

# Fermentation in a Bag: Biofuels Challenge Part 1

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Name: \_\_\_\_\_ Period \_\_\_\_\_ Date: \_\_\_\_\_

## Overview

Students apply the cell process of fermentation to the production of biofuel (alcohol) by testing various feedstocks. Students will measure the volume of CO<sub>2</sub> produced using displacement.

## What is Fermentation?

Fermentation is a type of **anaerobic respiration** in which a cell breaks down sugar to release energy without using oxygen.

Yeast is an organism that ferments. When yeast ferments sugar, the yeast eats sugar and produces alcohol. This is used to make beverages or biofuel and to make bread rise. Yeast can be also used to grow bakery products like bread and cakes faster. In some cases, yeast might be used to speed up the process of creation of wine.

Other cells make vinegar or lactic acid when they ferment sugar. In a different way, the fermentation process can continue and turn the alcohol into vinegar i.e. acetic acid.

When yeast ferments, it breaks down the glucose (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>) into ethanol (CH<sub>3</sub>CH<sub>2</sub>OH) and carbon dioxide (CO<sub>2</sub>).

Ethanol fermentation always produces ethanol and carbon dioxide. It is important in bread-making, brewing, and wine-making.

Lactic acid fermentation produces lactic acid. It happens in muscles of animals when they need lots of energy fast. The pain of a cramped muscle is caused by the build-up of lactic acid. The pain eases as the product is taken away by the blood supply.

## Fermentation in a bag Procedure:

1. In a sealable bag, combine 5g of sugar, corn meal, or whole wheat flour and 5g of yeast. You should have three bags, each with a different feedstock (sugar, corn, or wheat)
2. Add 50mL of warm tap water and zip the bag closed, removing all the air from the bag. Mix gently. Lay bag on a flat surface and watch for results – fastest results should be achieved in 15 minutes.
3. Start time \_\_\_\_\_ End time \_\_\_\_\_

## Questions

1. Write your observations for each bag below. Observations should include ALL of the following: **A)** what visual changes did you observe after combining all the ingredients; **B)** What differences did you notice between each of the three bags; **C)** How did these changes occur over time? Did they happen immediately? Did these differences change as time went on?

a. Bag w/ Sugar

A \_\_\_\_\_

B \_\_\_\_\_

C \_\_\_\_\_

b. Bag w/ Corn

A \_\_\_\_\_

B \_\_\_\_\_

C \_\_\_\_\_

c. Bag w/ Whole Wheat

A \_\_\_\_\_

B \_\_\_\_\_

C \_\_\_\_\_

2. What do you think made the bags inflate? \_\_\_\_\_

\_\_\_\_\_

3. Why would this make sense? \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

4. Write a hypothesis to explain the differences that you observed:

*I hypothesize that the differences between the bags were the result of...* \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

5. Write a rationale for your hypothesis.

*I think this is true because...* \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

6. Use the water displacement method to find the volume of the CO<sub>2</sub> in each bag. Record your measurements in the data table. Be careful not to break the seal on the bag as you submerge it in the water.

Feedstock	Beginning volume	Ending Volume	Difference
Sugar	60mL		
Corn	60mL		
Whole Wheat	60mL		

7. The amount of Carbon Dioxide produced during fermentation is directly proportional to the amount of alcohol produced. Based on your data, which feedstock produces the most biofuels for 5g of feed?

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Based on the data, which feedstock would you choose if you were planning to build a biofuels manufacturing plant?

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8. BUT NOT SO FAST...Not all feedstocks cost the same amount, and not all feedstocks grow at the same rate. Look at the data tables below.

Crop	Fuel Output (gallons/acre/year)	Land area (acres/ sq mi) needed to meet total fuel demands of U.S.*
Soybean	40	3.36 billion/5.6 million
Corn	400	336 million/563,000
Sugarcane	800	168 million/263,000
Algae	4,000 - 6,000	34 - 22 million/53,000 - 34,000

\*Based on U.S. usage of 368 million gallons per day of gasoline and diesel fuel (~134 billion gallons annually)

\*\* Demand expected to reach 135 billion gallons

Sugar	\$0.31 Kg
Corn Meal	\$0.28 Kg
Whole Wheat	\$0.45 Kg

Explain why the cost of the feedstock and the fuel output per acre are important considerations when planning your biofuels plant.

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Keep these things in mind as we get ready to move on to the next part of the design challenge!

*\*Lesson modified from an activity found at Great Lakes Bioenergy Research Center*

# Fermentation and Biofuels Part 2: Developing a Biofuel Company

## The Challenge

Biofuels are rapidly becoming a significant source of energy in America. As technology advances and the demand grows for alternative fuel sources, there will be an increasing need for innovative new business ideas involving biofuels. In this design challenge, you will apply the concept of fermentation to the production of biofuels.

Your task is to design a biofuel company. Your company needs to be different than companies that already exist and it needs to have a clear plan for making a profit. You are not limited to the fermentation techniques learned in class. By developing your plan and “pitching” it to potential investors (your classmates) you will learn what it takes to launch a business.

## Step 1: Define the problem

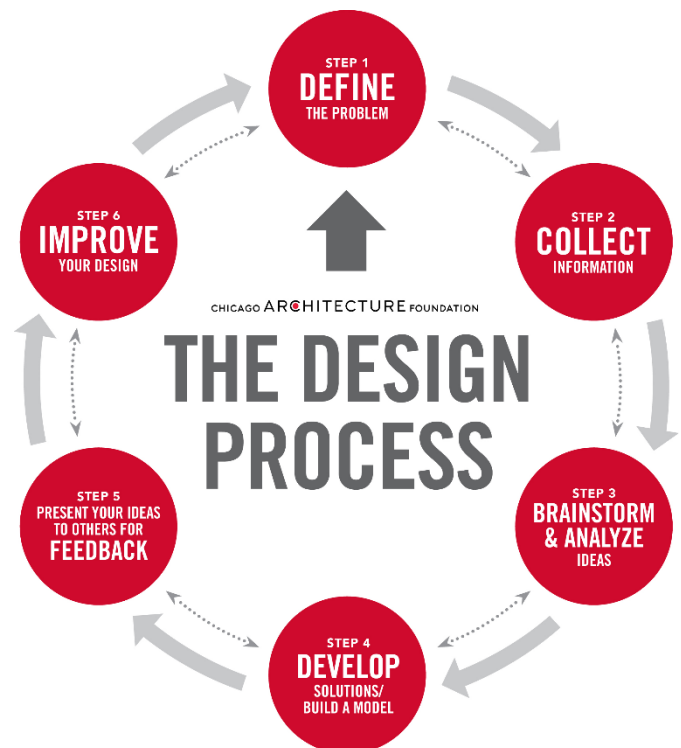
The first step is to determine the problem to be solved and identify the design constraints.

- **Problem:** Design a business plan for a biofuel processing plant
- **Constraints:** Must be related to alcohol production through cellular processes. Must include financial information. Must be scientifically sound. Must include visual representation of the process in some way. Must not be a duplicate of a system found elsewhere.
- **Budget & Materials:** For this project, the budget is theoretical. Your job is to develop a business plan and pitch it to a group of potential investors (the class).
- **Required Elements:** Your finished product will include two parts:
  1. A detailed **1-page** business plan
  2. A **2-minute** sales pitch presentation

## Step 2: Collect information

In this step, research and reflect on yesterday’s experiment to help inform your design.

First, do some research on different methods for producing biofuels using cellular processes. Take notes on the page provided. Consider things like cost, space, and ease of production.



## Research Notes (Source 1)

web address	
Describe and/or sketch your ideas	
What are the benefits of this design?	
What materials are needed? Estimated cost of production?	

## Research Notes (Source 2)

web address	
Describe and/or sketch your ideas	
What are the benefits of this design?	
What materials are needed? Estimated cost of production?	

## Research Notes (Source 3)

web address	
Describe and/or sketch your ideas	
What are the benefits of this design?	
What materials are needed? Estimated cost of production?	

### **Step 3: Brainstorm ideas**

When engineers brainstorm ideas, they are open to as many creative ideas as possible. No idea or suggestion is “silly”; in fact, the wilder the idea, the better!

- Discuss ideas for how to build your biofuels manufacturing plant. In the space below, write down and/or sketch every idea suggested.



#### **Step 4: Select the most promising concept**

Read through your ideas again, discuss options with your group, and choose the concept that you think will work best.

- Sketch your idea in the space below. The drawing should show and label all of the necessary parts of the system and show your system from two angles (aerial view, side view, etc.).

Drawings need to include scale.

## **Step 5: Presenting Your Ideas**

A business plan is a description of what you plan to do with your business and how you plan to do it. Your business plan will be used to attract investors to your company and should therefore include description of the following information:

- 1) *Business Name*: Your business' name needs to be original and somehow relate to your business concept
- 2) *Business Concept*: Your business concept describes what you plan to have your business do. In this instance, you will be describing your plans for biofuel production and how you plan to make it successful
- 3) *Business Market*: This is where you describe where you will be selling your product or service. Who are your customers? Why is there a demand for what you plan to do? What will your market look like in the future?
- 4) *Financials*: This is where you describe how you plan to make a profit. You will need to explain how much you plan to charge for your product or service and how much it will cost you to produce it. You will need to provide some basic calculation about how long it will take for your company to break even or make a profit.

### **How will it be graded**

Your **1-page** business plan will be the most important part of your business proposal. It will be worth 60 points. You will receive 10 point for following the guidelines for each section of the business plan (Business Name, Business Concept, Business Market, and Financials) and you will receive 10 points if your business uses some realistic source of biomass for energy and 10 points for proposing a business idea that does not already exist.

### **How to Prepare A “Sales Pitch”**

Each business needs to attract investors that will provide the initial cash to get the business started. To do this you will need to get your business plan condensed into what is called a “sales pitch” or “elevator pitch” because it shouldn't take longer than an elevator ride to get the message across and get an investor on board with your idea. For your “pitch” you will have to do the following:

- 1) Make a slide presentation or large visual that contains ***preferably 2 and no more than 3 slides/pictures***
- 2) Explain using your presentation why investors should invest in your company in no more than ***two minutes***

### **What you will need to deliver a successful “elevator pitch”:**

- 1) Explain what type of biomass you will use and why (5 points)
- 2) Explain how you plan to make energy from the biomass you chose (5 points)
- 3) Explain how your business is different than others that already exist (5 points)
- 4) Explain how you propose to make your business profitable in what time frame (5 points)
- 5) Explain who your competitors are and how you plan to beat them (5 points)

- 6) You will need to deliver a well-organized, logical presentation that also conveys enthusiasm for your business idea (15 points)

### **How will your presentation be graded?**

Your presentation will be worth **40 points**. You will receive 5 points for following each first 5 components of a successful presentation and 15 points for the final component.

### **Step 6: Reflection**

In order to improve your designs, it's important to reflect on your design process. After presenting, use the space below to answer the following reflection questions.

Tell what you learned from completing this project.

What challenges or problems did you face?

How did you solve problems while completing this project?

What might you do differently or better if you continued to work on improving this project?