Lesson Name: *What makes a habitable planet?*

EXPEDITION LINK: Biology°™this activity simulates conditions on other planets using simple materials. Because the conditions on top of the Licancabur Volcano are so extreme, scientists are studying how life can survive in such extreme conditions: High UV radiation, cold temperatures, and low oxygen levels. The conditions in this environment could be similar to what an early Mars could have been like. Therefore the study of a Mars analog environment and the conditions favorable for life is important to understanding the conditions under which life can survive.

National Science Standards:

Standard A: Abilities necessary to do scientific inquiry
Standard G: Nature of Science

California State Science Standards:

Kindergarten: 1a,b,c, 2a,b,c, 4a,b,c,d,e
Grade 1: 3a, 4a,b,c,d,e
Grade 2: 2a,b,c,d,e,f 4a,b,c,d,e,f,g
Grade 3: 1a,b,c 3a,b,c,d,e 5a,b,c,d,e
Grade 4: 3a,b,c,d 6a,b,c,d,e,f
Grade 5: 2a,b,f,g, 6a,b,c,d,e,f,g,h,i
Grade 7: 1a,b,c,d,e,f, 3a,b,c,d,e, 4a,b,c,d,e,f,g, 7a,b,c,d,e
Grade 9-12: Biology/Life Sciences: 6a,b,c,d,e,f,g, 7a,b,c,d,e,f,g

---

What makes a habitable planet?

(Adapted from °∞Planets in a Bottle°± by Space Science News, Marshall Space Flight Center)

Materials:

- 1 cup lukewarm water
- 3 cubes sugar
- 1 quarter-oz package of yeast
- 1 empty half-liter plastic water bottle
- 1 25 cm. (9 or 10 inch) party balloon
- 1 cloth measuring tape
- 1 small funnel (optional)
- OPTIONAL: see variations

Overview:

Students mix yeast with a nutrient broth consisting of warm water and table sugar in a plastic water bottle. A common 25 cm. (9 inch) party balloon is used to cap the bottle. As yeast digests the sugar they produce carbon dioxide and inflate the balloon. A healthy 1/4 oz sample of baker's yeast can inflate a balloon to 30 cm. circumference in less than 30 minutes. Simple variations of this experiment may be used to discover environmental

factors that inhibit or promote the health of the yeast colony. Students can compare these factors to conditions on other planets.

Procedure:

1. Mix water + sugar in water bottle until the cubes are dissolved.
2. Using the funnel add yeast, the gently swirl the mixture.
3. Cap the bottle with a balloon.
4. Use the cloth measuring tape to measure the circumference of the balloon every 15 minutes.

This basic recipe can be considered an "Earth in a Bottle." It is a warm, healthy environment for yeast with plenty of nutrients. The total amount of CO2 in the balloon when it reaches its greatest volume is proportional to the number of healthy yeast microbes present in the initial sample. For the procedure outlined above, the balloon will achieve its maximum volume less than two hours after the yeast are added to the nutrient mix.

The rate at which the balloon inflates is proportional to the growth rate of the yeast colony. After the yeast is added to the nutrient broth they begin to divide and increase in number. As the colony size increases so does the rate of CO2 production, so long as there is an ample supply of nutrients. If the environment inside the bottle is conducive to yeast growth, the maximum rate of CO2 production will be high. Conversely, if the environment is hostile to yeast, the maximum rate of CO2 production will be low.

Students can begin to explore conditions on other planets with simple variations to the basic recipe. Although we cannot create truly accurate extraterrestrial conditions in a grade school classroom, there are many simple variations that are representative of conditions on other planets. A few examples are listed below:

Example variations:

- Mercury's surface is very hot.
    - Mercury in a Bottle: Boil the water before adding sugar and yeast.
- Venus is very hot, and has an acidic atmosphere.
    - Venus in a Bottle: Instead of water and sugar, use scalding hot orange juice as a nutrient mix. Citric acid in the juice represents sulfuric acid in Venus's hot atmosphere. Lemon juice or vinegar can also be used to increase the acidity of the nutrient mix. Venus's atmosphere also has a high pressure, so that the simulation can be made more realistic by heating the nutrient mix in a pressure cooker.
- The Moon has no atmosphere, so that yeast on its surface would be exposed to a strong vacuum and solar radiation.
    - Moon in a Bottle: Expose the yeast to a vacuum, using a hand pump bell jar, and to radiation in a microwave oven and/or from a UV lamp.

- **Mars** is cold and has a thin atmosphere which allows much solar UV radiation to penetrate to its surface.
    - Mars in a Bottle: freeze the yeast, and then expose the microbes to ultraviolet radiation from a UV lamp before adding yeast to the nutrient mix.
- **Europa**, this moon of Jupiter may harbor the largest ocean in the solar system. The icy surface is a combination of pure water ice, Epsom salts, and unknown minerals.
    - Europa in a Bottle: Freeze a briny mixture of water and Epsom salt. Break the ice into chips and mix the salty ice chips with a cold nutrient solution.
- **Callisto**, this moon of Jupiter may have a salty ocean beneath its frozen crust.
    - Callisto in a Bottle: Add common table salt or Epsom salts to the nutrient mix to simulate a salty environment.
- **Pluto** is the most distant planet from the sun and is very cold.
    - Pluto in a Bottle: freeze the yeast in a deep freezer before adding to the nutrient mix.

Activity Sheet

Which ingredients are you using?

Which planet are you representing?

A

What do you predict will happen in your planet?

A

Record your measurements:

ATime	Time Elapsed	Measurement
A	10 minutes	A
A	20 minutes	A
A	30 minutes	A

What happened? Why do you think that happened?