

## Fermentation in a Bag

### Objectives

- Understand that fermentation is a process in which microorganisms convert simple sugars (glucose) into energy.
- Explain that fermentation is an important process in the creation of biofuels.
- Know that ethanol is a byproduct of fermentation of cellulosic sources.
- Recognize that ethanol is biofuel currently used as a motor fuel additive.

**Skill Level:** High School

**Class time:** 45 minutes

**Prep time:** 10 minutes for students to collect materials

### Materials

- Three snack-size, resealable zipper bags per group
- 1 tsp. of glucose per student
- 1 tsp. of yeast per student
- 3/4 cup (150 ml) of warm tap water per student
- Yeast feedstocks:
  - Cornmeal
  - Corn stover
  - Sawdust
  - Grass trimmings/ woody debris

### Next Generation Science Standards

**Disciplinary Core Idea:**

LS1.C: Organization for Matter and Energy Flow in Organisms

**Performance Expectations:**

HS-LS1-7: Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a new transfer of energy.

**Practices**

Asking questions / defining problems

**Crosscutting Concepts**

Patterns

<input checked="" type="checkbox"/> Developing / using models <input type="checkbox"/> Planning / carrying out investigations <input type="checkbox"/> Analyzing / interpreting data <input type="checkbox"/> Math / computational thinking <input checked="" type="checkbox"/> Constructing explanations / design solutions <input type="checkbox"/> Engaging in argument from evidence <input checked="" type="checkbox"/> Obtaining / evaluate / communicate	<input type="checkbox"/> Cause and effect: Mechanism / explanation <input type="checkbox"/> Scale, proportion, and quantity <input checked="" type="checkbox"/> Systems and system models <input checked="" type="checkbox"/> Energy / matter: Flows, cycles, conservation <input checked="" type="checkbox"/> Structure and function <input type="checkbox"/> Stability and change
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## Background Information

This classroom activity is a basic experiment that allows students to observe the process of fermentation and the challenge of producing ethanol from cellulosic sources. Fermentation is a process by which sugar is converted into carbon dioxide and alcohol with yeast. There are three factors that allow this process to happen. First, fungi or bacteria must be present. Second, no oxygen must be present. Third, an organic energy source must be present.

Yeast is the most common organism present for fermentation to occur. But yeast is not an organism to fear; it is present in our drinking water, soils, and makes the fermentation process possible. Yeasts secrete their own enzymes that allow them to break down the food source around them. The food sources for yeast are usually monosaccharides, glucose, and other simple sugars. After breaking down their food source, yeast produces gas. The most visible sign that yeast is working is that the substance is expanding, like when dough rises, due to the release of gas.

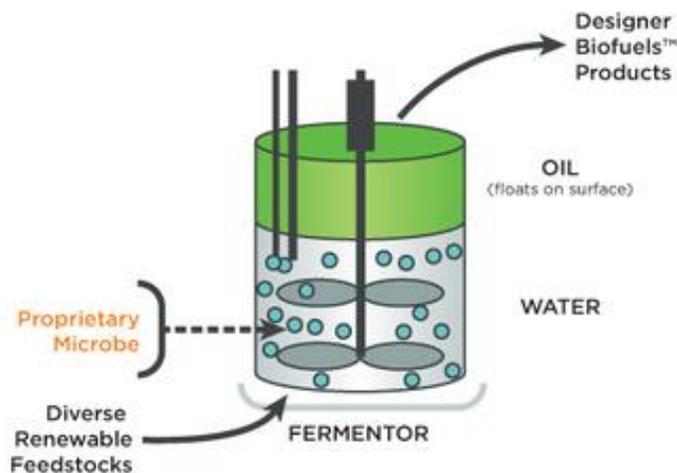


Figure one shows the genetically modified fermentation process. [Reference](#)

Recently, researchers have looked into yeast as a source of biofuel. Yeast can be genetically modified to produce oils and lipids that can be used in place of petroleum based products. The process starts with a soybean or even table sugar and the yeast cells convert it to petroleum making

this a renewable process. Working with genetically modified yeast can be tricky though. It often takes many experiments to find the exact gene that could make this process happen. There are also many safeguards to working with yeasts. They have to stay in a contained, sterile container because there is no knowing what could happen to there microorganisms in an open environment.

Students should be able to identify the point of change during the experiment. The students will combine yeast and warm water with a feedstock in a “snack” size resealable zipper bag and observe as the yeast “eats” the feedstock such as sugar, cornmeal, or sawdust, and produces carbon dioxide and ethanol. Students should be able to determine what makes a better biofuel based upon what the yeast eats.

### Engage

Students should be interested in learning this process because it happens in everyday life. Fermentation is used in processing foods like yogurt. Yeasts properties make bread rise and give cheeses their distinct flavor. It is important to understand these processes so that students can understand how our food is made.

### Explore

#### **Experiment Questions:**

- What types of compounds can yeasts use as a food-source?
- What types of byproducts does yeast create?
- Which compounds make yeast the most productive?

#### **Procedure:**

1. Have students collect a small reusable bag of grass clippings or woody debris and bring it to class the day before this lab.
2. Divide the students into groups. Each group will have the opportunity to test four to five different feedstocks. Give each group four to five reusable bags. Have them label one of the bags ‘control’ (this will only have yeast in it). Have the students label the others cornmeal, glucose, and grass clippings (or any other debris brought from home). If students desire, they can also test corn stover and sawdust in separate reusable bags.
3. Have students add one teaspoon of the appropriate feedstock to each bag.
4. Have students add one teaspoon of yeast to each reusable bag.
5. Have the students add 50mL (1/4 cup) of warm tap water to each bag and zip the bag closed, removing as much air as possible. Have them add water to the glucose bag last since this bag will expand fastest.
6. Mix gently. Lay bag on a flat surface and watch for results – the fastest results should be achieved in 15 minutes. Some will take the full 45 minutes.
7. **Warning:** As the yeast produce carbon dioxide, the bag will expand – it may even pop! Be sure

to monitor the bag and release the gas if becomes too inflated.

8. Have students compare their results with others in the class and discuss any similarities or differences they found between their results. Did they observe differences between the corn stover, corn meal, and sawdust?

### Explain

- How do you know fermentation is occurring? What is the gas being produced? Which bag has the most ethanol? Which bag has the least?
- Glucose, a simple sugar, is the food yeast use to create energy. Why might we want to use cellulosic plant materials such as corn stover or woody debris instead of corn kernels or sugar for making ethanol?
- How did the yeast respond to different kinds of “food”? Which fermented the fastest? Which fermented the slowest? Why do you think there is a difference?
- What is happening when the bags expand?
- Which bag expanded the fastest?
- How did your results compare to others?
- Why did a certain bag expand the fastest?

### Elaborate

- Do some research to find out if there are other things besides yeast that you could use to ferment sugar, and design an experiment to test it. Compare your results to fermentation by yeast.
- What other processes use fermentation?
- Research the design of yeast bioreactors (vessel that holds the yeast and its foodsource). Find some photos of bioreactors for the various types of processes that yeast are involved in (beer, biofuels, bioproducts).
- Identify some challenges of using yeast to create ethanol for vehicles. Are there enough foodstocks available to feed the yeast? Are there any byproducts that will be difficult to dispose of?

## Resources

### Resources Used:

- [Fermentation in a Bag](#)

- [Fun Facts About Fungi](#)
- [Yeast As A Biofuel](#)

**Additional Resources:**

- [Fermentation for Spices](#)
- [Yeast Turns Crops To Liquid Fuel](#)