Mission 12
Can You “Gas” What’s Happening?

Gas Production in Living and Nonliving Systems

Overview

In mission 12.1, students examine gas production in two soil samples, one seeded with seltzer and one with yeast. They activate the soils with a hot, nutrient solution and observe their gas production. In mission 12.2, students graph their results from their soil samples and discover some of the characteristics of living and nonliving systems. They deduce which of their soils contain life.

Notes

In mission 11, students used Life Traps to collect airborne microbes. If extraterrestrial scientist sent a robotic space to Earth, could they detect life in the soil without collecting the microbes? Living things give off gases, but so do simple chemical reactions A nonliving system will produce gas rapidly until the Limiting reasctant is no longer available. Then gas production ceases. A living system’s gas production begins slowly as the organism’s population increases. This is followed by a period of steady gas production and a long slowdown as space or nutrient supply limits the living system’s growth.

Mission 12.1
Materials

For a Class of 30

- Overhead projector
- “Measuring Gas Production” transparency
- 6 liters of dechlorinated water at about 60” C
- 2 cups of sugar
- 13 seltzer tablets (Alka Seltzer@ works well)
- 16 1/4-ounce packages of yeast
- 2 cups of clean or sterile fine-grained sand
- 2 soil-sample holding bowls
- Small jar of glycerin or liquid soap
- Thermometer
- 250 – ml Erlenmeyer flask
- Clock with the second hand
- Tablespoon

For Each Team

- 2 250-ml Erlenmeyer flasks
- 2 single-holed stoppers (must fit into the Erlenmeyer flasks)
- 2 10-cm glass tubes (must fit into the stopper holes)
- 2 30-cm rubber tubes (must fit onto glass tubes)
- 2 100-ml graduated cylinders
- Water tub (must be large enough to hold 2 Erlenmeyer flasks)
- Ruler
- 2 pencils
- 2 soil-sample carrying dishes
- "Measuring Gas Production" directions

For Each Student

- "It's a Gas!" worksheet
- Pencil

Getting Ready

1. Make a nutrient solution just before class. Use a thermometer and obtain six liters of hot water (approximately 60º C). Mixing two cups of sugar with the hot water will make enough nutrient solution for 15 teams. The ideal temperature for yeast gas-production is 50º C. By the time students transport and introduce a soil sample into the nutrient solution, it will have cooled to about 50º C. Yeast gas-production is not as dramatic alien the nutrient temperature is less than 40ºC, and yeast are killed when the nutrient temperature is above 55º C.

2. Make a demonstration soil sample and two soil sample mixtures as follows. (Two of these soil sample mixtures were used in mission 10. If you made extra of these mixtures or have leftover material, use it now.)

   Demonstration Sample - Crush 5 seltzer tablets and mix with 5 tablespoons of sand. Put this mixture into the 250-ml demonstration flask.

   Earth Sample # 3-Crush the seltzer tablets into fine pieces using the back of a spoon to press on the packets before they are opened. Open the packets and mix the seltzer with 32 tbs (2 cups) of sand. Put the mixture into a bowl and label it "Earth Sample # 3."

   Earth Sample # 4-Mix the yeast with 32 tablespoons (2 cups) of sand. Put the mixture into a bowl and label it "Earth Sample # 4."

3. Because there is the possibility of students breaking the glass tubes and injuring themselves, you should put the glass tubes into the single-holed stoppers yourself.

Use glycerin or liquid soap as a lubricant. Hold the tube at the point where it enters the stopper and gently twist the tube as you insert it into the stopper. Do not use excessive force!

4. Practice Readings. The teacher should practice taking readings before the students take the practice readings. Students may have difficulty reading the levels of gas because the seltzer reaction occurs so fast. You may want to set up inverted cylinders around the room so that students can practice taking readings before they do their experiment. You may sketch a diagram on the board showing how to read the level.

5. Copy the “Measuring Gas Production” directions for each team and the “It's a Gas!” worksheet for each student.

6. Prepare the “Measuring Gas Production” transparency. Set up the overhead projector.

Classroom Action

1. **Discussion**. Divide the class into teams of two students each. Show students the two soil samples. Tell them that their extraterrestrial probes can send back a picture of each soil sample, but that they do not have microscopes to enlarge the view. Have students look at the soil. Ask them to see if they can find life in either sample by direct observation. Could there be dormant life in the samples? Ask students to think of ways to activate the samples. *(Some answers might include addition of water or other liquids, or changes in temperature.)* Tell students that they will use a nutrient solution and heat to activate any dormant life.

2. **Demonstration.** Introduce the warm nutrient solution to the demonstration flask of soil seeded with 5 seltzer tablets (more seltzer than the student sample, for a greater effect). The flask should overflow with bubbles. Ask students if they think that this shows that the soil contains life. Are released gases a sign of life?

3. **Discussion.** Ask students to name some of the gases given off by living things. *(Living things give off carbon dioxide (C02) during respiration, oxygen (02) during photosynthesis, and methane (CH4) and numerous sulfides during flatulence.)* Ask students to name some nonliving things that release these and other gases. *(Nonliving things that release gases include automobiles: NO, N02, C02 and CO; gas stoves: H20, CO2, and CO; baking soda and vinegar: C02; chemical factories: a great variety of gases; fires: COs.)*

   Tell students that they will test their two Earth Sample soils and then decide which one has life in it by examining released gases. Ask students if measuring the release of a gas from an unknown substance is a good way to detect life. How might we be able to tell if a system is living by observing the gases given off? Have students hypothesize how the rate of gas production might differ between living and nonliving systems. For both living and nonliving systems, try to address these issues: Will gas production start quickly or slowly? Will gas production stay constant or fluctuate?

Will gas production stop and, if so, why, when, and how quickly? Which system will give off more gas?

4. **Activity.** Hand out the "Measuring Gas Production!" directions to each team and the "It's a Gas!" worksheet to each student (note that there is no teacher's key for this worksheet because student answers to the questions will vary; all reasonable attempts should be accepted). Have students complete the graph for their hypothesized living and nonliving systems. Distribute soil samples to each team.

5. **Transparency.** Show the "Measuring Gas Production" transparency. Use it to explain the setup. By putting a soil sample into an Erlenmeyer flask and adding a warm nutrient solution, you are trying to cause gas production, either by means of a living metabolic reaction, or from a nonliving chemical reaction. Quickly sealing the flask after the addition of the warm nutrient solution with a single-holed stopper allows you to route any gas formed in the flask through a tube and collect it in a partially submerged and inverted graduated cylinder.

   As gas is produced, it will force water out of the cylinder. If the change in volume is timed and recorded, you will be able to find the rate of the gas production of the sample being tested. The rate is important in determining if life is responsible for the gas production. After testing both samples, a graph of your data will tell you if one of the samples contained dormant life that was activated by the warm nutrient solution.

6. **Demonstration.** After the explanation, do a hands-on demonstration. Choose a student assistant for the last few steps of the demonstration.

Procedure

a. Measure 2 Tbs. of a soil sample into your carrying dish and write down which sample number you are using.

b. Insert a glass tube through a single holed stopper. If students are inserting their own glass tubes, then they should coat one end of the glass tube with glycerin or liquid soap, and put that end of the glass tube into the single-holed stopper. Students should hold the glass tube at the point where it enters the stopper and gently twist the tube as they push it through the stopper. Do not use excessive force!

c. Connect 1 ft. of rubber tube to one end of the glass tube.

d. Fill a water tub halfway with warm water.

e. Place the stopper-tube assembly and the graduated cylinder underwater in the tub. Let any air bubbles escape. While the equipment is still under water, insert the rubber tube 10 cm up into the mouth of the graduated cylinder. Be careful to keep the rubber tube in the graduated cylinder and the mouth of the graduated cylinder underwater throughout the entire experiment.

f. Raise the base of the graduated cylinder until it is inverted (held upside down). Trapped air should be much less than 5 ml; if there is too much trapped air, repeat the procedure. One student must continue to hold the graduated cylinder. This student also holds the rubber tube in the cylinder, keeps track of timing, and will make the readings on gas production.

g. The other student should pour 200 ml of hot nutrient solution into the Erlenmeyer flask and hold the flask on the bottom of the tub. As quickly as possible this student pours the soil flask and seals the flask with the stopper end of the stopper-tube assembly.

h. The first student should take an initial reading of the graduated cylinder by holding it vertical and lowering his or her eye level to the reading level.

i. The second student records all readings on the student worksheet. Readings should be made at 30-second intervals. After three minutes, change the reading interval to every minute instead of every half minute. Stop taking readings after 15 minutes or after the gas level in the cylinder has not changed for two minutes.

- Earth Sample # 3: The seltzer will require two minutes of reading time. It will initiate rapid gas production immediately and then stop producing completely within 30 seconds. In this time, the seltzer will have produced approximately 80 ml of gas.

- Earth Sample # 4: The yeast will require 15 minutes of reading time. Its gas production will start gradually and then steadily increase. Within 15 minutes, the yeast will have produced approximately 70 ml of gas. Gas production will begin slowing after about 20 minutes; it won't completely stop until a few days later.

  Now is a good time for your students to practice reading graduated cylinders. Refer to step 4 in Getting ready.

7. **Activity.** Have teams gather their materials and begin experimenting. Tell students that after they have finished testing one Earth sample, they should test the other Earth sample as well. Have team members switch tasks on their second test. Have students answer their worksheet questions while they are taking readings.

Mission 12.2
Materials

For a Glass of 30

- Projector
- “Gas Production Graphs” transparency

For Each Student

- Sheet of graph paper
- “Gas Analysis” worksheet
- Pencil

Getting Ready

1. Copy the “Gas Analysis” worksheet for each student.

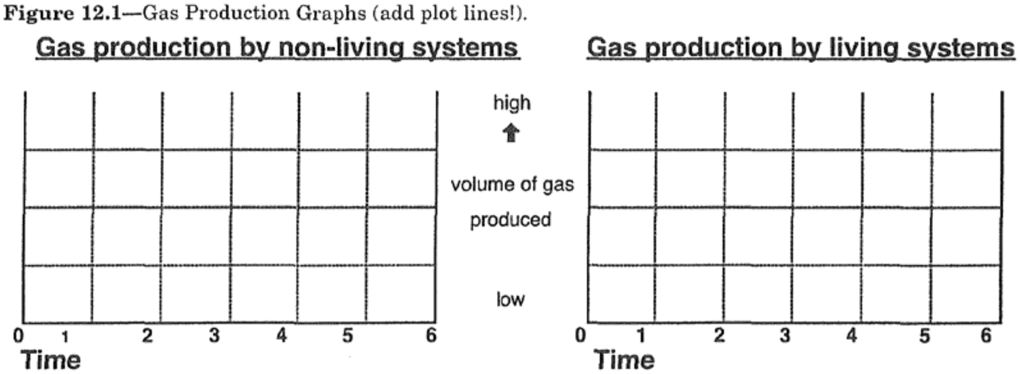
2. Prepare the “Gas Production Graphs” transparency. Set up the overhead projector.

Classroom Action

1. **Activity.** Hand out the “Gas Analysis” worksheet and a sheet of graph paper to each student. Explain to students that they will be graphing the data from their gas production experiment. If necessary, review with the class how to plot a graph. Use the x-axis for time in minutes and the y-axis for volume in milliliters or cubic centimeters (1 ml = 1 cm3). Have each student graph the results of their two tests. Make sure they use a different kind of line for each test.

2. **Transparency.** Show the “Gas Production Graphs” transparency. Plot the class's results onto this transparency or have students come up and plot them as shown in figure 12.2.

Figure 12.1—Gas Production Graphs (add plot lines!).



Invite the class to describe each of the plots. How are the lines the same? How are they different? What does this say about the gas production in the nonliving system? What does this say about gas production in the living system? Focus on different sections of the slope from each plot. Ask the class to interpret what is happening to the reaction rate in each time interval you point out. By observing the graphs, would it be possible to determine which of the soil samples contained life? How could you tell? How could you use this information for detecting the presence of life in an unknown system?

Going Further

Activity: A Better Probe

Imagine an expensive extraterrestrial probe that has a microscope, and imagine that it can send back to Earth images of its microscopic observations. Have students put small amounts of the soil samples onto slides and observe the yeast reaction and the seltzer reaction under a microscope. One student should keep an eye focused on the dried powder while a second student adds a drop of warm nutrient solution to the soil. Then students should switch. Ask them if they observed any differences between the yeast reaction and the seltzer reaction. Could this observation, by itself, prove that life was or was not present?

Activity: Bakers and Brewers
Activity: Fruit of the Vine

The white film that appears on growing grapes is a natural yeast. (Ultra clean supermarket grapes may be stripped of their yeast.) Ask students to gather such grapes and make slides of the yeast to observe its growth under a microscope. Ask students to deduce a way to measure gas production from the yeast. What "warm nutrients" are activating the yeast? How did the yeast get onto the grapes?

Discussion: Confusing Results

Pose a question to students: What if a soil sample that you tested for gas production had life in it as well as nonliving chemicals that were capable of producing gas? Ask students to graph what the gas production of such a sample might look like. Ask students to repeat this experiment with the following soil sample: 2 tablespoons of Earth Sample # 4 mixed with 1 tablespoon of Earth Sample # 3.

Gas production by yeast is essential to the process of making bread and beer. Give students a recipe for a bread that uses yeast and a recipe for an unleavened bread. Ask them to prepare the two doughs and observe them side-by-side: the yeasty dough will rise while the unleavened dough will not. Students bake and eat the two breads, comparing taste and texture. Arrange to have the bread baked in the school cafeteria or have students do it at home with adult supervision. Different varieties of yeast contribute to the difference in breads. Each bakery maintains its own yeast culture, which provides a characteristic taste. Have students visit a bakery or a brewery to observe commercial production of yeast.

Mission 12 Logbook
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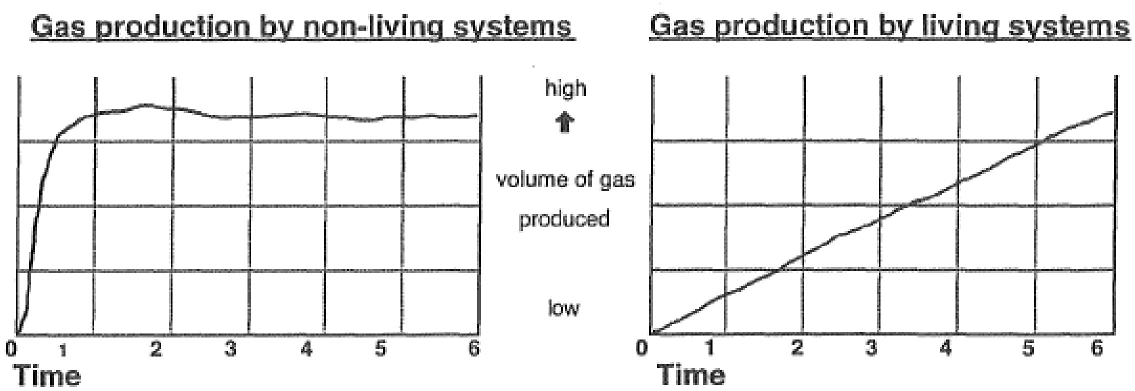
Gas Analysis-Teacher's Key

1. Wow! Earth Sample # 3 produced gas extremely rapidly, and it stopped producing gas within 30 seconds. In this time it produced approximately 80 ml of gas.

2. Earth Sample # 4's gas production started out gradually and proceeded steadily to a production of approximately 70 ml within 15 minutes. (This sample will only show signs of slowing its rate of gas production after 20 minutes.)

3. See the graphs below.

Figure 12.2—Teacher's Key for “It's a Gas” and “Gas Analysis.”



4. This looks like a chemical reaction! It began fast, went fast, and ended abruptly, as if one reactant chemical had been used up. It could be that the warm nutrient contained a chemical that reacted with a chemical in the soil.

5. This looks like a living system! Gas production began slowly, built up, and is still continuing. It could be that the warm nutrient activated dormant life, much as water activates dormant brine shrimp eggs in soil.

6. Yes! Earth Sample # 4.

7. Student responses will vary. Accept all reasonable attempts.