Exploring Ethanol Activity

Objectives

To understand how different bioenergy sources may be used in ethanol fuel and other biofuel production.

Skill Level: Middle School and High School	**Prep time:** 10 minutes **Class time:** 40 minutes

Materials (per group)

- Seven sandwich or snack-sized Ziploc bags
- Plastic spoon
- One spoonful of dry quick rise yeast
- One spoonful of each:
  - High fructose corn syrup
  - White table sugar
  - Honey
  - Powdered milk
  - Powdered milk with crushed Lactaid (lactase) tablet
  - Aspartame-based artificial sweetener (Equal or NutraSweet)
- Warm water
- Timer/clock

Next Generation Science Standards

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

Performance Expectations:

MS-LS1-7: Develop a model to describe how food is rearranged through chemical reaction forming new molecules that support growth and/or release energy as this matter moves through an organism.
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	Crosscutting Concepts
☐ Asking questions / defining problems	☒ Patterns
☒ Developing / using models	☐ Cause and effect: Mechanism / explanation
☒ Planning / carrying out investigations	☐ Scale, proportion, and quantity
☐ Analyzing / interpreting data	☐ Systems and system models
☐ Math / computational thinking	☒ Energy / matter: Flows, cycles, conservation
☐ Constructing explanations / design solutions	☐ Structure and function
☐ Engaging in argument from evidence	☐ Stability and change
☐ Obtaining / evaluate / communicate	

Background Information

Introduction: In this experiment, students will gain an understanding of how different energy sources may be used to produce ethanol fuel and other biofuels. Students will observe the fermentation process of different types of simple sugars present in common, consumable foodstuffs and use CO_2 (carbon dioxide) accumulation to see how much ethanol is made with each type of sugar.

Background: There are many different types of energy sources. Bioenergy is energy contained in living or recently living biological organisms like plants and animal fats. Biofuels are liquid or solid fuels produced from biomass (organic material containing bioenergy). Biofuels are classified into three "generations," based on the type of biomass from which they are produced. First-generation biofuels are made from sugar, starch, vegetable oil, or animal fats using conventional technology, but using these biomasses can contribute to rising food costs. Second-generation biofuels are produced from non-food crops, such as cellulosic and waste biomass (corn stalks, poplar trees, etc.), but they still require farmland and water resources to produce them. Extracting oil from algae produces third-generation biofuels, but this practice is very high cost and small scale due to the harvesting process and the low biomass concentration in algae.

Ethanol, a liquid biofuel used as an alternative to gasoline, is generally made from corn, but it can also be made from many other biological materials. Petroleum-based fossil fuels, like coal and oil, are sources of energy from plants and animals that died millions of years ago and are currently our most common means of acquiring fuel. However, fossil fuels are in limited supply and are quite harmful to the environment as they add greenhouse gases to the atmosphere which will increase the likelihood of global warming. Bioenergy obtained through the use of biofuels and biomass is becoming a more sustainable and eco-friendly option to using petroleum-based fuels in everyday life.

So how do we take corn and other biological materials and turn them into fuel? The process of producing ethanol is very similar to that of producing alcohol or vinegar from grains. Plants like corn contain glucose and fructose sugars that can be broken down by yeast to make carbon dioxide gas

and ethanol. The yeast uses sugar as an energy source for this process, which is called fermentation. The ethanol is then removed from the mixture, added to gasoline, and sold at gas stations. The state of Oregon requires that gasoline sold commercially must contain 10% ethanol by volume, but future fuels may have higher percentages of ethanol in them (for example, "E85" gasoline is 85% ethanol and 15% gasoline for use in "Flex Fuel" vehicles).

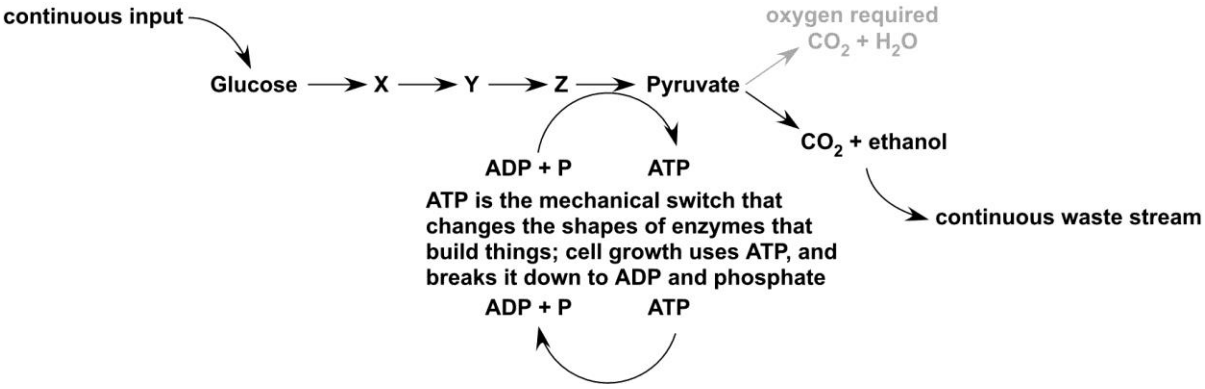

Figure 1. Basics of a yeast reaction. Reference

Corn is in the spotlight as a source of ethanol, as it is inexpensive and the United States is the world's largest producer of corn. However, we can use other plants to make ethanol! Why would we want to use other plants? There are some drawbacks for using corn for ethanol production. Corn requires lots of nutrients, usually from fertilizers, which can create a greater burden on the environment than necessary. It must also be grown on land that's flat and fertile, and there is only so much land we can use to grow corn. We also need corn for human and animal food as well as the production of countless other products. When we have a bad corn year, there might not be enough corn for food AND fuel, and both would become very expensive. We need corn for so many reasons other than fuel!

As mentioned above, there are other "generations" of biofuels that are currently being researched. Cellulosic ethanol (second-generation biofuel) is created using the sugar cellulose, which is found in plant material other than corn kernels, for fermentation into transportation fuels. Cellulosic ethanol can be produced from crops that aren't used for food like grasses and agricultural "left overs" like corncobs, husks, and stalks.

Engage

Students should be excited to learn that there are alternatives to gasoline. Ethanol is a product that is easy usually renewable. Ethanol can be corn based, which is beneficial because corn can be regrown. This experiment will show students that corn is not the only source of ethanol. The gas yeast produces is ethanol and should show students that there is a source of energy that is capable of being harnessed and can be used as a fuel. Ethanol has many sources, all of which have their

benefits and downfalls. Students should be able to recognize these pros and cons and reflect on whether these make ethanol a better source of fuel.

Explore

Experiment Questions:

- Which type of sugar is most effective in producing ethanol?
- How will we know which sugar is most effective?

Procedure:

1. Gather seven sandwich or snack-sized Ziploc bags and label them with the six different sugar products, plus one control bag.
2. Fill each bag half-full of with warm water (it should be warm to the touch, not scalding). Add one spoonful of yeast to each bag.
3. One bag will serve as a control, so it will only contain water and yeast.
4. Add the different sugars to their appropriately labeled bags, push any excess air out of the bags, and seal the bags.
5. Mix the contents of the bags until they are dissolved. Lay the bags on a flat surface and start the timer.
6. A reaction will begin in the bags after a few minutes, and the bags will start to expand and "puff up."
7. After 5 minutes, make an initial observation. What do the contents of the bag look like? What has happened to the bag? Do you smell, hear, see, or feel anything?
8. Repeat observations every 3 minutes until 17 minutes have elapsed. Record your observations in the worksheet provided.

Explain

- Define biofuel.
- What process are you observing?
- What are some downsides to yeast as a biofuel?
- During the procedure, why was warm water used? Would it work with cold water?
- Why is it important to have a control in this experiment?
- Why do the bags expand during the experiment? What by-products are being produced?

Elaborate

Once the best sugar source is determined, running the reaction with that sugar source at varying temperatures can do a variation of this experiment. The reaction would be done with boiling water, warm water, cold tap water, and ice water, and students would observe the rate of reaction among the different temperatures. (*Why does differing temperature affect the rate of reaction? What seems to be the optimal temperature for the yeast fermentation reaction?*)

Resources

Additional Resources:

- The Biofuel FAQs

Resources Used:

- Exploring Ethanol
- Teacher Guide: Ethanol
- UC Davis: Bioenergy Research Center
- Bill and Melinda Gates Foundation
- Biofuels from Algae for Sustainable Development

Exploring Ethanol Activity Data Collection

Reaction Observations

	Control	**Table Sugar**	**Corn Syrup**	**Honey**	**Powdered Milk**	**Powdered Milk w/ Lactaid Tablet**	**Aspartame Sweetener**
Observations after 5 minutes							
Observations after 8 minutes							
Observations after 11 minutes							
Observations after 14 minutes							
Observations after 17 minutes							

After the Experiment…

1. Based on your results, which type of sugar produced the most ethanol? How did you reach this conclusion?

2. What factors may have affected fermentation by yeast in this experiment? (Think about temperatures, sugar sources, and other variables in the experiment.)

3. Were you surprised by any of the results that you got? Did you get the same results as other students? Why or why not?

4. Global warming occurs when carbon dioxide (and other greenhouse gases) accumulate in the atmosphere. What are the impacts of biofuels on global warming?

5. Corn is also used to produce a large amount of food in the United States. How do you think ethanol production using corn will affect our food supply? What would be a better alternative to using corn for ethanol production?