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Why Is Water a Priority for Mars Exploration?

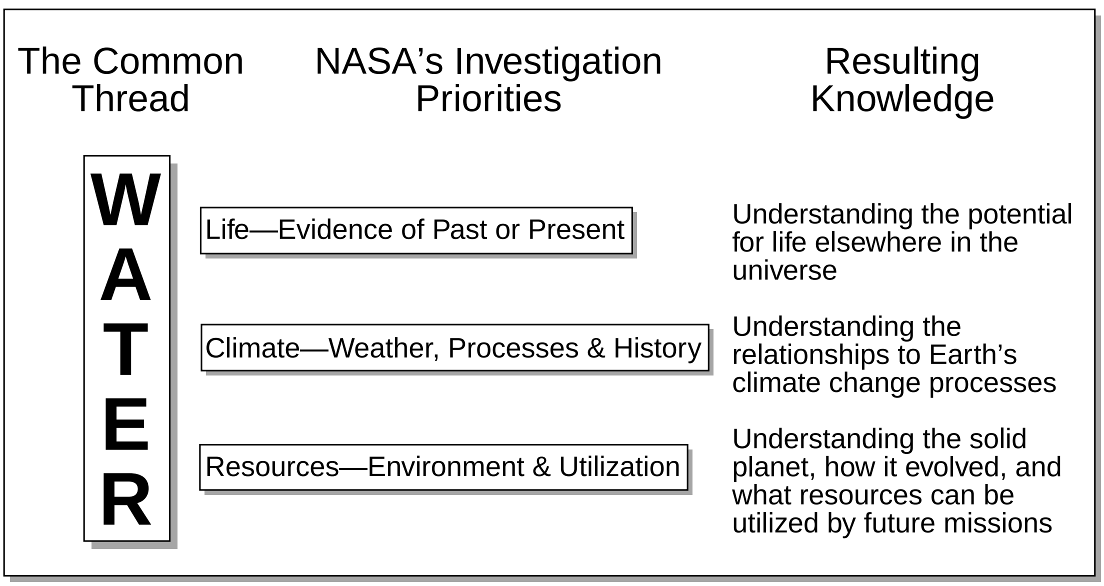
Studying water on Mars gives scientists insights into how planets evolve, how water accumulates, how climates develop, and, possibly, how life begins. For these reasons, understanding the story of water is central to most of NASA's planetary missions.

Scientists believe that 3.5 billion years ago, Mars experienced the largest known floods in the solar system. This water may even have pooled into lakes or shallow oceans. Knowing where this water came from, how long it lasted, and where it went will reveal much about the past history of the planet. Consequently, many scientists who want to understand the history of Mars need to understand the story of water on Mars.

To try to account for this water, the scientific community is debating whether the climate of Mars has slowly changed over time or whether it has remained the same for the last several billion years. The two positions lead to two very different views of the planet and of life and water on Mars:

- If Mars has always had the climate we find today, huge quantities of water must have been released over a short period of time to create the water-related landforms found on the surface, many of which require significant amounts of water to form. These great quantities of water would have to have shaped the surface quickly, before evaporating or boiling away. Also, life would not have had a chance to evolve in such short-lived bodies of water.
- If Mars once had a warmer, wetter climate, water could have existed over a long period of time, altered the surface gradually, and allowed for the possible formation of life.

These different water scenarios give rise to different views of the planet's evolution. Regardless of whether water existed for long or short periods of time, it probably escaped into space and/or sank into the ground to become permafrost.



What Is So Special About Water?

Water is critical to so many biologic and physical processes that it is one of the first things planetary scientists look for when they study planets and planetary bodies, such as moons and asteroids. Water's unique properties make it an important compound in a number of ways.

Property	Attribute Because of This Property	Examples
Bi-polar molecule	Superior solvent of ionic compounds	• Diffuses across cell membranes to deliver nutrients and to remove wastes • Dissolves many surface materials
Forms hydrogen bonds	Chemically active molecule	• Exhibits surface tension (cohesion) • Exhibits capillary action (adhesion) • Present in many classes of compounds
High-density liquid	Exerts force and distributes pressure	• Provides organisms mobility and buoyancy • Erodes and transports surface materials
High specific heat capacity	Stores large amounts of heat	• Moderates climates on Earth • Moderates daily temperature swings • Moves equatorial heat toward the poles
Expands upon freezing	Ice is less dense than water	• Ice floats on water and protects organisms below the ice from colder temperatures • Water expands upon freezing and cracks rocks and minerals through physically weathering
Relatively low vapor pressure given its molecular weight	Changes phase within a moderately narrow temperature range	• Exists in all three states on Earth • Enables a water cycle that moves water through the environment • Enables cooling through evaporation
Molecule resonates at a number of frequencies	Absorbs wavelengths such as ultraviolet and infrared	• Liquid water shields aquatic organisms • Water vapor shields land organisms • Acts as a greenhouse gas
Contains hydrogen and oxygen	Electrolysis can separate these elements	• Possible fuel source for Earth-returning missions

What Is Distinctive About the Module Series?

Brings Science Topics to Life in an Engaging, Relevant Way

Students not only learn about Mars, Earth science, astronomy, chemistry, biology, physics, engineering, and geography, but they also develop and hone their science thinking skills, such as designing experiments, devising models, analyzing data, developing and refining hypotheses, and applying their understanding to real-world situations.

Provides Multiple Paths to Investigate a Topic

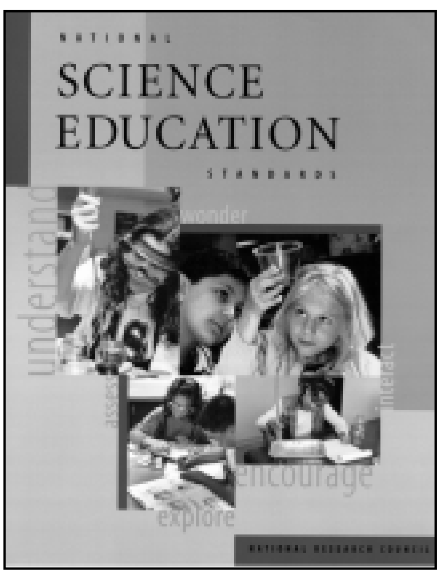
In the module activities, students use experimentation, modeling, Mars-Earth comparisons, and image analysis to amass evidence to support their ideas.

Promotes Student Ownership of the Investigative Process

Because the mastery of fundamental science concepts is dramatically enhanced when students feel ownership for their work, the activities directly involve students in the intellectual process going on in the classroom.

Builds a Foundation for Understanding Data from Mars

NASA is using the Internet to provide the public with the latest images and data from its missions to Mars. To help prepare students to make effective use of this information, the modules provide students background experiences, such as analyzing data and images, knowing NASA's key research questions, understanding the missions, and recognizing Martian features. Having well-prepared students opens a new chapter in the way students can participate in ongoing research.



Gives Students a Stake in the Missions

Mars exploration is at its beginning. The competing explanations within the scientific community and the gaps in the existing evidence leave plenty of room for students to develop their own hypotheses. Students can use evidence from their own investigations to take positions on a particular question, debate the alternate hypotheses, and refine their own thinking about the planet.

Helps Transform Science Education

The educator guide provides detailed, standards-based, hands-on activities that promote inquiry-based learning and address student misconceptions. The teaching strategies and assessments provide guidance for teachers unfamiliar with student-centered teaching.

Implements National Science Education Standards

The module series develops skills and understanding by responding to many of the National Science Education Standards' recommendations for science teaching, professional development, assessment, and content. The series can help schools implement these standards in a creative, innovative, and multifaceted program.

The Scientific Research Techniques Used in the Modules

Each module is designed around a question that is examined through four different investigative paths—experimentation, modeling, Mars-Earth comparisons, and image and data interpretation. Each path sheds light on a different aspect of the question. Students piece together the evidence to develop hypotheses, debate and refine their thinking, and address their misconceptions.

Conducting Classroom Experiments and Creating Models

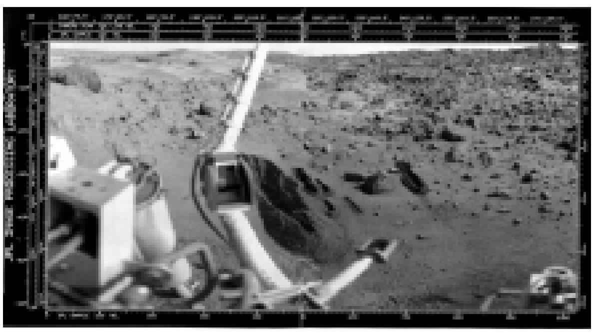
Students conduct hands-on experiments to generate data and model processes that occur on Earth and Mars. These inquiry-based experiences build understanding and lay the conceptual and experiential base for subsequent activities.

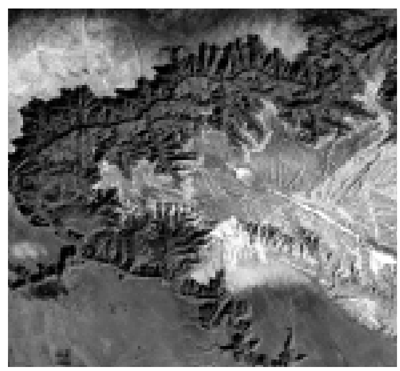
Making Mars/Earth Comparisons

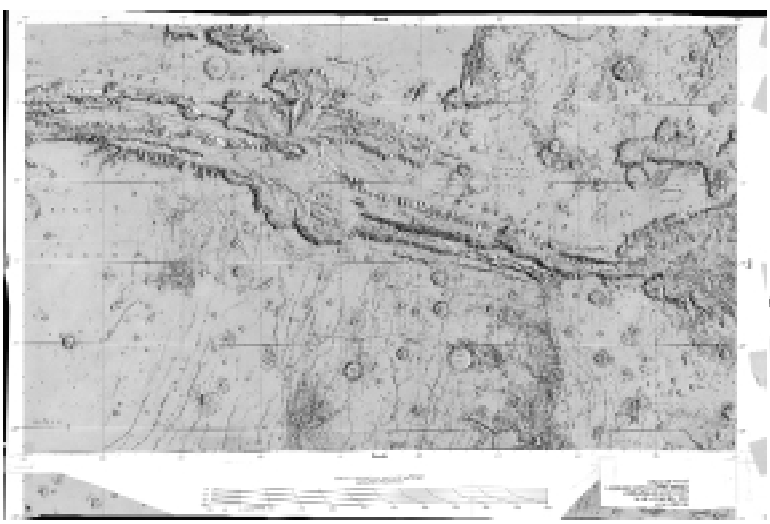
Mars-Earth comparisons help students bridge the gap from a local, familiar environment on Earth to distant Mars.

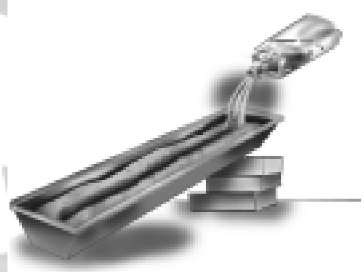
Using Real Data and Images from Mars

The modules' image sets provide students with maps and photos of the surface of Mars. Many activities are based on these images, and the students use them to provide clues for their investigations. NASA also makes many of its data and images from current and previous missions available over the Internet. By obtaining the latest data and images, students can experience the excitement of scientific exploration and discovery as they happen.









Glossary

Atmospheric Pressure	The force produced by the gas molecules in the atmosphere. Atmospheric pressure is a function of the height and density of the atmosphere in conjunction with a planet's gravitational field. At sea level, Earth's atmosphere pushes with a force of 1,013 millibars. On Mars, surface pressures are typically in the range of 6.8 millibars.
Barometer	A device with an enclosed volume of air that measures changes in air pressure. As pressure changes, the enclosed air either increases or decreases, depending on the pressure gradient between the room air and the trapped air. An arm on the barometer displays this change.
Boiling Point	Boiling is when the vapor pressure of the liquid equals the atmospheric pressure. At this point, the liquid can turn to vapor. The bubbles one sees are bubbles of water vapor. They arise from the bottom of a pot because this is usually where the heat is concentrated and where the particles have the most kinetic energy.
Boyle's Law	A gas law described by Robert Boyle in 1662 that states when the volume of a given mass of gas increases, its pressure decreases, provided that the temperature remains constant.
Equilibrium	When the rate of molecules leaving a particular phase equals the number returning. For example, water is in equilibrium with ice when it freezes at the same rate that the ice melts. It is in equilibrium with water vapor when it evaporates at the same rate that the vapor condenses.
Kinetic Energy	The internal energy of an atom or molecule often thought of as the vibrational energy of a particle. Higher kinetic energies translate into higher temperatures.
Mars Global Surveyor	An orbiter launched in November 1996 to map the Martian atmosphere and surface. The data it collects are used to 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 Pathfinder	A lander launched in December 1996 that contained the radio link to Earth, most of the science instruments, and a rover named Sojourner. Sojourner was used to deploy two imagers and an instrument that could determine the composition of rocks and minerals on the surface.
Meander	A bend in a river caused by the erosion of the bank along the outer edge of the bend and the deposit of sediment along the inner bend of the curve. Meanders occur in mature, slow-flowing rivers.
Phase Change Diagram (also called Phase Diagram)	Researchers have measured the phase changes of water over a wide variety of temperatures and pressures. The resulting graph is called a phase change diagram. Every substance has its own, unique phase diagram.
Phase Change Plateau (also called Change of State Plateau)	When melting or boiling, any heat added is absorbed by the particles changing state. The particles use the energy from the heat source to gain the extra kinetic energy required to change state and to maintain themselves in the new state. As a result, the temperature during these transitions never changes. On a graph, these transitions graph as plateaus. When condensing or freezing, particles give off heat, and there is a similar transition plateau.

Sol	One Martian day, 24.67 hours long.
Sublimation	A change from the solid phase directly to the vapor phase.
Thermocouple	A device that measures temperature by measuring how the resistance to electrical flow changes with temperature.
Triple Point	At the triple point, all three phases are in equilibrium with one another—vapor sublimates to ice and condenses to liquid at the same rate that the liquid evaporates to vapor and freezes to ice at the same rate that the ice melts to liquid and sublimates to vapor.
Vapor Pressure	The inclination of a molecule to change phase and establish an equilibrium. Vapor pressure changes with temperature—the higher the temperature, the higher the vapor pressure.
Viking Missions	A series of two missions, each with a lander and an orbiter. These missions studied Mars from 1976 to 1978. Viking was the first mission to land on Mars.

Resources for Educators Interested in Mars

Web Sites

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 '98	*http://mars.jpl.nasa.gov/msp98/*
Mars Surveyor '01	*http://mars.jpl.nasa.gov/2001/*
The Planetary Society	*http://planetary.org/tps/*
Center for Mars Exploration	*http://cmex-www.arc.nasa.gov/*
Arizona Mars K–12 Education Program	*http://esther.la.asu.edu/asu_tes/*

Periodicals

The Planetary Report
The Planetary Society
65 North Catalina Avenue
Pasadena, CA 91106-2301
Phone: (818) 793-5100
Fax: (818) 793-5528

Mars Underground News
The Planetary Society
65 North Catalina Avenue
Pasadena, CA 91106-2301
Phone: (818) 793-5100
Fax: (818) 793-5528

Recommended Maps and Photomosaics of Selected Martian Features

General

Map of Olympus Mons to Ares Valles	I-1618
Map of Eastern Valles Marineris to Ares Valles	I-1448
Topographic Map of Mars (1:25,000,000) (1 map)	I-961
Topographic Map of Mars (1:15,000,000) (3 maps)	I-2160

Volcanoes

Photomosaic of Olympus Mons	I-1379
Map and photomosaic of Tharsis volcanoes	I-1922

Canyons

Map of Central Valles Marineris	I-1253
Photomosaic of entire Valles Marineris	I-1206, I-1207, I-1208, I-1184, I-1381

Floods

Photomosaic of channels and eroded landforms	I-1652
Photomosaic of Dromore crater with breached ridge	I-1068

Pathfinder

Map of Ares Valles	I-1551
Photomosaic of the flood channels near landing site	I-1343
Closeup photomosaic of landing site	I-1345, I-2311

U.S. Geological Survey ($4.00, 3- to 4-week turnaround)
Box 25286
Federal Center, Building 810
Denver, CO 80225
Phone: (800) 435-7627

Posters

Two Faces of Mars (Item #1338, $15.00)
Spaceshots
33950 Barnaby Road
Acton, CA 93510
Phone: (800) 272-2779
Fax: (805) 268-1653

An Explorer's Guide to Mars (Item #505, $6.00)
The Planetary Society
65 North Catalina Avenue
Pasadena, CA 91106-2301
Phone: (818) 793-1675
Fax: (800) 966-7827