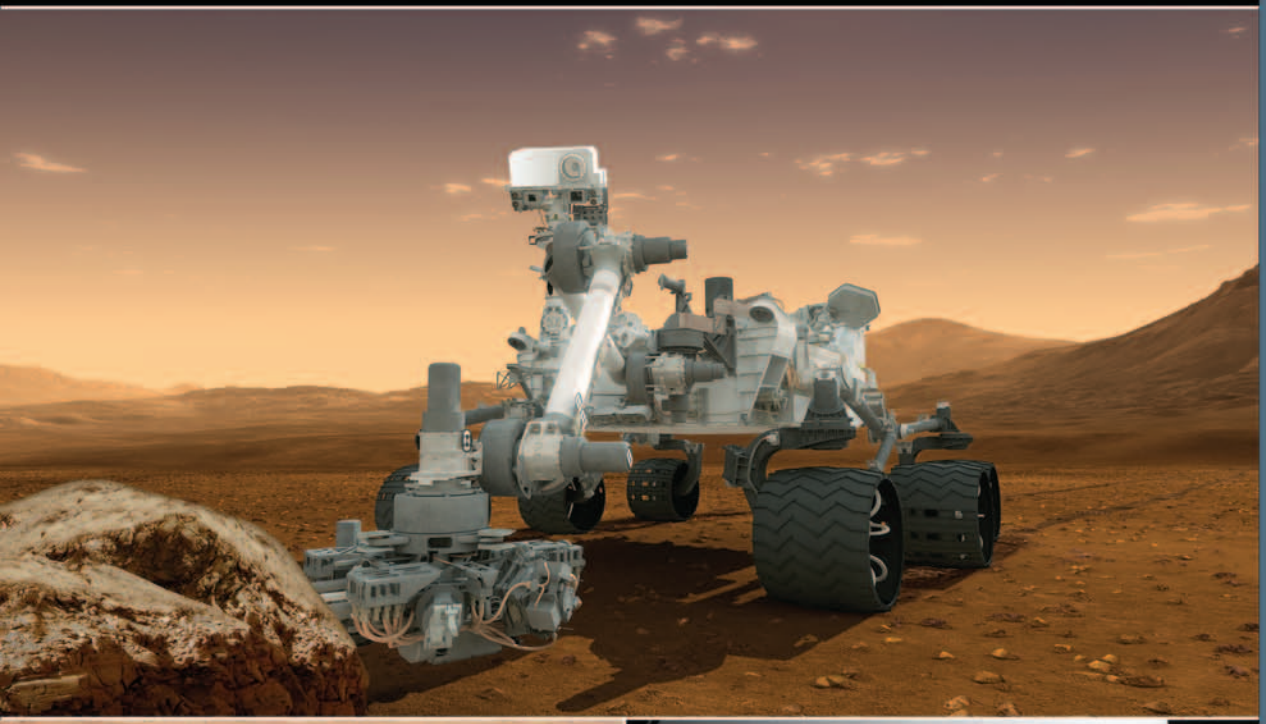
CURIOSITY
GETS THE BETTER OF MARS



CONTENTS

Lunar and Planetary Information

BULLETIN

August 2012
Issue 130

Universities Space Research Association — Lunar and Planetary Institute

www.lpi.usra.edu/lpib

Curiosity Gets the Better of Mars

In the early morning hours of August 6 (PST), a large robot the size of a small car landed on Mars. The landing of the Mars Science Laboratory (MSL) was remarkable for several reasons. The complex and unique landing system —which worked beautifully — gave engineers and managers cold sweats as they imagined everything that could potentially go wrong. After all, Mars has had a reputation for eating robots on a regular basis since 1961, including an ill-fated Russian attempt late last year to land on the Mars moon Phobos. The joy (and relief) that greeted touchdown was palpable. The mission and landing represented an investment of $2.5 billion and many, many manhours of effort. It was indeed an accomplishment to be proud of.

Crowds watch The Toshiba Vision screen in Times Square during the landing of the Curiosity rover on Mars. Credit: Toshiba.

A major and perhaps unexpected effect of the landing was the degree to which the public became involved. Hundreds of thousands of people followed the live streams on NASA TV as engineers monitored the landing, calling out each milestone. When thousands more gathered at public venues to watch the event live — including Times Square in New York City — it was evident that the drama of landing had captured the fascination of the public. Although the rover will take months to reach its main scientific objectives, the mission will likely continue to hold the public's imagination. The sight of the wheeled vehicle driving across Mars is something to which we can all relate on some level. We can even imagine ourselves at the wheel, joyriding across the rocky plains of the Red Planet.

The MSL story is about more than just a six-wheeled dirt-bike, however. It has a major science and exploration mission to perform. It will study whether the area surrounding Gale Crater on Mars has evidence of past and present habitable environments. These studies will be part of a broader examination of past and present processes in the martian atmosphere and on its surface. The research will use 10 instrument-based science investigations.

The payload includes mast-mounted instruments to survey the surroundings and assess potential sampling targets from a distance; instruments on Curiosity's robotic arm for close-up inspections; laboratory instruments inside the rover for analysis of samples from rocks, soils, and atmosphere; and instruments to monitor the environment around the rover.

To make best use of the rover's science capabilities, a diverse international team of scientists and engineers will make daily decisions about the rover's activities for the following day. Even if all the rover's technology performs flawlessly, some types of evidence the mission will seek about past environments may not have persisted in the rock record. While the possibility that life might have existed on Mars provokes great interest, a finding that conditions did not favor life would also pay off with valuable insight about differences and similarities between early Mars and early Earth.

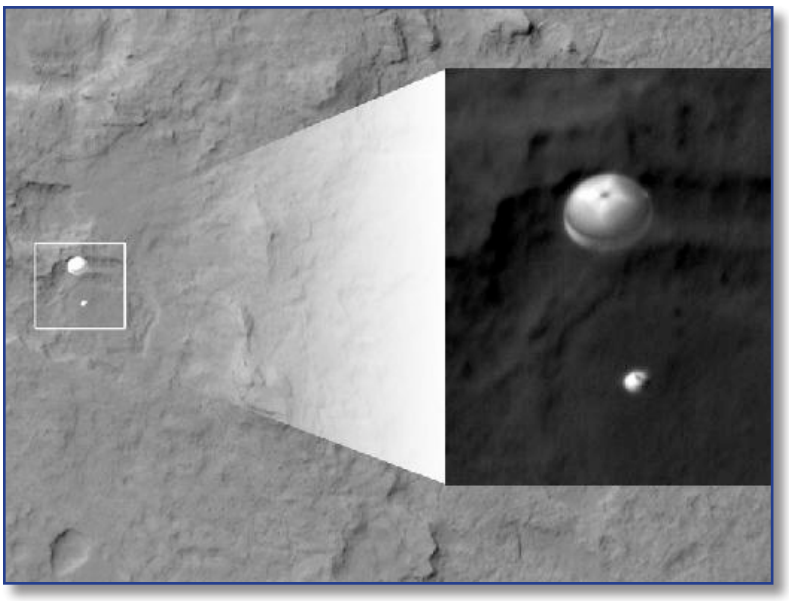
QUICK FACTS

Rover dimensions: Length: 9 feet, 10 inches (3.0 meters) (not counting arm); width: 9 feet, 1 inch (2.8 meters); height at top of mast: 7 feet (2.1 meters); arm length: 7 feet (2.1 meters); wheel diameter: 20 inches (0.5 meters).

Mass: 8463 pounds (3893 kilograms) total at launch, consisting of 1982-pound (899-kilogram) rover; 5293-pound (2401-kilogram) entry, descent, and landing system (aeroshell plus fueled descent stage); and 1188-pound (539-kilogram) fueled cruise stage.

Landing site: 4.6°S latitude, 137.4°E longitude, near base of Mount Sharp (Aeolis Mons) inside Gale Crater.

Whether life has existed on Mars is an open question that this mission, by itself, is not designed to answer. Curiosity does not carry experiments to detect active processes that would signify present-day biological metabolism, nor does it have the ability to image microorganisms or their fossil equivalents. However, if this mission finds that the field site in Gale Crater has had conditions favorable for habitability and for preserving evidence about life, those findings can shape future missions that would bring samples back to Earth for life-detection tests or for missions that carry advanced life-detection experiments to Mars. In this sense, MSL is the prospecting stage in a step-by-step program of exploration, reconnaissance, prospecting, and mining evidence for a definitive answer about whether life has existed on Mars.



NASA's Curiosity rover and its parachute were spotted by NASA's Mars Reconnaissance Orbiter as Curiosity descended to the surface on August 5 (PDT). The High-Resolution Imaging Science Experiment (HiRISE) camera captured this image of Curiosity while the orbiter was listening to transmissions from the rover. Curiosity and its parachute are in the center of the white box; the inset image is a cutout of the rover stretched to avoid saturation. The rover is descending toward the etched plains just north of the sand dunes that fringe Mount Sharp. From the perspective of the orbiter, the parachute and Curiosity are flying at an angle relative to the surface, so the landing site does not appear directly below the rover. Credit: NASA/JPL-Caltech/University of Arizona.

Every environment on Earth where there is liquid water sustains microbial life. For most of Earth's history, the only life forms on this planet were microorganisms, or microbes. Microbes still make up most of the living matter on Earth. Scientists who specialize in the search for life on other worlds expect that any life on Mars, if it has existed at all, has been microbial.

Curiosity landed in a region where this key item on the checklist of life's requirements has already been determined: It was wet. Observations from Mars orbit during five years of assessing candidate landing sites have made these areas some of the most intensely studied places on Mars. Researchers have used NASA's Mars Reconnaissance Orbiter to map the area's mineralogy, finding exposures of clay minerals. Clays, other phyllosilicates, and

Curiosity Gets the Better of Mars

Landing ellipse in Gale Crater, in overhead view with north at top. Credit: NASA/JPL-Caltech/ESA/DLR/FU Berlin/MSSS.

This color-enhanced view of NASA's Curiosity landing site on the surface of Mars was taken by the High Resolution Imaging Science Experiment (HiRISE) on NASA's Mars Reconnaissance Orbiter as the satellite flew overhead. Colors have been enhanced to show the subtle color variations near the rover, which result from different types of materials. The descent stage blast pattern around the rover is clearly seen as relatively blue colors (true colors would be more gray). The scale of this image cutout is about 12 inches (31 centimeters) per pixel. Credit: NASA/JPL-Caltech/University of Arizona.

sulfates form under conditions with adequate liquid water in a life-supporting, medium range between very acidic and very alkaline.

Curiosity will inventory other basic ingredients for life, seek additional evidence about water, and investigate how conditions in the area have changed over time. The wet environment in which the clay minerals formed is long gone, probably occurring more than 3 billion years ago. Examining the geological context for those minerals, such as the minerals in younger rock layers, could advance our understanding of habitat change to drier conditions. The rover can also check for traces of water still bound into the mineral structure of rocks at and near the surface.

Carbon-containing compounds called organic molecules are an important class of ingredients for life that Curiosity can detect and inventory. This capability adds a trailblazing "follow the carbon" aspect to MSL, as part of the sequel to NASA's "follow the water" theme.

Organic molecules contain one or more carbon atoms bound to hydrogen and, in many cases, additional elements. They can exist without life, but life as we know it cannot exist without them, so their presence would be an important plus for habitability. If Curiosity detects complex organics that are important to life on Earth, such as amino acids, these might be of biological origin, but also could come from nonbiological sources, such as carbonaceous meteorites delivered to the surface of the planet.

The rover will definitively identify minerals, which provide a lasting record of the temperatures, pressures, and chemistry present when the minerals were formed or altered. Researchers will add that information to observations about geological context, such as the patterns and processes of sedimentary rock accumulation, to chart a chronology of how the area's environments have changed over

time. Energy for life on Mars could come from sunlight, heat, or mixtures of chemicals with an energy gradient that could be exploited by biological metabolism. The information Curiosity collects about minerals and about the area's modern environment will be analyzed for clues about possible past and present energy sources for life.

Curiosity will measure the ratios of different isotopes of several elements. Isotopes are variants of the same element with different atomic weights. Ratios such as the proportion of carbon-13 to carbon-12 can provide insight into planetary processes. For example, Mars once had a much denser atmosphere than it does today, and if the loss occurred at the top of the atmosphere, that process would favor increased concentration of heavier isotopes in the retained, modern atmosphere. Such processes can be relevant to habitability and biology. Curiosity will assess isotopic ratios in methane if that gas is in the air around the rover. Methane is an organic molecule, and its carbon isotope ratio can be very distinctive. Observations from orbit and from Earth indicate traces of it may be present in Mars' atmosphere. Isotopic ratios could hold clues about whether methane is being produced by microbes or by a nonbiological process.

In summary, the mission has four primary science objectives to meet NASA's overall habitability assessment goal:

- Assess the biological potential of at least one target environment by determining the nature and inventory of organic carbon compounds, searching for the chemical building blocks of life and identifying features that may record the actions of biologically relevant processes
- Characterize the geology of the rover's field site at all appropriate spatial scales by investigating the chemical, isotopic, and mineralogical composition of surface and near-surface materials and interpreting the processes that have formed rocks and soils
- Investigate planetary processes of relevance to past habitability (including the role of water) by assessing the long-timescale atmospheric evolution and determining the present state, distribution, and cycling of water and carbon dioxide
- Characterize the broad spectrum of surface radiation, including galactic cosmic radiation, solar proton events, and secondary neutrons

Science Payload

The science payload is designed to accomplish the above science objectives through use of the following suite of instruments:

Mast Camera (Mastcam)

Two two-megapixel color cameras on Curiosity's mast are the left and right eyes of the Mastcam investigation. These versatile cameras have complementary capabilities for showing the rover's surroundings in exquisite detail in stereo and in motion.

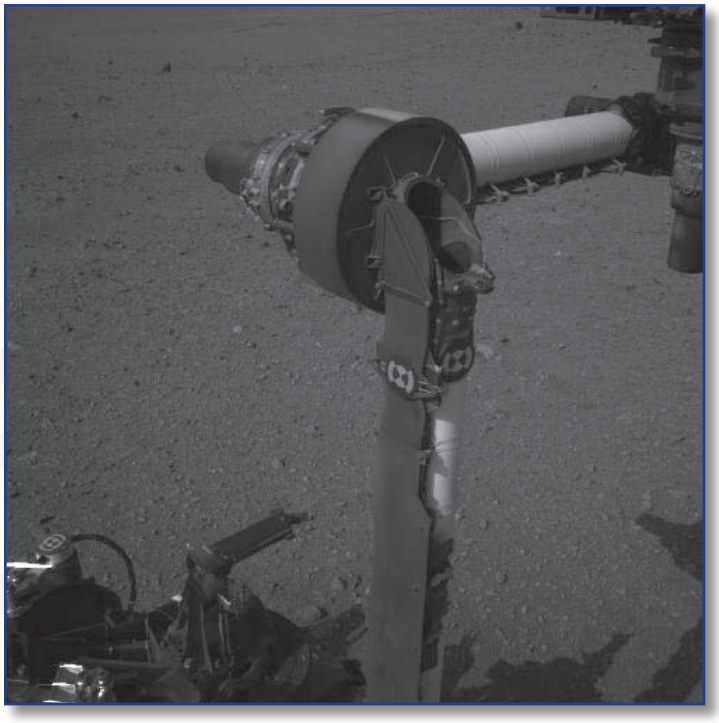
Chemistry and Camera (ChemCam)

ChemCam uses a rock-zapping laser and a telescope mounted on top of Curiosity's mast. It also includes spectrometers and electronics down inside the rover. The laser can hit rock or soil targets up to about 23 feet (7 meters) away with enough energy to excite a pinhead-sized spot into a glowing, ionized gas, called plasma. The instrument observes that spark with the telescope and analyzes the spectrum of light to identify the chemical elements in the target.

Alpha Particle X-Ray Spectrometer (APXS)

The APXS on Curiosity's robotic arm will identify chemical elements in rocks and soils. The APXS instruments on the rovers Sojourner, Spirit, and Opportunity produced important findings from those missions, including salty compositions indicative of a wet past in bedrocks examined by Opportunity and the signature of an ancient hot spring or steam vent in soil examined by Spirit. The APXS on

Curiosity Gets the Better of Mars



This full-resolution image from Curiosity shows the elbow joint of the rover's extended robotic arm on August 20. The Navigation Camera captured this view. Credit: NASA/JPL-Caltech.

Curiosity delivers greater sensitivity, better scheduling versatility, and a new mode for optimal positioning. A pinch of radioactive material emits radiation that "queries" the target and an X-ray detector "reads" the answer. The Canadian Space Agency contributed this Canadian-made instrument for MSL.

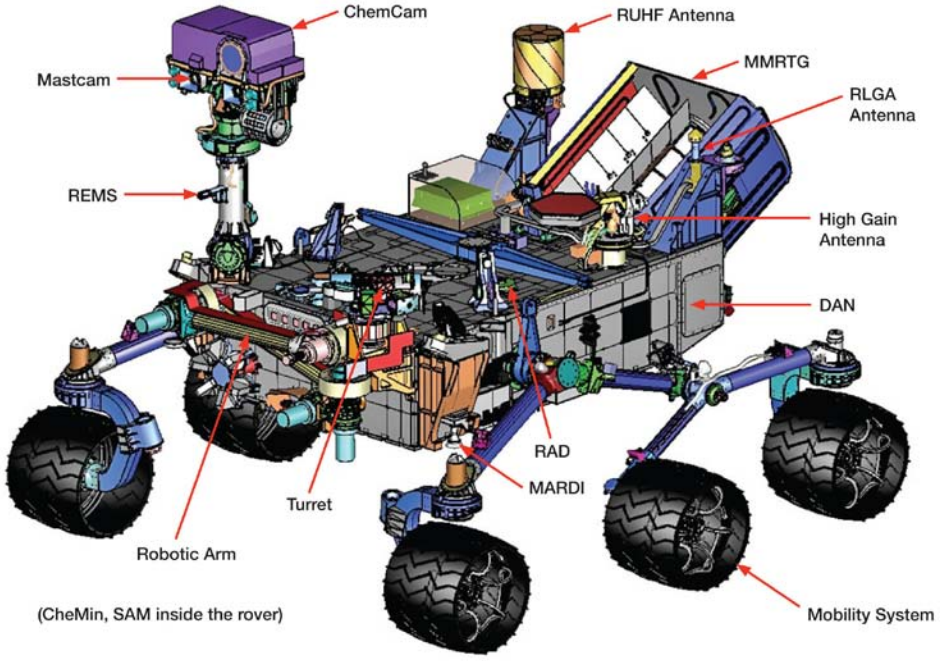
Mars Hand Lens Imager (MAHLI)
MAHLI is a focusable color camera on the tool-bearing turret at the end of Curiosity's robotic arm. Researchers will use it for magnified, close-up views of rocks and soils, and also for wider scenes of the ground, the landscape, or even the rover. Essentially, it is a handheld camera with a macro lens and autofocus.

Chemistry and Mineralogy (CheMin)
CheMin is one of two investigations that will analyze powdered rock and soil samples delivered by Curiosity's robotic arm. It will identify and quantify the minerals in the samples. Minerals provide a durable record of past environmental conditions, including information about possible ingredients and energy sources for life. CheMin uses X-ray diffraction, a first for a mission to Mars. This is a more definitive method for identifying minerals than was possible with any instrument on previous missions. The investigation supplements the diffraction measurements with X-ray fluorescence capability to determine further details of composition by identifying ratios of specific elements present.

Sample Analysis at Mars (SAM)
SAM will use a suite of three analytical tools inside Curiosity to study chemistry relevant to life. One key job is checking for carbon-based compounds that on Earth are molecular building blocks of life. It will also examine the chemical state of other elements important for life, and it will assess ratios of different atomic weights of certain elements for clues about planetary change and ongoing processes.

One of SAM's tools, a mass spectrometer like those seen in many TV crime-solving laboratories, identifies gases by the molecular weight and electrical charge of their ionized states. It will check for several elements important for life as we know it, including nitrogen, phosphorous, sulfur, oxygen, hydrogen, and carbon. Another tool, a tunable laser spectrometer, uses absorption of light at specific wavelengths to measure concentrations of methane, carbon dioxide, and water vapor. It also identifies the proportions of different isotopes in those gases. Isotopes are variants of the same element with different atomic weights, such as carbon-13 and carbon-12, or oxygen-18 and oxygen-16. Ratios of isotopes can be signatures of planetary processes, such as how Mars might have lost much of its former atmosphere.

The suite's third analytical tool, a gas chromatograph, separates different gases from a mixture to aid identification. It detects organic compounds exiting a capillary column, and then it feeds the separated fractions to the mass spectrometer for a more definitive identification.



Locations of several science instruments and major subsystems on the NASA Mars rover Curiosity are indicated. These include (clockwise from left): Rover Environmental Monitoring Station (REMS); Mast Camera (Mastcam); Chemistry and Camera (ChemCam); rover ultra high-frequency (RUHF) antenna; multi-mission radioisotope thermoelectric generator (MMRTG); rover low-gain (RLGA) antenna; high-gain antenna; Dynamic Albedo of Neutrons (DAN); mobility system (wheels and suspension); Radiation Assessment Detector (RAD); Mars Descent Imager (MARDI); turret (see larger image for tools on the turret at the end of the robotic arm); and robotic arm. Two science instruments — Chemistry and Mineralogy (CheMin) and Sample Analysis at Mars (SAM) — are inside the body of the rover. Credit: NASA/JPL-Caltech.

Rover Environmental Monitoring Station (REMS)
REMS will record information about daily and seasonal changes in martian weather. This investigation will assess wind speed, wind direction, air pressure, relative humidity, air temperature, ground temperature, and ultraviolet radiation. Operational plans call for taking measurements for at least five minutes every hour of the full-martian-year (98-week) mission. Damage to part of this suite during landing is currently being assessed. Spain provided this instrument for MSL.

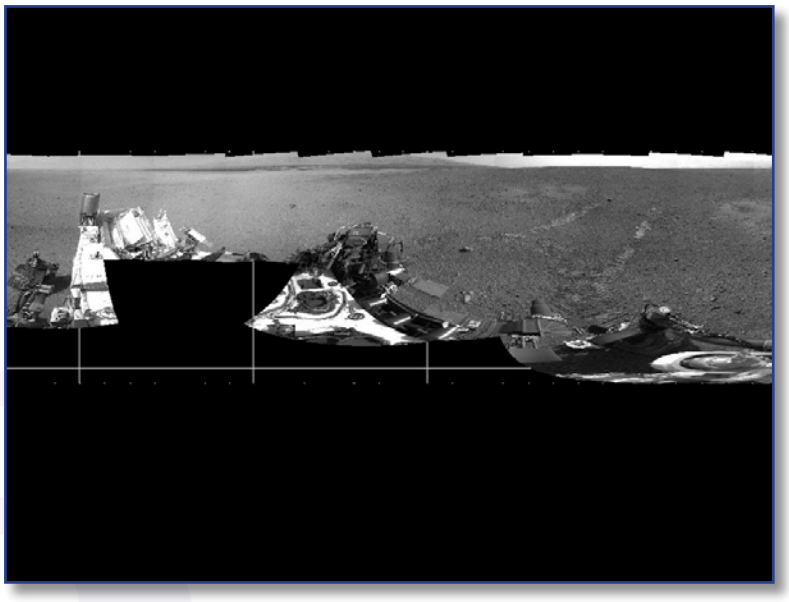
Radiation Assessment Detector (RAD)
RAD investigation on Curiosity monitors high-energy atomic and subatomic particles coming from the Sun, from distant supernovae, and from other sources. These particles constitute naturally occurring radiation that could be harmful to any microbes near the surface of Mars or to astronauts on a future Mars mission. RAD was built by Southwest Research Institute in Boulder and in San Antonio, together with Christian Albrechts University in Kiel, Germany.

Dynamic Albedo of Neutrons (DAN)
DAN can detect water bound into shallow underground minerals along Curiosity's path. The DAN instrument shoots neutrons into the ground and measures how they are scattered, giving it a high sensitivity for finding any hydrogen to a depth of about 20 inches (50 centimeters) directly beneath the rover. The Russian Federal Space Agency contributed DAN to NASA as part of a broad collaboration between the United States and Russia in the exploration of space.

Mars Descent Imager (MARDI)
During the final few minutes of Curiosity's flight to the surface of Mars, MARDI recorded a full-color video of the ground below. This provided the MSL team with information about the landing site and its

Curiosity Gets the Better of Mars

This color full-resolution image showing the heat shield of NASA's Curiosity rover was obtained during descent to the surface of Mars on August 5 (PDT). The image was obtained by the Mars Descent Imager (MARDI) instrument and shows the 15-foot-diameter (4.5-meter) heat shield when it was about 50 feet (16 meters) from the spacecraft. Credit: NASA/JPL-Caltech/MSSS.



This 360° panorama shows evidence of a successful first test drive for the Curiosity rover. On August 22 the rover made its first move, going forward about 15 feet (4.5 meters), rotating 120° and then reversing about 8 feet (2.5 meters). Curiosity is about 20 feet (6 meters) from its landing site, now named Bradbury Landing. Visible in the image are the rover's first track marks. A small 3.5-inch (9-centimeter) rock can be seen where the drive began, and scour marks left by the rover's descent stage during landing can be seen to the left and right of the wheel tracks. The lower slopes of Mount Sharp are visible at the top of the picture, near the center. Credit: NASA/JPL-Caltech.

surroundings, to aid interpretation of the rover's ground-level views and planning of initial drives. Hundreds of the images taken by the camera showed features smaller than what can be discerned in images taken from orbit.

On August 22, Curiosity began driving from its landing site, Bradbury Landing, which scientists named after the late author Ray Bradbury, who died this year at the age of 92. The first driving destination for the rover is Glenelg, a natural intersection of three kinds of terrain. Many important firsts will be taking place for Curiosity over the next few weeks, with a roomful of rover-driver engineers providing turn-by-turn navigation. The mission is certain to provide a wealth of new data and surprises as the rover completes its two-year prime mission.

For more images, breaking news, and updates about the mission, visit *www.nasa.gov/msl* or *mars.jpl.nasa.gov/msl*.

Curiosity Gets the Better of Mars

About the cover:

Top: This artist's concept features NASA's Mars Science Laboratory Curiosity rover, a mobile robot for investigating Mars' past or present ability to sustain microbial life. In this picture, the rover examines a rock on Mars with a set of tools at the end of the rover's arm, which extends about 7 feet (2 meters). Two instruments on the arm can study rocks up close. A drill can collect sample material from inside of rocks and a scoop can pick up samples of soil. The arm can sieve the samples and deliver fine powder to instruments inside the rover for thorough analysis. The mast, or rover's "head," rises to about 6.9 feet (2.1 meters) above ground level. This mast supports two remote-sensing science instruments: the Mast Camera, or "eyes," for stereo color viewing of surrounding terrain and material collected by the arm; and the Chemistry and Camera instrument, which uses a laser to vaporize a speck of material on rocks up to about 23 feet (7 meters) away and determines what elements the rocks are made of. Credit: NASA/JPL-Caltech.

Bottom left: This image from NASA's Curiosity rover looks south of the rover's landing site on Mars toward Mount Sharp. This is part of a larger, high-resolution color mosaic made from images obtained by Curiosity's Mast Camera. In this version of the image, colors have been modified as if the scene were transported to Earth and illuminated by terrestrial sunlight. This processing, called "white balancing," is useful for scientists to be able to recognize and distinguish rocks by color in more familiar lighting. The image provides an overview of the eventual geological targets Curiosity will explore over the next two years, starting with the rock-strewn, gravelly surface close by, and extending toward the dark dunefield. Beyond that lie the layered buttes and mesas of the sedimentary rock of Mount Sharp. Credit: NASA/JPL-Caltech/MSSS.

Bottom right: This image shows the tracks left by NASA's Curiosity rover on August 22 as it completed its first test drive on Mars. The rover went forward 15 feet (4.5 meters), rotated 120°, and then reversed 8.2 feet (2.5 meters). Curiosity is now 20 feet (6 meters) from its landing site, named Bradbury Landing. This image was taken by a front Hazard-Avoidance camera, which has a fisheye lens. Credit: NASA/JPL-Caltech.

Image of Venus transiting Sun on June 5 taken by amateur astronomer (the Editor) in his Houston backyard.

Venus' Transit and the Search for Other Worlds

It was the final opportunity of the century to witness the rare astronomical reunion of the Sun, Venus, and Earth. On June 5/6, 2012, viewers were able to see Venus as a small dot slowly drifting across the golden disk of the Sun, at least from the western hemisphere.

Transits of Venus are very rare, separated by more than 100 years. There have been 53 transits since 2000 B.C., but only six have been witnessed since the invention of the telescope in 1608. These rare events occur in pairs, with the first transit occurring June 8, 2004. The next opportunity won't be until December 10/11, 2117.

Jeremiah Horrocks and William Crabtree, two young astronomers from England, recorded the first observation of a transit in 1639. In 1769, survey crews, including Captain James Cook, gathered transit data from various locations around the world that were later used to calculate the distance between Earth and the Sun, thereby establishing the solar system's scale.

"Throughout history, astronomers have creatively used nature's coincidences as opportunities to learn something new about the universe," said Natalie Batalha, Kepler mission scientist at NASA Ames Research Center. "As Venus crosses the disk of the Sun, her shadow [swept] across the face of Earth in the same way that the shadows cast by distant exoplanets sweep across the face of the Kepler photometer." Today, transit events are used to detect planets beyond the solar system. NASA's Kepler space telescope continuously measures changes in brightness of more than 150,000 stars to detect when a planet passes or transits in front of a star. Kepler does not directly image distant planets, as they are too far away.

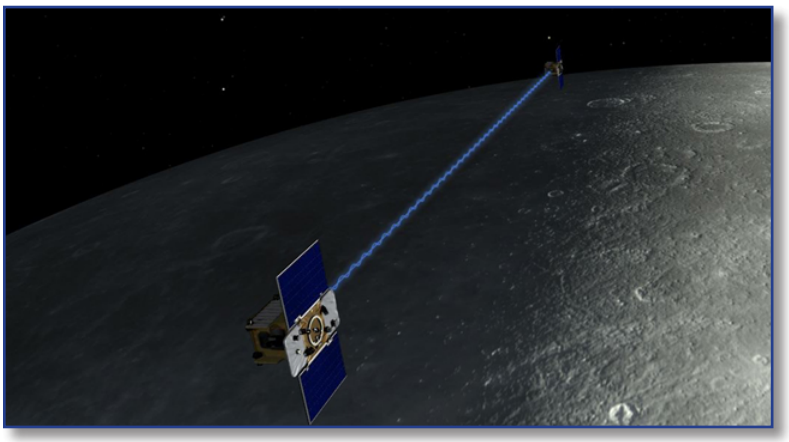
Different-sized planets block different amounts of starlight. Kepler's exquisitely precise photometer, or light sensor, is designed to detect fractional changes in brightness. For an Earth-sized planet transiting a Sun-like star, the change in brightness is only 84 parts per million. That is less than 1/100th of 1%, or the equivalent of the amount of light blocked if a gnat crawled across a car's headlight viewed from several miles away.

Transit data are rich with information. By measuring the depth of the dip in brightness and knowing the size of the star, scientists can determine the size or radius of the planet. The orbital period of the planet can be determined by measuring the elapsed time between transits. Once the orbital period is known, Kepler's Third Law of Planetary Motion can be applied to determine the average distance of the planet from its stars. Using the transit method, the Kepler mission has identified 61 planets and more than 2300 planet candidates during the spacecraft's first 16 months of observation from May 2009 to September 2010.

For a recap of transit and educational activities, visit *venustransit.nasa.gov/transitofvenus*. For more about the Kepler mission, visit *kepler.nasa.gov*.

NASA Lunar Spacecraft Completes Prime Mission Ahead of Schedule

A NASA mission to study the Moon from crust to core has completed its prime mission earlier than expected. The team of NASA's Gravity Recovery and Interior Laboratory (GRAIL) mission, with twin probes named Ebb and Flow, is now preparing for extended science operations starting August 30 and continuing through December 3, 2012. The GRAIL mission has gathered unprecedented detail about the internal structure and evolution of the Moon. This information will increase our knowledge of how Earth and its rocky neighbors in the inner solar system developed into the diverse worlds we see today.



An artist's depiction of the twin spacecraft that comprise NASA's Gravity Recovery And Interior Laboratory (GRAIL) mission. During the GRAIL mission's science phase, spacecraft (Ebb and Flow) transmit radio signals precisely defining the distance between them as they orbit the Moon in formation. Credit: NASA/JPL-Caltech/MIT.

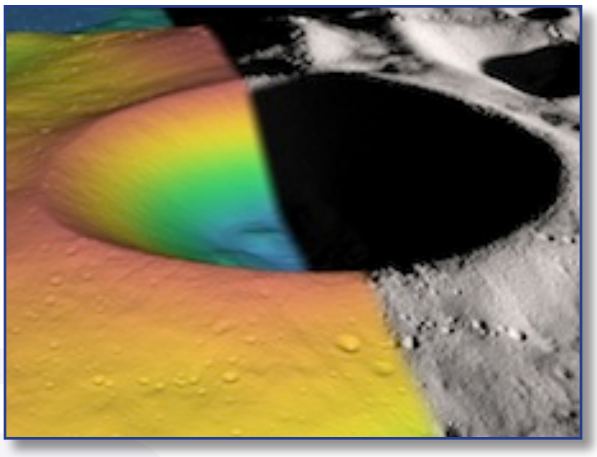
Since March 8, the spacecraft have operated around the clock for 89 days. From an orbit that passes over the lunar poles, they have collected data covering the entire surface three times. An instrument called the Lunar Gravity Ranging System onboard each spacecraft transmits radio signals that allow scientists to translate the data into a high-resolution map of the Moon's gravitational field. The spacecraft returned their last dataset of the prime mission on May 29. The instruments were turned off at 10:00 a.m. PDT (1:00 p.m. EDT) when the spacecraft were 37 miles (60 kilometers) above the Sea of Nectar.

"Many of the measurement objectives were achieved from analysis of only half the primary mission data, which speaks volumes about the skill and dedication of our science and engineering teams," said Maria Zuber, principal investigator of GRAIL at the Massachusetts Institute of Technology. "While there is a great deal of work yet to be done to achieve the mission's science, it's energizing to realize that what we traveled from Earth to the Moon for is right here in our hands."

The extended mission goal is to take an even closer look at the Moon's gravity field. To achieve this, GRAIL mission planners will halve their current operating altitude to the lowest altitude that can be safely maintained. "Orbiting at an average altitude of 14 miles (23 kilometers) during the extended mission, the GRAIL twins will be clearing some of the Moon's higher surface features by about 5 miles (8 kilometers)," said Joe Beerer of JPL, GRAIL's mission manager. "If Ebb and Flow had feet, I think by reflex they'd want to pull them up every time they fly over a mountain."

Along with mission science, GRAIL's MoonKAM (Moon Knowledge Acquired by Middle school students) education and public outreach program is also extended. To date over 70,000 student images of the Moon have been obtained. The MoonKAM program was led by the late Sally Ride, America's first woman in space, and is continued by her team at Sally Ride Science in collaboration with undergraduate students at the University of California in San Diego.

For more information about GRAIL, visit *www.nasa.gov/grail*. For more information about MoonKAM, visit *moonkam.ucsd.edu*.



Elevation (left) and shaded relief (right) image of Shackleton, a 21-kilometer-diameter (12.5-mile-diameter) permanently shadowed crater adjacent to the lunar south pole. The structure of the crater's interior was revealed by a digital elevation model constructed from over 5 million elevation measurements from the Lunar Orbiter Laser Altimeter (LOLA). Credit: NASA/M. Zuber et al.

NASA Spacecraft Reveals Ice Content in Moon Crater

NASA's Lunar Reconnaissance Orbiter (LRO) spacecraft has returned data that indicate ice may make up as much as 22% of the surface material in a crater located on the Moon's south pole. The team of NASA and university scientists using laser light from LRO's laser altimeter examined the floor of Shackleton crater. They found the crater's floor is brighter than those of other nearby craters, which is consistent with the presence of small amounts of ice. This information will help researchers understand crater formation and study other uncharted areas of the moon. The findings are published in a recent edition of the journal *Nature*.

"The brightness measurements have been puzzling us since two summers ago," said Gregory Neumann of NASA's Goddard Space Flight Center, a co-author on the paper. "While the distribution of brightness was not exactly what we had expected, practically every measurement related to ice and other volatile compounds on the Moon is surprising, given the cosmically cold temperatures inside its polar craters."

The spacecraft mapped Shackleton crater with unprecedented detail, using a laser to illuminate the crater's interior and measure its albedo or natural reflectance. In addition to the possible evidence of ice, the group's map of Shackleton revealed a remarkably preserved crater that has remained relatively unscathed since its formation more than three billion years ago. The crater's floor is itself pocked with several small craters, which may have formed as part of the collision that created Shackleton.

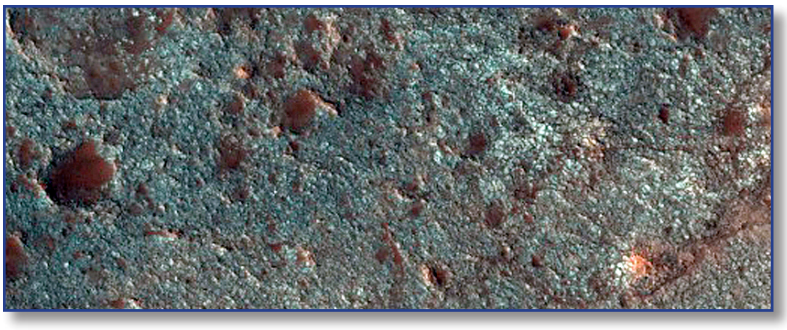
The crater, named after the Antarctic explorer Ernest Shackleton, is 2 miles (3.2 kilometer) deep and more than 12 miles (19.3 kilometers) wide. Like several craters at the Moon's south pole, the small tilt of the lunar spin axis means Shackleton crater's interior is permanently dark and therefore extremely cold. "The crater's interior is extremely rugged," said Maria Zuber, the team's lead investigator from the Massachusetts Institute of Technology in Cambridge. "It would not be easy to crawl around in there."

The initial primary objective of LRO was to conduct investigations that prepare for future lunar exploration. Launched in June 2009, LRO completed its primary exploration mission and is now in its primary science mission. For more information, visit *lro.gsfc.nasa.gov* or *www.nasa.gov/lro*.

Mars Spacecraft Detects Large Changes In Martian Sand Dunes

NASA's Mars Reconnaissance Orbiter (MRO) has revealed that movement in sand dune fields on the Red Planet occurs on a surprisingly large scale, about the same as in dune fields on Earth. This is unexpected because Mars has a much thinner atmosphere than Earth, is only about 1% as dense, and its high-speed winds are less frequent and weaker than Earth's.

For years, researchers debated whether or not sand dunes observed on Mars were mostly fossil features related to past climate, rather than currently active. In the past two years, researchers using images from MRO's High Resolution Imaging Science Experiment (HiRISE) camera have detected and reported sand movement. Now, scientists using HiRISE images have determined that entire dunes as thick as 200 feet are moving as coherent units across the martian landscape. The study was recently published online by the journal *Nature*.



This set of dark sand dunes lies within the northeastern edge of a dune field in Nili Patera, a volcanic caldera in the Syrtis Major region of Mars. Credit: NASA/JPL/University of Arizona.

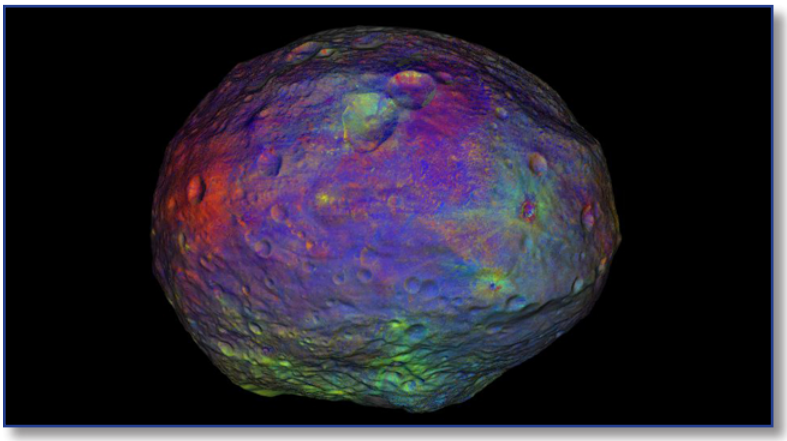
"This exciting discovery will inform scientists trying to better understand the changing surface conditions of Mars on a more global scale," said Doug McCuistion, director of NASA's Mars Exploration Program in Washington. "This improved understanding of surface dynamics will provide vital information in planning future robotic and human Mars exploration missions."

Researchers analyzed before-and-after images using a new software tool developed at the California Institute of Technology (Caltech) in Pasadena. The tool measured changes in the position of sand ripples, revealing the ripples move faster the higher up they are on a dune. The study examined images taken in 2007 and 2010 of the Nili Patera sand dune field located near the martian equator. By correlating ripples' movement to their position on the dune, the analysis determined the entire dunes are moving. This allows researchers to estimate the volume, or flux, of moving sand.

"We chose Nili Patera because we knew there was sand motion going on there, and we could quantify it," said Nathan Bridges, a planetary scientist at Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland, and lead author of the *Nature* paper. "The Nili dunes also are similar to dunes in places like Antarctica and to other locations on Mars." Added Jean-Philippe Avouac, Caltech team leader, "Our new data shows wind activity is indeed a major agent of evolution of the landscape on Mars. This is important because it tells us something about the current state of Mars and how the planet is working today, geologically."

Scientists calculate that if someone stood in the Nili Patera dunes and measured out a one-yard width, they would see more than two cubic yards of sand pass by in an Earth year, about as much as in a children's sand box. For more information, visit *hirise.lpl.arizona.edu*.

Dawn Mission Video Shows Vesta's Coat of Many Colors



This still is taken from an animation of Vesta made from images taken with Dawn's framing camera. Many of the images were taken at different viewing angles to provide stereo for use in determining the topography. Credit: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA/PSI.

A new video from NASA's Dawn mission reveals the dappled, variegated surface of the giant asteroid Vesta. The animation drapes high-resolution false color images over a three-dimensional model of the Vesta terrain constructed from Dawn's observations. This visualization enables a detailed view of the variation in the material properties of Vesta in the context of its topography. The video is available online at *www.jpl.nasa.gov/video/index.cfm?id=1085*.

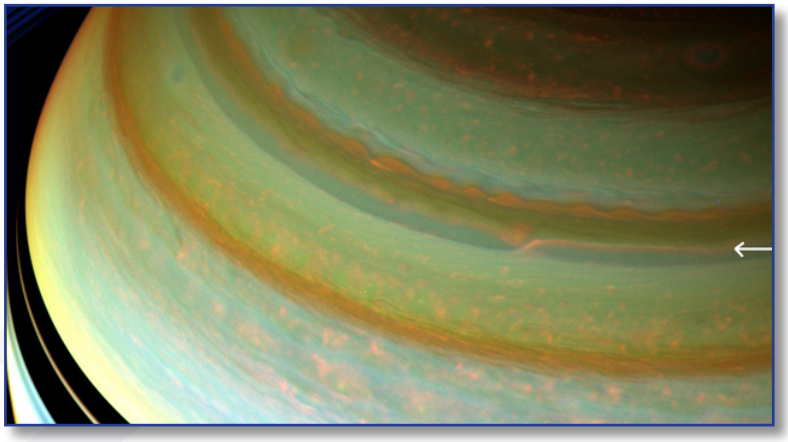
The colors were chosen to highlight differences in surface composition that are too subtle for the human eye

to see. Scientists are still analyzing what some of the colors mean for the composition of the surface. But it is clear that the orange material thrown out from some impact craters is different from the surrounding surface material. Green shows the relative abundance of iron. Parts of the huge impact basin known as Rheasilvia in Vesta's southern hemisphere, for instance, have areas with less iron than nearby areas.

Dawn observed a pattern of minerals exposed by deep gashes created by space rock impacts, which may support the idea the asteroid once had a subsurface magma ocean. A magma ocean occurs when a body undergoes almost complete melting, leading to layered building blocks that can form planets. Other bodies with magma oceans ended up becoming parts of Earth and other planets. Data also confirm a distinct group of meteorites found on Earth did, as theorized, originate from Vesta. The signatures of pyroxene, an iron- and magnesium-rich mineral, in those meteorites match those of rocks on Vesta's surface. These objects account for about 6% of all meteorites seen falling on Earth. This makes the asteroid one of the largest single sources for Earth's meteorites. The finding also marks the first time a spacecraft has been able to visit the source of samples after they were identified on Earth.

Dawn has imaged the majority of the surface of Vesta with the framing camera to provide this three-dimensional map. While some areas in the north were in shadow at the time the images were obtained by the camera, Dawn expects to improve its coverage of Vesta's northern hemisphere with additional observations. Dawn's viewing geometry also prevented mapping of a portion of the mountain of the south pole.

The spacecraft is currently spiraling up from its lowest-altitude orbit into its final science orbit, where its average altitude will be about 420 miles (680 kilometers). Dawn is scheduled to leave Vesta around August 26. For more information, visit *dawn.jpl.nasa.gov*.



A particularly strong jet stream churns through Saturn's northern hemisphere in this false-color view from NASA's Cassini spacecraft. Credit: NASA/JPL-Caltech/SSI.

Cassini Shows Why Jet Streams Cross-Cut Saturn

Turbulent jet streams, regions where winds blow faster than in other places, churn east and west across Saturn. Scientists have been trying to understand for years the mechanism that drives these wavy structures in Saturn's atmosphere and the source from which the jets derive their energy. In a new study appearing in the June edition of the journal *Icarus*, scientists used images collected over several years by NASA's Cassini spacecraft to discover that the heat from within the planet powers the jet streams. Condensation of water from Saturn's internal heating led to temperature differences in the atmosphere. The temperature differences created eddies, or disturbances that move air back and forth at the same latitude, and those eddies, in turn, accelerated the jet streams like rotating gears driving a conveyor belt.

A competing theory had assumed that the energy for the temperature differences came from the Sun. That is how it works in Earth's atmosphere. "We know the atmospheres of planets such as Saturn and Jupiter can get their energy from only two places: the Sun or the internal heating. The challenge has been coming up with ways to use the data so that we can tell the difference," said Tony Del Genio of NASA's Goddard Institute for Space Studies in New York, the lead author of the paper and a member of the Cassini imaging team.

Rather than having a thin atmosphere and solid-and-liquid surface like Earth, Saturn is a gas giant whose deep atmosphere is layered with multiple cloud decks at high altitudes. A series of jet streams slice across the face of Saturn visible to the human eye and also at altitudes detectable to the near-infrared filters of Cassini's cameras. While most blow eastward, some blow westward. Jet streams occur on Saturn in places where the temperature varies significantly from one latitude to another. Thanks to the filters on Cassini's cameras, which can see near-infrared light reflected to space, scientists now have observed the Saturn jet stream process for the first time at two different, low altitudes. One filtered view shows the upper part of the troposphere, a high layer of the atmosphere where Cassini sees thick, high-altitude hazes and where heating by the Sun is strong. Views through another filter capture images deeper down, at the tops of ammonia ice clouds, where solar heating is weak but closer to where weather originates. This is where water condenses and makes clouds and rain.

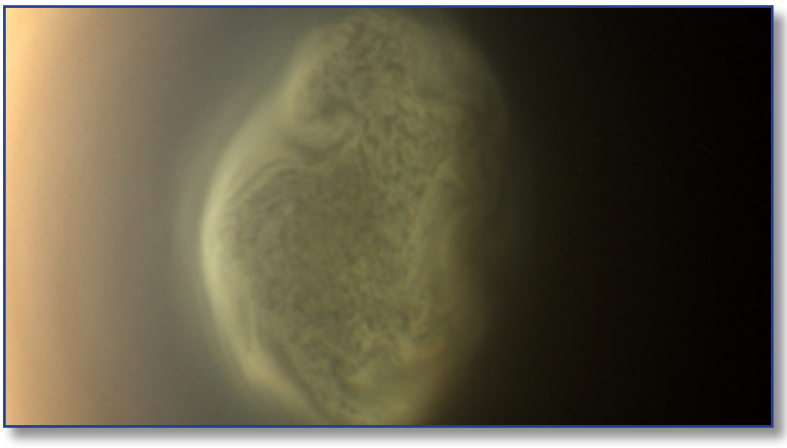
"With our improved tracking algorithm, we've been able to extract nearly 120,000 wind vectors from 560 images, giving us an unprecedented picture of Saturn's wind flow at two independent altitudes on a global scale," said co-author and imaging team associate John Barbara, also at the Goddard Institute for Space Studies. The team's findings provide an observational test for existing models that scientists use to study the mechanisms that power the jet streams.

By seeing for the first time how these eddies accelerate the jet streams at two different altitudes, scientists found the eddies were weak at the higher altitudes where previous researchers had found that most of the Sun's heating occurs. The eddies were stronger deeper in the atmosphere. Thus, the authors could discount heating from the Sun and infer instead that the internal heat of the planet is ultimately driving the acceleration of the jet streams, not the Sun. The mechanism that best matched the observations would involve internal heat from the planet stirring up water vapor from Saturn's interior. That water vapor condenses in some places as air rises and releases heat as it makes clouds and rain. This heat provides the energy to create the eddies that drive the jet streams.

For more information, visit *www.nasa.gov/cassini*, *saturn.jpl.nasa.gov*, and *ciclops.org*.

Polar Vortex Churns on Titan

Images from NASA's Cassini spacecraft show a concentration of high-altitude haze and a vortex materializing at the south pole of Saturn's moon Titan, signs that the seasons are turning on Saturn's largest moon. "The structure inside the vortex is reminiscent of the open cellular convection that is often seen over Earth's oceans," said Tony Del Genio, a Cassini team member at NASA's Goddard Institute for Space Studies in New York. "But unlike on Earth, where such layers are just above the surface, this one is at very high altitude, maybe a response of Titan's stratosphere to seasonal cooling as southern winter approaches. But so soon in the game, we're not sure."



This true-color image captured by NASA'S Cassini spacecraft before a distant flyby of Saturn's moon Titan on June 27, 2012, shows a south polar vortex, or a mass of swirling gas around the pole in the atmosphere of the moon. Credit: NASA/JPL-Caltech/Space Science Institute.

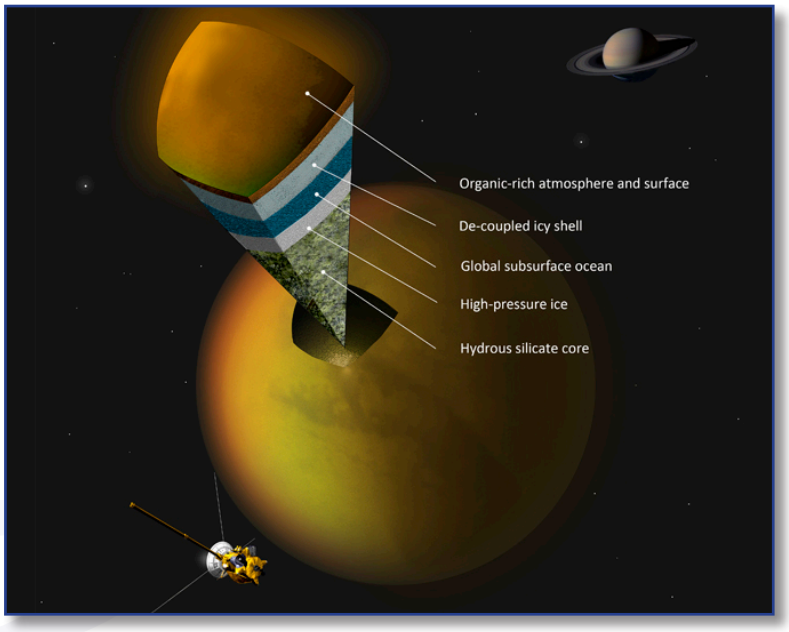
Cassini first saw a "hood" of high-altitude haze and a vortex, which is a mass of swirling gas around the pole in the moon's atmosphere, at Titan's north pole when the spacecraft arrived in the Saturn system in

2004. At the time, it was northern winter. Multiple instruments have been keeping an eye on the Titan atmosphere above the south pole for signs of the coming southern winter. While the northern hood has remained, the circulation in the upper atmosphere has been moving from the illuminated north pole to the cooling south pole. This movement appears to be causing downwellings over the south pole and the formation of high-altitude haze and a vortex. Cassini's visible light cameras saw the first signs of hazes starting to concentrate over Titan's south pole in March, and the spacecraft's visual and infrared mapping spectrometer (VIMS) obtained false-color images on May 22 and June 7.

"VIMS has seen a concentration of aerosols forming about 200 miles (300 kilometers) above the surface of Titan's south pole," said Christophe Sotin, a VIMS team member at NASA's Jet Propulsion Laboratory. "We've never seen aerosols here at this level before, so we know this is something new."

During a June 27 distant flyby, Cassini's imaging cameras captured a crow's-eye view of the south polar vortex in visible light. New images show this detached, high-altitude haze layer in stunning new detail. "Future observations of this feature will provide good tests of dynamical models of the Titan circulation, chemistry, cloud and aerosol processes in the upper atmosphere," said Bob West, deputy imaging team lead at JPL.

For more information, visit *www.nasa.gov/cassini*, *saturn.jpl.nasa.gov*, and *ciclops.org*.



This artist's concept shows a possible scenario for the internal structure of Titan, as suggested by data from NASA's Cassini spacecraft. Credit: A. Tavani/NASA.

Cassini Finds Probable Subsurface Ocean on Titan

Data from NASA's Cassini spacecraft have revealed Saturn's moon Titan likely harbors a layer of liquid water under its ice shell. Researchers saw a large amount of squeezing and stretching as the moon orbited Saturn. They deduced that if Titan were composed entirely of stiff rock, the gravitational attraction of Saturn would cause bulges, or solid "tides," on the moon only 3 feet (1 meter) in height. Spacecraft data show Saturn creates solid tides approximately 30 feet (10 meters) in height, which suggests Titan is not made entirely of solid rocky material. The finding appears in the June 28 edition of the journal *Science*.

"Cassini's detection of large tides on Titan leads to the almost inescapable conclusion that there is a hidden ocean at depth," said Luciano Iess, the paper's lead author and a Cassini team member at the Sapienza University of Rome, Italy. "The search for water is an important goal in solar system exploration, and now we've spotted another place where it is abundant."

Titan takes only 16 days to orbit Saturn, and scientists were able to study the moon's shape at different parts of its orbit. Because Titan is not spherical but slightly elongated like a football, its long axis grew when it was closer to Saturn. Eight days later, when Titan was farther from Saturn, it became less

elongated and more nearly round. Cassini measured the gravitational effect of that squeeze and pull. Scientists were not sure Cassini would be able to detect the bulges caused by Saturn's pull on Titan. By studying six close flybys of Titan from February 27, 2006, to February 18, 2011, researchers were able to determine the moon's internal structure by measuring variations in the gravitational pull of Titan using data returned to NASA's Deep Space Network (DSN).

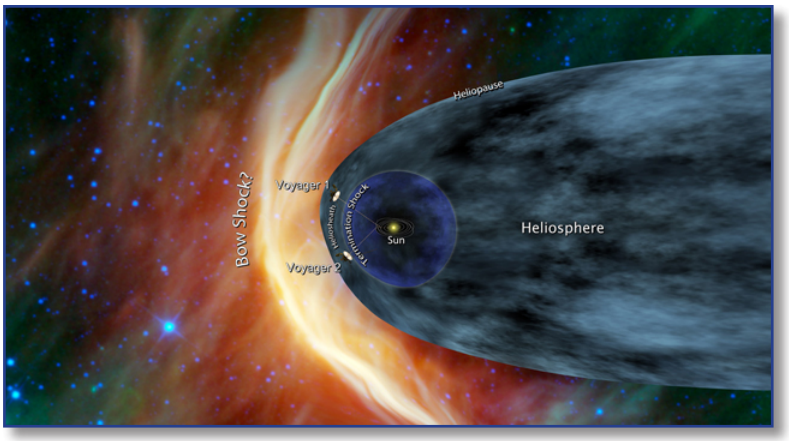
"We were making ultrasensitive measurements, and thankfully Cassini and the DSN were able to maintain a very stable link," said Sami Asmar, a Cassini team member at NASA's Jet Propulsion Laboratory. "The tides on Titan pulled up by Saturn aren't huge compared to the pull the biggest planet, Jupiter, has on some of its moons. But, short of being able to drill on Titan's surface, the gravity measurements provide the best data we have of Titan's internal structure."

"The presence of a liquid water layer in Titan is important because we want to understand how methane is stored in Titan's interior and how it may outgas to the surface," added Jonathan Lunine, a Cassini team member at Cornell University. "This is important because everything that is unique about Titan derives from the presence of abundant methane, yet the methane in the atmosphere is unstable and will be destroyed on geologically short timescales."

A liquid water ocean, "salted" with ammonia, could produce buoyant ammonia-water liquids that bubble up through the crust and liberate methane from the ice. Such an ocean could serve also as a deep reservoir for storing methane. For more information, visit *www.nasa.gov/cassini*, *saturn.jpl.nasa.gov*, and *ciclops.org*.

Data from Voyager 1 Point to Interstellar Future

Data from NASA's Voyager 1 spacecraft indicate that the venerable deep-space explorer has encountered a region in space where the intensity of charged particles from beyond our solar system has markedly increased. Voyager scientists looking at this rapid rise draw closer to an inevitable but historic conclusion — that humanity's first emissary to interstellar space is on the edge of our solar system. "The laws of physics say that someday Voyager will become the first human-made object to enter interstellar space, but we still do not know exactly when that someday will be," said Ed Stone, Voyager project scientist at the California Institute of Technology in Pasadena. "The latest data indicate that we are clearly in a new region where things are changing more quickly. It is very exciting. We are approaching the solar system's frontier."



This artist's concept shows NASA's two Voyager spacecraft exploring a turbulent region of space known as the heliosheath, the outer shell of the bubble of charged particles around our Sun. Credit: NASA/JPL-Caltech.

The data making the 16-hour-38-minute, 11.1-billion-mile (17.8-billion-kilometer) journey from Voyager 1 to antennas of NASA's Deep Space Network on Earth detail the number of charged particles measured by the two High Energy telescopes onboard the 34-year-old spacecraft. These energetic particles were generated when stars in our cosmic neighborhood went supernova.

"From January 2009 to January 2012, there had been a gradual increase of about 25% in the amount of galactic cosmic rays Voyager was encountering," said Stone. "More

recently, we have seen very rapid escalation in that part of the energy spectrum. Beginning on May 7, the cosmic ray hits have increased five percent in a week and nine percent in a month." This marked increase is one of a triad of datasets that need to make significant swings of the needle to indicate a new era in space exploration. The second important measure from the spacecraft's two telescopes is the intensity of energetic particles generated inside the heliosphere, the bubble of charged particles the Sun blows around itself. While there has been a slow decline in the measurements of these energetic particles, they have not dropped off precipitously, which could be expected when Voyager breaks through the solar boundary.

The final dataset that Voyager scientists believe will reveal a major change is the measurement in the direction of the magnetic field lines surrounding the spacecraft. While Voyager is still within the heliosphere, these field lines run east-west. When it passes into interstellar space, the team expects Voyager will find that the magnetic field lines orient in a more north-south direction. Such analysis will take weeks, and the Voyager team is currently crunching the numbers of its latest dataset.

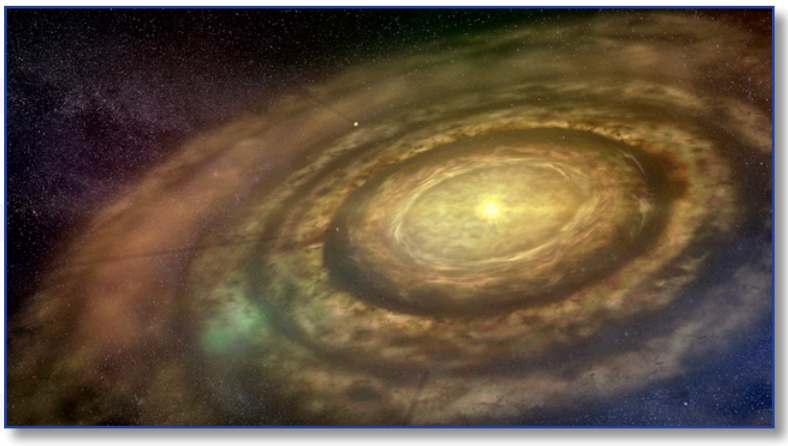
"When the Voyagers launched in 1977, the space age was all of 20 years old," said Stone. "Many of us on the team dreamed of reaching interstellar space, but we really had no way of knowing how long a journey it would be — or if these two vehicles that we invested so much time and energy in would operate long enough to reach it."

Launched in 1977, Voyager 1 and 2 are in good health. Voyager 2 is more than 9.1 billion miles (14.7 billion kilometers) away from the Sun. Both are operating as part of the Voyager Interstellar Mission, an extended mission to explore the solar system outside the neighborhood of the outer planets and beyond. NASA's Voyagers are the two most distant active representatives of humanity and its desire to explore.

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

Small Planets Don't Need "Heavy Metal" Stars to Form

The formation of small worlds like Earth previously was thought to occur mostly around stars rich in heavy elements such as iron and silicon. However, new groundbased observations, combined with data collected by NASA's Kepler space telescope, show small planets form around stars with a wide range of heavy element content and suggest they may be widespread in our galaxy.



This artist's conception shows a newly formed star surrounded by a swirling protoplanetary disk of dust and gas. Debris coalesces to create rocky "planetesimals" that collide and grow to eventually form planets. The results of this study show that small planets form around stars with a wide range of heavy element content, suggesting that their existence might be widespread in the galaxy. Credit: University of Copenhagen/ Lars Buchhave.

A research team led by Lars A. Buchhave, an astrophysicist at the Niels Bohr Institute and the Centre for Star and Planet Formation at the University of Copenhagen, studied the elemental composition of more than 150 stars harboring 226 planet candidates smaller than Neptune. "I wanted to investigate whether small planets needed a special environment in order to form, like the giant gas planets, which we know preferentially develop in environments with a high content of heavy elements," said Buchhave. "This study shows that small planets

do not discriminate and form around stars with a wide range of heavy metal content, including stars with only 25 percent of the Sun's metallicity."

Astronomers refer to all chemical elements heavier than hydrogen and helium as metals. They define metallicity as the metal content of heavier elements in a star. Stars with a higher fraction of heavy elements than the Sun are considered metal-rich. Stars with a lower fraction of heavy elements are considered metal-poor.

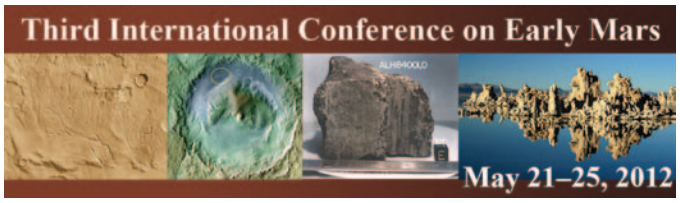
Planets are created in disks of gas and dust around new stars. Planets like Earth are composed almost entirely of elements such as iron, oxygen, silicon, and magnesium. The metallicity of a star mirrors the metal content of the planet-forming disk. Astronomers have hypothesized that large quantities of heavy elements in the disk would lead to more efficient planet formation. It has long been noted that giant planets with short orbital periods tend to be associated with metal-rich stars. Unlike gas giants, the occurrence of smaller planets is not strongly dependent on the heavy element content of their host stars. Planets up to four times the size of Earth can form around stars with a wide range of heavy element content, including stars with a lower metallicity than the sun. The findings are described in a new study published in the journal *Nature*.

"Kepler has identified thousands of planet candidates, making it possible to study big-picture questions like the one posed by Lars. Does nature require special environments to form Earth-size planets?" said Natalie Batalha, Kepler mission scientist at NASA's Ames Research. "The data suggest that small planets may form around stars with a wide range of metallicities — that nature is opportunistic and prolific, finding pathways we might otherwise have thought difficult."

The groundbased spectroscopic observations for this study were made at the Nordic Optical Telescope on La Palma in the Canary Islands; Fred Lawrence Whipple Observatory on Mt. Hopkins in Arizona; McDonald Observatory at the University of Texas at Austin; and W. M. Keck Observatory atop Mauna Kea in Hawaii. For more information about the Kepler mission, visit *www.nasa.gov/kepler*.

Third International Conference on Early Mars: Geologic and Hydrologic Evolution, Physical and Chemical Environments, and the Implications for Life

May 21–25, 2012, Lake Tahoe, Nevada



On May 21–25, 2012, approximately 100 scientists gathered at the Hyatt Regency in Lake Tahoe, Nevada, to participate in the Third International Conference on Early Mars: Geologic and Hydrologic Evolution, Physical and Chemical Environments, and the Implications for Life. The meeting location was chosen because of its proximity to Mono Lake, which was the focus of the all-day mid-conference field trip.

The influx of new data received from recent spacecraft missions, the study of martian meteorites, recent progress in early climate modeling, the growing evidence for abundant water, and the rapid pace of new discoveries about the origin and diversity of life on Earth have reinvigorated interest in both the conditions that prevailed on Mars during its first billion years of geologic history and their potential implications for the development of life.

These issues were first discussed at the First Early Mars Conference, which was held in Houston, Texas, in April 1997, and then again at the Second Early Mars Conference, which was held in Jackson Hole, Wyoming, in October 2004. Like its predecessors, the Third Early Mars Conference placed a strong emphasis on interdisciplinary discussion and debate, bringing together scientists from fields as diverse as planetary geology, atmospheres, climate, meteoritics, microbiology, and molecular biochemistry, to focus on the conditions that prevailed on the Earth and Mars during their first billion years of geologic history.

The purpose of the conference was twofold: (1) to consider how impacts, volcanism, the presence of abundant water, and the nature of the early terrestrial and martian climates affected the physical and chemical environments that existed on both planets >3.7 Ga — especially with regard to the geologic and mineralogical evolution of their surfaces, their hydrologic cycles, the development of life, and the preservation of its signature in the geologic record; and (2) to discuss the investigations that might be conducted by present and future missions to test the hypotheses arising from (1).

Some of the specific issues and questions that were addressed at the meeting included those identified as key questions at the second conference *(Beaty et al., 2005, mepag.jpl.nasa.gov/workshop/Beaty_etal_2005.pdf)*:

1. What was the nature of the early martian environment? How did the formation, initial composition, and differentiation of early Mars affect the evolution of its crust, mantle, and core? What was the cratering rate on early Mars, and how did it evolve with time? What were the principal resurfacing processes and rates on early Mars, and why did they later decline with time?

2. How did the early martian atmosphere and hydrosphere form, and what role did they play in the geologic and mineralogic evolution of the planet's surface? Was Mars volatile-rich at the time of its formation, especially with regard to the initial abundance of water and CO_2? What were the principal mechanisms (and associated magnitudes) of volatile loss on early Mars? Did oceans or large seas exist on early Mars, and, if so, what was their significance and ultimate fate? What was the nature of the early martian atmosphere and climate, and how did they evolve with time? What conditions and processes gave rise to the valley networks, and what were their discharge rates, durations, and continuity of flow? How was the chemistry and mineralogy of the early martian crust influenced by atmospheric, surface, and subsurface processes?

3. Did life arise on early Mars? Did life develop on early Mars, either through seeding by meteorite transport from Earth, or by an independent genesis? Were habitable environments present on early Mars? If life appeared on Mars, and has subsequently gone extinct, is its record preserved?

To ensure enough time to rigorously assess our current understanding of early martian environments, promote the exchange of new ideas, and address some of the most critical and controversial issues in Mars research, approximately 50% of the total program (which consisted of a mix of invited and contributed talks, panel discussions, poster presentations, special sessions, and an all-day field trip to Mono Lake) was reserved for discussion and debate. The conference also included a discussion of key questions and needed observations, led by Mike Carr and David Des Marais, that will serve as the conference input into the next revision of the MEPAG Science Goals and Objectives document.

A special section of *JGR-Planets* has been organized to capture the scientific output of the conference — and attendance at the meeting is not required to submit a manuscript. The due date for submission is December 14, 2012. For more details about the meeting, including the program and abstracts, visit *www.lpi.usra.edu/meetings/earlymars2012*.

— Text courtesy of Stephen Clifford

Concepts and Approaches for Mars Exploration

June 12–14, 2012, Houston, Texas

A recent workshop conducted for NASA by the Lunar and Planetary Institute (LPI) in Houston, Texas, marked a key step in the agency's effort to forge a new Mars strategy in the coming decades. A report that summarizes the wide range of cutting-edge science, technology, and mission concepts discussed is available online.

The meeting was held to seek ideas, concepts, and capabilities to address critical challenge areas in exploring the Red Planet. Discussions provided information for reformulating NASA's Mars Exploration Program (MEP) to be responsive to high-priority science goals and the challenge of sending humans to Mars orbit in the 2030s.

Participants identified a number of possible approaches to missions that can be flown to Mars in the coming decade that would make progress toward returning martian samples — a top priority of the Planetary Science Decadal Survey — and make significant advances in scientific understanding of the planet, developing key technologies and advancing knowledge necessary for human exploration on and around Mars.

NASA's Mars Program Planning Group (MPPG), tasked with developing options for a reformulated MEP, will consider the workshop inputs in addition to budgetary, programmatic, scientific, and technical constraints.

"Scientists and engineers came together to present their most creative ideas for exploring Mars," said John Grunsfeld, an astronaut, astrophysicist, and associate administrator for NASA's Science Mission Directorate at NASA Headquarters in Washington. "Great ideas come from challenging the best and brightest and igniting their passion and determination to succeed."

The MPPG reports to Grunsfeld, who chairs the agency-wide Mars reformulation effort along with William Gerstenmaier, NASA's associate administrator for Human Exploration and Operations Mission Directorate; Chief Scientist Waleed Abdalati; and Chief Technologist Mason Peck. The official draft MPPG report is expected to be delivered to NASA for review at the end of the summer.

Concepts put forth tapped into significant benefits that could be gained from technology investments by NASA's Science Mission Directorate, Human Exploration and Operations Mission Directorate, and Office of the Chief Technologist. The participants also stressed the importance of establishing international collaboration early in the planning process and sustaining it throughout future missions. "Future Mars exploration missions will require new concepts and technologies," said Michael Gazarik, director of NASA's Space Technology Program. "There were many innovative and transformational concepts presented at the workshop. With continued investments in cutting-edge technology, these will lead to increased capability, reduced mission risk and lower mission costs."

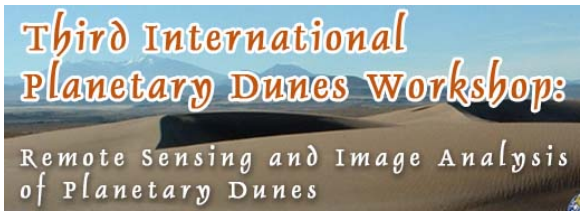
Workshop attendance included nearly 200 scientists, engineers, and graduate students from academia, NASA centers, federal laboratories, industry, and international partner organizations. More than 1600 people participated online as the workshop presentations and discussions were streamed live on the Internet. The workshop provided a forum for broad community input on near-term mission concepts. Ideas for longer-term activities will be used to inform program architecture planning beyond the early 2020s. Workshop results represent individual perspectives from members of the scientific and technical community.

To view the summary report, presentation videos, and the program and abstracts, visit *www.lpi.usra.edu/meetings/marsconcepts2012*.

— Text courtesy of NASA

Third International Planetary Dunes Workshop: Remote Sensing and Image Analysis of Planetary Dunes

June 12–16, 2012, Flagstaff, Arizona



A dune field is an integrated record of climate, wind, and sediment source history. Deconvolving these processes into a coherent history can be a complex process involving geologists, hydrologists, climatologists, and remote sensing experts. While winds move the sand that forms dune fields, the sand sediment source may be a river, a volcanic field, or a meteor impact. The rate of migration of the dune field is not solely a function of wind speed, but can be slowed, or even stopped, by changes in moisture, vegetation, or other cementing processes. The topography of the dune field can modify the wind regime, thus changing the very environment that is forming the dune bedforms. Dune fields are not only observed on Earth, but have been identified on Venus, Mars, and on Titan. Understanding dune formation and history on other planets, where the atmosphere, surface gravity, and sediment compositions vary greatly from Earth, can provide new insights into the physical, chemical and geologic processes that form dunes — thus increasing our understanding of Earth and the solar system.

This workshop, the third in a series, was convened as a means of bringing together terrestrial and planetary researchers from diverse backgrounds with the goal of fostering collaborative interdisciplinary research. Attendees included 40 professionals and 11 students, and the small group setting facilitated intensive discussion of problems and issues associated with aeolian processes on Earth, Mars, Venus, Titan, and Pluto. The results of the workshop resulted in a list of key scientific questions described below.

Key questions related to the source and composition of the sediment include the following: What are the compositions of the dune fields? Can composition be used to determine the source of the sediment? What were the processes that created the source material? What were the processes that made the sediment available for transport? Can olivine, or some other mineral, be used as a maturity index for dunes on other planetary surfaces? (For Earth, the maturity index is a comparison of feldspars and quartz.)

The scale of bedforms was a common theme throughout many discussions. Observations of sand ripples, megaripples, gravel ripples, transverse aeolian ridges (TARs), and sand dunes show that all have similar

bedform morphologies. These bedforms are seen on Earth, Mars, Venus, and Titan despite the range of gravity and atmospheric pressures on those bodies, leading to the following questions: What are the physical processes that allow these bedforms to maintain similar shapes (morphologies) over several orders of magnitude of size? What are all the important boundary conditions that determine the observed range of morphologies? Current observations suggest that these boundary conditions include, but are not limited to, gravity, surface pressure, and grain size.

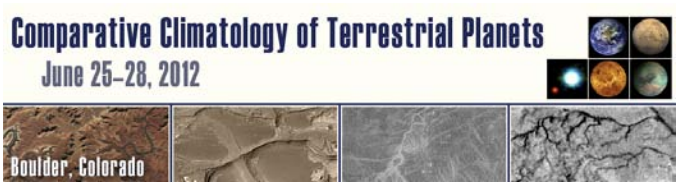
Regarding the migration rates of dunes, key questions included the following: What are the wind regimes that form the dune fields? What are the effects of topography on dune migration rates and how does the dune field morphology modify these wind regimes? How do seasonal or climatic changes affect dune migration rates? What are the processes and materials that cause cementation of the dune? (e.g., salts, vegetation, moisture, ices). Are dunes active today? If not, when were they or under what conditions would they become active? For all planetary surfaces, the threshold speed to keep sediment moving is lower than the threshold speed to initiate movement. How important is this hysteresis effect in determining morphology and migration rates?

Details about the workshop, along with the program and abstracts, are available at *www.lpi.usra.edu/meetings/dunes2012*.

— Text courtesy of Tim Titus and Rose Hayward

Comparative Climatology of Terrestrial Planets

June 25–28, 2012, Boulder, Colorado



The conference on Comparative Climatology of Terrestrial Planets was held June 25–28 in Boulder, Colorado. This conference brought together international specialists from a broad range of disciplines that presented the latest ideas on the comparative aspects of climates on Earth, Venus, Mars, Titan, and extrasolar planets. This meeting was the first to be supported by all four NASA Science Mission Divisions, and attendance exceeded 125 scientists from the Earth Sciences, Planetary Science, Astrophysics, and Heliophysics communities. The science program presented a balanced representation of science topics that spanned all four NASA science divisions. Many excellent presentations were made covering climate processes in Earth's atmosphere; terrestrial planet climate models; interactions between planetary interiors, surfaces, and atmospheres; solar-atmosphere interactions; and exoplanet atmospheres. Most importantly, the conference achieved its primary goal of providing a unique opportunity for scientists to advance understanding in climate research by stimulating cross-discipline collaboration.

In addition to the formal science program, the public event sponsored by the Planetary Society featuring Bill Nye the Science Guy was also a huge success. More than 575 people from the Boulder area attended this event. Audience members listened attentively to presentations from Bill Nye (The Planetary Society), Brian Toon (University of Colorado), Jim Hansen (NASA GSFC), Karen Rice (USGS), and David Grinspoon (Denver Museum of Nature and Science). Following the presentations, audience members supplied the panelists with questions for over an hour.

More information about the conference, including the program and abstracts, is available at *www.lpi.usra.edu/meetings/climatology2012*. A video of the public event can be found at *www.youtube.com/watch?v=CVcoEP8z2Q0*.

— Text courtesy of Mark Bullock and Lori Glaze

Second Conference on the Lunar Highlands Crust

July 12–16, 2012, Bozeman, Montana

The lunar highlands are the accessible exposures of the Moon's pre-mare crust, and so are a principal source of data on the Moon's origin and early history. The past few years have seen a wealth of new information on the lunar highlands, including remote sensing data from optical wavelengths and radar, from gravity measurements, and from new samples and new analyses of older samples. The last conference devoted solely to the lunar highlands was in 1979, so the time seemed ripe for another conference that would be augmented by field study of a terrestrial analog for lunar crust formation

Allan Treiman of the Lunar and Planetary Institute convened this workshop, held in Bozeman, Montana, to focus on the newest results on the lunar surface and interior, and facilitate incorporation of these results into a more unified understanding of the Moon. The workshop featured invited contributions by David Kring, who discussed the Moon's impact history (including the nature of the putative cataclysm) and the sources of the impactors; Maria Zuber, who talked about the new gravity maps from the GRAIL mission; Carlé Pieters, who covered the topic of optical remote sensing and mineral constitution of the lunar surface; and Randy Korotev, who discussed the nature of the lunar highlands revealed by meteorites and returned samples. Contributed talks and posters spanned a huge range of topics, from terrestrial analogs, to details of optical properties and models, to petrologic studies of samples new and old.

Free discussion was an important part of the meeting, and the conversations were active and cordial. Much of the discussion aimed at finding commonalties among the datasets on the history and nature of the lunar highlands. The participants generally felt that it was very valuable to have attended the workshop — its small size allowed for open exchanges of views, and for significant interactions between senior and younger lunar scientists.

To complement the technical sessions, Stewart McCallum of the University of Washington led two field trips to view rocks of the nearby Stillwater Complex, a layered basic intrusion that has provided much of the conceptual basis for understanding lunar highlands rocks. Prior to the workshop, McCallum led ~35 participants through the lower section of the Stillwater. There, he explained the origins of peridotites, pyroxenites, chromite-rich rocks, and anorthosites, including the famous inch-scale layered anorthosites. After the workshop, McCallum and a dozen young hardies climbed up Picket Pin Mountain and examined part of the Stillwater's upper section, which features massive anorthosites, norites with sedimentary structures, and a sulfide-rich zone. After summiting, the group retreated from a massive thunderstorm, soaked but alive and happy.

For more details regarding the workshop and field trips, or view the complete program and abstracts, go to *www.lpi.usra.edu/meetings/highlands2012*.

— Text courtesy of Allan Treiman

NAIF/SPICE Update

The IERS announced a new leap second that took effect at midnight preceding July 1, 2012. In response, the Navigation and Ancillary Information Facility (NAIF) has created a new SPICE leapseconds kernel (LSK) that is now available from the NAIF server: *ftp://naif.jpl.nasa.gov/pub/naif/generic_kernels/lsk/*. Separate versions for Unix/Linux/Mac (naif0010.tls) and for PCs running Windows (naif0010.tls.pc) are available. All users MUST switch to this new LSK for any time conversions involving epochs after July 1.

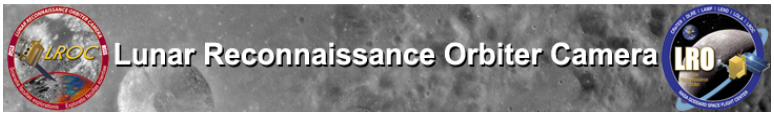
The new LSK has been deployed by NAIF to the appropriate SPICE kernel locations on JPL flight project servers where SPICE kernels are managed by NAIF. However, this will cover just a fraction of locations where the SPICE LSK is needed; users should make certain that local copies are updated, and appropriate coordination of this update is done where needed.

The best way to receive important announcements about SPICE updates is to sign up with the "spice_announce" mail notification system at *naif.jpl.nasa.gov/mailman/listinfo/spice_announce*.

Apollo Lunar Surface Experiment Package (ALSEP) Documents Available in Digital Format

As part of its work on a NASA-funded Apollo Lunar Surface Experiment Package (ALSEP) data recovery project, the Lunar and Planetary Institute (LPI) has scanned a collection of ALSEP-related documents and posted them on its Apollo-era documents website at *www.lpi.usra.edu/lunar/documents#alsep*.

This data archive currently includes more than 6700 pages of material, including ALSEP Systems Handbooks and Flight Systems Familiarization Manuals for several of the ALSEP arrays, ALSEP Data Processing Procedures, the ALSEP Archive Tape Description Document, and daily status reports for the ALSEP network from initial deployment in 1969 to termination in 1977. Material on this website may be useful to individuals who are reanalyzing data obtained from ALSEP experiments. Based on funding from NASA's LASER program, LPI intends to continue scanning other ALSEP-related material in its collection and will post this material to the website on an ongoing basis.



LROC Feature Sites

The Lunar Reconnaissance Orbiter Camera (LROC) team is happy to announce the availability of its new Featured Sites webpage, centralizing LROC images of important locations on the Moon. The initial beta release of the webpage includes LROC data for the Apollo landing sites.

LROC has been designed to address landing site certification and polar illumination. Images will be aquired to assess meter- and smaller-scale features to facilitate safety analysis for potential lunar landing sites near polar resources and elsewhere on the Moon. Synoptic 100 m/pixel imaging of the poles during every orbit for a year will unambiguously identify regions of permanent shadow and permanent or near-permanent illumination.

In addition to these two primary objectives, LROC will return six other high-value datasets: (1) meter-scale mapping of regions of permanent or near-permanent illumination of polar massifs; (2) multiple coregistered observations of portions of potential landing sites and elsewhere for derivation of high-resolution topography through stereogrammetric and photometric stereo analyses; (3) a global multispectral data set in seven wavelengths (300–680 nm) to characterize lunar resources, in particular ilmenite; (4) a global 100-m/pixel basemap with incidence angles favorable for morphologic interpretations, (5) submeter imaging of a variety of geologic units to characterize physical properties and variability of the regolith; and (6) meter-scale coverage overlapping with Apollo-era Panoramic images (1–2 m/pixel) to document the number of small impacts since 1971–1972, to ascertain hazards for future surface operations and interplanetary travel.

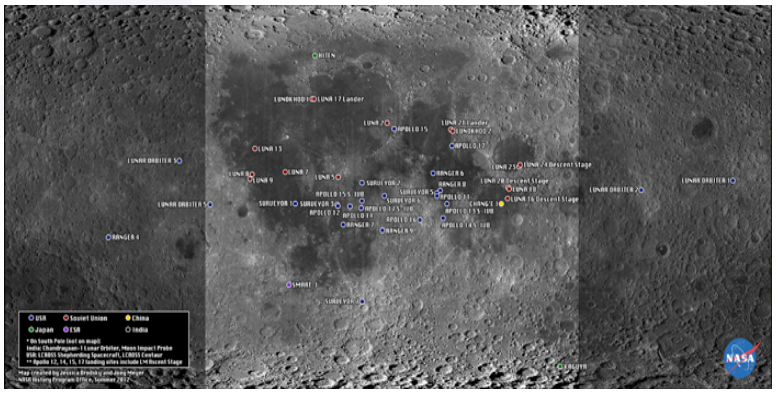
The new Featured Sites page is available at *featured-sites.lroc.asu.edu*.

3D Models of Future Lunar Landing Sites

Three-dimensional models are incredibly useful tools for teaching students about the geologic processes that shape planetary surfaces, but few examples exist within the lunar science community and the educational systems (K–12 and university levels) that develop talent for that community. In an effort to solve that problem, the Center for Lunar Science and Exploration teamed up with LandPrint.com to produce a series of models that represent major landforms on the lunar surface. The first two products are models of Tycho Crater, which is a classic central peak complex crater, and the Schrödinger Basin, which is one of the two best-preserved ancient impact basins. Both impact sites are leading targets for future missions to the lunar surface. Schools, universities, and libraries can order reproductions of these models from LandPrint.com for their own classroom activities. The Center for Lunar Science and Exploration is preparing models of other representative lunar landforms; for more information, visit *www.lpi.usra.edu/nlsi/training/3dModels/*.

A Compilation of Human Artifacts on the Moon

For the past half-century, the Moon has been the destination of some of humankind's most monumental and challenging expeditions. As the Moon becomes more accessible to both national space programs and private enterprise, it is increasingly important that we protect lunar artifacts for both their historical and scientific value. The first step in preserving these artifacts is establishing exactly what is there and where it is. This resource offers a comprehensive catalogue and maps of human artifacts on the Moon based on the currently available data. For more information, visit *history.nasa.gov/humanartifacts.html*.



ADS Labs

Tired of cluttered user interfaces? Looking for new ways to explore the literature? The team from the SAO/NASA Astrophysics Data Systems (ADS) has been working hard on reinventing its services and interfaces to better support the community's research needs. ADS Labs is a new interface built on the old tried-and-true ADS Abstract Databases, so all of ADS' content is available through it.

ADS Labs currently features a streamlined interface for abstract searches, new ranking options, and support for advanced searches; filtering of results based on a variety of criteria; interactive visualizations of paper and author networks; recommendations and notifications; and impact evaluation via bibliometric summaries. ADS Labs also features a full-text search of the current and historical astronomical literature, useful for locating mentions of specific terms in the full-text archive currently indexed by ADS, which includes all the major astronomy journals and an increasingly larger portion of the physics literature.

ADS Labs is work in progress, so changes in the looks and functionality of these services are to be expected. Feedback about any aspects of the system are highly encouraged. To get started, visit *labs.adsabs.harvard.edu/wiki/doku.php*. For more information, check out the ADS article of the day featured on their Facebook page at *www.facebook.com/nasaads*.

USGS Meteor Crater Sample Collection

USGS Meteor Crater Sample Collection is an ongoing project funded by the NASA Planetary Geology and Geophysics Program. Geologic samples from this invaluable collection of rotary drill cuttings are now available to the planetary science community for scientific research.

During the early 1970s, the USGS led a program of rotary drilling on the rim and flanks of Meteor Crater. During this program, 161 drill holes were completed, and over 2500 m of drill cuttings were collected. Drill depths ranged from a few meters to 50 m, and drill cuttings were sampled every 0.3 m. Approximately 72% of these holes were drilled in the overturned ejecta flap, with the remaining 28% drilled beyond the flap. The drill cuttings are now being curated by the U.S. Geological Survey's Astrogeology Science Center in Flagstaff, Arizona, and are available for request. This collection represents an invaluable source of material that provides geologic context for impact-generated lithologies and spans the entire extent of the ejecta blanket.

For more information, visit *astrogeology.usgs.gov/geology/meteor-crater-sample-collection*.

"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.

Continuing the Year of the Solar System (YSS)

The Year of the Solar System (YSS) — a synthesis of NASA's 50-year exploration history — provides ways for educators, scientists, and the public to get involved with NASA's amazing science discoveries. YSS includes 20 topics that share thematic NASA solar system mission educational resources and activities (tied to the national science standards), and upcoming event opportunities! Although the "year" concluded in August 2012, the resources will remain as the salute to 50 years of solar system exploration continues! For more information, visit *solarsystem.nasa.gov/yss*.

Get Involved! Share Your YSS Events and Stories: Advertise your YSS Events on the YSS Calendar. Share your YSS stories through the YSS story space, and Flickr and YouTube. Visit *solarsystem.nasa.gov/yss/getinvolved.cfm*.

Link to YSS from Your Website: We invite you be a YSS partner during the Year of the Solar System! Post the YSS graphic element on your website and link to the YSS page. You can find YSS graphics at *solarsystem.nasa.gov//yss/display.cfm?Year=2010&Month=12&Tab=Downloads*.

Ideas? Feedback? Contact us at *planetaryforum@lpi.usra.edu*.

Mars for Earthlings GSA 2012 Workshop

This workshop will provide lesson modules integrating Earth analog concepts and recent Mars imagery to engage students in STEM disciplines. Lesson modules are easily integrated into any introductory classes. Accompanying hands-on activities will utilize Google Mars and JMARS software, as well as HiRISE imagery. Example topical themes include: "What is the evidence for water on Mars?" (mineralogy, diagenesis, sedimentary geology, and surfaces processes), "Is there life on Mars?" (extremophiles and habitable environments), and "How do craters shape the martian landscape?" (relative dating, stratigraphy, surface processes). This workshop is open to any faculty and postdoctoral scientists/graduate students teaching undergraduate introductory Earth or planetary science. Fee to include a coupon redeemable at the GSA bookstore onsite for $20 when registrant signs in at the course. Participants will need to bring their own laptops. For more information, visit *www.geosociety.org/meetings/2012*.

Outer Planets Colloquium Series

The Outer Planets Colloquium Series is a collaboratively planned program of visits by planetary scientists to university campuses and research institutions, and is designed to raise awareness of current research in outer solar system science. Participation is open to two- and four-year undergraduate colleges, and to research institutions throughout the United States. The series is specially designed for host institutions that have planetary science research programs and the commitment to make the necessary local arrangements. More information is available at *outerplanets.jpl.nasa.gov/index.htm*.

Hasta La Vesta

Saturday, September 8

Dawn's mission extension studying the asteroid Vesta concludes in late August. Once this mission phase ends, we will be saying hasta la vista, Vesta, to our favorite giant asteroid as we begin our journey to dwarf planet Ceres!

How are we celebrating? Dawn scientists and engineers will share mission stories in a live, interactive video chat — and all are invited! Submit questions in advance via Twitter and Facebook, and connect with Dawn team members in real time with other Dawn mission fans during the event.

Host your own Hasta La Vista, Vesta event, or find a celebration in your community. Check out their online site at *dawn.jpl.nasa.gov/news/hasta_la_vesta.asp* for information about local events, games, activities, and more!

International Observe the Moon Night (InOMN)

Saturday, September 22

This night will be dedicated to encouraging as many people as possible, worldwide, to spend an evening observing and learning about the Moon. Information, a map of registered events, instructions on hosting your own event, activities, a Moon map, star charts, and other resources are available at *observethemoonnight.org*.

Eugene M. Shoemaker Impact Cratering Award

Applications for the GSA Planetary Science Division's Eugene M. Shoemaker Impact Cratering Award are due September 14, 2012. The Eugene M. Shoemaker Impact Cratering Award is for undergraduate or graduate students, of any nationality, working in any country, in the disciplines of geology, geophysics, geochemistry, astronomy, or biology. The award, which will include $2500, is to be applied for the study of impact craters, either on Earth or on the other solid bodies in the solar system. Areas of study may include but shall not necessarily be limited to impact cratering processes; the bodies (asteroidal or cometary) that make the impacts; or the geological, chemical, or biological results of impact cratering. Details about the award as well as an application form for interested students can be found at *www.lpi.usra.edu/science/kring/Awards/Shoemaker_Award/index.html*.

NOVA's Finding Life Beyond Earth Collection

This education collection consists of an activity guide with seven hands-on activities and accompanying video excerpts from NOVA's "Finding Life Beyond Earth" program. The activities and videos explore questions at the heart of the search for extraterrestrial life, such as "What is life?" and "Where do we find habitable conditions?" The resources enable educators to engage audiences with this program's subject and encourage a better understanding of the existence of life in our solar system. More information is available at *www.pbs.org/wgbh/nova/space/finding-life-beyond-earth-collection.html*.

Discover Earth: Hands-On Science Activities

The Lunar and Planetary Institute is pleased to announce new modules within its Explore program of Earth and Space Science materials for informal audiences. Discover Earth activities focus on Earth science topics close to home (such as local weather and the plants, animals, crops, and environmental features unique to your region) as well as a global view of our changing planet. Through hands-on investigations and discussions, young audiences discover that Earth's global environment changes — and is changed by — the local environment. The activities explore three key messages relating to this overall theme: (a) We belong to Earth; (b) each region is unique; and (c) your home is changing. The activities were developed with guidelines set forth by the National Science Education Standards and American Association for the Advancement of Science benchmarks, and they were designed for audiences in the following age ranges: 5–7, 8–9, 10–13, and teens. Facilitators are invited to download and use the activities, supporting reading games, and facilitator resources for educational purposes. For more information, visit *www.lpi.usra.edu/education/explore/discoverEarth*.

"How will humans use science and technology to explore space, and what mysteries will we uncover?"

Mayisha Nakib, 17, discusses her vision with a NASA scientist at the 2010 Humans in Space Symposium.

NASA DLR USRA

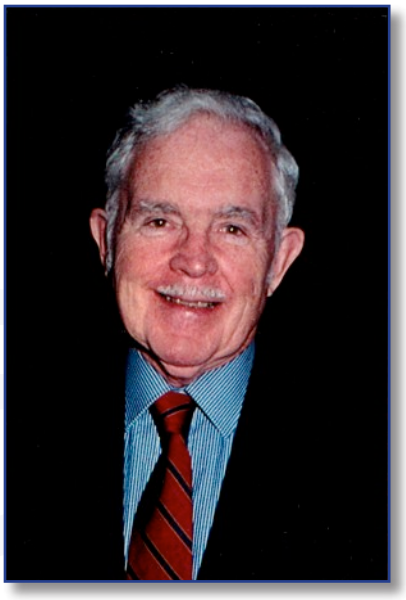
YOUTH ages 10–18 worldwide:

- Make **your voice** heard.
- Express yourself through **Visual, Literary, Musical,** and **Video Art** and submit by October 21, 2012.
- Win and have your artwork displayed and performed **worldwide!**

ADULTS:

- **Inspire** the world about space!
- Become a **judge**.
- Invite your community to **participate**.

Be Inspired Be Creative Be Heard



John "Jack" McCauley, 1932–2012

John "Jack" McCauley, 80, died April 20 in Bonita Springs, Florida, his winter home since 1999. He was 80 years old.

McCauley enjoyed a lifelong, joyful, and storied career as an eminent scientist in Menlo Park, California, and Flagstaff, Arizona, where he led pioneering research in geology of Earth's deserts, the Moon, Mercury, and Mars. He was a loving father for his children and a world traveler with his wife and fellow geologist, Carol.

McCauley was born April 2, 1932, in Millburn, New Jersey, the oldest son of Frank and Margaret McCauley. He graduated from La Salle Academy and Fordham University in 1953, and served as a Line Officer onboard the U.S. Coast Guard Cutter "Dione" during the Korean War. After military service, he earned a Ph.D. in Geology at Columbia University in 1959.

McCauley was an Associate Professor of Geology at the University of South Carolina in 1962 when he was invited (by Gene Shoemaker) to join a new group at the U.S. Geological Survey (USGS). The new Branch of Astrogeologic Studies, working together with NASA, was charged with preparations to land astronauts safely on the Moon. McCauley's work involved geologic mapping of parts of the Moon, using first the visual observations and photographs from telescopes, and later, images from Surveyor landers and Lunar Orbiters. His work supported the identification and selection of safe and scientifically interesting landing sites for the Apollo Project. The Moon-mapping effort and astronaut training by USGS geologists, including McCauley, are described in the book *To a Rocky Moon* by McCauley's friend and colleague Don Wilhelms. With Wilhelms, McCauley co-authored the classic *Geologic Map of the Near Side of the Moon.*

When the Apollo era ended with the Apollo 17 mission, McCauley, as Chief of the Branch of Astrogeology, turned his attention to the planet Mars, serving as Geology Team Leader for the first orbital mission to Mars. Mariner 9 arrived in orbit during a planetwide dust storm, but when the dust cleared, television images revealed an enormous canyon system and huge volcanos in addition to the expected impact craters. McCauley recognized geologic evidence for extensive wind erosion on Mars and went on to study similar wind-formed features in deserts of Earth, including coastal Peru, North Africa, central Iran, and the American Southwest. His field work, using space shuttle radar images over the hyperarid Eastern Sahara of Egypt and Sudan, revealed ancient, sand-buried river systems and associated prehistoric stone tools. McCauley retired from USGS in 1986 after the explosion of the shuttle Challenger, which destroyed the onboard imaging radar experiment needed to support his further research.

McCauley earned numerous scientific awards, including the Special Astronaut Training Award from the Geological Society of America; an Autometric Award from the American Society of Photogrammetry; a Special Award from the Government of Egypt; a Group Award from the U.S. Army Corps of Engineers; and the Meritorious Service Award from the U.S. Department of the Interior.

— Text courtesy of azdailysun.com

John Guest, 1938–2012

John Guest was a pioneer in planetary science, contributing to the first geological map of Mercury, as well as the first comprehensive map of the eastern equatorial region of Mars. He participated in the Mariner 10 and Viking missions to Mars, and the Magellan mission to Venus. Primarily though, Guest was a volcanologist, happiest when he was in the field, especially at Mt. Etna in Sicily, for which he led the UK contribution to the Anglo-Italian collaboration that in 1979 produced the modern geological map of the volcano — the first in more than a hundred years.

Guest was associated with University College London (UCL) for more than 40 years in the Department of Earth Science and the Department of Physics and Astronomy. For his Ph.D. at UCL, he mapped volcanic fields in Chile, including the Chao Dacite and Upper Tertiary ignimbrites in Antofagasta Province. He then went to the University of London Observatory to work with Gilbert Fielder on lunar craters, quickly realizing that craters on the Moon are not volcanic, but the results of impacts, thereby starting his long interest in planetary science. He founded the NASA Regional Planetary Image Facility at UCL (at the time the only such facility outside the USA), and taught many students there. He wrote several books on Italian volcanos with Dave Chester, Paul Cole, Angus Duncan, and Christopher Kilburn, including the seminal work on Mt. Etna, where he also initiated with John Murray annual campaigns for monitoring the volcano's deformation. He made a significant contribution to the study of the geology of Furnas volcano and established close links with the University of the Azores.

His work on the terrestrial planets firmly established UCL's global standing in the fields of volcanology and planetary science. He had a particular talent for being able to interpret geology from surface morphology — whether in the field, from aerial photographs, or from planetary images. He was much loved by his collaborators and students for his kind and generous spirit and his sense of humour. He received the Geological Society of America's G. K. Gilbert award in 1991; that same year the asteroid 1982 HL was named Guest by the International Astronomical Union Nomenclature Committee.

— Text courtesy of Ellen Stofan, Angus Duncan, Rosaly Lopes, and Christopher Kilburn

James Ross Underwood Jr., 1927–2012

Dr. James Ross Underwood Jr. passed away on May 16. He loved his family, his friends, his students, and all the wonders and mysteries of the Earth and heavens. He devoted his professional life to sharing his knowledge of geology and space with others. In addition to his academic contributions, "Granddaddy" was a dignified, gentle giant who loved being a father and grandfather. He had many gifts, one of the greatest being his ability to make everyone to whom he spoke feel like the most important person in the room.

Underwood was born May 15, 1927, in Austin, Texas, to James Ross and Marion Underwood and was raised in Corpus Christi. He joined the U.S. Naval Reserve upon graduating high school in 1944 and served in the reserves during his tenure at Southwestern University in Georgetown, Texas. He moved on to the University of Texas at Austin (UT), where he was involved in many activities, serving as the Longhorn Band Drum Major and as a high jumper on the track team. He spent time in Korea with the Navy in the early 1950s before returning to UT to teach and continue his studies. He earned his Ph.D. in Geology from UT Austin in 1962.

Underwood's teaching career took him and his wife on many adventures, where they made many lifelong friends. He taught at The University of Baghdad, The University of Florida, West Texas State University, the University of Libya, Tripoli, and Kansas State University. He also worked for NASA's Planetary Geology and Geophysics Program from 1972 until his retirement, and was among other things a member of the Viking Lander Imaging Team in 1976. Upon his retirement Underwood returned to Austin, Texas, where he enjoyed close proximity to family, lifelong friends, and his deep Texas roots.

— Text courtesy of the Austin American-Statesman

Forrest McCartney, 1931–2012

Retired Air Force Lt. Gen. Forrest McCartney, a former director of Kennedy Space Center who was crucial in getting NASA's shuttles flying again after the Challenger tragedy, died of cancer on July 17 at a hospice near Cape Canaveral. He was 81 years old.

McCartney was given command of the Kennedy Space Center 18 months after the Challenger exploded on January 28, 1986, killing all seven crew members and leading to suspension of the shuttle orbiter program. His deployment from the ranks of a largely secret military space program made him the focus of initial apprehension in the parallel civilian space-exploration organization. But historians of NASA credit him with rebuilding public confidence in manned space missions and helping to restore the morale of a shaken work force at Cape Canaveral. He directed an extensive review of construction and launching protocols, oversaw the first shuttle launching after the Challenger disaster, and became known as a relentless defender of Kennedy Space Center turf in the perennial struggle with other NASA power centers, including the Johnson Space Center in Houston, the Marshall Space Flight Center in Huntsville, Alabama, and NASA headquarters in Washington.

Confusion over the chain of command had been identified by investigators as one of the causes of the 1986 disaster. In a 2001 interview with the Kennedy Space Center's oral history project, General McCartney referred to that problem in describing his efforts to make the Kennedy Space Center's leaders first among equals in decision making, at least for launchings. Friction with NASA officials over policy and management issues eventually led to his resignation in 1991.

If he had never directed the space center, McCartney would have been known as a pioneer of the U.S. military's unmanned space program. "He played a key role in getting the first reconnaissance satellites into space," said Neil Sheehan, the Pulitzer Prize-winning journalist who wrote *A Fiery Peace in a Cold War,* a 2009 history of the secret space program led by General Bernard Schriever of the Air Force, whom General McCartney served as a top aide in the 1960s. Schriever's group is credited with a string of breakthroughs, including the first photo reconnaissance satellites, the first satellite mapping technology, and the first successful recovery of an orbiting object after its return to Earth. In the 1970s, McCartney became program director for a project that established the ability of naval vessels and airplanes to communicate by satellite. A nuclear engineer by training, he became involved in the early 1980s in developing the MX intercontinental ballistic missile, known as the Peacekeeper.

"In the 50-year history of Kennedy Space Center there have been only 10 directors. Forrest McCartney was one of the finest," said NASA Administrator Charles Bolden. "As an engineer, a patriot, and a leader, McCartney leaves an indelible mark on America's space program. We are grateful for his many contributions and we honor his legacy by rededicating ourselves to the values of exploration, education, and inspiration that were the hallmarks of his life."

McCartney's military decorations and awards included the Distinguished Service Medal, Legion of Merit with one oak leaf cluster, Meritorious Service Medal and Air Force Commendation Medal with three oak leaf clusters. He also wore the master missileman badge and the master space badge. McCartney was also a member of the Board of Trustees of the Florida Institute of Technology in Melbourne, Florida, and was awarded an honorary doctorate degree from that institution. He also served on the Board of Directors of the Space Coast Science Center. He was the recipient of the General Thomas D. White Space Trophy, 1984; the 1987 Military Astronautical Trophy; NASA's Distinguished Service Medal; and the National Space Club's Goddard Memorial Trophy. McCartney was promoted to his retirement rank of lieutenant general on May 1, 1983.

— Text courtesy of NASA and the Boston Globe

Sally Ride, 1951–2012

Sally Kristen Ride, who blazed trails into orbit as the first American woman in space, died on July 23 at her home in the San Diego suburb of La Jolla after a 17-month battle with pancreatic cancer. She was 61.

Ride rode into space on the space shuttle Challenger in 1983 when she was only 32 years old. She was, and still remains, the youngest American to enter space. Subsequent to her flight, more than 42 other American women have flown in space. NASA Administrator Charles Bolden, a former astronaut, issued a statement saying that Ride "broke barriers with grace and professionalism — and literally changed the face of America's space program."

The elder child of Carol Joyce (Anderson) and Dale Burdell Ride, Sally was born in Encino, part of Los Angeles, California. She attended Portola Middle School and Westlake School for Girls in Los Angeles (now Harvard-Westlake School) on a scholarship. In addition to being interested in science, she was a nationally ranked tennis player. Ride attended Swarthmore College for three semesters, took physics courses at UCLA, and then entered Stanford University as a junior, graduating with a bachelor's degree in English and physics. At Stanford, she earned a master's degree and a Ph.D. in physics, while doing research in astrophysics and free electron laser physics.

Ride was one of 8000 people to answer an advertisement in a newspaper seeking applicants for the space program, and joined NASA in 1978. During her career, Ride served as the groundbased Capsule Communicator (CapCom) for the second and third space shuttle flights (STS-2 and STS-3) and helped develop the space shuttle's robot arm. On June 18, 1983, she became the first American woman in space as a crew member on space shuttle Challenger for STS-7. Her second space flight was in 1984, also onboard Challenger. She spent a total of more than 343 hours in space. Ride, who had completed eight months of training for her third flight when the space shuttle Challenger accident occurred, was named to the presidential commission investigating that accident and later served on the panel for the 2003 Columbia shuttle accident, the only person to serve on both boards.

In 1987, Ride left her position in Washington, DC, to work at the Stanford University Center for International Security and Arms Control. In 1989, she became a professor of physics at the University of California, San Diego, and Director of the California Space Institute. During the mid 1990s until her death, Ride led the public outreach efforts of the ISS EarthKAM and GRAIL MoonKAM projects in cooperation with NASA's Jet Propulsion Laboratory and UCSD, which permitted middle school students to study imagery of the Earth and Moon. She was the president and CEO of Sally Ride Science, a company she founded in 2001 that creates entertaining science programs and publications for upper elementary and middle school students, with a particular focus on girls, and wrote or co-wrote five books on space aimed at children, with the goal of encouraging children to study science.

—Text courtesy of NASA and Sally Ride Science

Neil Armstrong, 1930–2012

Neil Armstrong, the first man to walk on the Moon during the 1969 Apollo 11 mission, died on August 25 following complications resulting from cardiovascular procedures. He was 82. Armstrong's words "That is one small step for (a) man, one giant leap for mankind," spoken on July 20, 1969, as he became the first person ever to step onto another planetary body, instantly became a part of history. Those few words from the Sea of Tranquillity were the climactic fulfillment of the efforts and hopes of millions of people and the expenditure of billions of dollars. A plaque on one of the lander's legs that concluded "We came in peace for all mankind," further emphasized that Armstrong and fellow astronaut Edwin "Buzz" Aldrin were there as representatives of all humans.

The following statement was issued by Armstrong's family:

"We are heartbroken to share the news that Neil Armstrong has passed away following complications resulting from cardiovascular procedures. Neil was our loving husband, father, grandfather, brother and friend. Neil Armstrong was also a reluctant American hero who always believed he was just doing his job. He served his nation proudly, as a navy fighter pilot, test pilot, and astronaut. He also found success back home in his native Ohio in business and academia, and became a community leader in Cincinnati. He remained an advocate of aviation and exploration throughout his life and never lost his boyhood wonder of these pursuits.

As much as Neil cherished his privacy, he always appreciated the expressions of good will from people around the world and from all walks of life. While we mourn the loss of a very good man, we also celebrate his remarkable life and hope that it serves as an example to young people around the world to work hard to make their dreams come true, to be willing to explore and push the limits, and to selflessly serve a cause greater than themselves.

For those who may ask what they can do to honor Neil, we have a simple request. Honor his example of service, accomplishment and modesty, and the next time you walk outside on a clear night and see the Moon smiling down at you, think of Neil Armstrong and give him a wink."

In addition to the unique distinction of being the first man to land a craft on the Moon and the first to step onto its surface, Armstrong was decorated by 17 countries and was the recipient of many special honors, including the Presidential Medal of Freedom; the Congressional Space Medal of Honor; the Explorers Club Medal; the Robert H. Goddard Memorial Trophy; the NASA Distinguished Service Medal; the Harmon International Aviation Trophy; the Royal Geographic Society's Gold Medal; the Federation Aeronautique Internationale's Gold Space Medal; the American Astronautical Society Flight Achievement Award; the Robert J. Collier Trophy; the AIAA Astronautics Award; the Octave Chanute Award; and the John J. Montgomery Award. In the words of NASA Administrator Charles Bolden, "As we enter this next era of space exploration, we do so standing on the shoulders of Neil Armstrong. We mourn the passing of a friend, fellow astronaut, and true American hero."

Stuart Ross Taylor Receives 2012 Shoemaker Distinguished Lunar Scientist Award

The NASA Lunar Science Institute (NLSI) is pleased to announce that Stuart Ross Taylor of the Australian National University will receive the Shoemaker Distinguished Lunar Scientist Award for 2012. Taylor is one of the pioneers of lunar science, having studied lunar samples since the first Apollo sample return in July 1969. His books, such as *Lunar Science: A Post-Apollo View*, have greatly influenced a generation of lunar and planetary scientists. As a member of the Preliminary Examination Team at the NASA Johnson Space Center, he carried out the first analysis of the first lunar sample returned to Earth. Subsequently, as a NASA principal investigator for 20 years, he worked on models for lunar composition, evolution, and origin.

The Shoemaker Distinguished Lunar Scientist Medal is an annual award given to a scientist who has significantly contributed to the field of lunar science throughout the course of their scientific career. The first Distinguished Lunar Scientist Award was given posthumously to Gene Shoemaker and presented to his wife Carolyn. The award was subsequently named after Shoemaker and includes a medal with the Shakespearian quote, "And he will make the face of heaven so fine, that all the world will be in love with night." Previous Shoemaker medalists include Don E. Wilhelms (2010) and G. Jeffrey Taylor (2011). The prize is presented at the annual Lunar Science Forum held each July, sponsored by the NLSI.

Taylor grew up on a farm in New Zealand and earned both M.S. and B.S. degrees in chemistry and geology at the University of New Zealand before completing his Ph.D. in geochemistry at Indiana University under advisor Brian Mason. He lectured at the Universities of Oxford and Cape Town before moving to the Research School of Earth Sciences at the Australian National University, where he is currently an emeritus professor. He has also had many appointments at the Lunar and Planetary Institute (LPI) in Houston as a visiting scientist, and in 2005 was the LPI's first Heritage Fellow.

His research involves studies of the composition and evolution of the Moon, Earth's continental crust, tektites and impact glasses, island arc rocks, and many other topics involving trace-element geochemistry. He has published 240 scientific papers and nine books, including *Lunar Science: A Post-Apollo View, Planetary Science: A Lunar Perspective, Solar System Evolution: A New Perspective, Destiny or Chance, The Continental Crust* (with Scott McLennan), and *Planetary Crusts* (with Scott McLennan).

Taylor has been awarded the Goldschmidt Medal of the Geochemical Society, the Leonard Medal of the Meteoritical Society, the Bucher Medal and the Bowen Award of the American Geophysical Union, and the Gilbert Award of the Geological Society of America. Asteroid 5670 is named Rosstaylor. He is a foreign member of the National Academy of Sciences of the United States of America; a fellow of the Australian Academy of Science; and holds honorary fellowships of the Royal Society of New Zealand, the Geological Society (London), and the Geological Society of India. He is a former president of the Meteoritical Society, holds a doctor of science degree from Oxford, and is a Companion of the Order of Australia (AC).

For more information, visit *lunarscience.nasa.gov/shoemaker-award/*.

Barringer Award Recipients Announced

The Lunar and Planetary Institute (LPI) is pleased to announce the names of the students whose research will be supported by The Barringer Family Fund for Meteorite Impact Research. The 2012 awardees are Sanna Holm (Lund University, Sweden), Magnus Ivarsson (Stockholm University, Sweden), Sarinya Paisarnsombat (University of New Brunswick, Canada), and Alaura Singleton (University of Western Ontario, Canada).

The Barringer Family Fund for Meteorite Impact Research was established to support field work by eligible students interested in the study of impact cratering processes. The Fund provides a small number of competitive grants each year for support of field research at known or suspected impact sites worldwide. The Fund was established as a memorial to recognize the contributions of Brandon, Moreau, Paul, and Richard Barringer to the field of meteoritics and the Barringer family's strong interest and support over many years in research and student education. In addition to its memorial nature, the Fund also reflects the family's long-standing commitment to responsible stewardship of The Barringer Meteorite Crater and the family's steadfast resolve in maintaining the crater as a unique scientific research and education site.

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

President Barack Obama presents former United States Marine Corps pilot, astronaut, and United States Senator John Glenn with a Medal of Freedom, Tuesday, May 29, 2012, during a ceremony at the White House in Washington. Credit: NASA/Bill Ingalls.

John Glenn Selected for Presidential Medal of Freedom

John Glenn, the first U.S. astronaut to orbit the Earth, was honored by President Barack Obama with the Presidential Medal of Freedom during a ceremony held at the White House on Tuesday, May 29. Glenn was present at the event with this year's 12 other medal recipients, including influential musician Bob Dylan, former Secretary of State Madeline Albright, and Juliette Gordon Low, who founded the Girl Scouts in 1912. Since 1963, the Presidential Medal of Freedom has been awarded to individuals for "meritorious contributions to the security or national interests of the United States, to world peace, or to cultural or other significant public or private endeavors," according to the White House.

Glenn, 90, is a former Marine Corps Colonel, NASA astronaut, and Senator. On February 20, 1962, he became the third U.S. astronaut in space and the first to circle the planet. "On the morning that John Glenn blasted off into space, America stood still," Obama said before presenting Glenn with the Medal of Freedom. "For a half an hour, the phone stopped ringing at Chicago police headquarters. New York subway drivers offered a play-by-play account over

the loud speakers. President Kennedy interrupted a breakfast with congressional leaders to join 100 million TV viewers to hear the famous words 'Godspeed John Glenn.'" Nearly four decades after his first mission and a quarter century after being elected to Congress, Glenn lifted off onboard the space shuttle to become the oldest person to fly in space.

The honor came three months after NASA and the nation celebrated the 50th anniversary of Glenn's Mercury-Atlas 6 mission onboard his Friendship 7 spacecraft. In addition to referencing Glenn's spaceflight experiences, the award was also in recognition for the Senator's political achievements. Glenn was an architect and sponsored the 1978 Nonproliferation Act and served as chairman of the Senate Government Affairs committee from 1987 to 1995. Glenn retired from Congress in 1999 after representing his home state of Ohio for 25 years.

NASA Announces 2012 Space Technology Research Fellowship Grants

NASA has selected the 2012 class of Space Technology Research Fellows. Forty-eight students will receive graduate student fellowships from NASA's Space Technology Program to pursue master's or doctoral degrees in relevant space technology disciplines at their respective institutions. Through the Space Technology Research Fellowships Program, NASA is providing the nation with a pipeline of highly skilled engineers and technologists to improve U.S. competitiveness while developing the intellectual and technological foundation needed for future science and exploration missions. The program is part of a renewed emphasis on technology at NASA, which is designed to inspire the nation and contribute to an innovation-driven economy.

NASA Space Technology Fellows will perform innovative space technology research while building the skills necessary to become future technological leaders. Selected candidates will perform graduate student research on their respective campuses and at NASA centers and nonprofit U.S. research and development laboratories.

For a list of fellowship recipients and their respective research institutions and research topics, visit *go.usa.gov/BfN*. The fellowships program is managed for NASA's Space Technology Program by the agency's Glenn Research Center in Cleveland. For information about NASA's Space Technology Program and the fellowships program, visit *www.nasa.gov/oct*.

NASA Announces 2012 Aeronautics Scholarship Recipients

NASA has selected 25 students to receive the agency's Aeronautics Scholarship for the 2012–2013 school year. This scholarship program, which is in its fifth year, is designed to aid undergraduate and graduate students enrolled in fields of study related to aeronautics and aviation. Recipients were selected from hundreds of applications to the program. The students will have the opportunity to intern with NASA researchers and work on developing technologies for managing air traffic more efficiently; reducing aircraft noise, fuel consumption and emissions; and improving safety.

This year's recipients are enrolled at universities in California, Colorado, Florida, Georgia, Indiana, Maryland, Massachusetts, Michigan, Mississippi, Missouri, New Jersey, New York, and Texas. The 2012

scholarship recipients' names and their schools are depicted on an interactive map of the United States located at *www.aeronautics.nasa.gov/aeronautics_scholarships*.

Undergraduate scholarship winners will receive $15,000 per year to cover tuition costs for two years and a $10,000 stipend during a summer internship with NASA. Graduate scholarship winners will receive approximately $45,000 per year for as many as three years and $10,000 stipends for as many as two summer internships. To maintain their scholarship awards, all recipients must continue to meet the academic standards of the universities they attend.

The NASA Aeronautics Scholarship Program annually awards 20 two-year undergraduate scholarships plus summer internships, and 5 two- or three-year graduate scholarships plus summer internships. Acceptance of online applications for the 2013 school year will begin in September. Applicants must be citizens of the United States or its territories. The application requirements include information on the students' proposed area of study.

For more information about aeronautics research at NASA, visit *www.aeronautics.nasa.gov*.

NASA Administrator Receives Excellence in Public Service Award

NASA Administrator Charles Bolden was presented the Excellence in Public Service Award on June 21 by former Senator and astronaut John Glenn on behalf of the John Glenn School of Public Affairs at The Ohio State University. "As NASA Administrator, Charlie has charted America's future in space, leading NASA's strategic efforts to fully utilize the International Space Station and launch our astronauts beyond low Earth orbit," Glenn said. "Throughout his career of public service, he has inspired a generation of future astronauts, researchers and innovators who are using what we learn in space to improve life here on Earth."

"I always have believed that service is the rent you pay for your room here on Earth, so it is an honor for me to accept this award from Senator Glenn and the School of Public Affairs," Bolden said. "The John Glenn School of Public Affairs is the starting point for the young people here for making the commitment to public service. Nothing is more important than the path they have chosen."

The Excellence in Public Service Award honors a person who demonstrates outstanding dedication to public service. For more information about the John Glenn School of Public Affairs, visit *glennschool.osu.edu/index.html*. For more information about Bolden, visit *www.nasa.gov/about/highlights/bolden_bio.html*.

President Honors NASA Scientists and Engineers

President Barack Obama has named six NASA individuals as recipients of the 2011 Presidential Early Career Award for Scientists and Engineers (PECASE). The NASA recipients and 90 other federal researchers received their awards in a ceremony held in Washington in late July.

The awards represent the highest honor bestowed by the U.S. government on scientists and engineers beginning their independent careers. They recognize recipients' exceptional potential for leadership at the

In this image from last year's award ceremony, President Barack Obama greets the 2010 PECASE recipients in the East Room of the White House. Credit: Official White House Photo by Pete Souza.

frontiers of scientific knowledge, and their commitment to community service as demonstrated through professional leadership, education or community outreach.

The 2011 NASA recipients were nominated by the agency's Science Mission Directorate, Office of the Chief Engineer, and Office of the Chief Technologist: Morgan B. Abney, NASA Marshall Space Flight Center, recognized for innovative technical leadership in advancing technologies for recovering oxygen from carbon dioxide for self-sustaining human space exploration; Ian Gauld Clark, NASA Jet Propulsion Laboratory and California Institute of Technology, recognized for exceptional leadership and achievement in the pursuit of advanced entry, descent, and landing technologies and techniques for space exploration missions; Temilola Fatoyinbo-Agueh, NASA Goddard Space Flight Center, recognized for exceptional achievement in merging scientific priorities with advanced technology to develop innovative remote-sensing instrumentation for carbon-cycle and ecosystems science; Jessica E. Koehne, NASA Ames Research Center, recognized for exceptional dedication to the development of nano-bio sensing systems for NASA mission needs; Francis M. McCubbin, Institute of Meteoritics, University of New Mexico, recognized for studies of the geochemical role of water and other volatiles in extraterrestrial materials from the inner solar system; and Yuri Y. Shprits, University of California, Los Angeles, recognized for early-career leadership and innovative research and modeling in the realm of the Earth's Van Allen radiation belts.

The PECASE awards were created to foster innovative developments in science and technology, increase awareness of careers in science and engineering, give recognition to the scientific missions of participating agencies, enhance connections between fundamental research and many of the grand challenges facing the nation, and highlight the importance of science and technology for America's future. Eleven federal departments and agencies nominated scientists and engineers for the 2011 PECASE awards. For a complete list of award winners, visit *www.whitehouse.gov/the-press-office/2012/07/23/president-obama-honors-outstanding-early-career-scientists*.

NASA Selects Innovative Museum Exhibits and Planetarium Shows

Exhibits, planetarium shows, and community-based programming are among 18 projects NASA has selected to receive agency funding in 2012. The projects consist of 11 informal education providers and seven NASA visitor centers that will share $10 million in grants through NASA's Competitive Program for Science Museums and Planetariums Plus Opportunities for NASA Visitor Centers and Other Informal Education Institutions. Project topics will feature NASA missions in engineering, astronomy, human spaceflight, aeronautics, technology, and Earth science. The selected projects will partner with NASA's Museum Alliance, a nationwide network of informal education professionals at more than 500 museums, science centers, planetariums, NASA visitor centers, Challenger centers, visitor centers at observatories and parks, nature centers, aquariums, and zoos.

Projects selected in this year's program will engage learners of all ages, as well as educators who deliver formal or informal science, technology, engineering, and mathematics (STEM) education. The projects will produce NASA-inspired educational opportunities, including planetarium shows, exhibits, community-based programming, and other hands-on activities. In conjunction with NASA's Museum Alliance, the grants focus on NASA-themed space exploration, aeronautics, space science, Earth science, microgravity, or a combination of themes. Some projects will include partnerships with elementary and secondary schools, colleges and universities, as well as with community-based organizations.

The museums, science-technology centers, and planetarium selected for project funding are located in California, Georgia, Hawaii, Massachusetts, Minnesota, North Carolina, Pennsylvania, Texas, and Wisconsin. The selected NASA visitor centers are located in Alabama, California, Maryland, Mississippi, Ohio, Texas, and Virginia. Proposals were selected through a merit-based, peer-reviewed process from the 63 proposals received, and institutions from 30 states and the District of Columbia competed.

Congress established the inaugural Competitive Program for Science Museums and Planetariums in 2008. NASA will open the fourth competition for new proposals in Fiscal Year 2013. For a list of selected organizations and project descriptions, visit *go.nasa.gov/NKC2V0*. For information about the Alliance, visit *informal.jpl.nasa.gov/museum*.

Future Female Explorers Hosted by NASA

Eighty-four female high school students from 29 states had the opportunity to plan a simulated mission to Mars and experience life as an engineer or scientist when NASA's Johnson Space Center in Houston hosted two events focused on science, technology, engineering, and mathematics (STEM) in June and July.

The Women in STEM High School Aerospace Scholars project (WISH) sponsored two six-day summer camps for rising high school seniors. The young women worked in teams with female NASA mentors to develop mission plans for launching to Mars, living and working there, and integrating the many components necessary for a successful planetary mission. They worked within the confines of a fictitious budget and built several small mockups of vehicles to demonstrate a successful launch and landing of the Mars spacecraft.

Young women who participated June 24–29 heard a firsthand account of life in space from NASA astronaut Shannon Walker. Participants July 8–13 had a chance to speak with a current space station astronaut via ham radio as part of the Amateur Radio on the International Space Station program, a NASA educational initiative that facilitates direct links between students and astronauts.

The young women were selected based on completion of interactive, online lessons focused on space exploration and mapped to national education standards, academic merits, and geographic diversity. The WISH program encourages young women to pursue STEM degrees and exposes them to the real-world applications of STEM careers at NASA. This program is in its second year. It began as a NASA accompaniment to the White House Council on Women and Girls. For more information about WISH and a list of student participants, visit *go.usa.gov/dsP*.

NASA's Social Media Team Receives Space Foundation Award

NASA's social media team has received the Space Foundation's Douglas S. Morrow Public Outreach Award, which is presented annually to an individual, team, or organization that has made significant contributions to public awareness and understanding of space programs. The award was presented on Monday, April 16, during the opening ceremony of the 28th National Space Symposium. The NASA social media team was selected for creative and pioneering use of social media platforms including Facebook and Twitter, actively engaging millions of people around the world and inspiring followers while in orbit.

NASA uses a host of social media sites to communicate its mission to followers around the world. NASA Socials, formerly known as NASA Tweetups, allow social media followers to attend functions and interact with NASA engineers and scientists. The @NASA Twitter account has surpassed 2 million followers, and NASA maintains a presence on Facebook, Google+, Flickr, and other popular platforms. To view all of NASA's social media sites, visit *www.nasa.gov/connect*.

New NASA App 2.0 Released for iPhone, iPod Touch

NASA recently released an updated version of the free NASA App for iPhone and iPod touch. The NASA App 2.0 includes several new features and a completely redesigned user interface that improves the way people can explore and experience NASA content on their mobile devices. A team at NASA's Ames Research Center completely rebuilt the NASA App for iPhone and iPod touch. It now has a fast and intuitive interface for the approximately 4.7 million people who've downloaded it so far. Other new features of NASA App 2.0 include weather forecasts in the spacecraft sighting opportunities section; maps, information, and links to all the NASA visitor centers; a section about NASA's programs; and the ability to print, save, and access favorite items and bookmark images. The NASA App 2.0 requires iOS 5.0 or later.

All the NASA Apps for iPhone, iPod touch, iPad, and Android showcase a wealth of NASA content, including thousands of images, videos on-demand, live streaming of NASA Television, the agency's Third Rock online radio station, mission and launch information, featured content, stories, and breaking news. Users also can find sighting opportunities for the International Space Station and track the position of the orbiting laboratory. App users also easily can share NASA content with their friends and followers on Facebook, Twitter, or via e-mail. In total, the apps have been downloaded by more than 8.8 million people. For more information, visit *www.nasa.gov/nasaapp*.

NASA 3D App Gives Public Ability to Experience Robotic Space Travel

A NASA-created application that brings some of the agency's robotic spacecraft to life in 3D now is available for free on the iPhone and iPad. Called Spacecraft 3D, the app uses animation to show how spacecraft can maneuver and manipulate their outside components. Presently, the new app features two NASA missions, the Curiosity rover that recently touched down on the surface of Mars, and the twin GRAIL spacecraft, Ebb and Flow, currently orbiting the Moon.

With augmented reality app Spacecraft 3D, you can get up close and personal with some of NASA's heroes of robotic exploration Credit: NASA/JPL-Caltech.

Spacecraft 3D is among the first of what are known as augmented-reality apps for Apple devices. Augmented reality provides users a view of a real-world environment where elements are improved by additional input. Spacecraft 3D uses the iPhone or iPad camera to overlay information on the device's main screen. The app instructs users to print an augmented-reality target on a standard sheet of paper. When the device's camera is pointed at the target, the spacecraft chosen by the user materializes on screen.

"Let's say you want to get an idea what our Curiosity Mars rover is all about," said Kevin Hussey, manager of visualization technology at JPL. "Like Hollywood directors sizing up their next shot, you move your camera-equipped iPad or iPhone in and out, up and down, and the spacecraft perspective moves with you. It is a great way to study the 3D nature of NASA spacecraft." Spacecraft 3D also has a feature where you can take your own augmented-reality picture of the rover or GRAIL spacecraft. You can even make a self-portrait with a spacecraft, putting yourself or someone else in the picture.

"In the near future, we will incorporate the Cassini spacecraft, which is orbiting Saturn, the Dawn spacecraft, which is deep in the heart of the asteroid belt, and the Voyagers, which are right now at the very edge of our solar system," said Hussey. "Looking down the road, we've got a veritable solar system full of spacecraft to work with." Spacecraft 3D currently is available only for Apple formats, but should be available on other formats in the near future. The detailed computer models of the spacecraft used in Spacecraft 3D originally were originally generated for NASA's "Eyes on the Solar System" web application. "Eyes on the Solar System" is a 3D environment full of NASA mission data that allows anyone to explore the cosmos from their computer. For information on how to download the Spacecraft 3D app, visit *itunes.apple.com/us/app/spacecraft-3d/id541089908?mt=8*.

NASA History Now Available on iTunes U

Marking the 43rd anniversary of the Apollo 11 landing on the Moon, NASA has added an extensive collection of historical video, audio, photographs, and documents to iTunes U. iTunes U is a platform for making educational resources available to a wide audience through the iTunes Store. NASA's History Program Office iTunes U site currently contains about 300 items that represent a broad sweep of NASA history related to important moments, activities, and figures in NASA history. The site's content is free to download.

"New materials will continue to be uploaded as we expand the coverage both in depth and breadth," said Bill Barry, NASA's chief historian. "We're thrilled to educate people on NASA's rich history and are open to user suggestions and requests."

The site includes Apollo program material with a collection of items for each of the Apollo missions, as well as a special Politics of Apollo collection of key documents related to the U.S. lunar program. The site also features eBooks from the NASA History Series. Available titles include reader favorites such as Asif Siddiqi's *Challenge to Apollo,* the *Exploring the Unknown* series of documentary histories, and all four volumes of Boris Chertok's *Rockets and People.*

Other agency programs using iTunes U include NASA's Academy of Program, Project and Engineering Leadership (APPEL); NASA Spinoffs from the Office of the Chief Technologist; and collections from NASA's Jet Propulsion Laboratory. To view all of NASA's iTunes U sites and download material, visit *www.nasa.gov/connect/itunesu.html*. To view Apollo materials not found on iTunes U, visit NASA's history website at *history.nasa.gov/apollo.html*.

The *Lunar and Planetary Information Bulletin* collects, synthesizes, and disseminates current research and findings in the planetary sciences to the research community, science libraries, educators, students, and the public. The *Bulletin* is dedicated to engaging, exciting, and educating those with a passion for the space sciences while developing future generations of explorers.

The *Bulletin* welcomes articles dealing with issues related to planetary science and exploration. Of special interest are articles describing web-based research and educational tools, meeting highlights and summaries, and descriptions of space missions. Peer-reviewed research articles, however, are not appropriate for publication in the *Bulletin*. 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 (*rdotson@hou.usra.edu*)

Copy deadline for the next issue: October 15, 2012

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*, or visit *www.lpi.usra.edu/publications/newsletters/lpib/subscribe/index.cfm*.

The *Bulletin* is published quarterly by the Lunar and Planetary Institute (LPI), 3600 Bay Area Boulevard, Houston TX 77058. Material in this issue may be copied without restraint for library, abstract service, education, or personal research purposes.

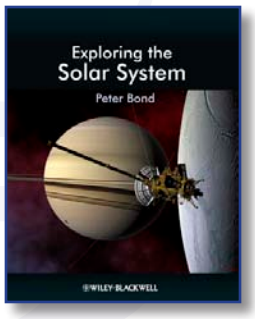
ISSN 1534-6587

The LPI is operated by the Universities Space Research Association under a cooperative agreement with the Science Mission Directorate of the National Aeronautics and Space Administration. Any opinions, findings, and conclusions or recommendations expressed in this issue are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration.

BOOKS

Exploring the Solar System.

By Peter Bond. Wiley-Blackwell, 2012, 470 pp., Paperback, $110.00. *www.wiley.com*



The exploration of our solar system is one of humanity's greatest scientific achievements. The last 50 years in particular have seen huge steps forward in our understanding of the planets, the Sun, and other objects in the solar system. While planetary science is now a mature discipline — involving geoscientists, astronomers, physicists, and others — many profound mysteries remain, and there is indeed still the tantalizing possibility that we may find evidence of life on another planet in our system. Drawing upon the latest results from the second golden age of solar system exploration, author Peter Bond provides an authoritative and up-to-date account of the planets, satellites, and smaller debris that orbit the Sun. Written in an informal style, with minimal use of mathematics, this book is the ideal introductory text for non-science students and other readers with little or no science background. With the aid of numerous illustrations, many in full color, this exciting book brings to life the weird and wonderful worlds that populate our corner of the universe.

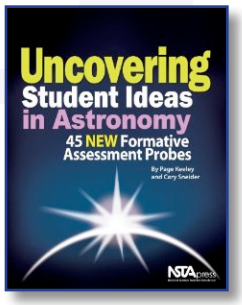
The Space Report 2012.

By The Space Foundation, 2012. 164 pp. Available in hardcopy and CD-ROM formats. $139.00. *www.spacefoundation.org/store*

The Space Report is the definitive overview of major global space developments over the past year. Valuable to space professionals, students, policymakers, researchers, and the media, *The Space Report* includes highlights from all space sectors — from defense to exploration — and illustrates how space activity affects people around the world. It provides a wealth of information on global space budgets, revenues, and industry performance tracked by the Space Foundation Indexes. New content for the 2012 edition includes a discussion of the impact of budget austerity on the global space economy and space programs around the world; information on global launch capabilities, successes, and failures in 2011; demographic information for the European Space Agency (ESA) and the Japan Aerospace Exploration Agency (JAXA); outlook for human spaceflight and global positioning systems in major spacefaring countries; new figures for jobs created and revenue generated by commercialization of NASA spinoffs; and first-time data on South Korea's space workforce.

Uncovering Student Ideas in Astronomy: 45 NEW Formative Assessment Probes.

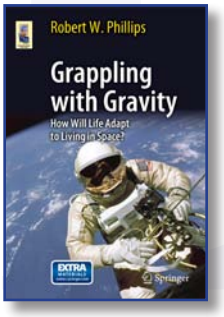
By Page Keeley and Cary Sneider. National Science Teachers Association Press, 2012. 281 pp., Paperback, $36.95. *www.nsta.org/store*



What do students know — or think they know — about what causes night and day, why days are shorter in winter, and how to tell a planet from a star? Find out with this book on astronomy, the latest in the National Science Teachers Association's popular *Uncovering Student Ideas in Science* series. The 45 astronomy probes provide situations that will pique students' interest while helping explain how students think about key ideas related to the universe and how it operates. The book is organized into five sections: the Nature of Planet Earth; the Sun-Earth System; Modeling the Moon; Dynamic Solar System; and Stars, Galaxies, and the Universe. As the authors note, it's not always easy to untangle mistaken ideas. Using this powerful set of tools to identify preconceptions is an excellent first step to helping students achieve scientific understanding.

Grappling with Gravity: How Will Life Adapt to Living in Space?

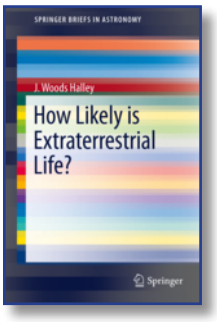
By Robert W. Phillips. Springer, 2011. 282 pp., Paperback, $39.95. *www.springer.com*



This book explores the physiological changes that will occur in humans and the plants and animals that accompany humans as we move to new worlds, whether it be to a colony in the emptiness of space or settlements on the Moon, Mars, or other moons or planets. The focus is on the biomedical aspects, while not ignoring other life-changing influences of space living. For example, what happens to people physiologically in the microgravity of space, where weight and the direction "up" are meaningless? Adapting to microgravity represents the greatest physical challenge that human life will have encountered since our ancestors moved from the seas to solid Earth. It will be the next great adventure!

How Likely is Extraterrestrial Life?

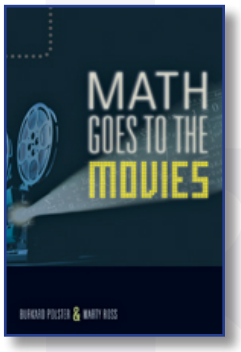
By J. Woods Halley. Springer, 2012. 151 pp., Paperback, $49.95. *www.springer.com*



This book reviews the various scientific issues that arise in considering the question of how common extraterrestrial life is likely to be in our galaxy and whether humans are likely to detect it. The book stands out because of its very systematic organization and relatively unbiased treatment of the main open question. It covers all relevant aspects of many disciplines required to present the different possible answers. The difficulties and the range of possible answers to the title question are carefully addressed in the light of present understanding.

Math Goes to the Movies.

By Burkhard Polster and Marty Ross. Johns Hopkins University Press, 2012. 304 pp., Paperback, $35.00. *www.press.jhu.edu*



Authors Burkard Polster and Marty Ross pored through the cinematic calculus to create this thorough and entertaining survey of the quirky, fun, and beautiful mathematics to be found on the big screen. *Math Goes to the Movies* is based on the authors' own collection of more than 700 mathematical movies and their many years using movie clips to inject moments of fun into their courses. With more than 200 illustrations, many of them screenshots from the movies themselves, this book provides an inviting way to explore math, featuring such movies as *Good Will Hunting, A Beautiful Mind, Stand and Deliver, Pi, Die Hard,* and *The Mirror Has Two Faces*. The authors use movies to introduce and explain important and famous mathematical ideas: higher dimensions, the golden ratio, infinity, and much more. Not all math in movies makes sense, however, and Polster and Ross talk about Hollywood's most absurd blunders and outrageous mathematical scenes. Interviews with mathematical consultants to movies are included to round out this journey into the realm of cinematic mathematics. This behind-the-scenes look at movie math shows how fun and illuminating equations can be.

GLOBE

Sky & Telescope Moon Globe.

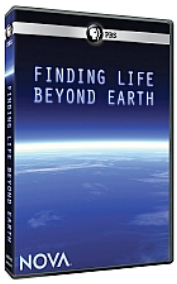
Produced by Sky Publishing, 2012. $99.95. *www.shopatsky.com*

Previous Moon globes have used artistic renderings of the lunar surface. *Sky & Telescope's* new Moon globe is based on actual images from cameras on NASA's Lunar Reconnaissance Orbiter (LRO) taken under nearly consistent ideal lighting conditions — 15,000 actual images to be exact. This globe is the first that shows the Moon as it really is. The 12-inch globe is illustrated with more than 850 labeled lunar features including craters, valleys, Apollo landing sites, and many more. It also comes with a *Sky & Telescope Moon Guide* and stand.

DVD

Finding Life Beyond Earth.

Produced by PBS, 2011, one disc, $24.99. *www.shoppbs.org*



Scientists are on the verge of answering one of the greatest questions in history: Are we alone? *Finding Life Beyond Earth* immerses audiences in the sights and sounds of alien worlds, while top astrobiologists explain how these places are changing how we think about the potential for life in our solar system. We used to think our neighboring planets and moons were fairly boring — mostly cold, dead rocks where life could never take hold. Today, however, the solar system looks wilder than we ever imagined. Powerful telescopes and unmanned space missions have revealed a wide range of dynamic environments — atmospheres thick with organic molecules, active volcanos, and vast saltwater oceans. This ongoing revolution is forcing scientists to expand their ideas about what kinds of worlds could support life.

FOR KIDS!!!

The Space Race.

By Peter Benoit. Children's Press, 2012. 64 pp., Paperback, $8.95. *www.scholastic.com*

Humans first walked on the Moon in 1969. This book describes the race between the United States and the Soviet Union to explore space and how it has shaped our nation today. The book also discusses why the two nations competed to make important discoveries in space, how NASA was created, and how scientists have created new technology to see farther into space. For ages 9 and up.

Oblo Puzzle Sphere.

Produced by Great Circle Works. $24.99. *oblospheres.com*

Oblo is the award-winning, three-dimensional spherical puzzle that challenges and inspires kids of all ages. This colorful layer of spheres creates a compelling puzzle. The initial discovery of its parts happens when the puzzle is taken apart, and the challenge is putting the spherical elements back together. The user must find the correct position for each piece to progressively build spheres within spheres. It provides a fun way to introduce young minds to simple geometry and develops motor skills and hand-eye coordination as well as engaging children's curiosity. Using both hands to manipulate the Oblo, it is used as a great preparation for learning to write and draw. Winner of the Industrial Design Excellence Award in 2008 and winner of the Red Dot Design Award in 2011, the Oblo Puzzle Sphere was designed in Croatia and is made in Canada. For ages 5 and up.

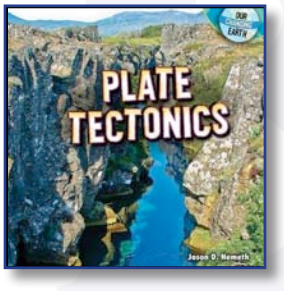
The Mighty Mars Rovers: The Incredible Adventures of Spirit and Opportunity.

By Elizabeth Rusch. Houghton Mifflin Books for Children, 2012. 80 pp., Hardcover, $18.99. *www.hmhco.com*

On June 10, 2003, a little rover named Spirit blasted off on a rocket headed for Mars. On July 7, 2003, a twin rover named Opportunity soared through the solar system with the same mission: to find out if Mars ever had water that could have supported life. A thrilling addition to the acclaimed Scientists in the Field series, *The Mighty Mars Rovers* tells the greatest space robot adventure of all time through the eyes — and heart — of Steven Squyres, professor of astronomy at Cornell University and lead scientist on the mission. This suspenseful page-turner captures the hair-raising human emotions felt during the adventures with two tough rovers. For ages 9 and up.

Plate Tectonics.

By Jason D. Nemeth. PowerKids Press, 2012. 24 pp., Hardcover, $21.25. *www.rosenpublishing.com*



Around 225 million years ago, Earth was home to the supercontinent Pangaea and the massive sea Panthalassa. In fact, Earth's land and water existed in several configurations before today's familiar continents and oceans formed. Readers of this book will get an accessible introduction to plate tectonics. This key scientific theory explains why Earth's landmasses have changed over time. The theory posits that the planet's crust is broken up into plates that are constantly, if slowly, on the move. The book also examines the impact of plate tectonics on volcanos, earthquakes, and the formation of mountains and rift valleys. For grades 2–3.

Calendar 2012

September

3–7 **Astronomical Instruments for Robotic Telescopes,** Ensenada, Mexico. *http://ciaens.astrosen.unam.mx/*

3–7 **ESO@50 — The First 50 Years of ESO,** Garching, Germany. *http://www.eso.org/sci/meetings/2012/ESOat50.html*

3–7 **Planet Formation and Evolution 2012,** Munich, Germany. *http://www.usm.uni-muenchen.de/people/preibisch/planets2012/index.html*

4–7 **GALEX Fest: Exploring the UV Universe,** Pasadena, California. *http://www.galex.caltech.edu/galexfest/*

5–6 **Life in the Cosmos,** Washington, DC. *http://hea-www.cfa.harvard.edu/lifeandthecosmos/wkshop/sep2012/index.html*

10–12 **The Mantle of Mars: Insights from Theory, Geophysics, High-Pressure Studies, and Meteorites,** Houston, Texas. *http://www.lpi.usra.edu/meetings/marsmantle2012/*

10–12 **World Congress and Expo on Biowaivers and Biosimilars,** San Antonio, Texas. *http://www.omicsonline.org/biosimilars2012/*

10–12 **1970–2010: The Golden Age of Solar System Exploration,** Rome, Italy. *http://goldenage2012.ifac.cnr.it/index.php/goldenage2012/goldenage2012*

10–13 **United Nations/Japan Nano-Satellite Symposium,** Nagoya, Japan. *http://www.nanosat.jp/*

15–23 **The Fourth Byurakan International Summer School (4BISS) for Young Astronomers,** Byurakan, Armenia. *http://www.aras.am/SS2012/index.html*

17–20 **Instabilities and Structures in Proto-Planetary Disks,** Marseille, France. *http://wiki.oamp.fr/ispp/IsppWorkShop*

18–21 **Future Science with Metre-Class Telescopes,** Belgrade, Serbia. *http://futurescience.aob.rs/*

19–21 **Third Planetary Crater Consortium Meeting,** Flagstaff, Arizona. *http://www.PlanetaryCraterConsortium.nau.edu*

23–28 **European Planetary Science Congress 2012,** Madrid, Spain. *http://www.epsc2012.eu/*

25–28 **Searching for Life Signatures,** San Marino, Italy. *http://luth7.obspm.fr/Life-Signatures-25-28-Sep2012.pdf*

October

3–4 **26th Meeting of the Mars Exploration Program Analysis Group (MEPAG),** Monrovia, California. *http://mepag.nasa.gov*

8–11 **Rocks n Stars: The Solar System Within Geo- and Astrophysics,** Göttingen, Germany. *http://rocksnstars.de/*

9–12 **Joint Meeting "Paneth Kolloquium" and "The First 10 Million Years of the Solar System" (DFG SPP 1385),** Nördlingen, Germany. *http://www.paneth.eu*

10–12 **International Workshop on Instrumentation for Planetary Missions,** Greenbelt, Maryland. *http://ssed.gsfc.nasa.gov/IPM.html*

14–19 **44th Annual Meeting of the Division for Planetary Sciences of the American Astronomical Society,** Reno, Nevada. *http://www.psi.edu/dps12/*

15–17 **12th European Workshop on Astrobiology (EANA 2012),** Stockholm, Sweden. *http://agenda.albanova.se/conferenceDisplay.py?confId=2996*

15–18 **Science from the Next Generation Imaging and Spectroscopic Surveys,** Garching, Germany. *http://www.eso.org/sci/meetings/2012/surveys2012.html*

17 **LunarCubes Science Briefing,** Reno, Nevada. *http://www.lunar-cubes.com/*

18–20 **Solar System Exploration @50,** Washington, DC. *http://history.nasa.gov/*

22–24 **Annual Meeting of the Lunar Exploration Analysis Group (LEAG 2012),** Greenbelt, Maryland. *http://www.lpi.usra.edu/meetings/leag2012/*

24–26 **Conference on Intelligent Data Understanding 2012,** Boulder, Colorado. *https://c3.nasa.gov/dashlink/events/1/*

25–27 **Third Conference on Terrestrial Mars Analogues,** Marrakech, Morocco. *http://www.ibnbattutacentre.org/conf/mars2012/*

30–Nov 1 **The Evolution and Constitution of Mercury's Interior,** New York, New York. *https://sites.google.com/a/case.edu/messenger-bepicolombo-workshop/*

November

4–7 **Geological Society of America Annual Meeting,** Charlotte, North Carolina. *http://www.geosociety.org/meetings/2012/*

9 **LunarCubes Science Briefing,** Moffett Field, California. *http://www.lunar-cubes.com/*

11–15 **2012 PISCES Conference: Pioneering Planetary Surface Systems Technologies and Capabilities,** Waikoloa, Hawaii. *http://www.pisces.hawaii-conference.com/*

12–13 **Lessons Learned in Decadal Planning in Space Science: A Workshop,** Irvine, California. *http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_070954*

12–16 **Eclipse on the Coral Sea: Cycle 24 Ascending,** Palm Cove, Australia. *http://moca.monash.edu/eclipse/*

13–15 **Tenth Meeting of the Venus Exploration Analysis Group (VEXAG),** Washington, DC. *http://www.lpi.usra.edu/vexag/*

14–16 **2012 Canadian Space Summit: Bridging Communities: Unifying the Canadian Space Sector,** London, Ontario, Canada. *http://cpsx.uwo.ca/news?post_id=6281*

19–22 **APCTP Workshop on Astrophysics: Magnetic Fields in Astrophysics,** Pohang, Korea. *http://www.apctp.org/plan.php/kj2012*

28–30 **NASA Advisory Council Meeting,** Huntsville, Alabama. *http://www.nasa.gov/offices/nac/meetings/index.html*

December

2 **MAVEN Science Community Workshop,** San Francisco, California. *http://lasp.colorado.edu/maven*

3–7 **AGU Fall Meeting,** San Francisco, California. *http://fallmeeting.agu.org/2012/*

January 2013

6–10 **Second Symposium on Planetary Atmospheres,** Austin, Texas. *http://annual.ametsoc.org/2013/index.cfm/programs-and-events/conferences-and-symposia/second-symposium-on-planetary-atmospheres/*

14–16 **8th Meeting of the NASA Small Bodies Assessment Group,** Washington, DC. *http://www.lpi.usra.edu/sbag/meetings/*

16–17 **Astrobiological and Cosmochemical Implications of Marco Polo-R Sampling of a Primitive Asteroid,** Barcelona, Spain. *http://www.ice.csic.es/research/Marco_Polo-R_2013/index_en.html*

February

1–28 **Morocco 2013 Mars Analog Field Simulation,** Erfoud, Morocco. *http://www.oewf.org/cms/mars2013.phtml*

4–8 **Magnetic Fields in the Universe IV: From Laboratory and Stars to the Primordial Structures,** Playa del Carmen, Mexico. *http://www.nucleares.unam.mx/mfu4*

9–16 **Exoplanets in Multi-Body Systems in the Kepler Era,** Aspen, Colorado. *http://www.astro.ufl.edu/~eford/meetings/aspen2013/*

26–27 **27th Meeting of the Mars Exploration Analysis Group (MEPAG),** Washington, DC. *http://mepag.nasa.gov*

March

4–8 **Ganymede Lander: Scientific Goals and Experiments,** Moscow, Russia. *http://glcw2013.cosmos.ru*

18–22 **44th Lunar and Planetary Science Conference (LPSC 2013).** *http://www.lpi.usra.edu/meetings/lpsc2013/*

April

3–6 **From Stars to Life — Connecting our Understanding of Star Formation, Planet Formation, Astrochemistry and Astrobiology,** Gainesville, Florida. *http://conference.astro.ufl.edu/STARSTOLIFE/*

8–12 **Transformational Science with ALMA: From Dust to Rocks to Planets Formation and Evolution of Planetary Systems,** Waikoloa, Hawaii. *http://www.cv.nrao.edu/rocks/index.html*

15–18 **Light Pollution: Theory, Modelling, and Measurements (LPTMM-2013),** Smolenice, Slovak Republic. *http://lptmm.org/*

15–19 **International Young Astronomer School on Exploiting the Herschel and Planck Data (2013),** Meudon, France. *http://ufe.obspm.fr/rubrique344.html*

17–19 **UK Astrobiology Conference,** Edinburgh, Scotland. *http://www.astrobiology.ac.uk/astrobiology-conference-2013*

May

5–9 **43rd Annual Meeting of the American Astronomical Society Division on Dynamical Astronomy,** Paraty, Brazil. *http://dda.harvard.edu/meetings/2013/*

6–8 **Humans to Mars Summit (H2M),** Washington, DC. *http://www.exploremars.org*

15–17 **Ice and Planet Formation,** Lund, Sweden. *http://www.astro.lu.se/~anders/IPF2013/*

28–31 **High Resolution Optical Spectroscopy,** Postdam, Germany. *http://www.aip.de/en/calendar/scientific-events/thinkshop-10*