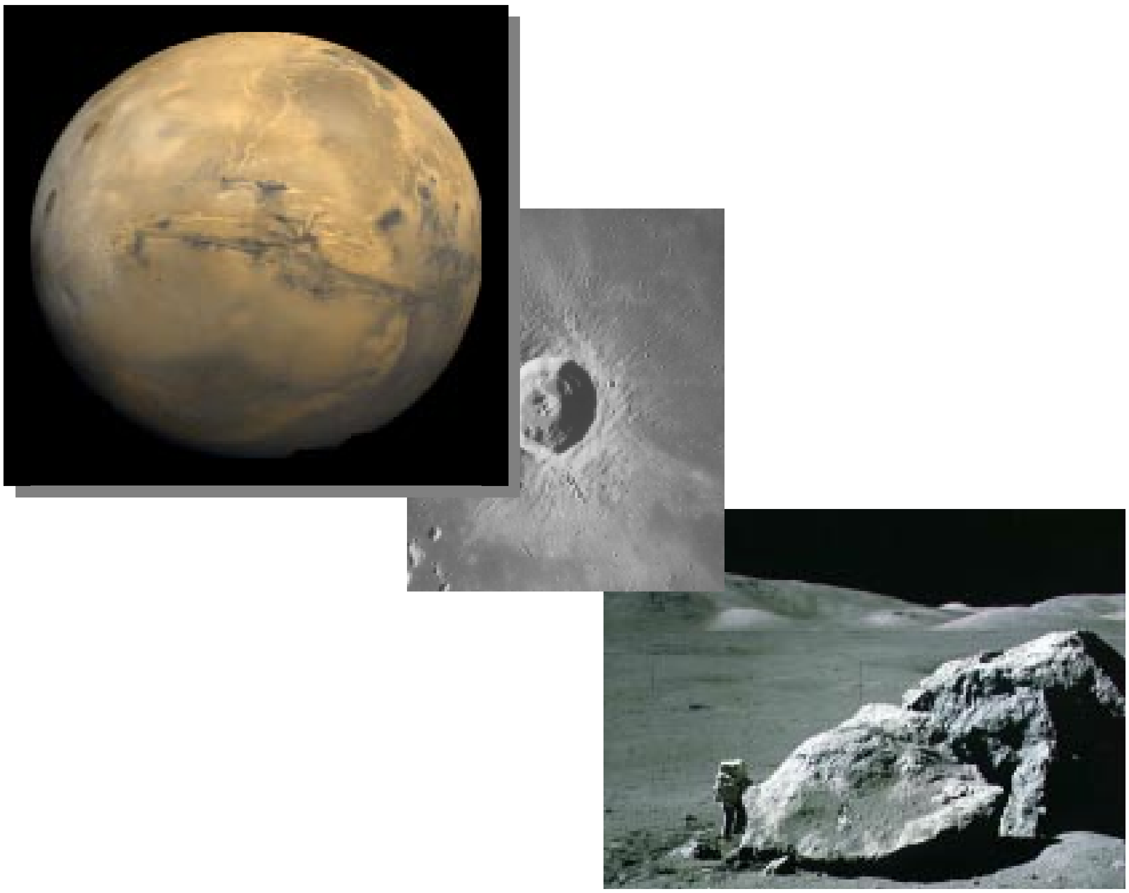
USGS
science for a changing world
Astrogeology Research Program

USGS Educational Outreach



Mars Module

Mars Module

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Mars

Why Explore Mars?

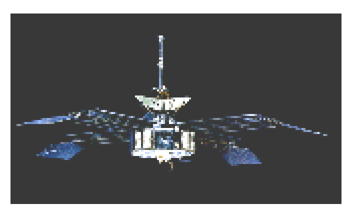
- By studying other worlds, we learn more about our own world
- We have focused our attention on one of our closest neighbors in the solar system, Mars
- Mars is a lot like the earth, it has seasons, an atmosphere, and an earthlike day (sol)
- Mars may have once had a climate very similar as Earth's present climate, but today Mars is a cold, dry barren planet
- Why has Mars evolved differently than the earth?
- Will the earth eventually suffer the same fate as Mars?

Humans have known about Mars since before recorded history. The red planet personified "Ares" the god of war to the ancient Greeks, and the Romans renamed the planet "Mars" for their god of war after conquering the Greeks. In 1609 Galileo Galilei first observed Mars through a telescope. It was only in 1877 when astronomer Schiaparelli observed thin dark lines which he named "canali" that the idea of life on other planets could be a reality. Percival Lowell, who set up his observatory in Flagstaff, believed that these canals were proof of a Martian civilization, which he set out to prove. This led to the initiation of exploration of the solar system that exists today.

Mariners

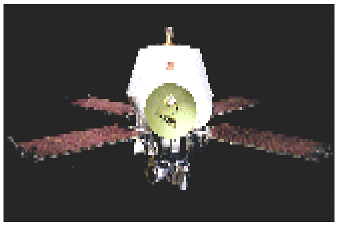
http://marsweb.jpl.nasa.gov/missions/past/mariner3-4.html

Launch (Mariner 4): November 28, 1964
Flyby (Mariner 4): July 14, 1965
Launch: February 24, 1969 (Mariner 6); March 27, 1969 (Mariner 7)
Mars Flyby: July 31, 1969 (Mariner 6); August 5, 1969 (Mariner 7)
Launch (Mariner 9): May 30, 1971
Arrival (Mariner 9): November 13, 1971



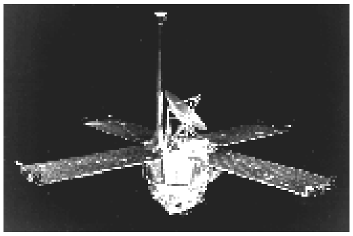
Mariner 4

People began exploring space using telescopes at first and finally in 1965, NASA launched the Mariner 4 spacecraft which flew only 10,000 km above the surface of Mars and sent back the first close-up pictures of the planet’s surface. The images showed that mars in fact, had a surface very much like our moon's surface scarred by impact craters. Mariner 4 also took readings of the atmosphere and the data revealed that it was too thin to support life.



Mariners 6 and 7

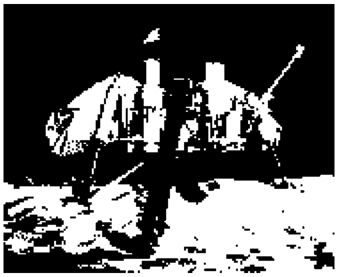
Mariners 6 and 7 were launched several years later and results from these missions showed that surface temperatures were very cold and that Mars' thin atmosphere was nearly all carbon dioxide. These missions also sent back images of the largest volcano in the solar system, Olympus Mons. In 1971, Mariner 9 was the first artificial object to ever orbit another planet. The spacecraft took more than 7,000 images of the planet, allowing geologists back on earth to make maps of the surface. Mariner 9 also discovered the largest canyon yet found in the solar system, Valles Marineris, gigantic valleys that resembled river valleys on earth, and numerous large volcanoes. The spacecraft also took the first close-up images of Mars' moons, Phobos and Deimos.



Mariner 9

Vikings 1 and 2

http://marsweb.jpl.nasa.gov/missions/past/viking.html



Viking Lander

Orbiters

Launch: August 20, 1975 (Viking 1); September 9, 1975 (Viking 2)
Arrival: June 19, 1976 (Viking 1); August 7, 1976 (Viking 2)
Mass: 2,325 kilograms (5,125 pounds) with fuel
Science instruments: High-resolution Camera, Atmospheric Water-vapor Mapper, Surface Heat Mapper, Occultation Experiment

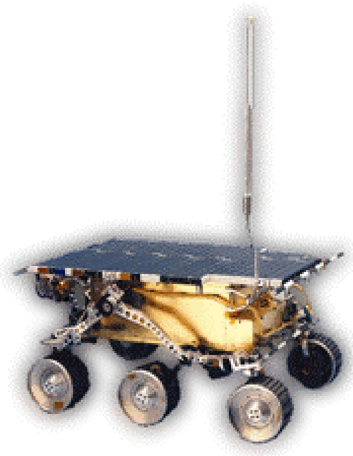
Landers

Landing: July 20, 1976 (Viking 1); September 3, 1976 (Viking 2)
Mass: 576 kilograms (1,270 pounds)
Science instruments: Biology instrument, gas chromatograph/mass spectrometer, X-ray fluorescence spectrometer, seismometer, meteorology instrument, stereo color cameras, physical and magnetic properties of soil, aerodynamic properties and composition of Martian atmosphere with changes in altitude

Because the Mariner missions were such a success and revealed a “New Mars”, in 1975 NASA launched Vikings 1 and 2. Each Viking was made up of two spacecraft, an orbiter and a lander. The Viking 1 lander touched down in an area of Mars called Chryse Planitia and took the first ever pictures of the Martian surface. The Viking 2 lander came to rest in Utopia Planitia, a little further north. Although both landers took many pictures, they saw nothing alive, only a thin veneer of frost on rocks in the morning which quickly vanished into Mars’ dry air. Furthermore, the only thing they saw moving on the planet’s surface was blowing sand and the spacecrafts themselves. Many experiments were done on the soil and atmosphere. Meanwhile, overhead the Viking orbiters were busy taking their own temperature and atmospheric readings. In the end, the orbiters sent over 52,000 images back to earth and scientists are still interpreting this data today.

Mars Pathfinder

http://marsweb.jpl.nasa.gov/missions/past/pathfinder.html
http://mars.jpl.nasa.gov/MPF/index1.html



Launch: December 4, 1996
Landing: July 4, 1997
Mass: 895 kilograms (1,973 pounds) at launch, fueled
Science instruments: Imager; Magnets for measuring magnetic properties of soil; Wind socks; Atmospheric structure instrument/meteorology package

Nearly 20 years since the last successful mission to Mars, the Mars Pathfinder was launched on December 4, 1996, and after traveling for seven months, reached Mars and successfully landed on the surface on July 4, 1997 in a region called Ares Vallis. Sojourner rolled onto the Martian surface and became the first robotic rover to independently explore the surface of another planet. Sojourner's mission was to measure the elements present in rocks and to take pictures of the surface. There were also instruments on the lander to measure Mars' weather patterns, such as wind, pressure and temperature. Mars Pathfinder is the first of a number of spacecraft that will visit Mars in the near future.

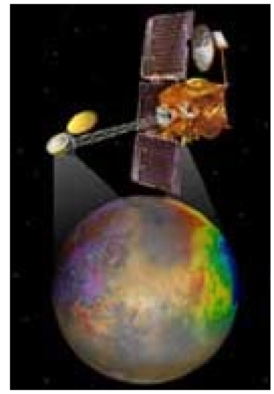
Mars Global Surveyor

http://marsweb.jpl.nasa.gov/missions/present/globalsurveyor.html

Launch: November 7, 1996
Arrival: September 12, 1997
Science instruments: High-resolution Camera, Thermal Emission Spectrometer, Laser Altimeter; Magnetometer/Electron Reflectometer, Ultra-stable Oscillator, Radio Relay System

MGS reached its primary mapping orbit in March 1999. The mission has studied the entire Martian surface, atmosphere, and interior, and has returned more data about the red planet than all other Mars missions combined. Among key science findings so far, Global Surveyor has taken pictures of gullies and debris flow features that suggest there may be current sources of liquid water, similar to an aquifer, at or near the surface of the planet. Magnetometer readings show that the planet's magnetic field is not globally generated in the planet's core, but is localized in particular areas of the crust. New temperature data and closeup images of the Martian moon Phobos show its surface is composed of powdery material at least 1 meter (3 feet) thick, caused by millions of years of meteoroid impacts. Data from the spacecraft's laser altimeter have given scientists their first 3-D views of Mars' north polar ice cap. MGS continues to orbit the planet still, in 2003.

2001 Mars Odyssey



http://marsweb.jpl.nasa.gov/missions/present/odyssey.html
http://mars.jpl.nasa.gov/odyssey/

Launch: April 7, 2001
Arrival: October 24, 2001
Mass: 758 kilograms (1,671 pounds), fueled
Science instruments: Thermal Emission Imaging System (THEMIS), Gamma Ray Spectrometer (GRS), Mars Radiation Environment Experiment (MARIE)

2001 Mars Odyssey is an orbiting spacecraft designed to determine the composition of the planet's surface, to detect water and shallow buried ice, and to study the radiation environment. Odyssey reached orbit on October 24, 2001 and is presently sending back images of the surface. By measuring the amount of hydrogen in the upper meter of soil across the whole planet, the spacecraft will help us understand how much water may be available for future exploration, as well as give us clues about the planet's climate history. The orbiter will also collect data on the radiation environment to help assess potential risks to any future human explorers, and can act as a communications relay for future Mars landers.

2001 Mars Odyssey is part of NASA's Mars Exploration Program, a long-term effort of robotic exploration of the red planet. The opportunity to go to Mars comes around every 26 months, when the alignment of Earth and Mars in their orbits around the sun allows spacecraft to travel between the two planets with the least amount of energy.

Mars Express

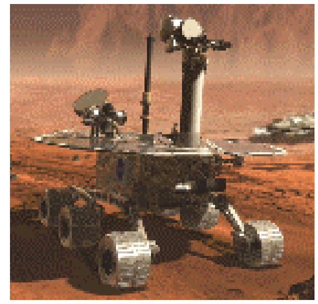
http://marsweb.jpl.nasa.gov/missions/present/globalsurveyor.html

Launch: June 2003
Arrival: December 2003
Mass: 1,042 kilograms (2,297 pounds)
Science instruments: Energetic Neutral Atoms Analyzer, Geochemical Lander, High/ Super Resolution Stereo *Color Imager, Radio Science, Subsurface Sounding Radar/ Altimeter, Infrared Mineralogical Mapping Spectrometer, Planetary Fourier Spectrometer, Ultraviolet and Infrared Atmospheric Spectrometer*

The mission's main objective is to search for sub-surface water from orbit and deliver a lander to the Martian surface. Seven scientific instruments onboard the orbiting spacecraft will study the Martian atmosphere, the planet's structure and geology. The lander is called Beagle 2 after the ship in which Charles Darwin set sail to explore unchartered areas of the Earth in 1831. After coming to rest on the surface, Beagle 2 will perform exobiology and geochemistry research.

2003 Mars Exploration Rovers

http://marsweb.jpl.nasa.gov/missions/future/2003.html



Launch: May-July 2003
Arrival: January-February 2004
Science instruments: Panoramic Camera, Miniature Thermal Emission Spectrometer, Mössbauer Spectrometer, Alpha Proton X-ray Spectrometer, Microscopic Imager

In 2003, two powerful new Mars rovers will be on their way to the red planet. With far greater mobility than the 1997 Mars Pathfinder rover, these robotic explorers will be able to trek up to 100 meters (about 110 yards) across the surface each Martian day. Each rover will carry a sophisticated set of instruments that will allow it to search for evidence of liquid water that may have been present in the planet's past. The rovers will be identical to each other, but will land at different regions of Mars. The landing for each will resemble that of the Pathfinder mission. Rocks and soils will be analyzed with a set of five instruments on each rover, and a special tool called the "RAT," or rock abrasion tool, will be used to expose fresh rock surfaces for study

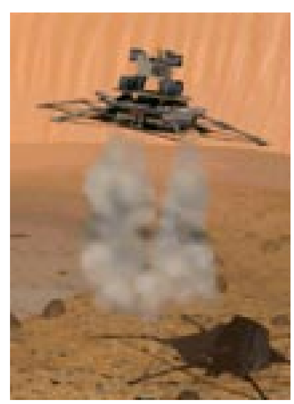
2005 Mars Reconnaissance Orbiter

http://marsweb.jpl.nasa.gov/missions/future/2005-plus.html

In 2005, NASA plans to launch a powerful scientific orbiter, the Mars Reconnaissance Orbiter. This mission will focus on analyzing the surface at new scales in an effort to follow tantalizing hints of water detected in images from the Mars Global Surveyor spacecraft, and to bridge the gap between surface observations and measurements from orbit. For example, the Reconnaissance Orbiter will measure thousands of Martian landscapes at 20- to 30-centimeter (8- to 12-inch) resolution, good enough to observe rocks the size of beach balls.

Smart Lander and Long-range Rover

http://marsweb.jpl.nasa.gov/missions/future/2005-plus.html



NASA proposes to develop and to launch a roving long-range, long-duration science laboratory that will be a major leap in surface measurements and pave the way for a future sample return mission. NASA is studying options to launch this mobile science laboratory mission as early as 2007. This capability will also demonstrate the technology for "smart landers" with accurate landing and hazard avoidance in order to reach what may be very promising but difficult-to-reach scientific sites.

Scout Mission

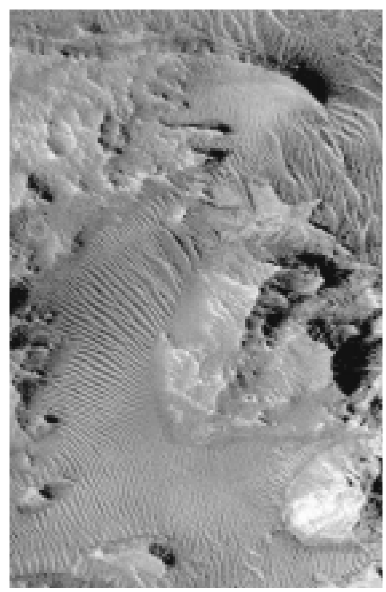
NASA also proposes to create a new line of small "Scout" missions that would be selected from proposals from the science community, and might involve airborne vehicles (e.g., airplanes or balloons) or small landers, as an investigation platform. Exciting new vistas could be opened up by this approach either through the airborne scale of observation or by increasing the number of sites visited. The first Scout mission launch is planned for 2007.

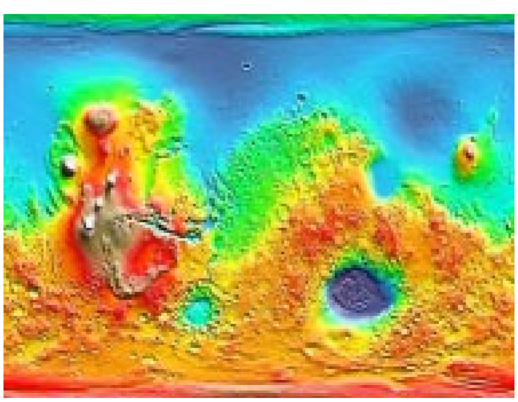
Sample Return and Other Missions

In the second decade of the century, NASA plans additional science orbiters, rovers and landers, and the first mission to return samples of Martian rock and soil to Earth. Current plans call for the first sample return mission to be launched in 2014, and a second in 2016. Options that would significantly increase the rate of mission launch and/or accelerate the schedule of exploration are under study, including launching the first sample return mission as early as 2011. Technology development for advanced capabilities such as miniaturized surface science instruments and deep drilling to hundreds of meters will also be carried out in this period.

The Results of Exploration

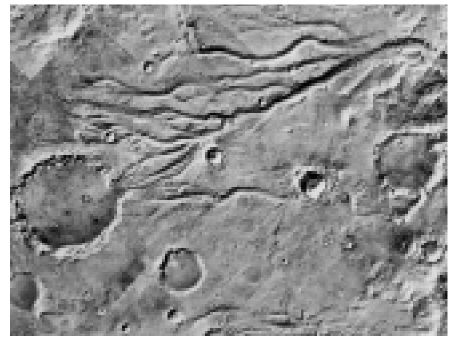
Spacecraft use a variety of instruments to gather data about planets. Scientists use **remote sensing** to gather information about planetary surfaces. Satellites above earth and spacecraft sent to other planets take pictures of the surface that reveal important insights into global, regional, and local geologic processes. Many thousands of such images have been sent to earth from Mars orbiting spacecraft allowing us to get a close up view of the planets surface. Thanks to these images we have learned that Mars has many landforms similar to the ones we see on earth, such as channel systems, canyons, craters, volcanoes, polar ice caps and sand dunes. Cameras are not the only instruments used to collect data from other planets. Spectrometers, magnetometers, and altimeters are also used. Information from these instruments can be combined with pictures to produce three-dimensional representations of a planetary surface. Scientists at the USGS interpret this information in to various types of maps, including geological maps, topography maps, thermal emission maps, shaded relief maps, and gravity anomaly maps. Remote sensing allows us to explore the surface of Mars and thus gives scientists the opportunity to interpret the geologic landforms they observe. Scientists often compare landforms seen on Mars





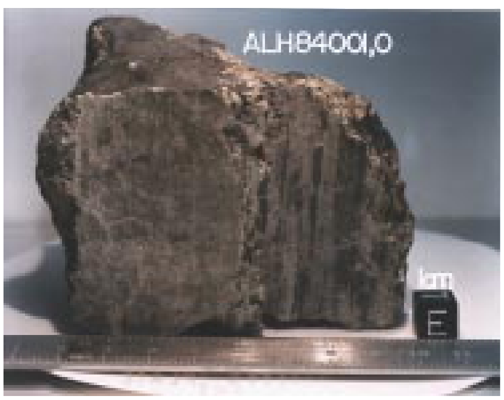
Olympus Mons shield volcano

to similar landforms found on earth. We now know that the largest volcanoes and canyon systems in the solar system exist on Mars. The largest volcano, Olympus Mons would cover the whole state of Arizona, and the longest canyon Valles Marineris would extend from New York to Los Angeles. Scientists agree that there is no evidence as of yet of plate tectonics on Mars. This may explain why volcanoes grow much larger there than on Earth.

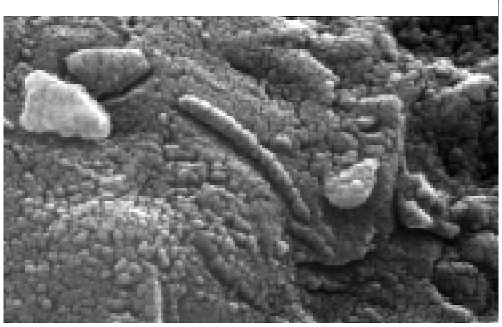


Channel system

Life Search



Martian Meteorite ALH 84001,0



Photomicrograph of ALH 84001,0 with possible evidence of ancient microbacterial life on Mars

The search for life on Mars is one of the driving forces of exploration. However, the main component for the existence of life is water. Therefore, scientist's primary goal at the present is to find proof of the existence of water on the planet. It is widely accepted that water was present at some time in the past on Mars as evidenced by the presence of large outflow channels and more recently gullies on the planet's surface. There is also evidence that water exists underground in the form of water ice or permafrost, much like the land in arctic areas of the earth. A variety of patterned surface features may help to prove this hypothesis. Mars has polar ice caps just like earth. However, the ice caps on Mars are composed mainly of frozen carbon dioxide, or dry ice. Presently, only a small amount of frozen water has been detected in the polar caps, but that doesn't mean that its not located somewhere else. As technology advances more sophisticated instruments are being sent to Mars in the search to unravel the mysterious history of the Red Planet. NASA has many missions scheduled to further explore the planet, and more than likely, the first manned space mission will be to the planet Mars so geologists themselves can collect real hands-on data which will inevitably lead to the unraveling of the mystery of it's geologic history.

References and Resources:

* **Mars Exploration:** http://marsweb.jpl.nasa.gov/index.html
* **2001 Mars Odyssey:** http://mars.jpl.nasa.gov/odyssey/
* **Mars Global Surveyor:** http://mars.jpl.nasa.gov/mgs/
* **Mars Education:** http://mars.jpl.nasa.gov/education/
* **The Mars Millennium Project:** http://www.lerc.nasa.gov/WWW/OEP/MMP/edresources.html
* **Arizona State University Mars Workshops:** http://learn.jpl.nasa.gov/news/020222azwrkshp.html
* **Mars Exploration Curriculum:** http://mars.jpl.nasa.gov/education/modules/webpages/curriculumwelcomepage.htm
* **Mars Pathfinder Education and Outreach:** http://mpfwww.jpl.nasa.gov/mpf/education/educoutr.html
* **NASA Spacelink:** http://spacelink.nasa.gov/
* **Thursday's Classroom:** http://www.thursdaysclassroom.com/index_26aug99.html
* **Destination Mars Virtual Adventure:** http://www.spaceday.com/en/mission/mars/index.php
* **Destination Mars Activity Packet:** http://www.jsc.nasa.gov/er/seh/destmars.pdf
* **Mars Activities Packet: Teacher Resources and Classroom Activities**, Mars Education Program. NASA/JPL and ASU.
* **Ames Center for Mars Exploration:** http://cmex-www.arc.nasa.gov/
* **The Nine Planets:** http://seds.lpl.arizona.edu/nineplanets/nineplanets.html