Hands-on Activity: Microbes Know How to Work!

Quick Look

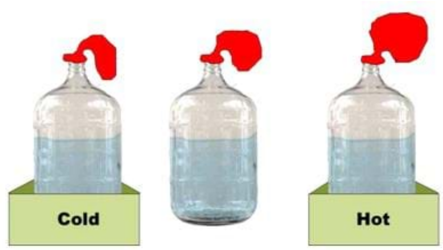
Grade Level: 8 (7-9)
Time Required: 45 minutes
Expendable Cost/Group: US $6.00
Group Size: 3
Activity Dependency:
Biological Processes: Putting Microbes to Work
Subject Areas: Biology, Chemistry, Life Science, Science and Technology

Summary

Students design systems that use microbes to break down a water pollutant (in this case, sugar). They explore how temperature affects the rate of pollutant decomposition.
This engineering curriculum aligns to Next Generation Science Standards (NGSS).

Engineering Connection

Environmental engineers rely on microbes to complete important tasks, including the clean-up of polluted locations. To do this, engineers must understand exactly which factors, such as pH and temperature, affect microbial growth. The more they cater conditions to the microbes' liking, the faster the work gets done.



What is the ideal temperature for microbe growth? (The activity set-up.)

Learning Objectives

After this activity, students should be able to:

- Identify one potential use of microbes.
- Determine which temperature best promotes the growth of yeast.
- Explain how experimentation helps engineers identify the best growing conditions for microbes.
- Design a system that uses microbes to do work.

Educational Standards

- NGSS: Next Generation Science Standards - Science
- Common Core State Standards - Math
- International Technology and Engineering Educators Association - Technology
- State Standards

Materials List

Each group needs:

- 3 small empty soda bottles (591 ml)
- 2 large tubs (large enough to contain ice and soda bottles)
- 4.5 kg bag of ice
- thermometer
- 45 sugar cubes
- 3 balloons
- 3 rubber bands
- baking yeast, 3 packets

Pre-Req Knowledge

An understanding that microbes are too small for the eye to see, thus other methods must be used to measure their growth.

Introduction/Motivation

Did you know that engineers put microbes to work? Microbes make all sorts of things and do all kinds of tasks for us. What comes to mind? (Listen to student ideas.) Examples are wastewater treatment and the creation of cheese and yogurt—all done by microbes. Engineers are always trying to find out how to make these biological processes faster and more efficient. One way of doing that is to make the microbes' environment as comfortable as possible.

In this activity, you are the engineer. This is your engineering challenge: A sugar factory just spilled thousands of pounds of sugar into a local river. Too much sugar dissolved in a natural environment can be very harmful to fish and other wildlife. The regulating governmental agency has called you to solve the problem! You know that microbes can break down sugar into harmless chemicals, so you decide to use a special microbe called yeast. You don't know much about yeast, except that it is sensitive to temperature. You only have a few days to clean up the river, so the faster the microbes break down the sugar, the better. What is the best temperature to keep your treatment system at if the aim is to break down as much sugar as possible?

Procedure

Background

In addition to the lesson on biological processes, it is important to understand the biological reaction that is at work in the process. In this activity, students use a harmless yeast species. Yeasts are a type of single-celled fungus. Most commonly, we use yeast to make bread rise and ferment wine. Engineers use types of yeasts to make ethanol, which is a biofuel. Yeasts have the enzymes needed to break down sugar into ethanol and carbon dioxide. To our benefit, carbon dioxide is a gas at room temperature and does not like staying dissolved in water. Thus, we can use the amount of gas produced as a way to measure how much sugar is broken down.

With the Students

1. Prepare the staging areas by filling one large tub with ice and the other with hot water (as hot as the tap provides).
2. Fill two soda bottles each with 530 ml cold tap water. Fill a third soda bottle with 530 ml hot tap water. Together, these three bottles are your bioreactors.
3. Place one of the cold-water soda bottles in the tub with ice, making sure that at least half of the bottle is surrounded by ice.
4. Place the hot bottle in the tub with warm water, also making sure that half of the bottle is covered with hot water.
5. Leave the third soda bottle on the table or workspace at room temperature.
6. Place a thermometer in the bottle surrounded by ice. Once its water temperature lowers past 15 °C room temperature, move to the next step.
7. Place 15 sugar cubes in each soda bottle and shake liberally.
8. Once the sugar has dissolved, empty the contents of one yeast package in each soda bottle.
9. Immediately cover the opening of each bottle with a balloon.
10. Secure the balloon to the bottle by wrapping the neck of the bottle with a rubber band.
11. Let the containers sit; observe the changes in the balloons.
12. Once the experiment is over, have students measure the circumference of the balloons.

Vocabulary/Definitions

reactor: An artificial environment in which organisms are encouraged to accomplish a particular task. Microbes' "work place."

Assessment

Pre-Activity Assessment

Do Yeast Like It Cold? As a class, ask the students: What temperature do you prefer to work in? Do you work better in a cold or warm room? What about microbes? What temperature do you think they prefer? Why do you think we refrigerate food? (Answer: We refrigerate food because it is a way to decrease the activity of most microbes. In other words, microbes do things much slower in cold environments compared to warm environments.)

Activity Embedded Assessment

Interactive Data Collection: As students observe the experiment, ask them to look closely at what is happening in the bottles. Small bubbles start to appear as carbon dioxide is produced. What type of gas are they seeing? Which bottle is making the most bubbles? What does that mean (in regard to the breakdown of sugar)?

Post-Activity Assessment

Graphing: Using the circumference of the three balloons, have the students calculate the volume of CO_2, using the formula for the volume of a sphere. Have students plot temperature vs. volume to visualize the CO_2 produced.

Concluding Discussion: As a class, share and review results and conclusions. Ask students:

- What is the best temperature for yeast to grow? How does this compare to what you predicted at the beginning? Do your answers differ significantly? (Answer: In most cases, yeast cells grow fastest in the warmest bottles.)
- Why do we refrigerate our food? (Answer: Temperature really affects microbes. We want to prevent them from growing on our food, which is why we store living food at low temperatures. It's not so important with processed foods, such as potato chips or breakfast cereal.)
- What temperature would you use if you wanted to break down sugar as fast as possible?(Answer: From the experiment, it should be clear that higher temperatures are best for breaking down sugar.)
- What other conditions might be important for the microbes? (See if students can test other parameters to produce the most efficient treatment system. Then, have them draw and describe the type of system they would design if they were to treat all of the water in the polluted river.)