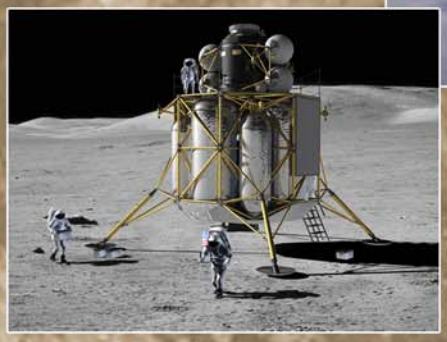
NASA's Lunar Science Institute Begins Work



Lunar and Planetary Information

BULLETIN

Lunar and Planetary Institute — Universities Space Research Association

Contents

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NASA's Lunar Science Institute Begins Work

It has been 40 years since humans first set foot upon the Moon, taking that historic "giant step" for mankind. Although interest in our nearest celestial neighbor has waned considerably, it has never disappeared completely and is now enjoying a remarkable resurgence. The Moon was born when our home planet encountered a rogue planet at its birth, and has since recorded the earliest history of the solar system (a record nearly obliterated on Earth). With four spacecraft orbiting the Moon in the past three years (from four separate nation groups) and a fifth, Lunar Reconnaissance Orbiter, due to arrive this spring, we are about to remake our understanding of this planetary body.

To further contribute to the advancement of our knowledge, NASA recently created a Lunar Science Institute (NLSI) to revitalize the lunar science community and train a new generation of scientists. This spring, NASA has selected seven academic and research teams to form the initial core of the NLSI. This virtual institute is designed to support scientific research that supplements and extends existing NASA lunar science programs in coordination with U.S. space exploration policy. The new teams that augment NLSI were selected in a competitive evaluation process that began with the release of a cooperative agreement notice in June 2008. NASA received proposals from 33 research teams.

"We are extremely pleased with the response of the science community and the high quality of proposals received," said David Morrison, the institute's interim director at NASA Ames Research Center in Moffett Field, California. "The institute represents a big step forward in developing a new generation of lunar scientists."

The selected teams are:

- The Moon as Cornerstone to the Terrestrial Planets: The Formative Years
  Principal investigator Carle Pieters, Brown University, Providence, Rhode Island
- Scientific and Exploration Potential of the Lunar Poles
  Principal investigator Ben Bussey, Johns Hopkins University Applied Physics Laboratory, Laurel, Maryland
- Impact Processes in the Origin and Evolution of the Moon: New Sample-driven Perspectives
  Principal investigator David Kring, Lunar and Planetary Institute, Houston
- Dynamic Response of the Environment at the Moon
  Principal investigator William Farrell, NASA Goddard Space Flight Center, Greenbelt, Maryland
- Understanding the Formation and Bombardment History of the Moon
  Principal investigator William Bottke, Southwest Research Institute, Boulder, Colorado
- Lunar University Node for Astrophysics Research: Exploring the Cosmos from the Moon
  Principal investigator Jack Burns, University of Colorado, Boulder
- NASA Lunar Science Institute: Colorado Center for Lunar Dust and Atmospheric Studies
  Principal investigator Mihaly Horanyi, University of Colorado, Boulder

"We look forward to solid contributions from these teams," said Jim Green, Director of the Planetary Science Division at NASA Headquarters. "These are some of the key individuals who will be vital to NASA successfully conducting the ambitious activities of returning to the Moon with robots and humans."

These U.S. teams are joined by three teams representing Canada, Korea, and the United Kingdom; the international teams are led by Gordon Osinski, Hyochoong Bang, and Mahesh Anand, respectively.

The Houston-based team is led by LPI and JSC, which have harnessed a long history of collaborative work to construct a new Center for Lunar Science and Exploration (CLSE). Locally the team also involves faculty and students at Rice University and the University of Houston. The science team is further enhanced by faculty, students, and facilities at the University of Arizona, University of Maryland, University of Notre Dame, and the National Institute for Polar Research (Japan).

The science objectives of the team's work is to examine the highest science priorities identified in the National Research Council's 2007 report that outlined *The Scientific Context for Exploration of the Moon*. The team will investigate the giant impact hypothesis, the lunar magma ocean hypothesis, and the lunar cataclysm hypothesis. Particular emphasis will

be placed on the collisional and impact cratering aspects of lunar evolution and implications the collisional evolution of the Moon has for the evolution of the Earth-Moon system and the entire solar system. New ideas and new analytical technologies will be applied to tease new information from the Apollo collection, which still remains the highest-fidelity view we have of the lunar surface, augmented with new analyses of lunar meteorites. The science objectives address fundamentally important science and should help foster a new era of excitement in the lunar science community.

The leading hypothesis for the origin of the Moon involves a huge collision between the Earth and a planet half its size. Some of that colliding material was added to Earth, but a large fraction of the impact debris went into orbit around Earth. The orbiting material accreted together to form the Moon. The CLSE team will be testing that hypothesis by examining the chemical composition of samples from the Moon and the ages of those samples. Credit: LPI.

These science activities will interface with the development of a lunar exploration architecture and the testing of science and exploration concepts. The team is integrated with the Constellation Program and will assist that program at several different levels, including simulations of lunar missions that exercise hardware and operational protocols in both robotic and crew mission scenarios. One of the team's milestones is to provide input to the Lunar Surface Systems concept review of June 2010. The team will also continue to expand LPI's Lunar Science and Exploration portal (*www.lpi.usra.edu/lunar*), which provides access of exploration-related information to the entire lunar community. This is a site that will be continually updated as new lunar science and exploration information becomes available. The latest group of assets added to the web-based information platform were released on March 17, 2009 (*www.lpi.usra.edu/features/clse*).

The CLSE will have a significant training component that is designed to capture Apollo experience and develop a new generation of lunar researchers. Graduate student and postdoctoral researchers will be trained at the lead institutions and at collaborating institutions.

Furthermore, the team has organized a consortium of over a dozen Texas universities that will foster new faculty-training and student-learning opportunities and thus expand the lunar community. The educational tools developed in this program will be available for distribution to universities throughout the world.

These university-based activities are part of an educational and training pipeline that provides opportunities for students across the entire spectrum of K–12 and secondary education programs. Parallel activities will also be developed to engage the general public. They will also be integrated with NLSI Central at NASA Ames Research Center and other NLSI teams, so that collectively the best educational and public outreach programs possible will be provided throughout the country.

Additional details about the team's science, exploration, training, education, and public outreach activities are available at *www.lpi.usra.edu/nlsi*. One of the Center's first activities will be the LPI Lunar Exploration Summer Intern Program, which is coordinated with JSC's Constellation Program. Two teams of five undergraduate and graduate students have been selected for this year's program, which will run from June 1 through August 8. The student teams will be evaluating landing sites on the lunar surface where science priorities in the NRC 2007 report can be addressed. More lunar exploration intern program details are available at *www.lpi.usra.edu/lunar_intern*.

In June 2008, team members tested a ground-penetrating radar system on the unpressurized crew rover called Chariot. They also worked with crew to develop and test geologic sample protocols. Credit: Essam Heggy (left) and NASA/JSC (right).

The work of the NLSI is just beginning. As the selected teams begin their activities, we can look forward to exciting new results and revitalization among the lunar science community. Many of these results will be published in future issues of the *Bulletin*.

The new NLSI teams are supported by the Science Mission Directorate and Exploration Systems Mission Directorate at NASA Headquarters in Washington. More information about NLSI is available at *lunarscience.arc.nasa.gov*.

NASA Lunar Spacecraft Prepares For Launch

Artist's rendition of the LCROSS spacecraft above the Moon's surface. Credit: NASA.

NASA's Lunar Reconnaissance Orbiter (LRO) spacecraft has arrived at Kennedy Space Center in Florida. Launch is targeted for April 24. The spacecraft was built by engineers at Goddard, where it recently completed two months of tests in a thermal vacuum chamber. During its time in the chamber, the spacecraft was subjected to hot and cold temperatures it will experience as it orbits the Moon.

The satellite's mission is one of the first steps in NASA's plan to return astronauts to the Moon. LRO will spend at least one year in a low polar orbit on its primary exploration mission, with the possibility of three more years to collect additional detailed scientific information about the Moon and its environment.

The orbiter will carry seven instruments to provide scientists with detailed maps of the lunar surface and enhance our understanding of the Moon's topography, lighting conditions, mineralogical composition, and natural resources. Information gleaned from LRO will be used to select safe landing sites, determine locations for future lunar outposts, and help mitigate radiation dangers to astronauts. The polar regions of the Moon are the main focus of the mission because continuous access to sunlight may be possible and water ice may exist in permanently shadowed areas of the poles.

Accompanying LRO on its journey will be the Lunar Crater Observation and Sensing Satellite (LCROSS), a mission that will impact the lunar surface in its search for water ice. Instruments onboard LCROSS are designed to search for evidence of water ice on the Moon as the spacecraft collides with a permanently shadowed crater near one of the Moon's poles. The resulting debris plumes are expected to be visible from Earth with telescopes 10 to 12 inches in diameter or larger.

NASA has selected four teams to observe the impact of LCROSS with the lunar surface during the mission's search for water ice on the Moon. These chosen observation teams will provide additional data and analysis about permanently shadowed craters to help researchers determine if water exists on the Moon and in what form. The LCROSS mission and the Universities Space Research Association (USRA) established specific selection criteria, and USRA administered the rigorous selection process.

The selected proposals are "Accessing LCROSS Ejecta: Water Vapor and Particle Size and Composition from Keck, Gemini, and the IRFT Telescopes" (principle investigator Eliot Young, Southwest Research Institute); "LCROSS Lunar Plume Observations with the Apache Point Observatory" (principle investigator Nancy Chanover, New Mexico State University); "Multi-Spectral Imaging of the LCROSS Impact" (principle investigator Marc Buie, Southwest Research Institute); "Searching for Polar Water Ice During the LCROSS Impact Using the MMT Observatory" (principle investigator Faith Vilas, University of Arizona).

On the night of the impacts, the LCROSS science team will be in constant contact with professional astronomers to provide live targeting information. This information is crucial to ensuring the astronomers point their large telescopes correctly to capture the exact moment of the impacts and the resulting debris plumes.

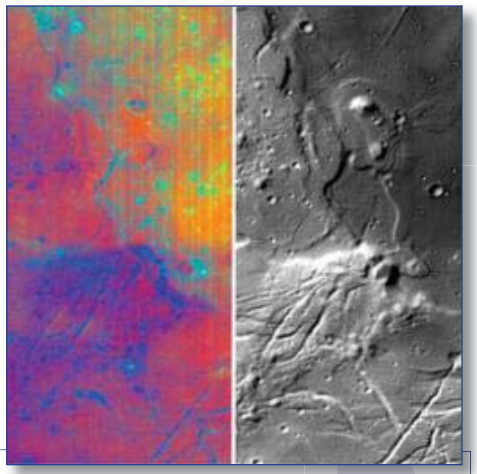
For more information about LRO, visit *www.nasa.gov/lro*. For more information about LCROSS, visit *www.nasa.gov/lcross*. For more information about the LCROSS Observation Campaign, visit *lcross.arc.nasa.gov/observation.htm*.

Moon Images from Chandrayaan-1

Different wavelengths of light provide new information about the Orientale Basin region of the Moon in a composite image taken by NASA's Moon Mineralogy Mapper, a guest instrument onboard the Indian Space Research Organization's (ISRO) Chandrayaan-1 spacecraft. The Moon Mineralogy Mapper is the first instrument to provide highly uniform imaging of the lunar surface. Along with the length and width dimensions across a typical image, the instrument analyzes a third dimension — color.

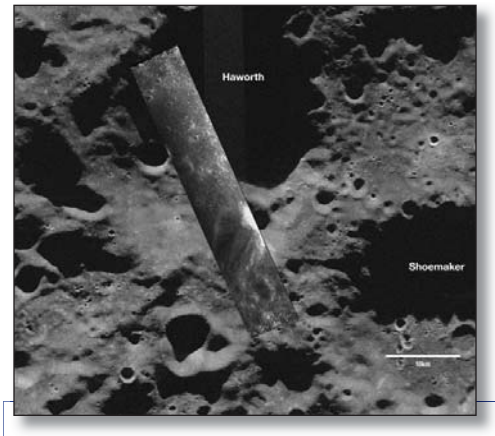
The Moon Mineralogy Mapper provides scientists their first opportunity to examine lunar mineralogy at high spatial and spectral resolution. "The Moon Mineralogy Mapper provides us with compositional information across the Moon that we have never had access to before," said Carle Pieters, the instrument's principal investigator, from Brown University. "Our ability to now identify and map the composition of the surface in geologic context provides a new level of detail needed to explore and understand Earth's nearest neighbor."

The Orientale Basin is located on the Moon's western limb. The data for the composite image were captured by the Moon Mineralogy Mapper during the commissioning phase of Chandrayaan-1 as the spacecraft orbited the Moon at an altitude of 100 kilometers (62 miles).



This composite image consists of a subset of Moon Mineralogy Mapper data for the Orientale region. The image strip on the left is a color composite of data from 28 separate wavelengths of light reflected from the Moon, and the image strip on the right is from a single wavelength of light that contains thermal emission, providing a new level of detail on the form and structure of the region's surface. Credit: NASA/JPL/Brown University.

Using a NASA radar flying onboard the Chandrayaan-1 spacecraft, scientists are getting their first look inside the Moon's coldest, darkest craters. The Mini-SAR instrument, a lightweight, synthetic aperture radar, has passed its initial inflight tests and sent back its first data. The images show the floors of permanently shadowed polar craters on the Moon that aren't visible from Earth. Scientists are using the instrument to map and search the insides of the craters for water ice.



This image is a Mini-RF synthetic aperture radar (SAR) strip overlain on an Earth-based, Arecibo Observatory radar telescope image. The south-polar SAR strip shows a part of the Moon never seen before: a portion of Haworth crater that is permanently shadowed from Earth and the Sun. Over the coming year of Chandrayaan-1 operations, Mini-RF (also known as Mini-SAR) will map both polar regions to look for water ice. Credit: ISRO/NASA/JHUAPL/LPI/Cornell University/Smithsonian.

"The only way to explore such areas is to use an orbital imaging radar such as Mini-SAR," said Benjamin Bussey, deputy principal investigator for Mini-SAR, from the Johns Hopkins University Applied Physics Laboratory. "This is an exciting first step for the team which has worked diligently for more than three years to get to this point."

The images, taken in November, cover part of the Haworth crater at the Moon's south pole and the western rim of Seares crater, an impact feature near the north pole. Bright areas in each image represent either surface roughness or slopes pointing toward the spacecraft. Further data collection by Mini-SAR and analysis will help scientists to determine if buried ice deposits exist in the permanently shadowed craters near the lunar poles.

Mini-SAR is one of 11 instruments on the Indian Space Research Organization's Chandrayaan-1 and one of two NASA-sponsored contributions to its international payload. Data from the tinstruments will contribute to NASA's increased understanding of the lunar environment as it implements America's space exploration plan, which calls for robotic and human missions to the Moon.

More information about Chandrayaan-1 is at *www.isro.org/Chandrayaan*. More information about NASA's Moon Mineralogy Mapper is at *m3.jpl.nasa.gov*, and more information about the Mini-RF is available at *www.nasa.gov/mini-rf*.

Next NASA Mars Mission Rescheduled for 2011

NASA's Mars Science Laboratory will launch two years later than previously planned, in the fall of 2011. The mission will send a next-generation rover with unprecedented research tools to study the early environmental history of Mars. A launch date of October 2009 no longer is feasible because of testing and hardware challenges that must be addressed to ensure mission success. The window for a 2009 launch ends in late October. The relative positions of Earth and Mars are favorable for flights to Mars only a few weeks every two years. The next launch opportunity after 2009 is in 2011.

"We will not lessen our standards for testing the mission's complex flight systems, so we are choosing the more responsible option of changing the launch date," said Doug McCuistion, director of the Mars Exploration Program at NASA Headquarters. "Up to this point, efforts have focused on launching next year, both to begin the exciting science and because the delay will increase taxpayers' investment in the mission. However, we've reached the point where we can not condense the schedule further without compromising vital testing."

Full-scale models of three generations of NASA Mars rovers show the increase in size from the Sojourner rover of the Mars Pathfinder project that landed on Mars in 1997 (center), to the twin Mars Exploration Rovers Spirit and Opportunity that landed in 2004 (left), to the Mars Science Laboratory rover for a mission to land in 2012 (right). Credit: NASA/JPL-Caltech.

The Mars Science Laboratory team recently completed an assessment of the progress it has made in the past three months. As a result of the team's findings, the launch date was changed. "Despite exhaustive work in multiple shifts by a dedicated team, the progress in recent weeks has not come fast enough on solving technical challenges and pulling hardware together," said Charles Elachi, director of NASA's Jet Propulsion Laboratory. "The right and smart course now for a successful mission is to launch in 2011."

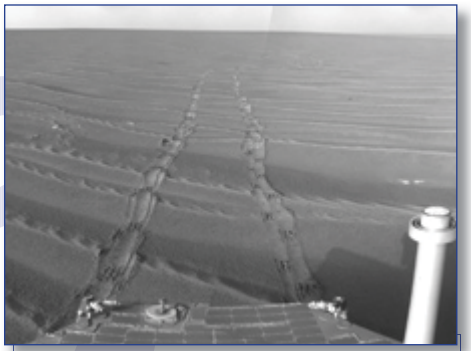
The advanced rover is one of the most technologically challenging interplanetary missions ever designed. It will use new technologies to adjust its flight while descending through the martian atmosphere, and to set the rover on the surface by lowering it on a tether from a hovering descent stage. Advanced research instruments make up a science payload 10 times the mass of instruments on NASA's Spirit and Opportunity Mars rovers. The Mars Science Laboratory is engineered to drive longer distances over rougher terrain than previous rovers. It will employ a new surface propulsion system.

Rigorous testing of components and systems is essential to develop such a complex mission and prepare it for launch. Tests during the middle phases of development resulted in decisions to re-engineer key parts of the spacecraft. "Costs and schedules are taken very seriously on any science mission," said Ed Weiler, associate administrator for NASA's Science Mission Directorate at NASA Headquarters. "However, when it's all said and done, the passing grade is mission success."

The mission will explore a Mars site where images taken by NASA's orbiting spacecraft indicate there were wet conditions in the past. Four candidate landing sites are under consideration. The rover will check for evidence of whether ancient Mars environments had conditions favorable for supporting microbial life and preserving evidence of that life if it existed there.

For more information about the Mars Science Laboratory, visit *mars.jpl.nasa.gov/msl*.

Mars Rovers Celebrate Five Years of Science and Discovery



This mosaic of frames from the navigation camera on Opportunity gives a view to the northeast from the rover's position on its 1687th martian day. Credit: NASA/JPL-Caltech.

NASA rovers Spirit and Opportunity may still have big achievements ahead as they recently celebrated the fifth anniversaries of their memorable landings on Mars. "The American taxpayer was told three months for each rover was the prime mission plan," said Ed Weiler, associate administrator for NASA's Science Mission Directorate at NASA Headquarters. "The twins have worked almost 20 times that long. That's an extraordinary return of investment in these challenging budgetary times."

The rovers have made important discoveries about wet and violent environments on ancient Mars. They also have returned a quarter-million images, driven more than 13 miles, climbed a mountain, descended into craters, struggled with sand traps and aging hardware, survived dust storms, and relayed more than 36 gigabytes of data via NASA's Mars Odyssey orbiter. To date, the rovers remain operational for new campaigns the team has planned for them.

Occasional cleaning of dust from the rovers' solar panels by martian wind has provided unanticipated aid to the vehicles' longevity. However, it

is unreliable aid. Spirit has not had a good cleaning for more than 18 months. Dust-coated solar panels barely provided enough power for Spirit to survive its third southern-hemisphere winter, which ended in December. "This last winter was a squeaker for Spirit," Callas said. "We just made it through."

With Spirit's energy rising for spring and summer, the team plans to drive the rover to a pair of destinations about 200 yards south of the site where Spirit spent most of 2008. One is a mound that might yield support for an interpretation that a plateau Spirit has studied since 2006, called Home Plate, is a remnant of a once more-extensive sheet of explosive volcanic material. The other destination is a house-sized pit called Goddard.

"Goddard doesn't look like an impact crater," said Steve Squyres of Cornell University. Squyres is principal investigator for the rover science instruments. "We suspect it might be a volcanic explosion crater, and that's something we haven't seen before."

A light-toned ring around the inside of the pit might add information about a nearby patch of bright, silica-rich soil that Squyres counts as Spirit's most important discovery so far. Spirit churned up the silica in mid-2007 with an immobile wheel that the rover has dragged like an anchor since it quit working in 2006. The silica was likely produced in an environment of hot springs or steam vents.

For Opportunity, the next major destination is Endeavour Crater. It is approximately 14 miles in diameter, more than 20 times larger than another impact crater, Victoria, where Opportunity spent most of the past two years. Although Endeavour is 7 miles from Victoria, it is considerably farther as the rover drives on a route evading major obstacles.

Since climbing out of Victoria, Opportunity has headed toward Endeavour and stopped to inspect several loose rocks the team plans to examine along the way. High-resolution images from NASA's Mars Reconnaissance Orbiter, which reached Mars in 2006, are helping the team plot routes around potential sand traps that were not previously discernable from orbit.

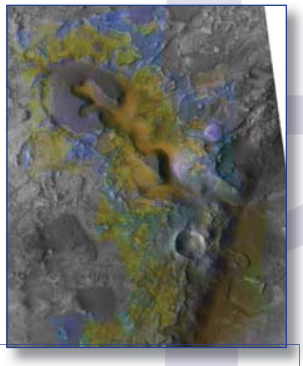
For more information about Spirit and Opportunity, visit *www.nasa.gov/rovers*.

Scientists Find "Missing" Mineral and Clues to Mars Mysteries

Researchers using a powerful instrument onboard NASA's Mars Reconnaissance Orbiter have found a long sought-after mineral on the martian surface and, with it, unexpected clues to the Red Planet's watery past.

Surveying intact bedrock layers with the Compact Reconnaissance Imaging Spectrometer for Mars, or CRISM, scientists found carbonate minerals, indicating that Mars had neutral to alkaline water when the minerals formed at these locations more than 3.6 billion years ago. Carbonates, which on Earth include limestone and chalk, dissolve quickly in acid. Therefore, their survival until today on Mars challenges suggestions that an exclusively acidic environment later dominated the planet. Instead, it indicates that different types of watery environments existed. The greater the variety of wet environments, the greater the chances one or more of them may have supported life. The findings were reported in the December 19 issue of *Science* magazine.

Carbonate rocks are created when water and carbon dioxide interact with calcium, iron, or magnesium in volcanic rocks. Carbon dioxide from the atmosphere becomes trapped within the rocks. If all of the carbon dioxide locked in Earth's carbonates were released, our atmosphere would be thicker than that of Venus. Some researchers believe that a thick, carbon-dioxide-rich atmosphere kept ancient Mars warm and kept water liquid on its surface long enough to have carved the valley systems observed today. "The carbonates that CRISM has observed are regional rather than global in nature, and therefore, are too limited to account for enough carbon dioxide to form a thick atmosphere," said Bethany Ehlmann, a spectrometer team member from Brown University. "Although we have not found the types of carbonate deposits which might have trapped an ancient atmosphere," Ehlmann said, "we have found evidence that not all of Mars experienced an intense, acidic weathering environment 3.5 billion years ago, as has been proposed. We've found at least one region that was potentially more hospitable to life."



Carbonate, which is indicative of a wet and nonacidic history, occurs in very small patches of exposed rock appearing green in this color representation of an area about 20 kilometers (12 miles) wide on Mars. Credit: NASA/JPL/JHUAPL/MSSS/Brown University.

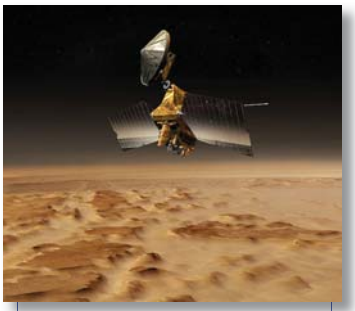
The article reports clearly defined carbonate exposures in bedrock layers surrounding the 925-mile-diameter Isidis impact basin, which formed more than 3.6 billion years ago. The best-exposed rocks occur along

a trough system called Nili Fossae, which is 414 miles long, at the edge of the basin. The region has rocks enriched in olivine, a mineral that can react with water to form carbonate.

NASA's Phoenix Mars Lander discovered carbonates in soil samples. Researchers had previously found them in martian meteorites that fell to Earth and in windblown Mars dust observed from orbit. However, the dust and soil could be mixtures from many areas, so the carbonates' origins have been unclear. The latest observations indicate carbonates may have formed over extended periods on early Mars. They also point to specific locations where future rovers and landers could search for possible evidence of past life.

For more information about the Mars Reconnaissance Orbiter, visit *www.nasa.gov/mro*.

Mars Orbiter Completes Prime Mission

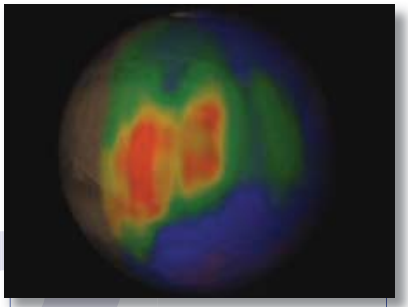


Artist's concept of the Mars Reconnaissance Orbiter. Credit: NASA/JPL.

NASA's Mars Reconnaissance Orbiter has completed its primary, two-year science phase. The spacecraft has found signs of a complex martian history of climate change that produced a diversity of past watery environments. The orbiter has returned 73 terabits of science data, more than all earlier Mars missions combined. The spacecraft will build on this record as it continues to examine Mars in unprecedented detail during its next two-year phase of science operations.

Among the major findings during the primary science phase is the revelation that the action of water on and near the surface of Mars occurred for hundreds of millions of years. This activity was at least regional and possibly global in extent, although possibly intermittent. The spacecraft also observed that signatures of a variety of watery environments, some acidic, some alkaline, increase the possibility that there are places on Mars that could reveal evidence of past life, if it ever existed.

Since moving into position 186 miles above Mars' surface in October 2006, the orbiter has also conducted 10,000 targeted observation sequences of high-priority areas. It has imaged nearly 40% of the planet at a resolution that can reveal house-sized objects in detail, 1% in enough detail to see desk-sized features. This survey has covered almost 60% of Mars in mineral mapping bands at stadium-sized resolution. The orbiter also assembled nearly 700 daily global weather maps, dozens of atmospheric temperature profiles, and hundreds of radar profiles of the subsurface and the interior of the polar caps. Orbiter data prompted the Phoenix team to change that spacecraft's landing site, and are being used to select the landing location for NASA's Mars Science Laboratory, which is scheduled for launch in 2011.



This image shows concentrations of methane on Mars. Credit: NASA.

Discovery of Methane Reveals Mars is Not a Dead Planet

A team of NASA and university scientists has achieved the first definitive detection of methane in the atmosphere of Mars. This discovery indicates the planet is either biologically or geologically active.

The team found methane in the martian atmosphere by carefully observing the planet throughout several Mars years with NASA's Infrared Telescope Facility and the W. M. Keck telescope, both at Mauna Kea, Hawaii. The team used spectrometers on the telescopes to spread the light into its component colors, as a prism separates white light into a rainbow. The team detected three spectral features called absorption lines that together are a definitive signature of methane.

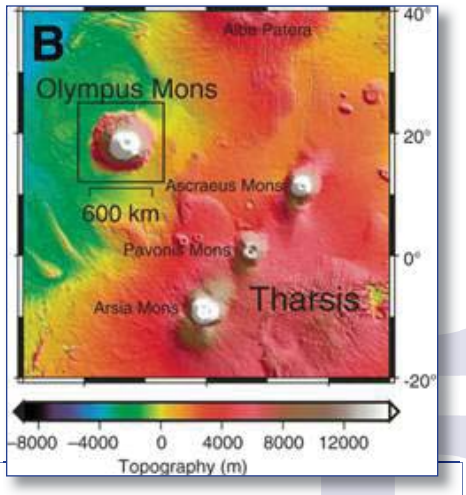
"Methane is quickly destroyed in the martian atmosphere in a variety of ways, so our discovery of substantial plumes of methane in the northern hemisphere of Mars in 2003 indicates some ongoing process is releasing the gas," said Michael Mumma of NASA's Goddard Space Flight Center. "At northern mid-summer, methane is released at a rate comparable to that of the massive hydrocarbon seep at Coal Oil Point in Santa Barbara, California." Mumma is lead author of a paper describing this research that appeared in *Science Express* in January.

Methane, four atoms of hydrogen bound to a carbon atom, is the main component of natural gas on Earth. Astrobiologists are interested in these data because organisms release much of Earth's methane as they digest nutrients. However,

other purely geological processes, like oxidation of iron, also release methane. If microscopic martian life is producing the methane, it likely resides far below the surface where it is warm enough for liquid water to exist. Liquid water is necessary for all known forms of life, as are energy sources and a supply of carbon.

Mountain on Mars May Answer Big Question

The martian volcano Olympus Mons is about three times the height of Mount Everest, but it's the small details that planetary scientists Patrick McGovern and Julia Morgan are looking at in thinking about whether the Red Planet ever had — or still supports — life. McGovern is a staff scientist at the Lunar and Planetary Institute and an adjunct assistant professor at Rice University; co-author Morgan is an associate professor of Earth science at Rice.



Using a computer modeling system to figure out how Olympus Mons came to be, McGovern and Morgan reached the surprising conclusion that pockets of ancient water may still be trapped under the mountain. Credit: Rice University/NASA.

Using a computer modeling system to figure out how Olympus Mons came to be, McGovern and Morgan reached the surprising conclusion that pockets of ancient water may still be trapped under the mountain. Their research is published in February's issue of the journal *Geology*.

The scientists explained that their finding is more implication than revelation. "What we were analyzing was the structure of Olympus Mons, why it's shaped the way it is," said McGovern. "What we found has implications for life — but implications are what go at the end of a paper."

In modeling the formation of Olympus Mons with an algorithm known as particle dynamics simulation, McGovern and Morgan determined that only the presence of ancient clay sediments could account for the volcano's asymmetric shape. The presence of sediment indicates water was or is involved.

Olympus Mons is tall, standing almost 15 miles high, and slopes gently from the foothills to the caldera, a distance of more than 150 miles. That shallow slope is a clue to what lies beneath, said the researchers. They suspect if they were able to stand on the northwest side of Olympus Mons and start digging, they'd eventually find clay sediment deposited there billions of years ago, before the mountain was even a molehill.

The European Space Agency's Mars Express spacecraft has in recent years found abundant evidence of clay on Mars. This supports a previous theory that where Olympus Mons now stands, a layer of sediment once rested that may have been hundreds of meters thick. Morgan and McGovern show in their computer models that volcanic material was able to spread to Olympus-sized proportions because of the clay's friction-reducing effect, a phenomenon also seen at volcanos in Hawaii.

What may be trapped underneath is of great interest, said the researchers. Fluids embedded in an impermeable, pressurized layer of clay sediment would allow the kind of slipping motion that would account for Olympus Mons' spread-out northeast flank — and they may still be there.

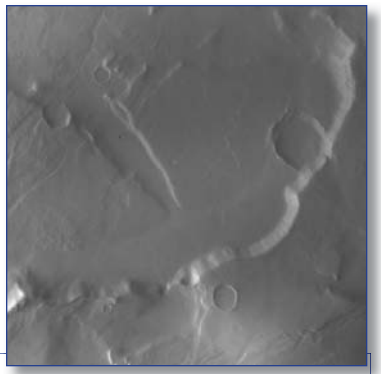
Thanks to NASA's Phoenix lander, which scratched through the surface to find ice underneath the red dust last year, scientists now know there's water on Mars. So Morgan and McGovern feel it's reasonable to suspect water may be trapped in pores in the sediment underneath the mountain.

"This deep reservoir, warmed by geothermal gradients and magmatic heat and protected from adverse surface conditions, would be a favored environment for the development and maintenance of thermophilic organisms," they wrote. This brings to mind the primal life forms found deep in Earth's oceans, thriving near geothermal vents.

Finding a source of heat will be a challenge, they admitted. "We'd love to have the answer to that question," said McGovern, noting evidence of methane on Mars is considered by some to be another marker for life. "Spacecraft up there have the capability to detect a thermal anomaly, like a magma flow or a volcano, and they haven't."

"What we need is 'ground truth' — something reporting from the surface saying, 'Hey, there's a Marsquake,' or 'Hey, there's unusual emissions of gas.' Ultimately, we'd like to see a series of seismic stations so we can see what's moving around the planet."

Dawn Falls for Mars



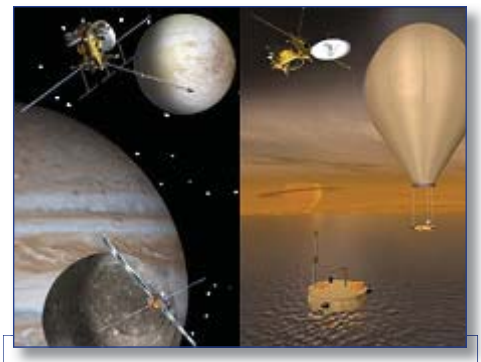
The Dawn spacecraft captured this image of Mars during its closest approach on February 17, 2009. Credit: NASA.

The near-infrared image featured here, from the framing camera on NASA's Dawn spacecraft, was taken near the point of closest approach to Mars on February 17, 2009, during Dawn's gravity assist flyby. A gravity assist is the use of the relative movement and gravity of a planet or other celestial body to alter the path and speed of a spacecraft, typically in order to save fuel, time, and expense. In the case of Dawn's case, it is using the Red Planet's tremendous angular momentum (the speed at which Mars orbits the Sun) to give it a little extra oomph. "A big oomph actually," said Marc Rayman, the Dawn project's chief engineer from NASA's Jet Propulsion Laboratory. "The gravity of Mars will change Dawn's path about the Sun, enlarging its elliptical orbit and sending the probe farther from the Sun. It will also change Dawn's orbital plane by more than 5 degrees. This is important because Dawn has to maneuver into the same plane in which Vesta orbits the Sun."

"The laws of physics tell us that Mars will pay a price for helping Dawn," said Rayman. "The flyby will cause Mars to slow in its orbit enough that after one year, its position will be off by about the width of an atom. If you add that up, it will take about 180 million years for Mars to be out of position by one inch (2.5 centimeters). We appreciate Mars making that sacrifice so Dawn can conduct its exciting mission of discovery in the asteroid belt."

Dawn's 4.8-billion-kilometer (3-billion-mile) odyssey includes orbiting asteroid Vesta in 2011 and the dwarf planet Ceres in 2015. These two giants of the asteroid belt have been witness to much of our solar system's history. The featured image, taken for calibration purposes, shows a portion of the fretted and cratered northwest margin of Tempe Terra, Mars. The scarp of the highlands/ lowlands boundary is illuminated by the light of dawn, and traces of fog appear in the lower portion. The area covered by the image is about 55 kilometers (34 miles) across.

To learn more about Dawn and its mission to the asteroid belt, visit *www.nasa.gov/dawn*.



Artist's concept of proposed missions to the Jupiter system (left) and the Saturn system (right). Credit: NASA/JPL.

NASA and ESA Prioritize Outer Planet Missions

At a meeting in Washington in February, NASA and ESA officials decided to continue pursuing studies of a mission to Jupiter and its four largest moons, and to plan for another potential mission to visit Saturn's largest moon Titan and Enceladus. Both of these proposed missions are grand endeavors that set the stage for future planetary science research. These outer planet flagship missions could eventually answer questions about how our solar system formed and whether life exists elsewhere in the universe.

The missions, called the Europa Jupiter System Mission and the Titan Saturn System Mission, are the result of NASA and ESA merging their separate mission concepts. NASA originally studied four mission concepts during 2007, which were narrowed down to two proposals in 2008. One finalist was a Europa Orbiter to explore that icy moon of Jupiter and its subsurface water ocean. The other was a Titan Orbiter to visit the Saturn moon. Independently, in 2007, ESA also initiated a competition to select its flagship mission for the Cosmic Vision 2015–2025 slot of the ESA scientific program. Two finalists, called Laplace and Tandem, were selected by ESA for further study. Laplace was a set of spacecraft to orbit Jupiter and eventually orbit and land on Europa. Tandem was a set of spacecraft intended to orbit Titan and explore its surface, after also exploring the surface of Saturn's moon Enceladus.

NASA and ESA engineers and scientists carefully studied both potential missions in preparation for last week's meeting. Based on these and other studies as well as stringent independent assessment reviews, NASA and ESA agreed that the Europa Jupiter System Mission, called Laplace in Europe, was the most technically feasible to do first. However, ESA's Solar System Working Group concluded the scientific merits of this mission and a Titan Saturn System Mission could not be separated. The group recommended, and NASA agreed, that both missions should move forward for further study and implementation.

"The decision means a win, win situation for all parties involved," said Ed Weiler, associate administrator for NASA's Science Mission Directorate in Washington. "Although the Jupiter system mission has been chosen to proceed to an earlier flight opportunity, a Saturn system mission clearly remains a high priority for the science community."

Both agencies will need to undertake several more steps and detailed studies before officially moving forward.

The Europa Jupiter System Mission would use two robotic orbiters to conduct unprecedentedly detailed studies of the giant gaseous planet Jupiter and its moons Io, Europa, Ganymede, and Callisto. NASA would build one orbiter, initially named Jupiter Europa. ESA would build the other orbiter, initially named Jupiter Ganymede. The probes would launch in 2020 on two separate launch vehicles from different launch sites. The orbiters would reach the Jupiter system in 2026 and spend at least three years conducting research.

Europa has a surface of ice, and scientists theorize it has an ocean of water beneath that could provide a home for living things. Ganymede, the largest moon in the solar system, is the only moon known to have its own internally generated magnetic field and is suspected to have a deep undersurface water ocean. Scientists long have sought to understand the causes of the magnetic field. Callisto's surface is extremely heavily cratered and ancient, providing a clear indication of a record of events from the early history of the solar system. Finally, Io is the most volcanically active body in the solar system.

The orbiters would spend nearly a year orbiting Europa and Ganymede. NASA's probe would investigate whether Europa might harbor life, and ESA's spacecraft would orbit Ganymede to conduct investigations of the surface and interior of this satellite, to better understand the formation and evolution of the jovian system.

For more information about the Outer Planet Flagship missions, visit *opfm.jpl.nasa.gov*.

Saturn's Dynamic Moon Enceladus Shows More Signs Of Activity

The closer scientists look at Saturn's small moon Enceladus, the more they find evidence of an active world. The most recent flybys of Enceladus made by NASA's Cassini spacecraft have provided new signs of ongoing changes on and around the moon. The latest high-resolution images of Enceladus show signs that the south polar surface changes over time.

On October 5, 2008, just after coming within 25 kilometers (15.6 miles) of the surface of Enceladus, Cassini captured this stunning mosaic as the spacecraft sped away from this geologically active moon of Saturn. Credit: NASA/JPL/Space Science Institute.

Close views of the southern polar region, where jets of water vapor and icy particles spew from vents within the moon's distinctive "tiger stripe" fractures, provide surprising evidence of Earth-like tectonics. They yield new insight into what may be happening within the fractures. The latest data on the plume— the huge cloud of vapor and particles fed by the jets that extend into space — show it varies over time and has a far-reaching effect on Saturn's magnetosphere.

"Enceladus has Earth-like spreading of the icy crust, but with an exotic difference — the spreading is almost all in one direction, like a conveyor belt," said Paul Helfenstein, Cassini imaging associate at Cornell University. "Asymmetric spreading like this is unusual on Earth and not well understood."

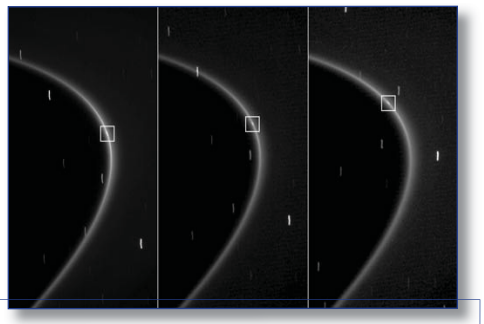
"Enceladus has asymmetric spreading on steroids," Helfenstein added. "We are not certain about the geological mechanisms that control the spreading, but we see patterns of divergence and mountain-building similar to what we see on Earth, which suggests that subsurface heat and convection are involved."

The tiger stripes are analogous to the mid-ocean ridges on Earth's seafloor where volcanic material wells up and creates new crust. Using Cassini-based digital maps of the moon's south polar region, Helfenstein reconstructed a possible history of the tiger stripes by working backward in time and progressively snipping away older and older sections of the map, each time finding that the remaining sections fit together like puzzle pieces.

Cassini's flybys on August 11 and October 31 targeted Enceladus' fractured southern region. An October 9 flyby took the spacecraft deep into the plume of water vapor and ice shooting out of the moon's vents. Cassini's next flyby of Enceladus will be in November 2009.

For more information about the Cassini-Huygens mission, visit *www.nasa.gov/cassini*.

Newfound Moon May Be Source of Outer Saturn Ring



This sequence of three images, obtained by the Cassini spacecraft over the course of about 10 minutes, shows the path of a newly found moonlet in a bright arc of Saturn's faint G ring. Credit: NASA/JPL/Space Science Institute.

The Cassini spacecraft has found within Saturn's G ring an embedded moonlet that appears as a faint, moving pinprick of light. Scientists believe it is a main source of the G ring and its single ring arc. Cassini imaging scientists analyzing images acquired over the course of about 600 days found the tiny moonlet, half a kilometer (about a third of a mile) across, embedded within a partial ring, or ring arc, previously found by Cassini in Saturn's tenuous G ring.

The finding was announced earlier this month in an International Astronomical Union circular. "Before Cassini, the G ring was the only dusty ring that was not clearly associated with a known moon, which made it odd," said Matthew Hedman, a Cassini imaging team associate at Cornell University. "The discovery of this moonlet, together with other Cassini data, should help us make sense of this previously mysterious ring."

Related images can be found at *www.nasa.gov/cassini*, *saturn.jpl.nasa.gov*, and *ciclops.org*.

Kepler Mission Rockets to Space in Search of Other Earths

Liftoff of the Delta II rocket carrying NASA's Kepler spacecraft. Credit: NASA/Jack Pfaller.

NASA's Kepler mission successfully launched into space from Cape Canaveral Air Force Station at 10:49 p.m. EST on Friday, March 6. Kepler is designed to find the first Earth-sized planets orbiting stars at distances where water could pool on the planet's surface. Liquid water is believed to be essential for the formation of life.

"It was a stunning launch," said Kepler Project Manager James Fanson of NASA's Jet Propulsion Laboratory. "Our team is thrilled to be a part of something so meaningful to the human race — Kepler will help us understand if our Earth is unique or if others like it are out there."

Engineers acquired a signal from Kepler at 12:11 a.m. Saturday, after it separated from its spent third-stage rocket and entered its final Sun-centered orbit, trailing 950 miles behind Earth. The spacecraft is generating its own power from its solar panels.

"Kepler now has the perfect place to watch more than 100,000 stars for signs of planets," said William Borucki, the mission's science principal investigator at NASA's Ames Research Center. Borucki has worked on the mission for 17 years. "Everyone is very excited as our dream becomes a reality. We are on the verge of learning if other Earths are ubiquitous in the galaxy."

Engineers have begun to check Kepler to ensure it is working properly, a process called "commissioning" that will take about 60 days. In about a month or less, NASA will send up commands for Kepler to eject its dust cover and make its first measurements. After another month of calibrating Kepler's single instrument, a wide-field charge-couple device camera, the telescope will begin to search for planets.

The first planets to roll out on the Kepler "assembly line" are expected to be the portly "hot Jupiters" — gas giants that circle close and fast around their stars. NASA's Hubble and Spitzer space telescopes will be able to follow up with these planets and learn more about their atmospheres. Neptune-sized planets will most likely be found next, followed by rocky ones as small as Earth. The true Earth analogs — Earth-sized planets orbiting stars like our Sun at distances where surface water, and possibly life, could exist — would take at least three years to discover and confirm. Groundbased telescopes also will contribute to the mission by verifying some of the finds.

In the end, Kepler will give us our first look at the frequency of Earth-sized planets in our Milky Way galaxy, as well as the frequency of Earth-sized planets that could theoretically be habitable. "Even if we find no planets like Earth, that by itself would be profound. It would indicate that we are probably alone in the galaxy," said Borucki.

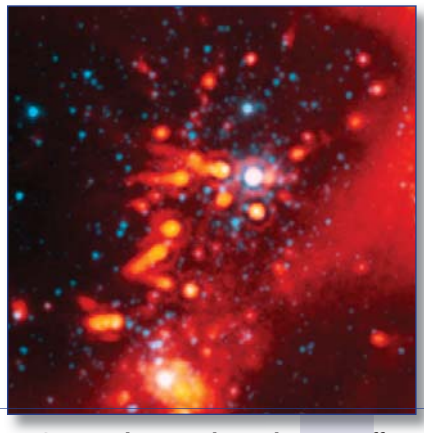
For more information about the Kepler mission, visit *www.nasa.gov/kepler*.

News from Exoplanets

Hubble Telescope Finds Carbon Dioxide on an Extrasolar Planet

NASA's Hubble Space Telescope has discovered carbon dioxide in the atmosphere of a planet orbiting another star. This breakthrough is an important step toward finding chemical biotracers of extraterrestrial life. The Jupiter-sized planet, called HD 189733b, is too hot for life. But the Hubble observations are a proof-of-concept demonstration that the basic chemistry for life can be measured on planets orbiting other stars. Organic compounds also can be a by-product of life processes and their detection on an Earthlike planet someday may provide the first evidence of life beyond our planet. Previous observations of HD 189733b by Hubble and the Spitzer Space Telescope found water vapor. Earlier this year, Hubble found methane in the planet's atmosphere.

"The carbon dioxide is the main reason for the excitement because, under the right circumstances, it could have a connection to biological activity as it does on Earth," Swain said. "The very fact we are able to detect it and estimate its abundance is significant for the long-term effort of characterizing planets to find out what they are made of and if they could be a possible host for life."



This image from NASA's Spitzer Space Telescope shows the nasty effects of living near a group of massive stars: radiation and winds from the massive stars (white spot in center) are blasting planet-making material away from stars like our Sun. The planetary material can be seen as comet-like tails behind three stars near the center of the picture. The tails are pointing away from the massive stellar furnaces that are blowing them outward. The picture is the best example yet of multiple sun-like stars being stripped of their planet-making dust by massive stars. Credit: NASA/JPL-Caltech/Harvard-Smithsonian CfA.

Planets Living on the Edge

Some stars have it tough when it comes to raising planets. A new image from NASA's Spitzer Space Telescope shows one unlucky lot of stars, born into a dangerous neighborhood. The stars themselves are safe, but the material surrounding them — the dusty bits of what might have been future planets — can be seen blowing off into space.

The hazard in this particular nook of space is a group of behemoth stars. Radiation and winds from the massive stars are wiping smaller, Sun-like stars clean of their planet-making material. "We are seeing the effects that massive stars have on smaller stars that are trying to form planets," said Xavier Koenig, lead author of a paper about the discovery, recently published in the *Astrophysical Journal Letters*. "These stars may or may not go on to form small, inner planets like the Earth, but it's probable that outer planets like Uranus and Neptune would never come to be."

The new Spitzer observations illustrate just how nasty these massive star-forming regions can be. It shows a portion of an active star-forming nebula called W5, located about 6500 light-years away in the constellation Cassiopeia. Radiation and winds from a hub of four stars, each about 20 times as massive as our Sun, are stripping the planet-forming material right off of three young, Sun-like stars about one light-year away.

Astronomers Observe Planet With Wild Temperature Swings

NASA's Spitzer Space Telescope has observed a planet that heats up to red-hot temperatures in a matter of hours before quickly cooling back down. The "hot-headed" planet is HD 80606b, a gas giant that orbits a star 190 light-years from Earth. It was already known to be quite unusual, with an orbit shuttling it nearly as far out as Earth is from our Sun, and much closer in than our planet Mercury. Astronomers used Spitzer, an infrared observatory, to measure heat emanating from the planet as it whipped behind and close to its star. In just six hours, the planet's temperature rose from 800 to 1500 Kelvin (980° to 2240°F).

"We watched the development of one of the fiercest storms in the galaxy," said astronomer Greg Laughlin of the Lick Observatory, University of California at Santa Cruz. "This is the first time that we've detected weather changes in real time on a planet outside our solar system." Laughlin is lead author of a new report about the discovery appearing in the January 29 issue of *Nature*.

The planet takes about 111 days to circle its star, but it spends most of its time at farther distances while zipping through the closest part of its orbit in less than a day. (This is a consequence of Kepler's Second Law of Planetary Motion, which states that orbiting bodies — planets and comets — sweep out an equal area in equal time.)

More information about Spitzer is at *www.spitzer.caltech.edu/spitzer*. More information about extrasolar planets is at *planetquest.jpl.nasa.gov*.

"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.

A Planetary Science Fieldtrip for Educators

Educators are invited to participate in *The Heat from Within: Earthly Insights into Planetary Volcanism*, a NASA-sponsored field-based workshop. The workshop will be held July 12–19, 2009, and is designed for intermediate-grade-level science teachers. Participants will spend the week with planetary scientists investigating different types of volcanos in the Bend and Crater Lake regions of Oregon, and will contrast these Earth-based analogs with volcanic features on Mars, the Moon, Venus, and even the moons of Jupiter, Saturn, and Neptune! From these field experiences and classroom exercises, participants will build an understanding of the planetary processes that produce volcanos, and the patterns of volcanism on planets in our solar system. Participants receive lesson plans, supporting resources, and presentations. A limited number of grants are available to cover registration.

For more information about costs and logistics, and to apply for the experience, please visit *www.lpi.usra.edu/education/fieldtrips/2009/*. Applications are due **April 7, 2009**.

NASA Planetary Science Summer School

NASA is accepting applications from science and engineering post-docs, recent Ph.D.s, and doctoral students for its 21st Annual Planetary Science Summer School, which will hold two separate sessions this summer (July 20–24 and August 3–7) at the Jet Propulsion Laboratory in Pasadena, California. During the program, student teams will carry out the equivalent of an early mission concept study, prepare a proposal authorization review presentation, present it to a review board, and receive feedback. At the end of the week, students will have a clearer understanding of the life cycle of a robotic space mission; relationships between mission design, cost, and schedule; and the tradeoffs necessary to stay within cost and schedule while preserving the quality of science. Applications are due **May 1, 2009**. Partial financial support is available for a limited number of individuals. Further information is available at *pscischool.jpl.nasa.gov*.

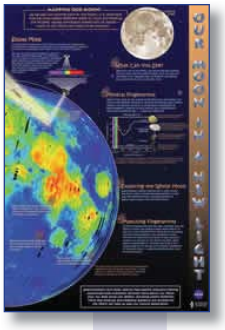
Moon Missions

The Lunar Reconnaissance Orbiter (LRO) and Lunar Crater Observation and Sensing Satellite (LCROSS) missions are scheduled to be launched in late May 2009, and Chandrayaan-1 is orbiting the Moon now. This is the ideal time for the science and education community to engage audiences with lunar exploration. There are many resources and activities available:

- *LRO Education and Outreach: lunar.gsfc.nasa.gov/outreach.html*
- *LCROSS Education and Outreach: lcross.arc.nasa.gov/education.htm*
- *Chandrayaan-1's Moon Mineralogy Mapper Education and Public Outreach: m3.cofc.edu/overview.html*
- *Explore to the Moon and Beyond: With NASA's LRO Mission: www.lpi.usra.edu/education/explore/LRO/*
- A plethora of engaging video clips: *lunar.gsfc.nasa.gov/gallery-multimedia.html*

New Lunar Education Resources

Three posters, designed for students in 6th through 9th grade, explore ideas about the Moon's formation, evolution, resources, and more. What — and how — do we know about how the Moon formed and changed through time, and how does its history impact what we find where? Our visits to six places on the Moon brought us new scientific understanding about its geologic history and the materials that make up the lunar landscape, but much of the Moon



remained unexplored during these landings. Past and present spacecraft missions carry instruments that measure different wavelengths of light reflected off the Moon's surface. These missions are presenting scientists and engineers with new data about the entire Moon, its features, environment, and materials. With this information we can plan how to use the available materials to support future lunar outposts. The posters are available for download at *www.lpi.usra.edu/education/moon_poster.shtml*.

Collaborate with Museums and Planetariums

Scientists interested in reaching out to the public may want to consider working with museums and planetariums. The *Museum Alliance* is a network of informal science educators at museums, science centers, planetariums, observatories, zoos, aquariums, and nature centers who wish to share NASA information with their visitors. It is a free service intended to bring current NASA science and technology to the public through professional development of the museums' staff and provision of materials such as visualizations, access to NASA experts, educational materials, etc. If you are interested in working with the *Museum Alliance*, please contact Anita Sohus at *anita.m.sohus@jpl.nasa.gov*. For more information, go to *informal.jpl.nasa.gov/museum/index.cfm*.

Carl Sagan Medal for Excellence in Public Communication in Planetary Science

Nominate a fellow scientist for their involvement in public outreach. The Carl Sagan Medal for Excellence is awarded annually by the Division for Planetary Sciences of the American Astronomical Society, to recognize and honor outstanding communication by an active planetary scientist to the general public. It is to be awarded to scientists whose efforts have significantly contributed to a public understanding of, and enthusiasm for, planetary science. The Sagan Medal consists of a medal with citation and a cash award. The recipient of the Sagan Medal is expected to present a public lecture on a subject in planetary science of his or her choosing. For more information, visit *dps.aas.org/prizes/sagan*.This year's deadline for prize nominations is **April 17, 2009**.

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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The Bulletin welcomes articles dealing with issues related to lunar and planetary science and exploration. The copy deadline for the next issue is April 16, 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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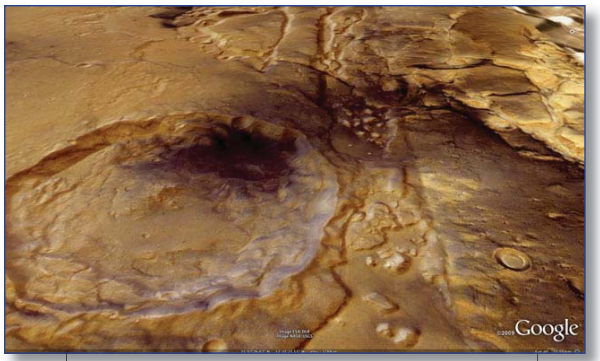
NASA and Google Launch Virtual Exploration Of Mars



Screenshot of the Red Planet from the new Google Mars 3D. Credit: Google, Inc.

NASA and Google have announced the release of a new Mars mode in Google Earth that brings to everyone's desktop a high-resolution, three-dimensional view of the Red Planet.

Besides providing a rich, immersive three-dimensional view of Mars that will aid public understanding of Mars science, the new mode, Google Mars 3D, also gives researchers a platform for sharing data similar to what Google Earth provides for Earth scientists.

The mode enables users to fly virtually through enormous canyons and scale huge mountains on Mars that are much larger than any found on Earth. Users can also explore the Red Planet through the eyes of the Mars rovers and other Mars missions, providing a unique perspective of the entire planet, and can see some of the latest satellite imagery from NASA's Mars Reconnaissance Orbiter and other probes orbiting the Red Planet. Viewers can learn about new discoveries and explore indexes of available Mars imagery. The new Mars mode also allows users to add their own 3D content to the Mars map to share with the world.

Google Mars 3D is the latest benefit of the Space Act Agreement that NASA Ames Research Center signed with Google in November 2006. Under the terms of the agreement, NASA and Google agreed to collaborate to make NASA's datasets available to the world. NASA Ames, along with its partners at Google, Carnegie Mellon University, SETI, and other institutions, helped produce the data to make this possible.

"Socializing" on Mars

After five groundbreaking years exploring the Red Planet, the communications engineers at NASA's Jet Propulsion Laboratory pretty much know what they are getting when another downlink from Spirit or Opportunity arrives. They know that with a typical transmission comes about 10 megabits of engineering data, another 4 megabits of science data, and around 26 megabits of images. They also realize that after the information is amassed and analyzed by the rovers' science teams, the most unique, scientifically exciting of that compiled data will be released via peer-reviewed papers, articles, science briefings, and press releases.

To date, literally thousands of rover images have been analyzed and discussed in detail. But the rovers have sent back about a quarter-million images. NASA decided this incongruity could be best addressed by making every single Mars rover image available to all who were interested — and had Internet access. Access to all that imagery brought the thrill of exploration to people around the world in a way never envisioned before the rovers began to roam the Red Planet. Now, the Mars Exploration Rovers have new life on the likes of "Second Life," "YouTube," online forums like "Unmannedspaceflight.com," and the social networking site "Facebook."

Like the majority of college students today, Keri Bean knows the ins and outs of Facebook. But the Texas A&M student did her Earth-based socializing peers one planet better when she opened a page for the Mars Rovers. "If I had to choose, I would say I like Spirit better," said the 20-year-old meteorology major from College Station, Texas. "She's had to work for everything. Opportunity gets a major discovery handed to her by landing nearly on top of it, but Spirit's had to work hard for everything she gets."

Bean started her Mars Rovers Facebook page to keep a few of her friends in the loop on what's happening up there on the Red Planet. She populated it with rover information and updates when she could find time. To her surprise, the rovers' friends list began to grow well beyond her goal of "a few friends." Then one day, she got a new friend that changed everything. "Steve Squyres, the scientist in charge of both of the rovers, messaged

me and said he liked my site," said Bean. "I knew then I had to get serious."

Bean and the Mars Rovers now have almost 1700 online friends from as far away as Norway and New Zealand. Her (or their, depending how you look at it) page includes links to interesting articles about the rovers, images, sometimes a heads-up about upcoming documentaries, and even some first-person dialogue between Mars' roving twosome. "I do not have a lot of time this semester, but I try to check it once a day," said Bean. "It is all about reaching out to people who would normally not pay attention."

The Mars Exploration Rovers have inspired fans from around the world, introducing a new generation to the wonder and excitement of space exploration. Credit: NASA/JPL-Caltech.

If Bean's Facebook page is for those with short martian attention spans, Doug Ellison of the United Kingdom has put together a website for those with an insatiable appetite. Ellison has been interested in the Red Planet ever since NASA's first scrappy Mars rover, Pathfinder, roved the martian surface back in 1997.

"Mars grabbed me in an unhealthy way," quipped Ellison, the United Kingdom-based web czar of unmannedspaceflight.com. "Just on the fringe of acceptable."

In those days, Ellison was reading everything he could on the journey of Pathfinder. Then, in February 2004, while Mars rovers Spirit and Opportunity were still under factory warranty, and after his day job, Ellison used imaging software to "stitch" his first Mars panorama from a collection of raw images from the JPL website (*marsrovers.jpl.nasa.gov/gallery/all/*). Like Bean, Ellison had "no ambition or expectation" other than impressing himself and a few friends. But then a few more friends took an interest in his nascent website, and then a few more. Ellison's site — *unmannedspaceflight.com* — was slowly being colonized with people with a serious jonesing for all things deep in deep space exploration.

"Our membership includes a care worker for the elderly here in the U.K. to a teacher in North Wales to a government employee in California," said Ellison. "In London, I recently met for the first time someone I had known through the website for four years. There were no 'getting to know you' pleasantries. Straight off the bat it was right into a detailed, in-depth, insightful discussion about something ridiculously space-geeky."

Online discussions of spacecraft and mission science are only a small part of unmannedspaceflight.com's allure to the truly space geeky. The majority of the site, and its appeal, is dedicated to those stark and beautiful and sometimes puzzling images coming down from Spirit and Opportunity each and every day.

Of course, not all Mars rover imagery that makes its way into the public consciousness is meant to be taken seriously (we think). Like Madison Avenue's pitch for an adult beverage that puts a new angle on the search for life in our solar system — available for viewing on YouTube at *www.youtube.com/watch?v=x_iPvUWyzhE*. Or a brace of commercials where both Mars rovers and their mission controllers meet their intellectual superiors on the martian surface: *www.youtube.com/watch?v=ZvY9vMAMxc4* and *www.youtube.com/watch?v=ZYzM1M1X790&feature=PlayList&p=74F444229EB256C3&playnext=1&index=98*. Or the hilarious "Mars 2020: Springtime" (*www.youtube.com/watch?v=yjiGH9QNiU0*) where multiple aspiring Mars landers meet an ignominious fate, much to the chagrin of local residents.

"Like any travel adventure, a big part of the fun is sharing the experience with family and friends back home," said John Callas, Mars Exploration Rover project manager at JPL. "For five years now, it has been very rewarding to see the fascination — and the love — for the rovers that runs deep and knows no international boundaries. And as many ways as we can find to share the experience of exploring Mars, we now know that many out in the general public will find even more ways to enrich the whole experience for everyone."

For more information about NASA's Mars Exploration Rovers, visit *marsrovers.nasa.gov/home/*.

LPI Career Development Award Recipients Announced

The Lunar and Planetary Institute (LPI) is proud to announce the winners of the LPI Career Development Award. The award is given to graduate students who submitted a first-author abstract to the 40th Lunar and Planetary Science Conference (LPSC), and recipients will receive a $750.00 travel stipend to help cover their expenses for attending the conference.

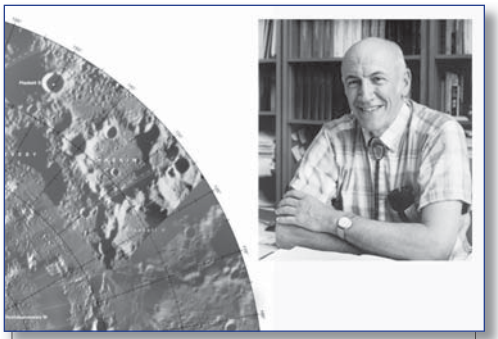
More than 1500 lunar and planetary scientists from all over the world gather each year for the annual LPSC, which has gained the reputation of being the premiere gathering place for scientists in this field. The meeting provides an invaluable opportunity for students, not only to present their own research, but also to hear and see first-hand the latest-breaking results from other researchers in their field. Opportunities are also provided for students to meet and network with an international group of distinguished researchers.

Congratulations to the 2009 recipients:

Paul Byrne, *Trinity College*
Colin Dundas, *University of Arizona*
Itay Halevy, *Harvard University*
Christa Hasenkopf, *University of Colorado*
Briony Horgan, *Cornell University*
Matthew Izawa, *University of Western Ontario*
Tomas Kohout, *University of Helsinki*
Anna Losiak, *Michigan State University*
Nancy McKeown, *University of California, Santa Cruz*
Michael Poelchau, *Museum für Naturkunde*
Rachel Smith, *University of California, Los Angeles*

The LPI maintains a highly focused education effort chartered to engage, excite, and educate the public about lunar and planetary science and invests in the development of future generations of scientists. The LPI Career Development Award has been provided from the generous endowments that the LPI has received over the past year from those in the community who are equally committed to the education of students in lunar and planetary science.

IAU Formally Adopts Name Haskin Crater



Moon image from the USGS Gazetteer of Planetary Nomenclature; Haskin photo courtesy of Washington University, St. Louis.

When Riccioli gave names to lunar craters in 1651, many were for his contemporaries, scholars he knew. This is happening again, with the recent addition of Ryder Crater in 2006 (named after Graham Ryder, 1949–2002) and now Haskin Crater, named in honor of Larry Haskin. Haskin died in 2005 of myelofibrosis, a bone marrow disease for which he had been treated for more than 15 years. He was 70 years old.

Haskin was a highly regarded lunar geochemist who was a major contributor to the Lunar and Planetary Science Conference for decades until his death in 2005. In the 1960s, his research helped establish the field of rare-earth-element geochemistry. In 1969, he was one of the researchers to study the first lunar samples returned by the Apollo 11 mission.

In 1973 he became Chief of the Planetary and Earth Sciences Division at the NASA Johnson Space Center (JSC) in Houston. One of his major accomplishments at JSC was to begin the task of securing the lunar sample collection for future researchers by building a safer, modern curatorial facility. Haskin continued his lunar research until his death.

Haskin's work on the Moon included many important discoveries, with the recognition of the Procellarum KREEP terrain as one of his final contributions. The IAU officially gave Haskin's name to a farside crater on January 22, 2009, along with 18 other scientists, most Nobel Prize winners. The crater Haskin is a degraded 58-km-wide feature, about 10° degrees from the north pole.

NASA Announces Winner of Lunar Lander Challenge

NASA recognized Armadillo Aerospace, the winner of the 2008 Northrop Grumman Lunar Lander Challenge, during a ceremony in December at NASA Headquarters. The winning vehicle successfully demonstrated some of the technologies needed for a lunar lander capable of ferrying payloads or humans back and forth between lunar orbit and the Moon's surface.

During the ceremony, NASA Administrator Mike Griffin spoke about NASA's commitment to commercial space development, and Doug Comstock, director of NASA's Innovative Partnerships Program, presented a ceremonial check for $350,000 to the Armadillo Aerospace team leader, John Carmack.

John Carmack (second from left), team leader for Armadillo Aerospace, is presented with a ceremonial check at the Lunar Landing Challenge awards ceremony.

Armadillo Aerospace won first prize in the level one competition of the challenge held at the Las Cruces International Airport in New Mexico last October. The team constructed a rocket-powered vehicle that lifted off vertically to a height of 50 meters, flew horizontally to a landing pad 100 meters away, landed safely after at least 90 seconds of flight time, and repeated the flight.

NASA's Centennial Challenges is a prize program to promote technical innovation through competitions. The Lunar Lander Challenge is one of seven current competitions designed to tap the nation's ingenuity in support of NASA's goals and missions. For more information about NASA innovation efforts, visit *ipp.nasa.gov*.

NASA Receives Shorty Twitter Award

NASA's activities in social networking media were recognized on February 11, when the agency received an award for its presence on the popular website Twitter. Known as the Shorty Award, it was created to honor the best producers of short content on Twitter during 2008. Updates on NASA's Mars Phoenix Lander mission received the most votes in the science category from users of the site.

The Mars Phoenix Twitter delivered more than 600 updates during the 152 days the lander was operating in the north polar region of Mars. By the end of the lander's mission in early November, more than 38,000 people were following its reports, called "tweets." The account is still used to provide updates on the mission's science results and has more than 41,000 followers.

"We created the account, known as Mars Phoenix, last May with the goal of providing the public with near real-time updates on the mission," said Veronica McGregor, manager of the news office at NASA's Jet Propulsion Laboratory, and originator of the updates. "The response was incredible. Very quickly it became a way not only to deliver news of the mission, but to interact with the public and respond to their questions about space exploration."

Twitter allows people to follow accounts of their choosing through the web, or by having updates sent to their mobile phones. Users post short updates that are limited to 140 characters or less. The Shorty Awards were created by Sawhorse Media in New York and are supported by a grant from the John S. and James L. Knight Foundation in Miami.

NASA's Mars Phoenix Twitter site is at *twitter.com/marsphoenix*. In addition to the Mars Phoenix site, NASA maintains another Twitter feed that includes updates on other agency programs at *twitter.com/nasa*. For more information about the Shorty Awards, and a complete listing of award winners, visit *shortyawards.com*.

Steven J. Ostro

Dr. Steven Jeffrey Ostro, a senior research NASA scientist who pioneered the field of asteroid radar astronomy, died on December 15, 2008, at age 62, following a two-and-a-half year battle with cancer.

Ostro earned bachelor's degrees in liberal arts and ceramic science from Rutgers University; a master's degree in engineering physics from Cornell University; and a doctorate in planetary sciences from the Massachusetts Institute of Technology. Beginning in 1979, after a personal invitation from Carl Sagan, Ostro served as an assistant professor at Cornell University. In 1984, he began creating his life's legacy through his work at NASA's Jet Propulsion Laboratory.

Essentially, Ostro created the field of asteroid radar astronomy, as well as mentoring and training the next group of scientists. Using the radar strength of radio telescopes such as the 305-meter telescope located at Arecibo Observatory in Puerto Rico and the telescopes at Goldstone Observatory in California, Ostro and his team produced fascinatingly detailed images of asteroids. In applying radar techniques to asteroids, he not only revolutionized the capacity to study the position, shape, size, spin state, and geological surfaces of these objects, but also greatly increased astronomers' ability to predict potential close encounters of asteroids with Earth, pushing predictions up to ten times further into the future. Ostro's work could also directly aid any potential manned missions to asteroids in future years, which could someday lead to the mining of these objects for natural resources.

Notable observations by Ostro include 4179 Toutatis, a contact binary asteroid with an exceptionally unique rotation state; 1999 KW4, one of the first binary near-Earth asteroids known; and 216 Kleopatra, the first asteroid confirmed to have a surface composition of nickel-iron. In addition to asteroid research, Ostro used the Cassini-Huygens RADAR instrument to observe the icy satellites of Jupiter and Saturn, while radar observations of the moons of Mars clarified knowledge of their orbits.

In 2003, the Division for Planetary Sciences of the American Astronomical Society awarded Ostro the prestigious Gerard P. Kuiper Prize for outstanding contributions to the field of planetary science. In both 1991 and 2004, Ostro was awarded NASA Medals for Exceptional Scientific Achievement as a result of his scientific accomplishments as well as his excellent leadership. The asteroid 3169 Ostro, discovered June 4, 1981, is named in his honor.

Mario H. Acuña

Dr. Mario H. Acuña, a research scientist at NASA Goddard Space Flight Center, passed away on March 5, 2009, after a lengthy and brave battle against multiple myeloma, a cancer of the blood.

Born March 21, 1940, in Córdoba, Argentina, Acuña became a naturalized U.S. citizen in April 1994. He earned a B.A. degree from the Universidad Nacional de Córdoba in 1958, an MSEE degree from the Universidad Nacional de Tucumán in 1967, and a Ph.D. from the Catholic University of America in 1974.

Acuña joined the staff of NASA Goddard in the early 1970s, first working as a research scientist in the Space Plasmas and Planetary Magnetospheres Branches, and then as a Senior Astrophysicist. He was a major pioneer in the field of planetary magnetism, and an original co-investigator on the MESSENGER mission from the time of the team's first proposal 13 years ago.

Acuña was a principal investigator on experiments flown on numerous missions over the years, from the Pioneer 11 Fluxgate Magnetometer Experiment in 1973 to the Mars Global Surveyor Magnetic Field Experiment in 1994. He was also the recipient of many professional awards, including the Moe Schneebaum Memorial Award (the highest engineering award at Goddard), the NASA Exceptional Scientific Achievement Medal, and the NASA Distinguished Service Medal.

Acuña passed away peacefully in the comfort of his home, surrounded by his family and loved ones, and content with all that life afforded him. His loss will be deeply felt by all who follow the progress of planetary science and space plasma physics.

Wolf von Engelhardt

Wolf Jürgen Freiherr von Engelhardt died on December 4, 2008, at the age of 98, in Tübingen, Germany. von Engelhardt was born on February 9, 1910, in Dorpat (Tartu), Estonia. He received his university education at the University of Halle, Germany, and his Ph.D. in 1935 at the University of Göttingen, Germany, under the supervision of the famous geochemist Victor Moritz Goldschmidt, with a dissertation on the geochemistry of barium. Later on, he joined the working group of Prof. Correns, the founder of modern sedimentology in Germany, at the University of Rostock. von Engelhardt completed the "Habilitation" (venia legendi) at Correns' institute in Göttingen in 1940, where he became Professor of Mineralogy in 1944. After World War II he joined Gewerkschaft Elwerath, a German oil exploration company. In 1957 he was appointed Professor of Mineralogy and Petrography and Director of the "Mineralogisch-Petrographisches Institut" of the University of Tübingen, where he remained until he became Professor Emeritus in 1978.

von Engelhardt was active as a scientist for more than 75 years and published more than 200 articles in journals and 20 books on a wide variety of topics. His fields of interest were extremely broad and often highly interdisciplinary. Starting as a geochemist, he became an internationally recognized expert in sedimentology and published a three-volume book on sedimentary petrography in 1967. Motivated by the discovery of coesite and stishovite in the Ries crater, he moved to a new field of interest — impact craters, including shock metamorphism of rocks and minerals, and lunar and planetary science, where he soon became a leading scientist. Together with his co-workers, he participated in the study of lunar rocks as a Principal Investigator of the Apollo and post-Apollo programs.

One of von Engelhardt's most impressive traits was his ability to combine natural science with philosophy and the history of science. He was instrumental in the modern analysis of publications and manuscripts on natural science and geology by Germany's greatest poet, Johann Wolfgang von Goethe. Among many articles on this topic, he edited more than a dozen books on Goethe's "Naturwissenschaftliche Schriften." Moreover, he published articles on the great revolutions in geology, such as the debate between neptunists and plutonists and the big step from Earth-bound geology to planetary geology, which he called "the Copernican change in geology." von Engelhardt continued to do research, mainly in the field of impact cratering, and specifically on the Ries impact crater and related tektites, and on Goethe's studies of natural science well into his nineties. Among these many contributions are a most impressive 2001 article on the debate between Goethe and Alexander von Humboldt entitled, "Goethe and Alexander von Humboldt — Bau und Geschichte der Erde" ("Constitution and History of the Earth") and a last major paper on impact processes — the formation of moldavite tektites — that appeared in 2005 in *Meteoritics and Planetary Science*.

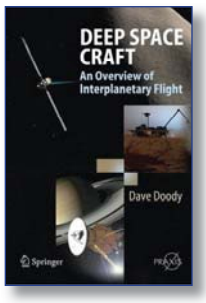
von Engelhardt was an extraordinary teacher, and his lectures usually attracted large numbers of students. Many of them received their diploma and Ph.D. under his supervision, and two of his Ph.D. students were awarded the Barringer Medal. Also active in administration and professional organizations, von Engelhardt served as "Rektor" (President) of the University of Tübingen from 1963 to 1964 and later served as President of the "Deutsche Mineralogische Gesellschaft" (German Mineralogical Association) and President of the "Geologische Vereinigung" (Geological Association).

On the occasion of his 75th birthday, he was awarded the "Großes Bundesverdienstkreuz," which is the highest and only honor conferred to individuals by the Federal Republic of Germany. Asteroid (4217) 1988 BO2 was named after him, and he received the Abraham-Gottlob-Werner Medal from the German Mineralogical Association in 1980. He also was one of the first "big five" recipients of the Barringer Medal of the Meteoritical Society: Shoemaker (1984), Dietz (1985), Gault (1986), von Engelhardt (1987), and Dence (1988).

We, as his students and grand-students, the whole scientific community in the field of planetary science, and the members of the Meteoritical Society have lost a great mentor, scholar, and wonderful colleague of the old school. We will keep him firmly in our memory.

— Dieter Stöffler and Wolf Uwe Reimold, Berlin, January 2009

Books

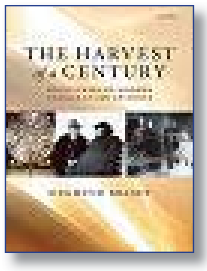


Deep Space Craft: An Overview of Interplanetary Flight. Dave Doody. Springer Praxis, 2009. 300 pp., Hardcover, $129.00. *www.springer.com*

Deep Space Craft opens the door to interplanetary flight. It looks at this world from the vantage point of real operations on a specific mission, and follows a natural trail from the day-to-day working of this particular spacecraft, through the functioning of all spacecraft, to the collaboration of the various disciplines to produce the results for which a spacecraft is designed. The author shows how, in order to make sense of all the scientific data coming back to Earth, the need for experiments and instrumentation arises, and follows the design and construction of the instruments through to their placement and testing on a spacecraft prior to launch. This highly focused, insider's guide to interplanetary space exploration uses many examples of previous and current endeavors. It enables the reader to research almost any topic related to spacecraft and to seek the latest scientific findings, the newest emerging technologies, or the current status of a favorite flight. In order to provide easy paths from the general to the specific, the text constantly refers to the Appendices. Within the main text, the intent is general familiarization and categorization of spacecraft and instruments at a high level, to provide a mental framework to place in context and understand any spacecraft and any instrument encountered in the reader's experience.

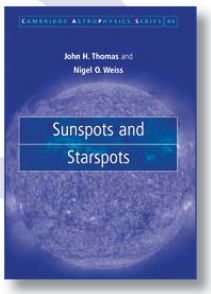
Canada's Fifty Years in Space: The COSPAR Anniversary. Gordon Shepherd and Agnes Kruchio. Apogee Books, 2008. 280 pp., Paperback, $26.95. *www.apogeespacebooks.com*

Detailing the last 50 years of the Canadian space science program, this extensive history explores everything from the aurora borealis studies of the late 1950s to the current Radarsat-1 and Canada's involvement with the NASA Phoenix mission. The people behind the country's spacecraft and programs and the long-overdue development of the Canadian Space Agency (CSA) are thoroughly discussed as well as the parallel growth of the Canadian space program and the Committee on Space Research (COSPAR). Never-before-published information on the ISIS-II satellite is also included.



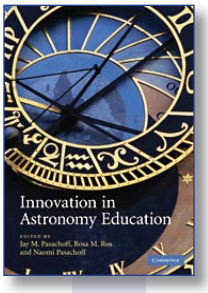
The Harvest of a Century: Discoveries in Modern Physics in 100 Episodes. Siegmund Brandt. Oxford University Press, 2008. 520 pp., Hardcover, $70.00. *www.oup.com*

Physics was the leading science of the twentieth century and the book retraces important discoveries, made between 1895 and 2001, in 100 self-contained episodes. Each is a short story of the scientists involved, their time, and their work. Together, they formed a mosaic of modern physics: formulating relativity and quantum mechanics, finding the constituents of matter and unraveling the forces between them, understanding the working of conductors and semiconductors, discovering and explaining macroscopic quantum effects (superconductivity, superfluidity, quantum Hall effect), developing novel experimental techniques like the Geiger counter and particle accelerators, building revolutionary applications like the transistor and the laser, and observing astonishing features of our cosmos (expanding universe, cosmic background radiation). The text is intended for easy reading. Occasionally, a more thorough discussion of experimental set-ups and theoretical concepts is presented in special boxes for readers interested in more detail. Episodes contain extensive references to biographies and original scientific literature. The book is richly illustrated by about 600 portraits, photographs, and figures.



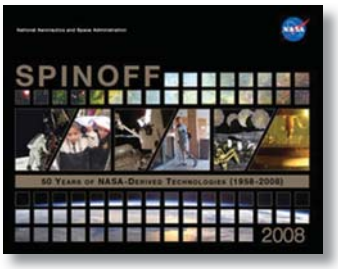
Sunspots and Starspots. By John H. Thomas and Nigel O. Weiss. Cambridge University Press, 2008. 296 pp., Hardcover, $130.00. *www.cambridge.org*

Written from both an observational and historical perspective, this book is the first to provide a comprehensive combined account of sunspots and starspots. It begins with a substantial historical introduction, then explores the intricate structure of a sunspot's magnetic field and the prevalence of polar spots on stars. Additional topics covered in depth include solar and stellar magnetic activity, dynamo models of magnetic cycles, and the influence of solar variability on Earth's magnetosphere and climate. It is a valuable reference for graduate students and specialists in solar and stellar physics, astronomers, geophysicists, space physicists, and experts in fluid dynamics and plasma physics.



Innovation in Astronomy Education. Edited by Jay M. Pasachoff, Rosa M. Ros, and Naomi Pasachoff. Cambridge University Press, 2008, 384 pp., Hardcover, $140.00. *www.cambridge.org*

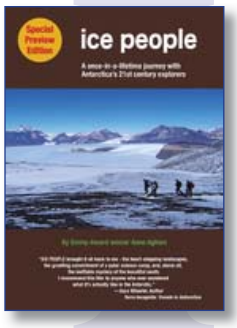
Astronomy leads to an understanding of the history and nature of science, and attracts many young people to education in science and technology. But while in many countries astronomy is not part of the standard curriculum, many scientific and educational societies and government agencies have produced materials and educational resources in astronomy for all educational levels. This volume highlights the general strategies for effective teaching and introduces innovative points of view regarding methods of teaching and learning, particularly those using new technologies. Technology is used in astronomy both for obtaining observations and for teaching. The book also presents ideas for how astronomy can be connected to environmental issues and other topics of public interest. This valuable overview is based on papers and posters presented by many of the world's leading astronomy educators at a Special Session of the International Astronomical Union General Assembly in Prague in 2006.



NASA Spinoff 2008: 50 Years of NASA-Derived Technologies (1958–2008). Produced by the Innovative Partnerships Program. NASA, 2008, 215 pp., Paperback, free of charge. *www.sti.nasa.gov/tto*

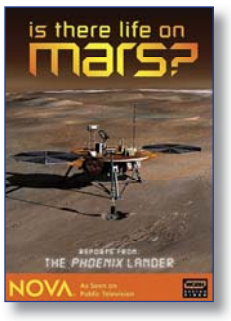
Spinoff is NASA's annual premier publication featuring successfully commercialized NASA technology. For more than 40 years, the NASA Innovative Partnerships Program has facilitated the transfer of NASA technology to the private sector, benefiting global competition and the economy. The resulting commercialization has contributed to the development of commercial products and services in the fields of health and medicine, industry, consumer goods, transportation, public safety, computer technology, and environmental resources. Since 1976, *Spinoff* has featured between 40 and 50 of these commercial products annually. Copies can be viewed as full-text documents or requested online.

DVDs



Ice People. Produced and directed by Anne Aghion, 2008, one disc. $24.95. *www.icepeople.com*

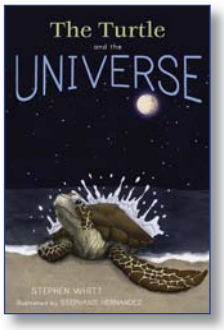
Ice People takes you on one of Earth's most seductive journeys — Antarctica. Emmy-winning documentary filmmaker Anne Aghion spent four months "on the ice" with modern-day polar explorers, to find out what drives dedicated researchers to leave the world behind in pursuit of science, and to capture the true experience of living and working in this extreme environment. Only a small number of scientific research teams get there, braving severe conditions to learn about our planet's history, and make predictions about our future. *Ice People* heads out into the "deep field" with noted geologists Allan Ashworth and Adam Lewis, and two undergraduate scientists-in-the-making, where they scour across hundreds of miles to find tiny, critical signs of ancient life. Their findings would give the first evidence of a green Antarctica over 14 million years ago, that disappeared with a sudden shift in the temperature of the continent. The most authentic film about life on the ice since the trailblazing expeditions to Antarctica chronicled nearly a century ago, *Ice People* conveys the vast beauty, the claustrophobia, the excitement, and the stillness of an experience set to nature's rhythm.



Is There Life on Mars? Reports from the Phoenix Lander. Produced by PBS/WGBH, 2008, one disc. $24.95. *www.shoppbs.org*

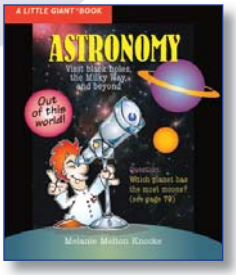
NASA's twin robot explorers, Spirit and Opportunity, have lasted for five years on Mars. And since May 25, 2008, they've had company: NASA's Phoenix probe, which dramatically "tasted" water ice on the planet in July. This NOVA program showcases the latest scientific results from the rovers and Phoenix, which are poised to reveal provocative new clues in the tantalizing search for water and life on the Red Planet.

FOR KIDS!!!



The Turtle and the Universe. Stephen Whitt. Prometheus Books, 2008. 86 pp., Paperback, $14.98. *www.prometheusbooks.com*

Science educator Stephen Whitt follows a mother sea turtle on the most difficult and dangerous journey of her life, the journey home to lay her eggs. Along the way he shows young readers how the events of the universe, many of them both far away and long ago, have resulted in a world where a turtle may swim through a salty sea, struggle up a sandy beach, and dig her nest just beyond the reach of the highest tide. This is a story of connection — through the life and struggles of one female turtle, youngsters learn that the universe is a single thing. Everything within the universe is linked to everything else, by time, by origin, by ultimate fate. In the elements that make up the sea turtle there are shadows of an exploded star from far away and long ago. In the movement of the turtle's flippers is the energy of the fireball that began our universe some 13 billion years ago. In the sand, in the seawater, in the eggs the turtle lays there are hints of the deep connections shared by all the things, and all the events, that we call the universe. Whitt also reveals how the actions of our own species are altering the world that we and the sea turtle share. He underscores the necessity of using our natural resources wisely to ensure the future of the whole interconnected Earth. This elegantly told story captures the many wonders that science discovers in the natural world while teaching children essential facts of astronomy, chemistry, and biology. For ages 9–12.



A Little Giant Book: Astronomy. Melanie Melton Knocke. Sterling Publishing, 2008. 352 pp., Paperback, $6.95. *www.sterlingpublishing.com*

This little book with big information will send kids flying into outer space to explore our fascinating universe. They'll learn about the planets, moons, and stars. But this lively information-packed guide also includes fantastic astronomical phenomena that will make a child's eyes open wide in amazement: everything from black holes to white dwarfs to red giants. The voyage begins in our own solar system, starting with the Sun and proceeding from Mercury to Pluto — with the occasional asteroid, comet, and meteor thrown in. Follow a star's life from beginning to end; do "deep sky" astronomy (the study of objects beyond our system), and have fun observing the heavens through binoculars and telescopes. There's lots of cool trivia and quizzes throughout, too! For ages 8–12.

A Traveler's Guide to the Solar System. By Patricia Barnes-Svarney. Sterling Publishing, 2008. 96 pp., Paperback, $6.95. *www.sterlingpublihing.com*

What would it be like to walk on a martian plain? Watch wild volcanos on Jupiter? All it takes to find out is a touch of imagination and this entertaining guide to the solar system, illustrated with NASA's most up-to-date color photos. So get ready to blast off, and fly through the skies from Mercury to Pluto, stopping to visit planets, asteroids, and moons along the way. Feel Venus' intense pressure and heat, thanks to a thick blanket of carbon dioxide. Alight on Saturn and gaze at its beautiful and mysterious rings. See greenish-blue Uranus, which takes 84 Earth-years to travel around the Sun. There's lots of fun information, related in a simple, appealing style kids will easily understand and enjoy. For ages 8–10.

GeoSafari Motorized Solar System. From Educational Insights. $32.99. *www.educationalinsights.com*

The "Sun" shines onto the nine planets as they orbit around it. The central tower and planetary support rods are black so that they "disappear" in a darkened room for a spectacular effect! Replace the solar dome with the star dome included to create a spectacular planetarium sky complete with major constellation names. In addition, the base features a special 1000-hour light bulb and planetary longitude marks so the planets can be set up to their correct positions. The solar system model is powered either by four C batteries (not included) or by an optional AC adapter (not included). For first grade and up.

March

2–6 **Planet Formation and Evolution: The Solar System and Extrasolar Planets**, Tuebingen, Germany. *www.tat.physik.uni-tuebingen.de/~fgp/Conf09/*

3–4 **Mars Exploration Program Analysis Group (MEPAG)**, Washington, DC. *mepag.jpl.nasa.gov/meeting/mar-09/index.html*

7–14 **2009 IEEE Aerospace Conference,** Big Sky, Montana. *www.aeroconf.org/*

9–10 **Outer Planets Assessment Group Meeting,** Bethesda, Maryland. *www.lpi.usra.edu/opag*

9–12 **Exoplanets and Disks: Their Formation and Diversity,** Keauhou, Hawaii. *www.naoj.org/SubaruConf09/*

16–19 **From Disks to Planets: Learning from Starlight (2009 EARA Workshop),** Leiden, The Netherlands. *www.lorentzcenter.nl/lc/web/2009/341/info.php3?wsid=341*

19–22 **NSTA National Conference on Science Education,** New Orleans, Louisiana. *www.nsta.org/conferences/2009new/*

21–22 **Volcanism on the Moon and Mercury: A New Paradigm in Comparative Planetology (Brown-Vernadsky Microsymposium 49),** The Woodlands, Texas. *www.planetary.brown.edu/html_pages/micro49.htm*

22 **MRO/CRISM Data Users' Workshop,** The Woodlands, Texas. crism.jhuapl.edu/CRISM_workshop_2009

23–27 **40th Lunar and Planetary Science Conference**, The Woodlands, Texas. *www.lpi.usra.edu/meetings/lpsc2009/*

April

2–4 **Conference on Micro-Raman Spectroscopy and Luminescence Studies in the Earth and Planetary Sciences**, Mainz, Germany. *www.lpi.usra.edu/meetings/spectroscopy2009/*

3–5 **CONTACT 2009**, Mountain View, California. *www.contact-conference.org*

6–10 **Astrophysical Magnetohydrodynamics**, Kiljava, Finland. *agenda.albanova.se/conferenceDisplay.py?confId=884*

19–24 **European Geosciences Union General Assembly**, Vienna, Austria. *meetings.copernicus.org/egu2009/*

20–23 **Microanalysis of Particles II**, Westmont, Illinois. *www.microbeamanalysis.org/meetings/topical/Particles2009/index.htm*

21–23 **Missions for Exoplanets: 2010–2020**, Pasadena, California. *exep.jpl.nasa.gov/exep_workshop.cfm*

26–30 **Hotwiring the Transient Universe 2: Real Time Astronomy,** Santa Cruz, California. www.cacr.caltech.edu/hotwired2/

27–30 **First IAA Planetary Defense Conference: Protecting Earth from Asteroids**, Granada, Spain. *www.congrex.nl/09c04/*

27–May 1 **Relativity in Fundamental Astronomy: Dynamics, Reference Frames, and Data Analysis (IAU Symposium 261)**, Virginia Beach, Virginia. *www.aas.org/divisions/meetings/iau/*

May

2–5 **American Astronomical Society Division on Dynamical Astronomy Meeting**, Virginia Beach, Virginia. *dda.cfa.harvard.edu/meetings/2009/*

4–8 **53rd Meeting of the Italian Astronomical Society (SAIt2009),** Pisa, Italy. *astro.df.unipi.it/sait09/index.php?m=1*

10–15 **Bolides and Meteorite Falls**, Prague, Czech Republic. *www.bolides09.com/*

11–15 **International Conference on Comparative Planetology: Venus — Earth — Mars**, Noordwijk, The Netherlands. *www.rssd.esa.int/eslab-2009/*

16–21 **Japan Geoscience Union Meeting**, Chiba City, Japan. *www.jpgu.org/meeting_e/*

18–20 **Scientific Writing for Young Astronomers,** Blankenberge, Belgium. *www.swya.org/*

18–21 **Joint Subaru/Gemini Science Conference,** Kyoto, Japan. *www.kusastro.kyoto-u.ac.jp/kyoto2009/index.html*

24–27 **Joint Assembly of the AGU, GAC, MAC, CGU: The Meeting of the Americas**, Toronto, Canada. *www.agu.org/meetings/ja09/*

June

1–3 **Workshop on Modeling Martian Hydrous Environments,** Houston, Texas. *www.lpi.usra.edu/meetings/hydrous2009*

1–5 **The 2nd Chaotic Modeling and Simulation International Conference (CHAOS 2009),** Chania, Greece. *www.chaos2009.net/*

7–11 **17th IAA Humans in Space Symposium,** Moscow, Russia. *iaa-his2009.imbp.ru/index00e-s.html*

7–11 **214th American Astronomical Society Meeting,** Pasadena, California. *aas.org/meetings/aas214*

8–12 **Millimeter and Submillimeter Astronomy at High Angular Resolution,** Taipei, Taiwan. *www2.asiaa.sinica.edu.tw/taipei09/*

9–11 **Lunar Reconnaissance Orbiter Science Targeting Meeting,** Tempe, Arizona. *ser.sese.asu.edu/LSM/*

13–14 **7th International Planetary Probe Short Course**, Barcelona, Spain. *www.planetaryprobe.eu/*

15–19 **7th International Planetary Probe Workshop (IPPW-7)**, Barcelona, Spain. *www.planetaryprobe.eu/*

15–29 **Seventh Serbian Conference on Spectral Line Shapes in Astrophysics**, Zrenjanin, Serbia. *www.scslsa.matf.bg.ac.yu/*

21–26 **Goldschmidt Conference 2009: Challenges to Our Volatile Planet**, Davos, Switzerland. *www.goldschmidt2009.org/*

21–26 **Evolution of Planetary and Stellar Systems: Dynamical Interactions with DNC Lin**, Prato, Italy. *users.monash.edu.au/~ro/LinFest/*

22–26 **First International Conference on Adaptive Optics for Extremely Large Telescopes**, Paris, France. *ao4elt.lesia.obspm.fr/*

July

5–10 **Gordon Conference on the Origin of Solar Systems**, South Hadley, Massachusetts. *www.grc.org/programs.aspx?year=2009&program=origins*

6–11 **Seventh International Conference on Geomorphology (ANZIAG)**, Melbourne, Australia. *www.geomorphology2009.com/*

13–18 **72nd Annual Meeting of the Meteoritical Society**, Nancy, France. *www.lpi.usra.edu/meetings/metsoc2009/*

27–31 **Magnetospheres of the Outer Planets 2009**, Cologne, Germany. *mop2009.uni-koeln.de/*

August

2–7 **42nd IUPAC Congress: Chemistry Solutions**, Glasgow, Scotland. *www.rsc.org/ConferencesAndEvents/RSCConferences/IUPAC2009/*

3–7 **IAU Symposium 263: Icy Bodies in the Solar System,** Rio de Janeiro, Brazil. *www.astronomia.edu.uy/congresos/symp263/*

3–14 **IAU XXVII General Assembly**, Rio de Janeiro, Brazil. *www.astronomy2009.com.br/*

11–15 **Sixth Annual Meeting and Exhibition of the Asia Oceania Geosciences Socity (AOGS 2009)**, Suntec City, Singapore. *www.asiaoceania.org/aogs2009/index.asp*

23–29 **International Association of Geomagnetism and Aeronomy (IAGA) 11th Scientific Assembly**, Sopron, Hungary. *www.iaga2009sopron.hu/*

24–26 **International Conference on Space Technology**, Thessaloniki, Greece. *www.icspacetechnology.com/*

30–Sept 5 **Natural Dynamos**, Stará Lesná, Slovakia. *rebel.ig.cas.cz/Tatry2009/*

September

13–18 **European Planetary Science Congress 2009 (EPSC 2009),** Potsdam, Germany. *meetings.copernicus.org/epsc2009/*

14–18 **Pathways Towards Habitable Planets,** Barcelona, Spain. *www.pathways2009.net/*

20–23 **Sedimentology and Stratigraphy in the Inner and Outer Solar System,** Alghero, Italy. *europlanet.cesr.fr/pages/evt/docs/Calendar_September20-23_2008_IAS.pdf*

21–25 **Deciphering the Universe Through Spectroscopy: The 82nd Annual Meeting of the Astronomische Gesellschaft (AG),** Potsdam, Germany. *www.aip.de/AG2009/*

21–25 **International Conference on Asteroid-Comet Hazard 2009,** St. Petersburg, Russia. *quasar.ipa.nw.ru/conference/ach2009/*

24–27 **International Meteor Conference 2009,** Porec, Croatia. *www.imo.net/imc2009/*

October

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

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/*

28–30 **Space Resources Roundtable XI,** Golden, Colorado. *www.isruinfo.com/*