

Planets in a Bottle

A SIMPLE LESSON PLAN FOR 2ND - 4TH GRADE CLASSES

Objective: The student will measure the viability of yeast samples and to explore environmental conditions which affect the health of yeast microbes. The yeast samples may be common store-bought Baker's yeast, or more exotic forms which have been exposed to extreme environments as part of the Life on the Edge program.

Overview: Students mix yeast with a nutrient broth consisting of warm water and table sugar in a plastic water bottle. A common 9 inch party balloon is used to cap the bottle. As yeast digest 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 12 inch 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.

Materials:

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

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 are 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 -- Mercury's surface is very hot. Mercury in a Bottle: Boil the water before adding sugar and yeast.
- Venus -- 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 -- 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 -- 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 -- 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.