Mission 13
The Viking Search for Life on Mars

Is There Life on Mars?

Overview

In mission 13.1, student teams go on a “Mission to the Schoolyard” to sample “target sites” much in the way Viking landers sampled sites on Mars. In mission 13.2, students analyze the results from Viking's three life detection experiments. Students decide whether or not the Viking mission found proof of life on Mars by solving two “Mysteries of Mars.” They then propose a new mission of their own to Mars.

Notes

Scientists and science fiction writers have always considered Mars the most likely planet in our solar system, other than Earth, to host life. In 1976, two Viking landers arrived on the red planet to investigate. Television cameras revealed a rocky landscape with no obvious plants or animals. The landers were not equipped with microscopes to look for microbes directly, but they did perform three microbial life detection experiments. These were the Gas Exchange (GEX) experiment, the Labeled Release (LR) experiment, and Pyrolytic Release (PR) experiment. The results of all three tests initially came back positive, causing considerable excitement. But the Viking scientists decided that this did not prove that life was present on Mars because the results could have been caused by nonbiological chemical reactions with water.

Mission 13.1
Materials

For a Class of 30

- 6 plastic rings at least 12 inches in diameter
- 6 blindfolds
- 6 plastic cups or scoops
- (optional) Instant film cameras
- (optional) Drawing materials
- (optional) Colored pencils

For Each Student

- “Mission to the Schoolyard” directions
- “Mission to the Schoolyard” worksheet
- Pencil

Getting Ready

1. Find six “target sites” around the schoolyard that students may “sample.” Some should be on grass or bare dirt, but others may be on concrete.

2. Copy the “Mission to the Schoolyard” directions and worksheet for each student.

Classroom Action

1. **Discussion.** Tell students about America's Viking mission to Mars in 1976. With this mission, space scientists were limited to those areas of Mars that they could sample. With only two landers, which were immobile after touchdown, the amount of Martian soil that could be tested was small. Additionally, the landing sites were not optimized for possible biology; it was more important that they be relatively smooth plains, so that the landers would not tip over. The exact touchdown points could not be predicted.

2. **Activity.** Hand out the “Mission to the Schoolyard” directions and worksheet to each student. Divide the class into six teams. Each team will play the role of an extraterrestrial probe sent on a mission to the schoolyard. Assign each team to one of the selected general target sites (*e.g.*, playground, grassy area). Give each team a plastic ring, a blindfold, a collecting scoop (plastic cup), and drawing materials. Set a time limit and launch the teams to their mission landing sites. Read the “Mission to the Schoolyard” directions aloud during this activity.

   (optional) During this activity, visit the teams and document this mission with instant film photographs. Standard cameras and overnight developing can be used to simulate delayed image retrieval, adding a second day to this activity.

3. **The Mission to the Schoolyard.** Lander: Go to your general target site. Choose one student to be the Lander. Blindfold the Lander, and turn him or her around a few times, and then lead him/her a few steps forward. Hand the Lander a sampling ring. The Lander should then gently toss the ring to the ground. This simulates the randomness in the exact touchdown point for Viking (assuming that the Lander is not too much directed by students who are not blindfolded!).

   Photographer and/or Data Recorders: If your team has a camera, photograph the area inside the sampling ring. (Alternatively, the teacher may come and do this.) This is the only view that your Lander has. If your team does not have a camera, then each of you should sketch what you see within the ring. This simulates the pictures of the landing site made by Viking, and sent to Earth.

   Soil Sampler: Another student should be the Soil Sampler. Give him or her a sampling scoop (the plastic cup). He or she must take a sample from the center of the ring and bring it back to class. If it is not possible to actually collect any soil (*e.g.*, if the target site is the cafeteria floor), sample anything that is present inside the ring that can be scooped up by the cup (*e.g.*, dust or crumbs). This simulates the collecting of soil for Viking's life detection experiments.

4. **Discussion.** Have each team present its observations to the class and discuss them in terms of a search for life. A concrete surface, for example, is not a living thing, but is it a sign of life? Could it be a hard clay surface left by evaporating water? Could it be very smooth rock? Based upon the sampling and observation, did your team detect any life or signs of life on Earth? Or would your mission lead you to believe that Earth is a dead planet? If there are no obvious signs of life, are there any tests that you could perform on a sample to detect unseen life? Recall the tests your class has done on other soil samples.

   (optional) Perform one or more tests from previous missions on students' samples. Ask students to decide which tests to use.

   (optional) If photographs were taken, put them on display and ask students to guess where they were taken. This may be particularly puzzling for close-up photographs.

Mission 13.2
Materials

For a Class of 30

- Overhead projector
- "The Viking Mission" transparency (2 pages)
- "Mystery of Mars # 1" clue cards

For Each Student

- "Viking's Life Detection Tests" (1 page)
- "Mysteries of Mars" worksheet
- "A New Mission to Mars" worksheet

Getting Ready

1. Copy the "Viking's Life Detection Tests," the "Mysteries of Mars" worksheet, and the "A New Mission to Mars" worksheet for each student.

2. Copy a set of clue cards for "Mystery of Mars # 1." Cut them apart into individual clues.

3. Prepare "The Viking Mission" transparency. Set up the overhead projector.

Classroom Action

1. **Transparency.** Show the overhead transparency. Briefly explain Viking's three life detection experiments. In the actual Viking mission to Mars, three life detection tests were made on random soil samples taken at two sites. Each test used a different detection method. We will look at the strange, and unexpected, results of these three tests. All the tests initially gave

positive readings. Of course, a positive result should indicate the presence of life. But when the Viking scientists looked at the tests again, they concluded that the results did not prove the existence of life on Mars.

Pose a mystery question to the class ("Mystery of Mars # 1"):

Why did Viking scientists conclude that their detection tests did not prove the existence of life on Mars even though all three tests initially gave positive readings?

Discuss the concept of a "false positive" result, in this case the idea that positive readings may not always mean what you think they mean.

2. **Activity.** Divide the class into teams of two students. Hand out the "Viking's Life Detection Tests" and the "Mysteries of Mars" worksheet to each student. Ask teams to examine the Viking experiments as described on their fact sheets and then brainstorm as to why the Viking scientists concluded that they could not prove that life was present on Mars, despite the positive results from their tests.

   If a team is completely lost, give them one of the four clue cards. These should be given out randomly; their order is unimportant, as each clue relates to every experiment. Challenge students to solve the mystery with as few clues as possible!

3. **Discussion.** After students have done all they can with the first mystery, hold a class discussion. Have students contribute ideas until all students see the answer: Each of the three positive results could have been caused by nonliving chemical reactions, specifically a reaction from adding water to the dry Martian soil. Make the point that not even trained scientists can foresee every possibility. Much thought went into designing the three life detection experiments, but even more thought must go into designing future life detection techniques!

   Pose a second mystery question to the class ("Mystery of Mars # 2"):

   Could it be that life is present on Mars and Viking failed to detect it?

4. **Activity.** Have teams brainstorm about the second "Mystery of Mars." Introduce any information you feel is appropriate. (There are no associated clue cards.)

5. **Discussion.** After students have done all they can with the second mystery, hold a class discussion. Have students contribute ideas until all students see the answer. There are at least two reasons why Viking could have failed to detect life even if it does exist:

   Insufficient sample. Viking's landers may have landed at lifeless locations. Only a tiny part of the Martian surface was actually sampled. The selected Viking landing sites were not optimized for possible biology. However, some scientists believe that planet-wide dust storms would probably distribute microscopic life over the entire surface of Mars.

Biochemical bias. Viking's experiments, like many of those that we are conducting in these missions, were all based upon the assumption that any life on Mars would be life as we know it on Earth. Viking's tests were designed to detect life with metabolisms similar to the metabolism of Earth life. But Martian life could be metabolically different than Earth life. However, based on our theories of the origin of life, most scientists believe that any life on Mars would be metabolically similar to Earth life.

6. **Activity.** Hand out "A New Mission to Mars" worksheet to each student. Tell students that future missions to the red planet may reveal new and surprising facts. What should we do differently next time to discover any life that is there? Have students answer the questions in class or as homework.

Going Further

Research: The Exobiologist's Nightmare

The Viking landers only sampled a tiny portion of the Martian surface. What if life existed everywhere on Mars except for the two little spots where we looked? This is the exobiologist's nightmare! Could this happen on Earth? Are there spots on our planet where there is no life? A desert? The ice sheets of Antarctica? Freshly fallen snow? Have students find out where the landers touched down on Mars. Were there indications that it was a good spot to look for life? What would have been a better location? In the canyons? Under the surface? Near the polar ice caps? What if microbial life was present on Mars four billion years ago (when running water probably existed) but then disappeared? How could we find evidence to support this hypothesis?

Research: More Missions to Mars

There are new missions to the red planet being planned now. In the late 1990s, Russia is scheduled to launch a Mars mission that will include orbiters, landers, and penetrating darts to take samples beneath the planet's surface. Future American missions will be using miniature rovers to scout the Martian landscape. Have students make posters showing the missions, the information scientists hope to gather, and when they will occur.

The *Viking* Search for Life on Mars
Is There Life on Mars?

Mission to the Schoolyard--Teacher's Key

1. Student responses and drawing ability will vary. Accept all reasonable attempts. Look for precision and careful observation.

2. Student responses will vary. Accept all reasonable attempts. You should have an idea of the physical characteristics of each site so that you may check on their accuracy.

3. Student responses will vary. Accept all reasonable attempts, depending upon the sample seen by the student. Look for logical patterns of response.

4. Such tests include looking for water in the samples, charring substances, iodine testing for starch, and so on.

5. Student responses will vary. Accept all reasonable attempts. In cases where life was found (*e.g.*, ants) or detected (positive iodine test on fragments in soil) it must be concluded that Earth has life. In cases where only dust and other lifeless materials were seen, it must be concluded that no life wasn't found, but students should not conclude that the entire planet is lifeless from one (or a few) random samples that turned out to be lifeless.

6. Student responses will vary. Accept all reasonable attempts. Consider that random sampling, in theory, may not be the most effective way to search for life on a planet, but in reality it is the only way to search for life. Scientists need to consider where the lander will set down on a planet's surface and how many samples can be taken.

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Mysteries of Mars—Teacher's Key

Mystery of Mars # 1

1. and 2. In the first two cases, the GEX and the LR, the initial positive results could be explained by nonliving chemical reactions caused when the chemicals in the dry soil of Mars reacted with the water that was added as part of the experiment. Water is a very reactive compound, and the chemical-rich soil of Mars is completely dry. This should remind students of mission 12, where gas production was caused by the addition of a warm nutrient solution (which was water-based) to their seltzer-containing soil sample. Purely chemical reactions can mimic the chemical actions of life.

3. In the Pyrolytic Release experiment, two of the soil samples were heated to a degree that should have destroyed any organisms. One wouldn't expect Martian organisms to be resilient to high temperatures in view of the fact that it never gets warmer than 0” Celsius at these landing sites. Instead the results were again positive, giving rise to the suspicion that some chemical reaction was responsible for the result. This should remind students of the results of the Venus Plates and Mars Jarsthe *Penicillium notatum* survived the freezing conditions in the Mars Jar but not the heat the Venus soil sample was exposed to.

4. In all three cases, the positive results can be explained by nonbiological processes. It is also possible, though highly unlikely, that contamination by some materials brought from Earth could be an explanation. The fact that many other tests run by *Viking* were clearly negative indicated that the positive results were far less likely to have been caused by life. Tests of the Martian soil showed no organic compounds. Tests of the Martian air showed no compounds

that would indicate the presence of life (such as oxygen or methane). The cameras saw no signs of life on the Martian surface and detected no movement of living things. The presence of life is unlikely given these negative results.

Mystery of Mars # 2

1. There are at least two reasons why Viking could have failed to detect life even if it does exist:

   I**nsufficient sample.** Viking's Landers may have landed at lifeless locations. Only a tiny part of Mars' surface was sampled. Life may exist at other locations on Mars. The selected Viking landing sites were not optimized for possible biology. However, some scientists feel that planetwide dust storms would probably distribute microscopic life over the entire surface of Mars.

   Biochemical bias. Viking's experiments, like many of those that we are conducting in these missions, were all based upon the assumption that any life on Mars would be life as we know it on Earth. Viking's tests were designed to detect life with metabolisms similar to the metabolism of Earth life. But Martian life could be metabolically different. However, based on our theories of the origin of life, most scientists believe that any life on Mars would be metabolically similar to Earth life.

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A New Mission to Mars-Teacher's Key

1. The Viking scientists did not consider the possibility of water reacting with chemicals in the dry soil. Also, they were not able to exclude all sources of contamination.

2. Any chemical experiments must take into account the possibility of nonliving chemical reactions and be able to tell them from those reactions caused by living things. Measures such as sterilization and containment barriers are needed to prevent contamination.

3. As many as possible! It would be best to have a “rover” on the lander so that many random samples could be taken. It would also help to pick the sites with the best chances for the presence of life, and to sample from all possible habitats.

4. Student answers will vary. Accept all reasonable attempts.