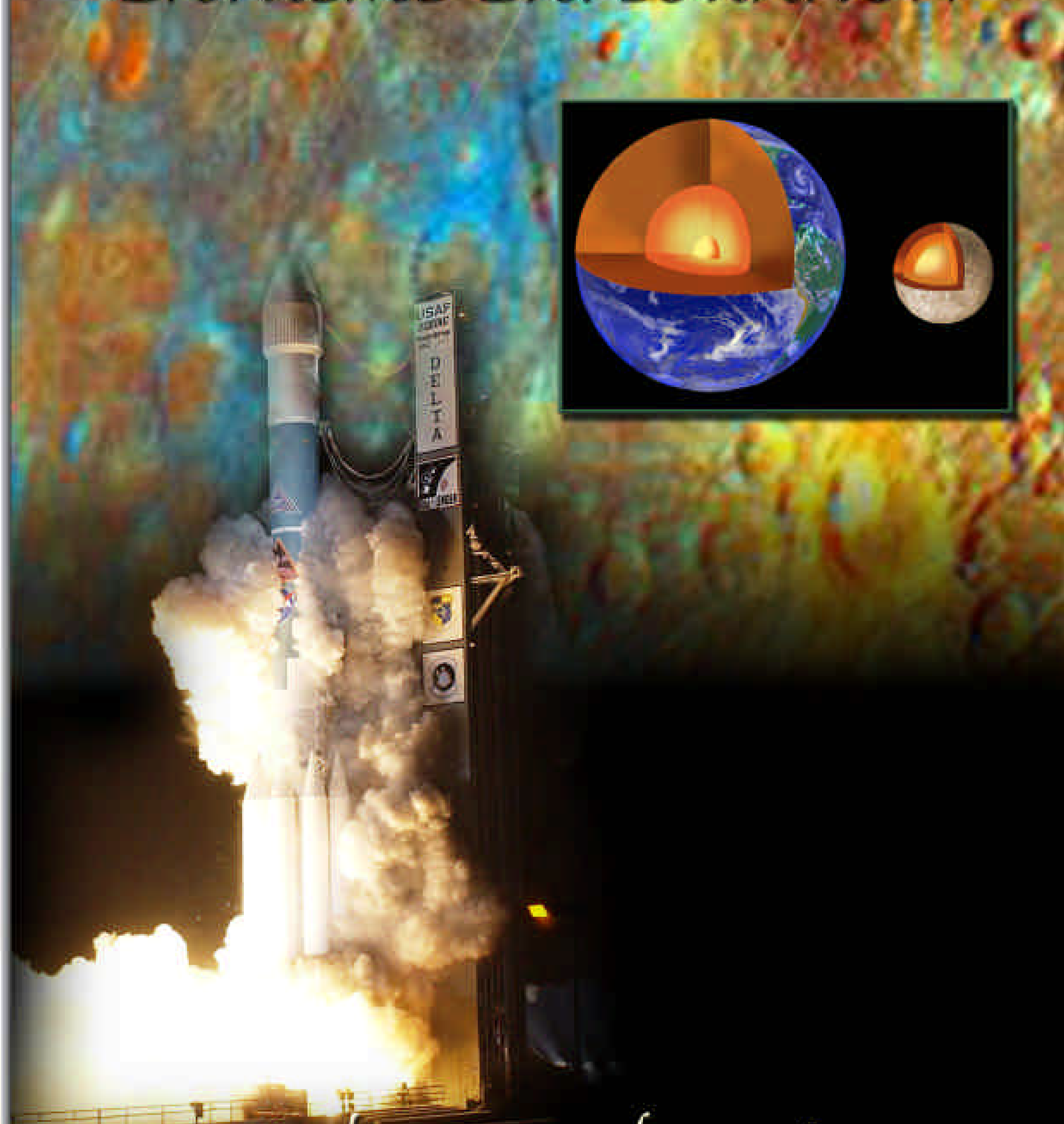
MESSENGER
Extreme Exploration



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MESSENGER
Extreme Exploration

— Deborah Domingue, MESSENGER Deputy Project Scientist,
Johns Hopkins University Applied Physics Laboratory

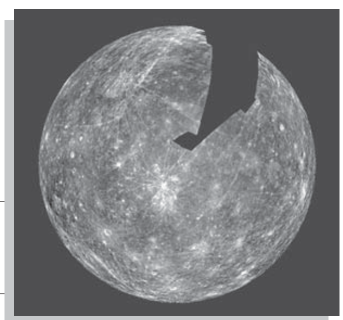
The first half of 2004 has been an exciting time for planetary exploration with the successful encounter and sampling of Comet Wild 2 by Stardust, the landing of two Mars rovers, orbital operations at Mars by three spacecraft, and the arrival of Cassini at Saturn. This month we wished "Bon Voyage" to the MESSENGER spacecraft, which successfully launched from Cape Canaveral on August 3, 2004, and began its journey to the innermost planet of our solar system, Mercury. MESSENGER is a MEcury Surface, Space ENvironment, GEochemistry, and Ranging mission that will orbit Mercury for one Earth year (beginning in March 2011) following three flybys (in January and September 2008 and October 2009) of the planet. It will be our first return to Mercury in over 30 years! The Mariner 10 spacecraft flew past Mercury three times in 1974 and 1975 and collected information on less than half the planet. MESSENGER will provide the first global map of Mercury, in addition to detailed information on the composition and structure of Mercury's crust, its geologic history, the nature of Mercury's thin exosphere and dynamic magnetosphere, and the makeup of its core and polar materials.

Mercury: A Place of Extremes

Mercury, the planet closest to the Sun, has a highly elliptical orbit such that its distance from the Sun ranges from 46 million kilometers (29 million miles) to 70 million kilometers (43 million miles). Because of its slow rotation, Mercury's day (sunrise to sunrise) actually lasts two Mercury years (88 Earth days of dark and 88 Earth days of daylight). As a result, temperatures on the surface range from 420ºC (800ºF) to below –180ºC (–300ºF). These temperatures are high enough to melt zinc (and lead) and low enough to freeze carbon dioxide and methane! Mercury resides deep in the Sun's gravity well and because of its proximity to the Sun has a higher exposure to its radiation environment. Polar regions may be impacted by the solar wind. Without a thick atmosphere such as those on Venus and Earth, the surface of Mercury is exposed to the radiative effects of sunlight at all wavelengths.

Mariner 10: Initial Science from an Extreme Environment

Using a relatively primitive television camera, Mariner 10 imaged about 45% of Mercury's surface and revealed a heavily cratered world superficially similar to the lunar highlands, as well as a relatively young, enormous impact basin (Caloris Basin, ~1300 kilometers in diameter). This basin is so large that it may reveal rocks from the lower crust or perhaps even the crust-mantle boundary, giving MESSENGER's instruments the possibility of probing the interior.



Mosaic of Mercury as seen by Mariner 10, the only spacecraft to visit Mercury. Mariner 10 flew past Mercury three times in 1974–1975, imaging about 45% of the planet at what we would now consider fairly coarse resolution. Photo courtesy of NASA/JPL/Northwestern University.

Also seen on Mercury were mysterious deposits of smooth, lightly cratered plains reminiscent of the Moon's maria, with one important difference: They are not dark like their lunar counterparts. These smooth deposits appear to be volcanic in nature, similar to lunar maria; however, they probably have a composition that varies significantly from the lunar maria. They may have formed from a magma deficient in iron relative to basalts found on the Moon, Earth, and Mars. The Mariner 10 images also showed the presence of long, sinuous cliffs and scarps that cross the surface for hundreds of kilometers. These cliffs and scarps are believed to be the surface expression of the cooling and subsequent contraction of the planet's interior. MESSENGER will complete the global map of all these features.

The smooth plains shown in the lower right of the picture fill a 440-kilometer-diameter basin. The flooded craters on the floor of the basin and smooth texture indicate that these plains are volcanic. Photo courtesy of NASA/JPL/Northwestern University.

Images on Cover —

Background: *This image mosaic, derived from the Mariner 10 color image data, shows compositional variations. It highlights differences in opaque minerals (such as ilmenite), iron content, and soil maturity. Photo courtesy of NASA/JPL/Northwestern University.*

Lower left: *Against the clear, black sky, spotlights flood the MESSENGER spacecraft as it lifts off aboard a Boeing Delta II rocket on August 3, 2004. MESSENGER is on a seven-year journey to the planet Mercury. The spacecraft will fly by Earth, Venus, and Mercury several times to burn off energy before making its final approach to the inner planet on March 18, 2011. MESSENGER was built for NASA by The Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland. Photo courtesy of NASA.*

Upper right: *Scientists believe that Mercury's enormous iron core is greater than 75% of the planet's total radius — a much larger fraction than Earth's core. One as-yet-unanswered mystery is whether the outer part of Mercury's core is molten and if Mercury's global magnetic field arises from motions within such a fluid outer core. MESSENGER will make key measurements that address the size and state of the core and the origin of the magnetic field.*

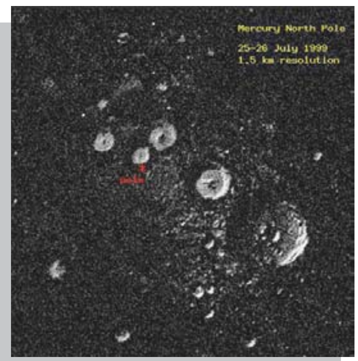
A surprising result from Mariner 10's magnetometer was the detection of a magnetic field. Although only ~1% as strong as Earth's field, these limited measurements suggest that it may be an internally generated dipole magnetic field. The only other terrestrial planet to possess such a dipolar field is Earth! In contrast, the Moon and Mars have only local magnetic fields that are considered relic, remanent fields. It is unclear how much of Mercury's magnetic field could be generated from remanent fields and how much is produced by active processes in the planet's core, as on Earth. The source of the magnetic field is one of Mercury's mysteries that MESSENGER will solve.

Another surprise was Mariner 10's detection of exospheric hydrogen, helium, and oxygen. The atoms in Mercury's tenuous exosphere do not collide with each other, but rather bounce from place to place on the surface (this is the definition of a surface-bounded exosphere). The pressure of Mercury's exosphere was determined to be about 10^{-12} bar.

The density of Mercury is 5.4 g/cm^3, which is comparable to Earth's density of 5.5 g/cm^3 (remember that water has a density of 1 g/cm^3). If you could magically suspend the laws of physics and release each planet's interior pressure, the minerals in the deep mantle and core would decompress, resulting in a larger and less-dense planet. If you take into consideration these effects, Mercury has an uncompressed density of 5.3 g/cm^3 compared to an average uncompressed density for Earth of 4.0 g/cm^3. Mercury's high uncompressed density implies that its interior is composed of at least 60% metallic iron by weight! As mentioned above, the large scarps are consistent with a planet that shrank as this large core cooled and solidified to some degree. Yet the magnetic field characteristics imply that part of the core could be liquid today. This is another of Mercury's intriguing mysteries!

Earth-Bound Insights: An Extremely Fascinating Mystery

What we have learned of Mercury in the past 30 years has been from groundbased telescopic and radar observations. One of the more exciting of the new discoveries is anomalously high radar backscatter on the floors and walls of polar craters, first detected in the 1990s. Some areas within polar craters are in permanent shadow and can act as "cold traps" for water molecules and other volatiles. Thermal modeling of the permanently shadowed areas show that many are cold enough to keep an insulated layer of water ice (a water layer covered with dust) stable, but not an exposed layer of water ice. Alternate interpretations of the polar deposits have included sulfur, either native to Mercury or brought in through meteoritic and micrometeoritic impacts, which is stable as a solid at higher temperatures than water ice. The composition of these radar anomalous materials is still a mystery. Understanding their composition and origin has implications for the origin and transport of volatile materials within the inner solar system.



This high-resolution radar image of Mercury's north polar region, obtained at Arecibo Observatory in Puerto Rico, shows several "bright" areas in the floors of very high-latitude craters. At radar wavelengths, these deposits match the characteristics of water ice. Photo courtesy of John Harmon, NAIC, Cornell University.

Ultraviolet observations have expanded our understanding of the constituents of Mercury's surface-bounded exosphere to include sodium, potassium, and calcium. Measurements of Mercury's exospheric sodium show that it is spatially and temporally variable, and that not all the variability is related to interactions with the solar environment. Sources for the known exospheric species include impact vaporization, ion sputtering, thermal and photon stimulated desorption, crustal outgassing, and neutralization of solar wind ions. The relative importance of these production mechanisms has been debated, but they predict the existence of several species (such as argon, silicon, aluminum, magnesium, iron, sulfur, and hydroxyl) that have yet to be detected.

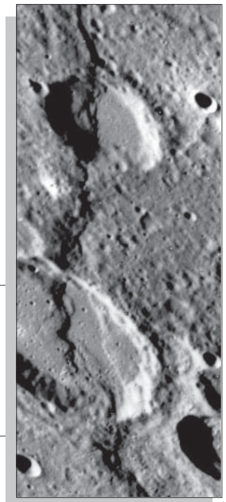
Infrared spectroscopic observations of Mercury have shown us a surface chemistry low in oxidized iron, possibly similar to large expanses of the lunar farside highlands. Interpretations of the telescopic spectra are complicated by the fact that Mercury experiences extreme space weathering. As micrometeorites impact an airless body (Mercury, Moon, asteroids), small portions of the surface melt, forming a glass rather than an orderly crystal structure and also converting iron oxide (Fe^{2+}) to iron metal. Both processes lower the albedo (brightness) of a surface and change its spectral reflectance, working to disguise the composition of the original rock. Thus our knowledge of Mercury's surface composition is very limited. The current consensus is that the surface contains 3–6 wt% iron oxide in a rock known as anorthosite. The Mariner 10 color images indicate that some compositional variations do exist within Mercury's crust. The smooth plains seem to have an unusual low-iron, low-silica composition, perhaps unique to Mercury. Other units include a relatively dark and blue unit that may be abundant in opaque minerals (perhaps ilmenite) and an enigmatic red and relatively bright unit. Until MESSENGER returns detailed compositional and mineralogic information, Mercury's crustal evolution history will remain a mystery.

MESSENGER: The Extreme Detective

The MESSENGER mission goals are to increase our understanding and comprehension of Mercury, as a planet and as a testbed for challenging our ideas on the nature and evolution of the terrestrial planets, especially our own world. The MESSENGER science payload will provide observations and data for answering six key science questions concerning this smallest member of the terrestrial planets.

Why is Mercury so dense? While the other terrestrial planets (Venus, Earth, and Mars) all have iron-rich cores surrounded by rocky mantles, only Mercury has a dense metallic core that comprises such a large percentage of its total mass (greater than 60%). Is this unusual bulk composition related to Mercury's proximity to the Sun? Some solar nebula condensation and accretion models of planetary formation predict that dense particles (such as iron) may be preferentially retained in the innermost regions of the solar nebula disk, leading to the formation of a metal-rich Mercury. Another suggestion is that a hot solar nebula during the early formation of Mercury vaporized part of the outer rock layer, leaving behind a metal-rich planet. Alternatively, a large protoplanet could have collided with Mercury soon after its formation and differentiation, removing most of its early crust and upper mantle. The key to solving this mystery lies in the mineral and elemental composition of surface materials.

What is Mercury's geologic history? There are many landforms and features on Mercury, such as the relatively "young" plains, scarps, and chaotic terrain, that are open to geologic interpretation. They all tell a piece of the story of the crust's history and Mercury's evolution. MESSENGER will map the entire surface at a much higher spatial resolution than seen by Mariner 10. In addition, it will use stereo imaging, altimetry, and the gravity field inferred from radio tracking to determine the thickness and structure of the crust. Coupled with the compositional information gathered by MESSENGER's spectrometers, a model of Mercury's crustal history will be created.



The Mariner 10 spacecraft took this image during its third and final encounter with Mercury in March 1975. The prominent scarp seen in this image is Discovery Rupes, thought to have been formed as the planet contracted due to cooling. Photo courtesy of NASA/JPL/Northwestern University.

What is the nature and origin of Mercury's magnetic field? On the basis of Mariner 10's surprising magnetometer measurements, Mercury's magnetic field appears to be dipolar (as is Earth's field). Earth's magnetic field is the result of a dynamo arising from convective motion in the molten outer core. Is this also the mechanism for generating Mercury's field? Or is the magnetic field on Mercury due to the remanent magnetization of the crust from a now-extinct early magnetic field, as is thought to be the case for the Moon and Mars? The magnetometer measurements onboard MESSENGER will measure the strength of Mercury's magnetic field and monitor how it varies with position, providing important clues for deciding among alternatives.

What is the structure of Mercury's core? If Mercury's core is pure iron, it should have solidified long ago, an event perhaps recorded by the large surface scarps formed as a result of the planet's contraction. A light element (e.g., sulfur) alloyed with iron, in contrast, would permit a fluid outer core to be present at least as a thin shell. MESSENGER will probe the interior of Mercury through measurements of its libration, gravity field, and rotational characteristics.

What are the unusual materials at Mercury's poles? Mercury's polar deposits pose two mysteries: (1) What is the material making up these deposits (suggestions have ranged from water ice to sulfur), and (2) where did the material come from? Could volatiles from comets and meteoroids have accumulated over time, or were the deposits formed from volatiles that seeped out from the interior and froze in these cold traps? It will be a challenge for MESSENGER to address these questions since the shadows that preserve these materials from the nearby solar inferno also make them invisible to many of MESSENGER's instruments. The gamma-ray and neutron spectrometers will potentially be sensitive to the elemental composition of these regions, and the ultraviolet and energetic particle spectrometers could also detect hydroxyl or sulfur emissions from the deposits. The shadowed areas in the polar craters are small relative to the field of view of the MESSENGER instruments, so detection and determination of the volatile material composition will be difficult if abundances are low.

What volatiles are important at Mercury? Of the six known elements within the exosphere, hydrogen and helium are thought to come from the solar wind. Oxygen, sodium, potassium, calcium, and some hydrogen are thought to originate from the rocks on the surface. Mercury's exospheric composition will be measured using the ultraviolet and energetic particle spectrometers onboard MESSENGER. Comparing these results with the surface elemental composition determined from the X-ray and gamma-ray measurements will provide evidence for the sources of these exospheric species.

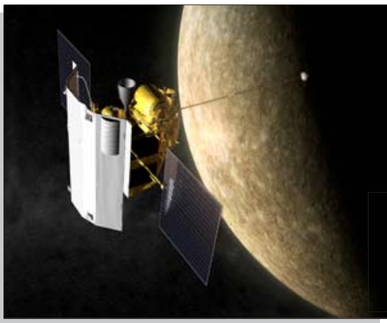
MESSENGER's Spacecraft: Challenging the Extremes

In order to answer these questions, a closer look from orbit is needed, which presents formidable technical obstacles. An orbiting spacecraft needs to withstand not only searing heat directly from the Sun, but also heat radiating from Mercury's daylit surface. MESSENGER also needs to be lightweight and compact. MESSENGER meets these challenges with an innovative design that includes a ceramic-fabric sunshade, heat radiators, and a mission design that limits time over the planet's hottest regions. The spacecraft's graphite composite structure makes it lightweight and heat tolerant, and its low-mass propulsion system efficiently stores and distributes ~600 kilograms (1323 pounds) of fuel. Behind the 2.5-meter (8-foot) by 2-meter (6-foot) sunshade, the wiring, electronics, subsystems, and instruments are packed into a small frame that could fit inside a large sport utility vehicle.

MESSENGER's Payload: The Science of Extremes

MESSENGER carries seven scientific instruments in addition to a radio science experiment. The Mercury Dual Imaging System (MDIS) has a wide-angle CCD camera that can observe Mercury through 12 filters ranging from the visible at 0.4 micrometers to the near-infrared at 1.1 micrometers. This system will enable MESSENGER to map compositional variations across its surface. MDIS also has a monochrome narrow-angle CCD camera that will provide images of features as small as 18 meters (~60 feet) across. MDIS will provide the first Mercury global map at a resolution ranging from 140 to 250 meters per picture element (pixel). Together both cameras will provide information for a detailed study of the geologic processes on and a history of Mercury's surface.

The visible-infrared spectrometer portion of the Mercury Atmospheric and Surface Composition Spectrometer (MASCS) will map the mineral composition of Mercury's surface based on measurements of reflected sunlight from 0.3 micrometers in the visible to 1.45 micrometers in the infrared at a spectral resolution of 4 nanometers. This sensor's spatial resolution on the surface will range from 100 to 7500 meters, depending on the spacecraft's altitude. This sensor will be able to determine if the surface contains minerals such as pyroxene, olivine, and ilmenite.



Artist's impression of the MESSENGER spacecraft in orbit at Mercury. In spite of Mercury's proximity to the Sun and surface temperatures that can reach above 420°C (800°F), MESSENGER's instruments will operate at room temperature behind a sunshade of heat-resistant ceramic fabric. Image courtesy of NASA/Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washington.

There are three spectrometer instruments within the science payload: an X-ray spectrometer (XRS), a gamma-ray and neutron spectrometer (GRNS), and the MASCS. The purpose of these instruments is to characterize the elemental and mineral composition of Mercury's surface and to further characterize the constituents within its exosphere. The XRS will map the elements (specifically magnesium, aluminum, silicon, sulfur, calcium, titanium, and iron) in the top millimeter of Mercury's crust. The gamma-ray and neutron spectrometers of the GRNS instrument also map the elemental composition of the surface, looking for geologically important elements such as hydrogen, magnesium, silicon, oxygen, iron, titanium, sodium, and calcium. Because the GRNS measures gamma-ray emission and thermal versus epithermal neutron emission, it can measure deeper into the surface (on the order of centimeters) than the XRS.

The ultraviolet-visible spectrometer sensor of MASCS will examine the composition and structure of Mercury's exosphere and its neutral gas emissions. Coupled with the information provided by the other spectrometers onboard the spacecraft, issues concerning the processes generating and maintaining the exosphere and the possible connection between the surface and exospheric compositions will be addressed.

MESSENGER's Magnetometer (MAG) will characterize the vector magnetic field in Mercury's vicinity, monitoring its strength and how it varies with position, altitude, and solar activity. These are all key observations needed to determine the geometry of the internal field and its implications concerning the planet's interior structure. The Energetic Particle and Plasma Spectrometer (EPPS) will examine the nature and characteristics of the charged particles in the magnetosphere and observe low-energy ions originating from the surface and exosphere.

The Mercury Laser Altimeter (MLA) will map the surface topography (providing information on geologic processes) and track Mercury's libration (which tells us about the state of the planet's core). Radio science tracking and ranging measurements will be used to map the planet's gravitational field, another key source of information for understanding the planet's interior.

With this battery of detective tools, MESSENGER is determined to reveal many of Mercury's mysteries, and perhaps discover a few more!

Suggested Reading Materials

Flight to Mercury by Bruce Murray and Eric Burgess, Columbia University Press, 1977 (ISBN 0-231-03996-4).

The Voyage of Mariner 10 by James A. Dunne and Eric Burgess, NASA SP-424, 1978 (QB621.D86 523.4'2 77-18956).

Mercury by Faith Vilas, Clark Chapman, and Mildred Shapley Matthews, University of Arizona Press, 1988 (ISBN 0-8165-1085-7).

Exploring Mercury by Robert Strom and Ann Sprague, Springer-Praxis Books, 2003 (ISBN 1-85233-731-1).

Mercury: The Elusive Planet by Robert Strom, Smithsonian Institution Press, Washington, DC, 1987 (ISBN 0-87474-892-5).

Suggested Web Sites

The MESSENGER Mission Site
http://messenger.jhuapl.edu

Mariner 10 Archive Project (Mark Robinson, Northwestern University)
http://cps.earth.northwestern.edu/merc.html

The SP-423 Atlas of Mercury On Line (NASA History Web Site)
http://history.nasa.gov/SP-423/mariner.htm

News from Space

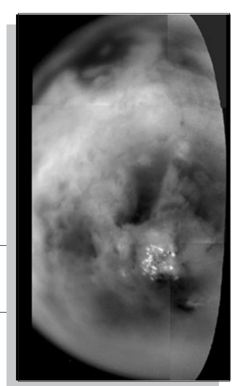
Cassini Arrivé!

Almost 23 years after Voyager last glimpsed Saturn back in 1981 on its way to mysterious Uranus and Neptune, Cassini arrived at Saturn on July 1, 2004, after a seven-year journey, fired its braking rocket, and entered orbit about the fabled ringed planet. The giant spacecraft is the largest planetary spacecraft built to date and is a joint project of NASA, the European Space Agency (ESA), and the Italian Space Agency. Bustling with 18 instruments, Cassini will spend at least the next four years studying the planet, rings, and multiple satellites in great detail. Orbit insertion early on July 1 could not have been more spectacular. Cassini passed over the top of Saturn's ring system and acquired some of the highest-resolution images ever taken. These images show ripples and waves within the rings that will take scientists years to analyze.

Passing over the rings during the engine burn to move into orbit, Cassini got a "bird's-eye" view of the absolutely fabulous ring system. This detailed view shows ripples along the edge of the Encke Gap, and shows details less than 10 kilometers (6.2 miles) across.

On approach to Saturn, Cassini got a close look at one of Saturn's outer moons, Phoebe. Passing within 2000 kilometers (1243 miles) on June 11, Cassini saw a heavily cratered but icy object, thought to be a captured asteroid from the region beyond Neptune.

Cassini will periodically examine and map most of Saturn's major moons. First up is Cassini's best look at two-faced Iapetus, with its mysterious charcoal black hemisphere. Equally exciting are several passes by tiny Enceladus, a moon that is volcanic but shouldn't be. Perhaps the biggest prize anticipated from Cassini (as described in the May 2004 issue of the *Bulletin*) is a detailed examination of the smog-shrouded moon Titan. The second-largest moon in the solar system, Titan is also the only one with a substantial atmosphere. Voyager saw only smog and the faintest of markings, but it also confirmed that the atmosphere is mostly nitrogen, with substantial amounts of methane and complex hydrocarbons. Titan's atmosphere could have similarities to Earth's very early atmosphere. At least 40 close passes of Titan are expected during the next four years, and Cassini will probe the surface with cameras and radar instruments over many wavelengths. The first of these close passes, at an altitude of roughly 1200 kilometers (746 miles), occurs on October 26 of this year, in preparation for release of the Huygens atmospheric probe scheduled to drop into Titan's atmosphere in early January 2005. Cassini got a sneak peak at Titan on July 2 from 300,000 kilometers (186,420 miles), shortly after orbit insertion. It showed a world of murky bright and dark markings, their nature and origins still a complete mystery. VIMS, one of the Cassini cameras that can see in the infrared, also detected what appear to be ices and organic material on the surface. As can be seen in the timetable on the next page, this winter's encounters with Titan are just the beginning of a very busy four-year tour for Cassini.



Cassini's first view of Titan shows mysterious wispy surface markings, but also a cluster of bright methane clouds near the south pole.

For more about the Cassini mission, visit the Cassini Web site at **http://saturn.jpl.nasa.gov/home/index.cfm.**

CASSINI'S MISSION PLAN

Orbit	Date	Event	Altitude (km)
0	2004 Jun 11	**Phoebe**	2000
	2004 Jul 01	**Titan** (T0)	300000
	2004 Jul 01	Saturn	78 400
A	2004 Oct 26	**Titan** (Ta)	1200
B	2004 Dec 13	**Titan** (Tb)	2360
	2004 Dec 25	*Huygens* release	
	2005 Jan 01	**Iapetus**	65000
C	2005 Jan 14	**Titan**	60000
	2005 Jan 14	*Huygens* descent	
3	2005 Feb 15	**Titan** (T3)	950
	2005 Feb 17	**Enceladus**	1180
4	2005 Mar 09	**Enceladus**	500
5	2005 Mar 31	**Titan** (T4)	2520
6	2005 Apr 16	**Titan** (T5)	950
7	2005 May 03	Saturn	217 000
8	2005 May 21	Saturn	217 000
9	2005 Jun 08	Saturn	217 000
10	2005 Jun 26	Saturn	217 000
11	2005 Jul 14	**Enceladus**	1000
12	2005 Aug 02	**Mimas**	45100
13	2005 Aug 22	**Titan** (T6)	4020
14	2005 Sep 07	**Titan** (T7)	950
15	2005 Sep 24	**Tethys**	33000
15	2005 Sep 26	**Hyperion**	990
16	2005 Oct 11	**Dione**	500
17	2005 Oct 28	**Titan** (T8)	450
18	2005 Nov 26	**Rhea**	500
19	2005 Dec 26	**Titan** (T9)	10400
20	2006 Jan 16	**Titan** (T10)	2040
21	2006 Feb 27	**Titan** (T11)	1810
22	2006 Mar 18	**Titan** (T12)	1950
23	2006 Apr 30	**Titan** (T13)	1850
24	2006 May 20	**Titan** (T14)	1880
25	2006 Jul 02	**Titan** (T15)	1910
26	2006 Jul 22	**Titan** (T16)	950
27	2006 Aug 16	Saturn	253 000
28	2006 Sep 07	**Titan** (T17)	950
29	2006 Sep 23	**Titan** (T18)	950
30	2006 Oct 09	**Titan** (T19)	950
31	2006 Oct 25	**Titan** (T20)	950
32	2006 Nov 09	Saturn	284 000
33	2006 Nov 20	Saturn	284 000
34	2006 Dec 02	Saturn	284 000
35	2006 Dec 12	**Titan** (T21)	950
36	2006 Dec 28	**Titan** (T22)	950
37	2007 Jan 13	**Titan** (T23)	950
38	2007 Jan 29	**Titan** (T24)	2780
39	2007 Feb 22	**Titan** (T25)	953
40	2007 Mar 10	**Titan** (T26)	956
41	2007 Mar 26	**Titan** (T27)	953
42	2007 Apr 10	**Titan** (T28)	951
43	2007 Apr 26	**Titan** (T29)	951
44	2007 May 12	**Titan** (T30)	950
45	2007 May 18	**Titan** (T31)	2430
46	2007 Jun 13	**Titan** (T32)	950
47	2007 Jun 27	**Tethys**	16200
	2007 Jun 29	**Titan** (T33)	1940
48	2007 Jun 19	**Titan** (T34)	1300
49	2007 Aug 30	**Rhea**	5100
	2007 Aug 31	**Titan** (T35)	3230
	2007 Sep 10	**Iapetus**	1000
50	2007 Oct 02	**Titan** (T36)	950
51	2007 Oct 24	Saturn	229 000
52	2007 Nov 19	**Titan** (T37)	950
53	2007 Dec 05	**Titan** (T38)	1300
54	2007 Dec 20	**Titan** (T39)	953
55	2008 Jan 05	**Titan** (T40)	949
56	2008 Jan 15	Saturn	199 000
57	2008 Jan 27	Saturn	199 000
58	2008 Feb 08	Saturn	193 000
59	2008 Feb 22	**Titan** (T41)	959
60	2008 Mar 03	Saturn	223 000
61	2008 Mar 12	**Enceladus**	995
62	2008 Mar 25	**Titan** (T42)	950
63	2008 Apr 01	Saturn	260 000
64	2008 Apr 11	Saturn	260 000
65	2008 Apr 20	Saturn	260 000
66	2008 Apr 30	Saturn	260 000
67	2008 May 12	**Titan** (T43)	950
68	2008 May 17	Saturn	199 000
69	2008 May 28	**Titan** (T44)	1320

Bold indicates scheduled close encounters with major satellites.

Resources for Researchers

Classic Lunar Science Resources in Digital Format

When you think of classic lunar science resources such as Apollo and Lunar Orbiter film products or pre-Apollo maps and charts, you might assume they are all stored away in archived collections — difficult to access, peruse, and study. Thanks to the efforts of the U.S. Geological Survey (USGS), the Northwestern University Center for Planetary Science, and the Lunar and Planetary Institute (LPI), many of these valuable research tools are now available on line and in DVD or CD-ROM format. These exciting new digital projects are providing expanded access to important data for researchers, students, and the general public.

Lunar Orbiter Digitization Project

http://astrogeology.usgs.gov/Projects/LunarOrbiterDigitization/

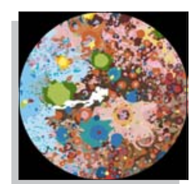
The Lunar Orbiter (LO) Project was initiated in the 1960s to provide vital information about potential landing sites for the Apollo program. The first three Lunar Orbiter missions were so successful that the remaining two missions were devoted to a general survey of the Moon and special sites of interest. The lunar imagery from these missions is the best global survey of the Moon to date, but has previously only been available in film format. The Lunar Orbiter Digitization Project is an effort to digitize, archive, and process a subset of the Lunar Orbiter photographic data, which will result in a global, cartographically accurate, cosmetically enhanced digital photographic mosaic of the Moon. The mosaic will be co-registered to the Clementine 750-nanometer global mosaic. As each frame is produced, constructed LO frames from the global product are being made available at 100-micrometer resolution through this Web interface. Concurrent with the global project effort is the task of digitizing and archiving many of the nearside, low-altitude photographs. Lunar Orbiter III photographed areas primarily to locate and confirm suitable landing sites for the Apollo program. The most promising landing sites were certified during Lunar Orbiter V, which also provided images of a number of sites of scientific interest. Ground resolutions for both datasets ranged from 1 to 40 meters.

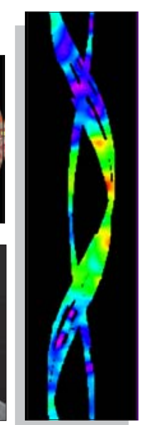
For information about the frame construction status and access to the currently available data, go to ***http://astrogeology.usgs.gov/Projects/LunarOrbiterDigitization/statusmaps.html***

Historical Lunar Data Archive: Lunar Images and Data from 1965 to 1992

http://astrogeology.usgs.gov/Projects/LunarConsortium/

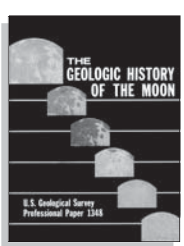
USGS has assembled a collection of data commonly referred to as the "Lunar Consortium Data," pre-Clementine data consisting of products derived from several lunar science missions as well as from Earth-based observations. This online resource includes lunar geology image files, Lunar Orbiter data and images, *Lunar Sourcebook* tables (reprinted with permission from Cambridge University Press), Galileo Solid State Imaging (SSI) Lunar Earth/Moon encounter data, Apollo mission data and topography, and Zond 8 images.





The Geologic History of the Moon

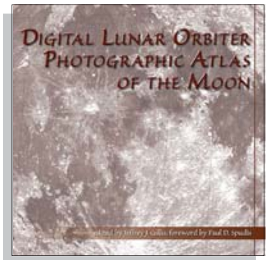
http://cps.earth.northwestern.edu/GHM/



The Geologic History of the Moon by Don E. Wilhelms is a benchmark reference for lunar geology. This volume, originally published in 1987 as USGS Professional Paper 1348, has long been out of print, but it is now available in digital format thanks to the efforts of the Northwestern University Center for Planetary Sciences. The staff at the Center for Planetary Sciences disassembled a copy of the book and scanned each page, color plate, and chapter cover page, completing production and final editing with Adobe Photoshop and Adobe Acrobat. This e-book is available to download in a single file or can be accessed on line chapter by chapter.

DIGITAL LUNAR ORBITER PHOTOGRAPHIC ATLAS OF THE MOON

http://www.lpi.usra.edu/research/lunar_orbiter/



Developed by the LPI, this updated online version of the venerable *Lunar Orbiter Photographic Atlas of the Moon* by David Bowker and Kenrick Hughes (NASA Special Publication 206) contains every plate from the book with enhanced search capabilities, including searches by photo number, feature name, or coordinate. The Web site also features farside feature names and annotated images to assist with the identification of the maria, craters, mons, and rimae. The Atlas is also available in DVD format from the LPI online store at ***https://www.lpi.usra.edu/store/products.cfm***

LUNAR MAP CATALOG

http://www.lpi.usra.edu/research/mapcatalog/

This digital catalog, produced by the LPI, provides access to a variety of lunar maps that have been out of print for many years. The charts and maps included on the website are Lunar Chart LPC-1, the Lunar Landing Site Chart, the Lunar Chart (LAC) series, and the Lunar Map (LM) series. The LAC maps, released between 1962 and 1967, used Earth-based photography as the base and source for topographic information; all 44 maps from this series are presented. The post-Apollo LM map series relied on orbital photography; although the series was to include a total of 144 maps, only 11 maps were produced before the series ended. The maps are presented in multiple resolutions. The entire collection of LAC and LM maps is also available in CD-ROM format from the LPI online store at ***https://www.lpi.usra.edu/store/products.cfm***

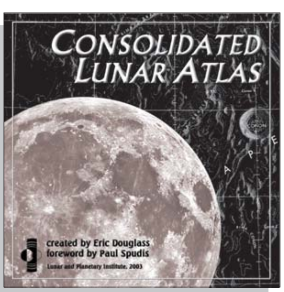
APOLLO IMAGE ATLAS

http://www.lpi.usra.edu/research/apollo/

After 32 years, NASA's Apollo Program (1961–1972) remains the pinnacle of human exploration. Through the efforts of engineering and scientific teams and courageous astronaut crews, and the dedication of the American public, the accomplishments of the Apollo program advanced human knowledge and stirred our collective imagination. The *Apollo Image Atlas*, digitally scanned from the LPI archives, features the 70-mm Hasselblad images from Apollo 4 and Apollo 6 through 17, along with the mapping (Metric) images from Apollo 15, 16, and 17. The image catalog can be browsed by each film roll or magazine or can be viewed as a slide show. The mapping camera images can be searched by feature name or coordinate. Panoramic images are currently being scanned and will be available by early 2005.

CONSOLIDATED LUNAR ATLAS

http://www.lpi.usra.edu/research/cla/



The *Consolidated Lunar Atlas* by Gerard Kuiper, Ewen Whitaker, Robert Strom, John Fountain, and Stephen Larson, which contains a collection of some of the best photographic images of the Moon, was published in 1967 for the Air Force Research Laboratories (Office of Aerospace Research) by the Lunar and Planetary Laboratory at the University of Arizona. Images were taken in two groups: non-full-Moon images were taken with the 61-inch NASA telescope at the Catalina Observatory, and full-Moon images were taken with the 61-inch U.S. Astrometric Telescope at the U.S. Naval Observatory. This digital rendition of the Atlas was created and edited by Eric J. Douglass and includes low-oblique and full-Moon images, plates in both tabular and positional presentations, thumbnail images of the entire collection, and the original *Consolidated Lunar Atlas* booklet. The *Consolidated Lunar Atlas* is also available in a set of two CD-ROMs from the LPI online store at ***https://www.lpi.usra.edu/store/products.cfm***

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.

Transit of Venus

Sun Earth Day 2004 celebrated the Transit of Venus on June 8, engaging the public in a once-in-a-lifetime viewing event. In just 40 hours, over 40 million Web hits pinged the Sun Earth Day Web site (***http://sunearthday.nasa.gov***). The media broadcast more than 1000 news reports and interviews over national, cable, and local television, inviting the public to participate. The Exploratorium Web casts of the event, viewed from the National Observatory of Greece outside Athens, are archived at ***http://www.exploratorium.edu/venus/index.html***. Activities and resources can be found through the Sun Earth Connection Education Forum and the Exploratorium Web site.

Educator Researcher Collaborative Project Grants Available

The SCORE (South Central Organization of Researchers and Educators) Broker/Facilitator program is offering a limited number of $1000 Educator Researcher Collaborative Project grants. These grants are intended to support small collaborative projects designed, developed, and implemented through new partnerships between OSS-funded space science researchers and educators in the states of Arizona, Kansas, Louisiana, New Mexico, Oklahoma, and Texas. The deadline for proposals is September 15, 2004. More information can be found at the SCORE Web site at ***http://www.lpi.usra.edu/education/score/collaborativeprojects.shtml***

New NOVA Series

On September 28 and 29, PBS will premier a four-part NOVA series entitled *Origins*. Produced by Tom Levenson and hosted by Dr. Neil deGrasse Tyson, director of the American Museum of Natural History's Rose Center and Hayden Planetarium, *Origins* will be the first major PBS project to explore the cutting-edge scientific story of the evolution of our universe as a living cosmos. More information can be found at ***http://www.pbs.org/wgbh/nova/origins***

Program One — "Birth of the Universe"

How did structure arise in the universe? How did the Big Bang cosmos develop into the cosmos we see today, in which galaxies dominate the visible sky and stars forge the chemical elements of life? The revolution in cosmological studies during the last decade has revealed that the basic parameters needed to generate that structure, and the habitat for life, were indeed begun by the Big Bang. Galaxies — vast cities of stars and planets — are the ultimate habitat for life; without them, nothing like ourselves could have emerged.

Program Two — "Home"

What is the origin of Earth, and what were the processes that set the stage for the most important origins event after the Big Bang: the moment when life arose out of non-living matter? Follow the evolution of the structured Earth, with core, mantle, and crust, through the period of bombardment that culminated in the cataclysmic formation of the Moon. Trace the critical stages in the transformation of Earth into potential habitat — exploring the formation of Earth's crust and then its oceans. With liquid water continuously present on Earth, and energy provided by violent volcanic activity, our still-barren planet became the place in which life first emerged.

Program Three — "An Unlikely Eden"

How did life first emerge on Earth? No final answer may be possible, but through genetic archaeology and laboratory experiments we are getting ever closer to demonstrating how the first life on Earth could have appeared. The program examines the evolution of complex lifeforms, ultimately humans. This is primarily the story of oxygen — produced by and poisonous to living cells. Oxygen was the catalyst that drove the Cambrian explosion of biological complexity and diversity. This new, complicated biosphere begs the question of whether our kind of intelligent life is an inevitable outcome of evolution. There are powerful arguments on both sides, but only one fact is certain: On Earth the evolution of life yielded only one species capable of looking up and out and asking where it all came from.

Program Four: "Are We Alone?"

Is life common in our universe? To find out, we explore the hunt for planets around other stars, along with the ambitious program of laboratory studies of the complex chemistry occurring within star-forming regions. But even if we establish that simple life exists elsewhere in the cosmos, the mystery remains: No one knows if technological intelligence is common, rare, or unique in the universe. Whatever we may find as a result of our ongoing search — whether it be simple life only, or, stunningly, cosmic kin to our own consciousness, or, perhaps most humbling, a cosmic desert — we will have completed humankind's most profound journey of discovery and self-discovery.

Educational materials to support *Origins* program content for teachers and students will be posted on the NOVA Web site and will be available through the Pacific Science Center (***http://www.pacsci.org/default.html***). The Pacific Science Center will coordinate educational programs with 10 partner museums across the nation. Activities will focus on electromagnetic energy and how scientists use it to enhance understanding of objects beyond Earth, as well as the fossil record available to scientists and how it is used to tell us what we know about the history of Earth and life on Earth. The partnering museums will host events to bring together scientists, community-based organizations, educators, students, and the public to immerse them in a wide variety of experiences, from stargazing and demonstrations to enrichment classes about the future of astronomy and space science research.

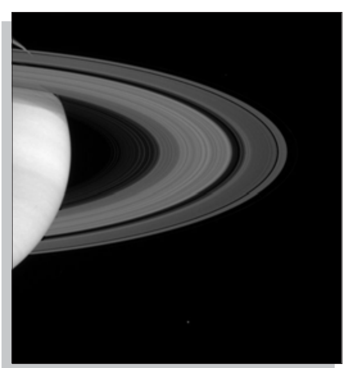
MISSIONS IN THE NEWS

Genesis

On September 8, 2004, the Genesis sample return capsule will return to Earth to be captured in mid-air above the Utah Test and Training Range. Launched in 2001 to acquire samples of the solar wind, the Genesis mission (***http://www.genesismission.org/***) will help scientists learn more about what the Sun is made of and conditions in the early solar system. A series of online middle- and high-school education modules support the Genesis mission. Prepared for classroom teachers, the modules are designed to be inserted in place of traditional units within a typical secondary school science curriculum. Materials include online lesson plans, teacher guides and student activities, suggested assessments, and lists of additional resources and references. Modules explore the design process of collecting and analyzing solar particles, cosmic chemistry aspects of elements in our solar system and planetary diversity, and other Genesis-based topics.

Cassini

Phoebe, June 13, 2004
NASA/JPL/Space Science Institute



Rings and Moons of Saturn, June 21, 2004
NASA/JPL/Space Science Institute

On July 1, 2004, the Cassini-Huygens spacecraft fired its main engine, reduced its speed, and was captured by Saturn's gravity to begin its four-year exploration of Saturn, its moons, rings, and magnetic environment.

The Cassini-Huygens Education Program offers a variety of educational materials for different grade levels:

The K–4 Program ***http://saturn.jpl.nasa.gov/education/edu-k4.cfm*** utilizes the planet Saturn and the Cassini-Huygens mission as a model in primary reading and writing, encouraging young students to develop an interest in scientific exploration and discovery.

The 5–8 Program ***http://saturn.jpl.nasa.gov/education/edu-58.cfm*** focuses on interdisciplinary learning, integrating science, math, language, fine arts, and social studies. Existing Saturn educational resources are utilized, such as the lesson plans, content, and resources of the Saturn Educator Guide (***http://saturn.jpl.nasa.gov/education/edu-58-guide.cfm***).

The 9–12 Program ***http://saturn.jpl.nasa.gov/education/edu-912.cfm*** is being designed to focus on data use in the classroom, modeling in-depth investigations and the scientific methods used in the mission. Elements of engineering, physics, chemistry, and astronomy will be incorporated into the materials.

NIGHT SKY NETWORK

The Night Sky Network, a partnership of amateur astronomy clubs, NASA, the Astronomical Society of the Pacific, and the Astronomical League, invites astronomy clubs to join the Network! The Network shares the science, technology, and inspiration of NASA's missions with the general public. It offers amateur astronomy clubs materials; training in public communication, NASA mission science, and materials use; and access to a community of amateur astronomers conducting public outreach. Member clubs of the Night Sky Network share time and telescopes to create unique astronomy experiences at science museums, observatories, classrooms, and under the night sky. Clubs with 15 or more members are encouraged to apply. More information can be found at ***http://nightsky.jpl.nasa.gov/***.

Interested in becoming more involved in space science education and public outreach? NASA's OSS 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://spacescience.nasa.gov/education/index.htm***

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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 **October 1, 2004**. Articles or announcements should be submitted via e-mail to **lpibed@lpi.usra.edu**

To be added to the mailing list to receive notification of future issues, please send your address (along with phone, fax, and e-mail), to LPIB Editor, 3600 Bay Area Boulevard, Houston TX 77058-1113, USA, or send an e-mail message to ***lpibed@lpi.usra.edu***

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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.

Dr. Paul Schenk,
Scientific Editor (schenk@lpi.usra.edu)
Renée Dotson,
Production Editor (dotson@lpi.usra.edu)

MILESTONES

THOMAS GOLD, CORNELL ASTRONOMER, DIES AT 84

Thomas “Tommy” Gold, a brilliant and controversial figure in twentieth century science and professor emeritus of astronomy at Cornell University, died June 22, 2004, after a long battle with heart disease. He was 84 years old. Gold’s reputation as a Renaissance man was surpassed only by his penchant for unconventional theories—from the origin of the universe to the source of petroleum. Few scientists ever attempt what Gold made a career of, staking their reputations on ideas that radically challenge the methods and assumptions of an entire discipline. Famous for stirring up conflict and controversy, Gold was variously described as a “gadfly,” a “maverick,” and a “world-class contrarian.” Gold, however, saw his departures from conventional wisdom as simply doing his job as a scientist. Gold received many professional honors during his career, including election to the National Academy of Sciences and fellowships in the Royal Society (the British scientific academy) and the American Academy of Arts and Sciences. He also served on the President’s Science Advisory Committee. *Photo courtesy of Cornell University.*

MCCANTA AWARDED UREY FELLOWSHIP

The Universities Space Research Association’s Lunar and Planetary Institute (LPI) in Houston, Texas, announces that Dr. Molly McCanta is the first awardee under its new Urey Fellows program. This prestigious program is aimed at the postdoctoral level and recognizes excellence in research for scientists within five years of completion of the Ph.D. McCanta will conduct research in the general area of experimental and analytical igneous petrology of terrestrial and extraterrestrial materials, and will contribute to the general research effort associated with the Oxygen in the Solar System initiative currently sponsored by the LPI.

DIVISION OF PLANETARY SCIENCES NAMES 2004 AWARD RECIPIENTS

The Division of Planetary Sciences (DPS) of the American Astronomical Society is the largest organization of professional planetary scientists in the world. The following award recipients have been announced for 2004:

The Gerard P. Kuiper Prize has been awarded to Dr. Carlé M. Pieters of Brown University. The Kuiper Prize recognizes and honors an active researcher who is a member of the DPS for their outstanding contributions to planetary science. It is awarded to scientists whose achievements have most advanced our understanding of the planetary system. Pieters has dedicated herself, through a wide range of laboratory and telescopic studies, to the establishment of a rigorous basis for the physical reasons behind the behavior of reflected light from a wide variety of planetary surfaces. Her work has been fundamental to understanding the mineralogical diversity and surface alteration processes for the Moon and asteroids.

The Harold C. Urey Prize has been awarded to Dr. Jean-Luc Margot of Cornell University. The Urey Prize recognizes and encourages outstanding achievements in planetary science by a young scientist. Margot is recognized for his broad-ranging studies of solar system binary objects, planetary spin states, and water ice on the surface of the Moon, using ground- and space-based telescopes sensitive at radio, infrared, and optical wavelengths. Margot has discovered and characterized binary systems from near-Earth space to the Kuiper belt. His high-precision measurements of the spin states of Mercury and Venus are yielding important information about the interiors of those planets.

Dr. David Morrison of the NASA Ames Research Center has been awarded the 2004 Carl Sagan Medal. The Sagan Medal is awarded to an active researcher in the DPS for long-term excellence in the communication of planetary science to the public. Throughout his scientific career as an expert on solar system small bodies and as an investigator for numerous spacecraft missions, Morrison has enthusiastically dedicated himself to sharing the excitement of planetary exploration with the public. He has been instrumental in illuminating the scientific basis for potential hazards due to asteroid and comet impacts.

The Harold Masursky Award has been awarded to Dr. Alexander Basilevsky, Director of the Laboratory of Comparative Planetology at the Vernadsky Institute in Moscow, Russia. The Masursky Award recognizes and honors individuals who have rendered outstanding service to planetary science and exploration through engineering, managerial, programmatic, or public service activities. As scientific colleagues and close personal friends during the Cold War era, Drs. Basilevsky and Masursky were together responsible for establishing some of the most basic and productive interactions between planetary scientists of the Soviet Union and those of the United States and Western Europe. As a leading expert in the study of cratering processes and planetary geology for the Moon, Mars, and Venus, Basilevsky was a natural Soviet scientific counterpart to Masursky. Basilevsky’s detailed involvement and pushing of a scientific agenda in all Soviet lunar and planetary missions was a major factor in inserting science into otherwise political and engineering missions.

NEW AND NOTEWORTHY

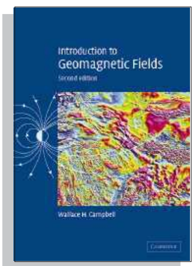
These products are available from booksellers or the publisher listed.
Please note that the LPI does not offer these products through its Order Department.

BOOKS

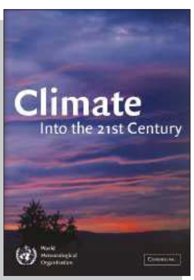
Dynamic Sun. Edited by B. N. Dwivedi. Cambridge University Press, 2003. 462 pp., Hardcover, $95.00. ***www.cup.org***

Dynamic Sun presents a comprehensive and authoritative overview of the Sun, from its deep core to the outer corona, and the solar wind. Chapters are written by leading scientists in solar physics and deal with solar models and neutrinos, seismic Sun, rotation of the solar interior, helioseismic tomography, solar dynamo, spectropolarimetry, solar photosphere and convection, dynamics and heating of the solar chromosphere, and solar transition region. With an introduction by eminent astrophysicist Eugene Parker, the 20 chapters are fully illustrated and have comprehensive reference lists.

Introduction to Geomagnetic Fields, 2nd edition. By Wallace H. Campbell. Cambridge University Press, 2003. 350 pp., Hardcover, $100.00. ***www.cup.org***



This second edition of a textbook for advanced undergraduate and graduate students of geophysics reflects the most recent research on the natural magnetic fields in and surrounding Earth arising from a variety of electric currents. Readers are introduced to the instrumentation for measuring geomagnetic fields and the applications of these techniques. Designed for use in a semester course, the volume includes student exercises at the end of each chapter.



Climate: Into the 21st Century. Edited by William Burroughs. Cambridge University Press, 2003. 240 pp., Hardcover, $35.00. ***www.cup.org***

Compiled by an international team formed under the auspices of the World Meteorological Organization (WMO), *Climate: Into the 21st Century* features a collection of essays by the world's leading meteorological experts. These fully integrated contributions provide a perspective of the global climate system across the twentieth century and describe some of the most arresting and extreme climatic events and their effects that have occurred during that time. The book also traces the development of our capabilities to observe and monitor the climate system and outlines our understanding of the predictability of climate on timescales of months and longer. It concludes with a summary of the prospects for applying the twentieth-century climate experience in order to benefit society in the twenty-first century.

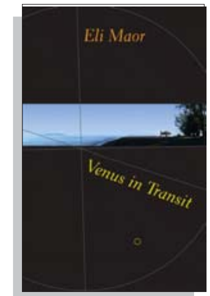
Mars Expedition Planning: Proceedings of the Martian Expedition Planning Symposium of the British Interplanetary Society (held February 24, 2003, London, England, plus additional invited papers). Edited by Charles S. Cockell. Univelt Incorporated, 2004. 518 pp. and CD-ROM, Paperback, $65.00. ***www.univelt.com***

This volume brings together perspectives of Earth and Mars explorers to consider the surface of Mars from the explorer's viewpoint. A starting assumption is made that there is already a base on Mars that can support expeditions. The authors describe how they would plan expeditions across Mars, including environmental, psychological, and scientific factors that would influence these expeditions. This book, as well as presenting new ideas on the planning of expeditions to Mars, can also be regarded as a field guide for future Mars explorers. It provides some of the foundation knowledge for planning expeditions to the martian volcanos, poles, deserts, and caves.

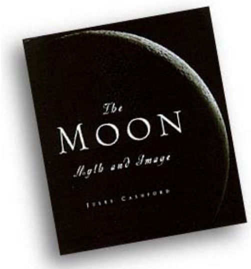
Space Science. Edited by Louise K. Harra and Keith O. Mason. Imperial College Press, 2004. 528 pp., Paperback, $42.00. ***www.icpress.co.uk***

This introduction to space science brings together the various space science disciplines in one volume to benefit a wide audience, particularly students starting their graduate studies. The text presents a unique outlook and will encourage students of space science to think in broad terms across a variety of topics, from Earth's climate system to cosmology. There are also chapters describing basic techniques necessary to progress in space science research. *Space Science* is a useful text for undergraduates, graduate students, and researchers in astronomy, astrophysics, and cosmology.

Venus in Transit. By Eli Maor. Princeton University Press, 2004. 240 pp., Paperback, $17.95. ***www.pupress.princeton.edu***



On June 8, 2004, Venus crossed the Sun's face for the first time since 1882. Eli Maor tells the tale of the five Venus transits previously observed and the fantastic efforts made to record them. This is a story of scientific reputations earned and squandered, told against a backdrop of geopolitical and scientific change. Maor presents historical accounts of the work of astronomers Johannes Kepler, Jeremiah Horrocks, Le Gentil, David Rittenhouse, and Maximilian Hell, as well as others. Throughout, Maor guides readers to the Venus transits in 2004 and 2012, opportunities to witness a phenomenon seen by no living person and not to be repeated until 2117.



The Moon: Myth and Image. By Jules Cashford. Four Walls Eight Windows, 2003. 372 pp., Hardback, $25.95. ***www.4w8w.com***
With its subtle light illuminating the night sky, the Moon has always been an object of fascination for humanity. The earliest record of the Moon and her cycles is attributed to humans in the Paleolithic age, when it was used to measure lengths of time greater than 24 hours. Author Jules Cashford explores the myths, symbols, and poetic images of the Moon throughout history, tracing our customs and secular events back to their sacred lunar source, providing a startling perspective on the genesis of human thought and behavior. This volume includes 176 illustrations.

MISCELLANEOUS MARS ITEMS

Spirit on Mars Poster. By Spaceshots, Incorporated, 2004. 36-inch × 24-inch poster, $9.98. ***www.spaceshots.com***

This poster features the panoramic image taken from the Mars Exploration Rover Spirit's camera as well as the STS-107 Shuttle Columbia Plaque tribute. This poster comes with a double-sided key loaded with links and educational sites to further enrich adults and children alike on many different astronomy subjects.

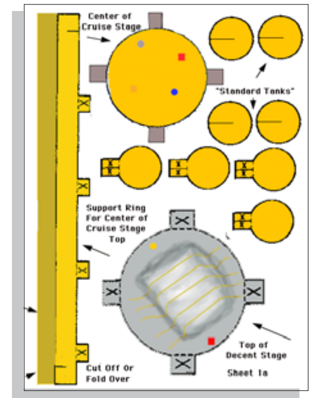
Mars Rover Matted Prints. By Stankraft Graphic Technologies, 2004. Various sizes and quantities available at various prices. ***www.stankraftgraphics.com***

Collect the first high-resolution pictures of Mars beamed back to Earth by the Mars Exploration Rovers Spirit and Opportunity. Available matted and in a variety of sizes — from 8-inch × 10-inch matted size to 16-inch × 20-inch matted size — these images include short informative captions and are suitable for framing.

Planetary Terrain Models. By Space Model Systems, 2004. 5-inch × 5-inch and 8-inch × 8-inch plaques, $24.95 to $64.95. ***www.spacemodelsystems.com***

Each of these new terrain plaques features a hand-cast piece of another world for display. The castings are based on terrain height information from the Mars Orbiter Laser Altimeter (MOLA) onboard the Mars Global Surveyor. The accuracy of the models is driven by recorded mission data, making these representations of Mars surface features uncannily precise. The computer fabrication technique known as Rapid Prototyping is provided by Gentle Giant Studios, a company that has provided high-tech object creation services for the motion picture and toy industries. These castings are hand-finished and hand-painted using color data from Mars Global Surveyor images. Each is affixed to a walnut plaque with a brass nameplate for display on a desktop or hanging on a wall. Available features are Gusev Crater, Olympus Mons, and Kasei Valles.

ONLINE RESOURCE



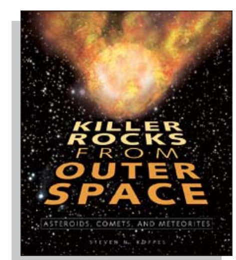
JPL Spacecraft Scale Models. Online resource. ***www.jpl.nasa.gov/scalemodels***

A great way to learn more about a Jet Propulsion Laboratory (JPL) space-exploring machine and its mission is to build a scale model. The scale models offered at this JPL Web site have parts to download and print on card stock, instructions for putting them together, and links to mission information. All supplies that are needed, such as white glue, scissors, etc., are listed; some require use of a sharp art knife, so if children are involved, strict adult supervision is recommended. Some models are quick and easy to assemble while others require several hours' time and great care. Spacecraft scale models available include Galileo, Stardust, Cassini, Mars Pathfinder, Mars Odyssey, and Genesis.

NEW FOR KIDS!!!

Planetaire, The Grand Tour Card Game. By Home Star Games, 2003. 96 playing cards and 25 score cards. For one to four players, ages 8 to adult, $12.95. ***www.homestargames.com***

Planetaire, The Grand Tour is a rummy-type card game that is fun and challenging. Take a tour of the solar system as you race to be the first player to complete The Grand Tour by exploring all nine planets and their moons. While you play, learn about the planets, moons, and the myriad strange and wonderful objects that share our neighborhood in space. The game combines elements similar to some of your favorite card games (such as *UNO*, *Phase 10*, and solitaire) into a unique format. It is easy to play and provides hours of educational fun.



Killer Rocks from Outer Space: Asteroids, Comets, and Meteorites. By Stephen N. Koppes. Lerner Publishing Group, 2004. 112 pp., Hardcover, $26.60. ***www.lernerbooks.com***

This book takes a look at planetary impacts by comets, asteroids, and meteorites. Topics discussed include historic impacts, impact scars on Earth and how they are recognized, the extinction of dinosaurs, the possibility that past impacts delivered to Earth the chemical building blocks of life, recent and planned space missions to observe comets and asteroids, and proposals to protect Earth from future collisions.

Albert Einstein Action Figure. Archie McPhee & Company, 2003. Five-inch tall figure, $8.95. ***www.mcphee.com***

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3-D Space Projector with Journey into Space CD Audio Tour. Uncle Milton Industries, Inc., 2003. Projector, two pair 3-D glasses, 25 slides, and audio CD. Ages 6 to adult, $29.99. ***www.unclemilton.com***

Blast off on a three-dimensional sight and sound journey through our solar system and beyond. Watch as 25 color images of planets, comets, and other fascinating space objects are projected on your walls and ceiling. Listen to amazing facts about each three-dimensional image with the synchronized CD audio tour, including music and sound effects. Projector requires three "C" batteries, not included.

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Calendar 2004

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For more information see the Web sites listed.

August

2–6 **Astrophysics in the FAR Ultraviolet: Five Years of Discovery with FUSE**, Victoria, British Columbia.
http://fuse-conference.pha.jhu.edu/

2–6 **67th Annual Meeting of the Meteoritical Society**, Rio de Janeiro, Brazil.
http://www.cbpf.br/~metsoc04/

16–21 **Meteoroids 2004**, London, Ontario, Canada.
http://aquarid.physics.uwo.ca/meteoroids2004/

20–28 **International Geological Congress,** Florence, Italy.
http://www.32igc.org/default1.htm

23–27 **Second International Planetary Probe Workshop**, Moffet Field, California.
http://probews2.arc.nasa.gov

September

8–11 **2004 Meeting of the High Energy Astrophysics Division of the American Astronomical Society**, New Orleans, Louisiana.
http://www.confcon.com/head_2004/head_2004.html

13–17 **Remote Sensing Europe 2004**, Maspalomas, Gran Canaria, Spain.
http://www.spie.org/Conferences/Calls/04/ers/

20–24 **International Geoscience: A Remote Sensing Symposium (IGARSS)**, Anchorage, Alaska.
http://www.ewh.ieee.org/soc/grss/igarss.html

28–30 **Space 2004 Conference and Exhibit,** San Diego, California.
http://www.aiaa.org/space2004/

October

4–8 **Three Dimensional Universe with GAIA**, Paris, France.
http://wwwhip.obspm.fr/gaia2004/

10 –15 **Society of Exploration Geophysicists — International Exposition and 74th Annual Meeting**, Denver, Colorado.
http://meeting.seg.org/

11–13 **New Windows on Star Formation in the Universe**, College Park, Maryland.
http://www.astro.umd.edu/october/2004/2004.html

11–15 **Second Conference on Early Mars: Geologic, Hydrologic and Climatic Evolution and the Implications for Life**, Jackson Hole, Wyoming.
http://www.lpi.usra.edu/meetings/earlymars2004/

20–22 **International Science Symposium on Sample Returns from Solar System Minor Bodies: The First Hayabusa Symposium — Characterization of Asteroid Itokawa, Its Sample Analyses and Related Topics**, Kanagawa, Japan.
http://planetb.sci.isas.jaxa.jp/symp2004/index.html

November

1–3 **Space Resources Roundtable VI**, Golden, Colorado.
http://www.mines.edu/research/srr

7–10 **2004 GSA Annual Meeting and Exhibition, Geoscience in a Changing World**, Denver, Colorado.
http://www.geosociety.org/meetings/2004

8–11 **Workshop on Chondrites and the Protoplanetary Disk**, Kaua'i, Hawai'i.
http://www.lpi.usra.edu/meetings/chondrites2004

8–12 **36th Annual Meeting of the Division for Planetary Sciences of the American Astronomical Society**, Louisville, Kentucky.
http://dps04.org

22–Dec. 3 **XVI Canary Islands Winter School of Astrophysics**, Canary Islands, Spain.
http://www.iac.es/winschool2004/info.html

December

13–17 **22nd Texas Symposium on Relativistic Astrophysics at Stanford University**, Palo Alto, California.
http://texasatstanford.slac.stanford.edu/

13–17 **AGU Fall Meeting**, San Francisco, California.
http://www.agu.org/meetings/