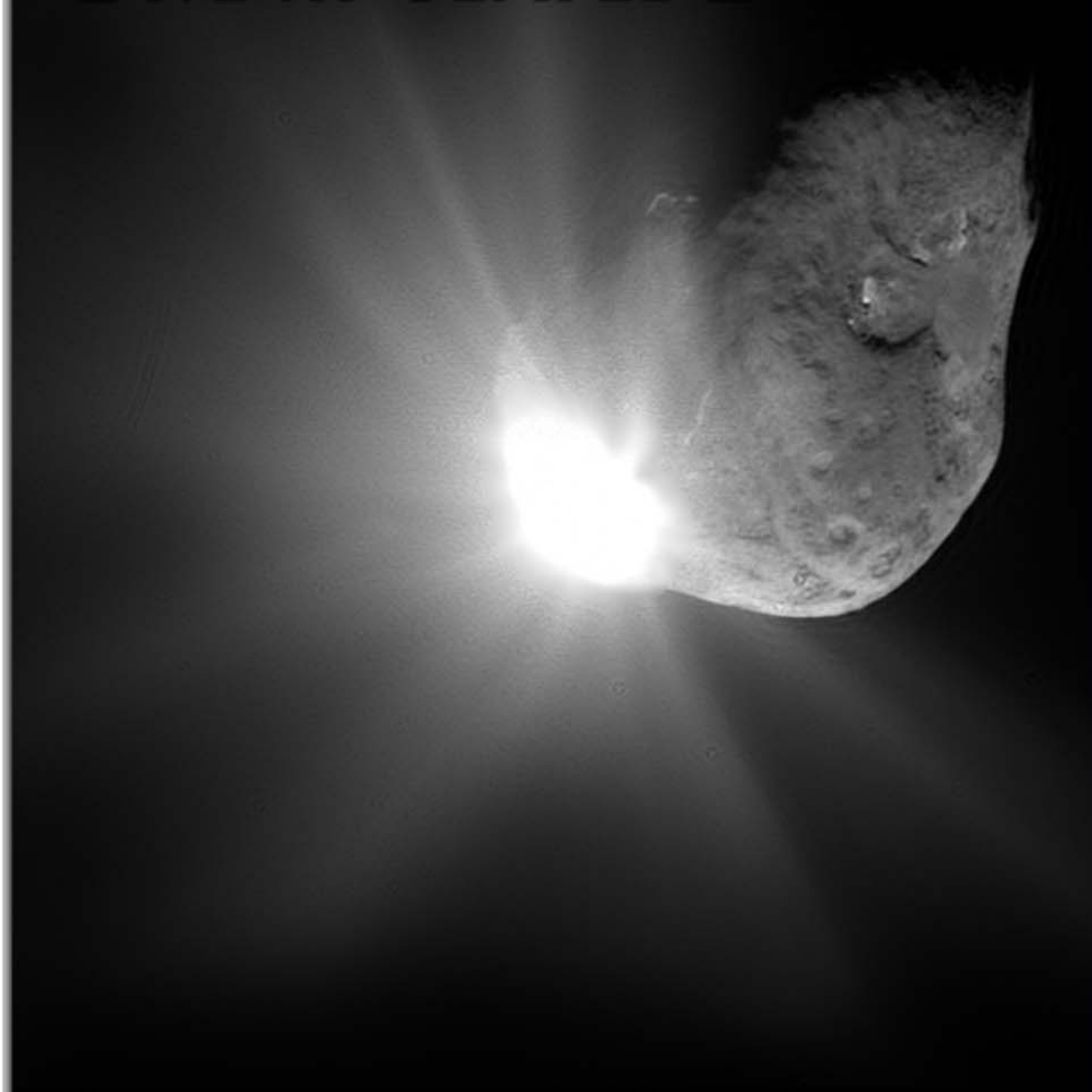
Deep Impact Takes a Dive at Tempel 1



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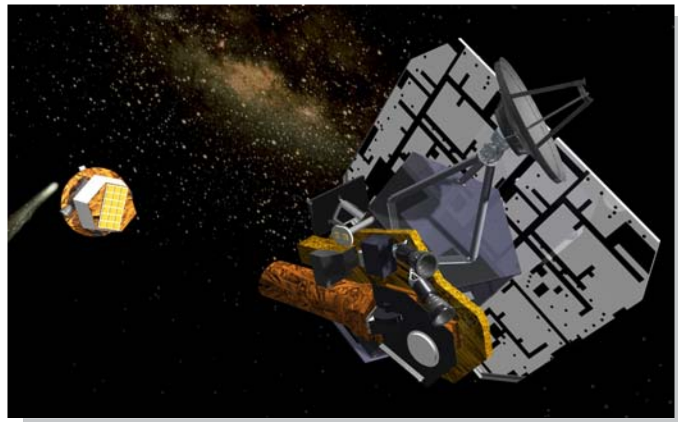
Deep Impact Takes a Dive at Tempel 1

— Paul Schenk, Editor,
Lunar and Planetary Institute

After 172 days and 431 million kilometers (268 million miles) of deep space stalking, Deep Impact successfully reached out and touched Comet Tempel 1. The collision between the coffee-table-sized impactor and city-sized comet occurred at 1:52 a.m. U.S. Eastern Daylight Time (EDT) on July 4.

"What a way to kick off America's Independence Day," said Deep Impact Project Manager Rick Grammier of NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California. "This mission is truly a smashing success," said Andy Dantzler, director of NASA's Solar System Division.

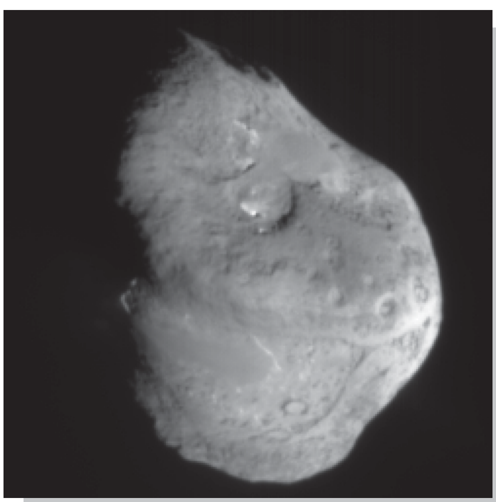


The Deep Impact spacecraft. At left is the copper impactor, designed to hit the surface of Comet Tempel 1 and blast material into space. At right is the main spacecraft, designed to carry the impactor to Tempel 1 and observe the collision from a relatively safe distance.

Deep Impact was designed to look into the heart of a comet. Comets originate from the far reaches of the solar system, beyond Neptune , and are believed to be remnants of the formation of the solar system. Most comets have dark and dusty surfaces that may cover the volatile ices believed to lie inside, including ices of water, carbon monoxide, carbon dioxide, and other hydrocarbons such as formaldehyde. Hence the motivation behind Deep Impact: to fire a projectile into the surface to blast materials from the interior into space and measure them with a suite of scientific instruments.

Official word of the impact came five minutes after impact. At 1:57 a.m. EDT, an image from the spacecraft's medium-resolution camera, downlinked to the computer screens of the mission's science team, showed the telltale signs of a high-speed impact.

"The image clearly shows a spectacular impact," said Deep Impact principal investigator Dr. Michael A'Hearn of the University of Maryland in College Park. "With this much data we have a long night ahead of us, but that is what we were hoping for."



The best view of Tempel 1 immediately prior to the impact events. The round features are old craters formed either by impacts or by "eruptions" of gas and dust.Several curved ridges of unkown origin cross near the center of Tempel 1. Tempel 1's icy nucleus is roughly half the size of Manhattan.

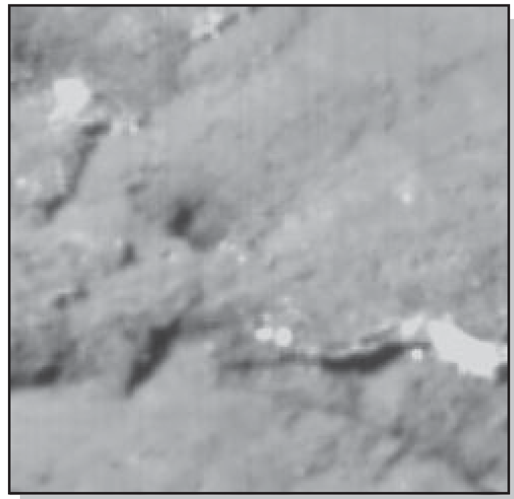
The celestial collision and ensuing data collection by the nearby Deep Impact mothership was the climax of a very active 24-hour period for the mission, which began with impactor release at 2:07 a.m. EDT on July 3. Deep space maneuvers and final checkouts of both spacecraft and comet imaging took up most of the next 22 hours. The impactor then began its last two hours of life.

These final hours provided some last-minute drama. "The impactor kicked into its autonomous navigation mode right on time," said Deep Impact navigator Shyam Bhaskaran of JPL. "Our preliminary analysis indicates the three impactor targeting maneuvers occurred on time at 90, 35, and 12.5 minutes before impact. Due to the flight software program this initial maneuver moved us seven kilometers off course. This was not unexpected but at the same time not something we hoped to see. But then the second and third maneuvers put us right where we wanted to be."

The data review process is not overlooking a single frame of approximately 4500 images taken during the encounter from the spacecraft's three imaging cameras. "We are looking at everything from the last moments of the impactor to the final look-back images taken hours later, and everything in between," added A'Hearn. "Watching the last moments of the impactor's life is remarkable. We can pick up such fine surface detail that objects that are only 4 meters in diameter can be made out. That is nearly a factor of 10 better than any previous comet mission."

DEEP IMPACT

The final moments of the impactor's life are important, because they set the stage for all subsequent scientific findings. Knowing the location and angle the impactor slammed into the comet's surface is the best place to start. From this, we can calculate the energy resulting from the impact event. Engineers have established the impactor took two not-unexpected coma particle hits prior to impact. The impacts slewed the spacecraft's camera for a few moments before the attitude control system could get it back on track. The penetrator hit at an approximately 25° oblique angle relative to the comet's surface. That's when the fireworks began.

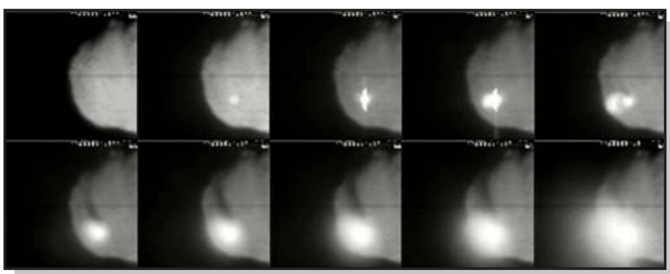


One of the last images taken by the Deep Impact impactor, less than 20 seconds before impact. The dark features are shadows.

At a press conference held the morning of July 4, Deep Impact team members displayed a movie depicting the final moments of the impactor's life. The final image from the impactor was transmitted from the short-lived probe for all of three seconds before it met its fiery end.

"The final image was taken from a distance of 18.6 miles from the comet's surface," said A'Hearn. "From that close distance we can resolve features on the surface that are less than 4 meters across."

Once the impactor had arrived at the target, attention shifted to the main Deep Impact spacecraft, now monitoring the unfolding events from a safe distance with its suite of cameras and instruments. The hyperspeed demise of NASA's Deep Impact probe generated a short but intense flash of light. Deep Impact scientists theorize the 820-pound impactor vaporized deep below the comet's surface when the two collided at 1:52 a.m. July 4, at a speed of 10 kilometers per second (22,500 miles per hour).



Time-lapse sequence of images of the impact, as seen from the main spacecraft. From upper left, they show the undisturbed comet, followed by the bright flash of impact. This was followed by the expanding plume of gas and dust. A shadow of this plume can be seen in the lower frames.

"You cannot help but get a big flash when objects meet at 23,000 miles per hour," said Deep Impact co-investigator Dr. Pete Schultz of Brown University in Providence, Rhode Island. "The heat produced by impact was at least several thousand degrees Kelvin and at that extreme temperature just about any material begins to glow. Essentially, we generated our own incandescent photo flash for less than a second."

The flash created by the impact was just one of the visual surprises that confronted the Deep Impact team. The fireball of vaporized impactor and comet material shot skyward in an expanding plume of gas and dust, casting a long narrow shadow across the surface. It expanded rapidly above the impact site at approximately 5 kilometers per second (11,200 miles per hour) as the crater continued to form. Scientists are still analyzing the data to determine the exact size of the crater. They say the crater was at the large end of original expectations, which was from 50 to 250 meters (164 to 820 feet).

Data from Deep Impact's instruments indicate an immense cloud of fine powdery material was released when the probe slammed into the nucleus of Comet Tempel 1. The cloud indicated that the comet is covered in powdery stuff. The Deep Impact science team continues to wade through gigabytes of data collected during the July 4 encounter with the 4.8-kilometer-wide by 11.2-kilometer-long (3 by 7 miles) comet.

"The major surprise was the opacity of the plume the impactor created and the light it gave off," said A'Hearn. "That suggests the dust excavated from the comet's surface was extremely fine, more like talcum powder than beach sand. And the surface is definitely not what most people think of when they think of comets — an ice cube."

Another surprise was the duration and intensity of the expanding cloud of gas and dust, which continued to brighten and expand hours after the event. Such expansion might indicate that gas and dust continued to escape from the crater long after it formed, like popping a cork from champagne.

Deep Impact team members weren't the only ones looking. Earth-based telescopic observers were also monitoring the impact event. Dr. Karen Meech, an astronomer from the University of Hawai'i, is the coordinator of the pioneering network linking all the world's major observatories for Deep Impact observations.

"Earth observers didn't see a sudden brightening," Meech said. "Instead they saw more of a gradual brightening."

Together with observers on Earth, the Deep Impact results will take several months to decipher. These data should provide invaluable information on the composition and history of comets, where the materials from the formation of the solar system may remain relatively unchanged since the formation of our planet.

The University of Maryland is responsible for overall Deep Impact mission science, and project management is handled by JPL. For more information about Deep Impact on the Internet, visit http://www.nasa.gov/deepimpact.

As Deep Impact receded from Tempel 1, it saw the expanding cloud of gas and dust silhouetted by the Sun.

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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.

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NEWS FROM SPACE

NASA-FUNDED SCIENTISTS DISCOVER "TENTH PLANET"

An object larger than Pluto has been discovered in the outlying regions of the solar system. The object was discovered using the Samuel Oschin Telescope at Palomar Observatory near San Diego, California. The discovery was announced in July by planetary scientist Dr. Mike Brown of the California Institute of Technology in Pasadena, whose research is partly funded by NASA. The object is a typical member of the Kuiper belt, but its sheer size in relation to the nine known planets means that it can only be classified as a planet, Brown said. Currently about 97 times further from the Sun than Earth, the planet is the farthest-known object in the solar system, and the third brightest of the Kuiper belt objects.

Brown, Trujillo, and Rabinowitz first photographed the new planet with the 48-inch Samuel Oschin Telescope on October 31, 2003. However, the object was so far away that its motion was not detected until they reanalyzed the data in January of this year. In the last seven months, the scientists have been studying the planet to better estimate its size and its motions. "It's definitely bigger than Pluto," said Brown, who is a professor of planetary astronomy. Scientists can infer the size of a solar system object by its brightness, just as one can infer the size of a faraway light bulb if one knows its wattage. The reflectance of the planet is not yet known. Scientists can not yet tell how much light from the Sun is reflected away, but the amount of light the planet reflects puts a lower limit on its size. "Even if it reflected 100 percent of the light reaching it, it would still be as big as Pluto," says Brown. "I'd say it's probably one and a half times the size of Pluto, but we're not sure yet of the final size." Brown added, "We are 100 percent confident that this is the first object bigger than Pluto ever found in the outer solar system."

The size of the planet is limited by observations using NASA's Spitzer Space Telescope, which has already proved its mettle in studying the heat of dim, faint, faraway objects such as the Kuiper-belt bodies. Because Spitzer is unable to detect the new planet, the overall diameter must be less than 2000 miles, said Brown. For more information and images visit ***http://www.nasa.gov/vision/universe/solarsystem/newplanet-072905-images.html***.

NASA'S NEW MARS ORBITER WILL SHARPEN VISION OF EXPLORATION

NASA's newest mission to Mars, the Mars Reconnaissance Orbiter (MRO), was successfully launched on August 12. MRO will examine Mars in unprecedented detail from low orbit. It will provide more data about that intriguing planet than all previous missions combined. The spacecraft will examine martian features ranging from the top of the atmosphere to underground layering. Researchers will use it to study the history and distribution of martian water. It will also support future Mars missions by characterizing landing sites and providing a high-data-rate communications relay.

"Mars Reconnaissance Orbiter is the next step in our ambitious exploration of Mars," said NASA's director, Mars Exploration Program, Science Mission Directorate, Douglas McCuistion. "We expect to use this spacecraft's eyes in the sky in coming years as our primary tools to identify and evaluate the best places for future missions to land." The spacecraft carries six instruments for probing the atmosphere, surface, and subsurface to characterize the planet and how it changed over time. One of the science payload's three cameras will be the largest-diameter telescopic camera ever sent to another planet. It will reveal rocks and layers as small as the width of an office desk. Another camera will expand the present area of high-resolution coverage by a factor of 10. A third will provide global maps of martian weather. The other three instruments are a spectrometer for identifying water-related minerals in patches as small as a baseball infield; a ground-penetrating radar, supplied by the Italian Space Agency, to peer beneath the surface for layers or rock, ice, and, if present, water; and a radiometer to monitor atmospheric dust, water vapor, and temperature. Two additional scientific investigations will analyze the motion of the spacecraft in orbit to study the structure of the upper atmosphere and the martian gravity field.

The Mars Reconnaissance Orbiter as it orbits over the martian poles. Image courtesy of NASA/JPL.

Dr. Richard Zurek of NASA's Jet Propulsion Laboratory (JPL), project scientist for the orbiter, said, "Higher resolution is a major driver for this mission. Every time we look with increased resolution, Mars has said, 'Here's something you didn't expect. You don't understand me yet.' We're sure to find surprises."

The orbiter will reach Mars in March 2006. It will gradually adjust the shape of its orbit by aerobraking, a technique that uses the friction of careful dips into the planet's upper atmosphere. For the mission's 25-month primary science phase, beginning in November 2006, the planned orbit averages about 190 miles above the surface, more than 20% lower than the average for any of the three current Mars orbiters. The lower orbit adds to the ability to see Mars as it has never been seen before. To get information from its instruments to Earth, the orbiter carries the biggest antenna ever sent to Mars and a transmitter powered by large solar panels. "It can send 10 times as much data per minute as any previous Mars spacecraft," said JPL's James Graf, project manager. "This increased return multiplies the value of the instruments by permitting increased coverage of the surface at higher resolution than ever before. The same telecommunications gear will be used to relay critical science data to Earth from landers." To loft so big a spacecraft, weighing more than two tons fully fueled, NASA used a powerful Atlas V launch vehicle for the first time on an interplanetary mission.

For information about Mars Reconnaissance Orbiter on the Web, visit ***http://www.nasa.gov/mro***.

NASA Spacecraft Completes Successful Earth Swingby

NASA's MESSENGER spacecraft, headed toward the first study of Mercury from orbit, swung by Earth on August 2 for a gravity assist that propelled it deeper into the inner solar system. Mission operators at the Johns Hopkins University Applied Physics Laboratory (APL) in Laurel, Maryland, said MESSENGER's systems performed flawlessly. The spacecraft swooped around Earth, coming to a closest approach point of approximately 1458 miles (2347 kilometers) over central Mongolia at 3:13 p.m. EDT.

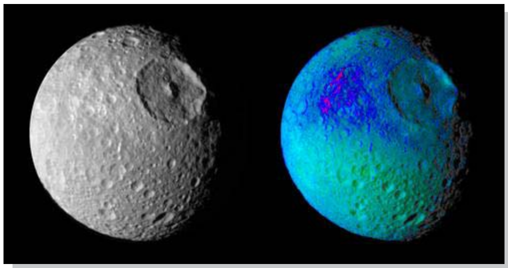
The spacecraft used the tug of Earth's gravity to significantly change its trajectory. Its average orbit distance is nearly 18 million miles closer to the Sun. The maneuver sent it toward Venus for another gravity-assist flyby next year. Launched August 3, 2004, from Cape Canaveral Air Force Station, Florida, the solar-powered spacecraft is approximately 581 million miles (930 million kilometers) into a 4.9-billion-mile (7.9-billion-kilometer) voyage that includes 14 more loops around the Sun. MESSENGER will fly past Venus twice and Mercury three times before moving into orbit. The Venus flybys in October 2006 and June 2007, along with the Mercury flybys in January 2008, October 2008 and September 2009, will set up the maneuver in March 2011 that starts a year-long science orbit around Mercury.

"Not only did [the Earth flyby] help the spacecraft sharpen its aim toward our next maneuver, it presented a special opportunity to calibrate several of our science instruments," said Dr. Sean C. Solomon, the mission's principal investigator from the Carnegie Institution of Washington.

MESSENGER will conduct the first orbital study of Mercury, the least explored of the terrestrial planets that include Venus, Earth, and Mars. During one Earth year (four Mercury years), MESSENGER will provide the first maps of the entire planet. It will collect detailed information about the composition and structure of Mercury's crust, its geologic history, nature of its atmosphere and magnetosphere, makeup of its core, and polar materials.

MESSENGER, short for MErcury Surface, Space ENvironment, GEochemistry, and Ranging, is the seventh mission in NASA's Discovery Program of lower-cost scientifically focused exploration projects. For more information about the spacecraft and mission on the Web, visit ***http://messenger.jhuapl.edu***.

Cassini Flies by Saturn's Tortured Moon Mimas



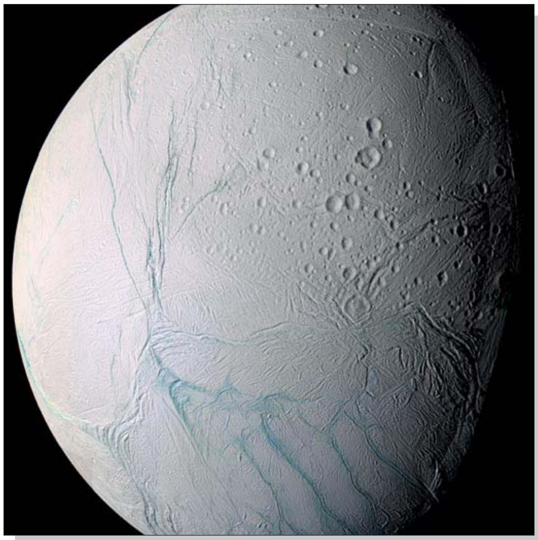
Mimas in false color. Image courtesy of Jet Propulsion Laboratory/Space Science Institute.

On its recent close flyby of Mimas, the Cassini spacecraft found the Saturnian moon looking battered and bruised, with a surface that may be the most heavily cratered in the Saturn system. The August 2 flyby of Saturn's "Death Star" moon returned eye-catching images of its most distinctive feature, the spectacular 140-kilometer diameter (87-mile) landslide-filled Hershel crater. Numerous rounded and worn-out craters, craters within other craters, and long grooves reminiscent of those seen on asteroids are also seen in the new images.

The closest images show Mimas, measuring 397 kilometers (247 miles) across, in the finest detail yet seen. One dramatic view acquired near Cassini's closest approach shows the moon against the backdrop of Saturn's rings. A false-color composite image reveals a region in blue and red of presumably different composition or texture just west of, and perhaps related to, the Hershel crater. Scientists hope that analysis of the images will tell them how many crater-causing impactors have coursed through the Saturn system, and where those objects might have come from. There is also the suspicion, yet to be investigated, that the grooves, first discovered by NASA's Voyager spacecraft but now seen up close, are related to the giant impact that caused the biggest crater of all, Herschel, on the opposite side of the moon.

The new Mimas images are available at ***http://saturn.jpl.nasa.gov***, ***http://www.nasa.gov/cassini***, and ***http://ciclops.org***.

Cassini Finds an Active, Watery World at Saturn's Enceladus



Zooming in on Enceladus. Photo courtesy of NASA/JPL/Space Science Institute

Saturn's tiny icy moon Enceladus, which ought to be cold and dead, instead displays evidence for active ice volcanism. NASA's Cassini spacecraft has found a huge cloud of water vapor over the moon's south pole, and warm fractures where evaporating ice probably supplies the vapor cloud. Cassini has also confirmed Enceladus is the major source of Saturn's largest ring, the E-ring.

Cassini flew within 175 kilometers (109 miles) of Enceladus on July 14. Data collected during that flyby confirm an extended and dynamic atmosphere. This atmosphere was first detected by the magnetometer during a distant flyby earlier this year. The ion and neutral mass spectrometer and the ultraviolet imaging spectrograph found the atmosphere contains water vapor, with molecular hydrogen at about 20% with smaller amounts of carbon dioxide, molecular nitrogen, and carbon monoxide. The fact the atmosphere persists on this low-gravity world, instead of instantly escaping into space, suggests the moon is geologically active enough to replenish the water vapor at a slow continuous rate.

Images show the south pole has an even younger and more fractured appearance than the rest of Enceladus, complete with icy boulders the size of large houses and long, bluish cracks or faults dubbed "tiger stripes." Another Cassini instrument, the composite infrared spectrometer, shows the south pole is warmer than anticipated. Temperatures near the equator were found to reach a frigid 80 K (–316°F), as expected. The poles should be even colder because the Sun shines so obliquely there. However, south polar average temperatures reached 85 K (–307°F), much warmer than expected. Small areas of the pole, concentrated near the "tiger stripe" fractures, are even warmer: well over 110 K (–261°F) in some places.

Scientists find the temperatures difficult to explain if sunlight is the only heat source. More likely, a portion of the polar region, including the "tiger stripe" fractures, is warmed by heat escaping from the interior. Evaporation of this warm ice at several locations within the region could explain the density of the water vapor cloud detected by other instruments. How a 500-kilometer (310-mile)-diameter moon can generate this much internal heat and why it is concentrated at the south pole is still a mystery.

Cassini's cosmic dust analyzer detected a large increase in the number of particles near Enceladus. This observation confirms Enceladus is a source of Saturn's E-ring. Scientists think micrometeoroids blast the particles off, forming a steady, icy, dust cloud around Enceladus. Other particles escape, forming the bulk of the E ring.

Additional information and graphics on these results are available at ***http://www.nasa.gov/cassini***.

Spotlight on Education

"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 Lunar and Planetary Institute at ***outreach@lpi.usra.edu***.

Life at the Limits: Earth, Mars, and Beyond

Twenty-eight educators met in Reno, Nevada, in July to embark on the exploration of extreme environments to better understand the conditions in which life on Earth can thrive and to extend that knowledge to evaluating the possibility of past or present life on other planets. The educators, primarily middle- and high-school teachers of biology and life sciences, visited Carson Sink salt flats, east of Reno, Nevada, to research and sample hypersaline environments. Two additional days of field work concentrated on the alkaline and thermal extreme environments of the Mono Lake, California, region. During the field experience, planetary scientists, a microbial ecologist, and an astrobiologist helped participants build a picture of the intricate interactions of geology, chemistry, biology, and ecology in these unique environments — and their connections to conditions on other planets.

The Lunar and Planetary Institute conducts these annual summer field workshops to provide K–12 educators with the opportunity to develop a deeper understanding and excitement about planetary processes through first-hand experiences. These workshops combine field observations with content lectures and discussions. The field experiences are designed to enhance the participant's abilities to undertake authentic scientific inquiry in the classroom, help educators develop a deeper understanding of scientific content and the process of science, and create a learning environment in which teachers and scientists interact as colleagues — effectively demystifying and putting a human face on science. A primary outcome of the experience is that participants have the opportunity to interact with each other and share ideas about classroom implementation. The participants develop a network in which they can interact once back in their individual classrooms.

Through their experiences the educators are better prepared to bring science alive for their students. During the workshop they undertake hands-on, standards-based activities that are designed to enhance student learning. To achieve a long-term impact, the participating educators are expected to transfer their experiences not only into their classroom, but also to share what they have learned with colleagues.

During the workshop, group discussions focused on challenges and ideas for effective classroom implementation, as well as ideas for involving other educators in the exploration of extreme environments in the classroom. Participant field journals, links to activities and other resources, photographs, and other information about the field experience can be found at ***http://www.lpi.usra.edu/education/fieldtrips/2005/***. The annual field experience is made possible by supplemental E/PO funding to a research grant provided by NASA's Science Mission Directorate, supporting funds from the Lunar and Planetary Institute, a generous contribution from the Sandia National Laboratories, and the support for educator participation by several state Space Grants and school districts.

Planetary Data in Education Workshop

The Solar System Exploration Education Forum co-hosted the second Planetary Data in Learning Environments workshop with the South Central Organization of Researchers and Educators (SCORE) Broker/Facilitator program. Thirty-two participants attended, including museum and planetarium staff, classroom educators, education specialists, learning technology specialists, product developers, and scientists. The intended outcomes of the workshop were for participants to increase their awareness of the range of existing Earth and planetary science programs, tools, data resources, and expertise; build their knowledge about key elements of a success in programs that integrate planetary data into educational initiatives; and reflect on a specific application of best practices in the design, implementation, or revision of programs.

Roundtable discussions in the morning concentrated on the challenges found within some of the educational venues in which planetary data are presented. Group discussions focused on planetary data use in planetariums and exhibits, student investigations, student collection and comparison projects, and citizen science programs. Participants examined several programs, including the Mars Student Imaging Project (student investigations), GLOBE (data collection and comparison), and Clickworkers (citizen science) to determine what data are used and how they are used, the evidence of success and the elements that contributed to success, the challenges and how they were addressed, and the needs and priorities of data use in these venues.

Several roundtable discussions concluded that data are available through venues such as Planetary Data Systems (PDS), but not in a format that the end-user can digest; development of meaningful programs using planetary data requires development of appropriate learner interfaces. All members of the community — data providers such as PDS, product developers, learning technologists, scientists, and educators — should be involved in the design, development, and implementation of educational programs and products using planetary data.

Afternoon group discussions examined engaging current and future audiences that will use planetary data products, technical issues involved in data access and use, points of intersection between the use of planetary data in the classroom and education standards, and possible dissemination mechanisms for NASA data and information to museums and planetariums.

Recommendations from the workshop, as well as presentations, discussion notes, and related resources, will be posted during August and September at ***http://www.lpi.usra.edu/education/score/planetary_data/***.

MARS RECONNAISSANCE ORBITER

http://marsprogram.jpl.nasa.gov/mro/ The Mars Reconnaissance Orbiter (MRO), launched August 12, is NASA's next step in our exploration of Mars (see related article on page 5). The spacecraft, due to arrive at Mars in March 2006, will occupy a low orbit and is anticipated to provide detailed information about planetary features from the upper atmosphere to layers beneath the surface. Through MRO results, scientists hope to better understand how the martian environment has changed through time, providing further insights into the history of water on Mars. A variety of educational resources developed for K–12 classrooms support this mission, as well as other Mars Exploration Program missions. Resources include

- Imagine Mars, a program for K–8 students that integrates science with the arts, letters, and humanities
- The Mars Student Imaging Project, through which students in grades 5–12 use an Odyssey orbiter camera to take images of Mars and subsequently analyze the data
- The Mars Robotics Education program, designed for students in grades 5–12, which integrates science and technology

These programs, as well as additional curriculum supplements, educator professional development opportunities, posters, and other classroom resources, can be found at *http://marsprogram.jpl.nasa.gov/classroom/*.

EDUCATOR RESEARCHER COLLABORATIVE PROJECTS

The South Central Organization of Researchers and Educators (SCORE) Broker/Facilitator program offers grants of up to $1000 to collaborative teams of educators and NASA-funded space science researchers in Arizona, Kansas, Louisiana, New Mexico, Oklahoma, and Texas. The grants are intended to help initiate new partnerships. Funds can be used in the development of programs to increase student or public understanding of space science content. More information can be found at ***http://www.lpi.usra.edu/education/score/collaborativeprojects.shtml***.

EDUCATION SESSIONS AT THE FALL AMERICAN GEOPHYSICAL UNION MEETING

Abstracts for the Fall AGU meeting are due electronically by **September 8** (7:59 p.m. Eastern Daylight Time). Twenty-three sessions have been proposed, including

- Deciphering Data: Communicating Research Activities and Findings to Diverse Audiences
- Global Geoscience Education and Outreach: The World's Best Practices in Earth and Space Science Education
- Earth and Planetary Sciences Education and Public Outreach in Developing Countries: Local and International Initiatives

Other planned sessions examine effective practices of involving students and educators in research, engagement of minority students, integration of research into teaching, exploration of workforce pipeline issues, reflection on practices for effective education and public outreach, and enhancement of science department capacity.

Education and Human Resources sessions can be found at ***http://www.agu.org/meetings/fm05/?pageRequest=search&show=session&section=18&cosection=0&category=&keysearch=&title=1&desc=1&searchBy=sponsor***. For abstract submission or session search, go to ***http://www.agu.org/meetings/fm05/?pageRequest=program_abstracts***.

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 http://science.hq.nasa.gov/research/ecosystem.htm.

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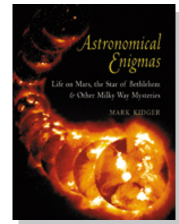
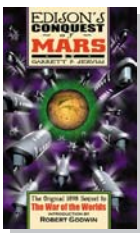
BOOKS



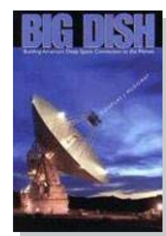
Astronomical Enigmas: Life on Mars, the Star of Bethlehem & Other Milky Way Mysteries. By Mark Kidger. Johns Hopkins University Press, 2005. 304 pp., Hardcover, $29.95. *www.press.jhu.edu*

Astronomer Mark Kidger has spent his career helping the general public understand the nature of the universe and what astronomy can tell us about its composition, history, and future. In *Astronomical Enigmas*, he presents the questions he is asked most frequently and offers clear and succinct answers. He presents an exploration of the heavens from the perspective of our forebears, moving from Stonehenge and the earliest theories about the planets and stars to one of the great historical mysteries in astronomy: the identity of the star of Bethlehem. He answers questions that provoke some of the most passionate and heated arguments between astronomers: Is there life on Mars? Is Pluto a planet? What did we learn by going to the Moon? He uses these questions to look at how astronomers deduce information about objects they could never visit. Finally, he looks to the future by examining two urgent questions — the possibility that an asteroid might devastate life on Earth and the impact of climate change as witnessed on other planets — before coming full circle to look at our own origins, answering the question "Are we stardust?" *Astronomical Enigmas* illustrates how much we know about our solar system — and how much there still is to discover.



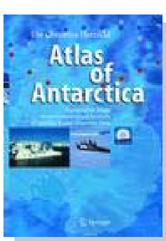
Edison's Conquest of Mars. By Garrett P. Serviss. Apogee Books, 2005. 264 pp., Paperback, $9.95. *www.cgpublishing.com*

In 1897 H. G. Wells created one of the greatest science-fiction masterpieces ever written, *The War of the Worlds*. The story was serialized in newspapers across America and proved to be so popular that the Hearst newspaper group commissioned a sequel, to be written by their own science editor, Garrett Putnam Serviss. This sequel appeared in February 1898 and quickly entered into the annals of science-fiction history. This is the first time that story has appeared in print, complete and unabridged with the original illustrations since that time. This new edition comes with a 13-page essay by editor Robert Godwin and original cover art by Tom Miller.



Big Dish: Building America's Deep Space Connection to the Planets. By Douglas J. Mudgway. University Press of Florida, 2005. 272 pp., Hardcover, $34.95. *www.upf.com*

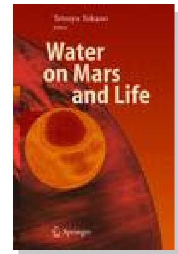
Set against the Cold War race for technical supremacy in space, *Big Dish* offers an inside view of the antennas that have been indispensable in missions to the farthest reaches of our solar system. Located at remote sites in California, Spain, and Australia, these gigantic instruments — about one acre in surface area and weighing over 6 million pounds — have provided an international community of scientists with a deep space connection to the planets that has enabled unmanned spacecraft to return a wealth of data to Earth. *Big Dish* describes how these instruments work, how they came into being, and the problems encountered in their construction and in enhancing their performance over time to meet the demands of ever more ambitious planetary missions. The complexities of deep space communications are presented in accessible language, and readers are introduced to the human story of perseverance and ingenuity that has maintained these great antennas for more than 40 years. Take a behind-the-scenes look at NASA's Jet Propulsion Laboratory in California, where political challenges, personal intrigue, and feats of brilliant engineering all contributed to the United States' preeminence in deep space exploration.



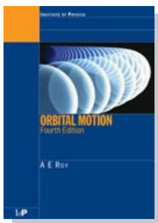
Atlas of Antarctica: Topographic Maps from Geostatistical Analysis of Satellite Radar Altimeter Data. By Ute C. Herzfeld. Springer, 2004. 364 pp. with CD-ROM, Hardcover, $159.00. *www.springer-ny.com*

The *Atlas of Antarctica* is the first atlas on the seventh continent to be published in 20 years. It contains 145 accurate topographic and elevation maps derived from satellite data (GEOSAT and ERS-1 radar altimeter data), which are the best of their kind available today. Each map includes a description of geographic and glaciological features. The introductory chapters familiarize the reader with the world of the Antarctic Ice Sheet and its role in the global system, as well as discussing satellite remote sensing and geostatistical methods at textbook level. Applications include detailed regional studies of 15 outlet glaciers of the inland ice, some of which are currently changing rapidly. Despite its state-of-the-art scientific accuracy, the *Atlas of Antarctica* is not only intended for use by researchers and students in glaciology, geophysics, remote sensing, cartography, and Antarctic research, but is also informative and enjoyable for any reader interested in the seventh continent. This book is accompanied by a CD-ROM containing all the atlas maps and elevation models.

Water on Mars and Life. Edited by Tetsuya Tokano. Springer, 2005. 332 pp., Hardcover, $89.95.
www.springer-ny.com



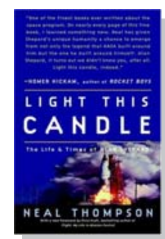
Growing evidence, based on observations from orbiters, landers, and telescopes, indicates that Mars may still have numerous hidden water reservoirs. From the point of view of habitability, Mars is a prime target for astrobiologists in search of extant or extinct microbial life because we know that life exists in Earth's permafrost regions, such as parts of Siberia and the Antarctic, which are the closest terrestrial analogs to Mars. *Water on Mars and Life* surveys recent advances made in research into water on Mars together with its astrobiological implications. This volume addresses not only scientists working in the field but also nonspecialists and students in search of a high-level but accessible introduction to this exciting field of research.



Orbital Motion, 4th Edition. By A. E. Roy. Institute of Physics Publishing, 2004. 538 pp., Paperback, $65.00.
www.bookmarkphysics.iop.org

This comprehensive mathematically detailed textbook on classical celestial mechanics covers numerical methods, astrodynamics of artificial satellites, and interplanetary craft. This revised edition involves updates to all chapters and the addition of a new chapter on the Caledonian symmetrical N-body problem, explaining the principles and applications from first principles. This will be the first time this new method has appeared in a textbook. In this new edition, the contents have been reorganized and extended to encompass new methods and teaching demands and to cover more modern applied areas such as satellite dynamics. A long established course text for advanced undergraduates and graduate students in a range of disciplines from physics to astronomy, this book extends the use to cover the needs of the growing number of students in aerospace and satellite engineering and the growing number of planetary scientists who now need to cover this material in more detail.

Light This Candle: The Life and Times of Alan Shepard. By Neal Thompson. Three Rivers Press, 2005. 560 pp., Paperback, $14.95. *www.randomhouse.com/crown/trp.html*



"Why don't you fix your little problem and light this candle."
— Alan Shepard to NASA technicians at liftoff for America's first manned spaceflight

Alan Shepard was the brashest, cockiest, and most flamboyant of America's original Mercury Seven, but he was also regarded as the best. Intense, colorful, and dramatic, he was among the most private of America's public figures and, until his death in 1998, he guarded the story of his life zealously. *Light This Candle*, based on Neal Thompson's exclusive access to private papers and interviews with Shepard's family and closest friends — including John Glenn, Wally Schirra, and Gordon Cooper — offers a riveting, action-packed account of Shepard's life.

DVD

Rocket Science DVD. From Univelt Incorporated, 2005. 540 minutes, $25.00. *www.univelt.com*

This new three-DVD, 12-part series examines the frontiers of rocket science and space discovery. *Rocket Science* takes an inspired look at the past, present, and future of space exploration. Through personal interviews, never-before-seen film footage, and classified tours of top-secret facilities, *Rocket Science* investigates some of the most exciting moments in the race to reach space. Some of science's most significant breakthroughs are highlighted, from breaking the sound barrier, to the exploration of the Moon and beyond. Colorful commentary and personal anecdotes from the personalities who influenced and shaped space flight history add a captivating element of human drama to this unique series. Included are exclusive interviews with Walter Cronkite, Chuck Yeager, Scott Crossfield, James Lovell, Frank Borman, Gene Cernan, and Wally Schirra. *Rocket Science* also visits a variety of locations where groundbreaking research and advancements in aerospace technology took place including the legendary Jet Propulsion Laboratory, the facility responsible for developing most of the robotic planetary space probes flown by the United States; Lovelace Clinic, the training and testing ground for NASA astronauts; the Lowell Observatory, where Mars was first mapped, and where astronomers continue to carry out forefront research in all areas of astronomy; and Edwards Air Force Base, the site where the sound barrier was first broken.

ONLINE RESOURCE

Ranger Photographs of the Moon. *www.lpi.usra.edu/resources/ranger/*

Ranger Photographs of the Moon is the online version of the NASA documents on the 1964–1965 NASA Lunar Ranger Program. It contains selected Ranger 7, Ranger 8, and Ranger 9 mission images and documentation from the photographic edition of the following Ranger publications:

Ranger VII Photographs of the Moon, Part I: Camera "A" Series, Photographic Edition (1964)
Ranger VII Photographs of the Moon, Part I: Camera "B" Series, Photographic Edition (1965)
Ranger VII Photographs of the Moon, Part I: Camera "P" Series, Photographic Edition (1965)
Ranger VIII Photographs of the Moon, Photographic Edition (1966)
Ranger IX Photographs of the Moon, Photographic Edition (1966)

For Kids!!

MoonBalloon Lighted Balloons and Launch Kit. From Moonballoons. Includes one Core Illuminating Pod, three MoonBalloons, three preinstalled button cells (batteries), three lengths of docking string, and one asteroid balloon weight. $19.95. *www.moonballoons.net*

Presenting the cutting edge of balloon technology! After a 12-year developmental curve spent perfecting the patented formula that optimizes the light trapping and topographical characteristics that make MoonBalloon Lighted Balloons so unique, the wait is over. MoonBalloons are finally available to the public. Powered by helium and a Core Illuminating Pod, MoonBalloon Lighted Balloons utilize a patent-pending illumination system equipped with cutting-edge, super-high-output diodes and a specially engineered balloon. The proprietary composite balloon dipping process consists of nontoxic luminous and fluorescent pigment coatings to evoke a haunting glow and depth of simulated lunar topography. (A MoonBalloon can double as a great nighttime child safety marker too!) Collect the entire solar system series! For ages 9 and up.

Reaching for the Moon. By Buzz Aldrin. HarperCollins, 2005. 40 pp., Hardcover, $15.99. *www.harpercollins.com*

In this picture book for children in grades 2–4, Buzz Aldrin, the second man to step foot on the Moon, relates the life events that led him to the space program and his assignment on Apollo 11:

> *This is my journey. It didn't begin when I stepped on board Apollo 11 on July 16, 1969. It began the day I was born — Edwin Eugene Aldrin, Jr. — whom everyone called Buzz. Becoming an astronaut took more than education, discipline, and physical strength. It took years of determination and believing that any goal is possible — from riding a bike alone across the George Washington Bridge at age ten to making a footprint on the Moon. I always knew the Moon was within my reach — and that I was ready to be part of the team that would achieve the first landing. But it was still hard to believe when I took my first step onto the Moon's surface. We all have our own dreams — this is the story of how mine came true.*

Special Edition MONOPOLY Board Games. From Hasbro/USAopoly. Game board, cards, and pieces, $35.95. *www.usaopoly.com*

This year marks the seventieth anniversary of the ever-popular board game MONOPOLY. In the height of the Depression, Charles B. Darrow of Germantown, Pennsylvania, showed his creation, the MONOPOLY game, to the executives at Parker Brothers. Parker Brothers rejected the game due to numerous "design errors." Mr. Darrow, like many other Americans, was unemployed at the time, and the game's exciting promise of fame and fortune inspired him to produce it on his own. With help from a friend who was a printer, Darrow sold 5000 handmade sets of the game to a Philadelphia department store, and the people loved it. But as demand grew, he couldn't keep up with all the orders and came back to talk to Parker Brothers again. And the rest is history. In its first year, 1935, the MONOPOLY game was the best-selling game in America and remains a favorite today. The game is now available in a hundred different themes, including **Astronomy**, **Night Sky**, **Century of Flight**, and **U.S. Space Program** versions. For ages 8 and up.

Calendar 2005

Information was valid as of this issue's publication and is subject to change without notice. For more information see the Web sites listed.

August

7–12 IAU Symposium No. 229, Asteroids, Comets and Meteors, Rio de Janeiro, Brazil. *http://www.on.br/acm2005/*

7–12 Meeting of the Magnetospheres of the Outer Planets, Leicester, United Kingdom. *http://www.ion.le.ac.uk/mop/*

8–11 Earth System Processes 2, Calgary, Alberta. *http://www.geosociety.org/meetings/esp2/*

11–14 8th International Mars Conference, University of Colorado, Boulder. *http://www.marssociety.org/convention/2005/index.asp*

15–19 International Astronomical Union Symposium No. 230, Populations of High Energy Sources in Galaxies, Dublin, Ireland. *http://www.dunsink.dias.ie/IAUS230/menu.html*

17–20 2005 Astrobiology Graduate Conference, La Jolla, California. *http://www.cab.inta.es/Astrobiology/*

19–21 The Fifth Australian Mars Exploration Conference, Canberra, Australia. *http://www.marssociety.org.au/amec/AMEC2005.htm*

21–26 Engineering Sciences for Space Exploration, Les Diablerets, Switzerland. *http://www.grc.uri.edu/programs/2005/space.htm*

22–26 Dynamic Planet 2005, Cairns, Australia. *http://www.dynamicplanet2005.com/*

22–26 10th Anniversary of 51 Peg-b: Status of and Prospects for Hot Jupiter Studies, Observatorie de Haute-Provence, France. *http://www.obs-hp.fr/~51peg10y/*

30–Sept. 1 Space 2005, Long Beach, California. *http://www.aiaa.org/content.cfm?pageid=230&lumeetingid=1181*

September

1–3 9th Conference on Environmental Science and Technology – 2005, Rhodes Island, Greece. *http://www.gnest.org/cest/*

1–3 The 3rd 21 COE Symposium: Astrophysics as an Interdisciplinary Science, Tokyo, Japan. *http://www.gravity.phys.waseda.ac.jp/coe_astro/*

4–9 36th Annual Meeting of the Division for Planetary Sciences, Cambridge, England. *http://www.dps2005.com/*

5–9 Workshop on "Geology and Habitability of Terrestrial Planets," Bern, Switzerland. *http://www.issi.unibe.ch/workshops/Geology/*

5–10 PHD Conference on Astrophysics of Variable Stars, Pecs, Hungary. *http://icsip.elte.hu/phd2005/*

7–9 1st International Conference on Remote Sensing and Geoinformation Processing in the Assessment and Monitoring of Land Degradation and Desertification, Trier, Germany. *http://fern39.uni-trier.de/feut/rgldd/*

8 Remote Sensing of Volcanoes and Their Hazards, Trier, Germany. *http://www.grsg.org/volc_announce_05.html*

8–11 Recent Advances in Astronomy and Astrophysics, Kefallinia Island, Greece. *http://comas.interzone.gr/cgi/article.cgi*

11–19 AAPG International Conference and Exhibition, Paris, France. *http://www.aapg.org/paris/*

12–16 The Dynamic Sun: Challenges for Theory and Observations, Leuven, Belgium. *http://www.wis.kuleuven.ac.be/cpa/spm11.html*

12–16 68th Annual Meeting of the Meteoritical Society, Gatlinburg, Tennessee. *http://www.lpi.usra.edu/meetings/metsoc2005/*

15–16 Mars Exploration – Past, Present, and Future, Pasadena, California. *http://www.jpl.nasa.gov/events/lectures/sep05.cfm*

15–18 International Meteor Conference2005, Oostmalle, Belgium. *http://www.imo.net/imc2005/*

18–23 International Lunar Conference, Toronto, Canada. *http://www.ilewg.org/ILC2005/*

18–23 International Geochemical Exploration Symposium, Perth, Western Australia. *http://www.promaco.com.au/conference/2005/iges/contents.htm*

19–20 Workshop on Dust Devils on Earth and Mars, Flagstaff, Arizona. *http://gaspra.la.asu.edu/dustdevil/*

19–22 Workshop on Oxygen in the Earliest Solar System, Gatlinburg, Tennessee. *http://www.lpi.usra.edu/meetings/ess2005/*

19–22 Remote Sensing Europe 2005, Bruges, Belgium. *http://spie.org/conferences/programs/05/ers/*

21–23 European Low Gravity Research Association Biennial Meeting and General Assembly, Santorini, Greece. *http://www.elgra.org/Bulletin/Santorini-2005/Meeting_2005.htm*

26–30 **Workshop on Dust in Planetary Systems**, Kaua'i, Hawai'i. *http://www.lpi.usra.edu/meetings/dust2005/*

26–30 **The X-Ray Universe 2005**, Madrid, Spain. *http://www.congrex.nl/05a11/*

27–28 **13th Annual Mapping, Imaging, GPS and GIS User's Conference "Standards in the Evolving Geospatial World,"** Silver Spring, Maryland. *http://www.asprspotomac.org/geotech05/*

October

3–7 **Direct Imaging of Exoplanets: Science Techniques**, Nice, France. *http://pleiades.unice.fr/colloqueUAI/*

4–6 **Strategic Space**, Omaha, Nebraska. *http://www.stratspace.org/information/index.cfm*

9–15 **XIX Planetary Congress: Our Destiny in Space: Worlds Without Borders**, Salt Lake City, Utah. *http://www.space-explorers.org/congress/congress.html*

10–12 **5th European Workshop on Astrobiology**, Budapest, Hungary. *http://www.mbft.hu/eana/index.html*

11–13 **Low-Cost Planetary Missions**, Kyoto, Japan. *http://iclcpm2005.isas.jaxa.jp/*

16–18 **Frank N. Bash Symposium 2005: New Horizons in Astronomy**, Austin, Texas. *http://www.as.utexas.edu/new_horizons/*

16–19 **56th International Astronomical Congress**, Fukuoka, Japan. *http://www.iac2005.org/welcome/index.html*

16–19 **2005 Geological Society of America Annual Meeting**, Salt Lake City, Utah. *http://www.geosociety.org/meetings/2005/*

16–21 **Solar and Space Physics and the Vision for Space Exploration**, Wintergreen Resort, Virginia. *http://hesperia.gsfc.nasa.gov/sspvse*

17–19 **The 9th International Symposium on Physical Measurements and Signatures in Remote Sensing (ISPMSRS)**, Beijing, China. *http://www.ewh.ieee.org/soc/grss/meeting18.html*

17–21 **International Council for Science 28th General Assembly**, Suzhou and Shanghai,China. *http://www.icsu.org/*

17–21 **56th International Astronautical Congress**, Fukuoka, Japan. *http://www.iac2005.org/welcome/index.html*

17–21 **Extrasolar Planetary Systems**, Bad Honnef, Germany. *http://www.mpia-hd.mpg.de/EXTRA2005/*

21–23 **European Low Gravity Research Association Biennial Meeting and General Assembly**, Santorini, Greece. *http://www.elgra.orgBulletin/Santorini-2005/Meeting_2005.htm*

23–27 **Pecora 16: Global Priorities in Land Remote Sensing**, Sioux Falls, South Dakota. *http://www.asprs.org/pecora16/*

24–28 **Protostars and Planets V**, Waikoloa, Hawai'i. *http://www.lpi.usra.edu/meetings/ppv2005/*

25–28 **Space Resources Roundtable VII: LEAG Conference on Lunar Exploration**, League City, Texas. *http://www.lpi.usra.edu/meetings/leag2005/*

November

2–3 **Mars Exploration Program Analysis Group (MEPAG) Meeting**, Monrovia, California. *http://mepag.jpl.nasa.gov/meeting/nov-05/index.html*

2–4 **World Scientific & Engineering Academy & Society**, Venice, Italy. *http://www.worldses.org/conferences/2005/venice/remote/index.html*

2–5 **Annual Applied Geography Conference**, Washington, DC. *http://appliedgeog.org/html/main.htm*

7–11 **Relativistic Astrophysics and Cosmology**, Munich, Germany. *http://www.mpe.mpg.de/~e05*

8–10 **2005 Core Technologies for Space Systems**, Colorado Springs, Colorado. *http://www.spacecoretech.org/*

10–12 **World Science Forum**, Budapest, Hungary. *http://www.sciforum.hu/*

14–18 **The 2nd European Space Weather Week**, Noordwijk, The Netherlands. *http://www.estec.esa.nl/wmwww/wma/events.html*

15–17 **Florida Space 2005**, Kennedy Space Center, Florida. *http://www.floridaspace.org/*

22–24 **4th International Symposium on Geophysics ISPG-4**, Tanta, Egypt. *http://www.tanta.edu.eg/EN/isg.htm*

December

5–9 **AGU Fall Meeting**, San Francisco,California. *http://www.agu.org/meetings/fm05/*

7–9 **Annual Convention and Meeting on Earth System Processes Related to Earthquakes and Tsunamis and Volcanic Eruptions**, Hyderabad, India. *http://www.igu.in/schedule.htm*

16 **GRSG Annual Meeting: Advances in Geological Remote Sensing**, London, England. *http://www.grsg.org/meeting.html*

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	C-RSPECTG	ALTA REFLECTANCE SPECTROMETER CLASSROOM LESSONS **(CD-ROM)**	$5.00	
	C-CLA	CONSOLIDATED LUNAR ATLAS **(CD-ROM)**	$10.00	
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