



Getting Dirty on Mars

Teaching Tips



Mars Education Program

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Lunar and Planetary
Laboratory

Getting Dirty on Mars Teaching Tips

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Goals:

Through comparison, facilitate understanding about the similarities and differences between soil properties on Earth and Mars.

Objectives:

Students will...

- ✓ *Work in cooperative groups to collect soil samples from the field similar to NASA's robotic Phoenix Mars Mission.*
- ✓ *Understand the properties of soils.*
- ✓ *Examine soils for their ability to sustain organisms.*

Time Frame:

Three to four 50-minute class periods

National Science Education Standards:

See end of Teaching Tips for more detail

- Standard A: Science as Inquiry (grades 5-12)
- Standard B: Physical Science (grades 9-12)
- Standard C: Life Science (grades 5-12)
- Standard D: Earth and Space Science (grades 5-8)
- Standard G: History and Nature of Science (grades 5-8)

National Math Education Standards:

See end of Teaching Tips for more detail

- Measurement
- Data analysis and Probability

Grade Levels: 5-12

Materials Needed (per team of 4 students):

- ✓ At least one soil sample per team (number the samples for reference—each sample will be divided into 2 parts)

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- ✓ Abbreviated Munsell Color Chart (Appendix 1) – Must be printed in color or displayed on an overhead projector. If possible, laminate for field use.
- ✓ Soil Parent Material Chart (Appendix 2)
- ✓ Data Log
- ✓ Spray bottle of water
- ✓ Plastic laundry scoop or similar collection device
- ✓ Tweezers or sieve (instructions below)
- ✓ Vinegar
- ✓ Balance or electronic scale
- ✓ Flame proof beaker (if heating the sample with a burner)
- ✓ Heat source (Bunsen burner or the Sun)
- ✓ Paper plates and paper towels
- ✓ Magnifying glass
- ✓ pH test strips or a pH meter
- ✓ Distilled water
- ✓ Ziplock baggies
- ✓ Styrofoam cups
- ✓ Dirt samples for students to examine for the KWL portion of the module.

Optional Materials:

- ✓ Full Munsell Color Chart

Introduction

In August 2007, the next mission to Mars will be launched from Kennedy Space Center, Florida. The spacecraft, called Phoenix, will be our second attempt to land near the Martian poles. The first attempt, called Mars Polar Lander, failed in 1999, so it is up to Phoenix gather the data we need to understand this important region of Mars.

The Phoenix Lander will study the Martian soil to measure its physical and chemical properties much like a gardener on Earth would test soil in his or her own yard.

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In this series of activities, you will learn what the important properties of soil are and how to measure them. Because we have no Martian dirt for testing, you will use Earth soil taken from your own region. If available, however, your teacher may prepare you to better understand the discoveries of the Phoenix lander by giving you practice with Johnson Space Center's "Mars Soil Simulant," the closest match to Mars soil that we have here on Earth.

Why Is Soil Important?

We experience soil every day of our lives. Even the cleanest city street has some dust and dirt on it, but when we talk about soil, we are usually talking about the thick layer of dirt that covers the natural ground.

Soil is a critical component of Earth's ecosystem. It holds water and nutrients for plants, many of which are eaten by animals – and humans, too! Soil is important to farmers, as the properties of a particular kind of soil determine what crops will grow best in it. Much of our building materials, such as bricks, also come from certain kinds of soil.

Soil can change the chemistry of groundwater (e.g., acidity, saltiness) and the type of soil in a region will determine whether groundwater will collect in an area for use by its inhabitants or if it will run off downstream, eroding the landscape. Soil helps regulate Earth's temperature and its atmosphere, and soil affects the types of gases released into the atmosphere as well.

Microbes living in the soil break down organic material into nutrients that can be used by plants. Soil is critical to life on Earth, so it is important that we understand its properties. Soil is equally important on Mars. Just as on Earth, the pedosphere (the outermost layer of a planet's surface, primarily composed of soil) of Mars can tell us a great deal about the planet's history and whether Mars was ever capable of supporting life, or could support life in the future.

Teaching Tips

Getting Dirty on Mars is a fun and interactive way to introduce your students to the basics of soil science. By measuring for themselves many of the properties scientists use to characterize soil samples, your students will be better prepared to interpret those properties as used in actual applications.

KWL Inquiry Activity

To prepare students to understand why studying soil is important to scientists, you will perform an activity with them called a "KWL" (what I Know, what I Want to know, and what I Learned). This inquiry based activity focuses students thinking on what they already know about soil (or dirt as they may call it). It then prompts them to be thinking about what they may want to know about soil samples, and finally, helps them to assess what they learned through this module. An additional section helps to stimulate students to think about additional research they can conduct about the soil on Mars. Through library resources, and the Internet, students can find a lot of information about studies on Mars that have already been conducted by scientists, which will then help them to be thinking about questions that haven't been answered yet, or questions that haven't been asked. This is the ultimate goal of science, to test ideas and answer questions.

The "Hands-on" portion of this pre-activity helps students to look closely at soil samples. You will need to prepare soil samples for the class (you can simply get a gallon of dirt from outside, and keep it in a

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bucket). Place a sample of soil into a Styrofoam cup for students. Students can then pour the samples onto white sheets of paper (for better contrast).

The last activity in this Phoenix Mission Curriculum will allow your students to begin to assess directly the habitability of a soil sample – from Earth or from Mars! In addition, your students will use their understanding of these properties to interpret actual data taken by the Phoenix Lander on Mars.

When organizing materials for your students to conduct this set of activities, you may want to consider the following suggestions:

- Print out a class set of the instructions (page SG1-SG16). That way, you are able to conserve resources for your classroom.
- Each student should get their own copy of the KWL chart (1 page), Data Log (2 pages) and the Soil Properties Report (1 page). Again, this allows you to print only the necessary pages for students to complete the lab.
- Finally, print out Soil Color Comparison Chart (appendix I), Soil Parent Material Identification Chart (appendix II), and the Soil Context Cards. Consider laminating the comparison chart and context cards to be able to use them in the field, and for durability.

The tips below touch on activities that will provide you with extra background knowledge and tips to keep in mind as your students begin their investigations.

IMPORTANT NOTE: The moisture content assessment in Activity 3 (part 1 and 3) will take some time to carry out (1-2 days, unless you use an oven or Bunsen burner to dry the sample). So, on the first day, you will need to complete the activities through Soil Color (Part 2). Soil changes color as it dries, so it is important to examine the soil sample immediately after collection to see it as close as possible to its natural state.

Field Work

Soil Context: The introductory material in the student guide provides the foundation for discussing soil and its properties. The material carefully defines what we mean by “soil” and discusses the important issue of the context from which the soil samples were taken from. Students should collect the context information for each sample, recording it on the “soil context cards.” Each card should be kept with its sample. This will help students conducting lab work on their samples and students absent on the day of field work. Context card forms have been created for you to include in the soil samples you collect.

If you know information about the parent material then you can place this on the soil context cards. You can research information about the parent material at your local library, or at <http://www.usgs.gov>.

Lab Work

Soil Moisture Content: This activity is done in 3 parts: part 1: weighing the sample before it is dry, part 2: determine the soil color (before it is dry), and part 3: drying the sample.

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Part 3 of the experiment requires your students to dry the sample by heating or in some other way. Drying goes best using an oven (not a microwave), but few classrooms have this available. A Bunsen burner works quite well, provided you set the heat low and keep the sample in the coolest part of the flame. If you use a Bunsen burner, make sure the sample is in a flameproof container, resting it on a ring-stand during heating. Be sure to follow all lab safety procedures when using open flames.

Removing moisture takes some patience. One way to test for remaining moisture is to periodically hold a mirror over the sample while it is heating. As moisture escapes, steam will fog the mirror slightly. Of course, depending on the flame source, other vapors besides steam may be released, so use this technique as a guide, not an absolute.

Samples can also be dried in the Sun over a couple of days, if this can be worked into your classroom schedule. One of the easiest ways is to spread the soil sample out onto a paper towel and a paper plate. Sandwiching the sample between two paper towels will help it to dry out. By placing a paper towel under and over the sample, you can store several samples with paper plates on top of each other. If you dry them outdoors, watch for wind and remember to bring the samples indoors and cover them before nightfall each evening.

Soil Color: The Munsell Color Chart must, obviously, be printed in color. If possible, laminate and cut the sample cards to be more durable for field and lab work. Printing and laminating several color copies is the ideal solution. However, if you have no access to a color printer, the color chart could be brought up on a computer screen (or projected on the wall using an LCD projector). This becomes a “station” for students to use when they need that data. All other charts and diagrams can be printed in grayscale with no loss of information.

Biomarkers: This portion of the lab will give the students an opportunity to assess the habitability of the sample. One way to know if a sample is habitable for life is by detecting organic material. If you can see roots or living creatures in the sample, then you can be sure it supports life!

You can create your own sieve in this part by purchasing screen material at a local hardware store. Cut pieces of screen into 10 cm by 10 cm squares, and use masking tape to tape the edges. This helps to stiffen the screen so when you sieve the soil through it, it won’t be too flimsy.

Later in the module, students will take their sample and place portions of it into ziplock baggies with seeds to determine if the soil is capable of supporting life.

pH Measurement: The easiest way to measure pH is with test strips that are commercially available for use with swimming pools and hot tubs. While the liquid pH test kits are more accurate, paper test strips are quick, easily managed by younger students, and give results that are accurate enough for instructional purposes.

It is important that your students measure the pH of the distilled water used for the soil solution – distilled water stored in classrooms often becomes contaminated over time. Having several medicine droppers will make this portion of the experiment easier, but they are not strictly necessary.

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Assessment: After completing this activity, students will create and present a “Soil Properties Report” which describes, in narrative form, the properties of their soil sample. The report should show the students have mastered the definitions and interpretations of the soil properties discussed in this activity.

Soil Properties Report: The Soil Properties Report is a one-page narrative summary of the students’ results. It can follow any format, but ask your students to move beyond simply reporting the data in bullet form. Encourage them to write complete sentences that present the information in an easy-to-understand way. Also encourage them to comment on and interpret the data – what does it all mean? Students should also determine whether or not their samples were habitable. While studying Earth-based samples for habitability is easy (relatively speaking), samples we look at on Mars might not be so easy. This should be an important part of their reports.

Key words: For words that could cause confusion for students, we have identified words that will help with the understanding of concepts within the activities. This is included at the end of the activity.

EXTENSIONS: If you are interested in having the students take the soil samples for themselves, we strongly encourage you to investigate the Global Learning and Observations to Benefit the Environment (GLOBE) Project. Information on this excellent in-depth program is available at <http://www.globe.gov>

Content Standards—Details

Science

Grades 5-8

Standard A: *Science as Inquiry*

- **Design and conduct a scientific investigation:** Students should develop general abilities, such as systematic observation, making accurate measurements, and identifying and controlling variables. They should also develop the ability to clarify their ideas that are influencing and guiding the inquiry, and to understand how those ideas compare with current scientific knowledge. Students can learn to formulate questions, design investigations, execute investigations, interpret data, use evidence to generate explanations, propose alternative explanations, and critique explanations and procedures. (Does Mars have life? Is Mars soil habitable? Did previous Mars spacecraft find evidence of life?)
- **Use appropriate tools and techniques to gather, analyze and interpret data:** The use of tools and techniques, including mathematics, will be guided by the question asked and the investigations students design. The use of computers for the collection, summary, and display of evidence is part of this standard. Students should be able to access, gather, store, retrieve, and organize data, using hardware and software designed for these purposes.
- **Think critically and logically to make the relationships between evidence and explanations:** Thinking critically about evidence includes deciding what evidence should be used and accounting for anomalous data. Specifically, students should be able to review data from a simple experiment, summarize the data, and form a logical argument about the cause-and-effect relationships in the experiment. Students should begin to state some explanations in terms of the relationship between two or more variables. (Did Viking find signs of life with its biology experiment? Why or Why not?)
- **Communicate scientific procedures and explanations:** With practice, students should become competent at communicating experimental methods, following instructions, describing observations, summarizing the results of other groups, and telling other students about investigations and explanations.
- **Use mathematics in all aspects of scientific inquiry:** Mathematics is essential to asking and answering questions about the natural world. Mathematics can be used to ask questions; to gather, organize, and present data; and to structure convincing explanations.

Standard B: *Physical Science*

- **Properties and changes of properties in matter:** Substances react chemically in characteristic ways with other substances to form new substances (compounds) with different characteristic properties. In chemical reactions, the total mass is conserved. Substances often are placed in categories or groups if they react in similar ways; metal is an example of such a group. (Phoenix will heat soil samples for spectral analysis, and test for chemicals in the samples)

Content Standards—Details

Standard C: *Life Science*

- **Populations and ecosystems:** The number of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition. Given adequate biotic and abiotic resources and no disease or predators, populations (including humans) increase at rapid rates. Lack of resources and other factors, such as predation and climate, limit the growth of populations in specific niches in the ecosystem.

Standard D: *Earth and Space Science*

- **Structure of the Earth system:** Soil consists of weathered rocks and decomposed organic material from dead plants, animals, and bacteria. Soils are often found in layers, with each having a different chemical composition and texture.

Standard G: *History and nature of science*

- **Science as a human endeavor:** Science requires different abilities, depending on such factors as the field of study and type of inquiry. Science is very much a human endeavor, and the work of science relies on basic human qualities, such as reasoning, insight, energy, skill, and creativity—as well as on scientific habits of mind, such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas.

Grades 9-12

Standard A: *Science as inquiry*

- **Understandings about scientific inquiry:** Scientists usually inquire about how physical, living, or designed systems function. Conceptual principles and knowledge guide scientific inquiries. Historical and current scientific knowledge influence the design and interpretation of investigations and the evaluation of proposed explanations made by other scientists. Scientists conduct investigations for a wide variety of reasons. For example, they may wish to discover new aspects of the natural world, explain recently observed phenomena, or test the conclusions of prior investigations or the predictions of current theories. (comparison of the results of past exploration and understanding what scientists have already discovered about the soil on Mars).

Standard B: *Physical Science*

- **Chemical reactions:** Chemical reactions may release or consume energy. Some reactions such as the burning of fossil fuels release large amounts of energy by losing heat and by emitting light. Light can initiate many chemical reactions such as photosynthesis and the evolution of urban smog. (The chemical and spectral analysis of experiments on the Phoenix Lander).

Content Standards—Details

Standard C: *Life Science*

- **Biological evolution:** The great diversity of organisms is the result of more than 3.5 billion years of evolution that has filled every available niche with life forms.

Mathematics

Grades 5-8

- **Measurement:** Students should be able to: Understand measurable attributes of objects and the units, systems, and processes of measurement.
 - **Grades 3-5:** Understand such attributes as weight, volume, and size of angle and select the appropriate type of unit for measuring each attribute. Understand the need for measuring with standard units and become familiar with standard units in the customary and metric systems.
 - **Grades 6-8:** understand both metric and customary systems of measurement. Understand relationships among units and convert from one unit to another within the same system. Understand, select, and use units of appropriate size and type to measure angles, perimeter, area, surface area, and volume.
 - **Grades 9-12:** Make decisions about units and scales that are appropriate for problem situations involving measurement.
- **Data Analysis and Probability:** Students should be able to: Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them.
 - **Grades 3-5:** Collect data using observations, surveys, and experiments.