It All Comes Down to Glucose

Objectives

- Describe the characteristics of a variety of different types of biomass that contain glucose and starch.
- Understand that the energy stored in glucose in various foods can provide us with energy, and can also be used as a biofuel.
- Design an experiment, develop and test a hypothesis, and describe results.

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

Materials

- Dropper bottles of water
- Iodine (0.1 percent)
- 8 TesTape strips (2-inch [5-cm] strips)
- 8 brown-paper squares (paper sack, cut into 2-inch [5-cm] squares)
- 4 wooden tasting spoons
- 4 forceps
- 4 small plastic cups (2-ounce nut cups)
- Small plate with 2 oyster crackers
- 2 miniature marshmallows
- Small amount of smooth peanut butter
- Small amount of unsweetened applesauce
- A few corn kernels
- About .1 g ground biomass (cornstalks and/or grass)
- Paper towels
- Goggles
- Clear tape

Next Generation Science Standards

Disciplinary Core Idea:

PS3.D: Energy in Chemical Processes and Everyday Life

Performance Expectations:

MS-LS1-7: Develop a model that describes how food is rearranged through chemical reactions 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 the production of biofuels, it is important for scientists to understand the chemical structure of natural polysaccharides, because the biofuel production process involves breaking these down into glucose monomers. These can then be used to produce biofuels like ethanol. The activity below is the second in a series of activities that convert monomers into polymers.

Background:

Biofuels are made by breaking down the glucose found in plants. Glucose is made of polymers, which are long chemical chains composed of repeating chemical units that are linked together. For example, starch is a polymer is made from linked glucose molecules. Plants create another polysaccharide, cellulose, which they use in their cell walls. Plants produce almost one hundred billion tons of cellulose per year. It is the most abundant organic compound on Earth, thus making it an important source of bioenergy.

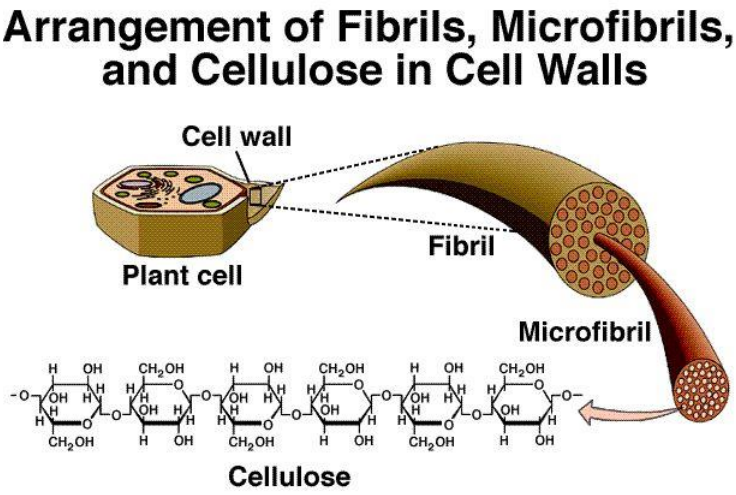

Figure 1. This shows where cellulose can be found in plant cells. Reference

Polysaccharides are polymers of hundreds to thousands of monosaccharides joined by glycosidic linkages. Cellulose and starch are made up of hundreds of linked glucose monomers. In the production of biofuels, it is important for scientists to understand the chemical structure of these polysaccharides, because the biofuel production process involves breaking these down into glucose monomers, which can then be used to produce biofuels like ethanol. The activity below is analogous to what plants do when building polymers out of glucose. Students will use this knowledge to test what food sources have glucose.

Engage

Students should be interested to learn about the plant processes that help make alternative fuels. Cellulose in plants is a useable source of fuel that can be found in plants and yeast fermentation processes. Plants can also be replanted and scientists are currently looking for plants that require less water and chemical outputs. This can mean more plants without needing to use precious resources.

Explore

Experiment Questions:

- What are the physical characteristics of the foods that contain glucose and/or starch? Do foods that contain glucose and/or starch have similar characteristics?

Procedure:

1. Label 6 cups with the numbers 1-6 with a sharpie.
    a. Use one of the wooden tasting spoons to crush one of the oyster crackers on the plate. With the spoon, transfer the cracker crumbs to cup 1 Add a few drops of water to create a liquid mixture.
    b. Place a marshmallow in cup 2, and use a clean tasting spoon to tear it into small pieces. Add a few drops of water to create a liquid mixture.
    c. Place half the peanut butter in cup 3.
    d. Place half the applesauce in cup 4.
    e. Grind your corn kernels with a spoon on a plate. Transfer to cup 5 and add a few drops of water.
    f. Add your ground biomass to cup 6.
    g. Add a few drops of water.
2. Label six of the brown-paper squares with the names of the foods. Use forceps to rub the second sample of each food against a brown-paper square. Place these on a paper towel.
3. Label TesTape strips with the name of each food, and then dip it into that food's cup. Place each strip on a paper towel to dry.
4. Place two drops of iodine on the food remaining in each cup.
5. Observe the reactions in each test, recording them on the attached worksheet.
    a. If a stain is observed on the brown paper, the sample tests positive for fat.
    b. If a color change is observed on the TesTape glucose test strip, the sample tests positive for glucose. Record color on Observation Worksheet.

If a color change is observed when iodine is added, the sample tests positive for starch. Record color.

6. Compare your group's results with those of another group.
7. What other foods would you like to test? Develop a list of 10 additional foods with your group, and arrange to bring them in for testing. Test them using iodine, TesTape strips, and brown-paper squares. Be sure to add your results to the worksheet table.

Explain

- Identify whether each food contains starch, glucose, or fat.
- What part of the plant does each food come from? Can you infer anything about what parts of a plant contain starch, glucose, or fat?
- How did your results compare to other groups?
- Were the results a surprise?
- What does the glucose in these foods provide us with?
- How is the glucose in these foods formed, or where does it come from?
- Which of these foods could be used to produce biofuel? Why?

Elaborate
• Test other foods like dairy and meat. What are the results? Would these sources make good ethanol producers? Why or why not? • How could these "biofuels" be produced on a large scale? • What is the purpose and composition of the TesTape strips? What does a color change occur?

Resources

Additional Resources:

- The Biofuel FAQs
- Purdue University: Biofuels Beyond Corn

Resources Used:

- U.S. Department of Energy
- Cellulose

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STUDENT OBSERVATION SHEET

Food Source	Observations	Glucose (+/-)	Starch (+/-)	Fat (+/-)
Crackers				
Marshmallows				
Peanut Butter				
Applesauce				
Corn				
Biomass				