Mission 3
Mars Jars! (Phase 1)
Could an Earth Microbe Survive on Venus or Mars?

Overview

In mission 3.1, students culture *Penicillium notatum* to observe how this microbe lives on Earth. In mission 3.2, students observe the early growth of their *Penicillium notaturn* cultures. They simulate the low pressure and low temperature conditions of Mars in an experiment to determine whether *Penicillium notatum* could survive under Martian conditions. Students learn about conditions on Venus. By introducing soil seeded with *Penicillium notatum* to this simulated environment, students become exobiologists assessing the capacity of Mars to support life. In mission 3.3, students observe the continued growth of their *Penicillium notatum* cultures.

Notes

In mission 2, students journeyed to the Microworld and to the Macroworld with ZOOM! Cards; they saw their Earth Environment at microscopic and macroscopic scales. But what about life on other worlds? Exobiologists study the possibility of life on other planets, where there are extremes in temperature, atmospheric pressure, chemical compositions. Certain microscopic organisms can survive in harsh environments, such as green and purple sulfur bacteria, which live in the sulfurous super heated water of sea floor vents. Exobiologists stimulate the environments on other planets and use the resiliency of Earth organisms to test the capacity of these environments to test the capacity of the environments to support life as we know it.

Mission 3.1
Materials

For a Class of 30

- 200 ml of Sterigel Instant Medium (for an alternative recipe, see Making Your Own Mediurn, in appendix)
- 1cup of dry clay and/or sand (red, if possible)
- 3 vials of freeze-dried *Penicillium notatum* spores (MicroKwik Culture is recommended; see Ordering Information, in appendix)
- Two sealable containers (optional) Ice cubes (at least 15)
- (optional) Dry ice (do not store in a sealed container)

For Each Team

- Masking tape

- 2 sterile 60-by-15-mm Petri dishes (see Sterile Dishes, see appendix)
- 2 sterile soil-sample carrying dishes
- 2 stick-on labels or a grease pen
- Spatula
- 2 alcohol swabs
- (optional) Tongs or scoops for handling dry ice
- CulturingPenicillium notatum on Earth directions

Getting Ready

1. f you are sterilizing your own Petri dishes (instead of buying sterilized Petri dishes, which require no preparation), do so the day before class. Follow the instructions in the appendix (see Sterile Petri Dishes, see appendix).

2. f you are preparing your own medium (instead of using the Sterigel Instant Medium), do so the day before class. Follow the instructions in the appendix (see Making Your Own Medium, in appendix).

3. terilize your sealable containers by microwaving with water until the water boils away or by rinsing in boiling water.

4. repare a batch of seeded soil before class. Microwave the clay-sand mixture for three minutes, or heat it in an oven at 400 F for half an hour. Let the clay-sand mixture cool. Separate it into two equal quantities and store in the sterile (sealable) containers. Label one container pure soil and set it aside to be used as a control. Mix the vials of Penicillium lzotatuna into the other sample; label this mixture seeded soil. Seal both soils until you are ready to use them.

   The seeded soil will be used in mission 3.1 and in mission 3.2. When this mission is completed, cover the unused seeded soil and store it in a refrigerator; it will be used in mission 6, Venus Plates and Mars Jars! (Phases II).

5. Copy the Culturing *Penicillium notatum* on Earth directions for each team.

Classroom Action

1. **Discussion.** Ask students if they know of any Earth life that could survive on Venus or Mars without artificial support. Are there any experiments that can be conducted to find such an Earth life-form? Ask them if they could simulate Venusian and Martian environmental conditions here on Earth. What if they were to introduce some life-form into these simulated environments? Would they know, based on such an experiment, if the life-form could survive on Venus or Mars? Explain to students that this is an important method used by exobiologists to study the possibility of life on other planets. Exobiologists also study life in harsh Earth environments to better understand if Earth life can survive in the types of environments

found on other planets. When spacecraft are sent to Venus or Mars, they are carefully sterilized to prevent possible contamination of these planets by sturdy Earth microbes!

Tell students that they will conduct an experiment to determine whether a very resilient Earth microorganism called *Penicillium notatum* could survive on Venus and Mars. This fungus is the source of penicillin. Urge caution when working with the *Penicillium notatum.* Some may have an allergic reaction to the organism. Ask if anyone is allergic to penicillin. If so, make sure those students work: only with the pure soil (the control soil for the experiment, which is free of *Penicillium notatum).*

Explain to students that it is important to understand and test the conditions needed to grow *Penicillium notatum* on Earth so that, after it has been exposed to the simulated environments of Venus and Mars, the *Penicillium notatum* can be checked to see if it has actually survived according to its life processes as they occur on Earth.

2. **Demonstration**. Divide the class into teams of two students each. Wash with soap and water the work area you will be using. Demonstrate the use of Petri dishes. Show students how to sterilize a spatula by wiping it with an alcohol swab. Demonstrate how to plate out a sample of the soil onto the gelatin: using the sterilized spatula, lightly sprinkle about 114 teaspoon of the soil over the gelatin. Discuss the need for a control and its role in any scientific experiment.

3. Activity. Hand out the Culturing *Penicillium notatum* on Earth directions to each team. Each team should now make two Petri dishes. Students should wash their hands and their work areas with soap and water. Give teams their sterile Petri dishes and four pieces of masking tape. Have students tape shut their Petri dishes without opening them; this makes a hinge on one side of each dish and a rebreakable seal on the other.

While students are taping their Petri prepare the Sterigel at a central area in the classroom: Close any windows to pre-drafts. Open an alcohol swab and place it on the table. Open the two jars in the Sterigel kit. Place their lids on the alcohol swab. Pour the Sterigel liquid into the bottle of Sterigel powder and shake the bottle for 30 seconds. Sterigel must be used quickly after it is made; it cannot be melted for later use.

Teachers Note: *The following instructionsassume the use of Sterigel Instant Medium. If you have prepared your own medium, refer to the appendix at this point.*

Each team should now obtain nutrient gelatin medium for its sterile Petri dishes by bringing them to the Sterigel area. Make sure students remove only one piece of tape from each dish. The teacher should pour the Sterigel, enough to halfway cover the bottom of each Petri dish. Students should then quickly close and retape their dishes, swirling them gently to evenly distribute the Sterigel. Work rapidly and swirl the Sterigel bottle frequently to keep the nutrient suspension even. The Sterigel in the Petri dishes will set rapidly, and students can add soil samples to their dishes within a few minutes.

Students should obtain two soil samples (pure soil and seeded soil) using the two sterile carrying dishes. Have students plate out one Petri dish with pure soil and one Petri dish with the seeded soil that contains the *Penicillium notatum.* Store the Petri dishes (do not freeze, room temperature is okay) by team for observations during missions 3.2 and 3.3.

4. **Discussion**. Ask students how the conditions on Venus and Mars could be simulated. How would they change the temperature and pressure to simulate Venus? To simulate Mars? The surface pressure on Venus is 90 ATM (atmospheres) and its temperature is 460 C. The surface pressure on Mars is 0.006 ATM and its temperature is -17 C.

   Explain that the surface of Venus is very hot and under extreme pressure. The surface temperature is 460 C and the surface pressure is 90 ATM (atmospheres), which means that the pressure on Venus is 90 times greater than it is on Earth. Ask students what they think such heat and pressure would do to a human body. Could we survive on Venus even with space suits? Tell students that they will simulate the high temperature of Venus and investigate its effect on *Penicilliurn notatum* in mission 6.

   Explain that the surface of Mars is cold enough to freeze any water and that the pressure on Mars is so low that some of the ice would sublimate (change directly from a solid to a gas without becoming a liquid). The surface temperature is -17 C and the surface pressure is .006 ATM. Tell students that frozen carbon dioxide, or dry ice, shows how frozen *water* would sublimate on Mars.

5. **Optional Activity**. Pass out a chunk of dry ice and an ice cube (frozen water) to each team. Explain that regular ice is frozen water and that dry ice is frozen carbon dioxide. Urge caution: dry ice can burn skin! Dry ice should be handled with tongs or scoops. Have students observe the dry ice and the ice cube. Ask them if they can see any water forming on the dry ice as it melts. Which one turns to water? *(Ice cube.)* Which one turns directly into a gas? *(Dry ice.)* Is this gas a water vapor? *(No.)* What is it? *(Carbon dioxide.)* If table knives are available, have students hold the blades against their dry ice; this will produce a chattering sound due to the sublimation.

Mission 3.2
Materials

For a Class of 30

- Overhead projector
- A Mars Jar transparency
- Growth of Microbial Colonies transparency
- Freezer space for several days or weeks
- 8 Cathada syringes, 50 cc or 60 cc (see Ordering Information, in appendix), or any syringes that fit into the rubber tubes
- Small jar of glycerin or liquid soap
- Seeded soil from mission 3.1

For Each Team

- 2 tube clamps
- 250-ml Erlenmeyer flask
- Double-holed stopper (must fit into the Erlenmeyer flask)
- 2 glass tubes (must fit into the stopper holes)
- 2 7-cm rubber tubes (must fit onto the glass tubes)
- Rubber tubing (must fit around the glass tubes)
- 7-cm glass tube
- Balloon
- Beaker
- 20-cm length of string
- Plastic metric ruler
- 2 hand lenses
- Scissors
- Sterile carrying dish for soil sample
- Making a Mars Jar directions

For Each Student

- Growth of *Penicillium notatum* worksheet
- Pencil

Getting Ready

1. Copy the Making a Mars Jar directions for each team and the Growth of *Penicillium notatum* worksheet for each student.

2. Because there is the possibility of students breaking the glass tubes and injuring themselves, you should put the glass tubes into the double-holed stoppers yourself. Use glycerin or liquid soap as a lubricant. Hold the tube at the point where it enters the stopper and twist the tube as you insert it into the stopper. Do not use excessive force! Twist until the glass tubes extend below the stopper by about two centimeters.

3. Sterilize the Erlenmeyer flasks in a microwave by heating on high for 2-3 minutes.

4. Prepare the transparencies A Mars Jar and Growth of a Microbial Colony. Set up the overhead projector.

Classroom Action

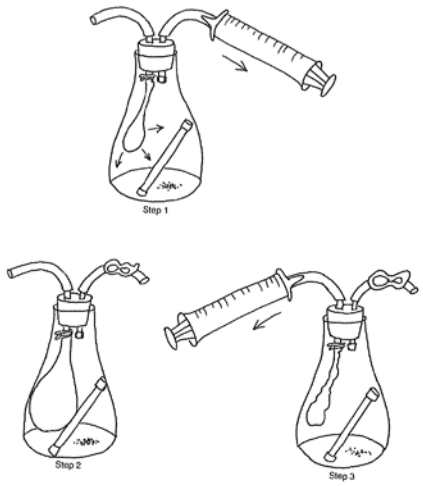
1. **Activity.** Reassemble the teams from mission 3.1. Hand out the Making a Mars Jar directions to each team and the Growth of *Penicillium notatum* worksheet to each student. Have students briefly observe their experimental and control *Penicillium notatum* cultures and

record any signs of *Penicillium notatum* growth without opening the Petri dishes (this would contaminate them). There may not be much growth evident after one day. Each day for the next few days, allow students To briefly inspect their Petri dishes and chart the growth of their *Penicillium notatum.* Have students keep their worksheets; or, you may want to distribute and collect them each day.

2. **Demonstration.** Tell students that both the low pressure and the low temperature on Mars can be simulated in Mars Jars, which will be kept in a freezer for several days or weeks. Show the A Mars Jar transparency as a background to help students envision what you are talking about.

   Demonstrate how to set up the apparatus and how to pump air out of the Erlenmeyer flask as shown in figure 3.1**.**

Figure 3.1—A Mars Jar!



Also, show students how to inflate and deflate the balloons with the syringes. Do not let students inflate the balloons by mouth because there is a chance that someone might inhale *Penicillium notatum* spores. Make sure students understand that differences in air pressure are what cause the balloons to inflate and deflate. Give students time to experiment with the balloon system before they add the seeded soil to their Mars Jars.

Demonstrate the following procedure, which is enumerated on the Making a Mars Jar directions.

Procedure

a) Put 114 tsp. of the seeded soil in the Mars Jar, a sterilized 250 ml Erlenmeyer Flask.

b) Cut four 1 cm. lengths of rubber tubing and carefully cover the four ends of the glass rods that will be exposed to the balloon. Cover the two ends of the glass rods that extend through the stopper and cover the two ends of a short (about 7 cm) glass rod equalization tube.

c) Place the glass rod equalization tube into the Erlenmeyer Flask. (It is used to keep the balloon from sealing with the edge of the flask which would prevent its inflation.)

d) Put a balloon on one of the glass rods that extend through the stopper. (There should be rubber tubing on the tube under the balloon as well, to prevent popping of the balloon by that glass rod.)

e) Make a slip knot around the mouth of the balloon and wrap three inches of string around the mouth to prevent leaking. Put the stopper tightly on the Erlenmeyer Flask, with the balloon hanging inside.

f) Cut two rubber tubes to about 7 cm., and place the rubber tubes over the two exposed ends of the glass rods that extend through the stopper.

To Change Pressure Inside the Mars Jar

a) Tell students to always keep hold of the Erlenmeyer Flask to keep it from falling.

b) First, attach the syringe to the rubber tube that is NOT tied to the balloon. Draw air OUT of the Erlenmeyer Flask with the syringe. The balloon inside the flask will inflate. Keep sucking until the balloon is full, pressing against the glass rod equalization tube. Then use a tube clamp to clamp this rubber tube tightly shut.

c) Attach the Cathada Syringe (or any syringe that fits) to the open rubber tube, with the balloon attached. Ask for a student volunteer to assist you to suck air from the balloon with the syringe until the balloon starts to deflate. To do this you must pinch the rubber tube shut each time you reset the syringe for another pull. The whole operation should take about 25 to 35 pulls of the syringe. Tell students that they should completely deflate their balloon which should take between 25 and 35 pulls on the syringe.

3. **Activity**. Allow students to proceed with their Mars Jars. By the end of one class period, Students should have their seeded soil samples under the simulated atmospheric conditions of Mars. Have students label their jars, record the date, and place them in the freezer until mission 6. Tell students that they will create their Venus Plates in mission 6, Venus Plates and Phase I1 Mars Jars!

   Teacher's Note: *If you have limited freezer space, seed your demonstration Mars Jar with enough soil for the whole class plate out in mission 6. Put this big Mars Jar in the freezer.*

Mission 3.3
Materials

For Each Student

- Harsh Environments worksheet
- Pencil

Getting Ready

1. Copy the Harsh Environments worksheet for each student.

Classroom Action

1. **Activity.** Tell students that, over the next few days, they should make detailed observations and notes of their control and experimental *Penicillircm notatum.* Petri dishes. This is for future reference. By mission 6, Venus Plates and Phase I1 Mars Jars!, these cultures will have died, so students will have to rely on their notes. Stress that scientists always rely on good note-taking skills. Save the Growth of *Penicillium notatum* worksheets for use in mission 6.

2. **Activity**. Hand out the Harsh Environments worksheet to each student. Have students answer these summary questions in class or as a homework assignment.

3. **Disposal.** After all observations of the Petri dishes have been made, the cultures need to be disposed of.

   You may be able to reuse the Petri dishes if they are sturdy enough to be autoclaved or otherwise sterilized.

   Teacher's Note-Caution: *A teacher should dispose of the cultures because they may contain harmful, even pathogenic, microbes. Your school may require certain disposal procedures. Disposal bags can be ordered from any biological supply catalog. Ideally, the cultures should be sterilized (autoclaved or microwaved) before disposal. In a microwave, heat on high for several minutes to boil the water. Avoid touching or inhaling spores from the microbial colonies; you may wish to wear a dust mask.*

Going Further

Activity: Alien Environments on Earth

Invite students to research alien environments on Earth, including superheated and sulfurous saltwaters of sea floor vents and hot springs, the Sahara desert, and the ice sheets and desert valleys of Antarctica. Show a video about an alien environment on Earth.

Ask students if there are any alien environments present where they live. Is there life deep down in the mud of a pond? In the sand of a beach? In a mineral spring? On desert rocks? Conduct an alien hunt to search for life in such places. You may need hand lenses and microscopes!

Ask students to draw some of the alien environments on Earth. Create a mural of an alien environment; have each student contribute a hand-drawn life-form.

Demonstration: Under Pressure

Demonstrate the high pressure on Venus by letting atmospheric pressure crush a can. Find a thin-metal can with a screw-on lid. Fill the can half full with water. Leave off the lid. Paint thinner cans work well, but it is important to remove all traces of paint thinner before use. Place the can on a hot plate and heat it until the water escapes as steam. Nearby, make an ice-water bath using ice or dry ice. Use an oven mitt to put the lid on the can. Immerse the can in the ice-water bath. The can should collapse dramatically. Explain to students that this happened because the pressure outside the can was several times greater than the pressure inside the can.

Activity: Close-up Views of *Penicillium Notatum*

If you have microscopes, slides, and cover slips, try looking at some *Penicillium notatum* under magnification..

Research: Microbes from Earth

When planning the Viking mission to Mars and the Magellan mission to Venus, scientists worried about contaminating these planets. They did not want to accidentally bring along any terrestrial microbial life that might survive in the harsh environments of these two planets. So they went to a great deal of trouble to sterilize the spacecraft before they were launched. Have students research exactly what was done, and why it was done.

Mars Jars! (Phase I)
Could an Earth Microbe Survive on Venus or Mars?

Harsh Environments--Teacher's Key

1. An exobiologist is a scientist who studies the possibility of life on planets that have environments with extremes in temperature, atmospheric pressure, and chemical compositions.

2. An exobiologist would determine if an Earth life-form could survive on Mars or Venus by exposing a microbe such as *Penicillium notatum* to conditions that simulate those on Mars or Venus.

3. It was necessary to culture *Penicillium notatum* under Earth conditions to see what it looks like as it grows, so it can be recognized after it has grown under simulated non-Earth conditions.

4. It was necessary to use a control dish plated with pure soil to see what lifeless soil looks like (for purposes of comparison), and to rule out the possibility of the presence of foreign organisms in the experiment, despite precautions.

5. Student answers will vary. Accept all reasonable attempts. Some students will think that the *Penicillium notatum* will die; some will think that the *Penicillium notatum* will live. The point is this: One may guess, but one doesn't know for certain what the result will be. This is the point of performing any experiment.