National Aeronautics and Space Administration

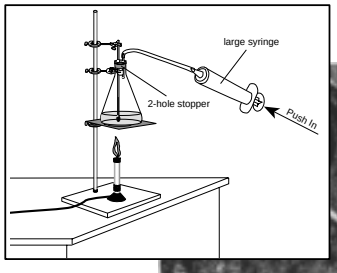
Educational Product	
Educators	Grades 9–12

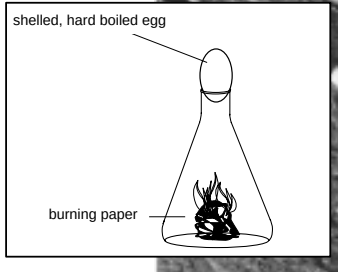
EG-2000-03-121-HQ

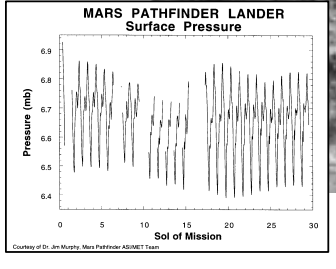
Mars Exploration

Is There Water on Mars?

An Educator's Guide With Activities for Physical and Earth and Space Science





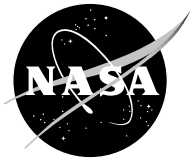


Is There Water on Mars?—An Educator's Guide With Activities for Physical and Earth and Space Science is available in electronic format through NASA Spacelink—one of the Agency's electronic resources specifically developed for use by the educational community.

This guide and other NASA educational products may be accessed at the following address:
http://spacelink.nasa.gov/products

Is There Water on Mars?

An Educator's Guide With Activities for Physical and Earth and Space Science



NASA Aeronautics and Space Administration
Office of Human Resources and Education
Education
Washington, DC

Prepared by TERC, Inc.
2067 Massachusetts Avenue
Cambridge, Massachusetts 02140

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Mars Exploration Education and Public Outreach Program

These modules were prepared by the TERC Center for Earth and Space Science Education with assistance from personnel of NASA's Mars Exploration Education and Public Outreach Program. This Program is managed for NASA by the Jet Propulsion Laboratory, a division of the California Institute of Technology.

These materials were developed for JPL's Mars Exploration Education and Public Outreach Program, which is part of NASA's Mars Exploration Program. The work is funded by NASA's Jet Propulsion Laboratory (JPL), which has overall responsibility for the Mars Exploration Program.

The curriculum materials were developed through a subcontract to the Center for Earth and Space Science Education (CESSE) at TERC, Inc., a nonprofit educational research and development company. The materials have been reviewed by NASA scientists and field-tested by scores of teachers.

Government Sponsorship is acknowledged under contract NASA7-1260.

Welcome to the Mars Education Program

Between 1997 and 2007, NASA plans to send 10 spacecraft to investigate Mars. To take advantage of this historic set of explorations, NASA's Mars Exploration Program has created a series of curriculum modules to connect students to the excitement and learning potential of these missions. The Mars Exploration Program will help you:

- Engage your students in hands-on, inquiry-based learning
- Involve students in questions central to current Mars exploration
- Teach engineering concepts and physical, life, and Earth and space science in a relevant way
- Provide a context for learning about both Mars and Earth
- Address student misconceptions
- Prepare students for using live data and images from Mars

The module series was developed and field tested by a team of educators and scientists to make sure that it is both scientifically accurate and educationally powerful. Each module contains a set of activities that relate to an over-arching theme. The activities are sequenced so students can progress from introductory experiences to more advanced investigations and deeper understandings. The educator handbook and correlated student materials enable you and your students to do the activities regardless of your previous knowledge about Mars and planetary exploration.

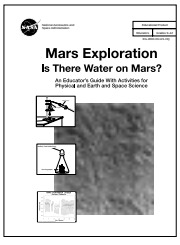
Modules Available in the Mars Exploration Series

Getting Started in Mars Exploration

Grades 4–10, 2 Weeks

How can students study Mars and Mars exploration in the classroom?

This comprehensive introduction to studying Mars in the classroom develops students' understanding of Mars, the solar system, and planetary exploration. The module introduces many of the intriguing riddles posed by Mars and provides teachers a variety of ways to integrate the study of Mars into their classrooms.

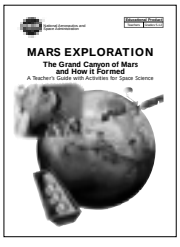


Is There Water on Mars?

Grades 9–12, 3 Weeks

Can water exist on Mars today?

By experimenting with water as it changes state and investigating some effects of air pressure, students not only learn core ideas in physical science but can deduce the water situation on Mars by applying those concepts. They use evidence from their work as well as data and images from NASA's missions to Mars to take a position on whether there was ever water on Mars.

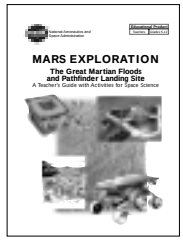


The Grand Canyon of Mars and How It Formed

Grades 6–12, 3 Weeks

What can a colossal fracture tell us about Mars?

Students investigate the formation of Mars' 3,000-mile-long rift valley. After investigating how a planet's surface can be altered and analyzing data and images from NASA's missions to Mars, students develop hypotheses to explain the rift valley's formation and amass evidence to support their ideas.



The Great Martian Floods and Pathfinder Landing Site

Grades 6–12, 3 Weeks

Is the landing site in a floodplain, and why would that be good news?

Students learn how sediment, landforms, and drainage patterns provide clues about a planet's geologic history. They use evidence from their work and data and images from NASA's missions to Mars to understand the advantages of landing at the end of a flood channel.

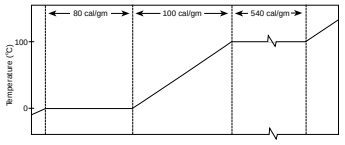
An Overview of What the Modules Provide

- Hands-on, inquiry-based activities written by educators, reviewed by NASA scientists, and field-tested by students
- Engaging physical and Earth science activities that use experiments, models, analogs, and image and data interpretation to investigate questions central to Mars research
- Practical applications of the National Science Standards
- Educator's guides with background information, procedures, teaching strategies, student sheets, assessment recommendations, and a resource list

Table of Contents

Module Overview

Is there liquid water on Mars? By experimenting with water as it changes state and investigating some effects of air pressure, students not only learn core ideas in physical science but can deduce the water situation on Mars by applying those concepts.

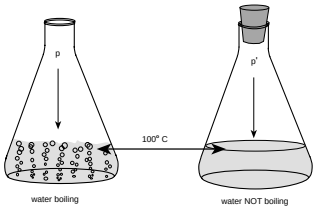


Calories added to 1 gram of water

In Activities 1 and 2, students discover the existence of two temperature plateaus as water changes state. Students have to make sense of these plateaus and come to grips with what changes of state mean at the molecular level. Once students understand the process of boiling and melting, they are ready to examine another factor that significantly impacts the existence of liquid water and atmospheric pressure.

Key Concepts in Activities 1 and 2

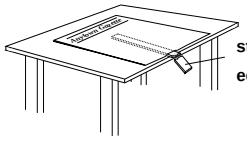
- Water can only be heated to its boiling temperature.
- The temperature of ice water can rise only after all the ice has melted.
- Temperature measures the average vibrational energy of a particle or group of particles.
- As the water in Activity 1 boiled and the ice in Activity 2 melted, the particles used the energy from the heat source to gain the extra kinetic energy required to change state. As a result, the temperature during these transitions never changed.



In Activity 3, students increase the boiling temperature of water by increasing the pressure in the container. In this activity, students not only develop an understanding of pressure's role in water's boiling temperature but also of its role in maintaining liquid water.

Key Concept in Activity 3

- Water boils when its vapor pressure equals atmospheric pressure. As a result, water's boiling temperature is pressure, rather than temperature, dependent.



strike with edge of hand

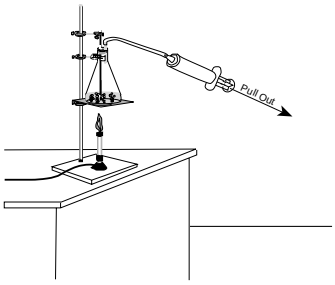
In Activity 4, students perform several activities showing that Earth's atmosphere exerts considerable force at the surface. Many students are unaware that they are subject to considerable atmospheric pressure and have little appreciation for how important this pressure is in their world. By acknowledging air pressure and understanding its role in maintaining water, students can consider questions such as: Why doesn't water on Earth boil away? Could water exist on planets such as Mars?

Key Concepts in Activity 4

- Air has mass and volume.
- Air pressure is a function of the height and density of the atmosphere in conjunction with a planet's gravitational pull.
- The particles in high-pressure air are packed more densely than those in low-pressure air.

- Air flows from areas of high pressure to areas of low pressure to equalize the pressures.
- When the volume of a given mass of gas increases, its pressure decreases, provided that the temperature remains constant (Boyle's Law).

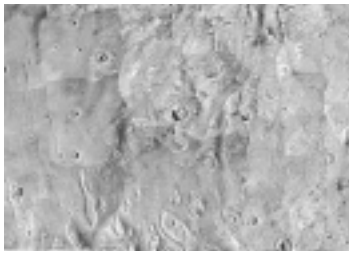
In Activity 5, students build on ideas introduced earlier and discuss ways to reduce the boiling temperature of water. Students find that water can boil well below its typical boiling temperature by reducing the pressure above the surface of the liquid. They learn about phase change diagrams and use one to better understand their previous work with pressure and changes of state.



Key Concepts in Activity 5

- Water boils when its vapor pressure equals atmospheric pressure. As a result, water's boiling temperature is pressure, rather than temperature, dependent.

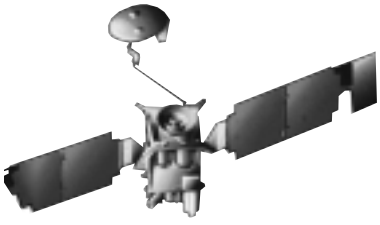
In Activity 6, students analyze temperature and pressure graphs from the first 30 days of the Pathfinder mission and realize that liquid water could not have existed under these conditions. Next, students look at a number of images of Mars. By interpreting the landforms and comparing a river-cut valley on Mars with Earth's Grand Canyon, they identify water as the agent that shaped the surface. They hypothesize about how water could have flowed across the Martian surface, even though current conditions make it virtually impossible for liquid water to exist.



Key Concepts in Activity 6

- Current climatic conditions make the existence of liquid water virtually impossible.
- Features on the Martian surface provide strong evidence for past flows of large amounts of water.

In Activity 7, students generate questions based on their module experiences, and they 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, students create a calendar for the missions and consider how they will access the information returned by the missions.



Key Concepts in Activity 7

- 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.