visible. Astronaut footpaths are marked with unlabeled arrows, corresponding exactly with the mapped traverses of Pete Conrad and Alan Bean in 1969. This image is 824 meters (about 900 yards) wide.



Highlands boundary near Mare Frigoris.

Fractured floor of Compton, a peak-ring basin.

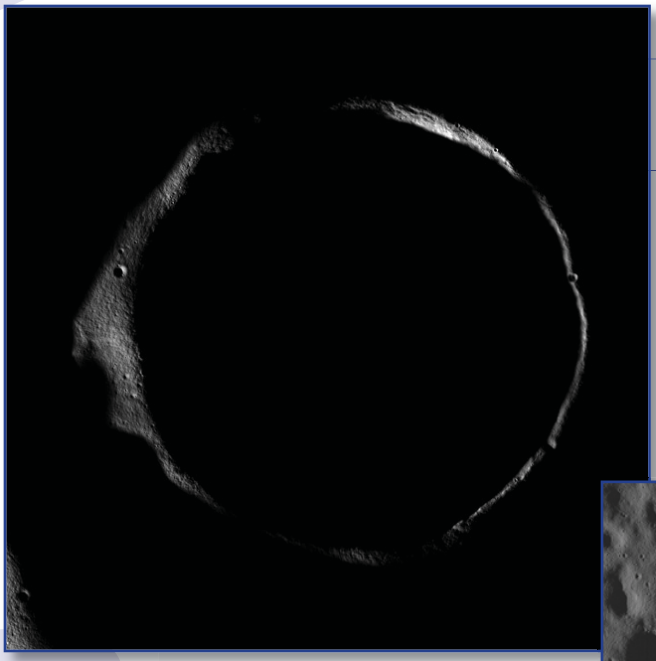
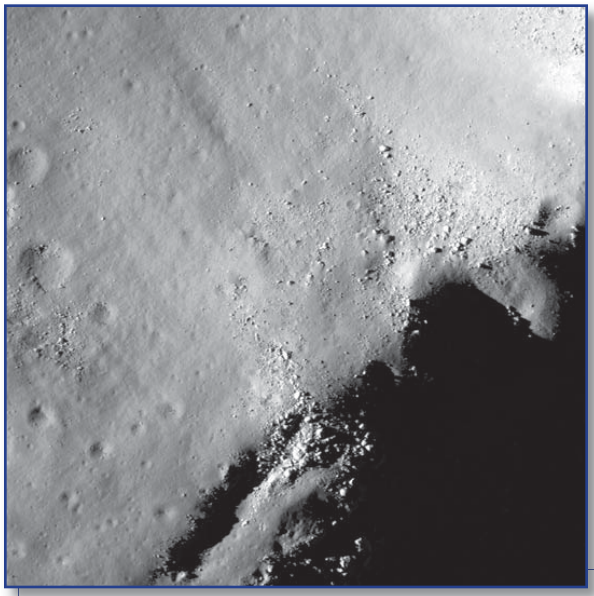


Image of Erlanger, the target crater for LRO's bistatic observations. Mini-SAR images suggest unusual scattering properties of the crater interior compared with its exterior.

A northwest-trending string of secondary craters formed by debris thrown out from a larger impact, most likely Giordano Bruno, 525 kilometers (about 326 miles) to the north. The structure of these craters suggests that the debris hit the surface at a low angle, heading to the south. Smaller pieces at the northwest end churned and scoured the surface while the larger pieces at the southeast end formed round craters. Secondary craters are common on the lunar surface and occur both in chains and as isolated small craters. It is easy to identify secondary craters when they form in chains, but it is much more difficult to distinguish individual secondary craters. Image width is 4.5 kilometers.

The images used for this mosaic were acquired on July 8. On the bottom left is Hahn Crater (approximately 80 kilometers in diameter), with its terraced walls that form as material slumps down the sides and central peak that rebounds from depth during the impact process. A portion of the large impact crater Gauss is in the upper right corner. Its floor appears to have been flooded with lava, which solidified and later fractured. The presence of these irregular cracks may be due to the intrusion of magma, which disrupted the crater floor as it rose and eventually stalled beneath the surface. Scene is approximately 160 kilometers across and in simple cylindrical projection at 155 meters/pixel.

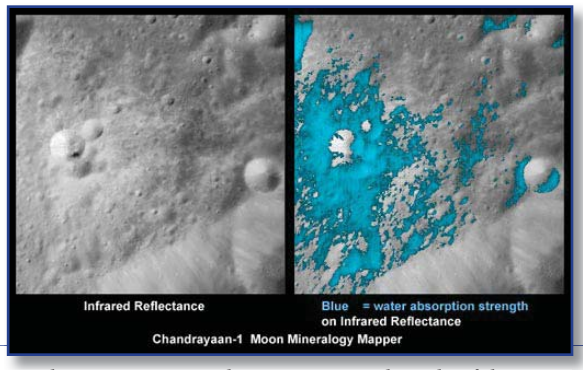
Impact craters feature prominently in this image, taken near the Moon's Mare Nubium region. Older craters have softened edges, while younger craters appear crisp. The image shows a region 1400 meters (0.87 miles) wide, and features as small as 3 meters (9.8 feet) wide can be discerned.



Boulders perched on the summit of the central peak of the 185-kilometer-wide (115 miles) Tsiolkovskiy Crater. This close-up image is about 14.4 kilometers (9 miles) wide.

Image of the Apollo 14 landing site and nearby Cone crater. Apollo 14 Astronauts Alan Shepard and Edgar Mitchell explored the Fra Mauro highlands, which are composed of ejecta from the massive Imbrium impact. During two lunar surface extravehicular activities, Shepard and Mitchell deployed an Apollo Lunar Surface Experiments Package (ALSEP), tested the Modular Equipment Transporter (MET; a small wheeled cart used to transport samples and equipment), and collected almost 90 kilograms of invaluable lunar rock and soil. The ALSEP is visible about 180 meters west of the lunar module; note the well-worn footpath connecting the two artifacts. Image width is 1.6 kilometers.

NASA Instruments Reveal Water Molecules on Lunar Surface



These images show a very young lunar crater on the side of the Moon that faces away from Earth, as viewed by NASA's Moon Mineralogy Mapper on the Indian Space Research Organization's Chandrayaan-1 spacecraft. On the left is an image showing brightness at shorter infrared wavelengths. On the right, the distribution of water-rich minerals (light blue) is shown around a small crater. Both water- and hydroxyl-rich materials were found to be associated with material ejected from the crater. Credit: ISRO/NASA/JPL-Caltech/USGS/Brown University.

NASA scientists have discovered water molecules in the polar regions of the Moon. Instruments onboard three separate spacecraft revealed water molecules in amounts that are greater than predicted, but still relatively small. Hydroxyl, a molecule consisting of one oxygen atom and one hydrogen atom, also was found in the lunar soil. The findings were published in the September 24 edition of the journal *Science*.

NASA's Moon Mineralogy Mapper (M^3) instrument reported the observations. M^3 was carried into space on October 22, 2008, onboard the Indian Space Research Organization's Chandrayaan-1 spacecraft. Data from the Visual and Infrared Mapping Spectrometer (VIMS) on NASA's Cassini spacecraft, and the High-Resolution Infrared Imaging Spectrometer on NASA's Epoxi spacecraft, contributed to confirmation of the finding. The spacecraft imaging spectrometers made it possible to map lunar water more effectively than ever before.

The confirmation of elevated water molecules and hydroxyl at these concentrations in the Moon's polar regions raises new questions about its origin and effect on the mineralogy of the Moon. Answers to these questions will be studied and debated for years to come. "Water ice on the Moon has been something of a holy grail for lunar scientists for a very long time," said Jim Green, director of the Planetary Science Division at NASA Headquarters in Washington. "This surprising finding has come about through the ingenuity, perseverance, and international cooperation between NASA and the India Space Research Organization."

From its perch in lunar orbit, M^3's state-of-the-art spectrometer measured light reflecting off the Moon's surface at infrared wavelengths, splitting the spectral colors of the lunar surface into small enough bits to reveal a new level of detail in surface composition. When the M^3 science team analyzed data from the instrument, they found the wavelengths of light being absorbed were consistent with the absorption patterns for water molecules and hydroxyl.

"For silicate bodies, such features are typically attributed to water and hydroxyl-bearing materials," said Carlé Pieters, M^3's principal investigator from Brown University, Providence. "When we say 'water on the Moon,' we are not talking about lakes, oceans, or even puddles. Water on the Moon means molecules of water and hydroxyl that interact with molecules of rock and dust specifically in the top millimeters of the Moon's surface.

The M^3 team found water molecules and hydroxyl at diverse areas of the sunlit region of the Moon's surface, but the water signature appeared stronger at the Moon's higher latitudes. Water molecules and hydroxyl previously were suspected in data from a Cassini flyby of the Moon in 1999, but the findings were not published until now.

"The data from Cassini's VIMS instrument and M^3 closely agree," said Roger Clark, a U.S. Geological Survey scientist in Denver and member of both the VIMS and M^3 teams. "We see both water and hydroxyl. While the abundances are not precisely known, as much as 1000 water molecule parts-per-million could be in the lunar soil. To put that into perspective, if you harvested one ton of the top layer of the Moon's surface, you could get as much as 32 ounces of water."

For additional confirmation, scientists turned to the Epoxi mission while it was flying past the Moon in June 2009 on its way to a November 2010 encounter with Comet Hartley 2. The spacecraft not only confirmed the VIMS and M^3 findings, but also expanded on them. "With our extended spectral range and views over the north pole, we were able to explore the distribution of both water and hydroxyl as a function of temperature, latitude, composition, and time of day," said Jessica Sunshine of the University of Maryland. Sunshine is Epoxi's deputy principal

investigator and a scientist on the M³ team. "Our analysis unequivocally confirms the presence of these molecules on the Moon's surface and reveals that the entire surface appears to be hydrated during at least some portion of the lunar day."

For additional information and images from the instruments, visit *www.nasa.gov/topics/moonmars*.

Meteorite Found on Mars Yields Clues About Planet's Past

This view of a rock called "Block Island," the largest meteorite yet found on Mars, comes from the panoramic camera (Pancam) on Opportunity. Analysis of Block Island's composition using the rover's alpha-particle X-ray spectrometer confirmed that it is rich in iron and nickel. The rock is about 60 centimeters (2 feet) across. This false-color, red-green-blue composite view was generated from images taken through the Pancam's 750-nanometer, 530-nanometer, and 430-nanometer filters. The exaggerated color is used for enhancing the visibility of differences among the types of rock and soil materials. Credit: NASA/JPL-Caltech/Cornell University.

NASA's Mars Rover Opportunity is investigating a metallic meteorite the size of a large watermelon that is providing researchers more details about the Red Planet's environmental history. The rock, dubbed "Block Island," is larger than any other known meteorite on Mars. Scientists calculate it is too massive to have hit the ground without disintegrating unless Mars had a much thicker atmosphere than it has now when the rock fell. Atmosphere slows the descent of meteorites. Additional studies also may provide clues about how weathering has affected the rock since it fell.

Previously, Opportunity had driven approximately 600 feet past the rock in a Mars region called Meridiani Planum. An image the rover had taken a few days earlier and stored was then transmitted back to Earth. The image showed the rock is approximately 60 centimeters (2 feet) in length, half that in height, and has a bluish tint that distinguishes it from other rocks in the area. The rover team decided to have Opportunity backtrack for a closer look, eventually touching Block Island with its robotic arm.

"There's no question that it is an iron-nickel meteorite," said Ralf Gellert of the University of Guelph in Ontario, Canada. Gellert is the lead scientist for the rover's alpha-particle X-ray spectrometer, an instrument on the arm used for identifying key elements in an object. "We already investigated several spots that showed elemental variations on the surface. This might tell us if and how the metal was altered since it landed on Mars."

The microscopic imager on the arm revealed a distinctive triangular pattern in Block Island's surface texture, matching a pattern common in iron-nickel meteorites found on Earth.

"Normally this pattern is exposed when the meteorite is cut, polished, and etched with acid," said Tim McCoy, a rover team member from the Smithsonian Institution in Washington. "Sometimes it shows up on the surface of meteorites that have been eroded by windblown sand in deserts, and that appears to be what we see with Block Island."

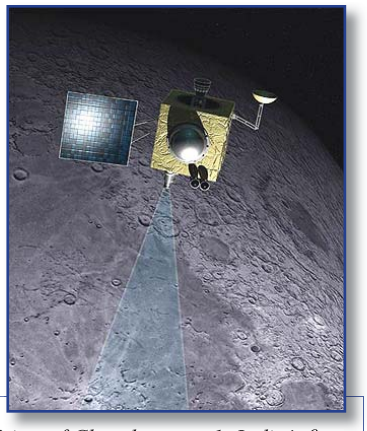
Opportunity found a smaller iron-nickel meteorite, called "Heat Shield Rock," in late 2004. At about a half ton or more, Block Island is roughly 10 times as massive as Heat Shield Rock and several times too big to have landed intact without more braking than today's martian atmosphere could provide.

"Consideration of existing model results indicates a meteorite this size requires a thicker atmosphere," said rover team member Matthew Golombek of NASA's Jet Propulsion Laboratory. "Either Mars has hidden reserves of carbon-dioxide ice that can supply large amounts of carbon-dioxide gas into the atmosphere during warm periods of more recent climate cycles, or Block Island fell billions of years ago."

When the investigation of Block Island concludes, the team plans to resume driving Opportunity on a route from Victoria Crater, which the rover explored for two years, toward the much larger Endeavour Crater. Opportunity has covered about one-fifth of the 12-mile route plotted for safe travel to Endeavour since the rover left Victoria nearly a year ago.

For more information, visit *www.nasa.gov/rovers*.

Chandrayaan-1 Mission Ends Prematurely



Artist's rendition of Chandrayaan-1, India's first unmanned lunar probe. Credit: Indian Space Research Organisation.

Chandrayaan-1 (meaning "Lunar Craft" in Sanskrit), India's first unmanned lunar probe, was launched by the Indian Space Research Organisation (ISRO) on October 22, 2008, successfully inserting into lunar orbit on November 8. The mission, which included a lunar orbiter and an impactor, made over 3000 orbits and its high-resolution cameras relayed over 70,000 digital images of the lunar surface, providing breathtaking views of mountains and craters, including those in the permanently shadowed area of the Moon's polar region.

After suffering from technical issues, including failure of the star sensors and poor thermal shielding, Chandrayaan-1 stopped sending radio signals at 1:30 a.m. IST on August 29, 2009. Shortly thereafter, ISRO officially declared the mission over. But although Chandrayaan-1 only operated for 312 days instead of the intended two years, the mission achieved 95% of its planned scientific objectives.

One of the more perplexing lunar mysteries, whether water in fact exists at the lunar poles, may soon be answered. According to Dr. Carlé Pieters, planetary geologist and principal investigator of NASA's Moon Mineralogy Mapper, one of the instruments onboard the mission, has announced that data obtained by the instrument shows evidence of traces of water on the Moon. Detailed spectra confirm that the polar regions are indeed "chock-full" of water-altered minerals (see related article on page 6).

The results are cause for celebration among lunar scientists who have been contemplating this possibility for several decades. According to a recently released report, they are increasingly confident that the decades-long debate is over, and that the polar regions in fact have water in all sorts of places; not just locked up in minerals, but scattered throughout the broken-up surface, and potentially in blocks or sheets of ice at depth.

For more information, visit *m3.jpl.nasa.gov*.

First Official Phoenix Science Results Point to Martian Climate Cycles

This mosaic of images from the Surface Stereo Imager camera on the Phoenix lander shows several trenches dug by Phoenix, plus a corner of the spacecraft's deck and the martian arctic plain stretching to the horizon. Credit: NASA/JPL-Caltech/University of Arizona/ Texas A&M University.

This approximately true color view combines images taken on several dates during the five months Phoenix studied its surroundings after landing on May 25, 2008.

Favorable chemistry and episodes with thin films of liquid water during ongoing, long-term climate cycles may sometimes make the area where NASA's Phoenix Mars mission landed last year a favorable environment for microbes. Interpretations of data that Phoenix returned during its five months of operation on a martian arctic plain filled four papers in this July 3 edition of the journal *Science*, the first major peer-reviewed reports on the mission's findings. Phoenix ended communications in November 2008 as the approach of martian winter depleted energy from the lander's solar panels.

"Not only did we find water ice, as expected, but the soil chemistry and minerals we observed lead us to believe this site had a wetter and warmer climate in the recent past — the last few million years — and could again in the future," said Phoenix Principal Investigator Peter Smith of the University of Arizona, Tucson. A paper about Phoenix water studies, for which Smith is the lead author with 36 coauthors from six nations, cites clues supporting an interpretation that the soil has had films of liquid water in the recent past. The evidence for water and potential nutrients "implies that this region could have previously met the criteria for habitability" during portions of continuing climate cycles, these authors conclude.

The mission's biggest surprise was nding a multitalented chemical named perchlorate in the martian soil. This Phoenix nding caps a growing emphasis on the planet's chemistry, said Michael Hecht of NASA's Jet Propulsion Laboratory, who has 10 coauthors on a paper about Phoenix's soluble-chemistry ndings. "The study of Mars is in transition from a follow-the-water stage to a follow-the-chemistry stage," Hecht said. "With perchlorate, for example, we see links to atmospheric humidity, soil moisture, a possible energy source for microbes, even a possible resource for humans."

Perchlorate, which strongly attracts water, makes up a few tenths of a percent of the composition in all three soil samples analyzed by Phoenix's wet chemistry laboratory. It could pull humidity from the martian air. At higher concentrations, it might combine with water as a brine that stays liquid at martian surface temperatures. Some microbes on Earth use perchlorate as food. Human explorers might nd it useful as rocket fuel or for generating oxygen.

Another surprise from Phoenix was nding ice clouds and precipitation more Earth-like than anticipated. The lander's Canadian laser instrument for studying the atmosphere detected snow falling from clouds. In one of the reports, Jim Whiteway of York University, Toronto, and 22 coauthors say that, further into winter than Phoenix operated, this precipitation would result in a seasonal buildup of water ice on and in the ground. "Before Phoenix we did not know whether precipitation occurs on Mars," Whiteway said. "We knew that the polar ice cap advances as far south as the Phoenix site in winter, but we did not know how the water vapor moved from the atmosphere to ice on the ground. Now we know that it does snow, and that this is part of the hydrological cycle on Mars."

Evidence that water ice in the area sometimes thaws enough to moisten the soil comes from nding calcium carbonate in soil heated in the lander's analytic ovens or mixed with acid in the wet chemistry laboratory. The University of Arizona's William Boynton and 13 coauthors report that the amount of calcium carbonate "is most consistent with formation in the past by the interaction of atmospheric carbon dioxide with liquid lms of water on particle surfaces."

The new reports leave unsettled whether soil samples scooped up by Phoenix contained any carbon-based organic compounds. The perchlorate could have broken down simple organic compounds during heating of soil samples in the ovens, preventing clear detection. The heating in ovens did not drive off any water vapor at temperatures lower than 295°C (563°F), indicating the soil held no water adhering to soil particles. Climate cycles resulting from changes in the tilt and orbit of Mars on scales of hundreds of thousands of years or more could explain why effects of moist soil are present.

Information and images from the mission are available online at *phoenix.lpl.arizona.edu* and *www.nasa.gov/phoenix.*

Mercury Encounter Presents New Opportunities for Magnetometer

On September 29, the MESSENGER spacecraft passed by Mercury for the third time, ying 141.7 miles above the planet's rocky surface for a nal gravity assist that will enable it to enter orbit about Mercury in 2011. This encounter also provided new observational opportunities for MESSENGER's Magnetometer, designed to determine the structure and origin of Mercury's intrinsic magnetic eld.

Artist's impression of the MESSENGER spacecraft as it leaves Earth, following its August 3, 2004, launch from Cape Canaveral. The spacecraft will fly past Earth once, Venus twice, and Mercury three times before starting a yearlong orbital study of the innermost planet in March 2011. Credit: NASA/Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washington.

The comparison of magnetosphere observations from MESSENGER's rst yby in January 2008 with data from the probe's second pass in October 2008 provided key new insight into the nature of the planet's internal magnetic eld and revealed new features of Mercury's magnetosphere, explains Brian Anderson, of the Johns Hopkins University Applied Physics Laboratory (APL) in Laurel, Maryland, MESSENGER's Deputy Project Scientist.

"The previous ybys yielded signi cant insight into the dynamics of Mercury's magnetosphere and its boundaries,"

Anderson says. "During the second flyby a plasmoid and a series of traveling compression regions were observed in Mercury's magnetotail, and a large flux transfer event was observed at the dayside magnetopause. These observations proved that the solar wind interaction, under the right circumstances, can drive intense magnetic reconnection at rates 10 times the rates observed at Earth."

The behavior during the second flyby was markedly different from that found in the first flyby, demonstrating the profound influence of the solar wind environment on Mercury's magnetosphere. "The third flyby is the last opportunity to survey the magnetotail and magnetopause regions in the equatorial plane, and the contrast in the system's structure under different solar wind conditions already observed make it likely that the third flyby will yield new insights and perhaps more surprises for the dynamics of this smallest and most highly variable of the solar system's planetary magnetospheres," Anderson says.

For more information, visit *messenger.jhuapl.edu* or *www.nasa.gov/messenger*.

Saturnian Moon Shows Evidence of Ammonia

Data collected during two close flybys of Saturn's moon Enceladus by NASA's Cassini spacecraft add more fuel to the fire about the saturnian ice world containing subsurface liquid water. The data collected by Cassini's Ion and Neutral Mass Spectrometer during Enceladus flybys in July and October 2008 were released in the July 23 issue of the journal *Nature*.

Saturn's moon Enceladus, as seen by the Cassini spacecraft. Credit: NASA/JPL/Space Science Institute.

"When Cassini flew through the plume erupting from Enceladus on October 8 of last year, our spectrometer was able to sniff out many complex chemicals, including organic ones, in the vapor and icy particles," said Hunter Waite, the Cassini Ion and Neutral Mass Spectrometer Lead Scientist from the Southwest Research Institute in San Antonio, Texas. "One of the chemicals definitively identified was ammonia." On Earth, the presence of ammonia means the potential for sparkling clean floors and countertops. In space, the presence of ammonia provides strong evidence for the existence of at least some liquid water.

How could ammonia equate to liquid water inside an ice-covered moon in one of the chillier neighborhoods of our solar system? As many a homeowner interested in keeping their abodes spick and span know, ammonia promptly dissolves in water. But what many people do not realize is that ammonia acts as antifreeze, keeping water liquid at lower temperatures than would otherwise be possible. With the presence of ammonia, water can exist in a liquid state to temperatures as low as 176 degrees Kelvin (–143°F). "Given that temperatures in excess of 180 Kelvin (–136°F) have been measured near the fractures on Enceladus where the jets emanate, we think we have an excellent argument for a liquid water interior," said Waite.

"Ammonia is sort of a holy grail for icy volcanism," said William McKinnon, a scientist from Washington University in St. Louis, Missouri. "This is the first time we've found it for sure on an icy satellite of a giant planet. It is probably everywhere in the Saturn system."

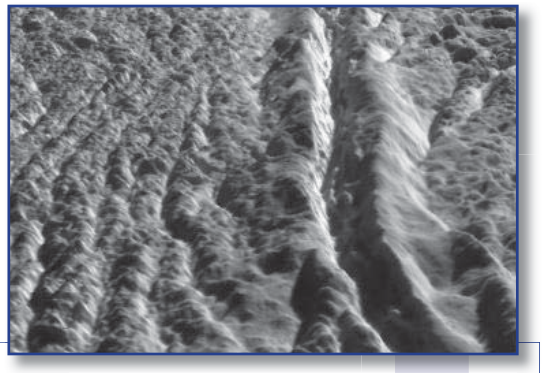
Just how much water is contained within Enceladus' icy interior is still up for debate. So far, Cassini has made five flybys of Enceladus, one of the chief targets for Cassini's extended mission. Two close flybys are scheduled for November of this year, and two more close flybys are scheduled for April and May or 2010. Data collected during these future flybys may help settle the debate.

"Where liquid water and organics exist, is there life?" asked Jonathan Lunine, a Cassini scientist from the University of Arizona, Tucson. "Such is the case for Earth; what was found on Enceladus bolsters this moon's promise for containing potential habitable environments."

More information about the Cassini mission is available at *www.nasa.gov/cassini* or *saturn.jpl.nasa.gov*.

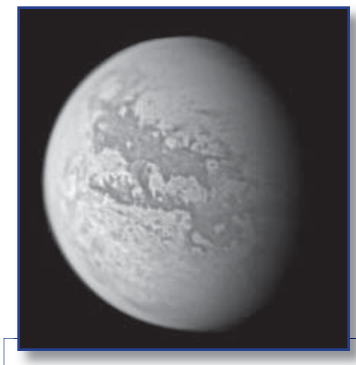
High-Resolution Topographic Map of Enceladus Released

With Cassini's extended mission comes added focus on Saturn's tiny but active icy moon Enceladus. Cassini had three very close passes of Enceladus in 2008, and acquired high-resolution images of the south polar vents powering the moon's icy plume. Now Dr. Paul Schenk, staff scientist at the Lunar and Planetary Institute in Houston, has used some of those images to create the first high-resolution topographic map of the region. The new map, at 35-meter resolution, shows the tiger stripes in rich detail. One of these narrow tectonic features is revealed in the data to be a double ridge 5 kilometers wide and 200 meters high. The plumes originate from a medial trough down the center, which is at least 250 meters deep. These new data provide a unique perspective on these geologically active sites. New perspective views of these features have been released to the NASA Planetary Photojournal (*photojournal.jpl.nasa.gov/index.html*) and on Schenk's blog (*stereomoons.blogspot.com*).



This perspective view of Damascus Sulcus was generated using high-resolution images of Enceladus acquired in August 2008. Damascus Sulcus is one of several prominent linear structures, dubbed "tiger stripes," within the geologically active south polar region of Enceladus. Credit: NASA/JPL/Paul Schenk, Lunar and Planetary Institute.

Saturn Moon Could Power 150 Billion Labor Day Barbecues



Titan as seen during Cassini's March 31, 2005, flyby. Credit: NASA/JPL/Space Science Institute.

Since its discovery by Dutch astronomer Christiaan Huygens in 1655, Saturn's most massive moon, Titan, has been known as a place of mystery and intrigue. The large, cloud-enshrouded moon is such a scientific enigma that for the past five years, it has been targeted by NASA's Cassini spacecraft with more than 60 probing flybys. One of its latest findings could be a valuable asset to future generations of space explorers hunting for materials to whip up a Labor Day barbecue. "Titan's atmosphere is extremely rich in an assortment of hydrocarbon chemicals, including propane, which we use to fill our barbecue tanks," said Cassini scientist Conor Nixon of the University of Maryland, College Park. "Titan's atmospheric inventory would fuel about 150 billion barbecue cookouts, enough for several thousand years of Labor Days."

For those who are burger, barbecue, or Titan challenged, propane is a three-carbon alkane (a chemical compound consisting of carbon and hydrogen) that is nontoxic and heavier than air. With its low boiling point of –43.6°F (–42°C), propane vaporizes as soon as it is released from its pressurized container. Here on Earth, propane is commonly used as a fuel for forklifts, flamethrowers, residential central heating, portable stoves, hot air balloons, and — of course — barbecues. On other worlds propane is an untapped resource. This gas of many terrestrial uses was first discovered in Titan's atmosphere back in 1980 when NASA's Voyager 1 spacecraft flew past the saturnian system. Over the years, both ground- and space-based instruments have added to the research, but accurately quantifying the amount of propane on Titan has proved elusive. Then, in 2004, the Cassini spacecraft entered orbit around Saturn.

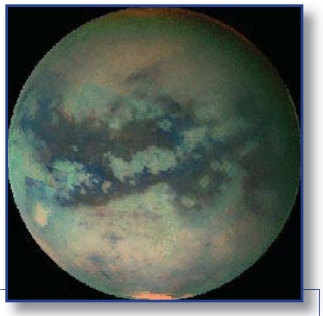
Measuring the amount of propane on Titan is important to scientists because the gas is a very complex molecule, and its signature in the infrared spectrum is close to those of several molecules scientists are hoping to discover in Titan's atmosphere. "It was not so much that measuring propane was our endgame, but it helps enormously in our hunt for other complex molecules," said Nixon. "These include pyrimidines that are potential building blocks for biological molecules, such as the nuceleobases of our DNA." If we can detect them on Titan, that would be very significant."

Propane on Titan was measured using data from Cassini's Composite Infrared Spectrometer instrument. During multiple flybys of the moon between June 2004 and June 2008, the instrument measured infrared light from the edge of Titan's atmosphere. After a detailed analysis of the gas's characteristic "emission bands" or signature, using computer predictions backed by the latest laboratory research into its infrared spectrum, the Composite

Infrared Spectrometer team came up with an estimate of the amount of propane in Titan's atmosphere. So exactly how much propane does it take to fire 150 billion cookouts?

"We estimate there are nearly 700 million barrels of propane on Titan, said Nixon. "That is enough to fill six-billion 20-pound tanks of liquefied propane gas. It sounds like a huge amount, but that would satisfy total U.S. consumption of propane for only 18 months." Which still leaves, with regards to Saturn's biggest moon, one Labor Day staple still to be determined. How many hamburgers could future generations of outer-planet explorers grill using Titan's atmospheric propane? "A dozen at a time, that's two trillion hamburgers," said Cassini's Nixon, "assuming you stop at medium-well."

Tropics of Saturn's Moon No Tropical Paradise On Some Days



This image of Titan shows data taken with Cassini's visual and infrared mapping spectrometer during the last three flybys of Titan.

Astronomers have identified a storm cell on Titan the size of the country of India. The storm system appeared in April 2008 in the moon's tropical region, an area not known for its cloudiness. Using the Gemini North Telescope and NASA Infrared Telescope Facility on Hawaii's Mauna Kea volcano, a team of astronomers from the University of Hawaii, the Lowell Observatory, and the California Institute of Technology found a significant mass of methane clouds in a cold desert area where no clouds were expected. Large cloud outbursts such as these are thought to be associated with significant amounts of precipitation and probably play a major part in shaping the geological features on the surface of Titan. The paper, "Storms in the tropics of Titan," appeared in the August 13 issue of *Nature*.

This Hubble picture, taken by the new Wide Field Camera 3, is the sharpest visible-light picture taken of the atmospheric debris from a comet or asteroid that collided with Jupiter on July 19. This is Hubble's first science observation following its repair and upgrade in May. The size of the impactor is estimated to be as large as several football fields. Credit: NASA, ESA, H. Hammel (Space Science Institute, Boulder), and the Jupiter Impact Team.

Hubble Space Telescope Captures Rare Jupiter Collision

NASA's Hubble Space Telescope has taken the sharpest visible-light picture yet of atmospheric debris from an object that collided with Jupiter on July 19. NASA scientists decided to interrupt the recently refurbished observatory's checkout and calibration to take the image of a new, expanding spot on the giant planet on July 23.

Discovered by Australian amateur astronomer Anthony Wesley, the spot was created when a small comet or asteroid plunged into Jupiter's atmosphere and disintegrated. The only other time such a feature has been seen on Jupiter was 15 years ago after the collision of fragments from Comet Shoemaker-Levy 9. "Because we believe this magnitude of impact is rare, we are very fortunate to see it with Hubble," said Amy Simon-Miller of NASA's Goddard Space Flight Center. "Details seen in the Hubble view shows a lumpiness to the debris plume caused by turbulence in Jupiter's atmosphere." The new Hubble images also confirm that a May servicing visit by space shuttle astronauts was a big success.

For the past several days, Earth-based telescopes have been trained on Jupiter. To capture the unfolding drama 360 million miles away, Matt Mountain, director of the Space Telescope Science Institute in Baltimore, gave observation time to a team of astronomers led by Heidi Hammel of the Space Science Institute in Boulder, Colorado. "Hubble's truly exquisite imaging capability has revealed an astonishing wealth of detail in the impact site," Hammel said. "By combining these images with our groundbased data at other wavelengths, our Hubble data will allow a comprehensive understanding of exactly what is happening to the impact debris."

Simon-Miller estimated the diameter of the impacting object was the size of several football fields. The force of the explosion on Jupiter was thousands of times more powerful than the suspected comet or asteroid that exploded over the Siberian Tunguska River Valley in June 1908.

For more information, visit *www.nasa.gov/hubble* and *hubblesite.org*.

NASA to Provide Web Updates on Objects Approaching Earth

NASA's Jet Propulsion Laboratory is introducing a new website that will provide a centralized resource for information on near-Earth objects — those asteroids and comets that can approach Earth. The "Asteroid Watch" site also contains links for interested public to sign up for NASA's new asteroid widget and Twitter account.

"Most people have a fascination with near-Earth objects," said Don Yeomans, manager of NASA's Near-Earth Object Program Office at JPL. "And I have to agree with them. I have studied them for over three decades and I find them to be scientifically fascinating, and a few are potentially hazardous to Earth. The goal of our website is to provide the public with the most up-to-date and accurate information on these intriguing objects."

The new Asteroid Watch site is online at *www.jpl.nasa.gov/asteroidwatch*. It provides information on NASA's missions to study comets, asteroids, and near-Earth objects, and also provides the basic facts and the very latest in science and research on these objects. News about near-Earth object discoveries and Earth flybys will be available and made accessible on the site via a downloadable widget and RSS feed. And for those who want to learn about their space rocks on the go, a Twitter feed is offered. "Asteroid Watch" also contains a link to JPL's more technical Near-Earth Objects website, where many scientists and researchers studying near-Earth objects go for information.

This artist's concept shows a celestial body about the size of our Moon slamming at great speed into a body the size of Mercury. NASA's Spitzer Space Telescope found evidence that a high-speed collision of this sort occurred a few thousand years ago around a young star, called HD 172555, still in the early stages of planet formation. The star is about 100 light-years from Earth. Credit: NASA/JPL-Caltech.

Planet Smash-Up Sends Vaporized Rock, Hot Lava Flying

NASA's Spitzer Space Telescope has found evidence of a high-speed collision between two burgeoning planets around a young star. Astronomers say that two rocky bodies, one as least as big as our Moon and the other at least as big as Mercury, slammed into each other within the last few thousand years or so — not long ago by cosmic standards. The impact destroyed the smaller body, vaporizing huge amounts of rock and flinging massive plumes of hot lava into space. An artist's animation of the event is available at *www.nasa.gov/mission_pages/spitzer/multimedia/spitzer-20090810.html*.

Spitzer's infrared detectors were able to pick up the signatures of the vaporized rock, along with pieces of refrozen lava, called tektites. "This collision had to be huge and incredibly high-speed for rock to have been vaporized and melted," said Carey M. Lisse of the Johns Hopkins University Applied Physics Laboratory, lead author of a new paper describing the findings in the August 20 issue of the *Astrophysical Journal*. "This is a really rare and short-lived event, critical in the formation of Earth-like planets and moons. We're lucky to have witnessed one not long after it happened."

Lisse and his colleagues say the cosmic crash is similar to the one that formed our Moon more than 4 billion years ago, when a body the size of Mars rammed into Earth. "The collision that formed our Moon would have been tremendous, enough to melt the surface of Earth," said co-author Geoff Bryden of NASA's Jet Propulsion Laboratory. "Debris from the collision most likely settled into a disk around Earth that eventually coalesced to make the Moon. This is about the same scale of impact we're seeing with Spitzer — we don't know if a Moon will form or not, but we know a large rocky body's surface was red hot, warped, and melted."

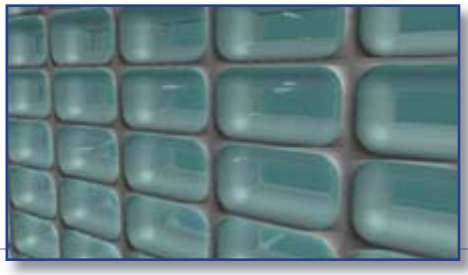
Our solar system's early history is rich with similar tales of destruction. Giant impacts are thought to have stripped Mercury of its outer crust, tipped Uranus on its side, and spun Venus backward, to name a few examples. Such violence is a routine aspect of planet building. Rocky planets form and grow in size by colliding and sticking together, merging their cores and shedding some of their surfaces. Though things have settled down in our solar system today, impacts still occur, as was observed last month after a small space object crashed into Jupiter.

Lisse and his team observed a star called HD 172555, which is about 12 million years old and located about 100 light-years away in the far southern constellation Pavo, or the Peacock (for comparison, our solar system is 4.5 billion years old). The astronomers used an instrument on Spitzer, called a spectrograph, to break apart the star's light and look for fingerprints of chemicals, in what is called a spectrum. What they found was very strange. "I had never seen anything like this before," said Lisse. "The spectrum was very unusual."

After careful analysis, the researchers identified lots of amorphous silica, or essentially melted glass. Silica can be found on Earth in obsidian rocks and tektites. Obsidian is black, shiny volcanic glass. Tektites are hardened chunks of lava that are thought to form when meteorites hit Earth. Large quantities of orbiting silicon monoxide gas were also detected, created when much of the rock was vaporized. In addition, the astronomers found rocky rubble that was probably flung out from the planetary wreck.

For more information about Spitzer, visit *www.spitzer.caltech.edu/spitzer* and *www.spitzer.caltech.edu/spitzer*. More information about NASA's planet-finding program is at *planetquest.jpl.nasa.gov*.

NASA Researchers Make First Discovery of Life's Building Block in Comet



This is an artist's concept of particle hits on the aerogel collection grid. The greenish areas represent the aerogel. Hits are the light green teardrop-shaped areas. Particles are represented by dots at the tips of the teardrops. Credit: NASA/JPL.

NASA scientists have discovered glycine, a fundamental building block of life, in samples of Comet Wild 2 returned by NASA's Stardust spacecraft. "Glycine is an amino acid used by living organisms to make proteins, and this is the first time an amino acid has been found in a comet," said Jamie Elsila of NASA's Goddard Space Flight Center. "Our discovery supports the theory that some of life's ingredients formed in space and were delivered to Earth long ago by meteorite and comet impacts." Elsila is the lead author of a paper on this research accepted for publication in the journal *Meteoritics and Planetary Science.* The research was presented on August 16 during the meeting of the American Chemical Society in Washington, DC.

Proteins are the workhorse molecules of life, used in everything from structures like hair to enzymes, the catalysts that speed up or regulate chemical reactions. Just as the 26 letters of the alphabet are arranged in limitless combinations to make words, life uses 20 different amino acids in a huge variety of arrangements to build millions of different proteins.

Stardust passed through dense gas and dust surrounding the icy nucleus of Wild 2 on January 2, 2004. As the spacecraft flew through this material, a special collection grid filled with aerogel — a novel sponge-like material that's more than 99% empty space — gently captured samples of the comet's gas and dust. The grid was stowed in a capsule that detached from the spacecraft and parachuted to Earth on January 15, 2006. Since then, scientists around the world have been busy analyzing the samples to learn the secrets of comet formation and our solar system's history. "We actually analyzed aluminum foil from the sides of tiny chambers that hold the aerogel in the collection grid," said Elsila. "As gas molecules passed through the aerogel, some stuck to the foil. We spent two years testing and developing our equipment to make it accurate and sensitive enough to analyze such incredibly tiny samples."

Earlier, preliminary analysis in the Goddard labs detected glycine in both the foil and a sample of the aerogel. However, since glycine is used by terrestrial life, at first the team was unable to rule out contamination from sources on Earth. "It was possible that the glycine we found originated from handling or manufacture of the Stardust spacecraft itself," said Elsila. The new research used isotopic analysis of the foil to rule out that possibility.

Isotopes are versions of an element with different weights or masses; for example, the most common carbon atom, Carbon 12, has six protons and six neutrons in its center (nucleus). However, the Carbon 13 isotope is heavier because it has an extra neutron in its nucleus. A glycine molecule from space will tend to have more of the heavier Carbon 13 atoms in it than glycine that's from Earth. That is what the team found. "We discovered that the Stardust-returned glycine has an extraterrestrial carbon isotope signature, indicating that it originated on the comet," said Elsila.

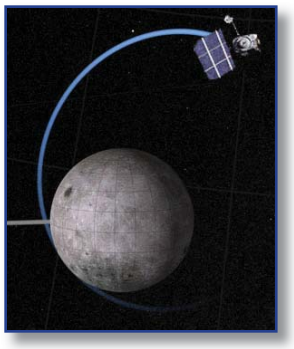
For more information, visit *www.nasa.gov/stardust*.

"Spotlight on Education" highlights events and programs that provide opportunities for planetary scientists to become involved in education and public outreach and to engage science educators and the community. If you know of space science educational programs or events that should be included, please contact the Lunar and Planetary Institute's Education Department at shupla@lpi.usra.edu.

New MyMoon Website Engages Public —

The Lunar and Planetary Institute's expanding lunar education portal, MyMoon, leverages our new scientific exploration of the Moon and innovative social networking opportunities to engage a fresh audience in lunar science and exploration — the Net Generation. LPI is collaborating with lunar scientists, educators, artists — and the public — to populate the site with science content, diverse media exhibits, events, and opportunities for involvement. Through **MyMoon**, the public can interact with lunar content that will inform them about NASA's lunar science research and missions, and engage them in future plans for lunar exploration and eventual habitation. Visitors can share their thoughts, creations, and experiences as they participate in online and web-conferenced discussions; submit video, art, and stories for a variety of competitions; vote on favorites; attend online events; and more. For more information, visit *mymoon.lpi.usra.edu*.

Launch a Lunar Event —



On June 18, 2009, NASA successfully launched the Lunar Reconnaissance Orbiter (LRO, *lunar.gsfc.nasa.gov*) and the Lunar Crater Observation and Sensing Satellite (LCROSS, *lcross.arc.nasa.gov*) on their way to the Moon. Scientists and education specialists have an opportunity to engage the public in an impact viewing event on October 9 at 7:30 a.m. U.S. Eastern Standard Time, as LCROSS impacts the Moon and sends a plume of material into space. Museums, science centers, planetaria, and astronomy clubs will be hosting early morning viewing events, lectures, presentations, and more. Contact your local organizations to see how you can be involved.

Education Sessions at 2009 Fall AGU —

The Fall American Geophysical Union (AGU) meeting in San Francisco, December 14–18, 2009, includes many education sessions; educators and scientists alike are welcome to attend! Some of these sessions are particularly geared toward planetary science:

- Bringing Back the Moon: Using Lunar Education Resources to Enhance K–12 STEM Education
- Connecting Science and Literacy in the Classroom: Using Space and Earth Science to Support Language Arts
- Developing Sustainable Education and Outreach Programs and Projects: Lessons Learned
- Simulations, Animations, and Interactive Multimedia for Planetary Sciences Teaching and Learning
- International Year of Astronomy 2009: Impacts in Education and Public Outreach and Plans Beyond

Working with Local Astronomy Clubs —

Planning an evening outreach event? Interested in giving a public talk about your latest research? Local amateur astronomy clubs are an excellent resource for planetary scientists and education communities. Many of them are happy to help bring telescopes to public observing sessions, and they also appreciate skilled speakers in planetary science topics. You can find a list of amateur astronomy clubs online at *www.skyandtelescope.com/community/organizations*.

Outer Planets Colloquium Series —

The Outer Planets Colloquium Series is a collaboratively planned program of visits by planetary scientists to university campuses and research institutions, and is designed to raise awareness of current research in outer solar system science. Presenters are scheduled to give a research colloquium or seminar presentation primarily for the professional, academic science community. They are strongly encouraged to address the needs of the next generation of scientists (graduate students, interns, and undergraduates). They are also encouraged to give an additional, more general presentation that is free and open to the public. More information and applications are available online at *outerplanets.jpl.nasa.gov/index.htm*.

Communicating Science —

This summer, the National Academies hosted the 2009 Communications Fair, featuring speakers and invited guests to address the issue of science communication in today's world. Topics included communicating science to diverse audiences, information and misinformation, and education through entertainment. Podcasts of the sessions are available online at *www.nap.edu/commfair.html?utm_medium=etmail&utm_source=National%20Academies%20Press&utm_campaign=Nap+mail+cb+08.27.09&utm_content=Downloader&utm_term=*.

An Afterschool Space Science Program —

Afterschool Universe is an out-of-school-time astronomy program targeted at middle-school students. It explores astronomy concepts through engaging hands-on activities and takes participants on a journey through the universe beyond the solar system. This program is now widely available to afterschool program providers to run in their local communities. For more information, go to *universe.nasa.gov/au/home.html*.

Kring Named as Fellow of the Geological Society of America

Dr. David A. Kring, Senior Staff Scientist at the Lunar and Planetary Institute, has been named as a Fellow of the Geological Society of America (GSA). Kring received his Ph.D. in Earth and planetary sciences from Harvard University. He specializes in impact cratering processes produced when asteroids and comets collide with planetary surfaces. Kring is perhaps best known for his work with the discovery of the Chicxulub impact crater, which he linked to the K-T boundary mass extinction of dinosaurs and over half of the plants and animals that existed on Earth 65 million years ago. He has also studied the environmental effects of impact cratering and shown how impact processes can affect both the geological *and* biological evolution of a planet. This work includes studies of the dramatic environmental perturbations (e.g., prolonged darkness, acid rain, wildfires) expected after the Chicxulub impact event, plus studies of several smaller local, regional, and global effects produced by the thousands of impact events that affected Earth after life evolved.

Kring has also explored how impact cratering may have affected the early evolution of the Earth-Moon system. In particular, he has led a decade-long campaign to test the lunar cataclysm hypothesis, which is one of the great intellectual legacies of the Apollo program. Indeed, the bombardment of the Earth-Moon system remains the highest science priority for our nation's return to the Moon. Kring has suggested that an intense period of impact bombardment may have affected the origin and early evolution of life on Earth. In particular, he suggested that early impact bombardment created vast subsurface hydrothermal systems that were crucibles for prebiotic chemistry and provided habitats for the early evolution of life. He calls this concept the impact-origin of life hypothesis.

GSA Fellowship is an honor that is bestowed on the best of geoscience professionals once per year at the GSA Spring Council meeting. GSA members are elected to Fellowship in recognition of distinguished contributions to the geosciences, and nominations may only be made by a Fellow of the Society. The newly elected Fellows will be recognized at the 2009 GSA Annual Meeting Presidential Address and Awards Ceremony on Saturday, October 17, at the Oregon Convention Center in Portland. A complete list of the newly elected Fellows can be found online at *www.geosociety.org/members/newFellows.htm*.

The following 2009 medal and award recipients, among others, will also be honored at the ceremony:

- GSA Public Service Award: *Bruce F. Molnia, U.S. Geological Survey–Reston*
- GSA Distinguished Service Award: *Karl E. Karlstrom, University of New Mexico*
- Subaru Outstanding Woman in Science Award: *Jaime D. Barnes, University of New Mexico*
- Penrose Medal: *B. Clark Burchfiel, Massachusetts Institute of Technology*
- Arthur L. Day Medal: *T. Mark Harrison, University of California at Los Angeles*
- Young Scientist Award (Donath Medal): *Cin-Ty A. Lee (Rice University)*

Barringer Family Fund for Meteorite Impact Research Announces 2009 Award Winners

The Barringer Crater Company has announced the names of the 2009 winners of grants Barringer Family Fund for Meteorite Impact Research. The Fund, designed to support field work by eligible students interested in the study of impact cratering processes, provides a small number of competitive grants each year for support of field research at known or suspected impact sites worldwide. Administration for the awards is provided by the Lunar and Planetary Institute in Houston.

The 2009 Awardees are Matthew Izawa (University of Western Ontario, Canada), Randy Kofman (University of Alberta, Canada), and Haley Sapers, University of Western Ontario, Canada.

The Barringer Family Fund for Meteorite Impact Research has been established as a memorial to recognize the contributions of Brandon, Moreau, Paul, and Richard Barringer to the field of meteoritics and the Barringer family's strong interest and support over many years in research and student education. In addition to its memorial nature, the Fund also reflects the family's long-standing commitment to responsible stewardship of The Barringer Meteorite Crater and the family's steadfast resolve in maintaining the crater as a unique scientific research and education site.

For more information, visit *www.lpi.usra.edu/science/kring/Awards/Barringer_Fund/*.

Meteoritical Society Announces 2010 Award Winners

The Meteoritical Society Council has announced the selection of the following award winners for 2010.

The Leonard Medal is for outstanding, original contributions to the science of meteoritics. Hiroshi Takeda has been selected for outstanding contributions to the study of meteorites, especially regarding the understanding of HED achondrites and the lunar crust.

The Barringer Medal and Award is for outstanding work in the field of impact cratering, and/or work that has led to a better understanding of impact phenomena. William K. Hartmann has been selected for his fundamental contributions to impact crater studies, including development and refinement of crater isochrons, discovery of Mare Orientale, and his seminal work on the origin of the Moon. He also has enlightened the general public about planetary science through his numerous books and artwork.

The Service Award is for advancing the Society's goals to promote research and education in meteoritics and planetary science. Joel Schiff is recognized for founding the quarterly publication, METEORITE, in 1995. The magazine serves as a forum for communication between amateurs, collectors, dealers, educators, and researchers interested in meteorites.

The Nier Prize is for a significant research contribution in the field of meteoritics and closely allied fields by a young scientist under the age of 35. Daniel Glavin is recognized for important contributions in the field of organic cosmochemistry, including organic compounds in martian meteorites, micrometeorites, and cometary samples from Stardust.

The Council also announced the selection of these other award winners:

The Pellas-Ryder Award is for best planetary science paper written by a student. The award is cosponsored by the Meteoritical Society and the Geological Society of America Planetary Geology Division. For best paper written in 2008, the award goes to Bethany Ehlmann of Brown University for her paper in Science, "Orbital identification of carbonate-bearing rocks on Mars."

The Brian Mason Award is for best abstract submitted by a student to the Meteoritical Society's Annual Meeting. The award is sponsored by the International Meteorite Collectors Association and Meteorite Magazine. The Program Committee for the 2009 meeting selected Gregory Brennecka for this award, for his abstract on $^{238}U/^{235}U$ variations in meteoritic materials.

For more information, visit *www.meteoriticalsociety.org*.

NASA Announces Latest Ambassadors of Exploration

In a ceremony held during the Apollo 40th anniversary celebration on July 20 at the National Air and Space Museum in Washington, DC, NASA posthumously honored President John F. Kennedy with the Ambassador of Exploration Award. The award was accepted by Kennedy's niece, Kathleen Kennedy Townsend, and at the request of the family will be on permanent display at Rice University in Houston, Texas.

NASA created the Ambassador of Exploration Award to recognize the first generation of explorers in the Mercury, Gemini, and Apollo space programs for realizing America's goal of going to the Moon. The award

is a Moon rock encased in Lucite, mounted for public display. The rock is part of the 842 pounds of lunar samples collected during six Apollo expeditions from 1969 to 1972. The awards remain the property of NASA, but awardees or their surviving families, in coordination with the agency, select a museum or other educational institution where their awards will be publicly displayed in their name to help inspire a new generation of explorers.

NASA Administrator Charles Bolden, Rice University student Max Paul, former Maryland Lt. Governor and niece of President John F. Kennedy, Kathleen Kennedy Townsend, and Apollo 11 astronauts Neil Armstrong, Buzz Aldrin, and Michael Collins pose in front of the Ambassador of Exploration Award given posthumously to President Kennedy.

Besides Kennedy, the only other nonastronaut to be given the award was famed CBS journalist Walter Cronkite. Millions of Americans experienced the drama and excitement of NASA's early years through the knowledgeable reports of Cronkite, who considered the space race as one of the most important events of the 20th century. During the Apollo 11 mission, Cronkite was on the air for 27 of the 30 hours it took for the Apollo 11 astronauts to complete their mission on the lunar surface.

Apollo 15 astronaut Al Worden was also presented with the award at a ceremony on July 30. The ceremony was held at the Apollo Saturn V Center at NASA's Kennedy Space Center Visitor Complex in Florida, where the Moon rock will remain on display. Worden served as command module pilot for the Apollo 15 mission, which set several Moon records for NASA, including the longest lunar surface stay time, the longest lunar extravehicular activity, and the first use of a lunar roving vehicle. Worden spent 38 minutes in a spacewalk outside the command module and logged a total of 295 hours, 11 minutes in space during the mission.

NASA Television Receives Philo T. Farnsworth Primetime Emmy Award

NASA Television has been honored with a Primetime Emmy Award by the Academy of Television Arts & Sciences. The 2009 Philo T. Farnsworth Award recognizes the agency for engineering excellence and commemorates the 40th anniversary of the technological innovations that made possible the first live TV broadcast from the Moon by the Apollo 11 crew on July 20, 1969.

The prestigious Emmy Award, named after the man credited with designing and building the world's first working television system, honors an agency, company, or institution with contributions over a long period of time that have significantly affected the state of television technology and engineering.

"I congratulate the many NASA staffers who are being recognized by the academy with this award for contributions to television engineering excellence," NASA Administrator Charles Bolden said. "From the first landing of man on the Moon in 1969 to today's high-definition broadcasts of America's ongoing space exploration initiatives, television has been a powerful communications tool that enables the agency to share its achievements in exploration and discovery with the world."

In 1927, Farnsworth was the first inventor to transmit a television image comprising 60 horizontal lines. He developed the dissector tube, the foundation of the modern electronic televisions. In a 1996 interview, his wife Elma, whose nickname was Pem, said the two of them watched with pride the televised Apollo 11 Moonwalk. "We were watching it and when Neil Armstrong landed on the Moon Phil turned to me and said, 'Pem, this has made it all worthwhile.' Before then, he wasn't too sure."

Over the agency's 50-year history, NASA TV has served as a vital engineering and mission support resource and a valuable communications outlet. "I am honored to have been selected to accept this award on behalf of NASA and the hundreds of engineers and technicians who made the telecast of this historic event possible,"

said Richard Nafzger, an engineer at NASA's Goddard Space Flight Center. Nafzger was 28 years old when he worked with the team that brought television from the Moon to a worldwide audience estimated at more than 600 million people. Joining Nafzger in accepting the honor were Apollo 11 Lunar Module Pilot and Moonwalker Buzz Aldrin.

Today, NASA TV is available on four digital channels, serving the general public, educators, and journalists. It also is streamed continuously over the agency's website. For more information about NASA TV, including program schedules and how to watch programs on the web, visit *www.nasa.gov/ntv*.

NASA Ames Designated 2009 AIAA Historic Aerospace Site

NASA Ames Research Center in Moffett Field, California.

In recognition of 70 years of pioneering aerospace research and its significant contributions to aerospace history, NASA Ames Research Center was recently honored as a 2009 Historic Aerospace Site by the American Institute of Aeronautics and Astronautics (AIAA).

Since its founding in 1939, Ames has made substantial strides in aerospace research. Ames pioneered the technology behind all reentry vehicles, starting with the blunt body concept. Ames developed simulation facilities, such as arc jets and ballistic ranges, designed thermal protection systems for manned spacecraft, and engineered probes that blazed into the atmospheres of Venus and Jupiter.

"To be designated as an AIAA Historic Aerospace Site is indeed an honor for Ames and for NASA," said S. Pete Worden, director of NASA Ames. "Since its inception, this center has played a vital role in aeronautics and space research and it's very gratifying that this legacy is being recognized by the premier aerospace organization in the country," Worden added. NASA Ames will celebrate the 70th anniversary of its founding on December 20, 2009.

"From its design of a revolutionary wing deicing system for aircraft in the 1940s to the development of modern-day spacecraft, NASA's Ames Research Center, and its creative, hard-working staff of engineers and scientists, has played a pivotal role in America's aerospace history, making atmospheric flight and space exploration possible," said David Thompson of Orbital Science Corp., and president of the AIAA. "In recognition of that legacy, AIAA is pleased to designate the center as an 'AIAA Historic Aerospace Site.' "

Ames Aeronautical Laboratory was established in 1939 as the second laboratory of the National Advisory Committee for Aeronautics. Ames achieved early fame in wind tunnel design and testing, flight testing, and supersonic and hypersonic aerodynamics. In 1958, Ames became a founding part of the National Aeronautics and Space Administration. The center conducted pioneering research in rotorcraft and vertical flight aircraft, spacecraft engineering, supercomputing and information technology, air traffic control, thermal protection for reentry vehicles, astrobiology and space life sciences, and Earth and planetary sciences.

In addition, NASA Ames led the development of simulators for human factors research, and has made major improvements to air traffic management. In space exploration, NASA Ames engineered the Pioneer series of high-impact robotic explorers and other small satellites, launched the discipline of astrobiology, led space sciences research in planetary atmospheres, conducted fundamental research in the space life sciences and designed and operated airborne science platforms.

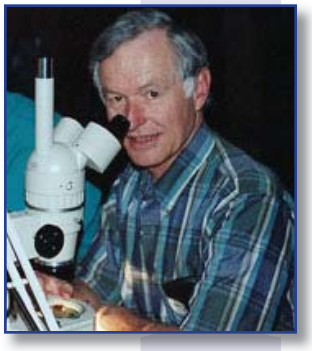
Ali Safaeinili, 1964–2009

Dr. Ali Safaeinili, a long-time and respected member of the Radar Science and Engineering team at NASA's Jet Propulsion Laboratory (JPL), passed away on Wednesday, July 29, from complications due to cholangiocarcinoma, a rare cancer. Safaeinili was 45 years old. He is survived by his wife of 20 years, Lisa; two daughters, Nadia, 17, and Roya, 10; his parents, siblings, and many, many friends and colleagues.

Born in Sari, Iran, Safaeinili always wanted to pursue his higher education in science and engineering in the United States and enrolled at Iowa State University in 1985 to study electrical engineering and computer science. He completed his undergraduate studies in two-and-a-half years by testing out of all the required math classes and finished his post-doctorate work in 1995. At JPL for more than a decade, Safaeinili pursued radar as a means to study ice on Earth and the planets. An energetic and innovative scientist, he participated in the design, development, testing, and operation of the Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS) still operating on Mars Express. He also participated in the design and operation of the Shallow Subsurface Radar (SHARAD) currently orbiting Mars on the Mars Reconnaissance Orbiter. Active in the analysis of radar data, Safaeinili served as the Investigation Scientist for the radar investigations on both projects. In addition to earlier work on the Shuttle Radar Topography Mission (SRTM), he led and contributed to efforts to develop new VHF and HF radars for Earth observations and potential applications to Europa and other icy bodies.

Safaeinili often expressed his gratitude for being given the opportunity to do what he loved most in his work at JPL. He also enjoyed giving back to the community, and volunteered with the Westminster Free Clinic, which provides medical care to the uninsured. He was appreciated by all for his warmth, good sense of humor, and generous spirit, and he will be sorely missed by his family, friends, and colleagues.

O. Richard Norton, 1937–2009



O. Richard Norton passed away in Bend, Oregon, on May 17, 2009, after a long illness. A lifelong educator and the author of popular books and articles about meteorites, astronomy, and planetariums, Norton discovered his life's passion when he built his first telescope at age 14. His love for the sky and all things astronomical led him from an afterschool job at Cave Optical Company in Long Beach, California, to a career in public science education.

While studying astronomy and meteoritics at UCLA, he was a lecturer at Griffith Observatory and Planetarium in Los Angeles. In 1957 he worked at the Nevada Test Site as a field researcher for the Atomic Energy Commission. There he witnessed the last 10 above-ground nuclear explosions and conducted research at the test site on the ecological effects of radiation. After graduation in 1960, he worked briefly as an optical engineer at Northrop Corporation and Tinsley Laboratories.

But he soon returned to his beloved planetariums. After two years at Morrison Planetarium in San Francisco, in 1963 he became Director of the University of Nevada's Fleischmann Planetarium in Reno, where he also taught astronomy. There Norton designed the world's first 35-mm fisheye motion picture system, called the *Atmospherium*, which was used to project realistic time-lapse motion pictures of developing weather systems onto the interior of a planetarium dome. His first book, *The Planetarium and Atmospherium, An Indoor Universe*, was published in 1969. He was a planetarium design engineer and consultant for Minolta Camera Company in Osaka, Japan. Norton became the founding director of the University of Arizona's Flandrau Planetarium in 1973, where he continued teaching and co-designed a fisheye projection camera system that flew on the space shuttle Challenger in 1984, producing the first full-sky motion pictures from space. In 1978

he started Science Graphics, a company that manufactured sets of teaching slides in astronomy and other sciences for use in college level courses.

Norton loved teaching and sharing his enthusiasm for astronomy, the space program, photography, geology, and telescope making. He gave public lectures and taught community education classes, even venturing into the Arizona State Penitentiary to teach in maximum security and protective custody. He led field trips to Cape Canaveral, where he had his fisheye cameras at most Apollo launches, and on solar eclipse trips around the world.

In 1986 he moved to Bend, where he taught astronomy at Central Oregon Community College for seven years. In Bend he rediscovered his early passion for meteorites. His book *Rocks from Space* was published in 1994, followed by *The Cambridge Encyclopedia of Meteorites* in 2002. His wife Dorothy Sigler Norton, a scientific illustrator, produced the illustrations and cover designs. The *Field Guide to Meteors and Meteorites,* published in 2008, was co-authored with Bend geologist Lawrence Chitwood, and was the recipient of the Mary B. Ansari Best Reference Work Award for 2009 from the GeoScience Information Society. He was also a contributing editor for *Meteorite* magazine and wrote the Centerpiece feature for 10 years. Many of Norton's meteorites are on display at the Sunriver Nature Center in Sunriver, Oregon.

— Dorothy Norton and Joel Schiff, courtesy of The Meteoritical Society

Solicitation for Contributions

Contributions to the **Lunar and Planetary Information Bulletin** (LPIB) are solicited from the planetary community and beyond. Articles exploring issues related to planetary science and exploration are welcome. Of special interest are articles describing web-based research and educational tools, meeting highlights and summaries, and descriptions of new space missions that may be of interest to our readers. Peer-reviewed research articles, however, are not appropriate for publication in the LPIB. The LPIB is published quarterly and serves the planetary research community, science libraries, educators, students, and lay readers interested in space-science-related research. Suggested topics can be e-mailed to the editors, who will provide guidelines for formatting and content.

Dr. Paul Schenk,
Scientific Editor (*schenk@lpi.usra.edu*)
Renée Dotson,
Production Editor (*dotson@lpi.usra.edu*)

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Production Editor: Renée Dotson
Graphic Design: Leanne Woolley

The Bulletin welcomes articles dealing with issues related to lunar and planetary science and exploration. The copy deadline for the next issue is November 18, 2009. Articles or announcements should be submitted via e-mail to *lpibed@lpi.usra.edu.*

To be added to the list to receive notification by e-mail of future issues, please send your e-mail address to *lpibed@lpi.usra.edu.*

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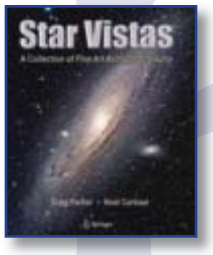
Books

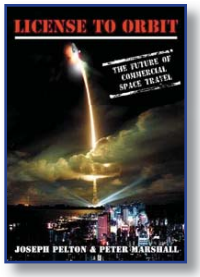
Rosetta: ESA's Mission to the Origin of the Solar System. Edited by Rita Schulz, Claudia Alexander, Hermann Boehnhardt, and Karl-Heinz Glaβmeier. Springer, 2009. 384 pp., Hardcover, $169.00. *www.springer.com*

This is the first book of its kind about ESA's Planetary Cornerstone Mission, Rosetta, that discusses the science and instrumentation involved. Until now, our knowledge of comets has come from Earth-based telescopes and flyby missions. Rosetta will be the first spacecraft to rendezvous with a comet and go in orbit around the nucleus. It will stay there for over one year in order to study the comet's evolution. Rosetta will also land on the surface of the comet with its Lander Philae to perform dedicated *in situ* analysis of the comet nucleus composition and structure. The Rosetta mission is an ambitious one that is poised to make a dramatic advance in our understanding of comets, and the origin of our solar system. *Rosetta: ESA's Mission to the Origin of the Solar System* is partially reprinted, with updates and corrections, from *Space Science Reviews, Volume 128(1–4),* 2007. This book is appropriate for researchers as well as graduate students working in astronomy, planetology, and astrobiology.



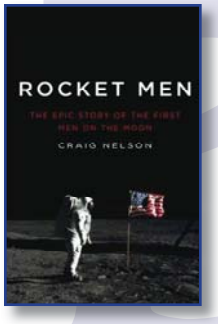
Star Vistas: A Collection of Fine Art Astrophotography. Greg Parker and Noel Carboni. Springer, 2009. 158 pp., Hardcover, $39.95. *www.springer.com*

This book is a collection of very-high-quality, full-page, true-full-color photographs of deep-sky objects, as beautiful as images produced by space telescopes. It illustrates what can be done by amateur astronomers using commercially available telescopes and cameras and features many deep-sky objects rarely imaged by the major space telescopes. With forewords by Sir Arthur C. Clarke, Sir Patrick Moore, and Dr. Brian May, this title was written for armchair astronomers and general science readers.



License to Orbit: The Future of Commercial Space Travel. Joseph Pelton and Peter Marshall. Apogee Books, 2009. 200 pp., Paperback, $23.95. *www.apogeespacebooks.com*

This book explores who the players are, the celebrities and technical innovators that are making this important new industry a reality. It offers the most comprehensive look at the industry, covering the companies, the role of NASA and other space agencies, as well as the strategic implications of private space systems, and examines the business risks and other possible showstoppers that might inhibit the growth of commercial spaceflight systems. Space tourism is seen as more than a fad but a crucial next step in the evolution of humankind. The book is unique in terms of exploring new technologies of the future, and reviewing the regulatory and legal ramifications of private space now and into the next decade.



Rocket Men: The Epic Story of the First Men on the Moon. Craig Nelson. Viking, 2009. 416 pp., Hardcover, $27.95. *us.penguingroup.com*

At 9:32 a.m. on July 16, 1969, the Apollo 11 rocket launched in the presence of more than a million spectators who had gathered to witness a truly historic event. It carried Neil Armstrong, Buzz Aldrin, and Mike Collins to the last frontier of human imagination: the Moon. *Rocket Men* is the thrilling story of the Moon mission, and it restores the mystery and majesty to an event that may have become too familiar for most people to realize what a stunning achievement it represented in planning, technology, and execution. Through interviews, 23,000 pages of NASA oral histories, and declassified CIA documents on the space race, Craig Nelson recreates a vivid and detailed account of the Apollo 11 mission. From the quotidian to the scientific to the magical, readers are taken right into the cockpit with Aldrin and Armstrong and behind the scenes at Mission Control. *Rocket Men* is the story of a twentieth-century pilgrimage; a voyage into the unknown motivated by politics, faith, science, and wonder that changed the course of history.

Antimatter. Frank Close. Oxford University Press, 2009. 166 pp., Hardcover, $19.95. *www.oup.com*

Antimatter explores this strange mirror world, where particles have identical yet opposite properties to those that make up the familiar matter we encounter everyday, where left becomes right, positive becomes negative, and where — should matter and antimatter meet — the resulting flash of blinding energy would make even thermonuclear explosions look feeble by comparison. Antimatter is an idea long beloved of science-fiction writers — but here, renowned science writer Frank Close shows that the reality of antimatter is even more intriguing than the fiction. We know that at one time antimatter and matter existed in perfect counterbalance, and that antimatter then perpetrated a vanishing act on a cosmic scale that remains one of the great mysteries of the universe. Today, antimatter does not exist normally, at least on Earth, but we know that it is real, as scientists are now able to make small pieces of it in particle accelerators, such as that at CERN in Geneva. Looking at the remarkable prediction of antimatter and how it grew from the meeting point of relativity and quantum theory in the early twentieth century, at the discovery of the first antiparticles, at cosmic rays, annihilation, antimatter bombs, and antiworlds, Close separates the facts from the fiction about antimatter, and explains how its existence can give us profound clues about the origins and structure of the universe. For all those wishing to take a closer look at the flip side of the visible world, this lucidly written book shines a bright light into a truly strange realm.

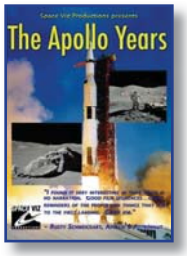
A Dictionary of the Space Age. Paul Dickson. Johns Hopkins University Press, 2009. 288 pp., Hardcover, $50.00. *www.press.jhup.edu*

The launch of Sputnik 1 in 1957 ushered in an exciting era of scientific and technological advancement. As television news anchors, radio hosts, and journalists reported the happenings of the American and the Soviet space programs to millions of captivated citizens, words that belonged to the worlds of science, aviation, and science fiction suddenly became part of the colloquial language. NASA used a litany of acronyms in much of its official correspondence in an effort to transmit as much information in as little time as possible. To translate this peculiar vocabulary, Paul Dickson has compiled the curious lingo and mystifying acronyms of NASA in an accessible dictionary of the names, words, and phrases of the Space Age. This dictionary captures a broader foundation for language of the Space Age based on the historic principles employed by the *Oxford English Dictionary* and *Webster's New Third International Dictionary*. Word histories for major terms are detailed in a conversational tone, and technical terms are deciphered for the interested student and lay reader. This is a must-own reference for space history buffs.

Missions to the Moon: The Complete Story of Man's Greatest Adventure. By Rod Pyle. Sterling Publishing Co., Inc., 2009. 64 pp. with slipcase, Hardcover, $40.00. *www.sterlingpublishing.com*

Missions to the Moon traces our quest to explore this final frontier, starting with the deadly development of German V1s and V2s in the Second World War, through the pioneering adventures of the Apollo Moon-landing program, and culminating in the future of lunar exploration with the recent missions by China, Japan, and Europe. Through 150 stunning photographs and 20 beautifully recreated rare facsimile documents that almost make you feel like part of the crew, we witness the lethal Apollo 1 fire; celebrate the success of Apollo 8, the first manned spacecraft to orbit a celestial body; marvel at Apollo 11 and the first man to land on the Moon; and share the dangers endured by the astronauts onboard the ill-fated Apollo 13. These are events the whole word watched in rapt attention. Now everyone can relive the experience or enjoy it for the first time. The historic facsimile documents include Werner von Braun's 1964 design for a space station, a 1969 issue of the USSR newspaper *Pravda* celebrating the success of Soyuz 4 and 5, the official NASA photograph of the Apollo 7 flight crew, the mission report from Apollo 11, the Apollo 13 flight log, and a memo outlining future plans for Apollos 18, 19, and 20 before they were canceled.

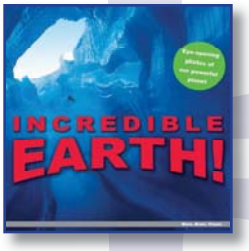
DVDs



The Apollo Years. Produced by Space Viz Productions, 2009, one disc. $29.99. *www.amazon.com*

The Apollo Years reviews the missions that were Apollo. This DVD is a historical document and documentary and was produced using only archival film and the authentic communications between the Apollo capsules and Mission Control. There is no narration, no fancy graphics, nothing but what happened, what was said, when, and by whom. Running time 139 minutes.

For Kids!!!



Incredible Earth! Eye-Opening Photographs of Our Powerful Planet. Play Bac Education Team. Play Bac, 2008. 96 pages, Hardcover, $12.95. *www.playbac.us*

From remarkable rocks to glassy glaciers, the Bungle Bungle Range to natural fountains in the middle of the desert, *Incredible Earth!* is an around-the-world journey that is as fantastic as it is fascinating. A global mapping feature helps young readers locate where each photo was taken. Jaw-dropping photos, fun facts, and amazing statistics draw young readers into the wonder of the natural world. Amazing and rarely seen images, presented in 46 panoramic spreads, presented with just the right amount of details about locations, behaviors, and the relationship we share with the living world around us, are the perfect introduction to a lifetime of interest in our incredible planet Earth. For ages 7 and up.

Tranquility Base Game: The Exciting Game of America's Race to the Moon. History in Action Games. $19.95/limited edition $69.95. *info@historyinactiongame.com*

Tranquility Base: The Exciting Game of America's Race to the Moon is the new and expanded second edition of the award-winning game *MOONSHOT: The Game*. Tranquility Base puts you in command of NASA projects Mercury, Gemini, and Apollo. Each historic event, heart-pounding crisis, and incredible machine is represented by a playing card. Players use these cards and a supply of fuel to launch missions, avoid hazards, and earn mission patches — all in an exciting race to be the first to land on the Moon! The game requires no special knowledge of the space program and includes many special features: 136-card collector deck that chronicles the early years of NASA; a commemorative, high-resolution lunar game board; full-color game manual featuring the history behind the cards, timeline of the Space Age, glossary of terms, and lunar facts; 30 mission patches from the Mercury, Gemini, and Apollo programs; 84 fuel counters; and 4 lunar module playing pieces. For ages 10 and up.

Ant Works Space Ants. Ant Works Toys. $18.99. *www.antworkstoys.com*

A three-dimensional "ant city" in the making! This is a new, smaller and more economical habitat design for easy observation of ants as they live and tunnel in nutritious space gel. This miraculous gel, derived from a 2003 NASA space shuttle experiment, serves as both habitat and nutrition for your ants, allowing you to watch in awe as they turn a brick of aqua-blue gel into a fascinating colony of tunnels. This set includes a 6.5 × 5.5 × 1-inch acrylic habitat, tunnel starter tool, space scope (for those up-close inspections), and multilingual packaging and instructions in Danish, English, French, German, Italian, and Spanish. The perfect interactive desktop pet or fascinating gift!

Going Around the Sun: Some Planetary Fun. Marianne Berkes. Dawn Publications, 2008. 32 pages, Paperback, $8.95. *www.dawnpub.com*

Our Earth is part of a fascinating planetary family — eight planets and an odd bunch of solar system "cousins" — that spin, roll, tilt, blow, and whirl around the Sun. Here, to the tune of "Over in the Meadow," young ones can get a glimpse of our remarkable neighborhood, and our place in a very big universe. For ages 4 to 9.

Calendar 2009

October

2–4 **Herschel Space Observatory: Discovering the Cold Universe**, Thessaloniki, Greece. *astro.imperial.ac.uk/outreach/cu.shtml*

4–9 **41st Annual Meeting of the Division for Planetary Sciences of the American Astronomical Society**, Fajardo, Puerto Rico. *dps09.naic.edu/*

5–7 **Earth Control on Planetary Life and Environment: 99th Annual Meeting of Geologische Vereinigung**, Göttingen, Germany. *www.gv-tagung2009.de/*

12–14 **9th European Workshop on Astrobiology (EANA '09)**, Brussels, Belgium. *www.exobiologie.be/eana/*

12–14 **Geological Mapping of Mars: A Workshop on New Concepts and Tools**, Il Ciocco, Tuscany, Italy. *www.irsps.unich.it/education/mapping09/*

12–16 **60th International Astronautical Congress (IAC)**, Daejeon, South Korea. *www.iac2009.kr/*

12–24 **The 50th Vernadsky/Brown Microsymposium on Comparative Planetology**, Moscow, Russia. *www.planetology.ru/micro.php*

15–16 **Field Trip on the Geology of Tuscany, Il Ciocco**, Tuscany, Italy. *www.irsps.unich.it/education/mapping09/*

16–18 **2nd Halifax Meeting on Computational Astrophysics**, Halifax, Canada. *www.smu.ca/partners/ICA/*

18–21 **Geological Society of America Annual Meeting**, Portland, Oregon. *www.geosociety.org/meetings/2009/*

19–23 **Towards Other Earths: Perspectives and Limitations in the ELT Era**, Porto, Portugal. *www.astro.up.pt/investigacao/conferencias/toe2009/*

21–23 **Women in Astronomy and Space Science 2009: Meeting the Challenges of an Increasingly Diverse Workforce**, College Park, Maryland. *wia2009.gsfc.nasa.gov/*

28–29 **Seventh Meeting of the Venus Exploration and Analysis Group (VEXAG)**, Irvine, California. *www.lpi.usra.edu/vexag/*

November

3–6 **From Circumstellar Disks to Planetary Systems**, Garching, Germany. *www.eso.org/sci/meetings/disks2009/index.html*

9–10 **The First Arab Impact Cratering and Astrogeology Conference** *(with field trip on Nov. 11)*, Amman, Jordan. *aicac.jga.org.jo/main1/*

15–18 **Out of Africa: 140 Years with Kevin Burke and Lew Ashwal**, Johannesburg, South Africa. *www.geodynamics.no/outofafrica/*

16–19 **Annual Meeting of the Lunar Exploration Analysis Group**, Houston, Texas. *www.lpi.usra.edu/meetings/leag2009*

20–22 **Colaboración Profesionales — Amateurs en investigación astronómica**, Cordoba, Spain. *www.iac.es/congreso/proam/*

23–27 **Mathematics and Astronomy: A Joint Long Journey**, Madrid, Spain. *www.astromath2009.com/welcome.html*

25–27 **Workshop on Methane on Mars: Current Observations, Interpretation and Future Plans**, Frascati, Italy. *www.congrex.nl/09c26/*

30–Dec 4 **Fifth Workshop on Lidar Measurements in Latin America**, Buenos Aires, Argentina. *www.lidar.camaguey.cu/wlmla/5w/w5en_main.htm*

December

5–15 **Workshop on Asteroid 2008 TC3**, Khartoum, Sudan. *asima.seti.org/2008TC3/workshop2008TC3.html*

7–8 **Geosciences — From Earth to Space: Second International Workshop on Mathematical Geosciences (MatGeoS'09)**, Freiberg, Germany. *www.iamg.tu-freiberg.de/matgeos09*

14–18 **AGU Fall Meeting**, San Francisco, California. *www.agu.org/meetings*

15 **Human-Tended Suborbital Science Workshop**, San Francisco, California. *suborbitalex.arc.nasa.gov/*

15–17 **20th Geological Remote Sensing Group (GRSG) Annual Meeting**, London, United Kingdom. *www.geolsoc.org.uk/gsl/site/GSL/lang/en/GRSG2009*

January 2010

3–7 **American Astronomical Society Meeting #215**, Washington, DC. *aas.org/meetings/aas215/*

4–9 **The Sixth CPS International School of Planetary Sciences: Planetary Atmospheres — Sisters, Relatives and Ancestors of Our Own**, Kobe, Japan. *cps.scitec.kobe-u.ac.jp/~pschool/2010-01-04/*

6–9 **Galileo's Medicean Moons: Their Impact on 400 Years of Discovery (IAU Symposium 269)**, Padua, Italy. *www.astro.unipd.it/galileo/*

9–10 **Origin of Life (Gordon Research Seminar)**, Galveston, Texas. *www.grc.org/programs.aspx?year=2010&program=grs_origin*

13–15 **Astrobio 2010**, Santiago, Chile. *www.astro.puc.cl/astrobio2010/HOME.html*

21–22 **Ground-Based Geophysics on the Moon**, Tempe, Arizona. *www.lpi.usra.edu/meetings/lunargeo2010*

25–26 **The Detection of Extra-Terrestrial Life and the Consequences for Science and Society**, London, United Kingdom. *royalsociety.org/event.asp?id=8602&month=1,2010*

February

5–10 **2010 NSBE Aerospace Systems Conference**, Los Angeles, California. *www.nsbe-asc.org/*

14–17 **Library and Information Services in Astronomy VI (LISA IV)**, Pune, India. *libibm.iucaa.ernet.in/conf/index.php/LISA/conf*

18–20 **Next-Generation Suborbital Researchers Conference (NSRC2010)**, Boulder, Colorado. *www.lpi.usra.edu/meetings/nsrc2010/*

March

1–5 **41st Lunar and Planetary Science Conference (LPSC 2010)**, The Woodlands, Texas. *www.lpi.usra.edu/meetings/lpsc2010/*

14–17 **4th Workshop on Granular Materials in Lunar and Martian Exploration**, Honolulu, Hawaii. *content.asce.org/conferences/earthspace2010/index.html*

14–17 **ASCI Earth and Space 2010 Conference**, Honolulu, Hawaii. *content.asce.org/conferences/earthspace2010/index.html*

29–Apr 2 **Exoplanets Rising: Astronomy and Planetary Science at the Crossroads**, Santa Barbara, California. *www.kitp.ucsb.edu/activities/auto/?id=983*

April

13–16 **JWST and the ELTs: An Ideal Combination**, Garching, Germany. *www.eso.org/sci/meetings/jwstelt2010/*

17–18 **High Spatial Resolution in Astronomy: The VLTI Training School**, Porquerolles Island, France. *www.european-interferometry.eu/training/2010*

19–23 **First International Conference on Mars Sedimentology and Stratigraphy** *(with accompanying field trip)*, El Paso, Texas. *www.lpi.usra.edu/meetings/marssed2010*

25–29 **Annual Meeting of the AAS Division on Dynamical Astronomy (DDA)**, Brookline, Massachusetts. *dda.harvard.edu/*

26–29 **Astrobiology Science Conference 2010: Evolution and Life: Surviving Catastrophes and Extremes on Earth and Beyond**, League City, Texas. *www.lpi.usra.edu/meetings/abscicon2010/*

26–May 1 **17th Young Scientists' Conference on Astronomy and Space Physics**, Kyiv, Ukraine. *ysc.kiev.ua/*

May

3–6 **Astronomical Data Analysis (ADA6)**, Monastir, Tunisia. *www.aset.org.tn/conf/ADA6/*

24–28 **Meteoroids 2010: An International Conference on Minor Bodies in the Solar System**, Breckenridge, Colorado. *www.cora.nwra.com/Meteoroids2010/*

30–Jun 25 **Vatican Observatory Summer School: The Chemistry of the Universe**, Castel Gandolfo, Vatican City State. *www.voss2010.va/*

June

12–13 **Short Course on Planetary Protection**, Barcelona, Spain. *www.planetaryprobe.eu/*

14–16 **Faraday Discussion 147: Chemistry of the Planets**, Saint Jacut de la Mer, France. *www.rsc.org/ConferencesAndEvents/RSCConferences/FD147/index.asp*

14–18 **7th International Planetary Probe Workshop (IPPW-7)**, Barcelona, Spain. *www.planetaryprobe.eu/*

27–Jul 2 **SPIE Astronomical Telescopes and Instrumentation 2010**, San Diego, California. *spie.org/astronomical-instrumentation.xml?WT.mc_id=Cal-AS*