SOIL HABITABILITY
Teaching Tips

Mars Education Program

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The University of Arizona
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SOIL HABITABILITY

Teaching Tips

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SOIL HABITABILITY

Goals:
Upon completing this activity, students will understand and be able to determine if a soil sample is habitable for life.

Objectives:

Students will...

- ***Work in cooperative groups to collect soil samples from the field in a manner consistent with the Phoenix Mission.***
- ***Understand what is needed for organisms to grow.***
- ***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 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

- **Data analysis and Probability**

Grade Levels: 5-12

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Materials Needed (per team of 4 students)**:**

- At least one soil sample per team (number the samples for reference)
- Spray bottle of water
- Tweezers or sieve (instructions below)
- Plastic laundry scoop or similar collection device
- A sunny windowsill to place soil samples onto
- Ziplock baggies
- Fast growing seeds (rye, grains, etc.) that germinate in 1-2 days
- Thermometers

Optional Materials:

- Magnifying glass

Introduction

In the fall of 2007, the next mission to Mars will be launched from Cape Canaveral, 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 measure the Martian regolith (soil) to measure its physical and chemical properties. These will include its ability to support Earth-based life, such as crops that future Martian settlers might plant, as well as its suitability for building materials.

In this lesson, students will determine whether or not the soil they collected in the field is habitable for organisms (specifically, fast-growing seeds). If you choose, you can get a sample of Johnson Space Center's "Mars Soil Simulant" which is the closest match to Mars soil that we have here on Earth. The Mars Soil Simulant chemical composition is compared to that of a typical Mars surface sample analyzed at the Viking lander 1 site. Current data from the Spirit rover's investigation of the surface material at Gusev Crater also confirms that the JSC Mars-1 simulant is still a fair match to the planet-wide dust and soil layer. (For a sample, please send a written request to the Office of the Curator, NASA Johnson Space Center, Houston, TX 77058)

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 and pH of groundwater, 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, or regolith, is equally important on Mars. Just as on Earth, the soil on 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

Soil habitability is a fun and interactive way to allow your students to begin to assess directly the habitability of a soil sample. In addition, your students will use their understanding of this to interpret actual data taken by the Phoenix lander on Mars.

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

Soil collection

Find a location where you can take soil samples using plastic laundry scoops (simulated Phoenix lander scoop). Identifying an area before the students get to the site will help.

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Your students will need to collect soil samples using the described soil collection procedures to simulate what the Phoenix lander might experience when taking soil samples on Mars. Make sure the students follow the procedures closely, and that they only make 5 scrapes with their instrument in the sampling area.

Soil habitability

In this series of activities, students 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, you may prepare your students to better understand the discoveries of the Phoenix lander by giving them practice with Johnson Space Center's "Mars Soil Simulant," the closest match to Mars soil that we have here on Earth.

Test kits are available to check terrestrial soils for fertility, but they are costly and impractical for classroom use. This simple experiment lets students see if their samples are fertile enough to allow plants to grow. For this portion of the activity, you will need some fast-growing seeds. Rye, garden beans (green beans, snap peas, etc), and some grain seeds can germinate in 1-2 days. For your geographic location, see what seeds local garden centers or hardware stores can provide for this experiment.

Students are to moisten the sample, not pour water onto the sample.

For the extension activity, students take their samples out of the freezer and fridge, allow them to thaw, and see how the seeds respond.

Key words

Some words might be confusing or unknown to some students. At the end of the activity, we have included a few key terms that will help students understand the terminology.

Additional Information--factors influencing habitability chart

Included at the end of the lesson is a chart that describes factors that influence whether or not a planet is habitable. In addition to describing the specific parameters that life needs to survive, it can also be used to compare other planets or moons that have atmospheres, but no signs of life.

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.

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.

Content Standards—Details

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 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

- **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.