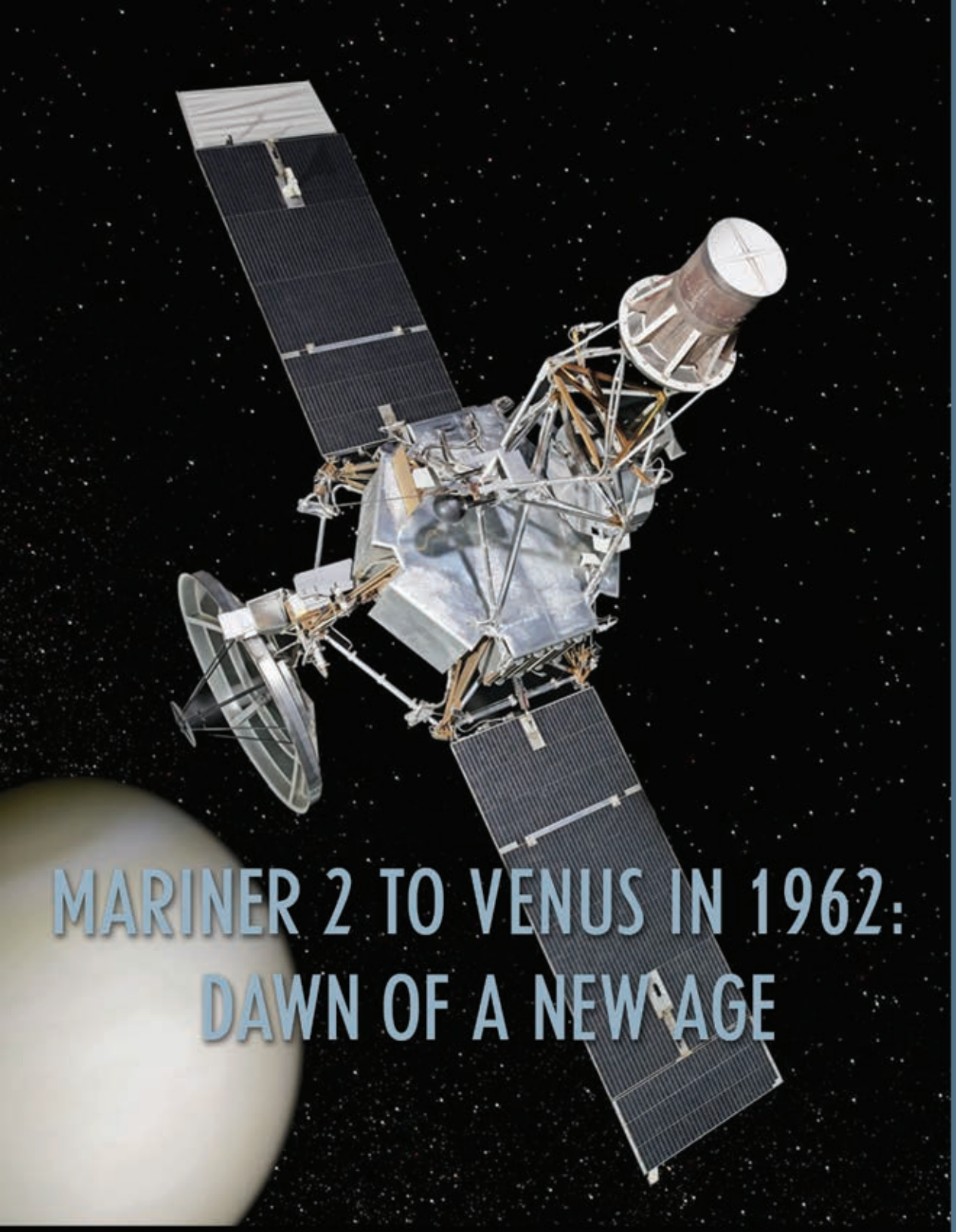

MARINER 2 TO VENUS IN 1962: DAWN OF A NEW AGE

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Mariner 2 to Venus in 1962: Dawn of a New Age

— By Dr. Paul M. Schenk, Lunar and Planetary Institute

This year we celebrate the 50th anniversary of mankind's first true steps beyond the Earth-Moon system and into deep space, for on December 14, 1962, Mariner 2 encountered the planet Venus. Scientists had been anticipating a flight to our nearest neighbor, Venus, for several years. The planet was literally shrouded in mystery, as its opaque cloud decks prevented us from determining even its rotation rate until radar beams suggested a very slow venusian day lasting months. There were no observable surface features on which to hang credible anthropomorphic concepts, such as the "canals" on Mars that were such a powerful stimulant to the imagination. The clouds thus gave free rein to fantasy, leading to lurid ideas of steaming jungles and large reptiles, bubbling oily wastes, or windblown craggy sand heaps. There were hints of very warm signals from Venus, but were they from the surface, or from high in the atmosphere? The only way to know was to go there.

In the race to Venus, politics intervened. With Sputnik in 1957, the road into space was finally opened, and thus began the Space Race. Venus was on the short list of targets to reach first by the two competing nations, the USA and the USSR. The Soviets launched first in 1961, but the mission failed when contact was lost after only a few weeks. The Americans knew that the Soviets would try again, so a pair of Ranger-derived spacecraft, Mariner-R, were built in a record time of 11 months. Because the high-energy Centaur upper stage was not yet ready for deployment, these twins had to be trimmed to less than 500 pounds with a minimal complement of instruments. No cameras were bolted onto these birds!

The Venus that might have been . . . Just one vision of a steamy hot Cretaceous style Venus from the late 1950s.

In those days, it was necessary to build two of everything, because rockets were notorious for blowing up on occasion. Sure enough, Mariner 1 fell into the Atlantic on July 22, 1962, when its Atlas launch vehicle veered off course. Nervous engineers made some corrections and then tried again, launching Mariner 2 on August 27. Even then, an unprogrammed roll of the Atlas during launch gave engineers a wild emotional ride.

With its 16-foot dragonfly-like solar panels and antenna extended, Mariner 2 began its 4-month cruise to Venus in good shape and (almost) on target. The first course correction maneuver was on September 5. Despite a few minor variances, cruise proceeded normally until October 31, when power from one of the two solar panels began to fall off. By November 7, power was back to normal, only to fail completely on November 15. By then, Mariner was close enough to the Sun to allow a single panel to supply the required power. Around this time, the temperature readings onboard began to climb, and on December 9, five days before the encounter, a fuse blew, taking four sensors off-line. The central computer then began exhibiting a tendency to refuse commands. Although limping a little, Mariner 2 approached Venus in relatively good shape.

The Venus encounter phase lasted 7 hours, and took the spacecraft to 34,854 kilometers above the surface of the planet at 19:59 GMT on December 14. All instruments performed as planned, including several

July 1962 launch of Mariner 1, the lost twin of Mariner 2.

radiometer scans across the disk of Venus. Final communications with Mariner 2 occurred on January 3, but by then all the data had been returned (at only 8 bits per second!), and the mission was complete.

A grand total of 60 Mb (!) of data was returned from Mariner 2. The readings proved Venus to be a hot, dry place, markedly different from Earth, under a dense atmosphere 90 times as heavy as our own and surface temperatures of at least 700°F. Limb-darkening observations confirmed that the measurements came from very near the surface. Venus also had no magnetic field to shield the surface from the direct effects of the Sun. It would be another 12 years before we had our first pictures from the surface, and another 30 years before we had a global map and could unravel the history of our nearby twin, all of which would show a fractured volcanic world not unfitting its hadean surface conditions. The planet was certainly no place to raise your kids.

As was noted at the time, despite the high scientific interest and prestige value, Mariner's flight did not "capture the public's imagination." This may have been due to the lack of an onboard camera, but in 1962 Venus just didn't have the popularity of Mars. Nonetheless, the flight of Mariner 2 counts as one of the seminal accomplishments of the Space Age, challenging engineers, smashing distance records, and ushering in a new age, and it is easy to forget how ambitious the mission was.

Beyond the scientific breakthrough in our understanding of another celestial body, Mariner 2 showed simply that a long-duration robotic flight into deep space could be accomplished. Long-range communications and command and control protocols were proven for the first time. Mariner 2 paved the way, and over the ensuing 50 years we have sent robotic emissaries to gather data at all 8 of the official planets and the largest of the dwarf planets (and indeed, today these emissaries have all either arrived at their destinations or are currently on their way). Spacecraft are on their way to both Ceres and Pluto for arrival in 2015, the 50th anniversary of Mariner 4's first pictures of Mars.

Aside from seeing images of towering volcanos and gaping canyons and craters, what have we learned over the past 50 years? In 1962, the planets and a few thousand small asteroids orbited around the Sun in perpetual platitude, unperturbed by naught except the stray comet. Since then, we have gained a fundamental understanding of how planetary systems form and evolve over time, and of the forces that act on them. These insights can be grouped into several major themes.

All those craters provided the first lesson: The impact process was fundamental to shaping the early and subsequent history of planetary bodies, and as shown by Comet Shoemaker-Levy 9 and similar impacts into Jupiter, is an ongoing process. Impact of water-rich materials may have helped make Earth habitable, and later impacts may have radically altered the course of life on this planet as recently as 65 million years ago.

A flight spare of the Mariner 1 and 2 spacecraft currently hanging in the Smithsonian Air and Space Museum. You might not notice this small part of space history if you don't look up.

The Jet Propulsion Laboratory celebrates the Mariner 2 mission with a float in the 1963 Rose Parade in Pasadena.

Our solar system is more complex than we imagined, with multitudes of satellites, rings, comets, and now the Kuiper belt. It is also vastly more dynamic than we imagined 50 years ago. Models suggest that the planets underwent a fundamental realignment 4 billion years ago, scattering asteroids and comets across the solar system. Much of our impact history may be rooted in these and subsequent events. The discovery of volcanism and resurfacing on the jovian satellites by Voyager in 1979 is often told, but it fundamentally reshaped our ideas about satellite systems and showed that orbital tidal energy can melt planetary bodies.

If you melt ice you get water and another revelation from the outer solar system. Ocean worlds, covered in thick layers of ice, may indeed be commonplace. Europa, Ganymede, Callisto, Titan — and possibly Enceladus, Triton, and Pluto — are all believed to be liquid deep inside. Liquid water is nice scientifically, but it is critical if you are interested in habitability.

Life on other worlds is the big question we have not yet been able to answer. Mars and Europa head the list of potential candidates for having at least at one time supported life, but the other water worlds also point to the possibility that other such environments may exist elsewhere in the galaxy, and a few of those worlds may be warm enough to support life.

We are just beginning to unravel the mysteries of the solar system, and it is not just long-range spacecraft, but also advances in telescopic instruments, planetary computer simulations, and amateur astronomers that have all contributed vitally to our increased knowledge of the solar system. With the discovery of extrasolar planets now becoming commonplace across the galaxy, we can only guess what the next 50 years will bring.

The past 50 years have seen a revolution in our understanding of the solar system and planetary systems in general. The recent landing of Curiosity into a once-water-filled impact crater on Mars highlights not only technical advances but also our understanding of the role of impacts, dynamics, and water in creating habitable environments on the planets. The sedimentary deposits in the center of Gale Crater, Mars, are visible in the distance.

This article is excerpted from a series of blogs by the author about this anniversary (available online at *stereomoons.blogspot.com/2012/08/the-planets-at-50-venus-mars.html*). Several articles have also appeared as part of the celebration, including those listed below; no doubt there will be others.

Suggested Reading

- Benningfield, Damond, "Venus Bytes the Dust," *StarDate,* Nov/Dec 2012, pp. 4–9.
- Chaikin, Andrew, "What a Long, Strange Trip: 50 Years of Planetary Exploration," *Lunar and Planetary Information Bulletin,* Issues #128/129, April/May 2012, Lunar and Planetary Institute, Houston.
- NASA, *Mariner-Venus 1962 — Final Project Report,* U.S. Govt. Printing Office, 1965.
- Schenk, Paul, "Why We Explore: Celebrating 50 Years of Exploration," *Planetary Report,* September 2012, pp. 13–18.

About the Author:

Dr. Paul Schenk is a staff scientist at the Lunar and Planetary Institute in Houston and serves as the science editor for the Lunar and Planetary Information Bulletin*. His first formal introduction to planetary sciences was as a NASA Planetary Geology summer intern in 1979 at JPL during the Voyager 2 Jupiter encounter. After completing his Ph.D. at Washington University in St. Louis under advisor William B. McKinnon, Schenk came to the LPI in 1991. Schenk's research at LPI centers on elucidating the geology and topography of the surfaces of the satellites of the outer planets and Vesta, with a particular interest in the unexpectedly rugged topographic relief on Europa and the shapes of impact craters on Europa, Enceladus, and the icy satellites in general. He currently serves as a participating scientist on the Dawn (at Vesta) and Cassini projects.*

Artist's concept of the two BepiColombo orbiters at Mercury. Credit: NASA/ESA.

Strofio Delivers Proto-Flight Model

Strofio is a unique mass spectrometer that is part of the Search for Exospheric Refilling and Emitted Natural Abundances (SERENA) suite of instruments that will fly onboard the European Space Agency's BepiColombo/Mercury Planetary Orbiter (MPO) spacecraft. Strofio will determine the chemical composition of Mercury's surface, providing a powerful tool to study the planet's geological history. Strofio is a NASA-funded Discovery Mission of Opportunity.

The Strofio team is continuing to test the instrument components. The project conducted the Strofio Proto-Flight Model (PFM) pre-ship review, part 1, on August 23 at Southwest Research in San Antonio. The PFM and the Ground Support Equipment were shipped to the University of Bern on August 27, and subsequently installed in the calibration chamber. Over the next few months, integration, testing, and calibration will continue. Delivery of Strofio to SERENA is currently planned for February 2013. SERENA will be delivered to ESA in April 2013. Launch of BepiColombo is scheduled for August 2015, with arrival at Mercury in 2022. For more information about the BepiColombo mission, visit *www.esa.int/esaSC/120391_index_0_m.html*.

GRAIL's principal investigator Maria Zuber with MoonKam students. Credit: NASA.

NASA's GRAIL Moon Twins Begin Extended Mission Science

NASA's twin, lunar-orbiting Gravity Recovery and Interior Laboratory (GRAIL) spacecraft, Ebb and Flow, have begun data collection for the start of the mission's extended operations. On August 30, while the two spacecraft were 19 miles (30 kilometers) above the Moon's Ocean of Storms, the Lunar Gravity Ranging System — the mission's sole science instrument onboard both GRAIL twins — was energized.

"The data collected during GRAIL's primary mission team are currently being analyzed and hold the promise of producing a gravity field map of extraordinary quality and resolution," said Maria Zuber, principal investigator for GRAIL from the Massachusetts Institute of Technology in Cambridge. "Mapping at a substantially lower altitude during the extended mission, and getting an even more intimate glimpse of our nearest celestial neighbor, provides the unique opportunity to globally map the shallow crust of a planetary body beyond Earth."

The science phase of GRAIL's extended mission runs from August 30 to December 3. Its goals are to

take an even closer look at the Moon's gravity field, deriving the gravitational influence of surface and subsurface features as small as simple craters, mountains, and rilles. To achieve this unprecedented resolution, GRAIL mission planners are halving the operating altitude — flying at the lowest altitude that can be safely maintained.

During the prime mission, which stretched from March 1 to May 29, the two GRAIL spacecraft orbited at an average altitude of 34 miles (55 kilometers). The average orbital altitude during the extended mission is 14 miles (23 kilometers), which places the GRAIL twins within 5 miles (8 kilometers) of some of the Moon's higher surface features.

Science data are collected when the Lunar Gravity Ranging System transmit radio signals between the two spacecraft, precisely defining the rate of change of distance between them. The distance between the twins changes slightly as they fly over areas of greater and lesser gravity caused by visible features, such as mountains and craters, and by masses hidden beneath the lunar surface. Mission scientists calculated that even as the last primary mission data were downlinked, four of the mission's six principal science measurement goals had already been achieved. The objective of the GRAIL mission is to generate the most accurate gravity map of the moon and from that derive the internal structure and evolution of Earth's natural satellite.

GRAIL's MoonKAM, the cameras taking images directed by students, has been extended also. To date, more than 80,000 student images have been snapped. Teachers can still register their classes to participate in the extended mission by visiting *moonkam.ucsd.edu/register*.

This past summer, middle-school students and their teachers gathered in Washington, DC, to demonstrate science lessons and highlight images they took from lunar orbit using GRAIL's MoonKAM system. Along with demonstrating their knowledge of the Moon and science, the students listened to presentations from Zuber, NASA deputy administrator Lori Garver, President Obama's science advisor John Holdren, and Sally Ride, who spoke to the students remotely. Zuber said she was blown away with the student demonstrations and their grasp of lunar science, noting that the GRAIL mission and MoonKAM are making a difference in young student's lives one image at a time.

For more information about GRAIL, visit *solarsystem.nasa.gov/grail*. More information about MoonKAM is available at *moonkam.ucsd.edu*.

An artist's illustration of NASA's Lunar Atmosphere and Dust Environment Explorer (LADEE) mission. Credit: NASA.

NASA'S LADEE Spacecraft Gets Final Science Instrument Installed, Will Fly Plaque in Honor of Gordon McKay

Engineers at NASA's Ames Research Center have installed the third and final science instrument that will fly onboard NASA's Lunar Atmosphere and Dust Environment Explorer (LADEE). LADEE is a robotic mission that will orbit the Moon to gather detailed information about the lunar atmosphere, conditions near the surface, and environmental influences on lunar dust.

In addition to LADEE's science instruments, a technology demonstration also will fly onboard. The science instruments include the Ultraviolet and Visible Light Spectrometer (UVS), which will examine the composition of the lunar atmosphere by analyzing light signatures of materials it finds; the Neutral Mass Spectrometer (NMS), set to measure variations in the lunar atmosphere over multiple lunar orbits with the Moon in different space environments; and the Lunar Dust Experiment (LDEX), which will collect and analyze samples of any lunar dust particles in the

tenuous atmosphere. The technology demonstration payload is called the Lunar Laser Communications Demonstration, and will enable the LADEE spacecraft to use lasers instead of radio waves to achieve broadband speeds to communicate with Earth.

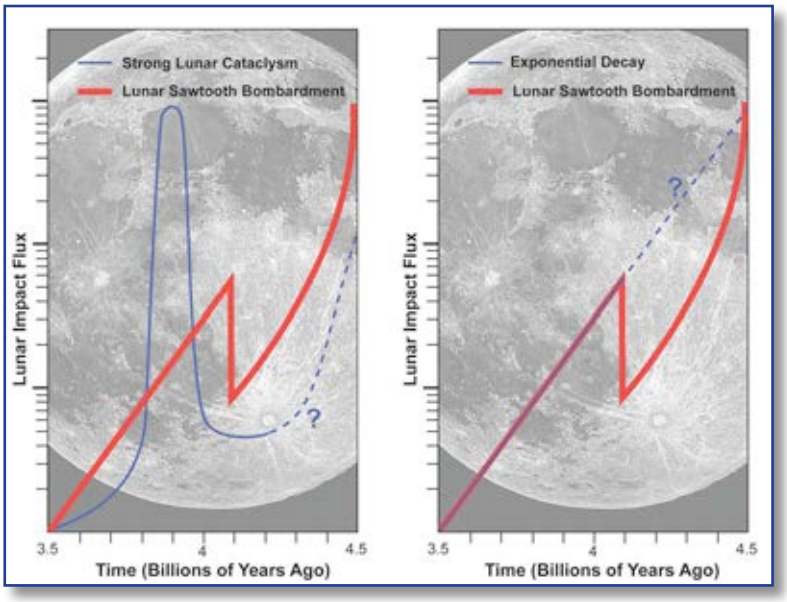
"We now have our full science suite, and LADEE has the tools it needs to address mysteries and questions that have lingered since Apollo," said Rick Elphic, LADEE project scientist. "Was electrostatically lofted lunar dust responsible for the horizon glow that the astronauts observed? LDEX and UVS will settle that question once and for all. What makes the exotic, tenuous atmosphere of the Moon breathe and change? NMS and UVS will tell us where the different species come from, how they move, and how they are lost. A mission like LADEE has been needed since Apollo, which left us with tantalizing hints about the dust and an exotic, tenuous atmosphere."

LADEE will also carry a tribute to the late Dr. Gordon A. McKay, a lunar petrologist at the NASA Johnson Space Center (JSC) who passed away suddenly in 2008. The plaque is a black and white version of a certificate that is on display in one of the conference rooms at JSC, laser printed on thin aluminum film. The wording on the plaque reads "This plaque is placed here in memory of Dr. Gordon A. McKay, a lunar petrologist and meteoriticist, an innovator in experimental techniques, a leader in understanding the evolution of the terrestrial planets, a bridge across international scientific communities, an insightful scientist, a generous mentor, a caring and competent manager, and a joy to have as a colleague. He is missed."

LADEE now begins its environmental test phase and will undergo tests simulating the conditions it will face during launch and operations in space. These tests include acoustic (the loud roar of the rocket), vibration (the shaking of the rocket), shock (the jolt when stages separate), and thermal-vacuum (the hot and cold vacuum conditions of deep space). LADEE's launch in August 2013 will mark several firsts. It will be the first payload to launch on a U.S. Air Force Minotaur V rocket integrated by Orbital Sciences Corporation, and will be the first deep space mission to launch from the Wallops Flight Facility in Virginia. For more information about the LADEE mission, visit *www.nasa.gov/ladee*.

Revisiting the Early Collisional Evolution of the Moon

In yet another example of the continued collaboration among the teams of the NASA Lunar Science Institute and the Observatoire de la Côte d'Azur in Nice, France, Alessandro Morbidelli, Simone Marchi, William Bottke, and David Kring have published a paper in the journal *Earth and Planetary Science Letters*.



Lunar sawtooth bombardment graph compared to the theories of a strong lunar cataclysm (left) and exponential decay (right). Credit: NLSI.

The researchers revisited the early evolution of the Moon's bombardment. Using the best available dynamical models of terrestrial planet formation and giant planet evolution, they predicted the lunar impact flux during its earliest stages, ranging from tens of millions of years after the Moon's formation to a billion years later (i.e., from 3.5 to 4.5 billion years ago). This model covers the so-called period of late lunar bombardment when many of the largest and oldest

lunar impact craters were formed. By calibrating their results against existing dynamical, geochemical, and crater density constraints, the team obtained a self-consistent picture of the early collisional evolution of the Moon. Specifically, the team combined their dynamical modeling work with constraints from the lunar crater record, radiometric ages of the youngest lunar basins, and the abundance of highly siderophile, or iron-loving, elements like gold, platinum, osmium, and iridium in the lunar crust and mantle.

The team deduced that the evolution of the impact flux did not decline as rapidly as previously thought over the first billion years of lunar history, and that there was no single, "narrow" impact spike some 3.9 billion years ago, as is often shown in graphical sketches of the lunar late heavy bombardment. Instead, the bombardment timeline that emerged from their study showed something of a "sawtooth" profile, with an uptick in the impact flux about 4.1 billion years ago.

The sawtooth-like bombardment timeline has important implications for Earth's habitability. In previous views, the Earth was either an increasingly hostile abode for life going back in time toward the Moon forming event, or it was relatively tranquil for several hundreds of million of years just prior to the hypothesized impact spike that took place 3.9 billion years ago. In the new sawtooth view, big impactors hit over an extended period, with more lulls and therefore more opportunities for the biosphere to recover. Perhaps in this scenario, life formed very early and survived in one form or another through the late heavy bombardment.

Artist's rendition of the InSight lander. Credit: JPL/NASA.

InSight Will Take First Look Deep Inside Mars

InSight, an investigation into the interior of Mars, is NASA's choice for the 12th Discovery Program mission. The new exploration, set to launch in 2016, seeks to answer one of science's most fundamental questions: How did the terrestrial planets form? InSight, short for Interior Exploration using Seismic Investigations, Geodesy and Heat Transport, is a terrestrial planet explorer that will address a key issue of planetary and solar system science — understanding the processes that shaped the rocky planets of the inner solar system more than four billion years ago. InSight will be the first to go below the surface of the Red Planet to find clues about why it evolved so differently from Earth.

To do this, InSight will place a single geophysical lander on Mars. Three instruments will delve deep beneath the surface, shedding new light on the processes of terrestrial planet formation, as well as measuring the planet's "vital signs": "pulse" (seismology), "temperature" (heat flow probe), and "reflexes" (precision tracking). InSight will carry two cameras. One will capture black-and-white images of the instruments on the lander's deck and a three-dimensional view of the ground where the seismometer and heat flow probe will be placed. These images will help engineers and scientists guide the deployment of the instruments to the ground. With a 45° field of view, the camera will also provide a panoramic view of the terrain surrounding the landing site. The second camera will provide a complementary view of the instrument deployment area.

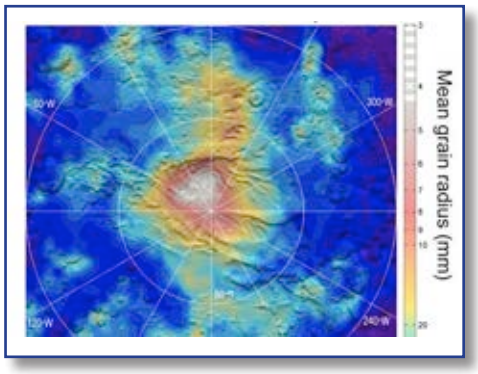
InSight will investigate whether the core of Mars is solid or liquid, or has components of both, like Earth, and why Mars' crust is not divided into tectonic plates that drift like those on Earth. Detailed knowledge of the interior of Mars in comparison to Earth will help scientists understand better how terrestrial planets form and evolve. "The exploration of Mars is a top priority for NASA, and the selection of InSight ensures we will continue to unlock the mysteries of the Red Planet and lay the groundwork for a future human mission there," said NASA Administrator Charles Bolden.

InSight will be led by W. Bruce Banerdt at NASA's Jet Propulsion Laboratory. InSight's science team includes U.S. and international co-investigators from universities, industry, and government agencies. The French space agency Centre National d'Etudes Spatiales (CNES) and the German Aerospace Center are contributing instruments to InSight, which is scheduled to land on Mars in September 2016 to begin its two-year scientific mission.

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

NASA Orbiter Observations Point to "Dry Ice" Snowfall on Mars

NASA's Mars Reconnaissance Orbiter data have given scientists the clearest evidence yet of carbon-dioxide snowfalls on Mars. This reveals the only known example of carbon-dioxide snow falling anywhere in our solar system. Frozen carbon dioxide, better known as "dry ice," requires temperatures of about –193°F (–125°C), which is much colder than needed for freezing water. Carbon-dioxide snow reminds scientists that although some parts of Mars may look quite Earth-like, the Red Planet is very different. The report was published in the *Journal of Geophysical Research*.



Observations by NASA's Mars Reconnaissance Orbiter have detected carbon-dioxide snow clouds on Mars and evidence of carbon-dioxide snow falling to the surface. Credit: NASA/JPL-Caltech.

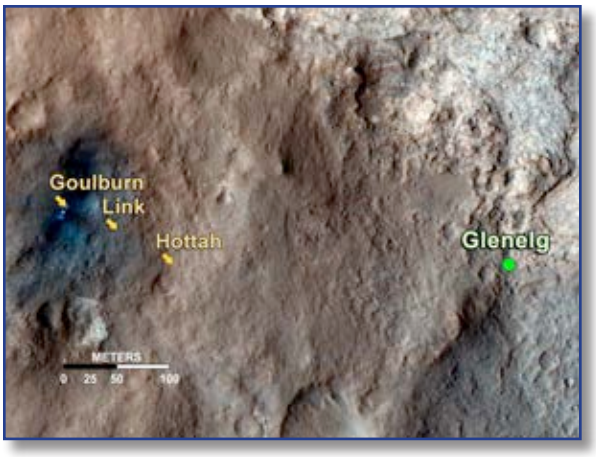
"These are the first definitive detections of carbon-dioxide snow clouds," said the report's lead author, Paul Hayne of NASA's Jet Propulsion Laboratory. "We firmly establish the clouds are composed of carbon dioxide — flakes of martian air — and they are thick enough to result in snowfall accumulation at the surface."

The snowfalls occurred from clouds around the Red Planet's south pole in winter. The presence of carbon-dioxide ice in Mars' seasonal and residual southern polar caps has been known for decades. In 2008, NASA's Phoenix Lander mission observed falling water-ice snow on northern Mars.

Hayne and six co-authors analyzed data gained by looking at clouds straight overhead and sideways with the Mars Climate Sounder, one of six instruments on the Mars Reconnaissance Orbiter. This instrument records brightness in nine wavebands of visible and infrared light as a way to examine particles and gases in the martian atmosphere. The data provide information about temperatures, particle sizes, and their concentrations. The new analysis is based on data from observations in the south polar region during southern Mars winter in 2006–2007, identifying a tall carbon-dioxide cloud about 300 miles (500 kilometers) in diameter persisting over the pole and smaller, shorter-lived, lower-altitude carbon dioxide ice clouds at latitudes from 70° to 80°S.

Mars' south polar residual ice cap is the only place on the Red Planet where frozen carbon dioxide persists on the surface year-round. Just how the carbon dioxide from Mars' atmosphere gets deposited has been in question. It is unclear whether it occurs as snow or by freezing out at ground level as frost. These results show snowfall is especially vigorous on top of the residual cap.

"The finding of snowfall could mean that the type of deposition — snow or frost — is somehow linked to the year-to-year preservation of the residual cap," Hayne said. For more information about the Mars Reconnaissance Orbiter, visit *www.nasa.gov/mro* or *mars.jpl.nasa.gov/mro*.



This map shows the path on Mars of NASA's Curiosity rover toward Glenelg, an area where three terrains of scientific interest converge. Credit: NASA/JPL-Caltech/ Univ. of Arizona.

Curiosity: Science from the First Three Months on Mars

Following its dramatic and successful landing on Mars in early August, NASA's Curiosity rover found evidence that a stream once ran vigorously across the area on Mars where the rover is now driving. There is earlier evidence for the presence of water on Mars, but this evidence — images of rocks containing ancient streambed gravels — is the first of its kind. Scientists are studying the images of stones cemented into a layer of conglomerate rock. The sizes and shapes of stones offer clues to the speed and distance of a long-ago stream's flow.

"From the size of gravels it carried, we can interpret the water was moving about 3 feet per second, with a depth somewhere between ankle and hip deep," said Curiosity science co-investigator William Dietrich of the University of California, Berkeley. "Plenty of papers have been written about channels on Mars with many different hypotheses about the flows in them. This is the first time we're actually seeing water-transported gravel on Mars. This is a transition from speculation about the size of streambed material to direct observation of it."

The finding site lies between the north rim of Gale Crater and the base of Mount Sharp, a mountain inside the crater. Earlier imaging of the region from Mars orbit allows for additional interpretation of the gravel-bearing conglomerate. The imagery shows an alluvial fan of material washed down from the rim, streaked by many apparent channels, sitting uphill of the new finds. The rounded shape of some stones in the conglomerate indicates long-distance transport from above the rim, where a channel named Peace Vallis feeds into the alluvial fan. The abundance of channels in the fan between the rim and conglomerate suggests flows continued or repeated over a long time, not just once or for a few years.

The discovery comes from examining two outcrops, called "Hottah" and "Link," with the telephoto capability of Curiosity's mast camera during the first 40 days after landing. Those observations followed up on earlier hints from another outcrop, which was exposed by thruster exhaust as Curiosity, the Mars Science Laboratory Project's rover, touched down. "Hottah looks like someone jack-hammered up a slab of city sidewalk, but it's really a tilted block of an ancient streambed," said Mars Science Laboratory Project Scientist John Grotzinger of the California Institute of Technology in Pasadena. The gravels in conglomerates at both outcrops range in size from a grain of sand to a golf ball. Some are angular, but many are rounded.

Curiosity has also completed initial experiments showing the mineralogy of martian soil is similar to weathered basaltic soils of volcanic origin in Hawaii. The minerals were identified in the first sample of martian soil ingested recently by the rover. Curiosity used its Chemistry and Mineralogy instrument (CheMin) to obtain the results, which are filling gaps and adding confidence to earlier estimates of the mineralogical makeup of the dust and fine soil widespread on the Red Planet.

"We had many previous inferences and discussions about the mineralogy of martian soil," said David Blake of NASA Ames Research Center, who is the principal investigator for CheMin. "Our quantitative results provide refined and in some cases new identifications of the minerals in this first X-ray diffraction analysis on Mars."

CheMin uses X-ray diffraction, the standard practice for geologists on Earth using much larger laboratory instruments. This method provides more accurate identifications of minerals than any method previously

used on Mars. X-ray diffraction reads minerals' internal structure by recording how their crystals distinctively interact with X-rays. Innovations from NASA Ames led to an X-ray diffraction instrument compact enough to fit inside the rover. These NASA technological advances have resulted in other applications on Earth, including compact and portable X-ray diffraction equipment for oil and gas exploration, analysis of archaeological objects, and screening of counterfeit pharmaceuticals, among other uses.

The specific sample for CheMin's first analysis was soil Curiosity scooped up at a patch of dust and sand that the team named Rocknest. The sample was processed through a sieve to exclude particles larger than 0.006 inches (150 micrometers), roughly the width of a human hair. The sample has at least two components: dust distributed globally in dust storms and fine sand originating more locally. Unlike conglomerate rocks Curiosity investigated a few weeks ago, which are several billion years old and indicative of flowing water, the soil material CheMin has analyzed is more representative of modern processes on Mars.

"Much of Mars is covered with dust, and we had an incomplete understanding of its mineralogy," said David Bish, CheMin co-investigator with Indiana University in Bloomington. "We now know it is mineralogically similar to basaltic material, with significant amounts of feldspar, pyroxene, and olivine, which was not unexpected. Roughly half the soil is non-crystalline material, such as volcanic glass or products from weathering of the glass." Bish added, "So far, the materials Curiosity has analyzed are consistent with our initial ideas of the deposits in Gale Crater recording a transition through time from a wet to dry environment. The ancient rocks, such as the conglomerates, suggest flowing water, while the minerals in the younger soil are consistent with limited interaction with water."

The first martian rock Curiosity reached out to touch presents a more varied composition than expected from previous missions. The rock also resembles some unusual rocks from Earth's interior. The rover team used two instruments to study the chemical makeup of the football-size rock called "Jake Matijevic" (matt-EE-oh-vick). The results support some surprising recent measurements and provide an example of why identifying rocks' composition is such a major emphasis of the mission. "This rock is a close match in chemical composition to an unusual but well-known type of igneous rock found in many volcanic provinces on Earth," said Edward Stolper of the California Institute of Technology, who is a Curiosity co-investigator.

On Earth, rocks with composition like the Jake rock typically come from processes in the planet's mantle beneath the crust, from crystallization of relatively water-rich magma at elevated pressure. "Jake is kind of an odd martian rock," said APXS Principal Investigator Ralf Gellert of the University of Guelph in Ontario, Canada. "It's high in elements consistent with the mineral feldspar, and low in magnesium and iron."

ChemCam found unique compositions at each of 14 target points on the rock, hitting different mineral grains within it. "ChemCam had been seeing compositions suggestive of feldspar since August, and we're getting closer to confirming that now with APXS data, although there are additional tests to be done," said ChemCam Principal Investigator Roger Wiens of Los Alamos National Laboratory in New Mexico.

Finally, Curiosity has already taken significant steps toward understanding how Mars may have lost much of its original atmosphere. Learning what happened to the martian atmosphere will help scientists assess whether the planet was ever habitable. The present atmosphere of Mars is 100 times thinner than Earth's. A set of instruments onboard the rover has ingested and analyzed samples of the atmosphere collected near the "Rocknest" site in Gale Crater where the rover is stopped for research. Findings from the Sample Analysis at Mars (SAM) instruments suggest that loss of a fraction of the atmosphere, resulting from a physical process favoring retention of heavier isotopes of certain elements, has been a significant factor in the evolution of the planet. Isotopes are variants of the same element with different atomic weights.

Initial SAM results show an increase of 5% in heavier isotopes of carbon in the atmospheric carbon dioxide compared to estimates of the isotopic ratios present when Mars formed. These enriched ratios of

heavier isotopes to lighter ones suggest the top of the atmosphere may have been lost to interplanetary space. Losses at the top of the atmosphere would deplete lighter isotopes. Isotopes of argon also show enrichment of the heavy isotope, matching previous estimates of atmosphere composition derived from studies of martian meteorites on Earth. Scientists theorize that in Mars' distant past its environment may have been quite different, with persistent water and a thicker atmosphere. NASA's Mars Atmosphere and Volatile Evolution (MAVEN) mission will investigate possible losses from the upper atmosphere when it arrives at Mars in 2014.

With these initial sniffs of martian atmosphere, SAM also made the most sensitive measurements ever to search for methane gas on Mars. Preliminary results reveal little to no methane. Methane is of interest as a simple precursor chemical for life. On Earth, it can be produced by either biological or nonbiological processes. Methane has been difficult to detect from Earth or the current generation of Mars orbiters because the gas exists on Mars only in traces, if at all. The Tunable Laser Spectrometer (TLS) in SAM provides the first search conducted within the martian atmosphere for this molecule. The initial SAM measurements place an upper limit of just a few parts methane per billion parts of martian atmosphere, by volume, with enough uncertainty that the amount could be zero.

"Methane is clearly not an abundant gas at the Gale Crater site, if it is there at all. At this point in the mission we're just excited to be searching for it," said SAM TLS lead Chris Webster of NASA's Jet Propulsion Laboratory. "While we determine upper limits on low values, atmospheric variability in the martian atmosphere could yet hold surprises for us."

For more information about Curiosity and its mission, visit *www.nasa.gov/msl* or *mars.jpl.nasa.gov/msl*, or follow the mission at *www.facebook.com/marscuriosity* or *twitter.com/marscuriosity*.

Artist's rendering of Juno at Jupiter. Credit: NASA/JPL-Caltech.

Juno Performs Two Deep Space Maneuvers

Juno continues its journey through the solar system, bound for Jupiter but on course for a flyby of Earth in 2013, to get a gravity assist to boost its speed, saving time, propellant, and money. In preparation for the Earth flyby, the mission team carried out two deep space maneuvers (DSM) to alter the spacecraft's velocity. An operations readiness test for the maneuver was completed in July with no issues. An event readiness review took place in August, as did a science planning working group meeting and a command process workshop to facilitate communication between the spacecraft and instrument operations teams.

Juno's navigators and mission controllers accomplished their successful first main engine burn on August 30. The Leros-1b main engine was fired for 29 minutes, 39 seconds, changing the spacecraft's velocity by about 770 miles (1239 kilometers) per hour while consuming about 829 pounds of fuel.

A second deep space maneuver, with similar duration and fuel consumption, took place on September 14, changing the velocity by 867 miles (1395 kilometers) per hour. Together, the two maneuvers place Juno on course for its Earth flyby, which will occur as the spacecraft is completing one elliptical orbit around the Sun. The Earth flyby will boost Juno's velocity by 16,330 miles (26,280 kilometers) per hour, placing the spacecraft on its final flight path for Jupiter. The closest approach to Earth, on October 9, 2013, will

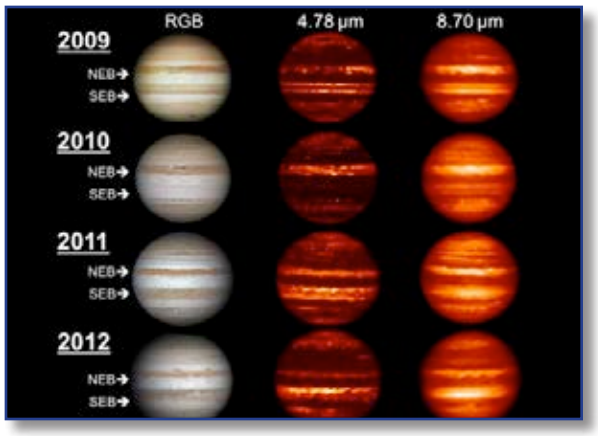
occur when Juno is at an altitude of about 310 miles (499 kilometers). Juno will arrive at Jupiter on July 4, 2016.

Currently Juno is about 300 million miles (483 million kilometers) from Earth. "We still have the Earth flyby and another 1.4 billion miles and four years to go to get to Jupiter," said Scott Bolton, Juno's principal investigator from the Southwest Research Institute in San Antonio. "The team will be busy during that whole time, collecting science on the way and getting ready for our prime mission at Jupiter, which is focused on learning the history of how our solar system was formed. Jupiter developed by grabbing most of the material left over from the Sun's formation. Earth and the other planets are really made from the leftovers of the leftovers, so if we want to learn about the history of the elements that made Earth and life, we need to first understand what happened when Jupiter formed."

Juno was launched on August 5, 2011. Once in orbit, the spacecraft will circle Jupiter 33 times, from pole-to-pole, and use its collection of 8 science instruments to probe beneath the gas giant's obscuring cloud cover. Juno's science team will learn about Jupiter's origins, structure, atmosphere, and magnetosphere, and look for a potential solid planetary core. For more information, visit *missionjuno.swri.edu*.

Jupiter: Turmoil from Below, Battering from Above

Jupiter, the mythical god of sky and thunder, would certainly be pleased at all the changes afoot at his namesake planet. As the planet gets peppered continually with small space rocks, wide belts of the atmosphere are changing color, hotspots are vanishing and reappearing, and clouds are gathering over one part of Jupiter, while dissipating over another. The results were presented by Glenn Orton, a senior research scientist at NASA's Jet Propulsion Laboratory, at the recent American Astronomical Society's Division for Planetary Sciences Meeting in Reno, Nevada.



Images in the visible-light and infrared parts of the spectrum highlight the massive changes roiling the atmosphere of Jupiter. Credit: NASA/IRTF/JPL-Caltech/NAOJ/A. Wesley/A. Kazemoto/C. Go.

"The changes we're seeing in Jupiter are global in scale," Orton said. "We've seen some of these before, but never with modern instrumentation to clue us in on what's going on. Other changes haven't been seen in decades, and some regions have never been in the state they're appearing in now. At the same time, we've never seen so many things striking Jupiter. Right now, we're trying to figure out why this is all happening."

Orton and colleagues Leigh Fletcher of the University of Oxford, England; Padma Yanamandra-Fisher of the Space Science Institute, Boulder, Colorado; Thomas Greathouse of Southwest Research Institute, San Antonio; and Takuyo Fujiyoshi of the Subaru Telescope, National Astronomical Observatory of Japan, Hilo, Hawaii, have been taking images and maps of Jupiter at infrared wavelengths from 2009 to 2012 and comparing them with high-quality visible images from the increasingly active amateur astronomy community. Following the fading and return of a prominent brown-colored belt just south of the equator, called the South Equatorial Belt, from 2009 to 2011, the team studied a similar fading and darkening that occurred at a band just north of the equator, known as the North Equatorial Belt. This belt grew whiter in 2011 to an extent not seen in more than a century. In March of this year, that northern band started to darken again.

The team obtained new data from NASA's Infrared Telescope Facility and the Subaru Telescope on Mauna Kea that matched up that activity with infrared observations. Those data showed a simultaneous

thickening of the deeper cloud decks, but not necessarily the upper cloud deck, unlike the South Equatorial Belt, where both levels of clouds thickened and then cleared up. The infrared data also resolved brown, elongated features in the whitened area called "brown barges" as distinct features and revealed them to be regions clearer of clouds and probably characterized by downwelling, dry air.

The team was also looking out for a series of blue-gray features along the southern edge of the North Equatorial Belt. Those features appear to be the clearest and driest regions on the planet and show up as apparent hotspots in the infrared view, because they reveal the radiation emerging from a very deep layer of Jupiter's atmosphere. (NASA's Galileo spacecraft sent a probe into one of these hotspots in 1995.) Those hotspots disappeared from 2010 to 2011, but had reestablished themselves by June of this year, coincident with the whitening and redarkening of the North Equatorial Belt.

While Jupiter's own atmosphere has been churning through change, a number of objects have hurtled into Jupiter's atmosphere, creating fireballs visible to amateur Jupiter watchers on Earth. Three of these objects — probably less than 45 feet (15 meters) in diameter — have been observed since 2010. The latest of these hit Jupiter on September 10, 2012, although Orton and colleagues' infrared investigations of these events showed this one did not cause lasting changes in the atmosphere, unlike those in 1994 or 2009.

"It does appear that Jupiter is taking an unusual beating over the last few years, but we expect that this apparent increase has more to do with an increasing cadre of skilled amateur astronomers training their telescopes on Jupiter and helping scientists keep a closer eye on our biggest planet," Orton said. "It is precisely this coordination between the amateur-astronomy community that we want to foster."

For more information about NASA's Infrared Telescope Facility, visit *irtfweb.ifa.hawaii.edu*. For more information about the Subaru Telescope, visit *www.naoj.org*. For more detailed background information about the planet Jupiter, visit *www.thesolarsystemplanets.com/jupiter*.

Artist's concept showing the descent and landing of Huygens. Credit: NASA/JPL/ESA.

Bounce, Skid, Wobble: How Huygens Landed on Titan

The European Space Agency's Huygens probe, ferried to Saturn's moon Titan by NASA's Cassini spacecraft, bounced, slid, and wobbled its way to rest in the 10 seconds after touching down on Titan in January 2005, a new analysis reveals. The moon's surface is more complex than previously thought.

Scientists reconstructed the chain of events by analyzing data from a variety of instruments that were active during the impact, in particular changes in the acceleration. The instrument data were compared with results from computer simulations and a drop test using a model of Huygens designed to replicate the landing. The analysis reveals that, on first contact with Titan's surface, Huygens made a dent 4.7 inches (12 centimeters) deep, before bouncing out onto a flat surface. The Huygens probe, which had a mass of about 400 pounds (200 kilograms), hit the ground with an impact speed that was similar to dropping a ball on Earth from a height of about 3 feet (1 meter). The probe, tilted by about 10° in the direction of motion, then slid 12 to 16 inches (30 to 40 centimeters) across the surface. It slowed due to friction with the surface and, upon coming to its final resting place, wobbled

back and forth five times. Each wobble was about half as large as the previous one. Huygens' sensors continued to detect small vibrations for another 2 seconds, until motion subsided nearly 10 seconds after touchdown.

"A spike in the acceleration data suggests that during the first wobble, the probe likely encountered a pebble protruding by around an inch [2 centimeters] from the surface of Titan, and may have even pushed it into the ground, suggesting that the surface had a consistency of soft, damp sand," said Stefan Schröder of the Max Planck Institute for Solar System Research in Katlenburg-Lindau, Germany, lead author of the paper reporting the results in the journal *Planetary and Space Science*.

Previous work measured the firmness of Titan's surface during the Huygens impact. Those results found the surface to be quite soft. The new work goes one step farther to demonstrate that if something put little pressure on the surface, the surface was hard, but if an object put more pressure on the surface, it sank in significantly. "It is like snow that has been frozen on top," said Erich Karkoschka, a co-author at the University of Arizona, Tucson. "If you walk carefully, you can walk as on a solid surface, but if you step on the snow a little too hard, you break in very deeply."

Had the probe impacted a wet, mud-like substance, its instruments would have recorded a "splat" with no further indication of bouncing or sliding. The surface must have therefore been soft enough to allow the probe to make a sizeable depression, but hard enough to support Huygens rocking back and forth. "We also see in the Huygens landing data evidence of a 'fluffy' dust-like material — most likely organic aerosols that are known to drizzle out of the Titan atmosphere — being thrown up into the atmosphere and suspended there for around four seconds after the impact," said Schröder. Since the dust was easily lifted, it was most likely dry, suggesting that there had not been any rain of liquid ethane or methane for some time prior to the landing.

To see an animation of the landing, visit *www.esa.int/esaSC/SEMJP13S18H_index_0.html*.

Transforming Asteroid Understanding: Dawn's Awesome Year at Vesta

Images of Vesta revealed by the Dawn spacecraft during its incredible year in orbit have shed enormous light on this large, mysterious space rock in the main asteroid belt. After a very successful science campaign in which the original mission goals were exceeded, Dawn "left the building" on September 5, departing from Vesta and beginning its journey to dwarf planet Ceres. Dawn will spend the majority of the next two-and-one-half years thrusting with the ion propulsion system, speeding to Ceres for an equally compelling rendezvous in early 2015.

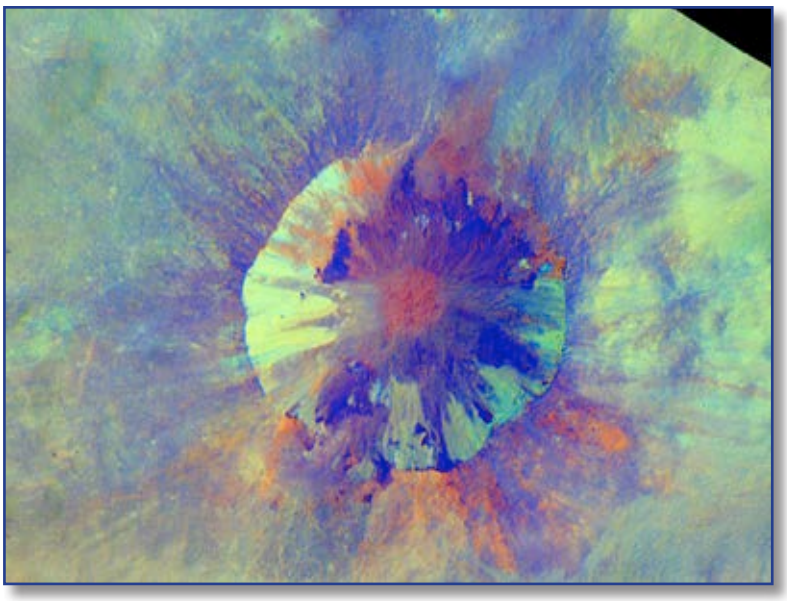
This mosaic synthesizes some of Dawn's best views of Vesta. The mountain visible at the bottom is more than twice the height of Mount Everest. The three craters known as the "snowman" are at the top left. Credit: NASA/JPL-Caltech/UCAL/MPS/DLR/IDA.

"As we respectfully say goodbye to Vesta and reflect on the amazing discoveries over the past year, we eagerly look forward to the next phase of our adventure at Ceres, where even more exciting discoveries await," said Robert Mase, Dawn project manager at the Jet Propulsion Laboratory. Over the past year, Dawn has comprehensively mapped this previously uncharted world, detecting unusual geologic features not seen previously on asteroids. The findings are helping scientists unlock some of the secrets of how the solar system, including our own Earth, was formed.

A stunning animation of Vesta was made from framing camera images taken September–October 2011 at different viewing angles to help determine the topography. Other images were taken through special infrared and visible light filters in the camera. The colors highlight the minerals on Vesta's surface. Green indicates iron, but scientists have not yet determined the composition represented by the other colors. It is clear from the wide range of colors that Vesta is one of the most diversely colored asteroids that has been imaged. The animation can be viewed at *dawn.jpl.nasa.gov/multimedia/video/vestarotate_20120530-640.mov*. Another great video celebrating Dawn's "greatest hits" at Vesta is available at *www.youtube.com/watch?v=GhjZ8NLHzZA&feature=plcp*. Made from images captured during the summer of 2012, it highlights the top accomplishments and identifies some of the amazing features.

Vesta is one of the brightest objects in our solar system and the only asteroid visible to the naked eye from Earth. Some areas are twice as bright as others, revealing clues about the asteroid's history. Analysis shows this bright material, most predominant in and around craters, has undergone little change since Vesta's formation over four billion years ago. The team is eager to learn more about what minerals make up this material and how the current surface came to be. Rocks crashing into the surface may have mixed the bright material with darker surface material. For more information about the Dawn mission, visit *www.nasa.gov/dawn* or *dawn.jpl.nasa.gov*.

Dawn and CosmoQuest have partnered to launch Asteroid Mappers, a new citizen science project where everyone can access high-resolution images of Vesta and assist scientists in identifying craters, boulders, and other features. Register now and join in this scientific adventure to help figure out Vesta's surface history and geology, how and when these features formed. Detectives are needed to reveal the clues hidden in this ancient object! For more information about Asteroid Mappers, visit *cosmoquest.org/mappers/vesta*.



These enhanced-color views from NASA's Dawn mission show an unusual "pitted terrain" on the floors of the craters named Marcia (left) and Cornelia (right) on the giant asteroid Vesta. Credit: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA/JHUAPL.

Dawn Sees Hydrated Minerals on Giant Asteroid

NASA's Dawn spacecraft has revealed that the giant asteroid Vesta has its own version of ring around the collar. Two new papers based on observations from the low-altitude mapping orbit of the Dawn mission show that volatile, or easily evaporated materials, have colored Vesta's surface in a broad swath around its equator. Pothole-like features mark some of the asteroid's surface where the volatiles, likely water, released from hydrated minerals boiled off. While Dawn did not find actual water ice at Vesta, there are signs of hydrated minerals delivered by meteorites and dust evident in the giant asteroid's chemistry and geology. The findings appeared in late September in the journal *Science*.

One paper, led by Thomas Prettyman, the lead scientist for Dawn's gamma ray and neutron detector (GRaND) at the Planetary Science Institute in Tucson, Arizona, describes how the instrument found

signatures of hydrogen, likely in the form of hydroxyl or water bound to minerals in Vesta's surface. "The source of the hydrogen within Vesta's surface appears to be hydrated minerals delivered by carbon-rich space rocks that collided with Vesta at speeds slow enough to preserve their volatile content," said Prettyman. A complementary paper, led by Brett Denevi, a Dawn participating scientist based at the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland, describes the presence of pitted terrain created by the release of the volatiles.

Vesta is the second most massive member of the main asteroid belt. The orbit at which these data were obtained averaged about 130 miles (210 kilometers) above the surface. Dawn left Vesta in early September, and is now on its way to its second target, the dwarf planet Ceres.

Scientists thought it might be possible for water ice to survive near the surface around the giant asteroid's poles. Unlike Earth's Moon, however, Vesta has no permanently shadowed polar regions where ice might survive. The strongest signature for hydrogen in the latest data came from regions near the equator, where water ice is not stable. In some cases, other space rocks crashed into these deposits later at high speed. The heat from the collisions converted the hydrogen bound to the minerals into water, which evaporated. The holes that were left as the water escaped stretch as much as 0.6 miles (1 kilometer) across and go down as deep as 700 feet (200 meters). Seen in images from Dawn's framing camera, this pitted terrain is best preserved in sections of the Marcia crater. "The pits look just like features seen on Mars, but while water was common on Mars, it was totally unexpected on Vesta in these high abundances," said Denevi. "These results provide evidence that not only were hydrated materials present, but they played an important role in shaping the asteroid's geology and the surface we see today."

GRaND's data are the first direct measurements describing the elemental composition of Vesta's surface. Dawn's elemental investigation by the instrument determined the ratios of iron to oxygen and iron to silicon in the surface materials. The new findings solidly confirm the connection between Vesta and a class of meteorites found on Earth called the howardite, eucrite, and diogenite (HED) meteorites, which have the same ratios for these elements. In addition, more volatile-rich fragments of other objects have been identified in these meteorites, which supports the idea that the volatile-rich material was deposited on Vesta.

For more information, visit *www.nasa.gov/dawn* or *dawn.jpl.nasa.gov*.

OSIRIS-REx Announces Earlier Rendezvous Date, Asteroid Naming Contest, and Citizen Science Project

OSIRIS-REx will use a robotic arm to pluck samples from a near-Earth asteroid that could better explain our solar system's formation and how life began. Credit: NASA.

OSIRIS-REx, the first American mission designed to return samples from an asteroid, will launch in 2016 and travel to near-Earth asteroid (101955) 1999 RQ36, study it in detail, and bring back samples of asteroid dirt to Earth. The spacecraft will map the asteroid's global properties and measure non-gravitational forces. It will also provide observations for comparison with data obtained by previous telescope observations from Earth that indicate 1999 RQ36 is made of primitive materials. In 2023, OSIRIS-REx will return to Earth with about two ounces of samples from the asteroid. OSIRIS-REx will reveal details about the asteroid's composition and structure, offering new insights into the nature of the early solar system, its evolution, and the building blocks that led to life on Earth. It will also tell us much more about the orbits of near-Earth objects and their impact risks.

In May, OSIRIS-REx conducted a Mission Definition Review at Lockheed Martin in Denver that covered many topics. The conclusion of the Goddard System Review Team was that the mission is ready to proceed toward the Preliminary Design Review in March 2013. Many other studies, meetings, and reviews are ongoing and a number of procurements are in process, including launch services. An Atlas 411 rocket has been selected as the launch vehicle. Mission staff met with Launch Services Program (LSP) team members to discuss roles and responsibilities and tour the LSP facilities.

On August 17, principal investigator Dante Lauretta announced a new date for rendezvous with 1999 RQ36 to provide additional operations time at the asteroid. The launch period, asteroid departure date, and Earth return date remain the same as previously scheduled, but the flight dynamics team is now planning an October 15, 2018, rendezvous date at the asteroid instead of December 16, 2019. The first attempt to capture a sample has been moved up to July 17, 2019.

Ron Mink, Deputy Systems Engineer, said, "The additional margin of time will provide the OSIRIS-REx team the opportunity to deal with any unexpected surprises that 1999 RQ36 may have in store, such as small moons, gas, and dust plumes, or a surface so rough that a good sampling site is hard to find. The early arrival also places the asteroid and spacecraft much closer to the Earth during the mission, permitting a more rapid return of science and engineering data and less time to get commands up to the spacecraft."

The asteroid was discovered in 1999 by the Lincoln Near Earth Asteroid Research (LINEAR) survey at MIT's Lincoln Laboratory. LINEAR is part of NASA's Near Earth Observation Program in Washington, which detects and catalogs near-Earth asteroids and comets. The asteroid has an average diameter of approximately one-third of a mile (500 meters).

Students worldwide are being given an opportunity to formally name the asteroid from which the OSIRIS-REx mission will return samples. "Because the samples returned by the mission will be available for study for future generations, it is possible the person who names the asteroid will grow up to study the regolith we return to Earth," said Jason Dworkin, OSIRIS-REx project scientist at NASA's Goddard Space Flight Center. The competition is open to students under age 18 from anywhere in the world. Each contestant can submit one name, up to 16 characters long. Entries must include a short explanation and rationale for the name. Submissions must be made by an adult on behalf of the student. The contest deadline is Sunday, December 2, 2012. The contest is a partnership with The Planetary Society in Pasadena, California; the Massachusetts Institute of Technology's (MIT) Lincoln Laboratory in Lexington, Massachusetts; and the University of Arizona in Tucson.

A panel will review proposed asteroid names. First prize will be awarded to the student who recommends a name that is approved by the International Astronomical Union Committee for Small-Body Nomenclature. "Our mission will be focused on this asteroid for more than a decade," said Dante Lauretta, principal investigator for the mission at the University of Arizona. "We look forward to having a name that is easier to say than (101955) 1999 RQ36." Details about the contest are available at *planetary.org/get-involved/contests/osirisrex*.

A citizen science project called "Target Asteroids!" is also supporting the mission by enlisting the help of amateur astronomers to better characterize the population of near-Earth objects (NEOs), including their position, motion, rotation, and changes in the intensity of light they emit. Professional astronomers will use this information to refine theoretical models of asteroids, improving their understanding about asteroids similar to the one OSIRIS-REx will encounter in 2018. Target Asteroids! data will be useful for comparisons with actual mission data. The project team plans to expand participation to students and teachers in 2014. Instructions for participation and registration information are available at *osiris-rex.lpl.arizona.edu/?q=target_asteroids*.

For more information about the OSIRIS-REx mission, visit *osiris-rex.lpl.arizona.edu*.

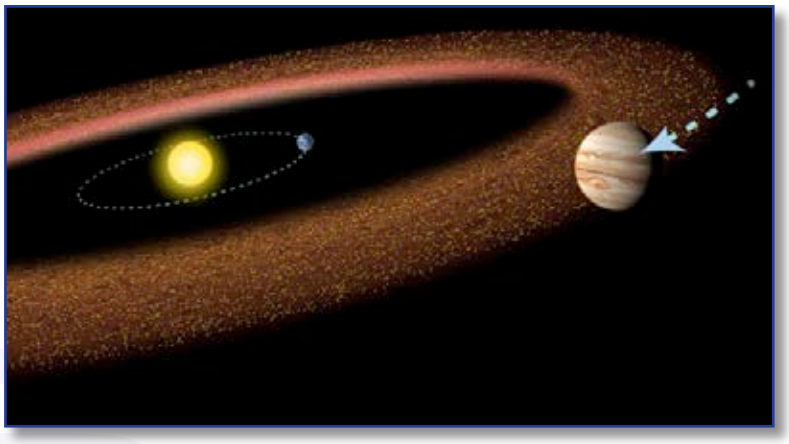


Illustration of a model of our solar system: A Jupiter-sized planet moves slightly inward but is just outside the asteroid belt. Credit: NASA/ESA/STScI.

Asteroid Belts at Just the Right Place are Friendly to Life

Solar systems with life-bearing planets may be rare if they are dependent on the presence of asteroid belts of just the right mass, according to a study by Rebecca Martin, a NASA Sagan Fellow from the University of Colorado in Boulder, and astronomer Mario Livio of the Space Telescope Science Institute in Baltimore, Maryland.

They suggest that the size and location of an asteroid belt, shaped by the evolution of the Sun's planet-forming disk and by the gravitational influence of a nearby giant Jupiter-like planet, may determine whether complex life will evolve on an Earth-like planet. This might sound surprising because asteroids are considered a nuisance due to their potential to impact Earth and trigger mass extinctions. But an emerging view proposes that asteroid collisions with planets may provide a boost to the birth and evolution of complex life.

Asteroids may have delivered water and organic compounds to the early Earth. According to the theory of punctuated equilibrium, occasional asteroid impacts might accelerate the rate of biological evolution by disrupting a planet's environment to the point where species must try new adaptation strategies. The astronomers based their conclusion on an analysis of theoretical models and archival observations, including infrared data from NASA's Spitzer Space Telescope.

"Our study shows that only a tiny fraction of planetary systems observed to date seem to have giant planets in the right location to produce an asteroid belt of the appropriate size, offering the potential for life on a nearby rocky planet," said Martin, the study's lead author. "Our study suggests that our solar system may be rather special." The findings appeared on November 1 in the *Monthly Notices of the Royal Astronomical Society: Letters*.

Martin and Livio suggest that the location of an asteroid belt relative to a Jupiter-like planet is not an accident. The asteroid belt in our solar system, located between Mars and Jupiter, is a region of millions of space rocks that sits near the "snow line," which marks the border of a cold region where volatile material such as water ice is far enough from the Sun to remain intact. When Jupiter formed just beyond the snow line, its powerful gravity prevented nearby material inside its orbit from coalescing and building planets. Instead, Jupiter's influence caused the material to collide and break apart. These fragmented rocks settled into an asteroid belt around the Sun.

Using our solar system as a model, Martin and Livio proposed that asteroid belts in other solar systems would always be located approximately at the snow line. To test their proposal, Martin and Livio created models of planet-forming disks around young stars and calculated the location of the snow line in those disks based on the mass of the central star. They then looked at all the existing space-based infrared observations from the Spitzer Space Telescope of 90 stars having warm dust, which could indicate the presence of an asteroid-belt-like structure. The temperature of the warm dust was consistent with that of the snow line.

The duo then studied observations of the 520 giant planets found outside our solar system. Only 19 of them reside outside the snow line. This suggests that most of the giant planets that may have formed

outside the snowline have migrated too far inward to preserve the kind of slightly dispersed asteroid belt needed to foster enhanced evolution of life on an Earth-like planet near the belt. Apparently, less than 4% of the observed systems may actually harbor such a compact asteroid belt. "Based on our scenario, we should concentrate our efforts to look for complex life in systems that have a giant planet outside of the snow line," Livio said.

A new technique developed by a team of astronomers shows the two faces of Uranus, in previously unattainable detail, through the Keck II telescope in Hawaii. Credit: Lawrence Sromovsky, Pat Fry, Heidi Hammel, and Imke de Pater.

Researchers Demystify Uranus' Weather Patterns

The surface of Uranus has been nebulous to astronomers for years, but researchers at the University of California (UC)-Berkeley and the University of Wisconsin-Madison have studied the planet's weather patterns and gained some clarity as to what its surface looks like. The team of researchers used infrared cameras on the telescopes at the W. M. Keck Observatory in Hawaii to take several high-resolution, overlapping images of the planet. The team then combined the images to discern weather features that were previously too difficult to notice, according to Lawrence Sromovsky, the project's head researcher and a senior scientist at the University of Wisconsin-Madison. "It's really a simple idea actually, but it hasn't been applied too often," Sromovsky said. "This is the first time the technique is being used to learn about Uranus."

From the images, the team discovered "popcornlike" cloud features on the north pole of Uranus, said Imke de Pater, a researcher on the team and chair of astronomy at UC Berkeley. De Pater said that these cloud features indicate convection at this stormlike region. The researchers also discovered wind patterns on Uranus that revealed asymmetry of wind patterns at the poles, Sromovsky said. He added that the team's most unusual discovery was a scalloped pattern of clouds south of Uranus' equator, which could indicate atmospheric instability.

Uranus, the third-largest planet in the solar system, is composed of gas like Neptune and Saturn. While astronomers have been able to discern many features about the planet, such as its atmospheric composition of hydrogen, helium, and methane — which gives the planet its blue-green color — its distance from Earth has prevented astronomers from learning about the planet's wind patterns and cloud features. Until recently, the flyby of the planet by the Voyager 2 spacecraft in 1986 was the only chance astronomers had to study the planet close-up.

Because of the difficulty in discerning the planet's features, researchers tried the new technique, which is commonly used to interpret the morphology of clouds in Earth's atmosphere, according to James Graham, a professor of astronomy at UC Berkeley. "This multi-filter technique is useful whenever a planetary atmosphere contains molecules with distinctive absorption bands," Graham said. "On the giant planets, filters matched to the absorption bands of methane are useful. On the terrestrial planets carbon dioxide and water, for example, could be used."

Voyager 2 was launched on August 20, 1977, from the NASA Kennedy Space Center at Cape Canaveral in Florida, propelled into space on a Titan/Centaur rocket. Voyager 2 is the first and only space probe that was able to reach Uranus and Neptune. Credit: NASA/JPL.

Voyager at 35: Break on Through to the Other Side

Thirty-five years ago, NASA's Voyager 2 spacecraft, the first Voyager spacecraft to launch, departed on a journey that would make it the only spacecraft to visit Uranus and Neptune and the longest-operating NASA spacecraft ever. Voyager 2 and its twin, Voyager 1, which launched 16 days later on September 5, 1977, are still going strong, hurtling away from our Sun. Mission managers are eagerly anticipating the day when they break on through to the other side — the space between stars.

"Even 35 years on, our rugged Voyager spacecraft are poised to make new discoveries as we eagerly await the signs that we've entered interstellar space," said Ed Stone, Voyager project scientist at the California Institute of Technology in Pasadena. "Voyager results turned Jupiter and Saturn into full, tumultuous worlds, their moons from faint dots into distinctive places, and gave us our first glimpses of Uranus and Neptune up close. We can't wait for Voyager to turn our models of the space beyond our Sun into the first observations from interstellar space."

Voyager 2 became the longest-operating spacecraft on August 13, 2012, surpassing Pioneer 6, which launched on December 16, 1965, and sent its last signal back to NASA's Deep Space Network on December 8, 2000. (It operated for 12,758 days.)

Scientists eagerly awaiting the entry of the two Voyagers into interstellar space have recently seen changes from Voyager 1 in two of the three observations that are expected to be different in interstellar space. The prevalence of high-energy particles streaming in from outside our solar system has jumped, and the prevalence of lower-energy particles originating from inside our solar system has briefly dipped, indicating an increasing pace of change in Voyager 1's environment. Voyager team scientists are now analyzing data on the direction of the magnetic field, which they believe will change upon entry into interstellar space.

Notable discoveries by Voyager 2 include the puzzling hexagonal jet stream in Saturn's north polar region, the tipped magnetic poles of Uranus and Neptune, and the geysers on Neptune's frozen moon Triton. Although launched second, Voyager 1 reached Jupiter and Saturn before Voyager 2, first seeing the volcanos of Jupiter's moon Io, the kinky nature of Saturn's outermost main ring, and the deep, hazy atmosphere of Saturn's moon Titan. Voyager 1 also took the mission's last image: the famous solar system family portrait that showed our Earth as a pale blue dot. For more information about the Voyager spacecraft, visit *www.nasa.gov/voyager* and *voyager.jpl.nasa.gov*.

SOFIA Embarks on New Cycle of Science Observations

The Stratospheric Observatory for Infrared Astronomy (SOFIA), a joint program between NASA and the German Aerospace Center (DLR), is set to begin its first full cycle of science flights starting in November 2012 and extending through December 2013. In August, SOFIA's Science Mission Operations Director Erick Young announced the list of researchers who have been awarded time to study the universe with this unique infrared observatory. SOFIA is a heavily modified 747SP aircraft that carries a telescope with

View aft on main deck during a SOFIA science flight, showing mission operations and science team personnel and consoles. The scientific instrument (red cylinder) is mounted on the flange at upper right. The telescope itself is behind the blue pressure bulkhead at the end of the cabin. Credit: NASA/DLR/USRA/DSI/FORCAST team.

an effective diameter of 100 inches (2.5 meters) to altitudes above 39,000 feet (12 kilometers), beyond the obscuring layer of water vapor in Earth's atmosphere.

In announcing the observing time awards, Young noted, "More than 1000 hours of observing time were requested, five times the amount available, evidence of SOFIA's desirability to astronomers. The approved projects make good use of the observatory's capabilities to study objects ranging from Earth's solar system neighbors to galaxies hundreds of millions of light years away." SOFIA's first airborne science observations were made in December 2010. During 2011, SOFIA accomplished 30 flights in the "Early Science" program, as well as a deployment to Germany from its base at NASA's Dryden Aircraft Operations Facility in Palmdale, California.

The newly announced observing period, known as Cycle 1, includes 46 science flights grouped in four multi-week observing campaigns spread through a 13-month span. The Cycle 1 science flights include approximately 330 research flight hours, about 200 hours of which have been awarded to guest investigators whose proposals to observe with SOFIA were evaluated by U.S. and German-chartered peer review panels.

For more information, visit *www.nasa.gov/sofia*, *www.sofia.usra.edu*, or *www.dlr.de/en/sofia*.

Comet Crystals Found in a Nearby Planetary System

Pristine material that matches comets in our own solar system have been found in a dust belt around the young star Beta Pictoris by the European Space Agency's Herschel Space Observatory. Twelve-million-year-old Beta Pictoris resides just 63 light-years from Earth and hosts a gas giant planet along with a dusty debris disk that could, in time, evolve into a torus of icy bodies much like the Kuiper belt found outside the orbit of Neptune in our solar system.

Thanks to the unique observing capabilities of Herschel, the composition of the dust in the cold outskirts of the Beta Pictoris system has been determined for the first time. Of particular interest was the mineral olivine, which crystallizes out of the protoplanetary disk material close to newborn stars and is eventually incorporated into asteroids, comets, and planets. "As far as olivine is concerned, it comes in different 'flavors'," explains Ben de Vries from the Katholieke Universiteit Leuven (KU Leuven) in Belgium, and lead author of the study reported in *Nature*. "A magnesium-rich variety is found in small and primitive icy bodies like comets, whereas iron-rich olivine is typically found in large asteroids that have undergone more heating, or 'processing'."

Herschel detected the pristine magnesium-rich variety in the Beta Pictoris system at 15–45 astronomical units (AU) from the star, where temperatures are around –190°C. For comparison, Earth lies at 1 AU from our Sun and the solar system's Kuiper belt extends from the orbit of Neptune at about 30 AU out

to 50 AU from the Sun. The Herschel observations allowed astronomers to calculate that the olivine crystals make up around 4% of the total mass of the dust found in this region. In turn, this finding led them to conclude that the olivine was originally bound up inside comets and released into space by collisions between the icy objects.

Artist's concept of the view toward the young star Beta Pictoris from the outer edge of its disk. This disk of dust and gas orbiting the star is produced by collisions between and evaporation of asteroids and comets. Credit: NASA/FUSE/Lynette Cook.

"The 4% value is strikingly similar to that of solar system comets 17P/Holmes and 73P/Schwassmann-Wachmann 3, which contain 2–10% magnesium-rich olivine," said de Vries. "Since olivine can only crystallize within about 10 AU of the central star, finding it in a cold debris disk means that it must have been transported from the inner region of the system to the outskirts."

The "radial mixing" transport mechanism is known from models of the evolution of swirling protoplanetary disks as they condense around new stars. The mixing is stimulated in varying amounts by winds and heat from the central star pushing materials away, along with temperature differences and turbulent motion created in the disk during planet formation.

For more information, visit *sci.esa.int/herschel*.

LPI Summer Intern Program in Planetary Science

The Lunar and Planetary Institute (LPI) invites undergraduates with at least 50 semester hours of credit to experience research in the planetary sciences. As a summer intern, you will work one-on-one with a scientist either at the LPI or NASA Johnson Space Center on a research project of current interest in planetary science. Furthermore, you will participate in peer-reviewed research, learn from top-notch planetary scientists, and preview various careers in science.

The 10-week program begins June 3, 2013, and ends on August 9, 2013. Selected students will receive a $5000.00 stipend plus a travel stipend of $1000.00 (U.S. students) (foreign nationals will receive a $1500.00 foreign travel reimbursement).

The LPI is located near Johnson Space Center, on the south side of Houston, Texas. The LPI provides, on NASA's behalf, leadership in the scientific community for research in lunar, planetary, and solar system sciences, and linkage with related terrestrial programs.

The deadline for applying for the 2013 program is **Friday, January 18, 2013**. For more information, including eligibility and selection criteria, areas of research, and an online application form, please visit *www.lpi.usra.edu/lpiintern*.

LPI

Career Development Award

Graduate Students Eligible for the LPI Career Development Award

The Lunar and Planetary Institute (LPI) is proud to announce its sixth LPI Career Development Award, which is open to both U.S. and non-U.S. applicants. This award will be given to graduate students who have submitted a first-author abstract for presentation at the 44th Lunar and Planetary Science Conference (LPSC). Nearly 2000 participants from all over the world are expected to gather for the annual meeting, which has gained the reputation of being the premiere gathering place for lunar and planetary scientists.

A travel stipend of $1000.00 will be awarded to the top applicants to help cover travel expenses for attending the LPSC in March. Awards will be based on a review of the application materials by a panel of lunar and planetary scientists. Applications must include a letter outlining why the applicant would like to participate at the LPSC and what he or she will contribute to the conference, a letter of recommendation from his or her research advisor, a copy of the first-author abstract, and a curriculum vitae for the applicant.

Applications and all accompanying materials must be submitted electronically. All documents uploaded must be in text or PDF format. For more information and a link to the application form, visit *www.lpi.usra.edu/meetings/lpsc2013/cdaAward*.

NASA's Planetary Science Summer School

Planetary Science Summer School

The Mission Lifecycle Process

NASA's 25th Annual Planetary Science Summer School seeks people who have completed their graduate work and beyond in science and engineering fields, and who have a keen interest in a career in planetary exploration. Preference is given to post-docs, recent Ph.D.s, and current doctoral students; applications from masters'-level students or faculty members will be considered on a space-available basis. Applicants must be living within the U.S. at the time of the application. Preference will be given to U.S. citizens and U.S. legal permanent residents ("green card" holders).

Session I will be held July 29–August 2, and Session II will be held August 12–16. Only 18 students can be accommodated in each session, and the deadline for application is **April 5, 2013**. Further information is available at *pscischool.jpl.nasa.gov*.

Texas Community College Aerospace Scholars

TEXAS
AEROSPACE SCHOLARS

This program provides an opportunity for Texas community college students to learn more about what NASA does and how they can become a part of the exciting future of space exploration! Texas Community College Aerospace Scholars is a program funded by the Texas legislature and administered by NASA Johnson Space Center (JSC). Community college students who are interested in the areas of science, technology, engineering, and mathematics will apply to travel to NASA Johnson Space Center (JSC) for a three-day experience. This opportunity will provide a hands-on project featuring engineering career possibilities. Selected students will begin the semester commitment with web-based preparation prior to visiting JSC. The three-day experience at JSC will allow participants to participate in a team project directed by NASA engineers; attend engineer, scientist, and astronaut briefings; tour NASA JSC facilities; and interact with community college students from across the nation.

The application deadline is **February 8, 2013**. For more information, visit *cas.aerospacescholars.org*.

NASA's Planetary Geology and Geophysics Undergraduate Research Program

Through the Planetary Geology and Geophysics Undergraduate Research Program (PGGURP) qualified undergraduates are paired with NASA-funded investigators at research locations around the United States for eight weeks during the summer. PGGURP's goals are to provide incentive and development of future planetary geoscientists; broaden the base of students who participate in planetary geoscience; introduce students interested in the traditional sciences to planetary science; and give potential planetary geoscientists a chance to explore the exciting field of planetary research. Students will spend the summer at the NASA scientist's home institution, and the program will pay for housing, travel, and a cost-of-living stipend.

NASA's Planetary Geology and Geophysics Undergraduate Research Program (PGGURP)

RESEARCH OPPORTUNITIES FOR UNDERGRADUATES IN PLANETARY GEOSCIENCES

The program consists of an eight-week summer internship, in which qualified students are matched with a NASA-funded planetary scientist. Care is taken to match the skills of the student with the needs of the NASA mentor.

The application deadline is **February 1, 2013**. For more information, visit *www.acsu.buffalo.edu/~tgregg/pggurp.html*.

California Institute of Technology Summer Undergraduate Research Fellowships

california institute of technology
Summer Undergraduate Research Fellowships

Caltech's Summer Undergraduate Research Fellowships (SURF) program introduces students to research under the guidance of seasoned research mentors at the California Institute of Technology (Caltech) and the Jet Propulsion Laboratory (JPL). Students experience the process of research as a creative intellectual activity. SURF is modeled on the grant-seeking process: students collaborate with potential mentors to define and develop a project; applicants write research proposals for their projects; a faculty committee reviews the proposals and recommends awards; students carry out the work over a 10-week period in the summer, mid-June to late August; and at the conclusion of the program, they submit a technical paper and give an oral presentation at SURF Seminar Day, a symposium modeled on a professional technical meeting.

The deadline for all application materials is **February 22, 2013**. For more information, visit *www.surf.caltech.edu*.

Research Experiences for Undergraduates (REU) Program, American Museum of Natural History

AMERICAN MUSEUM of NATURAL HISTORY

The AMNH Division of Physical Sciences, in collaboration with the City University of New York (CUNY), is pleased to offer summer research opportunities in astrophysics and Earth and planetary science. The program is open to all students who are U.S. citizens or permanent residents, in any four-year undergraduate degree program. Pending the approval of federal funding, successful applicants will receive a stipend of at least $4000.00. In addition, dormitory housing on a nearby university campus, or an equivalent housing stipend, will be provided together with a subsistence allowance. Based on need, travel costs to and from New York City are also covered.

The Research Experiences for Undergraduates (REU) program is funded by the U.S. National Science Foundation. Included in the program are a general orientation to the Museum and a series of weekly meetings at which students discuss their research, present informal progress reports, and participate in discussions and seminars as well as graduate and research career opportunities. At the conclusion of the internships, students deliver oral presentations of their work and prepare publication quality research papers.

The application deadline for the physical sciences program (which includes astrophysics and Earth and planetary science) is **February 1, 2013**. For more information, visit *rggs.amnh.org/pages/academics_and_research/fellowship_and_grant_opportunities#reu*.

SAO Summer Intern Program

The Smithsonian Astrophysical Observatory (SAO) Summer Intern Program is a Research Experiences for Undergraduates (REU) program where students work on astrophysics research with an SAO/Harvard scientist. In 2013 the program is expected to run 10 weeks, from early June through mid August, pending funding and the availability of housing. Students are expected to be in residence at the Harvard-Smithsonian Center for Astrophysics (CfA) for the full duration of the program.

The program is funded by the National Science Foundation and the Smithsonian Institution. Undergraduate students interested in a career in astronomy, astrophysics, physics, or related physical sciences are encouraged to apply. Applicants must be U.S. citizens or permanent residents ("green card" holders), and must be enrolled in a degree program leading to a bachelors" degree. Seniors who will graduate in June 2013 (or before) are not eligible.

The application deadline is **February 1, 2013**. For more information, visit *hea-www.harvard.edu/REU/REU.html*.

NASA Minority Innovation Challenges Institute

The mission of the Minority Innovation Challenges Institute (MICI) is to create a virtual training ground where minority undergraduate students learn how to compete in NASA technical challenges for both prestige and significant cash prizes. This NASA-funded program, which is managed by Florida Agricultural & Mechanical University (FAMU), provides a year-round virtual conference platform where students from across the country can participate in free interactive educational sessions of their choosing. Many of the sessions will focus on competitions found within NASA's Centennial Challenges program, which provides cash prizes ranging from $50,000 to $2 million to individuals/teams that can achieve specific technical accomplishments.

In addition to Centennial Challenges, students will also learn how to compete in other NASA-sponsored competitions created specifically for universities. The goal of MICI is to use NASA technical competitions as a way to inspire minority undergraduate students to pursue (1) an advanced degree in Science, Technology, Engineering, and Mathematics (STEM), and (2) a career in STEM-related disciplines that will ultimately contribute to NASA's future technological needs.

Registration to MICI is always open throughout the year. There are no cut-off dates because new content is being featured each month. For more information, visit *nasamici.com*.

NASA Wants Student Innovators for Great Moonbuggy Race

The 20th Annual Great Moonbuggy Race will be held April 25–27, 2013, in Huntsville, Alabama, at the U.S. Space & Rocket Center. Students are required to design a vehicle that addresses a series of engineering problems that are similar to problems faced by the original Moonbuggy team. Each Moonbuggy will be human powered and carry two students, one female and one male, over a half-mile simulated lunar terrain course including "craters," rocks, "lava" ridges, inclines, and "lunar" soil.

Moonbuggy entries are expected to be of "proof-of-concept" and engineering test model nature, rather than final production models. Each student team of six members is responsible for building their own buggy, and the course drivers, who are chosen from each team, must also be builders of the vehicle. U.S. registration closes on **February 4, 2013**, and international registration ends on **January 7, 2013**. For complete rules, vehicle design parameters, and registration for the race, visit *moonbuggy.msfc.nasa.gov*.

NASA Academies for College Students

The Academies are intensive educational programs that emphasize group activities, teamwork, research, leadership, and creativity. The curriculum balances direct contact with science and engineering research and development with an awareness of the managerial, political, financial, social, and human issues faced by aerospace professionals. Included are seminars, informal discussions, evening lectures, supervised research, visits to other NASA Centers and facilities, group projects, tours, posters/presentations, and assessment. Additionally, most weekends are filled with group activities, team building, and offsite trips. One free weekend is scheduled.

The Academy is not a 9 to 5 summer research internship program. It is a rigorous, immersive experience that will challenge you and push you outside your comfort zones. It offers participants an intense learning experience that is either space- or aeronautics-based. All Academy students will be immersed in a NASA environment where they will experience the agency from both inside and outside perspectives. Additionally, added interaction with NASA collaborators in industry and academia will provide a unique, exciting, and unforgettable summer experience designed to engage and capture students within the NASA family.

Eligibility requirements differ for each Academy. Applications are due **January 7, 2013**. For more information and to apply online, visit *https://www.academyapp.com/*.

NASA's DEVELOP Program

DEVELOP is a NASA Science Mission Directorate Applied Sciences-sponsored internship that fosters the training and development of students in the atmospheric and Earth sciences. The DEVELOP program extends the application of NASA Earth science research and technology to meet societal needs. Students conduct projects that focus on the practical application of NASA's Earth science research and demonstrate how results can benefit partner organizations and local communities. Advisors and mentors, from NASA and partner institutions, provide guidance and support for the program. Students gain experience using NASA science and technology in a professional setting.

Students from high school through doctoral levels are selected through a competitive application process. Students chosen by DEVELOP work on teams onsite at 10 locations nationwide. Activities are conducted during three 10-week terms per year: spring, summer, and fall. To apply to a DEVELOP center at a NASA location, applicants must be a citizen of the U.S. However, international students currently registered at an accredited school in the U.S. are eligible to apply to DEVELOP regional locations. International applicants must already have a visa that permits them to work in the U.S.

Applications for the summer 2013 session are due **February 4, 2013**. For more information about this unique internship opportunity, please visit the DEVELOP website at *develop.larc.nasa.gov*. Questions about the DEVELOP program should be directed to *NASA-DL-DEVELOP@mail.nasa.gov* or 757-864-3761.

International FameLab: Exploring Earth and Beyond

Passionate about science? Love to communicate? New frontiers await scientists in every field of research, whether on land, under the sea, or in space. From our origins as humans to the origins of our solar system, from species' interactions in an ecosystem to Earth's interaction with the Sun, from climate change to the possibility of life elsewhere in the universe, sheer curiosity and passion for knowledge will always keep us at the cutting edge of exploration. In today's media-intensive environment, your ability to convey your science can reshape the face of science exploration and discovery. FameLab asks . . . how are you exploring Earth and beyond?

At regional heats throughout the U.S. over the next 18 months, join early career scientists from numerous disciplines and compete to convey your research or related science concepts. Each contestant has the spotlight for only three minutes. No slides, no charts, just the power of words and any prop you can hold in your hands. A panel of experts in both science and science communication will do the judging. Beyond the competition element, the heart of FameLab is to improve your communication skills! At each preliminary event there will be a workshop with training in the principles and practices of good communication. Winners from the regional competitions will face off at National Geographic headquarters in Washington, DC, in April 2014 for a grand prize and the chance to compete with peers from around the world at the FameLab International Final in the UK in June 2014.

Information about locations, as well as registration, eligibility requirements, and more, can be found at *astrobiologyfamelab.arc.nasa.gov*.

NASA Student Airborne Research Program

The NASA Airborne Science Program announces the opportunity for highly motivated junior and senior undergraduates to participate in an eight-week summer 2013 internship program in Earth system science using its DC-8 flying laboratory. The NASA Student Airborne Research Program (SARP) is managed by the National Suborbital Education and Research Center. SARP 2013 will take place in southern California with research locations based at the University of California, Irvine, and at the NASA Dryden Aircraft Operations Facility in Palmdale.

Participants will acquire hands-on research experience in all aspects of a scientific campaign, including flying onboard a major NASA resource that is used for studying Earth system processes, calibration and validation of space-borne observations, and prototyping instruments for possible satellite missions. Participants will work in four multi-disciplinary teams to study surface, atmospheric, and oceanographic processes. Participants will assist in the operation of instruments onboard the DC-8 aircraft to sample and measure atmospheric gases and to image land and water surfaces in multiple spectral bands. Along with airborne data collection, students will participate in taking measurements at field sites.

Mission faculty and research mentors will guide participants through instrument operation, sample analysis, and data reduction. Each student will develop an individual research project from the data collected and will deliver a final presentation on their results. Many students in the past have gone on to present their research at national conferences. Applicants must have a strong academic background in any of the physical, chemical, or biological sciences, or engineering and an interest in applying their background to the study of the Earth system. We especially encourage applications from students majoring in Earth, environmental, or atmospheric sciences and related disciplines.

The deadline for applications for the 2013 program is **February 8, 2013**. For more information and to download the program application, visit *www.nserc.und.edu/learning/SARP2013.html*.

NASA Earth and Space Science Fellowship (NESSF) Program

NASA announces a call for graduate fellowship proposals to the NASA Earth and Space Science Fellowship (NESSF) program for the 2013–2014 academic year. This call for fellowship proposals solicits applications from accredited U.S. universities on behalf of individuals pursuing Master of Science (M.Sc.) or Doctoral (Ph.D.) degrees in Earth and space sciences, or related disciplines. The purpose of NESSF is to ensure continued training of a highly qualified workforce in disciplines needed to achieve NASA's scientific goals. Awards resulting from the competitive selection will be made in the form of training grants to the respective universities.

The deadline for NEW applications is **February 1, 2013**, and the deadline for RENEWAL applications is **March 15, 2013**.

The NESSF call for proposals and submission instructions are located at the NESSF 13 solicitation index page at nspires.nasaprs.com; click on "Solicitations," then click on "Open Solicitations," then select the "NESSF 13" announcement. Also refer to "Proposal Submission Instructions" and "Frequently Asked Questions" listed under "Other Documents" on the NESSF 13 solicitation index page.

All proposals must be submitted in electronic format only through the NASA NSPIRES system. The advisor has an active role in the submission of the fellowship proposal. To use the NSPIRES system, the advisor, the student, and the university must all register. Extended instructions on how to submit an electronic proposal package are posted on the NESSF 13 solicitation index page listed above.

For further information contact Claire Macaulay, Program Administrator for NESSF Earth Science Research (202-358-0151, *claire.i.macaulay@nasa.gov*) or Dolores Holland, Program Administrator for NESSF Heliophysics Research, Planetary Science Research, and Astrophysics Research (202-358-0734, *hq-nessf-Space@nasa.gov*).

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

Lunar and Planetary Science Conference: Education Opportunities

The 44th Lunar and Planetary Science Conference will be held at The Woodlands Waterway Marriott Hotel and Convention Center, The Woodlands, Texas, March 18–22, 2013. There will be a variety of events and opportunities that will be of interest to the E/PO community and scientists who are involved in — or are interested in — education and outreach, including:

- A forum exploring evaluation of E/PO programs
- A workshop for higher-education planetary science faculty teaching undergraduates
- An E/PO lunch

These opportunities are detailed below, and information is available on the LPSC website at *www.lpi.usra.edu/meetings/lpsc2013/events/education/*.

Submit an E/PO Abstract —

We invite all those involved with education and public outreach to submit an abstract for the 44th Lunar and Planetary Science Conference for the E/PO sessions. The abstract deadline is January 8, 2013; to submit, follow the abstract submission instructions posted on the LPSC website, and choose the topic "Education and Public Outreach" on the abstract submission form.

Planetary Undergraduate Faculty Workshop —

The fourth annual Planetary Science Undergraduate Teaching Workshop will be held in conjunction with LPSC at The Woodlands Waterway Marriott Hotel and Convention Center. This year, we are teaming with the Center for Lunar Science and Exploration to bring together scientists and educators to talk about the latest in lunar science, lunar science education products, and tools that can be used in the undergraduate classroom.

We invite you to attend the workshop! If you have a lunar-related activity that you would like to share, let us know. If you have a specific area of interest, scientific or educational, let us know and we'll try to get it included.

Please RVSP to Emily CoBabe-Ammann at *ecobabe@spaceeducation.org*. Additional information is available at *www.lpi.usra.edu/meetings/lpsc2013/events/education/*.

NASA YSS Undergraduate Planetary Science Research Conference —

Due to the popularity of last year's conference, the NASA YSS Undergraduate Planetary Science Research Conference is again being hosted in conjunction with LPSC.

The YSS Undergraduate Planetary Science Research Conference will include:

- Panels on "How to Choose the Grad School Right for You," "Alternative Careers in Science," and "Women in Planetary Science"
- Poster sessions where students will present their posters to other students and to the scientific community
- "Meeting Mentors," which will pair students with a scientist for a portion of the LPSC meeting, so students can learn how to engage at a scientific conference
- Opportunities to meet other undergraduate researchers, graduate students, and scientists

Undergraduate students currently conducting research in planetary sciences, astrobiology, and lunar sciences are eligible. For more information and to apply, please go to *www.lpi.usra.edu/meetings/lpsc2013/events/education/*.

Some travel support will be available to students who qualify. Priority will be given to students of diverse backgrounds. To receive support, students must attend the entire YSS Undergraduate Research Conference and present a poster. Students are encouraged to attend LPSC and any travel support can be applied to registration for and participation in LPSC.

For additional information, contact Dr. Emily CoBabe-Ammann at *ecobabe@spaceeducation.org*.

E/PO and Scientist Professional Development Workshop —
Educators and scientists attending the 44th Lunar and Planetary Science Conference are invited to register to attend a workshop on evaluation of E/PO programs. This free workshop is appropriate for all E/PO professionals and scientists who host education events (such as teacher workshops, intern experiences, and public outreach events) and faculty teaching K–12 and undergraduate classes. Learn how to assess your programs and students' learning, and how to gather the evaluation data to inform and improve your program. For more information, visit *www.lpi.usra.edu/meetings/lpsc2013/events/education/*.

New Asteroid Mappers Citizen Science Project

Dawn's new citizen science project, Asteroid Mappers, involves participants in the art of interpreting cool images from Vesta. The accumulated findings can help the Dawn Science Team make sense of new elements on the surface of Vesta: its age, its composition, and its revealing patterns. For more information, visit *dawn.jpl.nasa.gov/DawnCommunity/asteroid_mappers.asp*.

Planetary Science Education and Public Outreach Resources: A Sampler for Planetary Scientists Involved in E/PO

Looking for ideas for an activity you can do with students at your local school or with visitors during a night-sky viewing? Searching for classroom resources to share with a teacher? This new sampler and quick-start guide connects NASA's big questions and topics in planetary science to E/PO programs, topic highlights, resource examples, and ways that the resources can be used. For more information, visit *smdepo.org/sites/default/files/Planetary%20Science%20EPO%20Resources.pdf*.

Name that Asteroid Contest

Students have the chance to name an asteroid! The OSIRIS-REx mission will launch in 2016 and return samples from the surface of the near-Earth asteroid, currently designated 1999 RQ36. The Planetary Society, the Lincoln Laboratory of the Massachusetts Institute of Technology, and the University of Arizona are asking students around the world to suggest better names for the asteroid. The entry deadline is December 2, 2012. For more information, visit *www.planetary.org/get-involved/contests/osirisrex/*.

NASA Wavelength: New Online Science Education Resource

NASA WAVELENGTH
A Full Spectrum of NASA Resources for Earth and Space Science Education

NASA has a new online science resource for teachers and students to help bring Earth, the solar system, and the universe into their schools and homes. Called NASA Wavelength, the site features hundreds of resources organized by topic and audience level from elementary to college, and out-of-school programs that span the extent of NASA science. Educators can locate educational resources through information on educational standards, subjects and keywords, and other relevant details, such as learning time required to carry out a lesson or an activity, cost of materials, and more.

The site offers an innovative way to keep up with the latest developments in Earth and space science education. Users will be able to receive e-mail updates on new content, and share the latest information through social media and e-mail. More information is available at *nasawavelength.org*.

New Worlds, New Discoveries — Topics, Activities, and Resources

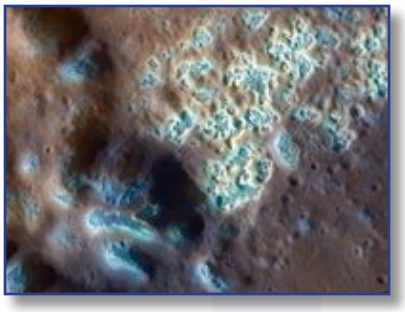
The martian year that marked the initial dates for the Year of the Solar System is over, but the celebration will continue to offer ways for you to get involved with NASA's groundbreaking science discoveries through a transition to New Worlds, New Discoveries!

New Worlds, New Discoveries provides an integrated picture of our new understanding of the solar system, combining the amazing discoveries of past NASA planetary missions with the most recent findings of ongoing missions, and connecting them to the related planetary science topics. For more information, visit *solarsystem.nasa.gov/yss/*.

New "Discoveries In Planetary Science" Classroom PowerPoints Available in English, Spanish, and Farsi

The DPS Education Subcommittee announces the sixth release of "Discoveries in Planetary Science" classroom PowerPoints, covering three new topics:

- Mercury Hollows
- Man in the Moon
- The Size of Eris



These are succinct summaries of discoveries too recent to appear in "Intro Astronomy" college textbooks; each set consists of just three slides to be shown: the discovery itself, a basic explanation based on good planetary science, and the "big picture" context. Another page for further information is provided as well. PowerPoints and PDF files can be downloaded from *dps.aas.org/education/dpsdisc*.

By popular request, all available slide sets have now been translated into both Spanish and Farsi. Versions in other languages should become available in the coming months. Feedback from the community on how these slide sets are used and received is always welcomed, and will be used to improve future releases. Planetary scientists with recent or upcoming results of broad interest are encouraged to submit them for consideration by providing an initial draft using the template provided on the website. For more information, contact Nick Schneider and Dave Brain at *dpsdisc@aas.org*.

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.

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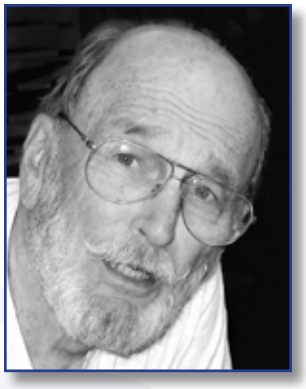


John William Dietrich, 1925–2012

John William Dietrich, former Lunar Sample Curator at the NASA Johnson Space Center (JSC), passed away at the age of 87, with his wife of 62 years, by his side.

Dietrich was born on April 26, 1925, in Beaumont, Texas. His 25-year career at JSC began in 1966 with support for the Apollo program, first as a photogeologist mapping the Moon with Lunar Orbiter data and then as an instructor in the geological training program for the astronauts who were to explore the lunar surface. After helping guide the Apollo missions to the Moon, Dietrich worked in the Earth Observations Division using data from a variety of space-based sensors, including LANDSAT. In 1981, he moved to the Solar System Exploration Division and joined the lunar sample curation effort. After accepting increasingly substantial responsibilities for lunar sample curation, he was appointed Lunar Sample Curator, and Deputy Chief of the Planetary Science Branch, in 1988. His NASA career achieved poetic completion as he supervised the distribution of samples from the same rocks that his mapping and coaching had helped to collect.

Dietrich retired from NASA service on December 31, 1991, after a long and successful career in lunar and planetary science, returning to the geology and scenery of Texas that he knew and loved so well. Volunteerism was a strong component of Dietrich's character, and after moving to Kerrville upon his retirement, he was active in a number of volunteer organizations, including Trailblazers, Us Too, NARFE, Judging for the Odyssey of the Mind, and the Fredericksburg Rockhounds.

David G. Koch, 1945–2012

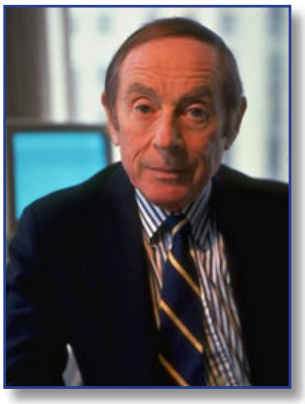
David G. Koch passed away on Wednesday, September 12, in Elm Grove, Wisconsin. He was 67 years old.

Koch was born and raised in Milwaukee, Wisconsin, and attended Milwaukee Lutheran High School where he built a Michelson interferometer, an instrument used to study the properties of light. This interferometer proved to be a stepping-stone for Koch to study physics. He graduated from the University of Wisconsin-Madison, where he earned a Bachelor of Science in applied mathematics and engineering physics in 1967. At Cornell University, Koch earned a master's degree in 1971, and a doctorate in 1972, both in physics.

His career began at American Science and Engineering Inc. in Cambridge, Massachusetts, where he worked in X-ray astronomy from 1972 to 1977. He was project scientist for the Uhuru X-ray satellite in NASA's Explorer Program, doing data analysis and producing X-ray catalogs. Later, he served as the project scientist for the development of the Einstein Observatory, the first X-ray telescope satellite and a predecessor to Chandra. Koch joined the Smithsonian Astrophysical Observatory in Cambridge in 1977, as project scientist for the Spacelab-2 infrared telescope. While there, he served as a co-investigator on the Space Infrared Telescope Facility (SIRTF) — Infrared Array Camera IRAC camera proposal, and co-investigator on the small explorer Submillimeter Wave Astronomy Satellite, which launched in December 1998. In 1988, Koch came to Ames to lead the mission operations for SIRTF and the Stratospheric Observatory for Infrared Astronomy (SOFIA). He was the last project scientist for the Kuiper Airborne Observatory, and in 1992, he created the Flight Opportunities for Science Teacher EnRichment (FOSTER) project.

In 1992, Koch began working on what has become the NASA Kepler mission, for which he served as deputy principal investigator until retiring in August 2011. His contributions were many, but most notably, he developed the Kepler Technology Demonstration used to prove that the transit photometry method would work under simulated operating and noise conditions. In particular, he devised the method to demonstrate that Earth-sized transits could be detected with a commercial off-the-shelf CCD (charge-coupled device) detector, which involved passing a small (mA) current through a ribbon wire across a rectangular aperture in a steel plate, thereby increasing the width of the wire by about the size of copper atom and blocking 0.01% of the light passing through the hole.

Koch loved to build things and was passionate about engaging young hearts and minds with the excitement of science and space exploration. He was particularly fond of educating and empowering teachers with the right tools to connect with the formal and informal classroom. Koch was a patient, intelligent man, who believed in and lauded the importance of Kepler's space exploration.



Credit: Time Inc.

Leon Jaroff, 1927–2012

Leon Jaroff, a science writer and editor who persuaded Time Inc. to launch *Discover* magazine in 1980, died on October 20 at his home in East Hampton, New York, after a four-year battle with throat cancer. He was 85 years old. Before launching *Discover*, he was the senior editor in charge of the science, medicine, behavior, and environment sections of *Time* magazine, where he noted that newsstand sales jumped when a science story was on the cover. Still, it took him a decade to persuade the editors that such a magazine could be a success. For many years Jaroff wrote the popular Skeptical Eye column challenging pseudosciences.

Jaroff was managing editor of *Discover* magazine for four years, overseeing cover articles on the search for life in space, the evolution of sex, and the secrets of the brain, among other topics. Circulation rose from about 400,000 in the first year to 935,000. While still at *Time* magazine, Jaroff wrote more than 40 cover articles, among them "Race for the Moon" and "Did Comets Kill the Dinosaurs?" Thirteen years after the latter article was published, the International Astronomical Union honored Jaroff by renaming a six-mile-wide asteroid 7829 Jaroff.

David Kring at Meteor Crater. Credit: Emily Worsham.

Kring Receives Award for Distinguished Service

The Lunar and Planetary Institute (LPI) is pleased to announce that Dr. David Kring, a senior staff scientist at the LPI, has been named as the 2012 recipient of the Ronald Greeley Award for Distinguished Service. The Planetary Geology Division (PGD) of the Geological Society of America (GSA) established the award in 2011. The award is given to those members of the PGD, and those outside the Division and GSA, who have rendered exceptional service to the PGD for a multi-year period.

Kring was selected as the recipient of this award for the work he has done in administering the Eugene M. Shoemaker Impact Cratering Award (see article below). In 1997, Kring and others affiliated with the GSA Planetary Geology Division were approached by Carolyn Shoemaker, widow of the late Eugene (Gene) Shoemaker, and asked if they could help set up an endowment with the GSA Foundation to support a research scholarship fund. The first award was given in 1999. Kring initially administered the award for GSA from the University of Arizona, but with the approval of the LPI Director, he has administered the award from the LPI since 2006.

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 includes a cash prize, is to be applied for the study of impact craters, either on Earth or on the other solid bodies in the solar system, which 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. For more information about the award, visit *www.lpi.usra.edu/science/kring/Awards/Shoemaker_Award*.

Mercer is Recipient of the 2012 Shoemaker Impact Cratering Award

The Lunar and Planetary Institute (LPI) is pleased to announce that the 2012 recipient of the Eugene M. Shoemaker Impact Cratering Award is Cameron Mercer of Arizona State University. Mercer is pursuing a Ph.D. with a heavy emphasis on geochronology that involves *in situ* laser ablation ^{40}Ar-^{39}Ar analyses of Apollo samples in Kip Hodges' laboratory and the geochemistry of select meteorites in Meenakshi Wadhwa's laboratory. He is supplementing those studies with a geochronologic study of Upheaval Dome, which is a terrestrial complex impact crater in Utah. That latter project is the one being supported through the GSA Planetary Geology Division's Eugene M. Shoemaker Impact Cratering Award.

Cameron Mercer. Credit: Arizona State University.

Charles Bolden. Credit: NASA.

NASA Administrator Receives Tuskegee Airmen Scholarship Foundation Memorial Award

The Tuskegee Airmen Scholarship Foundation presented NASA Administrator Charles Bolden with the Gen. James H. "Jimmy" Doolittle Memorial Award at the organization's Gold Medal Gala held in October in Los Angeles. Bolden is the first recipient of this award, which honors Gen. Doolittle's leadership as a founding board member of what began as the Tuskegee Airmen Scholarship Fund. The foundation presented the award to Bolden, a retired Marine Corps major general, for his outstanding military service, expert management as NASA's 12th administrator, and qualities of leadership that Gen. Doolittle practiced.

"I am honored to accept this award because my journey has been inspired by the example of courage and dedication against long odds that the Tuskegee aviators represent," Bolden said. "In addition to the example of my parents, I was fortunate to follow in the footsteps of the Tuskegee Airmen and serve my country as a Marine, an astronaut and now as head of NASA." For more information about Bolden, visit *www.nasa.gov/about/highlights/bolden_bio.html*.

Meteoritical Society Awards

The council of the Meteoritical Society is pleased to announce that Maartje Hamers has won the 2012 Gordon McKay Award for the best oral presentation by a student at the Society's 75th annual meeting in Cairns. Her presentation was entitled "Shocked Quartz in the SEM: Distinction Between Amorphous and Healed PDFs." This presentation and those listed below were made at the Society's 75th Annual Meeting in Cairns, Australia.

This year for the first time, Wiley-Blackwell, the publisher of the Society's journal, *Meteoritics and Planetary Science,* sponsored four awards of $500 each for outstanding oral presentations by students at the annual meeting. The 2012 winners are

- Evan Groopman, Washington University, St. Louis, for his talk entitled, "TiXANES and EELS of Presolar TiC Subgrains Within Low Density Supernova Graphite Grains"
- Matthew Huber, University of Vienna, for his talk entitled, "Distribution of Meteoritic Material in Sudbury Ejecta"
- Reto Trappitsch, University of Chicago, for his talk entitled, "Solar Cosmic Ray Irradiation of the Solar Nebula"
- Kelsey Young, Arizona State University, for her talk entitled, "The Age of Haughton Impact Structure as Determined by Zircon (UTh)/He Thermochronology"

Schultz Named as Recipient of the 2012 G. K. Gilbert Award

The Planetary Geology Division of the Geological Society of America (GSA) has announced that Pete Schultz, Professor in the Department of Geological Sciences at Brown University, has been selected as the recipient of the 2012 G. K. Gilbert Award. The G. K. Gilbert Award is presented annually by the Planetary Geology Division of the Geological Society of America for outstanding contributions to the solution of fundamental problems in planetary geology in the broadest sense, which includes geochemistry, mineralogy, petrology, geophysics, geologic mapping, and remote sensing. Such contributions may

Pete Schultz. Credit: Brown University.

consist either of a single outstanding publication or a series of publications that have had great influence in the field. The award is named for the pioneering geologist G. K. Gilbert, and consists of an engraved plaque and an appropriate certificate, which is recommended by the management board of the Division, and approved by the GSA Council.

Schultz received his Ph.D. in Astronomy at the University of Texas at Austin in 1972. A former staff scientist at the Lunar and Planetary Institute (LPI), he joined the faculty of Brown University in 1984 and was promoted to full Professor in 1994. In addition to his research and teaching responsibilities at Brown, Schultz has served as Director of the LPI's Planetary Image Facility, and is currently the Director for both the Northeast Planetary Data Center and the NASA/Rhode Island University Space Grant Consortium. His primary area of research is impact cratering, particularly the effect of the impact angle on cratering and the role of the atmosphere in modifying the process.

Nininger Meteorite Awards

The Center for Meteorite Studies is pleased to announce that David Baker, a graduate student at Brown University, has been awarded the 2011 Nininger Meteorite Award. Matthew Wielicki, a graduate student at the University of California Los Angeles, and Devin Schrader, a graduate student at the University of Arizona, both received an Honorable Mention for the Award.

In 1965, Dr. H. H. Nininger and Mrs. Addie D. Nininger endowed the Nininger Science of Meteoritics Fund to the Center for Meteorite Studies at Arizona State University in order to promote interest in meteorite-related topics among young scientists. The Fund supports the Nininger Meteorite Award, which recognizes outstanding student achievement in the "Science of Meteoritics" as embodied by an original research paper. Qualifying papers must cover original research conducted by the student, who must be the first author on the paper. Submissions for the award are reviewed by an international panel of experts from a broad array of fields in meteoritical science.

Baker's paper, "The Transition from Complex Craters to Multi-Ring Basins on the Moon: Quantitative Geometric Properties from Lunar Reconnaissance Orbiter Lunar Orbiter Laser Altimeter (LOLA) Data," demonstrates an improved, semi-automated technique to measure the morphometric properties of peak-ring basins and protobasins on the Moon using new topography data from the Lunar Reconnaissance Orbiter (LRO) Lunar Orbiter Laser Altimeter (LOLA). Analyses of these morphometric characteristics with crater size revealed new trends that now provide an observational framework for testing models for the formation of peak-ring basins on planetary bodies. Among the trends, Baker and his coauthors found a discontinuity in depth measurements from complex craters to peak-ring basins and continuous increases in central peak dimensions up to the transition to peak-ring basins. These observations of peak-ring basins on the Moon provide a foundation for understanding the formation of larger multi-ring basins and are already serving as a benchmark for similar morphometric analyses of basins on other planetary bodies such as Mercury.

David Baker. Credit: University of Arizona.

Schrader's paper, "The Formation and Alteration of the Renazzo-like Carbonaceous Chondrites II: Linking O-isotope Composition and Oxidation State of Chondrule Olivine," discusses the formation conditions of type-I and type-II chondrules in the Renazzo-like carbonaceous (CR) chondrites. Through an *in situ* major- and minor-element and O-isotope study, Schrader and his co-authors infer that type-II chondrule precursors contained enhanced S-bearing dust and ice abundances relative to type-I chondrules,

and find a relationship between the O-isotope composition and oxidation state of olivine, which may be related to the amounts of ^{16}O-poor ice and reduced carbon accreted by chondrule precursors before melting.

Devin Schrader. Credit: University of Arizona.

Wielicki's paper, "Geochemical Signatures and Magmatic Stability of Terrestrial Impact Produced Zircon," compares terrestrial impactites, ranging in age from ~35 Ma to ~2 Ga, with detrital Hadean zircon from Western Australia. Such comparisons may provide the only terrestrial constraints on the role of impacts during the Hadean and early Archean, a time predicted to have a high bolide flux. Ti-in-zircon thermometry indicates an average of 773°C for impact produced zircon, ~100°C higher than the average for Hadean zircon crystals. The agreement between whole-rock based zircon saturation temperatures for impactites and Ti-in-zircon thermometry implies that Ti-in-zircon thermometry record actual crystallization temperatures for impact melts. Zircon saturation modeling of Archean crustal rock compositions undergoing thermal excursions associated with the late heavy bombardment predict equally high zircon crystallization temperatures. The lack of such thermal signatures in the Hadean zircon record implies that impacts were not a dominant mechanism of producing the preserved Hadean detrital zircon record.

Matthew Wielicki. Credit: University of Arizona.

NASA Mars Exploration Rover Team Honored

The mission team for NASA's long-lived Mars Exploration Rovers Spirit and Opportunity was awarded the Haley Space Flight Award on September 12 during the American Institute of Aeronautics and Astronautics (AIAA) Space 2012 Conference and Exposition in Pasadena, California.

The award is presented for outstanding contributions by an astronaut or flight test personnel to the advancement of the art, science, or technology of astronautics. Past recipients include Alan Shepherd, John Glenn, Thomas Stafford, Robert Crippen, Kathryn Sullivan, and the crew of space shuttle mission STS-125, which flew in 2009 on the last shuttle mission to NASA's Hubble Space Telescope. The award citation praises the rover project's "new techniques in extraterrestrial robotic system operations to explore another world and extend mission lifetime." Mars Exploration Rover Project Manager John Callas of NASA's Jet Propulsion Laboratory accepted the award for the team.

Artist's concept of the Mars Exploration Rover. Credit: NASA.

"On behalf of the many hundreds of scientists and engineers who designed, built and operate these rovers, it is a great honor to accept this most prestigious award," Callas said. "It is especially gratifying that this comes right as Opportunity is conducting one of the most significant campaigns in the eight-and-a-half years since landing. We still are going strong, with perhaps the most exciting exploration still ahead."

In its eighth year operating on Mars, Opportunity is surveying a crater-rim outcrop of layered rock in search of clay minerals that could provide new information about a formerly wet environment. Spirit worked for more than six years — until 2010 — 24 times longer than its original three-month prime mission. As of September, Opportunity's total overland travel distance measured 21.76 miles (35 kilometers). Recent drives along the inner edge of the Cape York segment of the western rim of Endeavour Crater have brought the rover close to a layered outcrop in an area where clay minerals have been detected from orbit. These minerals could offer evidence of ancient, wet conditions with less acidity than the ancient, wet environments recorded at sites Opportunity visited during its first seven years on Mars. Opportunity's position overlooking 14-mile-wide (22-kilometer-wide) Endeavour Crater is about 5200 miles (8400 kilometers) from where Curiosity, NASA's next-generation Mars rover, landed inside Gale Crater in early August.

More information about Opportunity and Spirit can be found at *www.nasa.gov/rovers* and *marsrovers.jpl.nasa.gov*. The project can also be followed on Twitter and Facebook at *twitter.com/MarsRovers* and *www.facebook.com/mars.rovers*.

NASA Selects Science Teams for Astrobiology Institute

NASA has awarded five-year grants totaling almost $40 million to five research teams to study the origin, evolution, distribution, and future of life in the universe. The newly selected teams are from the University of Washington; Massachusetts Institute of Technology; University of Wisconsin, Madison; University of Illinois, Urbana-Champaign; and University of Southern California. Average funding to the teams is almost $8 million each. The interdisciplinary teams will become members of the NASA Astrobiology Institute (NAI), headquartered at NASA's Ames Research Center.

"These research teams join the NASA Astrobiology Institute at an exciting time for NASA's exploration programs," said John Grunsfeld, astronaut and associate administrator for NASA's Science Mission Directorate in Washington. "With the Curiosity rover preparing to investigate the potential habitability of Mars and the Kepler mission discovering planets outside our solar system, these research teams will help provide the critical interdisciplinary expertise needed to interpret data from these missions and plan future astrobiology-focused missions."

The University of Washington's "Virtual Planetary Laboratory," led by Victoria Meadows, will integrate computer modeling with laboratory and field-work across a range of disciplines to extend knowledge of planetary habitability and astronomical biosignatures in support of NASA missions to study extrasolar planets. The Massachusetts Institute of Technology team, led by Roger Summons, will focus on how signs of life are preserved in ancient rocks on Earth, with a focus on the origin and evolution of complex life, and how this knowledge can be applied to studies of Mars using the Curiosity rover. The University of Wisconsin team, led by Clark Johnson, will study how to detect life in modern and ancient environments on Earth and other planetary bodies. The University of Illinois team, led by Nigel Goldenfeld, seeks to define a "universal biology," or fundamental principles underlying the origin and evolution of life anywhere, through an interdisciplinary study of how life began and evolved on Earth. The University of Southern California team, led by Jan Amend, will study life in the subsurface, a potentially habitable environment on other worlds. They will use field, laboratory, and modeling approaches to detect and characterize Earth's subsurface microbial life.

"The intellectual scope of astrobiology is breathtaking, from understanding how our planet went from lifeless to living, to understanding how life has adapted to Earth's harshest environments, to exploring other worlds with the most advanced technologies to search for signs of life," said NAI Director Carl Pilcher. "The new teams cover that breadth of astrobiology, and by coming together in the NAI, they will make the connections between disciplines and organizations that stimulate fundamental scientific advances."

These five new teams join 10 other teams led by the University of Hawaii; Arizona State University, Tempe; The Carnegie Institution of Washington; Rensselaer Polytechnic Institute, Troy, New York; Pennsylvania State University; Georgia Institute of Technology; and teams at Ames, Goddard Space Flight Center, and NASA's Jet Propulsion Laboratory. For more information about the new teams, NAI, and NASA's astrobiology program, visit *astrobiology.nasa.gov*.

PC Magazine Honors NASA App as Editors' Choice

The NASA App, developed by a small team of software engineers at NASA's Ames Research Center, has been selected by *PC Magazine* as an Editors' Choice among educational apps. The NASA App gathers the agency's online content, breaking news, image and video collections, news and image feeds, social media accounts, and more in one easy-to-use location that aids public access to science, technology, and engineering discoveries. The NASA App supports many mobile platforms, including the iPhone, iPod touch, iPad Android phones, and tablets. The NASA App currently has more than 10 million user installations and receives more than 3 million hits per day on average.

"There are many good NASA-sponsored or NASA-related apps for the iPad, but none compares in breadth of content with NASA App HD," said Tony Hoffman, analyst at *PCMag.com*. "This app combines insightful articles and news stories, dazzling images and videos, live TV feeds, and more as a one-stop portal for most everything NASA. Everyone from children and young students to hardcore space geeks will find fascinating things in this app, and it's an easy pick."

In November, NASA plans to release an updated version of the NASA App for iPhone and iPod Touch that will include a feature to alert users 15 minutes before the International Space Station passes overhead. The new version also will support the larger screen on the iPhone 5 and new iPod Touch.

Last month, the NASA App co-won the 2012 NASA Software of the Year award for being an innovative software technology that significantly improves the agency's exploration of space and maximizes scientific discovery on Earth.

"The NASA App has been a huge success," said Jerry Colen, NASA App project manager at Ames. "I'm very proud to have been part of the team that developed a mobile app for millions of people to learn more about NASA's science and exploration efforts on Earth and beyond."

All of 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.

For more information about NASA Apps, visit *www.nasa.gov/nasaapp*.

Morris Named as Assistant Director for ASU's Center for Meteorite Studies

The Center for Meteorite Studies at Arizona State University (ASU) has announced that Dr. Melissa Morris has joined the staff as Assistant Director. Morris' research focuses on star and planet formation, in particular the use of astrophysical modeling to determine conditions during the birth of planetary systems. Her specific interests include hydrodynamic modeling (including radiative transfer) of protoplanetary disks and disk processes during planet formation that is constrained by mineralogical and chemical data on planetary materials. The oldest known solids in our own planetary system can be found in meteorites. By combining meteoritic data and the results of astrophysical modeling, Morris endeavors to further our understanding of the conditions that existed in the early solar nebula and exist in extrasolar disks today.

Morris is a past Goldwater Scholar and was one of the first Exploration Postdoctoral Fellows in the School of Earth & Space Exploration at ASU. She has been a visiting assistant professor in the Physics and Materials Science Department at Missouri State University, as well as a lecturer in the School of Earth & Space Exploration at ASU. She is also an active member of the Meteoritical Society.

NASA Announces Leadership Changes

NASA Administrator Charles Bolden recently announced changes to his senior leadership team. Robert Lightfoot, acting associate administrator at NASA Headquarters in Washington, has assumed that role on a permanent basis. Lightfoot began his assignment as acting associate administrator on March 5. As associate administrator, Lightfoot is the agency's highest-ranking civil servant, responsible for oversight and integration of NASA's broad efforts in human space flight, science, and aeronautics. Lightfoot began his NASA career as a test engineer and manager for the space shuttle main engine technology test bed program. He then served in leadership positions at Marshall, Stennis, and Headquarters. From 2003 to 2005, he was assistant associate administrator for the Space Shuttle Program, Office of Space Flight, at Headquarters.

Patrick Scheuermann, director of NASA's John C. Stennis Space Center near Bay St. Louis, Mississippi, has been named as director of NASA's Marshall Space Flight Center in Huntsville, Alabama. Scheuermann will replace Robin Henderson, who had filled the position on a temporary basis after Gene Goldman's retirement on August 3. Scheuermann has provided executive leadership, overall direction, and management of Stennis since being named that center's director in 2010. He is responsible for implementing NASA's mission in the area of rocket propulsion testing, and developing and maintaining NASA's world-class rocket propulsion test facilities. He previously served as Stennis' deputy director and associate director, in addition to working as chief operating officer of NASA's Michoud Assembly Facility in New Orleans. Since joining NASA in 1988 as a propulsion test engineer, he worked on numerous major test projects at Stennis, including serving as project manager for NASA's Reusable Launch Vehicle program, a NASA-industry effort to develop a new generation of safe and cost-effective rockets to send payloads to space.

Scheuermann's successor as the Stennis director is Dr. Richard J. Gilbrech, who has been serving as that center's deputy director. Gilbrech has served as Stennis' deputy director since 2010. He began his NASA career in 1991 at Stennis in the area of propulsion test technology. From 1998 to 2000, he served as chief of the Propulsion Test Engineering Division at Stennis, and in 2003, he was named manager of the Propulsion Integration Office, responsible for managing NASA's rocket propulsion test facilities. Later in 2003, Gilbrech relocated to Langley Research Center in Hampton, Va., to become a principal engineer in the NASA Engineering and Safety Center. He later served as deputy of the NASA Engineering and

Safety Center and as deputy director of Langley. In 2006, Gilbrech was named director of Stennis, serving in that role until assuming leadership of NASA's Exploration Systems Mission Directorate at Headquarters in Washington.

All three men are highly honored NASA leaders, earning the Presidential Rank Award of Meritorious Executive and agency medals for outstanding leadership. These management changes were effective in September.

"Robert, Patrick, and Rick are three of NASA's finest public servants who will continue to play key roles in our agency's future," NASA Administrator Charles Bolden said. "America is fortunate to have three such talented leaders assuming these important jobs at a pivotal time for NASA and space exploration."

In other NASA personnel news, on November 16 Bolden announced leadership changes for the agency's Glenn Research Center in Cleveland and Johnson Space Center in Houston. James Free will succeed Ramon (Ray) Lugo as Glenn's center director when Lugo retires in January. Free has served as Glenn's deputy director since January 2011. Free began his career in 1990 at NASA's Goddard Space Flight Center as a propulsion engineer and later as a systems engineer on NASA's Tracking and Data Relay Satellites. He joined Glenn in 1999 as the International Space Station liaison for the Fluids and Combustion Facility. His other NASA assignments have included director of Space Flight Systems at Glenn, Orion Service Module manager at Glenn, and chief of the center's Orion Project Office. He also worked at Johnson as the Orion Test and Verification manager.

Lugo's retirement brings to a close a 37-year career at NASA. In 1975, he began working at the agency's Kennedy Space Center in Florida as a cooperative education student. His first assignment was in the Construction and Modifications Branch as an engineer responsible for construction modifications to Launch Pad 39A in preparation for the first space shuttle mission. His other NASA assignments included serving as Glenn's deputy center director and deputy program manager for NASA's Launch Services Program.

Ellen Ochoa will succeed Michael Coats as Johnson's center director when Coats retires at the end of the year. Ochoa has served as Johnson's deputy director since September 2007. She is a four-time space shuttle astronaut who previously served as director and deputy director of flight crew operations at Johnson. She managed the Intelligent Systems Technology Branch at NASA's Ames Research Center before being selected as an astronaut candidate in 1990. Ochoa flew on space shuttle missions STS-56 in 1993, STS-66 in 1994, STS-96 in 1999, and STS-110 in 2002, logging a total of 978 hours in space.

Former space shuttle commander Coats was selected as an astronaut candidate from the U.S. Navy in 1978. He flew on three shuttle missions, serving as pilot for STS-41-D in 1984 and commander for STS-29 in 1989 and STS-39 in 1991. Following his final shuttle mission, Coats retired from the Navy and NASA's Astronaut Office in August 1991 to join the private sector. He returned to NASA in 2005 to become Johnson's 10th center director.

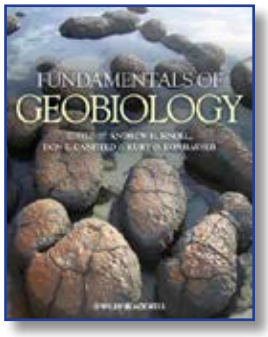
"Ellen and Jim are experienced, outstanding leaders who I know will continue to do great things as they take the helms of their field centers," Bolden said. "I also want to thank Mike and Ray for their years of leadership and dedicated service at NASA, most recently while guiding Johnson and Glenn through pivotal times for those centers. I am sad to see Mike leave, as he and I have been close friends and allies since coming together in the summer of 1964 as new plebes in the Great Naval Academy class of 1968. I also want to thank Ray for his years of tireless work at NASA, for a long while on the team at the Kennedy Space Center and, most recently, while leading Glenn."

BOOKS

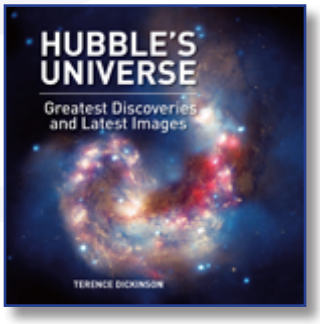
Destiny or Chance Revisited: Planets and Their Place in the Cosmos. By Stuart Ross Taylor.
Cambridge University Press, 2012. 320 pp., Hardcover, $30.00. *www.cambridge.org*

This exciting tour of our universe explores our current knowledge of exoplanets and the search for another Earth-like planet. Beginning with the basic concepts of planet formation and the composition of the universe, Taylor summarizes our knowledge of exoplanets, how they compare with our planets, and why some stars have better habitable zones. Further sections provide a detailed study of our solar system, as a basis for understanding exoplanetary systems, and a detailed study of Earth as our only current example of a habitable planet. The book concludes with a philosophical and historical discussion of topics surrounding planets and the development of life, including why our chances of finding aliens on exoplanets is very low. This is an engaging and informative read for anyone interested in planetary formation and the exploration of our universe.

Fundamentals of Geobiology. Edited by Andrew H. Knoll, Don E. Canfield, and Kurt O. Konhauser.
Wiley-Blackwell, 2012. 456 pp., Paperback, $79.95. *www.wiley.com*



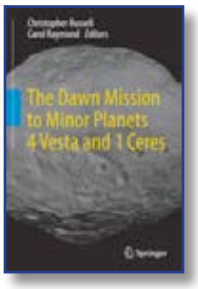
For more than 50 years scientists have been concerned with the interrelationships of Earth and life. Over the past decade, however, geobiology has emerged as an exciting and rapidly expanding field, fueled by advances in molecular phylogeny, a new microbial ecology made possible by the molecular revolution, increasingly sophisticated new techniques for imaging and determining chemical compositions of solids on nanometer scales, the development of nontraditional stable isotope analyses, Earth systems science and Earth system history, and accelerating exploration of other planets within and beyond our solar system. Geobiology has many faces: the microbial weathering of minerals, bacterial and skeletal biomineralization, the roles of autotrophic and heterotrophic metabolisms in elemental cycling, the redox history in the oceans, and its relationship to evolution and the origin of life itself. This book is the first to set out a coherent set of principles that underpin geobiology and will act as a foundational text that will speed the dissemination of those principles. It is aimed at advanced undergraduates and graduates in the Earth and biological sciences, and to the growing number of scientists worldwide who have an interest in this burgeoning new discipline.



Hubble's Universe: Greatest Discoveries and Latest Images. By Terence Dickinson.
Firefly Books, 2012. 300 pp., Hardcover, $49.95. *www.fireflybooks.com*

The Hubble Space Telescope. No other telescope combines instant name recognition with the production of consistently spectacular images. Yet few people outside the astronomy community realize that Hubble is now at the apex of its imaging capabilities. A collection of stunningly detailed pictures, made possible by the new Wide Field Camera 3, had yet to be incorporated into a popular-level book . . . until now. Bestselling astronomy writer Dickinson showcases extraordinary late-breaking pictures, many of which have yet to receive wide distribution as news stories or in publications outside scientific papers, and presents a breathtaking portfolio drawn from an archive of over 500,000 existing Hubble images. The accompanying text balances accuracy with accessibility, Dickinson's hallmark. And thanks to the author's

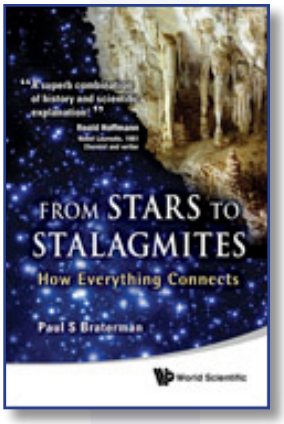
familiarity with Hubble's history and discoveries and his access to top Hubble scientists for insight and accuracy, the text includes facts and tidbits not found in any other book. Combined with hundreds of brilliant images, the clear narrative brings to life the fascinating forces at work in the universe.



The Dawn Mission to Minor Planets 4 Vesta and 1 Ceres. Edited by Christopher Russell and Carol Raymond.
Springer, 2012, 574 pp., Hardcover, $229.00. *www.springer.com*

Dawn is the first mission to orbit a main-belt asteroid and the first scientific mission to use ion propulsion. Major objectives of this mission include mapping of the surfaces of 4 Vesta and 1 Ceres, determining its topography from stereo measurements, determining its mineralogy, measuring its elemental composition, and obtaining gravity data. This book describes the Dawn mission, its exploration and scientific objectives, the instruments that accomplish those objectives, the operations plan, and the education and outreach plan. It is directed to those studying asteroids and the evolution of the solar system. This volume will be a valuable reference for anyone who uses data from the instruments of the Dawn mission.

From Stars to Stalagmites: How Everything Connects. By Paul S. Braterman.
World Scientific, 2012. 328 pp., Paperback, $37.00. *www.worldscientific.com*



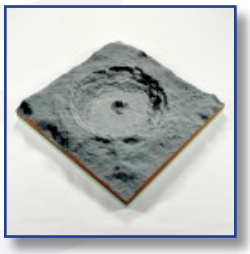
American physicist Richard Feynman declared that the single most important statement in science is that everything is made of atoms. It follows that the properties of everything depend on how these atoms are joined together, giving rise to the vast field we know of today as chemistry. In this unique book specifically written to bridge the gap between chemistry and the layman, Braterman has put together a series of linked essays on chemistry-related themes that are particularly engaging, beginning with the age of Earth, and concluding with the life cycle of stars. In between, there are atoms old and new, the ozone hole mystery and how it was solved, synthetic fertilizers and explosives, reading the climate record, the extraction of metals, the wetness of water, and how the greenhouse effect on climate really works. A chapter in praise of uncertainty leads on to the "fuzziness" and sharing of electrons, and from there to molecular shape, grass-green and blood-red, the wetness of water, and molecular recognition as the basis of life. Organized in a way that illustrates and develops underlying principles and approaches, this book will appeal to anyone interested in chemistry, its history, and key personalities. This book succeeds in capturing the spirit and essence of chemistry and delivering the science in easily digestible terms.

Mirror Earth: The Search for Our Planet's Twin. By Michael D. Lemonick.
Walker & Company, 2012. 294 pp., Hardcover, $26.00. *www.walkerbooks.com*

In the mid-1990s, astronomers made history when they detected three planets orbiting stars in the Milky Way. The planets were nothing like Earth, however: They were giant gas balls like Jupiter or Saturn. More than 500 planets have been found since then, yet none of them could support life. Now, armed with more powerful technology, planet hunters are racing to find a true twin of Earth. Science writer Lemonick has unique access to these exoplaneteers, as they call themselves, and *Mirror Earth* unveils their passionate quest. Geoff Marcy, at the University of California, Berkeley, is the world's most successful planet hunter, having found two of the first three extrasolar planets. Bill Borucki, at the NASA Ames Research Center, struggled for more than a decade to launch the Kepler mission — the only planet finder, human or machine, to beat Marcy's record. David

Charbonneau, at Harvard, realized that Earths would be much easier to find if he looked at tiny stars called M-dwarfs rather than stars like the Sun — and that he could use backyard telescopes to find them! Unlike those in other races, the competing scientists actually consult and cooperate with one another. But only one will be the first to find Earth's twin. Mirror Earth is poised to narrate this historic event as the discovery is made.

TERRAIN MODELS



Lunar Surface Landform Models.
Produced by the Center for Lunar Science and Exploration and Landprint.com, 2012. $90.00–$160.00. *landprint.com*

Here is a series of models that represent major landforms on the lunar surface. These three-dimensional representative models are useful educational resources for any classroom or library. Each one measures 20 cm × 20 cm or 25 cm × 25 cm and is made of a porcelain-like material. Lunar surface feature models currently available are Tycho Crater, Schrödinger Basin, and Linné Crater, and all were created from data and imagery obtained by the Lunar Reconnaissance Orbiter. The Center for Lunar Science and Exploration is preparing models of other representative lunar landforms that will be made available in the future.

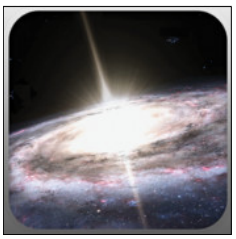
CALENDAR

Astronomy 2013. Edited by Terence Dickinson.
Firefly Books, 2013. $14.99. *www.fireflybooks.com*

Majestic spiral arms of a remote galaxy shimmer from the combined light of 50 billion stars. The ethereal curtains of the aurora borealis ripple across the night sky. Vast clouds of gas and dust, 10,000 times wider than the solar system, pervade the galaxy. Captured by the cameras of talented amateur astronomers and by the world's most powerful research telescopes, the universe's impressive wonders are presented in the *Astronomy 2013* calendar in brilliant high-resolution color. This 12-image collection was compiled by stargazing authority and best-selling author Dickinson. He brings a wealth of practical experience to the calendar's diary of predicted celestial events, which range from meteor showers to eclipses.

APP

Brian Cox's Wonders of the Universe.
From HarperCollins Publishers Ltd. $5.99. *www.harpercollins.co.uk*



Take a mind-blowing 3D tour of the universe with Professor Brian Cox as your guide. This is the official Wonders of the Universe app, produced by arrangement with the BBC. This new version 1.20 has added features: Cause the supernova explosion of Betelgeuse. Land on the surfaces of Mars, the Moon, Io, and Enceledus. See Pluto, Charon, and the Triangulum Galaxy in 3D. This update opens up the app to all Apple devices for the first time, including the iPhone, iPad, and iPad mini.

FOR KIDS!!!

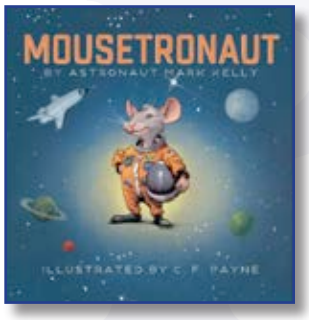
Hot Wheels Curiosity Rover.

Produced by Mattel. $5.00. Available from the JPL store.
bookstore.caltech.edu/JPLLAB/

To commemorate the Mars Rover Curiosity created by NASA/JPL-Caltech, Hot Wheels created a 1:64 scale version. Curiosity carries many tools, such as a drill, cameras, and a laser. Its mission is to see if Mars could have ever supported small life forms called microbes . . . or if humans could explore there someday. For ages 3 and up.

Mousetronaut: Based on a (Partially) True Story. By Mark Kelly.

Simon & Schuster/Paula Wiseman Books, 2012. 40 pp., Hardcover, $16.99. imprints.
simonandschuster.biz/paula-wiseman-books



Astronaut Mark Kelly flew with "mice-tronauts" on his first spaceflight onboard space shuttle Endeavour in 2001. *Mousetronaut* tells the story of a small mouse that wants nothing more than to travel to outer space. The little mouse works as hard as the bigger mice to show readiness for the mission . . . and is chosen for the flight! While in space, the astronauts are busy with their mission when disaster strikes — and only the smallest member of the crew can save the day. With lively illustrations by award-winning artist C. F. Payne, *Mousetronaut* is a charming tale of perseverance, courage, and the importance of the small. For ages 4–8.

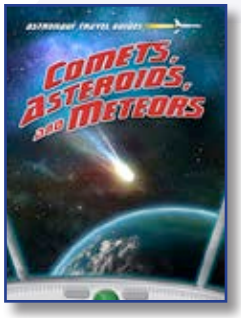
Angry Birds Space: A Furious Flight into the Final Frontier. By Amy Briggs.

National Geographic, 2012. 160 pp., Paperback, $13.95.
shop.nationalgeographic.com

It's one small step for birds, one giant leap for birdkind . . . Blast off with the Angry Birds as they fly through space on an intergalactic rescue mission! Evil space piggies have stolen their eggs and are hiding them somewhere in outer space. To save them, the Angry Birds have teamed up with National Geographic to learn all they can about planets, moons, stars, galaxies, and the mysteries of the universe. Four chapters take the readers deeper and deeper into space — each one packed with Angry Birds, astounding space photography, and fascinating "Astrofacts" and "Space Data" features. Join the birds as they observe robots on Mars; take a spin with Jupiter's Great Red Spot; visit where stars are born in galaxies far, far away; and look for life on strange new worlds. This official companion book to the Angry Birds Space game shows the furious fliers everything they'll need to know on their quest to explore the galaxy and rescue their precious eggs. The book is organized into four levels, each one taking the reader and the birds farther and farther into space: "You Are Here: What's Out There?," "Short Flights: The Inner Solar System," "Longer Journey: The Outer Solar System," and "Flying Farther: Deep Space." For ages 9–12.

Comets, Asteroids, and Meteors. By Stuart Atkinson.

Heinemann-Raintree, 2012. 48 pp., Hardcover, $24.00. *www.capstonepub.com*



What are comets and asteroids like, and could we ever visit one? Taking the form of an imaginary trip, this book from the Astronaut Travel Guides series explores the science and history of these objects, looking at recent studies and possibilities for the future. For grades 3–6.

Calendar 2012–2013

December 2012

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

3–4 **Annual International Conference on Geological and Earth Sciences (GEOS 2012),** Singapore. *http://www.geoearth.org/*

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/*

6–10 **221st Meeting of the American Astronomical Society,** Long Beach, California. *https://aas.org/meetings/aas221*

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*

23–24 **Calibration Targets for Astronomical Polarimetry for the 0.3 to 30 Micron Wavelength Range,** Zurich, Switzerland. *http://www.polarization.eu/index.php/meetings/calibration-workshop*

February

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

3–8 **Waves and Instabilities in Geophysical and Astrophysical Flows,** Les Houches, France. *https://www.irphe.fr/~meunier/Workshop2.html*

4–6 **The Present-Day Habitability of Mars,** Los Angeles, California. *http://planets.ucla.edu/meetings/mars-habitability-2013/*

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*

6–8 **Committee on Astrobiology and Planetary Science,** Washington, DC. *http://sites.nationalacademies.org/ssb/SSB_067577.htm*

10–15 **Fundamental Properties and Processes of Magnetotails,** Reykjavik, Iceland. *http://chapman.agu.org/magnetotails/*

11–12 **Characterising Exoplanets: Detection, Formation, Interiors, Atmospheres and Habitability,** London, United Kingdom. *http://royalsociety.org/events/2013/exoplanets/*

18–22 **44th Lunar and Planetary Science Conference (LPSC 2013),** The Woodlands, Texas. *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/*

7–12 **European Geosciences Union General Assembly 2013,** Vienna, Austria. *http://www.egu2013.eu/*

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*

11 **LunarCubes Missions Briefing,** Cocoa Beach, Florida. *http://www.lunar-cubes.com/*

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*

29–May 2 **Habitable Worlds Across Time and Space,** Baltimore, Maryland. *http://www.stsci.edu/institute/conference/habitable-worlds*

29–May 3 **Friends of Friends Meeting 2013,** Cordoba, Argentina. *http://fof.oac.uncor.edu/*

May

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

6–7 **First Annual International Conference on Space Environment & Aviation Technology (SEAT 2013),** Singapore. *http://www.space-aviation.org/index.html*

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/*

28–29 **iCubeSat 2013 — The 2nd Interplanetary CubeSat Workshop,** Ithaca, New York. *http://iCubeSat.org*

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

June

2–6 **222nd Meeting of the American Astronomical Society,** Indianapolis, Indiana. *https://aas.org/meetings/aas222*

2–7 **Exploring the Formation and Evolution of Planetary Systems,** Victoria, Canada. *http://www.iau.org/science/meetings/future/symposia/1064/*

3–4 **1st Annual International Conference on Astronomy and Astrophysics (Astro 2013),** Singapore. *http://www.astro-conf.org/*

23–28 **Gordon Conference on Origins of Solar Systems,** South Hadley, Massachusetts. *http://www.grc.org/programs.aspx?year=2013&program=origins*

24–27 **8th Workshop on Catastrophic Disruption in the Solar System (CD8),** Hapuna Beach, Hawaii. *http://www.cd8.hawaii-conference.com/*

24–28 **Crossing the Boundaries in Planetary Atmospheres: From Earth to Exoplanets,** Annapolis, Maryland. *http://chapman.agu.org/planetaryatmospheres/*

July

8–12 **Magnetospheres of the Outer Planets 2013,** Athens, Greece. *http://space.academyofathens.gr/mop2013/*

9–11 **Ninth Meeting of the NASA Small Bodies Assessment Group,** Pasadena, California. *http://www.lpi.usra.edu/sbag/meetings/*

15–19 **Eighth International Mars Conference,** Pasadena, California. *http://www.lpi.usra.edu/meetings/8thmars2013/*

15–20 **Protostars and Planets VI,** Heidelberg, Germany. *http://www.ppvi.org*

22–26 **The Pluto System on the Eve of Exploration by New Horizons: Perspectives and Predictions,** Columbia, Maryland. *https://dnnpro.outer.jhuapl.edu/plutoscience/Home.aspx*

29–Aug 2 **2013 Sagan Exoplanet Summer Workshop,** Pasadena, California. *http://nexsci.caltech.edu/workshop/2013/*

29–Aug 2 **76th Annual Meeting of the Meteoritical Society,** Edmonton, Canada. *http://metsoc2013edmonton.org/*

August

4–8 **Large Meteorite Impacts and Planetary Evolution V,** Sudbury, Ontario, Canada. *http://www.lpi.usra.edu/meetings/sudbury2013*

26–30 **Meteoroids 2013,** Poznan, Poland. *http://www.astro.amu.edu.pl/Meteoroids2013/index.php*

September

24–28 **Second International Congress of Astrobiology in Columbia,** Medellin, Columbia. *http://www.astrobiologia.org/2-congreso-internacional-de-astrobiologia.html*

October

15–18 **The (F)IR Universe Three Years Later — The Contributions by Herschel,** Noordwijk, The Netherlands. *http://herschel.esac.esa.int/The_FIR_Universe.shtml*

27–30 **2013 GSA Annual Meeting and Exposition,** Denver, Colorado. *http://www.geosociety.org/meetings/2013/*

30–31 **International Space Exploration Symposium in Japan: Space Exploration for Humanity and the Future,** Tokyo, Japan. *https://secure.mediatelier.com/ises/index_e.html*