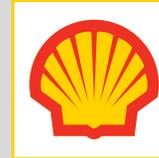


## TEST THAT BIOFUEL!



In this lesson, students will be introduced to the science, benefits, and trade-offs of biofuels as an alternative energy source. They will then conduct an experiment that simulates the fermentation process of ethanol production in order to determine which biomass source(s) they'd use if they were building a refinery in their state.

**Lesson Printable:** Which Biofuel Is Best?

### Objectives:

- Students will be introduced to biomass as an alternative energy source.
- Students will design and participate in an experiment to compare the ethanol that's produced by the fermentation of different biomass materials.
- Students will articulate factors that should be considered when selecting a type of biomass for biofuel production.

**Alignment with National Standards:** Science, Technology, Engineering, Math

**Skills:** Research and investigation, measurement, synthesis, reasonable prediction, data interpretation and analysis, design, evaluation

### MATERIALS

(Enough for groups of two to three students each)

- Internet access
- Printable, "Which Biofuel Is Best?" (PDF), one per student
- Paper or flip charts for small student groups
- Several different types of biomass such as wood, corn kernels, soybeans, fruit, potatoes, cooking oil, etc.
- Yeast
- 20-oz. soda bottles, 2–3 per group
- Balloons
- Calculators
- Scales
- Measuring tape
- Grinding instrument (such as mortar and pestle)

(cont.)

**Time Required:**

Introductory Activity: 15 minutes

Research Activity: 60–90 minutes (involves Internet)

Experiment: Up to one week

**DIRECTIONS****Part One**

**Note:** Before students enter the room, write the following question on the board: “Why does the United States need to develop alternative energy sources?”

1. Divide students into small groups and give each group five minutes to list as many answers as they can to the question on a sheet of paper or a flip chart.
2. After five minutes, have students stop writing. Explain that you will go around the room and each group will take a turn to answer the question. The challenge is that they must give an answer that has not previously been given. In other words, they must give a new and unique answer each time. Assign one student to list answers on the board as they are given. The group that gives the last unique answer wins. Ask students what they can learn from this exercise. Guide them to understand that there are many important environmental, political, social, and economic reasons why the United States needs to develop alternative energy sources. You may even want to group the reasons by these categories.
3. Place the samples of biomass in front of students (see materials list) and ask them what connection there is between these items and the problems/issues they just outlined. The answer is that all of the items can be converted to biofuel, and biofuel (when mixed with gasoline or diesel) can be used as an alternative energy source to power cars.
4. Have students share what they already know about biofuel, the science behind it, and its benefits and trade-offs. Based on that list, have students create a list of questions regarding what they would like to learn about biofuels. A suggested list of questions is below:
  - What materials (biomass) can be used to create biofuel?
  - What are the most common types of biomass?
  - What is the science behind the conversion of biofuels? (This can be more specific to include conversion to ethanol and/or biodiesel.)
  - Do we have an abundant supply of biomass in the United States? If so, where?
  - What are the economic, environmental, political, and social benefits of using biofuel as an energy source?
  - What are the economic, environmental, political, and social trade-offs of using biofuel as an energy source?
  - What is the “food vs. fuel” debate related to biofuels, and why is it significant?
  - Are biofuels a viable alternative to petroleum-based fuels?
  - What are advanced biofuels?
5. Have small student groups select 1-2 questions to answer. Give them ample time to conduct research. Several resources are included in the “Additional Resources” section.
6. After all groups have answered their questions, rearrange the groups so that one student from each group forms a new group. If this is not possible, form new groups from as many original groups as possible.

(cont.)

7. Have students from each original group share/teach their new group about the questions they researched.
8. Come together and challenge students to use evidence from their research to contribute answers to this final question, "If you were the U.S. government or an energy company, would you invest money in the development of biofuel technology? Why or why not?"

### Part Two

9. Tell students to imagine that they are engineers who have been asked to help design a refinery in your state. Their first step is to decide which type of biomass to use. In order to do this, they are going to design an experiment to compare the amount of ethanol produced in the fermentation of various biomass materials and research the pros and cons of each one.
10. Distribute the printable, "Which Biofuel Is Best?" Have each small group select 3-4 types of biomass that they want to test.
11. Direct students to follow the directions on the printable to set up the experiment.
12. Once the experiment is under way, have students record their observations each day. The fermentation may take several days. Observations might include expansion of the balloons, the presence of gas bubbles, etc.
13. While students are waiting for the fermentation, give them time to research information about the different types of biomass they selected to test. This information should include:
  - Name of biomass
  - How it is turned into a biofuel
  - How/where the biomass is grown
  - Any growth requirements (amount of land, water, climate, fertilizer)
  - Other uses of this biomass
  - Whether use of an abundance of this biomass for biofuel would negatively impact any other aspect of our society
14. After 4-5 days, record final observations for the experiment. Measure and record the expansion of each balloon. You may want to explain to students that the actual production of the fermentation includes a mix of carbon dioxide and ethanol, and that's what expands the balloon. The expansion will give them a sense of how much ethanol is being produced as each biomass breaks down. If they were actually creating biofuel, they would need to distill the ethanol from the mix of carbon dioxide and ethanol.
15. Have students compare the ethanol produced from each biomass both within their own group and among other groups.
16. Finally have students refer back to the imaginary refinery and select which biomass they would produce. They should consider all of the factors they researched about the biomass as well as its efficiency in producing ethanol. Have students present and justify their choices.

### ADDITIONAL RESOURCES

- Shell Alternative Transport Fuels Key Messages
- Shell Biofuels: Sustainable Low CO2 Fuel Today
- Biofuels: Finding a sustainable way forward

(cont.)

- U.S. Department of Energy: ABC's of Biofuels  
[www1.eere.energy.gov/biomass/m/abcs\\_biofuels.html](http://www1.eere.energy.gov/biomass/m/abcs_biofuels.html)
- U.S. Department of Energy: Energy Efficiency and Renewable Energy/Biomass Technologies  
[www.eere.energy.gov/basics/renewable\\_energy/biomass.html](http://www.eere.energy.gov/basics/renewable_energy/biomass.html)
- National Renewable Energy Laboratory: Biomass Energy Basics  
[www.nrel.gov/learning/re\\_biomass.html](http://www.nrel.gov/learning/re_biomass.html)

Visit [www.shell.us/energizyourfuture](http://www.shell.us/energizyourfuture) to learn more about how alternative energy resources will help provide energy for the future..

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