

# *NEW HORIZONS GETS A BOOST FROM JUPITER*

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**BULLETIN**

Lunar and Planetary Institute — Universities Space Research Association

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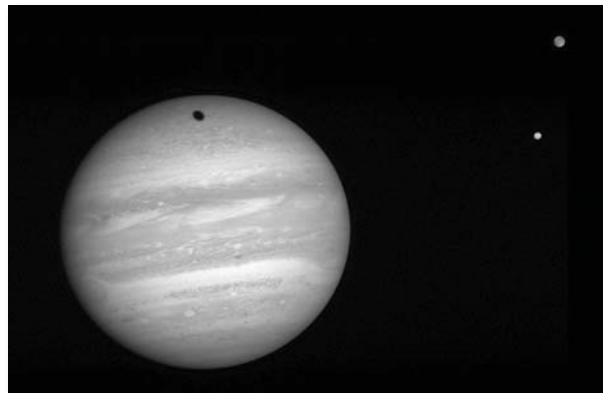
# New Horizons Gets a Boost From Jupiter

— Fran Bagenal, University of Colorado

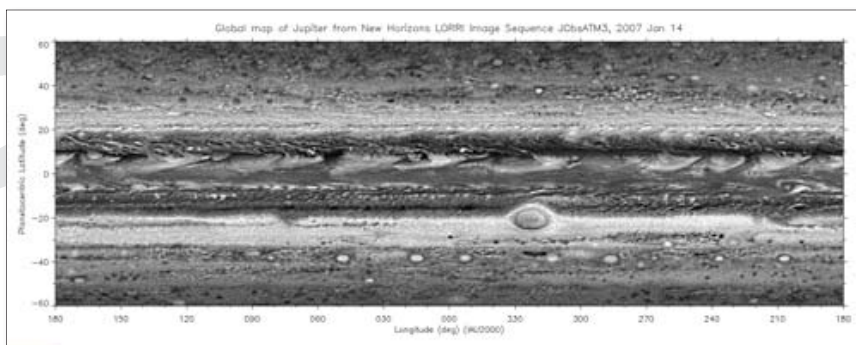
New Horizons Principle Investigator Alan Stern says the objective of the Jupiter flyby (aside from getting a gravitational boost out to Pluto) is to check out and learn about the spacecraft so that when we get to Pluto we can learn about Pluto and not worry about the spacecraft. Wise words, I will agree, but we are all hoping for some fun science at Jupiter too. We have to remember that New Horizons is tiny compared to Cassini (a piano instead of a school bus), and the instruments are optimized for observing faint, miniscule Pluto out beyond 30 AU, rather than bright, giant Jupiter at 5.2 AU. But with some ingenuity, there should be some excellent images of Jupiter's clouds, the rings, and the large Galilean moons.

New Horizons is carrying several instruments and two cameras: The long-range, telephoto Long Range Reconnaissance Orbiter (LORRI) takes high-resolution images, while Ralph takes images at multiple wavelengths to determine compositions of surface materials. Alice is an ultraviolet spectrometer that is designed to detect Pluto's tenuous atmosphere via stellar occultation. At Jupiter, Alice will sometimes look at ultraviolet emissions from hot gases (e.g., Jupiter's aurora), and at other times will look back at the Sun through atmospheric gases to determine composition, pressure, and temperature of upper regions of Jupiter's atmosphere as well as the tenuous atmospheres of the satellites. The particle detectors, Solar Wind Around Pluto (SWAP) (low energy) and Pluto Energetic Particle Spectrometer Science Investigation (PEPSSI) (high energy), will monitor the solar wind upstream as New Horizons approaches Jupiter and will then measure the charged particles trapped in Jupiter's strong magnetic field.

On approach to Jupiter, New Horizons has been and will be taking pictures of the planet's dynamic weather patterns, focusing on turbulence around the Great Red Spot and its new little brother, the Little Red Spot or Red Spot Jr., which amateur astronomer Christopher Go noticed was changing color from white to red a couple of years ago. Not only will New Horizons be watching how Jupiter's cloud systems are changing, but there is a worldwide observing campaign using telescopes at Earth, from very small to very large, as well as Hubble.



*The New Horizons spacecraft is on approach to Jupiter, and will use the giant planet's gravity to increase speed and reduce the time to Pluto. Also visible here are two of Jupiter's large moons, with one casting a long shadow on the turbulent cloud decks.*



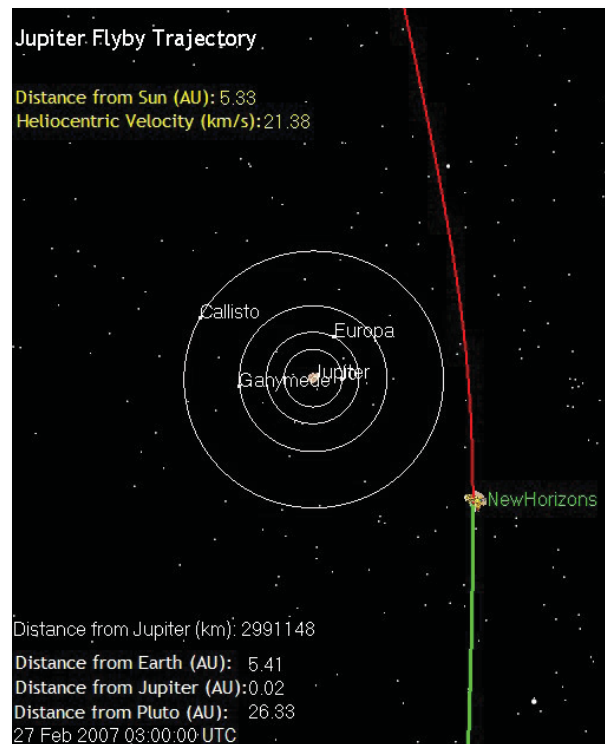
*Although almost a month out from Jupiter, the New Horizons spacecraft has already provided some surprises, as shown in this global map of Jupiter. The turbulent cloud mass usually situated to the west of the Great Red Spot is missing!*

For the two weeks around closest approach there is an intense program of observations scheduled: What havoc have Io's prodigious volcanos wreaked on the satellite's surface since the Galileo observational era

ended six years ago? Can we spot small satellites embedded in the ring? How much oxygen is sputtered off the surfaces of the icy moons to make their thin atmospheres? What's the composition of the dark material on Europa — is it erupting from the ocean below? Can we figure out what those strange “crop circles” (global-scale semicircular troughs) are doing on Europa?

Stern welcomes the involvement of the public in the mission and has harnessed the enthusiasm spread by the Internet to allow amateur astronomers to pick what they think will be opportunities to take particularly scenic pictures of the jovian system. These “Kodak moments” will be immediately released for public appreciation as soon as they are received on Earth.

*New Horizons will come very close to Callisto's orbit. Sadly, neither Ganymede nor Callisto will be on the same side of Jupiter on that day, but good views will be had of all four satellites.*



New Horizons will be closest to Jupiter on February 28, passing outside the orbit of Callisto at 32  $R_J$  (2.3 million kilometers) from the planet. The spacecraft takes a unique trajectory down the long, long tail of Jupiter's vast magnetosphere, where New Horizons' two particle detectors will ascertain whether the 2 tons per second of sulfur and oxygen ions spewed out from Io are expelled from the system in occasional big eruptive bubbles or form a steady drizzle. The whole flyby will extend from late January (when the energetic particle detector first started “sniffing” sulfur from Io) through perhaps as late as June, when the spacecraft finally exits the magnetotail and reenters the solar wind, possibly as far as 1 AU downstream.

The busy pace of encounter week means that the spacecraft will spend much of its time looking at Jupiter and not so much talking to Earth. The plan is to return several high-priority observations to Earth as quickly as possible. Most of the remainder of New Horizons' valuable data will be returned to Earth by the end of May.

Then the spacecraft goes into hibernation, waking up once a year for a series of tests, for the long journey to Pluto. While most of the spacecraft sleeps, the Student Dust Counter (SDC) will continue to count dust particles. Built by students at the University of Colorado, the SDC was recently renamed after Venetia Burney, in honor of the young girl who named Pluto in 1930. Collisions between various objects (asteroids, moons, Kuiper belt objects, etc.) constantly generate dust particles that are slowly swept out of the solar system by radiation pressure from the Sun. Instruments onboard the Pioneer spacecraft measured the distribution of dust out to ~18 AU, but we do not know if more dust is generated in the outer solar system, or whether the flux peters out.

New Horizons arrives at Pluto, its primary destination, in July 2015. Who knows; maybe the IAU will have changed its mind by then and redeclared that Pluto is a planet! Planet or not, Pluto remains one of the most fascinating and important bodies in the outer solar system.

For more information about the New Horizons mission, visit the website at [pluto.jhuapl.edu/](http://pluto.jhuapl.edu/). The latest observations can be found at [pluto.jhuapl.edu/soc/](http://pluto.jhuapl.edu/soc/).



## **RADAR LOVE: ASTEROID DETECTION AND SCIENCE WITH THE ARECIBO ANTENNA**

They are the celestial equivalent of sonograms. But their hazy outlines and ghostly features do not document the *in vivo* development of a future taxpayer. Instead, they chronicle the exoplanetary comings-and-goings of some of Earth's least known, most nomadic, and at times most impactful neighbors.

They are radar echoes that are bounced off of asteroids. Scientists from NASA's Jet Propulsion Laboratory (JPL) and around the world rely on their ethereal images to tell some out-of-this-world tales of near-Earth objects.

"The standard groundbased tools for asteroid science require a night's sky, and what you come away with in the end is an image of a dot," said JPL radar astronomer Dr. Steve Ostro. "With radar astronomy, the sky at high noon is just as inviting as that at midnight, and without launching a full-blown space mission we can actually get valuable information about the physical makeup of these objects."

In some respects, radar astronomy utilizes the same technology as your microwave oven. But do not bother to haul your glorified croissant warmer outside — it will just confuse the neighbors. Radar astronomy employs the world's most massive dish-shaped antennas, which beam directed microwave signals at their targets: as close as our Moon and as far away as the moons of Saturn. These pulses bounce off the target, and the resulting "echo" is collected and precisely collated. The results can be astounding.

"The closer the target, the better the echo," said Ostro. "From them we can generate detailed three-dimensional models of the object, define its rotation precisely and get a good idea of its internal density distribution. You can even make out surface features. A good echo can give us a spatial resolution finer than 10 meters."

Radar astronomy has detected echoes from over 190 near-Earth asteroids to date and has found that, like snowflakes, no two are the same. The returning echoes have revealed both stony and metallic objects, some flying through the cold, dark reaches of space alone, while others have their own satellites. The data indicate that some asteroids have a very smooth surface, while others have very coarse terrain. And finally, their shapes are virtually anything that can be imagined.

One thing that does not have to be imagined is radar astronomy's ability to nail down the location of an object in time and space. This invaluable capability came in handy in the winter of 2004 when JPL's Near-Earth Object office was looking for a potentially hazardous asteroid called Apophis.



*Radar observation of asteroid 1999 JM8 taken on August 3, 1999, with the Arecibo radar. The image reveals an asymmetric, irregularly shaped object.*

Discovered by astronomers using optical telescopes, Apophis quickly drew the interest of the near-Earth object monitoring community when its initial orbital plots indicated there was a possibility the 1300-foot-wide chunk of space rock could impact Earth in 2029. The Near-Earth Object office knew what was needed was more detailed information about Apophis' location, which they could then use to plot a more accurate orbit.

Under the watchful eye of Ostro and three other radar astronomers, microwaves from the Arecibo Observatory in Puerto Rico reached out and touched asteroid Apophis on January 27, 29, and 30, 2005. The Arecibo data significantly improved the asteroid's orbital estimate, ruling out a potential Earth collision in 2029.

The 1000-foot-diameter Arecibo telescope is one of only two places in the world where radar astronomy is effectively performed. The other is at the 70-meter Goldstone antenna in California's Mojave Desert. The two instruments are complementary. The Arecibo radar is not fully steerable (while Goldstone is), but it is 30 times more sensitive. Together they make a formidable asteroid reconnaissance team.



*The Arecibo Observatory in Puerto Rico is part of the National Astronomy and Ionosphere Center (NAIC), a national research center operated by Cornell University under a cooperative agreement with the National Science Foundation (NSF). Image courtesy of the NAIC/Arecibo Observatory/NSF.*

The future of radar astronomy may be just as amazing as some of the images and shape models of nearby space objects that its practitioners have already obtained. There is new technology in the pipeline that will allow imaging of surface

features with up to four times more detail than exists today. And there are proposals on the table for a potential space mission to a near-Earth asteroid. Candidate asteroids for said mission will need to be preapproved via detailed scientific analysis — the kind of scientific analysis you can only get with radar astronomy.

For more information, visit the Arecibo website at [www.naic.edu/index.htm](http://www.naic.edu/index.htm).

### **SPACECRAFT SET TO REACH MILESTONE, REPORTS TECHNICAL GLITCHES**

NASA's Mars Reconnaissance Orbiter (MRO) spacecraft this month is set to surpass the record for the most science data returned by any Mars spacecraft. While the mission continues to produce data at record levels, engineers are examining why two instruments are intermittently not performing entirely as planned. All other spacecraft instruments are operating normally and continue to return science data. Since beginning its primary science phase in November 2006, the orbiter has returned enough data to fill nearly 1000 CD-ROMs. This ties the record for Mars data sent back between 1997 and 2006 by NASA's Mars Global Surveyor mission.



*This MRO image of the martian surface shows the possible effects of ancient underground fluids.*

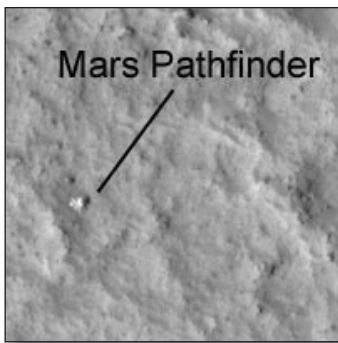
In late November 2006, the spacecraft team operating the High Resolution Imaging Science Experiment camera on MRO noticed a significant increase in noise, such as bad pixels, in one of its 14 camera detector pairs. Another detector that developed the same problem soon after launch has worsened. Images from the spacecraft camera last month revealed the first signs of this problem in five other detectors. While the current impact on image quality is small, there is concern as to whether the problem will continue to worsen.

Inflight data show that more warming of the camera's electronics before taking an image reduces or eliminates the problem. The imaging team aims to understand the root cause of the worsening over time and to determine the best operational procedures to maximize the long-term science benefits. The camera continues to make observations and is returning excellent images of the martian surface.

The second instrument concern onboard the MRO is related to an instrument designed to routinely scan from the surface across the atmosphere above Mars' horizon. The Mars Climate Sounder maps the temperature, ice clouds, and dust distributions in the atmosphere on each of nearly 13 orbits every day. In late December, the sounder appeared to skip steps occasionally, so that its field of view was slightly out of position. Following uplink of new scan tables to the instrument, the position errors stopped and the instrument operated nominally. In mid-January, the position errors reappeared. Although still intermittent, the errors became more frequent, so the instrument has been temporarily stowed while the science team investigates the problem.

The rate of data return is expected to increase over the coming months as the relative motions of Earth and Mars in their orbits around the Sun shrink the distance between the planets. By the conclusion of its first science phase in 2008, the mission is expected to have returned more than 30 terabits of science data, enough to fill more than 5000 CD-ROMs. Observations will be used to evaluate potential landing sites for future missions and to increase our understanding of Mars and how planets change over time. Additional information about the MRO is available at [www.nasa.gov/mro](http://www.nasa.gov/mro).

### **MARS RECONNAISSANCE ORBITER SEES DETAILS OF 1997 MARS PATHFINDER SITE**



*The Pathfinder lander on the surface of Mars, as viewed by the Mars Reconnaissance Orbiter.*

The high-resolution camera on the Mars Reconnaissance Orbiter has imaged the 1997 landing site of NASA's Mars Pathfinder, revealing new details of hardware on the surface and the geology of the region.

The Pathfinder mission's small rover, Sojourner, appears to have moved closer to the stationary lander after the final data transmission from the lander, based on tentative identification of the rover in the image. Pathfinder landed on July 4, 1997, and transmitted data for 12 weeks. Unlike the two larger rovers currently active on Mars, Spirit and Opportunity, Sojourner could communicate only with the lander, not directly with Earth.

The lander's ramps, science deck, and portions of the airbags can be discerned in the new image. The parachute and backshell used in the spacecraft's descent lie to the south, behind a hill from the viewpoint of the lander. Four bright features may be portions of the heat shield.

## **GEOLOGISTS FINDING A DIFFERENT MARS UNDERNEATH**

Mars is showing scientists its older, craggier face buried beneath the surface, thanks to a pioneering sounding radar co-sponsored by NASA onboard the European Space Agency's Mars Express orbiter.

Observations by the first project to explore a planet by sounding radar strongly suggest that ancient impact craters lie buried beneath the smooth, low plains of Mars' northern hemisphere. The technique uses echoes of waves that have penetrated below the surface.

"It's almost like having X-ray vision," said Dr. Thomas R. Watters of the National Air and Space Museum's Center for Earth and Planetary Studies in Washington, DC. "Besides finding previously unknown impact basins, we've also confirmed that some of the subtle topographic depressions mapped previously in the lowlands are related to impact features."

The researchers used the orbiter's Mars Advanced Radar for Subsurface and Ionospheric Sounding (MARSIS), which was provided to the European Mars mission by NASA and the Italian Space Agency. The instrument transmits radio waves that pass through the martian surface and bounce off features in the subsurface with electrical properties that contrast with those of materials that buried them.

The findings bring planetary scientists closer to understanding one of the most enduring mysteries about the geologic evolution of the planet. In contrast to Earth, Mars shows a striking difference between its northern and southern hemispheres. Almost the entire southern hemisphere has rough, heavily cratered highlands, while most of the northern hemisphere is smoother and lower in elevation. For more information about MARSIS, visit [www.marsis.com](http://www.marsis.com).

## **NASA SPACECRAFT READ LAYERED CLUES TO CHANGES ON MARS**

Layers on Mars are yielding history lessons thanks to instruments flying overhead and rolling across the surface. Some of the first radar and imaging results from the Mars Reconnaissance Orbiter (MRO) show details in layers of ice-rich deposits near the poles. Observed variations in the layers' thickness and composition will yield information about recent climate cycles on the Red Planet.

NASA's Mars Exploration Rover Opportunity has photographed patterns in the layering of crater-wall cliffs that are the clearest evidence of ancient sand dunes the rover has seen since arriving at Mars nearly three years ago. The science team for Opportunity's twin, Spirit, is using new orbital images of the rover's surroundings to interpret how some rocks with minerals altered by water fit into the area's complex layered structure.

"The combination of instruments on Mars Reconnaissance Orbiter is such a great advantage," said Dr. Jack Mustard of Brown University in Providence, Rhode Island. Mustard is deputy principal investigator for the Compact Reconnaissance Imaging Spectrometer for Mars, a mineral-identifying instrument on MRO. Researchers are using mineral information from analyses of spectrometer observations, combined with images from the orbiter's High Resolution Imaging Science Experiment, to seek the source of the mineral gypsum in dunes near the martian north pole and clay minerals elsewhere. Gypsum and clay minerals are indicators of formerly wet conditions.

Other new images from that camera show mysterious pitting in the layered terrain near the north pole. Nearby, a steep slope exposing the layers appears to be shedding blocks of icy material that disappear instead of accumulating at the bottom of the slope. "Observations of the polar layered deposits are telling us about the material properties there," said Dr. Ken Herkenhoff of the U.S. Geological Survey in Flagstaff, Arizona. "These deposits record relatively recent climate variations on Mars, like recent ice ages on Earth."

The Shallow Subsurface Radar instrument on MRO has begun probing through similar layered deposits at Mars' south pole. "The radar is penetrating through the entire thickness of these deposits and revealing the fine-scale internal layering," said Dr. Roger Phillips of Washington University in St. Louis, Missouri, the deputy team leader for that instrument.



*This false-color subframe of an image from the High Resolution Imaging Science Experiment camera on MRO shows the north polar layered deposits at top and darker materials at bottom, exposed in a scarp at the head of Chasma Boreale, a large canyon eroded into the layered deposits.*



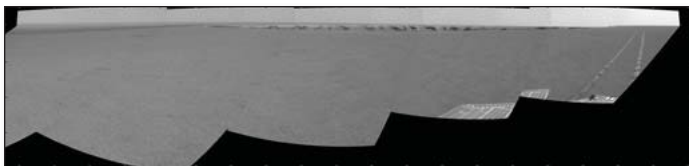
## **NASA MARS TEAM TEACHES OLD ROVERS NEW TRICKS TO KICK OFF YEAR FOUR**

NASA's twin Mars rovers, nearing the third anniversary of their landings, are getting smarter as they get older. The unexpected longevity of Spirit and Opportunity is giving the space agency a chance to field-test on Mars some new capabilities useful both to these missions and future rovers. Spirit began its fourth year on Mars on January 3, Opportunity on January 24. In addition to their continuing scientific observations, they are now testing four new skills included in revised flight software uploaded to their onboard computers.

One of the new capabilities enables spacecraft to examine images and recognize certain types of features. It is based on software developed for NASA's Space Technology 6 "thinking spacecraft." Spirit has photographed dozens of dusty whirlwinds in action, and both rovers have photographed clouds. Until now, however, scientists on Earth have had to sift through many transmitted images from Mars to find those few. With the new intelligence boost, the rovers can recognize dust devils or clouds and select only the relevant parts of those images to send back to Earth. This increased efficiency will free up more communication time for additional scientific investigations. To recognize dust devils, the new software looks for changes from one image to the next, taken a few seconds apart, of the same field of view. To find clouds, it looks for nonuniform features in the portion of an image it recognizes as the sky.

Another new feature, called "visual target tracking," enables a rover to keep recognizing a designated landscape feature as the rover moves. Khaled Ali of NASA's Jet Propulsion Laboratory (JPL), flight software team leader for Spirit and Opportunity, said, "The rover keeps updating its template of what the feature looks like. It may be a rock that looks bigger as the rover approaches it, or maybe the shape looks different from a different angle, but the rover still knows it's the same rock."

Visual target tracking can be combined with a third new feature: autonomy in calculating where it is safe to reach out with the contact tools on the rover's robotic arm. The combination gives Spirit and Opportunity a capability called "go and touch," which is yet to be tested on Mars. So far in the mission, whenever a rover has driven to a new location, the crew on Earth has had to evaluate images of the new location to decide where the rover could place its contact instruments on a subsequent day. After the new software has been tested and validated, the crew will have the option of letting a rover choose an arm target for itself the same day it drives to a new location.



*Opportunity extended its cumulative martian driving record to more than 10 kilometers (6.2 miles) by crossing 50.51 meters (165.7 feet) of flat ground during the 1080th martian day since arriving on Mars. This view, a mosaic of frames taken by Opportunity's navigation camera, shows the surroundings at the completion of the day's drive.*

The new software also improves the autonomy of each rover for navigating away from hazards by building better maps of their surroundings than they have done previously. This new capability was developed by Carnegie Mellon University in Pittsburgh and JPL.

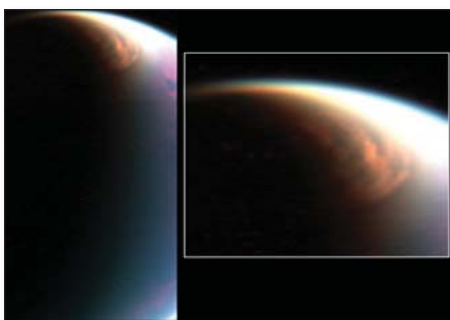
## **CASSINI IMAGES MAMMOTH CLOUD ENGULFING TITAN'S NORTH POLE**

A giant cloud half the size of the United States has been imaged on Saturn's moon Titan by the Cassini spacecraft. The cloud may be responsible for the material that fills the lakes discovered last year by Cassini's radar instrument. Cloaked by winter's shadow, this cloud has now come into view as winter turns to spring. The cloud extends down to 60°N latitude, is roughly 2400 kilometers (1490 miles) in diameter, and engulfs almost the entire north pole of Titan.

The new image was acquired on December 29, 2006, by Cassini's visual and infrared mapping spectrometer. Scientific models predicted this cloud system, but it had never been imaged in such detail before. "We knew this cloud had to be there but were amazed at its size and structure," said Dr. Christophe Sotin of the University of Nantes, France, a member of the visual and infrared mapping spectrometer team and distinguished visiting scientist at NASA's Jet Propulsion Laboratory. "This cloud system may be a key element in the global formation of organics and their interaction with the surface."

The Cassini radar team reported last year that the lakes at the north pole are partly filled, and some appear to have evaporated, likely contributing to this cloud formation, which is made up of ethane, methane, and other organics. These findings reinforce the idea that methane rains down onto the surface to form lakes and then evaporates to form clouds. Scientists compare this methane cycle to the hydrological cycle on Earth, dubbing it "methane-ologic cycle."

Groundbased observations show this Titan cloud system comes and goes with the seasons. A season on Titan lasts approximately seven Earth years. Based on the global circulation models, it seems that such cloud activity can last about



*Cassini's visual and infrared mapping spectrometer has imaged a huge cloud system covering the north pole of Titan. This composite image shows the cloud, imaged at a distance of 90,000 kilometers (54,000 miles) during a flyby designed to observe the limb of the moon.*

25 Earth years before almost vanishing for four to five years, and then appearing again for 25 years.

“With 16 more flybys to come this year, we should have the opportunity to monitor the evolution of this cloud system over time,” said Dr. Stephane Le Mouelic, working with the Cassini visual and infrared mapping spectrometer team, also at the University of Nantes.

The Cassini-Huygens mission is a cooperative project of NASA, the European Space Agency and the Italian Space Agency. For more information, visit the Cassini website at [saturn.jpl.nasa.gov](http://saturn.jpl.nasa.gov).

## **NASA SELECTS PROPOSALS FOR FUTURE MARS MISSIONS AND STUDIES**

NASA has selected for concept study development two proposals for future robotic missions to Mars. These missions would increase understanding of Mars' atmosphere, climate, and potential habitability in greater detail than ever before. In addition, NASA also will fund a U.S. scientist to participate in a proposed European Mars mission as well as fund instrument technology studies that could lead to further contributions to future Mars missions.

Each Mars mission proposal will receive initial funding of approximately \$2 million to conduct a nine-month implementation feasibility study. Following these detailed mission concept studies, NASA intends to select one of the two proposals by late 2007 for full development as a Mars Scout mission. The mission developed for flight would have a launch opportunity in 2011 and cost no more than \$475 million.

The selected Mars mission proposals are:

*Mars Atmosphere and Volatile Evolution mission (MAVEN):* This mission would provide first-of-its-kind measurements and address key questions about Mars climate and habitability and improve understanding of dynamic processes in the upper martian atmosphere and ionosphere. The principal investigator is Bruce Jakosky, University of Colorado, Boulder. NASA's Goddard Space Flight Center in Greenbelt, Maryland, will provide project management.

*The Great Escape mission:* This mission would directly determine the basic processes in martian atmospheric evolution by measuring the structure and dynamics of the upper atmosphere. In addition, potentially biogenic atmospheric constituents such as methane would be measured. The principal investigator is Alan Stern, Southwest Research Institute, Boulder, Colorado. Southwest Research Institute, San Antonio, will provide project management.

## **MOON-IMPACTOR MISSION PASSES MAJOR REVIEW**

NASA's drive to return astronauts to the Moon and later probe deeper into space achieved a key milestone recently when agency officials approved critical elements of a Moon impact mission scheduled to launch in October 2008. NASA's unmanned Lunar Crater Observation and Sensing Satellite (LCROSS) will strike the Moon near its south pole in January 2009. It will search for water and other materials that astronauts could use at a future lunar outpost. Scott Horowitz, Associate Administrator of the agency's Exploration Systems Mission Directorate, led a confirmation review panel that recently approved the detailed plans, instrument suite, budget, and risk factor analysis for the satellite.

NASA Ames Research Center in Moffett Field, California, manages the mission, which is valued at \$79 million, excluding launch costs. The mission will help NASA gain a new foothold on the Moon and prepare for new journeys to Mars and beyond.

The confirmation review authorized continuation of the lunar impactor project and set its cost and schedule. Another mission milestone, the critical design review, is scheduled for late February. That review will examine the detailed LCROSS system design. After a successful critical design review, the project team will assemble the spacecraft and its instruments.



*Artist's rendition of the LCROSS spacecraft above the Moon's surface.*



The lunar impactor will share a rocket ride into space with a second satellite, the Lunar Reconnaissance Orbiter. After the orbiter separates from the Atlas V launch vehicle for its own mission, LCROSS will use the spent Centaur upper stage of the rocket as a 4400-pound lunar impactor, targeting a permanently shadowed crater near the lunar south pole. For more information, visit [lcross.arc.nasa.gov](http://lcross.arc.nasa.gov).

### ***RADAR SUBSURFACE IMAGING LEADS TO DISCOVERY OF RARE METEORITE***

The recent discovery of a 70-kilogram (154-pound) pallasite in a wheat field just east of Greensburg, Kansas, in the Brenham strewn field, was the result of a collaborative effort between the Houston Museum of Natural Science (HMNS), the Lunar and Planetary Institute (LPI), the Rice Space Institute, and the Brenham Meteorite Company. The goal of the team was to develop new methods for finding and archiving meteorites. The team was led by Dr. Carolyn Sumners, senior director of the Astronomy Department at HMNS.

Pallasites are iron-rich meteorites and are very rare, comprising less than 1% of the world's found meteorite collection. What made this discovery particularly important was the method used to find and image the buried meteorite. LPI scientist Dr. Essam Heggy, who was responsible for the radar survey, developed an innovative algorithm that combined the use of multiple-frequency ground-penetrating radar (GPR) with three-dimensional polarimetric imaging to more narrowly focus the search, which allowed more accurate and faster reconnaissance of the object and allowed the team to obtain a record of the meteorite in the subsurface before it was extracted from the soil. This approach allows scientists to maximize the data collected during meteorite recovery, which is of critical importance when trying to model the fall that generated the strewn field.



*Dr. Essam Heggy (right) compares an image of a meteorite on his ground-penetrating radar with the actual meteorite while HMNS workers Andy Smith, left, and Chris Flis look on. Image courtesy of Associated Press/Charlie Riedel.*

### ***NASA SCIENTISTS FIND PRIMORDIAL ORGANIC MATTER IN TAGISH LAKE METEORITE***

NASA researchers at Johnson Space Center in Houston have found organic materials that formed in the most distant reaches of the early solar system preserved in a unique meteorite. The study was performed on the Tagish Lake carbonaceous chondrite, a rare type of meteorite that is rich in organic (carbon-bearing) compounds.

Organic matter in meteorites is a subject of intense interest because this material formed at the dawn of the solar system and may have seeded the early Earth with the building blocks of life. The Tagish Lake meteorite is especially valuable for this work because much of it was collected immediately after its fall over Canada in 2000 and has been maintained in a frozen state, minimizing terrestrial contamination. The collection and curation of the meteorite samples preserved its pristine state.

In a paper published in the December 1 issue of the journal *Science*, the team, headed by NASA space scientist Keiko Nakamura-Messenger, reports that the Tagish Lake meteorite contains numerous submicrometer hollow organic globules.

“Similar objects have been reported from several meteorites since the sixties. Some scientists believed these were space organisms, but others thought they were just terrestrial contamination,” said Nakamura-Messenger. The same bubble-like organic globules appeared in this freshest meteorite ever received from space. “But in the past, there was no way to determine for sure where these organic globules came from because they were simply too small. They are only 1/10,000 inch in size or less.”

The organic globules in the Tagish Lake meteorites were found to have very unusual hydrogen and nitrogen isotopic compositions, proving that the globules did not come from Earth. “The isotopic ratios in these globules show that they formed at temperatures of about  $-260^{\circ}\text{C}$ , near absolute zero,” said Scott Messenger, NASA space scientist and co-author of the paper. “The organic globules most likely originated in the cold molecular cloud that gave birth to our solar system, or at the outermost reaches of the early solar system.”



*The Tagish Lake carbonaceous chondrite. Image courtesy of the University of Calgary.*

## **PLANETARY SCIENTIST DR. ALAN STERN SELECTED TO LEAD MISSION DIRECTORATE**

NASA Administrator Michael Griffin recently announced that Dr. S. Alan Stern will be the agency's associate administrator for the Science Mission Directorate, effective April 2. Stern succeeds Dr. Mary L. Cleave, who recently announced her retirement. Stern joins NASA from the Southwest Research Institute in Boulder, Colorado, where he has been serving as Executive Director of the Space Science and Engineering Division.

As chief executive of NASA's Science Mission Directorate, Stern will direct a wide variety of research and scientific exploration programs for Earth studies, space weather, the solar system, and the universe beyond. In addition, he will manage a broad spectrum of grant-based research programs and spacecraft projects to study Earth and the universe.

Stern is a planetary scientist and an author who has published more than 175 technical papers and 40 popular articles. His research has focused on studies of our solar system's Kuiper belt and Oort cloud, comets, satellites of the outer planets, Pluto, and the search for evidence of solar systems around other stars. He has worked on spacecraft rendezvous theory, terrestrial polar mesospheric clouds, galactic astrophysics, and studies of tenuous satellite atmospheres, including the atmosphere of the Moon.

Stern has a long association with NASA, serving on the NASA Advisory Council and as the principal investigator on a number of planetary and lunar missions, including the New Horizons Pluto-Kuiper belt mission (see related story on page 2). He was the principal investigator of the Southwest Ultraviolet Imaging System, which flew on two space shuttle missions, STS-85 in 1997 and STS-93 in 1999.

Stern has also been a guest observer on numerous NASA satellite observatories, including the International Ultraviolet Explorer, the Hubble Space Telescope, the International Infrared Observer, and the Extreme Ultraviolet Observer. He holds bachelor's degrees in physics and astronomy and master's degrees in aerospace engineering and planetary atmospheres from the University of Texas, Austin. In 1989, Stern earned a doctorate in astrophysics and planetary science from the University of Colorado at Boulder.

For more information about NASA and its science programs, visit [science.hq.nasa.gov](http://science.hq.nasa.gov).

## **NASA ANNOUNCES JIM GREEN AS DIRECTOR, PLANETARY SCIENCE DIVISION**

During the sciences portion of the NASA Budget Briefing held in early February in Washington, DC, NASA announced the formal appointment of Dr. James Green to the position of Director, Planetary Science Division. Green has served as Acting Director since the departure of Andrew Dantzler in June 2006.

For more information about Green, see the interview published in the November 2006 issue of the *Bulletin*.

The community will have an opportunity to interact with Green at the upcoming Lunar and Planetary Science Conference. Green plans to be in attendance throughout the entire week, and will speak at the Monday evening NASA Headquarters Briefing.



*Dr. Alan Stern*



*Dr. James Green*

*“Spotlight on Education” highlights events and programs that provide opportunities for space 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 South Central Organization of Researchers and Educators at [score@lpi.usra.edu](mailto:score@lpi.usra.edu).*

### **2007 LPSC E/PO CONFERENCE — ENGAGING MULTICULTURAL AUDIENCES IN PLANETARY SCIENCE**

The Education/Public Outreach pre-Lunar and Planetary Science Conference workshop will take place on Sunday, March 11, from 8:30 a.m. to 3:00 p.m. in the Lecture Hall at the Lunar and Planetary Institute. This year's workshop is intended to initiate a conversation about how planetary scientists and educators can make the solar system accessible to our increasingly multicultural audiences. The unprecedented number of missions exploring our solar system, and the reinvigorated interest in the Moon and Mars, offer the opportunity to actively engage students of all ages from traditionally underserved cultures in exploration. Join the workshop to discuss the diverse needs of diverse audiences and learn strategies to engage multicultural audiences in scientific investigation and discovery.

The workshop is free, but participants must register online at [www.lpi.usra.edu/meetings/lpsc2007/lpsc2007.educ.cfm](http://www.lpi.usra.edu/meetings/lpsc2007/lpsc2007.educ.cfm). A limited number of travel grants are available; support must be requested by **February 9**. For more information about the workshop or travel grants, please contact Christine Shupla ([shupla@lpi.usra.edu](mailto:shupla@lpi.usra.edu); 281-486-2135).



### **LPI 2007 EDUCATOR FIELD EXPERIENCE — EARTH'S EXTREMOPHILES: IMPLICATIONS FOR LIFE IN THE SOLAR SYSTEM**

Middle-school science educators — and other science teachers — are invited to join planetary scientists on this week-long NASA-sponsored field-based workshop from July 22–29, 2007.

Participants will spend a week with planetary scientists and astrobiologists in Yellowstone National Park, investigating the geologic processes that result in extreme environmental conditions and the environments themselves. We will explore the different types of organisms that live in these conditions, the adaptations that allow them to survive and thrive, and how we might detect the organisms and their environments from Earth or from spacecraft. We will build an understanding of how life has evolved on Earth, the possibility of past or present similar environmental conditions on other planets, and what this implies for finding life in our solar system. The experience will be divided between the field and lab, where attendees will work with classroom-tested, hands-on inquiry-based activities and resources that can be used to enhance Earth, life, and space science teaching in the classroom. Participants receive lesson plans, supporting resources, and presentations.

Applications are due no later than **April 4, 2007**. A limited number of grants are available to cover registration. Please encourage educators to apply for this enriching experience! For more information, and to access the application, please visit [www.lpi.usra.edu/education/fieldtrips/2007/](http://www.lpi.usra.edu/education/fieldtrips/2007/).



*2007 offers an unprecedented number of opportunities for scientists to become involved with local educators and educational institutions! Space Day, Sun-Earth Day, Earth Science Week, the International Polar Year, the International Heliospherical Year — all provide direct connections between the planetary science community and classrooms, science centers, and museums. Each science event involves an education and*



public outreach initiative, and each offers supporting resources. Share these with local educators and take advantage of a meaningful opportunity to become involved.

## **INTERNATIONAL POLAR YEAR —**

NASA's Science Mission Directorate's participation in the International Polar Year (IPY), designated from March 2007 to March 2009, will provide new insights into the polar regions of Earth, the Moon, and Mars. Numerous education and public outreach projects are planned to complement research and exploration activities. Educator resources include:

### ***The International Polar Year Web Site***

[www.ipy.org/index.php?/ipy/audience/C27/](http://www.ipy.org/index.php?/ipy/audience/C27/)

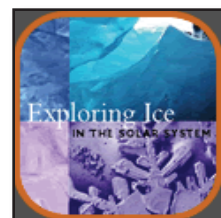
Educators can access numerous articles, brochures, posters, links to classroom activities, blogs, and additional resources, as well as world-wide educational events and traveling exhibits associated with the IPY.



### ***Exploring Ice in the Solar System***

[btc.montana.edu/messenger/teachers/MEMS\\_CompPlanetology.php](http://btc.montana.edu/messenger/teachers/MEMS_CompPlanetology.php)

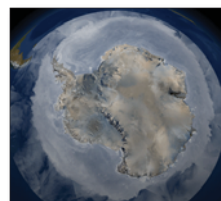
A plethora of inquiry-based activities support explorers in grades pre-K through 5 as they investigate the physical processes and properties of ice, and extend their exploration to Earth's icy regions and beyond, to ice elsewhere in the solar system.



### ***Tour of the Cryosphere***

[www.nasa.gov/vision/earth/environment/cryosphere.html](http://www.nasa.gov/vision/earth/environment/cryosphere.html)

Visitors explore Earth's icy polar realms in this animation, commencing in Antarctica and continuing to polar sea ice and onward to the North Pole. They gain a sense of both the natural annual changes in ice, and the increasing loss of ice globally in association with rising temperatures. The movie underscores the role of the cryosphere within the Earth system.



### ***Polar Palooza***

[passporttoknowledge.com/polar-palooza/](http://passporttoknowledge.com/polar-palooza/)

Living and working in Earth's extreme polar environments will come alive through several live presentations, broadcasts, and podcasts. *Stories from a Changing Planet* encompasses live presentations, throughout IPY, by leading polar researchers and Arctic residents at science centers, museums, libraries, and schools across North America. In addition, video clips and podcasts from the poles will be archived at the website with other classroom resources.



### ***IPY Symposia***

[institute.nsta.org/symposia.asp](http://institute.nsta.org/symposia.asp)

The National Science Teachers Association, in collaboration with NASA, will offer several half- to full-day professional development opportunities for educators at the National Conference on Science Education in St. Louis, Missouri, on March 29–April 1, 2007. Topics include *Impact of Polar Climate Change on Living Systems*; *Polar Climates, How Are They Changing?*; and *The Fragile Ice*. To further support content understanding, each symposium is followed by several online web seminars featuring NASA and NOAA scientists and education experts.

## **SUN-EARTH DAY —**

Sun-Earth Day 2007 aligns with the International Heliophysical Year (IHY). IHY builds on the International Geophysical Year and extends the Earth-focused studies into the heliosphere, incorporating the drivers of geophysical change into the global system. This year, Sun-Earth Day will celebrate "Living in the Atmosphere of the Sun." Educational materials will



help to build an understanding of the relevance and significance of the Sun's relationship to Earth and the solar system. Students can monitor the progress of a solar storm, assess the current space weather conditions, and share the results with peers around the world. Resources, including suggestions for how scientists can get involved, can be found at [sunearthday.nasa.gov/2007/](http://sunearthday.nasa.gov/2007/).

### **SPACE DAY —**

On May 4, 2007, numerous events and activities will take place to celebrate Space Day, an educational initiative intended to inspire young people to explore careers in mathematics, science, engineering, and technology and to realize the vision of our space pioneers. Educators can involve their classes in design challenges, as well as find numerous supporting materials, lists of planned events, and classroom resources, at [www.spaceday.com](http://www.spaceday.com).



*Interested in becoming more involved in space science education and public outreach? NASA's Space Science Education and Public Outreach Support Network encompasses a nationwide network of Broker/Facilitators and Education Forums that are prepared to assist space science investigators in developing high-quality, high-impact E/PO programs. For more information about the network, or to contact the Broker/Facilitator in your region, please visit [science.hq.nasa.gov/research/ecosystem.htm](http://science.hq.nasa.gov/research/ecosystem.htm).*

### ***Solicitation for Contributions***

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

Dr. Paul Schenk,  
Scientific Editor ([schenk@lpi.usra.edu](mailto:schenk@lpi.usra.edu))  
Renée Dotson,  
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Production Editor: Renée Dotson  
Graphic Design: Leanne Woolley

The Bulletin welcomes articles dealing with issues related to planetary science and exploration. The copy deadline for the next issue is April 13, 2007. Articles or announcements should be submitted via e-mail to [lpibed@lpi.usra.edu](mailto:lpibed@lpi.usra.edu).

To be added to the list to receive notification by e-mail of future issues, please send your e-mail address to [lpibed@lpi.usra.edu](mailto:lpibed@lpi.usra.edu).

To be added to the postal mailing list to receive notification by postcard of future issues, please send your name, address, and phone number to LPIB Notifications, 3600 Bay Area Blvd., Houston TX 77058-1113, USA.

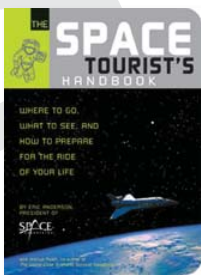
ISSN 1534-6587

## Books

**Bang! The Complete History of the Universe.** Brian May, Patrick Moore, and Chris Lintott. Carlton, 2006. 192 pp., Hardcover, \$30.00. [www.banguniverse.com](http://www.banguniverse.com)



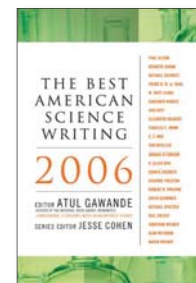
**BANG!** Space, time, matter . . . the universe was born 13.7 billion years ago. Infinitely small at first, it expanded more rapidly than anyone can contemplate. Authors Brian May (a founding member of Queen and world-renowned guitarist), Sir Patrick Moore, and Chris Lintott explain how all this came about, from that moment when time and space came into existence, to the formation of the first stars, galaxies, and planets, and to the evolution of human beings able to contemplate their own origins and ultimate destiny. Then on toward that destiny in the infinite future, long after the Earth has been consumed by the Red Giant Sun. The story is told in straightforward terms, in the strict order in which the events happened, and uses no mathematics. Is this amazing story fiction? The authors hope not, since it is based upon lifetimes of work by great scientists such as Albert Einstein, Stephen Hawking, and hundreds of other brilliant minds. **BANG!** includes original artwork by UK space artist Brian Smallwood.



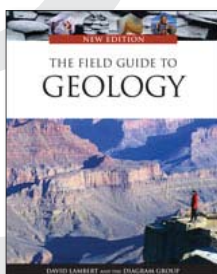
**The Space Tourist's Handbook: Where to Go, What to See, and How to Prepare for the Ride of Your Life.** Eric Anderson and Joshua Piven. Quirk Books, 2006. 192 pp., Paperback, \$15.95. [www.quirkbooks.com](http://www.quirkbooks.com)

In May 2001, billionaire Dennis Tito paid \$20 million to travel to the International Space Station and made history as the first “space tourist.” Since that landmark voyage, many others have followed in his footsteps — all courtesy of Space Adventures, the first travel agency devoted exclusively to outer space. But before you can blast off, there’s plenty to learn. In this illustrated handbook, Space Adventures CEO Eric Anderson gives would-be space tourists the exact same training program that he gives to the billionaires. There are step-by-step instructions for liftoff, sleeping in weightless environments, using the “vacuum toilet” on the spacecraft, living in zero gravity, and much more. The instructors at Space Adventures are already integrating this informative handbook into their lesson plans. With more than 25 illustrations and a special full-color section showing popular vacation “destinations,” *The Space Tourist's Handbook* is fascinating reading for amateur astronauts of all ages.

**The Best American Science Writing 2006.** Edited by Atul Gawande. Harper Perennial, 2006. 384 pp., Paperback, \$14.95. [www.harpercollins.com](http://www.harpercollins.com)



This installment of the popular annual anthology features 21 articles on a wide range of today’s most leading topics in science. Articles come from popular periodicals such as the *New Yorker*, *Harper's*, and *Discover*. Authors include Dennis Overbye, Jonathan Weiner, and Richard Preston, among others, and the full spectrum of scientific inquiry is represented, proving once again that “good science writing is evidently plentiful” (*American Scientist*).

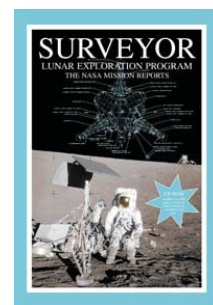


**The Field Guide to Geology, New Edition.** By David Lambert and the Diagram Group. Facts on File, Inc., 2006. 304 pp., Hardcover, \$39.95. [www.factsonfile.org](http://www.factsonfile.org)

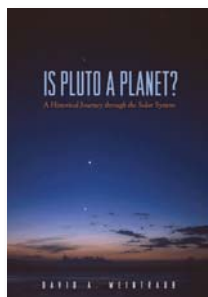
Written by a team of eminent geologists and educators, *The Field Guide to Geology, New Edition* features revised information that brings the previous edition up to date. Clear graphics and simple field-guide procedures offer readers ready access to the topic. This new edition features 200 new, two-color illustrations (more than 750 in all), updated graphs and tables, as well as two new chapters titled “Monitoring the Earth’s Changes” and “Geologists of Note.” The easy-to-follow text covers all the key rudiments of geology and is the perfect reference for students and geology lovers alike who share an interest in the great outdoors. Topics covered include air currents, composition, desertification, greenhouse effect, ice changes, seafloor profiling, seismic activity, tides, and waterflow.



**Surveyor Lunar Exploration Program: The NASA Mission Reports.** By Robert Godwin. Apogee Books, 2006. 176 pp. with CD-ROM, Paperback, \$17.95.  
[www.cgpublishing.com](http://www.cgpublishing.com)



The beginning of 1966 heralded the birth of the era of direct planetary exploration. NASA was engaged in the most ambitious scientific project in human history: to place a man on the Moon. In order to safely perform this task, some fundamental questions needed to be answered in advance of the journey. Could a spacecraft safely land on the Moon and not be swallowed up by lunar dust? Could the extreme temperatures and surface radiation disable the hardware? Were there places that were flat enough and debris-free to allow a safe landing? These and many other important questions would be answered between 1966 and 1968 by five robotic spacecraft, built by the Hughes Aircraft Corporation, and named Surveyor. This brief but critically important program consumed \$426 million of NASA's budget in just two years, but it not only proved the worthiness of new hardware, such as the hydrogen-propelled Centaur booster stage, but also that of the robust and ingenious Surveyor probes. Humankind sent explorers to six different lunar locations but the Surveyors visited five entirely different landing sites, and returned over 87,000 pictures from the lunar surface. This book contains previously unavailable documentation from this important program and is accompanied by a further 1800 pages of material on the accompanying CD-ROM.



**Is Pluto a Planet? A Historical Journey through the Solar System.** By David A. Weintraub. Princeton University Press, 2006. 272 pp., Hardcover, \$27.95.  
[press.princeton.edu](http://press.princeton.edu)

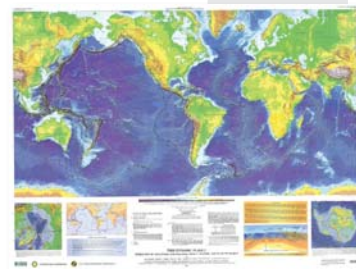
With the discovery of 2003 UB313 — an outer solar system object believed to be slightly larger than Pluto — astronomers have again been thrown into an age-old debate about what is and what is not a planet. This book tells the story of how the meaning of the word “planet” has changed from antiquity to the present day, as new objects in our solar system have been discovered. The number of possible planets has ranged widely over the centuries, from five to seventeen. This book makes sense of it all — from the ancient Greeks’ observation that some stars wander while others don’t; to Copernicus, who made

Earth a planet but rejected the Sun and the Moon; to the discoveries of comets, Uranus, Ceres, the asteroid belt, Neptune, Pluto, Centaurs, the Kuiper belt and 2003 UB313, and extrasolar planets. Weaving the history of our thinking about planets and cosmology into a single, remarkable story, this book is for all those who seek a fuller understanding of the science surrounding both Pluto and the provocative recent discoveries in our outer solar system.

## POSTERS

**This Dynamic Planet: World Map of Volcanoes, Earthquakes, Impact Craters, and Plate Tectonics Poster.** From USGS, 2006. 58.25-inch by 43.5-inch poster, \$14.00. [store.usgs.gov](http://store.usgs.gov)

This map shows Earth's physiographic features, the current movements of its major tectonic plates, and the locations of its volcanos, earthquakes, and impact craters. The use of color and shaded relief helped the reader to identify significant features of the land surface and the ocean floor. Over 1500 volcanos active during the past 10,000 years are plotted on the map in four categories. The locations (epicenters) of over 24,000 earthquakes, largely from 1960 through 1990, are plotted in three magnitude categories and in two depth ranges. This two-sided poster is intended as a teaching aid for classroom use and as a general reference for research. Additional information is on the backside.



## ONLINE RESOURCES

### **Earth Science World Image Bank.**

[www.earthscienceworld.org/images/index.html](http://www.earthscienceworld.org/images/index.html)

The *Earth Science World Image Bank* is a service provided by the American Geological Institute (AGI). The Image Bank is designed to provide quality geoscience images to the public, educators, and the geoscience community. Use the browse option, or search by category, continent, country, keyword, coordinates, or image ID. The Image Bank now has over 6000 images, making it one of the largest sources of Earth science imagery available on the web. Visit this website and start searching today!



## FOR KIDS!!!



***Stories of the Sun Book Series.*** By Clint Twist. School Specialty Publishing, 2006. 28 pp., Hardcover, \$14.95 each. [www.schoolspecialtypublishing.com](http://www.schoolspecialtypublishing.com)

*Stories of the Sun* takes the young reader through an exciting journey of the solar system. Making stops at *The Earth*, *The Moon*, *The Stars*, and *The Planets*, readers will learn interesting facts, history, myths, and legends about the solar system. Vibrant, scientifically accurate illustrations detail each celestial body. Presented on graduated pages that steadily increase, and finish with a detailed gatefold, *Stories of the Sun* is a dynamic introduction to the solar system. Each book in the series features die-cut covers, full-color illustrations, and a glossary and index. For grades 2 through 6.

***Space: Exploring the Moon, the Planets, and Beyond.*** By Olivier de Goursac. Harry N. Abrams, Inc., 2006. 78 pp., Hardcover, \$18.95. [www.hnabooks.com](http://www.hnabooks.com)

Space exploration — the final frontier — has always excited the world's imagination, especially children's. Now children can see for themselves what wonders the universe has to offer. Covering everything from the first rockets, to landing on the Moon, to new knowledge of other planets, to what a colony on Mars would look like, this book will satisfy the curiosity of young space enthusiasts and pique the interest of those learning about space exploration for the first time. Photographs from NASA coupled with artists' renderings of faraway planets beautifully illustrate the reaches of space, both near and far.



***The Planets DVD.*** Produced by Films Media Group, 2006. 31 minutes, one disc, \$89.95. [www.cambridgeol.com](http://www.cambridgeol.com)

Any study of the universe requires a solid understanding of the solar system — home sweet home and the launching pad for intergalactic exploration. This video explains how the solar system formed and offers plenty of detailed information on the inner planets, the gas giants, and mysterious Pluto. The minimum requirements for planetary life as we know it and the specifics of the Sun, asteroids, comets, and the planets' many moons are also given. This product has on-demand English subtitles and can be viewed using a DVD player or computer DVD-ROM drive. For grades 7 through 12.

***The First Moon Landing.*** By Thomas K. Adamson. Capstone Press, 2006. 32 pp., Hardcover, \$25.26. [www.capstonepress.com](http://www.capstonepress.com)

This new title in the Capstone Graphic Library series presents the drama of the first Moon landing and includes authentic astronaut-mission control conversations and detailed illustrations. Using bold, full-color graphic illustrations, this series portrays critical chapters in American history in a way that reluctant readers will find accessible. Simple, exciting text and vivid drawings work together to explain critical events that shaped the course of American history. For grades 3 and 4.



## FEBRUARY

- 5-7 First Workshop on Titan — Observations, Experiments, Computations, and Modeling, Honolulu, Hawaii.  
<http://www.chem.hawaii.edu/Bil301/Titan2007.html>
- 5-8 First GLAST Symposium, Stanford, California.  
<http://glast.gsfc.nasa.gov/science/symposium/2007/>
- 6-7 NASA Project Management Challenge 2007, Galveston, Texas. <http://pmchallenge.gsfc.nasa.gov/>
- 7-9 Third International Workshop on Remote Sensing of Vegetation Fluorescence, Florence, Italy.  
<http://www.congrex.nl/07c01/>
- 8-10 13th Annual Space Exploration Educators Conference, Houston, Texas.  
<http://spacecenter.org/TeachersSEEC.html>
- 21-23 11th Annual International ISU Symposium "Why the Moon?", Strasbourg, France.  
<http://www.isunet.edu/EN/573>
- 23-25 Twenty Years After SN1978A, What Did We Learn, What Will the Next Supernova Teach Us?, Waikoloa, Hawaii.  
<http://sn1987a-20th.physics.uci.edu/>
- 24-28 Second International Conference, Exhibition on Geo-Resources in the Middle East, Cairo, Egypt.  
<http://www.grmena.com.eg/>
- 27-Mar 1 Second Space and Society Conference: Space Options for the 21st Century, Noordwijk, The Netherlands. <http://www.congrex.nl/06a12/>
- 27-Mar 2 Workshop on Science Associated with the Lunar Exploration Architecture, Tempe, Arizona.  
<https://www.infonetic.com/tis/lea/>
- 5-9 LWS Geostorm CDAW and Conference, Melbourne, Florida.  
[http://cism.fit.edu/LWS-CDAW\\_2007\\_Schedule.html](http://cism.fit.edu/LWS-CDAW_2007_Schedule.html)
- 6-9 SOLAS Open Science Conference, Xiamin, China.  
<http://www.solas2007.confmanager.com/main.cfm?cid=457>
- 8-11 Marine Impact Craters on Earth: Field Investigation of the Wetumpka Impact Structure, Wetumpka, Alabama.  
<http://www.geosociety.org/fieldForums/07wetumpka.htm>
- 12-16 38th Lunar and Planetary Science Conference (LPSC 2007), League City, Texas.  
<http://www.lpi.usra.edu/meetings/lpsc2007/>
- 12-23 The Violent Universe — International Winter School, Les Houches, France.  
[http://www.apc.univ-paris7.fr/The\\_Violent\\_Universe/](http://www.apc.univ-paris7.fr/The_Violent_Universe/)
- 14-16 DGRL International Symposium to Moon and Beyond, Bremen, Germany. <http://www.beyondmoon.de/>
- 17 ISPRS IV/7: Extraterrestrial Mapping Workshop — Advances in Planetary Mapping 2007, Houston, Texas.  
<http://www.lpi.usra.edu/meetings/isprs2007>
- 18-20 The 3-D Sun and Inner Heliosphere: The Stereo View, Paris, France.  
<http://calys.obspm.fr/plasma/stereo/workshop1/>
- 22-23 MRO: New Details of Young and Old Mars, Pasadena, California.  
<http://www.jpl.nasa.gov/events/lectures/mar07.cfm>
- 22-24 Space Access 2007, Phoenix, Arizona.  
<http://www.space-access.org>
- 24-29 The Origins of Galaxies: Exploring Galaxy Evolution with the New Infrared Millimetre Facilities, Obergurgl, Austria. [http://www.esf.org/esf\\_genericpage.php?section=10&language=0&genericpage=2669&shortcut=1](http://www.esf.org/esf_genericpage.php?section=10&language=0&genericpage=2669&shortcut=1)
- 25-28 Space Exploration 2007, Albuquerque, New Mexico.  
<http://www.sesinstitute.org/>
- 25-30 A New Zeal for Old Galaxies 2007, Rotorua, New Zealand. <http://astronomy.swin.edu.au/nz2007/>

## MARCH

- 3-10 IEEE Aerospace Conference, Big Sky, Montana.  
<http://www.aeroconf.org/>
- 5-7 Observing Planetary Systems, Santiago, Chile.  
<http://www.sc.eso.org/santiago/science/OPSWorkshop/>
- 5-8 2007 Planetary Defense Conference, Washington, DC.  
<http://www.aero.org/conferences/planetarydefense/>
- 5-9 Second Alexander von Humboldt International Conference on the Role of Geophysics in Natural Disaster Prevention, Lima, Peru.  
<http://meetings.copernicus.org/avh2/>

## APRIL

- 1-4 Understanding Earth Systems, Long Beach, California.  
<http://www.aapg.org/longbeach/>
- 8-12 Exploring the Solar System and the Universe, Bucharest, Romania. <http://www.astro.ro/centenary/>



- 8–13 28th Annual International Gravitational Physiology Meeting, San Antonio, Texas. <http://www.isgp.org/>
- 9–12 23rd National Space Symposium, Colorado Springs, Colorado. <http://www.nationalspacesymposium.org>
- 11–14 From Stars to Planets, Gainesville, Florida. <http://conference.astro.ufl.edu/STARSTOPLANETS/>
- 12–13 Experiments in Space and Beyond, Brussels, Belgium. <http://www.ulb.ac.be/polytech/mrc/expinspace.html#>
- 12–14 The Future of Space Exploration: Solutions to Earthly Problems, Boston, Massachusetts. <http://www.bu.edu/pardee/events/conferences/2007/SPACE/MASTER/index.html>
- 13–14 14th Annual Great Moonbuggy Race, Huntsville, Alabama. <http://moonbuggy.msfc.nasa.gov/index.html>
- 15–20 European Geosciences Union General Assembly 2007, Vienna, Austria. <http://meetings.copernicus.org/egu2007/>
- 16–20 Subsurface and Atmospheric Influences on Solar Activity, Sunspot, New Mexico. <http://www.nso.edu/general/workshops/2007/>
- 22–23 Hot Topic, Cool Science: The Greenhouse Effect, Pasadena, California. <http://www.jpl.nasa.gov/events/lectures/apr07.cfm>
- 23–27 Pathways Through an Eclectic Universe, Tenerife, Spain. <http://www.iac.es/proyect/eclectic/>
- 23–28 14th Young Scientist's Conference on Astronomy and Space Physics, Kiev, Ukraine. <http://ysc.kiev.ua/>
- 24–27 Space Weather Workshop, Boulder, Colorado. <http://www.sec.noaa.gov/sww/>

## MAY

- 4–9 Greenland Space Science Symposium, Ann Arbor, Michigan. <http://www.gsss-2007.org/>
- 6–10 AAS Division of Dynamical Astronomy Annual Meeting, Ann Arbor, Michigan. <http://dda.harvard.edu/>
- 7–9 The EarthCare Workshop, Noordwijk, Netherlands. <http://www.congrex.nl/07c08/>
- 10–12 3MA International Symposium: Magmatism, Metamorphism, Associated Mineralizations, Fez, Morocco. <http://www.fsdmfes.ac.ma/3MA-FES07/>
- 14–16 2nd IAASS Conference — Space Safety in a Global World, Chicago, Illinois. <http://www.congrex.nl/07a02/>
- 14–18 Molecules in Space and Laboratory, Paris, France. [http://www.u-cergy.fr/Mol\\_Spa\\_Lab/](http://www.u-cergy.fr/Mol_Spa_Lab/)

- 22–25 2007 Joint Assembly (AGU), Acapulco, Mexico. <http://www.agu.org/meetings/ja07/>
- 22–27 ECO Summit 2007, Beijing, China. <http://www.ecosummit2007.elsevier.com/>
- 24–28 26th International Space Development Conference 2007, Dallas, Texas. <http://isd.c.nss.org/2007/>
- 27–31 AAS Solar Physics Division, Honolulu, Hawaii. [http://umbra.nascom.nasa.gov/aas\\_spd/](http://umbra.nascom.nasa.gov/aas_spd/)
- 27–01 Structure Formation in the Universe Galaxies, Stars, and Planets, Charmonix, France. <http://chamonix2007.ens-lyon.fr/>

## JUNE

- 9–12 37th International Conference on Environmental Systems, Chicago, Illinois. <http://www.sae.org/events/ice/>
- 11–15 Meteoroids 2007, Barcelona, Spain. <http://www.spmn.uji.es/meteoroids-2007/>
- 19–23 Second International Workshop on Exploring Mars and its Earth Analogues, Trento, Italy. <http://irsp.sci.unich.it/education/mars07>
- 25–29 32nd International Symposium on Remote Sensing of Environment, San Jose, Costa Rica. <http://www.cenat.ac.cr/simposio/>
- 25–29 Extreme Solar System, Santorini Island, Greece. <http://www.astro.northwestern.edu/Santorini2007/>

## JULY

- 2–13 IUGG XXIV General Assembly: Earth, Our Changing Planet, Perugia, Italy. <http://www.iugg.org/assemblies/2007perugia/>
- 9–13 Seventh International Conference on Mars, Pasadena, California. <http://www.lpi.usra.edu/meetings/7thmars2007>
- 16–20 Bioastronomy 2007: Molecules, Microbes, and Extraterrestrial Life, San Juan, Puerto Rico. <http://www.ifa.hawaii.edu/UHNAI/bioast07.htm>
- 18–21 NewSpace 2007, Washington, DC. <https://www.space-frontier.org/Events/NewSpace2007/>
- 23–27 Nuclear Astrophysics: Beyond the First 50 Years, Pasadena, California. <http://www.na2007.caltech.edu/>
- 30–Aug 4 Asia Oceania Geosciences Society 2007, 4th Annual Meeting, Thailand. <http://www.asiaoceania.org/aogs2007/>