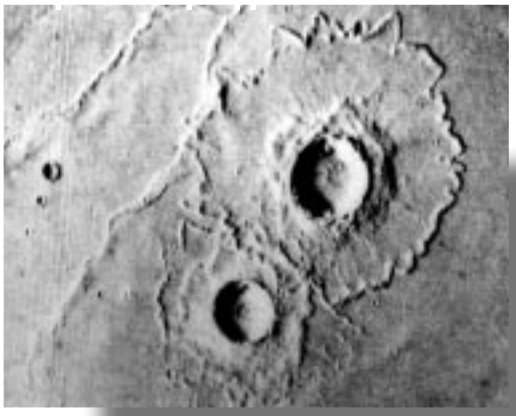
WELCOME TO THE MARS EDUCATION PROGRAM

Over the next ten years, NASA is sending ten 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, Earth and life science in a relevant way,
- provide a context for learning about both Mars and Earth,
- address student misconceptions, and
- prepare students for using live data and images from Mars.

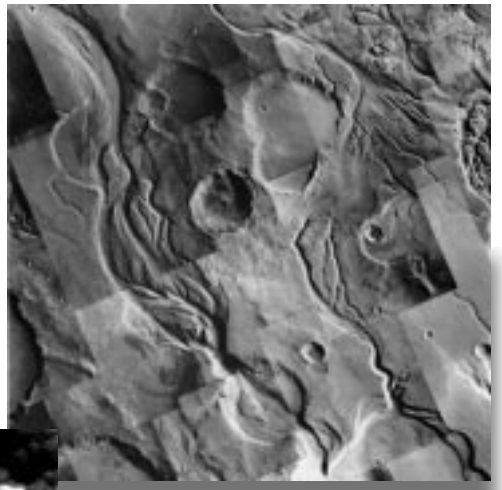
The module series was developed and field tested by a team of educators and scientists to make sure that it is both scientifically accurate and educationally powerful. Each module contains a set of activities that relate to an over-arching theme. The activities are sequenced so students can progress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

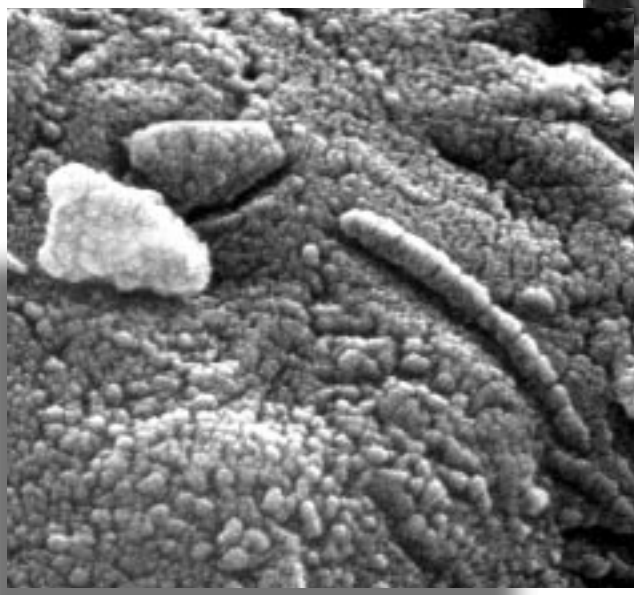
MARS IS A FASCINATING PLANET



What do the "mudflows" around this crater suggest about the sub-surface?
Craters can be used to study sub-surface ice and water on Mars.

Could water have flowed freely on a planet that today is dry and frozen?
Channels can be used to study the way water flowed on Mars.

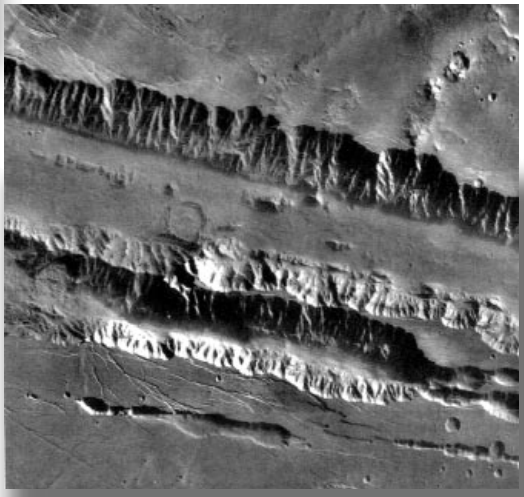




Was ancient Mars teeming with early life?
The controversial Martian "microfossil" can be used to evaluate the possibility of life on Mars.

How can such a small planet have the solars system's largest mountain?
Martian volcanoes can be used to investigate the presence or absence of plate tectonics.

How could a single crack go halfway around a planet?
Martian canyons can be used to study processes that alter a planet's surface.



Where does a dust storm that covers an entire planet originate?
Dust storms can be used to study the circulation of the Martian atmosphere.

WHAT'S DISTINCTIVE ABOUT THIS MODULE SERIES?

Brings Science Topics to Life in an Engaging, Relevant Way

Students not only learn a lot 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, refining and revising 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 a high degree of ownership for their work, the activities are structured so that students can own the intellectual process going on in the classroom.

Builds a Foundation for Understanding Live Data from Mars

Over the Internet, NASA will provide the public with images and data from the Mars missions on a weekly basis. Never before has material from a planetary mission been made available in near-real time. This opens a new chapter in the way students can participate in on-going research. Providing students meaningful background experiences is a central element of the Mars Exploration Program. Consequently, the modules prepare students to analyze images, understand NASA's key research questions, know the capabilities of the instruments on the spacecraft and recognize Mars' planetary features. Given such a foundation, students can contribute meaningfully to our understanding of the planet.

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 Mars.

Helps Transform Science Education

Mars is not only the focus of on-going scientific investigations, it also offers a wonderful opportunity to improve science education. The letter at the end of the preface from the Program Educator for the Mars Exploration and Education Program describes how the module series contributes to this effort.

Implements the National Science Education Standards

The content and skills in the module series relate closely to national, state and local curriculum standards. The series can help schools implement these standards in a creative, innovative and multi-faceted program. In particular, students will learn:

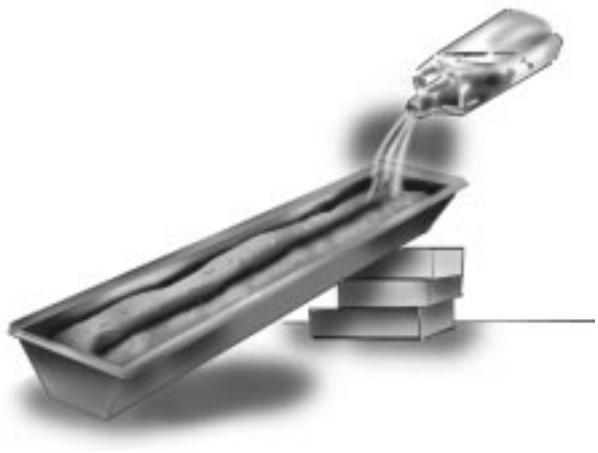
- fundamental concepts of Earth and space science
- skills of inquiry and investigation
- how to base arguments on evidence
- how to discuss alternate hypotheses
- how to gather information using computers and telecommunications

The modules develop such skills and understanding by responding to many of the National Science Education Standards' recommendations for science teaching, professional development, assessment and content.

THE THREE KINDS OF ACTIVITIES IN THE MODULES

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

- **Conducting Classroom Experiments and Creating Models**



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

- **Making Mars/Earth Comparisons**

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

Earth Image: Grand Canyon

Mars Image: Valles Marineris

• Using Real Data and Images from Mars

Students use data and high-quality images from previous Mars missions.* After NASA's missions arrive at Mars, students can use the Internet to obtain the latest data and images, enabling them to experience the excitement of scientific exploration and discovery as it happens.

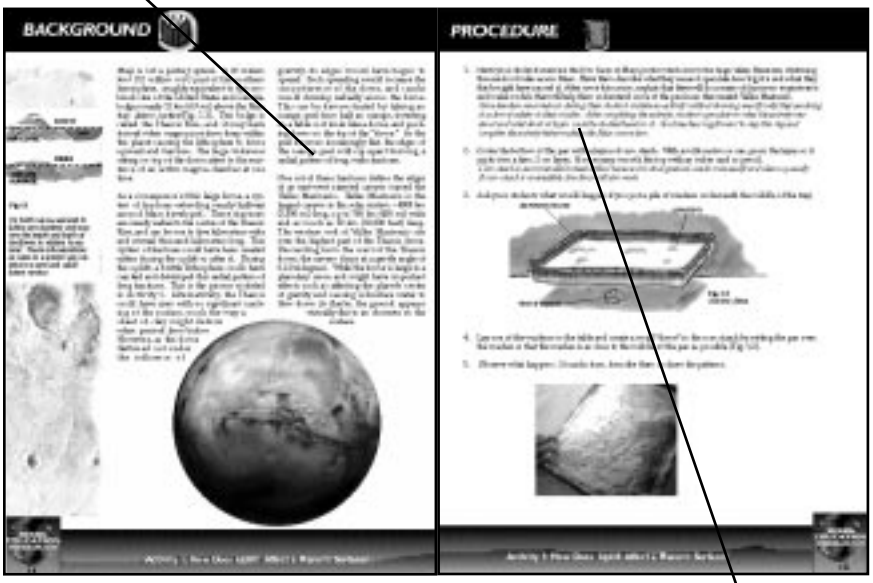
* Student Image Sets

The student image sets are the only printed student material for each module. They provide you and your students with a set of maps and photos of the surface of Mars. The activities are based on these images, and students use them to provide clues as they pursue their investigations. We recommend that you get one set for each group of two or three students. This enables each student to examine the images closely and supports dialogue about the images.

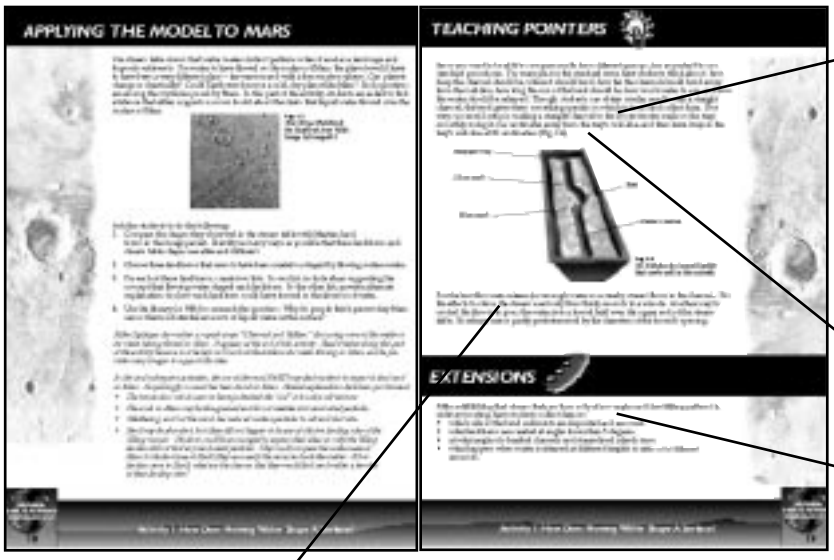
HOW IS THE TEACHER HANDBOOK ORGANIZED?

Each module is written as a Teacher Handbook which gives the module a conceptual and pedagogical structure while still providing teachers the flexibility to tailor the activities to the needs of their classes. The Teacher Handbook prepares teachers to conduct classes around core questions, and it outlines investigations that explore those questions.

Background
Thorough, easy to understand background information enables teachers to understand the key concepts in an activity.



Learning Activities
Clear, detailed activity procedures (with reproducible student sheets, when required) facilitates planning and classroom implementation.



Teaching Pointers

The pointers, classroom management strategies, discussion suggestions, extensions and answers to the questions listed here assist teachers in conducting hands-on, inquiry-based activities.

Assessment Suggestions

Each module provides teachers several options for assessing students including preassesment questions question sets, case studies and suggestions for alternate ways of exhibiting student understanding.

Technology /Internet Recommendations

Computers can give students access to a rich set of related support materials, and the modules tell you about particularly applicable Web sites, CD-ROM's and videos and about how to get the live images and data from Mars. However, you still can use these modules without the use of any classroom technology.

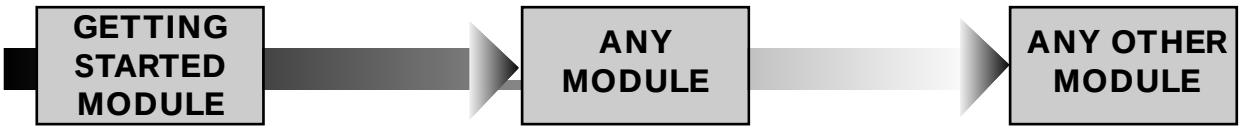
Case Studies

Each module has a particular story to tell, and each activity in a module provides a part of that story. A case study gives students the opportunity to piece together that module's story by applying and integrating the key concepts introduced in a module. Case studies help students synthesize their learning and can be used as an assessment tool.

HOW DO I GET STARTED?

Selecting Among the Modules

Getting Started is a comprehensive introduction to studying Mars in the classroom and is recommended as the first module. It contains investigations that showcase how the series uses inquiry-based learning, image analysis, models, and experiments to develop students' understanding of Mars and the solar system. If your students have a solid understanding of the solar system, or if you want to study a particular topic or question, you could also start with another module.



Finding Out What is in a Module

To understand how the activities examine the question around which a module is organized, read the "Overview of the Module Activities and Science Themes" section. Each activity is described, and you will learn about the conceptual sequence and the culminating project.

Finding Out What is in an Activity

To understand each activity in greater detail (including material and time requirements), read the "At a Glance" page at the beginning of each activity.

Materials

Turn to the "Materials Used in This Module" section at the end of the module. The activity procedures call for the use of these materials. As much as possible, the activities use readily available materials, but occasionally, specific maps, posters or videos will greatly enhance a lesson. In such cases, all ordering information is provided. If budget or time constraints make obtaining these materials difficult, read about their use in the activity description and judge for yourself which items are especially important for conducting the activity with your students. AT A MINIMUM, ORDER THE STUDENT IMAGE SETS. ONE IMAGE SET FOR EVERY TWO STUDENTS IS RECOMMENDED.

Jet Propulsion Laboratory
4800 Oak Grove Drive, Pasadena, CA 91109

An open letter from Dr. Meredith Olson, the Mars Program Educator for the Mars Exploration Education and Public Outreach Program.

Dear Colleague,

The ultimate goal of NASA's Mars Exploration Program is to use the adventure of going to Mars as a tool for the improvement of science education. We are at a moment in history when we have both the unprecedented Mars exploratory missions and tremendous interest in the improvement of science instruction. Both will unfold over the coming decade. The Mars Exploration Program provides a high-profile way to tap the excitement of planetary exploration and to promote teaching for scientific understanding.

Our goal is not just to teach about Mars. Our goal is to teach habits of mind. Very often the modules do not start with investigating Mars, but bring Mars science and engineering in at appropriate times when students are primed to make discoveries. We seek to promote the habits of mind that underlie science literacy, science reasoning and engineering ingenuity. The questions that underlie our task include how do we:

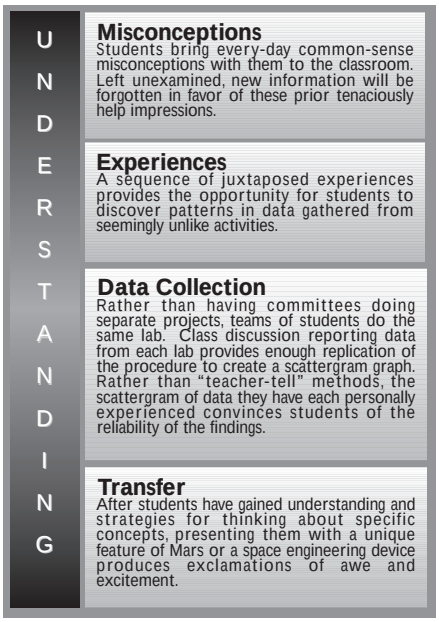
- engage their interest and ingenuity?
- inspire confidence and joy in their own reasoning abilities?
- teach without telling?
- help students develop habits of mind as they make meaning of Mars data?

We believe that a scientifically literate society is built from exposure to carefully crafted lessons that reveal students' misconceptions and which engage them in activities that help them reconstruct their understandings.

Educational research points out the severe limitations of communicating real understanding through lectures. The only time lectures communicate effectively is when one already understands the underlying concepts! One cannot internalize what one has not experienced. How can you explain a blizzard to someone who has never experienced snow? Consequently, as we develop lessons, we are guided by four questions:

1. What is the opening question of the lesson?
2. What series of experiences highlight patterns among seemingly unrelated events so students discover a concept?
3. How do we structure investigations to assure student ownership?
4. Which Mars topic best relates to the concept just learned?

1. Each activity starts with an introductory question
These questions a) attract students' attention and generate interest in the topic; b) challenge students to confront the extent to which they do or do not understand a concept; and, c) confront the contradictions between their assumptions and actual physical phenomena.



2. The activities follow a carefully considered sequence
Lesson activities contain concrete materials for students to manipulate. Handling real materials allows students to notice similarities and contrast attributes. It is important for students to experience several activities, one after another, so they discover subtle comparisons. Student interest is aroused by class debate over attributes they have detected from these experiences. By experiencing a concept in different activity settings, students are more likely to form connections among ideas and build a web of relationships by which these concepts acquire meaning.

3. Lab activities and data treatment become personal ventures for students
It is important that students feel they own the intellectual process going on in the classroom. For example, as they implement an activity designed in class discussion, they must figure out the details of how to set up their own equipment to perform procedures. They must measure and record data while watching the event happen. The public sharing of data provides regular feedback and prompts frequent reflection about a student's predictions, method, conclusions and accuracy. Disagreement in results can be a springboard for discussions that empower students to craft revised experiments. The mastery of fundamental science concepts is greatly enhanced and made meaningful when students feel a high degree of ownership for their work.

4. Students generalize their understandings of science to Mars
After students have gained understandings about specific concepts, presenting them with an image of a unique Martian feature or an engineering device produces exclamations of awe and excitement. Students are energized by their own powers of deduction as they generalize their understandings of fundamental science concepts to Mars and planetary science. For example, students find watching planetary rovers navigate remote sites more engaging after attempting to create their own rover. People are generally more interested in and appreciative of the devices of others when they have already tried to do the task independently.

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The Mars Exploration Program's module series offers experiences that students enjoy and which promote their understanding of fundamental science concepts. Such lessons can transform the "severe, terminal boredom" often exhibited by science students into an appreciation and excitement over the exploration of Mars. The Mars module series promotes understanding about Mars and aspires to transform science education in the United States.

Thank you for becoming involved in this important work.

Dr. Meredith Olson
Mars Program Educator

Dr. Meredith Olson is the Mars Program Educator for the Mars Exploration and Education Program. Based on her expertise and experience as a science teacher, she has a strong voice in shaping the educational philosophy and learning activities in the Mars Education modules. She is the Middle School Chairman and Science Education Specialist at the Seattle Country Day School, in Seattle, Washington.