Module 3: Detecting Life in Space

1. Introduction

Students will learn about methods of detecting life on other planets through the use of Rapid Rise yeast. The module will begin with an introduction to types of microbial life and metabolism (i.e. photosynthesis versus heterotrophy). Student will also be introduced to instruments on Curiosity that are capable of detecting gasses on Mars. Each student will then be given zip-lock bags containing mixtures of 1) yeast and sand, and 2) sand. Students will also be given cups of warm water to stimulate growth within the experiment bags. Within minutes, yeast cells will begin producing bubbles. Students will then test for metabolism type by giving their bubbling dirt a carbon food source (sugar). A visible increase in bubbling will indicate that these microbes respond to organic carbon and are therefore heterotrophs. Throughout the activity, students will be led through the scientific processes of making hypotheses, experimenting, and drawing conclusions.

Add-on activity 1: Life in harsh conditions Stress the yeast with acid (vinegar), salt or cold temperatures. What happens? Are there any signs of life? What challenges might scientists have to overcome to detect life in these harsh environments? (very sensitive instruments to detect stressed life).

Add-on activity 2: Abiotic gas production Combine Alka-Seltzer and sand for a third mixture. In this mixture, adding water will make it fizz and release CO_2, which will blow up the balloon on the bottle top. What is the rate at which the balloon blows up? [constant and then stops] How was this process different from the CO_2 released by the yeast? How might we determine the difference between microbes that produce CO_2 and rocks the release CO_2?

Add- on activity 3: Microscopy Use the microscope from Module 2, to look at the yeast cells, versus the "abiotic sand"

Add-on activity 4: Design and draw Have students draw /design their own extreme microbe.

Target Grades: K-6 (adapt discussions as appropriate for grade level)

2. **Learning Objectives**
   - Critical thinking about what life needs to survive (think back to Module 2)
     - Water
     - Energy source
     - Food (carbon) source
   - Critical thinking about how we may test for life – e.g. detect microbe breathing.
   - Introduce the Curiosity Rover and some of its instruments
     - Used to determine composition of rocks and soils, measure environmental conditions, analyze organics and gases from atmosphere and samples, etc.
   - Further develop knowledge of the Scientific Method through journaling
   - Develop an understanding on how we may detect life through chemical processes

3. Materials

- Sand
- Rapid Rise yeast packets (1 per group)
- Water
- Electric water heater (to heat water)
- Sugar
- Plastic flasks (3 per group)

- Optional: Alka-seltzer packets (1 per group)
- Optional: Vinegar, Salt, Ice
- Optional: Microscope from Module 2

- Journaling print-out (optional)
- *Handouts*

4. In-Class Guide

4.1. Introductory Discussion (20 m)

Mars and other planets we think might have life, either now or in the past, are very far away. This means we have to study these plants "remotely", or from earth, by sending rovers to explore for us.

Introduce students to the Curiosity Rover and its use of instruments to determine things likes the composition of rocks and soils as well as test for life. The life we think might be on these planets are microbes – Microbes live in the most extreme environments on Earth such as on rocks in the desert and ice on the polar ice sheets. Microbes have to breathe, like us, meaning they release gasses such as CO2. So how do scientists search for microscopic life so far away, like on Mars?

Rovers test for life by looking for water, organic carbon compounds in rocks, gasses that microbes might release, and fossils. Introduce curiosity rover and its tools.

4.2. Prepare the materials:

		Sample 1 (abiotic)		**Sample 2** (biotic)	**Sample 3** (Optional: stressed)
in a weight boat	2 tbsp. sand			1 tbsp. sand + 1 tbsp. yeast*	1 tbsp. sand + 1 tbsp. yeast*
in a Dixie cup	1 tsp. sugar			1 tsp sugar	1 tsp. sugar
in a Dixie cup	fill with warm water			fill with warm water	One of the following:
		Stressor 1		in a Dixie cup	2 tbsp. salt + water
		Stressor 2		in a Dixie cup	1-2 tbsp vinegar + water
		Stressor 3		in a Dixie cup	ice + ice water

* Yeast must be rapidrise, or instant (there are 2 tbsp per oz)

4.3. Hands-on Activity and Discussion (20 m)

Today, we are going to use tools like the Curiosity Rover to test for life! We will test two different soils and determine if their reactions are from chemical processes or biological processes.

1) Students will be divided into 4 groups and each group will be provided the following:
   a) 2 samples, Sample 1 with sand and Sample 2 with sand + yeast mixture
   b) Warm water and food source (sugar)
   c) 2 balloons

2) *Visual assessment:* Have the students start by looking at the two sand samples. Ask them to describe them. Can they see any differenced between the two samples? Takes notes as a class on your observations.

3) *Hypothesis:* Microbes are small – so we might not be able to see them even if they are there. But, if we give them food and water, what might happen? Can we wake them up and maybe get them to breathe – or produce gas?

4) Add the sand mixtures to the flasks, then add the sugar and warm water to each flask
   a) Flask 1 (sand only)
   b) Flask 2 (sand and Rapid Rise yeast mixture)

5) *Record:* Make observations and take notes for the next few min. What is happening in Flask 1? Flask 2? What is happening to the balloon? Did the rate of inflation change at all? Faster, slower or constant?

6) *Conclusions:* Which flask has life in it?

4.4. Optional Add-on 1: Life in harsh conditions

1) Give each group a 3rd flask and a mixture of the sand + yeast

2) Give each group one of the following:

   a. Vinegar (Acidic) (1 tbsp)
   b. Salt (1 tbsp)
   c. Ice + ice water

3) *Hypothesize:* What will happen when you add this additional component?

4) Have the students add water + sugar + the extreme condition additive.

7) *Record:* Make observations and take notes for the next few min. What is happening in Flask 3? What is happening to the balloon? Did the rate of inflation change at all? Faster, slower or constant? Is the balloon in Flask 3 as large as Flask 2?

5) *Conclusions:* What happened to the microbes in this flask? [they were stressed]

4.5. Optional Add-on 2: Biotic versus abiotic gas production

Include a flask that has powdered alka seltzer + sand in it. Follow the steps are described in 4.2 above. When water is added, CO2 is formed and will fill the balloon. The rate of CO2 production should be constant and end abruptly when the alka seltzer is completely dissolved.

Conclusions: Multiple life-detection methods are necessary to determine if life exists!

4.6. Optional Add- on 3: Microscopy

Use the microscopes from Module 2 to look at the yeast cells, versus the “abiotic sand”.

Conclusions: Multiple life-detection methods can help build evidence to determine if life exists!

5. Closing Discussion

Q: What does life require to exist? [water, energy, carbon]

Q: What are some ways we can look for microbial life?

Rovers like Curiosity can test for life on other plants through the use of many tools.

Add – on 1 conclusion:

Harsh conditions such as acid, salt and low temperatures can result in slow microbial growth and make it harder for life to survive.

Add – on 2 conclusions:

1) Sometimes chemical reactions can look like biologic reactions
    - Think about how both flasks bubbled and fizzed when we added water
    - Think about how they reacted differently when we added sugar (food)
2) How can we try to make sure we are testing for life?
    - Run multiple experiments, and try different methods!

Add – on 3 conclusions:

Multiple life-detection methods can help build evidence to determine if life exists!