Are There Other Neighborhoods Like Our Own?

Grades 5-8

Lesson 3: Searching for Signs of Life

Lesson Abstract

Students are presented with three soil samples representing simulated Martian soil. After visual inspection of the soil samples they 'feed' the samples with nutrient solution and assess if this causes any observable activity. They then explore the nature of the observed activity and determine if it represents chemical or biological processes.

The lesson is a direct analog to the life science experiments conducted by the Viking Landers on the surface of Mars in 1976 to look for photosynthesis, respiration, and gas exchange. The nature of the observed activity on Mars, once soil samples were fed 'chicken soup', allowed researchers to distinguish with high confidence between chemical and biological processes at the landing sites.

Grade Level
5-8

Searching for Signs of Life

Overview

One question we all ponder is whether or not we are alone in the universe. Mars is one of many places where we might find life. Being the planet most similar to Earth, Mars has water vapor and permafrost on the surface. At one time, Mars appears to have had an abundance of flowing water, similar to Earth. It is at these places—where there is or was water—that there is a possibility that life, or evidence of past life, may exist.

When scientists go in search of life, it is not necessarily a quest for large human-like beings, or even life that can be seen with the naked eye. Most scientists expect to find, at most, microscopic evidence, such as bacteria or their fossils. One recent search for life on Mars was centered on the Martian meteorite, ALH84001. Several meteorites are known to be from Mars, based on atmospheric gases trapped in pockets in the rock. The meteorite, found in Antarctica, dates back to an early period on Mars when the conditions were much wetter and more suitable for life. Formations in the rock suggest that it may contain a fossilized form of bacteria, although the proper interpretation of the rock's features is a subject of vigorous debate and inquiry among many scientists.

Scientists would like to study rock samples from areas on Mars that appear to be dried riverbeds. Collecting rock samples is one task for future Mars missions. In the past, however, we have looked for life in the soil on Mars. When Viking 1 and 2 landed on Mars in 1976, the landers analyzed the Martian soil in search of carbon-based life. Analysis of some soil samples seemed to indicate lifelike characteristics. However, scientists did not find evidence of organic matter. They did find unusual geochemistry to which they attributed the chemical reactions that had seemed at first to be signs of life.

In this activity, students research suitable criteria for defining the presence of life. They then analyze soil samples in tests similar to the experiments on the Mars Viking Lander.

ESSENTIAL QUESTION

How can we search for the presence of life?

OBJECTIVES

Students will:

- Conduct a simulated experiment with soil samples
- Identify relationships between the soil samples using an operational definition of life
- Make an inference based on data obtained

Students will have to be careful to distinguish between chemical reactions and biological reactions, and use an operational definition of life to determine whether there are any signs of life in three different soil samples. Teams make observations, draw pictures as they collect data from the samples, and draw conclusions.

Procedures

1. Preparation of the soil samples:
   - Label the set of jars for each group "A," "B," and "C."
   - Fill all jars 1/4 full of soil.
   - Mix half a packet of instant active dry yeast into the soil in each jar labeled "B." Stir.
   - Mix one powdered Alka-Seltzer® into each jar labeled "C." Stir.
2. Students must observe all safety procedures, including personal safety protection and safe handling of materials.
3. Divide students into groups of three or four.
4. Explain that each group will conduct research on the characteristics of living and non-living things in order to come up with criteria that indicate that life is present.
   - Provide dictionaries, books, encyclopaedias, CD-ROMs, and the Internet. Use the examples below to encourage students, but not to limit them.
   - Examples: Consider a bear and a chair—they both have legs, but one can move on its own and the other would need a motor made by humans; therefore, independent movement might be one characteristic that indicates life. Not every living organism needs legs or roots, but they have a mode of locomotion or a way to get nutrients. Also, the bear breathes (respiration) and the chair does not, another indication of life. Or consider a tree and a street light. We know that a streetlight cannot reproduce; it is made by humans, and we know that the tree makes seeds that may produce more trees. The tree also absorbs nutrients, gives off gases, and grows. The light uses electricity and gives off light through a strict energy exchange; there is no growth and there are no metabolic processes.
5. Let students share their research in their groups, encouraging them to consider examples from a diverse range of living things. The ideas of the whole class can then be summarized on a board, overhead, or chart.
6. If students have difficulty developing their own criteria, the following ideas can be used for this activity:
   - Metabolic processes that show chemical exchanges which may be detected in some sort of respiration. For example, animals take in carbon-based organic molecules and expel carbon dioxide.
   - Exchange of gases, liquids or solid materials

MATERIALS

Each student will need:

- Internet or library access

Each group of students will need:

- 3 baby food jars or small beakers, filled with the simulated soil samples (see below)
- 2 cups warm sugar water—40–50° C (104–122° F). **Ensure that temperatures are not higher or the yeast will not survive.** Add ~5 mL of sugar to 1 cup of water.
- Beaker for distributing the water
- Magnifying lens
- Goggles—1 per student
- Questions and conclusions sheet—1 per student, to be handed out after the experiment

Materials for simulated Martian soil samples:

- Sand or sandy soil
- Instant active dried yeast
- Alka-Seltzer® tablets, powdered

- Reproduction, replication, or cell division
- Continued reaction to stimuli

7. Explain to the students that each team has a set of simulated Martian soil samples. No one knows if there is anything alive in them. Their assignment is to make careful observations and check for indications of living material in the soils based on their criteria.
8. Give each group a cup of warm sugar solution at a temperature of 40-50° C (104-122° F). **Ensure temperatures are not higher or the yeast will not survive.** Instruct them to follow the directions on their worksheet.
9. When the students are finished with their observations, provide them with the Questions and Conclusions worksheet and have them complete only questions a through d. Here are the questions with answers:
   a) Prior to adding water, what differences did you see in the soil grains? (Students should notice smooth granules in jar B, and white specks in jar C.)
   b) Which samples showed activity after the first "feeding?" (B and C)
   c) Does the activity mean there is life in both B and C and no life in A? (There may be life in all or none. But we know something interesting seems to be happening in B and C. These reactions may be signs of life. But students should recognize that metabolic *and* chemical reactions may account for the activity.)
   d) Which samples showed activity after the second "feeding?" (The reaction is seen a second time in jar B, but not in jar C or A.)
9. Go over the Questions and Conclusions Worksheet with your students. Discuss as a class how they would answer Question e:
   e) How would you explain the difference you observed between the first and second "feeding?"
   After class discussion, tell the students that sample A contained only soil, sample B contained some added yeast, and sample C contained some added Alka-Seltzer®. Re-examine Question e in light of this new information.

Answer: *Jar A shows no reaction after the first or second feeding. It had soil without yeast or Alka-Seltzer®. Jar C had Alka-Seltzer®, which reacted chemically to the addition of water in the first feeding. All Alka-Seltzer® was used up in the first feeding. Therefore no reaction was observed in Jar C after the second feeding. Alka-Seltzer® is a chemical reactant, which is consumable. Jar B contained yeast, a biological reactant. The yeast enjoyed the first feeding, and continued to enjoy the second feeding. The biological reactant is not a consumable; it continued to thrive.*

10. Discuss with the students how the criteria for life they identified earlier are reflected in this experiment.

ASSESSMENT

Students' work can be evaluated using the following rubric:

4 Points
- All observations are complete.
- Observations accurately describe the results.
- Good use of adjectives to describe the observations.
- Writing is clear and understandable.

3 Points
- All observations are complete.
- Observations describe the results.

2 Points
- Observations are few but acceptable.
- Observations attempt to describe the results.
- Writing content is difficult to understand.

1 Point
- Observations are not complete.
- Observations do not describe the results.

0 Points
- No observations are complete.
- Off topic or unrelated.
- Writing is unreadable

Transfer and Extension.

1. Research the Viking life science experiments conducted on the surface of Mars and compare it to the experiment you did in the classroom. (The second feeding administered by Viking to a sample of Martian soil gave rise to little or no reaction, implying a chemical rather than a biological event. However, it is also possible for a biological reaction to cease due to the organisms dying in their own waste.)
2. Find out about the Mars meteorite ALH84001. Group students into teams to debate the presence or absence of fossilized life based on scientific evidence.
3. Consider some common phenomena with respect to your list of criteria for life.
   - Is fire alive? Doesn't it reproduce, consume, and react to a stimulus, e.g., throwing in a log?
   - Is rock candy alive? Doesn't it grow when it's in a sugar solution?

4. If aliens looked down at our cities from space, would they think all the yellow taxis were a species of life? If you left a wristwatch on Mars, and a martian happened to find it, how would she determine if it was or was not alive?
5. Does all life require the same kind of food? Research some exotic forms of life, such as bacteria in geysers.

Student Worksheet

You are provided with three different soil samples, which may or may not contain live material. The purpose of this activity is to make careful observations and check for signs of living material in the soils using the criteria you have researched.

Student Procedures

1. Smell and touch the samples but DO NOT TASTE them. Record your observations in the data log below.
2. Put a few grains from each sample on a flat surface and observe them with a magnifying glass. Record your observations.
3. Obtain a cup of warm sugar water, a nutrient solution for many living organisms.
4. Add the nutrient to each soil sample **by pouring on only enough nutrient solution to just cover the sample**. After this first "feeding", look for any immediate differences caused by adding the nutrient solution. Record your observations in the data log.
5. After 10 minutes, again record your observations of the soil samples.
6. After another 10 minutes, add 5 mL of nutrient solution to each soil sample. Observe carefully and record the reaction to the second "feeding."
7. When you are finished with your observations, ask your teacher for the Questions and Conclusions worksheet.

Data Log

	Sample A	Sample B	Sample C
Smell and touch observation			
Initial visual observation			
First feeding			
After 10 minutes			
Second feeding (after 20 minutes)			

Questions & Conclusions

a) Prior to adding water, what differences did you see in the soil grains?

b) Which samples showed activity after the first "feeding?"

c) Does the activity mean there is life in both B and C and no life in A? Why or why not?

d) Which samples showed activity after the second "feeding?"

e) How would you explain the difference you observed between the first and second "feeding?"