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Finding the Carbon in Sugar

The Science of Global Atmospheric Change:
Activity 5

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Finding the Carbon in Sugar

All living things are made out of molecules containing carbon. Plants take in carbon as carbon dioxide from the air. During photosynthesis, plants make energy-rich molecules, such as sugars, that have carbon as a backbone. Plants and all other organisms use these simple molecules to provide energy and raw materials to manufacture other substances necessary for life. We can see the evidence of the carbon in sugar as a black residue that appears when the sugar begins to burn.

The formula for table sugar (sucrose) is: $C_{12}H_{22}O_{11}$.

The objectives of this activity are aligned with the National Science Education Standards, specifically those related to Science as Inquiry and Physical Science. Finding the Carbon in Sugar uses guided inquiry to illustrate how fire combines fuel with oxygen in a reaction that releases energy in the form of light and heat. Students will learn about combustion and energy by observing a burning candle in a sealed jar and the burning of white sugar. They will observe, measure, predict, record observations, infer, and draw conclusions based on their investigation.

This activity addresses the following key science concepts.

- Burning, or combustion, takes place when a fuel combines rapidly with oxygen. This is a chemical change.
- When something burns, carbon dioxide (CO_2), water, and other substances are

released.

- Fuels made from living materials contain carbon.

Student Worksheets

Student pages in the teacher's guide are provided in English and in Spanish.

Reference

Moreno N., and B. Tharp. (2011). *The Science of Global Atmospheric Change Teacher's Guide*. Third edition. Baylor College of Medicine. ISBN: 978-1-888997-76-7. Development of this student activity was supported, in part, by grant numbers R25 ES06932 and R2510698 from the National Institute of Environmental Health Sciences of the National Institutes of Health to Baylor College of Medicine.

Image Reference

1. Photo of candle © 4028mdk09, Wikimedia Commons CC-BY-SA 3.0.
http://commons.wikimedia.org/wiki/File:Einzelne_Kerze.JPG

2. Photo of light, raw cane sugar © Fritz, CC-BY-SA 3.0.
http://commons.wikimedia.org/wiki/Sugar#mediaviewer/File:Raw_cane_sugar_light.JPG

Key Words

lessons, carbon, combustion, oxygen, carbon dioxide, CO₂, fuel, energy, fossil fuels,

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Materials



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Materials

Have students work in groups of 2 to 4.

Materials for Demonstration

- 1,000 ml clear beaker (or tempered glass bowl)
- Matches
- Tea candle
- Wet paper towels

Materials per Student Group

- 1/2 teaspoon of white sugar
- Small piece of aluminum foil (15 cm square)
- Tea candle
- Wet paper towels

Materials per Student

Copy of "Sugar as Fuel" page

Setup

Conduct Session 1 as a demonstration using the class materials. Session 2 may be conducted by students working in groups, or as a teacher demonstration using the student group materials.

Safety Note: Have students remove loose papers, tie back hair, and secure loose clothing before lighting candles.

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Image Reference

Photo by Christopher Burnett © Baylor College of Medicine.

Key Words

materials list, materials needed,

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Science Safety Considerations

- Follow all instructions.
- Begin investigation only when instructed.
- Tie back hair and secure loose clothing.
- Take caution around the lighted candle.
- Do not eat the sugar or melted sugar.
- Wash hands thoroughly after the investigation.



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Science Safety Considerations

Students always must think about safety when conducting science investigations. This slide may be used to review safety with your class prior to beginning the activity.

Safety first!

- Always follow school district and school science laboratory safety guidelines.
- Have a clear understanding of the investigation in advance.
- Practice any investigation with which you are not familiar before conducting it with the class.
- Make sure appropriate safety equipment and gear, such as safety goggles, fire extinguisher, are available.
- Continually monitor the area where the investigation is being conducted.

Safety note: FIRE HAZARD. BURN HAZARD. Have students remove loose papers, tie back hair, and secure loose clothing before lighting candles. Caution students to use care around the lighted candle, and not to eat the sugar or melted sugar.

References

1. Dean R., M. Dean, and L. Motz. (2003). *Safety in the Elementary Science*

Classroom. National Science Teachers Association.

2. Moreno N., and B. Tharp. (2011). *The Science of Global Atmospheric Change Teacher's Guide*. Third edition. Baylor College of Medicine. ISBN: 978-1-888997-76-7. Development of this student activity was supported, in part, by grant numbers R25 ES06932 and R2510698 from the National Institute of Environmental Health Sciences of the National Institutes of Health to Baylor College of Medicine.

Key Words

science, classroom, safety, lab, laboratory, rules, safety signs,

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What Happens When Wood Burns?

- Have you ever watched a campfire burn?
- What actually happens when you burn something?
- What does campfire wood look like after the fire goes out?
- Did the fire produce a physical or chemical change?
- Does fire use oxygen?



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What Happens When Wood Burns?

Ask students, *Have you ever watched a campfire burn? What actually happens when you burn something? What does campfire wood look like after the fire goes out?* Students should recognize that wood turns into ashes as it burns. When something burns, a chemical reaction occurs, in which the fuel—the thing that is burning—combines rapidly with oxygen, releasing energy as a byproduct.

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Image Reference

Photo of a small fire in a backyard fire pit courtesy of Jon Sullivan. Released into the public domain. http://commons.wikimedia.org/wiki/File:Montana_16_bg_062406.jpg

Key Words

lesson, fire, wood, campfire, chemical change, oxygen, physical change,

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Session 1: The Burning Candle

1. Gather materials.
2. Light the candle.
3. Predict what will happen if the candle is covered with the beaker.
4. Place the lighted candle on wet paper towels and cover it with the beaker.
5. Observe what happens to the candle.
6. Slowly lift the beaker and observe the other substances that are present in the beaker.



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Session 1: The Burning Candle

In this activity, students will learn about combustion and energy by sealing a burning candle in a jar and by burning white sugar. They will observe, measure, predict, record observations, infer and draw conclusions based on their investigations. Students will discover that burning (combustion) is a chemical reaction that 1) takes place when a fuel combines rapidly with oxygen and 2) produces substances such as CO_2 and water.

1. Direct students' attention to the materials you have gathered (a large beaker, candle, matches, and wet paper towels). Light the candle and ask, *What is happening to the candle?* After students answer that it is burning, ask, *Are we seeing a physical change in the candle, or a chemical change?* Remind students that chemical changes produce substances different from the ones that were originally present. Chemical changes also usually produce or consume energy.

2. Prompt students to predict what might happen if the candle is covered with the beaker. After students have made their predictions, place the lighted candle on the wet towels and cover it with the beaker. Fold the edges of the towels around the lip of the container to create a seal. Have students observe what happens to the candle. The flame will grow progressively smaller until it finally extinguishes (this usually takes less than a minute).

3. Ask students, *What happened to the candle? Did it run out of material to burn? Do you think it ran out of something else?* Help students understand that the candle used up all the oxygen trapped within the beaker. Lift the beaker slowly and have students observe the other substances present: smoke and condensed water vapor on the sides of the glass. Let them examine the candlewick. Ask, *What can we see or feel that was produced by the burning candle?* (heat, water, smoke, charred wick) *What did*

the candle use as fuel while it was burning? (melted wax and the wick as fuel, oxygen gas from air)

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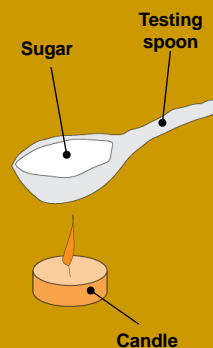
Key Words

lesson, candle, burning, experiment,

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Session 2: Sugar as Fuel

1. Collect materials.
2. Construct a “testing spoon” out of foil.
3. Measure 1/2 teaspoon of sugar into the spoon.
4. Record your prediction of what will happen when the sugar is heated.
5. Light the candle.
6. Hold the spoon over the flame.
7. Record your observations.



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Session 2: Sugar as Fuel

Have the Materials Manager for each group collect a candle, a square of aluminum foil, a wet paper towel and one or more copies of the “Sugar as Fuel page.” Have students create a “testing spoon” by shaping the foil into a spoon-like shape with a long handle (see student page). The bowl of the spoon should be made of only one layer of foil.

Instruct students to clear all papers and place the candle on the wet towel in the center of their work area.

After students have completed their spoons, have one person from each group measure about 1/2 teaspoon of sugar into the spoon. Have students predict what will happen when they heat the sugar over a lighted candle. They should record their predictions on the “Sugar as Fuel” page.

Light the candle (which should be placed on the wet paper towels) for each group. Direct each principal investigator to hold the bowl of the “spoon” over the candle flame. The other members of each group should observe and record what happens to the sugar. (The sugar will become liquid and turn amber-colored. This is caramel, similar to the topping used for desserts such as flan and custard. Finally, the sugar will burn and become blackened.)

Safety note: Students should not eat or touch blackened sugar. The used sugar will be hot and should be disposed of properly after the investigation.

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Image Reference

Illustration by M.S. Young © Baylor College of Medicine.

Key Words

lesson, experiment, test, sugar, heat, candle, melt, melting, observation, combustion,

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Let's Talk About It

- What happened to the sugar?
- Was this a physical or chemical change, or both?
- What is the black substance?
- Where did the carbon in the sugar come from?
- Where did the carbon on the bottom of the spoon come from?
- Was oxygen used?



Microscopic view of sugar crystals



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Let's Talk About It

In this activity, students observed an example of combustion: burning sugar. When placed over a flame, the sugar turned amber-colored, and then black.

Ask students, *What happened to the sugar?* Help them to recognize that the sugar underwent a physical change (solid to liquid) and a chemical change (burning of liquid sugar). Ask, *What do you think the black substance is?* Help students to understand that the remaining material is mostly composed of carbon. Have students think about coal and crude oil.

Now ask them, *Where did the carbon in the sugar come from?* Lead students to understand that the carbon was drawn from air, as carbon dioxide, during photosynthesis in the leaves of plants. Have students examine the bottom of the spoon. Ask, *Where did that carbon come from?* Help them understand that *that* carbon comes from the burning of the candle wax.

Challenge students to think of other examples of combustion (e.g., burning wood, combustion of gasoline that runs a car engine).

Reference

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Teacher's Guide. Third edition. Baylor College of Medicine. ISBN: 978-1-888997-76-7.
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Image Reference

Macro photo of sugar (saccharose) © Lauri Andler, CC-BY-NC 3.0.
http://eh.wikipedia.org/wiki/File:Sugar_2xmacro.jpg

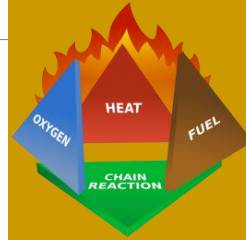
Key Words

lesson, experiment, test, sugar, heat, candle, melt, melting, carbon, oxygen, physical change, chemical change,

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The Science of Combustion

- Combustion (burning) is a chemical reaction.
- Combustion occurs when fuel combines with oxygen.
- Energy (heat), water, carbon dioxide, and other chemicals are released during combustion.
- Fuels made from living materials contain carbon.
- The carbon in sugar appeared black when the sugar was heated.



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The Science of Combustion

In this activity, students observed the following properties of global resources.

- **Burning, or combustion, takes place when a fuel combines rapidly with oxygen. This is a chemical change.** The process of burning releases energy, most of which is given off in the forms of light and heat.
- **When something burns, CO₂, water, and other substances are released.** Carbon dioxide, originally trapped by green plants during photosynthesis, forms again during burning and is released. Water, also essential for photosynthesis, also is released. Most fuels produce additional substances, such as smoke and soot, and gases like methane and carbon monoxide, when they are burned. Some fuels, such as natural gas, burn more cleanly than others, such as coal. However, all fossil fuels release carbon back into the atmosphere during combustion.
- **Fuels made from living materials contain carbon.** The pathway of energy through Earth's living and non-living systems closely parallels the routes followed by carbon in the carbon cycle. A simple element, carbon is a key element of the molecules produced and used by all living things. Plants and other photosynthetic organisms create food molecules from carbon dioxide, water, and energy from the sun. They use this energy to drive all other processes necessary for life. When carbon-containing substances (wood, oil, natural gas, coal) are burned, carbon dioxide is released back into the atmosphere.

Reference

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Image Reference

Fire tetrahedron graphic courtesy of Gustab, released into the public domain.
http://commons.wikimedia.org/wiki/File:Fire_tetrahedron.svg

Key Words

combustion, burning, chemical reaction, fuel, oxygen, energy, heat, water, carbon dioxide, CO₂, chemicals, carbon, sugar,

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Extensions

Use the library or on the Internet to explore the following.

- Where does wax come from? How have wax candles been used in the past?
- All plants produce sugar during photosynthesis. Which plants are used for the manufacturing of sweeteners, such as table sugar and syrup?



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Extensions

Encourage the students to think of variations to the experiment. For instance, they might ask additional questions about combustion or think of additional examples of combustion.

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Key Words

lesson, extension, combustion, photosynthesis, plants, sugar,

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