Corn Math

Objectives

- Students will understand energy transformation, matter, and organization.
- Students will understand the chemical reactions involved in making ethanol: conversion of starch to glucose and conversion of glucose to ethanol.
- Students will be able to discuss the challenges of biofuel efficiency.
- Students will understand how to use algebraic and chemical equations to determine how much biofuel is required to travel a specified distance.
- Students will understand how biofuel is produced.

Skill Level: High School	**Class time:** 45 minutes

Materials (per student)

- A student sheet
- A pencil
- A calculator
- Ethanol Production and Cost Worksheet

Next Generation Science Standards

Disciplinary Core Idea:
HS-PS1.B: Chemical Reactions

Performance Expectations:
HS-PS1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

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	

☐ Obtaining / evaluate / communicate	☐ Stability and change

Background Information

Introduction

Bioethanol, as a renewable resource, is one of the important alternatives to fossil transportation fuels, also known as gasoline. Ethanol (CH_3CH_2OH) can be made by fermenting simple sugars from starchy crops (corn), sugar crops (sugarcane), or cellulosic biomass (agricultural waste, forestry waste etc.). Ethanol is normally blended with gasoline and creates a product known as "gasohol". Most of the ethanol in the U.S. is produced from corn. In this activity, students will calculate how much corn it would take to make enough ethanol to make five gallons.

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).

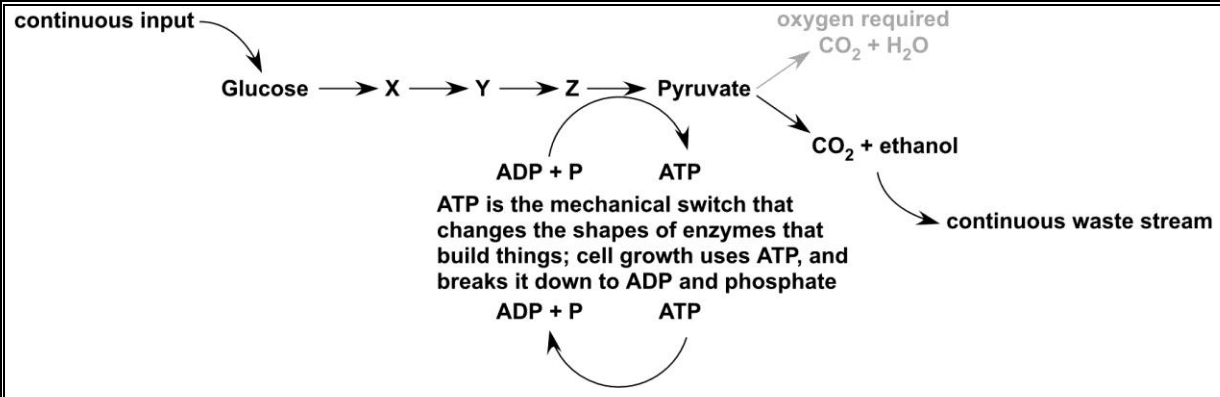

Figure 1. Basics of a yeast reaction. Reference

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 interested in learning about the real cost of biofuels such as ethanol. There are some trade offs when it comes to an alternative fuel. With ethanol in particular the fuel is good for the environment and corn can be regrown. However, ethanol does not create as much energy or last as long as fossil fuel gasoline, therefore an ethanol car may be at the pump more often. In this activity students have the opportunity to calculate the total cost of production and cost of using the fuel to see the trade-offs for themselves.

Explore

Experiment Questions:

- Is there a cost to alternative fuels? If so, what is it?
- How realistic is this exercise? How does it compare to the real world?
- Innovation is at the heart of alternative fuel creation, but so are some other skills such as observation and good math skills. What are some other skills and talents that could be used in the creation of alternative fuel?
- How would you compare fuel derived from corn versus fuel derived from oil?

Procedure:

1. Walk the students through the Ethanol Production and Cost Worksheet.
2. Have them compare answers to the class.
3. Drive home the point that corn costs less but will take a larger amount to travel the same distance that fossil fuel gas does.

Explain

- Define biofuel.
- Explore how renewable corn is as a resource.
- How would corn production work on a grand scale?
- Where is the glucose coming from?

Elaborate

- Determine how many kilograms of corn are in one acre. This will provide students with a sense of scale.
- Global climate change is one of the motivators for finding alternative fuels. Recently, anthropologists have discovered that our ancestors' migration from Africa may have been motivated by severe climate change. How might our current day situation be the same and/or different? Hold a debate about global climate change but from the perspective of early humans. What would be the pros about moving away from the current homeland? What would be the cons? How would the arguments change if you knew the climate change was permanent? What if it wasn't? Have students read the article below and compare this debate with the debate that is occurring today around climate change.

Resources

Additional Resources:

- National Geographic
- Energy Density

Resources Used:

- Renewable Resources: Ethanol Power
- Exploring Ethanol
- Teacher Guide: Ethanol
- UC Davis: Bioenergy Research Center