Where Would You Search for Water on Mars?

Purpose

To help students develop an ongoing connection to the Mars missions

Overview

Students generate questions based on their module experiences and pinpoint specific information they would like to obtain. They then read about the objectives and instrument payloads of the upcoming missions and see how these missions may provide data that can help them answer their questions. Finally, the students create a calendar for the missions and consider how they will access the information returned by the missions.

Key Concepts

- Each Mars mission has specific objectives and the instruments it needs to achieve them.
- Space missions arise out of questions people have about Mars, and students can generate questions worthy of future study.
- Every mission has a specific timetable, and students can follow the progress of each mission in a number of ways.

Context for This Activity

Over the next decade, NASA will be sending a series of spacecraft to Mars. In this activity, students see how they can access the information collected by these probes and how they can use this information to find out more about Mars and to answer their own questions.

Skills

- *Identifying* questions that really interest students
- *Devising* a plan for answering those questions

Materials

Calendar of the missions, length of paper to make a timeline

Preparation

If possible, obtain a computer with web access to visit some of the mission-related sites.

Time: 1 class period

Procedure

1. Have students reflect on their work with experiments and images and generate a list of questions of personal interest. What have they wondered about during the module? What struck them as particularly interesting? What additional information do they wish they had? Which features would they like to see in more detail? Why?

2. Have students read the essay on the upcoming missions.

3. Review the missions and the instruments (Figure 7.1). Which instrument(s) can help answer their questions about water on Mars? What instruments would they like to see on a future mission? Could they imagine themselves designing or operating such an instrument?

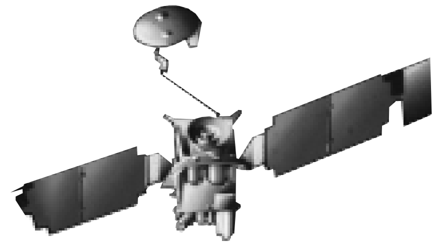

Figure 7.1. An artist's rendition of the Mars Global Surveyor.

4. Show students the calendar for the missions (Figure 7.2). Ask them:
   - Where they expect they might be at these times
   - How might they access information from the instruments or about the mission (*newspapers, magazines, the Web, television, radio, friends*)

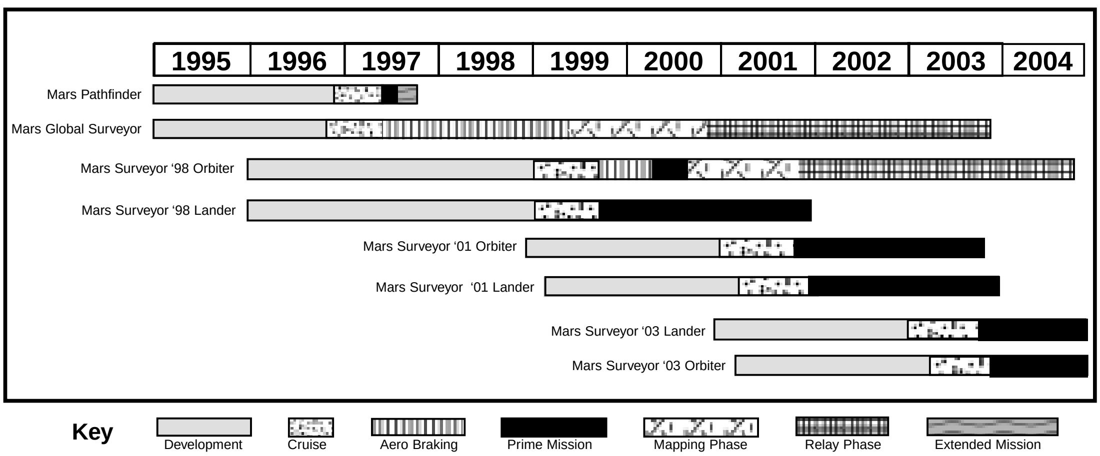

Figure 7.2. The timeline for NASA's missions to Mars.

5. Have each student devise a plan that outlines how he or she might obtain answers to his or her questions.

6. Put a timeline on the wall. Mark the events listed on the calendar to follow the progress of the missions.

7. Explain that NASA will regularly post data and images from its current missions on the World Wide Web. With these, your students can extend their study of Mars by following their own interests and building on their own questions.

To learn more about the Mars Exploration Program, explore the web pages in the box to the right.

Spacelink	*http://spacelink.nasa.gov*
Jet Propulsion Laboratory	*http://www.jpl.nasa.gov/*
Mars Pathfinder	*http://mpfwww.jpl.nasa.gov*
Mars Global Surveyor	*http://mgs-www.jpl.nasa.gov/*
Mars Surveyor 1998	*http://mars.jpl.nasa.gov/msp98/*
Mars Surveyor 2001	*http://mars.jpl.nasa.gov/2001/*

Extension

Have each group write a rationale for sending a space mission to particular parts of Mars to help us better understand the history of water on Mars.

How Can I Learn More About Mars? Where Do I Go From Here?

A spunky spacecraft about the size of a kitchen stove (Figure 7.3) recently left Earth forever and rocketed over to Earth's next-door neighbor, Mars. The 300-million-kilometer trip was short by space-travel standards, just 7 months. Because Pathfinder was small, scientists were limited in terms of the instruments they could send. They had to write detailed proposals to convince NASA that their instrument or experiment should be chosen over others and be one of the few sent to Mars. The competition was fierce. In the end, Pathfinder carried a microwave oven-sized rover, cameras, a spectrometer, and temperature, pressure, and wind sensors. Before its batteries ran down and it froze, Pathfinder collected data on:

- Structure of the Martian atmosphere
- Weather and meteorology on the surface
- Surface geology
- Form, structure, and composition of Martian rocks and soil

All these data help scientists understand more about the history of water on Mars and assess which of the current theories about water are valid.

To obtain more detailed maps of the Martian surface and a better understanding of surface features, NASA decided to send another spacecraft, the Mars Global Surveyor, to map

Figure 7.3. An artist's rendition of the Mars Pathfinder and Sojourner on Mars.

Mars (Figure 7.4). From its vantage point 400 kilometers above the Martian surface, the Mars Global Surveyor not only has a great view, but it has state-of-the-art instruments to analyze the surface in many different ways. Again, scientists competed fiercely to get their instruments included on the mission. The instruments include:

- Two low- and one high-resolution cameras to study daily changes and surface features
- A magnetometer/electron reflectometer to study the planet's magnetic field
- A radio system to study the planet's gravitational field and subsurface mass distribution

Prevailing Theory	Evidence	Upcoming Data
Water flowed across the Martian surface	• Large, runoff channels • Extensive river networks • Eroded landforms	• High-resolution images of valley networks and small-scale features, such as boulders carried long distances by floods • Spectroscopy that can reveal the composition of rocks and sediments
Water pooled numerous times throughout Martian history	• Shorelines • Sediment layers	• Closeups of shorelines and rock and sediment layers • Identification of hydrated minerals and deposits of rocks that are deposited in bodies of water (such as carbonates and tufa)
There is much water and/or ice below the surface	• Large channels lead from areas where magma heated the ground • Surface patterns formed by repeated freezing and thawing • Mud flows created by impacts that melted sub-surface ice	• High-resolution images of active seeps, melted ice, temporary pools of water, talus slopes, pits, valleys, channels, patterned ground, and lobed ejecta blankets • Spectroscopy that can reveal the composition of rocks and sediments

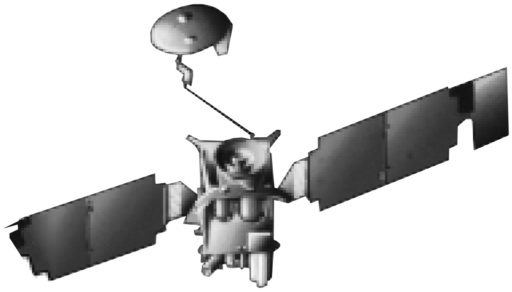

Figure 7.4. An artist's rendition of the Mars Global Surveyor.

- A laser altimeter to study the planet's surface topography and overall shape
- A thermal emission spectrometer to study the heat coming from the surface and atmosphere (This information will enable scientists to create weather maps and identify the size and composition of surface materials.)

Mars Global Surveyor has helped scientists understand more about the surface and subsurface geology. This information has helped them understand more about the history of water on Mars.

Particularly relevant to the study of water are the three cameras. The Mars Global Surveyor has two low-resolution cameras capable of recognizing features 500 meters across and one narrow-angle camera able to see things as small as 3 meters across (Figure 7.5). This compares to the highest resolution images from Viking of 20 meters. The low-resolution cameras will make daily maps of the entire planet, enabling scientists to see daily changes in such things as ice caps and dust and ice clouds. The narrow-angle camera, which can see boulders the size of cars, will be used to search for evidence of erosion, shorelines, glaciers, the effects of water seeping from canyon walls, and layers in polar deposits that reflect climate changes.

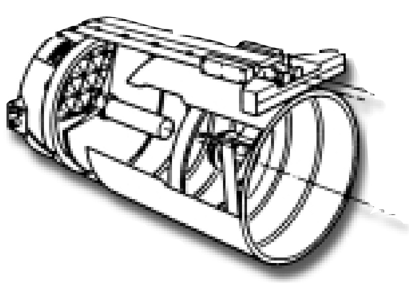

Figure 7.5. A camera from the Mars Global Surveyor mission.

The Thermal Emission Spectrometer measures the amount of heat coming from the surface and atmosphere at many different wavelengths (Figure 7.6). The spectrometer will determine:

- Atmospheric temperature and pressure at several different altitudes
- The concentration of dust both in layers and spread throughout the atmosphere
- The size of particles on the surface, from dust grains to bedrock, by comparing the temperature during the day with that observed at night (the same effect that causes beach sand to be very hot during the day and to be cool at night)—the sizes of particles on the surface tell scientists how the particles were moved (such as by wind water or other processes)

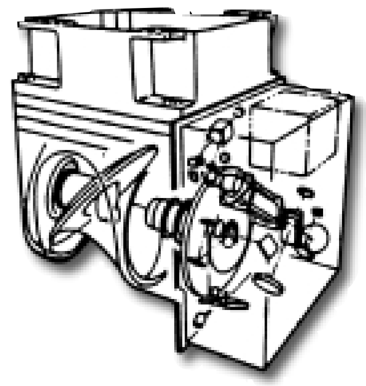

Figure 7.6. The Thermal Emission Spectrometer from the Mars Global Surveyor mission.

- Of what the Martian rocks, soil, and dust are made and in what proportions (The spectrometer will be able to discriminate volcanic rocks similar to those found in Hawaii (basaltic) from rocks and ash similar to those erupted by Mount St. Helens (rhyolitic). It will search for minerals left behind as possible lakes or other bodies of water dried up and for minerals that formed when the atmosphere was potentially thicker and wetter than it is today.)

Visit the Pathfinder and Global Surveyor web sites to learn about the missions, to access the data and images from the instruments, to see the kinds of conclusions scientists have been able to draw, and to discover the new questions emerging from the missions. You will find all sorts of information that will help you answer your questions and that may inspire you to undertake a research project to investigate these questions.

The Pathfinder and Global Surveyor missions are just the first two spacecraft in a series of missions to Mars. Every 2 years, Mars and Earth align so that a spacecraft can travel efficiently between the two planets. Over the next decade, NASA plans to launch new missions each time Earth and Mars are in a position for efficient travel (Figure 7.7):

- Mars Global Surveyor (1997)—The orbiter will map the planet's atmosphere and surface. It will look for evidence of surface water, study the surface geology and structure, and examine changes in Martian weather for at least 1 Martian year (about 2 Earth years).
- Mars Surveyor '98 (1998–99)—The lander will land near the edge of Mars' south polar cap and focus on studies of geology, weather, and past and present water resources. Before touchdown, it will release two microprobes that will drop into the soil to search for the presence of subsurface water. The orbiter will examine the atmosphere and changes in water vapor during the Martian seasons.
- Mars Surveyor '01 (2001)—The lander will carry a rover capable of traveling dozens of kilometers to gather surface dust and soil samples. There will also be a test of our ability to produce rocket propellant using Martian rocks and soil as raw materials. The orbiter will study the mineralogy and chemistry of the surface, including the identification of water resources just below the Martian surface.
- Mars Surveyor '03 (2003)—This lander will carry a wide-ranging rover to collect samples from a different part of the planet. The orbiter will provide the complex links needed for communication and navigation for this and future surface missions.

NASA scientists are waiting to see what this current set of missions will reveal about Mars before deciding where to send the 2005 and 2007 missions and what data they should collect.

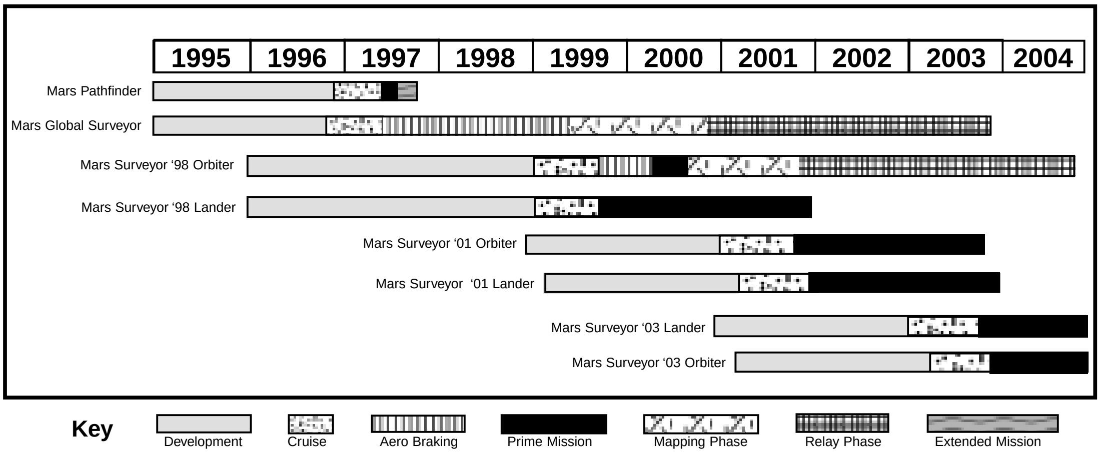

Figure 7.7. The timeline for NASA's missions to Mars.