THE SCIENCE OF Global Atmospheric Change

Finding the Carbon in Sugar

Activity from *The Science of Global Atmospheric Change Teacher's Guide*
and for *Mr. Slaptail's Curious Contraption*

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Baylor College of Medicine

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NATIONAL ACADEMIES OF SCIENCES
dels.nas.edu/Climate/Climate-Change/Reports-Academies-Findings

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http://en.wikipedia.org/wiki/File:North_season.jpg

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
sis.nlm.nih.gov/enviro/climatechange.html

U.S. GEOLOGICAL SURVEY, OFFICE OF GLOBAL CHANGE
usgs.gov/global_change

U.S. GLOBAL CHANGE RESEARCH PROGRAM
globalchange.gov

GRAY WATSON
http://en.wikipedia.org/wiki/File:Solar_panels_on_house_roof.jpg

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http://www.bath.ac.uk/bio-sci/research/profiles/wheals-a.html

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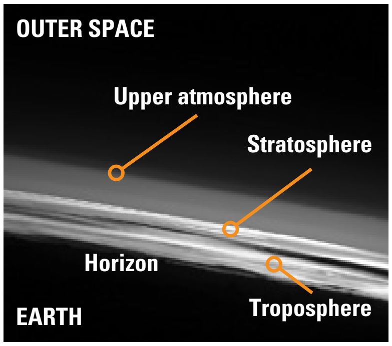
Solar Energy and Living Things

Life Science Basics



Reductions in the amount of ozone in the stratosphere are allowing more ultraviolet radiation (UV) from the sun to reach Earth's surface.

The effects of some kinds of UV exposure are cumulative and may not show up for many years.

In humans, increased exposure to UV radiation (especially UV-B, with wavelengths between 290–320 nanometers) is linked to skin cancer, the development of cataracts and effects on the immune system. UV-B radiation also is toxic to plants, including crop plants, and phytoplankton, which forms the basis of marine food chains.

Photo courtesy of NASA.

SUN AND SKIN

Skin is especially vulnerable to the effects of ozone depletion in the upper atmosphere. Ultraviolet radiation produced by the sun can damage skin, causing premature wrinkling and loss of elasticity, as well as skin cancer. As increased amounts of UV radiation reach the surface of the planet, the risks for skin damage also increase. Sunburns and suntans both are evidence that skin has been exposed to too much damaging radiation.

Life on Earth depends directly or indirectly on energy from the sun. Solar energy, which reaches us as heat, light and other types of electromagnetic radiation (such as ultraviolet, or UV, radiation), also can be harmful to living things.

Most of the energy we use each day comes in some way from materials photosynthesized by plants and other producers, such as algae. During photosynthesis, energy from the sun is trapped to build molecules necessary for life. The oil, natural gas and coal that have been essential for the development of our modern industrial world all are made up of the remains of dead organisms that relied on photosynthesis. Similarly, all of our food, which provides energy for our bodies, ultimately comes from plants and other producers—whether we eat plants directly or eat other organisms that consume plants.

The pathway of energy through Earth's living and non-living systems closely parallels the routes followed by carbon in the carbon cycle. This simple element (the fourth most abundant element in the universe) forms the backbones of the molecules produced and used by all living things—from DNA to fossil fuels. Plants and similar organisms create food molecules from carbon dioxide (CO_2), 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 or coal, for example) are burned, CO_2 is released back into the atmosphere. Similarly, when living cells use the chemical energy stored in food, CO_2 is released. This process is known as respiration.

Shorter wavelengths of solar radiation (such as UV radiation) can damage cells. This is important because more UV radiation is reaching Earth's surface as a result of ozone depletion in the statrosphere. Stratospheric ozone, which absorbs UV radiation, is destroyed by certain chemicals, particularly those known as chlorofluorocarbons (CFCs). Exposure to UV radiation can increase a person's chances of getting skin cancer or of developing cataracts. Other organisms, from frogs to marine algae, also can be harmed by UV radiation.

It is particularly important to protect skin from the sun. Less than one millimeter in thickness, skin plays an essential role in the body. It protects inner tissues and provides communication (through the sensory system) with the outside environment. The skin also aids in maintaining a constant temperature within the body. The numerous blood vessels in the skin and sweat glands help cool the body when outside temperatures are warm.

The skin is composed of layers, each with different characteristics. The layers of skin act like thin boards pressed together in a sheet of plywood, giving skin greater strength than it would have otherwise.

Finding the Carbon in Sugar

Life Science

Most of the fuels we use come from dead plant or animal matter. The origin of fuel wood, of course, is obvious. However, all fossil fuels also are derived from decomposed organisms that have been buried at high temperatures and pressures for millions of years. The energy in these fuels was captured from the sun during photosynthesis by plants, some bacteria and algae.

When something burns, it combines rapidly with oxygen in a reaction that releases energy. Most of this energy is given off in the forms of light and heat. Other things are given off at the same time. Carbon dioxide, once trapped by green plants during photosynthesis, is formed again and released. Water, also essential for photosynthesis, is released as well. In addition, most fuels produce substances such as smoke and soot, and other gases like methane and carbon monoxide, when they are burned. Some fuels, such as natural gas, burn much more cleanly than others, such as coal. However, all fossil fuels release carbon back into the atmosphere during combustion.

Unit Links

Mr. Slaptail's Curious Contraption
Story, pp. 12–15

Explorations
Let's Talk About the Atmosphere and Health, pp. 2–3

SETUP

Conduct Session 1 as a demonstration. Session 2 may be conducted by students working in groups of 2–4, or as a teacher demonstration.

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

PROCEDURE

Session 1: What happens when something burns?

1. Have the following materials ready: large beaker or tempered glass bowl, candle, matches and several wet paper towels folded together to make a mat larger than the opening of the beaker or bowl.
2. Direct students' attention to the materials you have gathered. Light the candle and ask, *What is happening to the candle?* After students answer that it is burning, ask, *What do you think it means to burn something? Are we seeing a physical change in the candle or a chemical change?* Remind students that a chemical change produces substances different from the ones that originally were present. Chemical changes usually give off or take in energy.
3. Ask students to predict what might happen if the candle is covered with the beaker. After students respond, place the lighted candle on the wet towels and cover it with the container. Fold the edges of the towels around the lip of the container to create a seal.

CONCEPTS

- Burning or combustion takes place when a fuel combines rapidly with oxygen. This is a chemical change.
- When something burns, CO_2, water and other substances are given off.
- Fuels made from living materials contain carbon.

OVERVIEW

Students learn about combustion and energy by observing a burning candle in a sealed jar and the burning of white sugar.

SCIENCE, HEALTH & MATH SKILLS

- Observing
- Measuring
- Predicting
- Recording observations
- Inferring
- Drawing conclusions

TIME

Preparation: 20 minutes
Class: Two sessions of 30 minutes

MATERIALS

- Clear beaker, 1,000-mL (or tempered glass bowl)
- Matches
- Tea candle
- Wet paper towel

Each group will need:

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

Each student or group will need:

- Copy of "Sugar as Fuel" student sheet

CARBON IN LIVING THINGS

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: $C_{12}H_{22}O_{11}$.

COMBUSTION

Combustion is a chemical reaction. When something burns, it combines rapidly (sometimes violently) with oxygen. Energy is released in this process, which usually also yields water, carbon dioxide and small amounts of other chemicals.

The ultimate clean-burning fuel is pure hydrogen (H_2), which combines with oxygen to yield only pollution-free water (H_2O). However, practical daily applications of this explosive substance are still being designed.

4. Have students observe what happens to the candle. The flame will become smaller until it finally extinguishes (this usually takes less than a minute). Ask, *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 as much oxygen gas (one of the gases in air) as was possible.
5. Lift the container slowly and have students observe the other substances present: smoke and condensed water vapor on the sides of the container. 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 was used by the burning candle?* (melted wax and the wick as fuel, oxygen gas from air).

Session 2: Sugar as fuel

1. Have each Materials Manager collect a candle, a square of aluminum foil, a wet paper towel and one or more copies of the student sheet. Students should clear all papers and place their candles on the wet toweling in the center of their work areas.
2. Let students create a "testing spoon" by forming the foil into a spoon-like shape with a long handle (see illustration, p. 21). The bowl of the spoon should be made of only one layer of foil.
3. When students have completed their spoons, have one person from each group measure about 1/2 teaspoon of sugar into the spoon.
4. Have the students in each group predict what will happen when they heat the sugar over a lighted candle. They should record their predictions on their student sheets.
5. Light the candles (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. Other group members should observe and record what happens to the sugar. (It will become liquid and turn amber-colored. This is caramel, similar to the topping used for desserts like flan and custard. Finally, the sugar will burn and become blackened.)
6. Ask, *What happened to the sugar?* Help students recognize that the sugar underwent a physical change (solid to liquid) and a chemical change (burning of liquid sugar). Also ask, *Where did the carbon in the sugar come from?* Lead students to understand that the carbon was taken from air as carbon dioxide during photosynthesis. Have students examine the bottom of the spoon. Ask, *Where did that carbon come from?*

QUESTIONS FOR STUDENTS TO THINK ABOUT

Where does wax come from? How have wax candles been used in the past? Have students look for answers in the library or Internet.

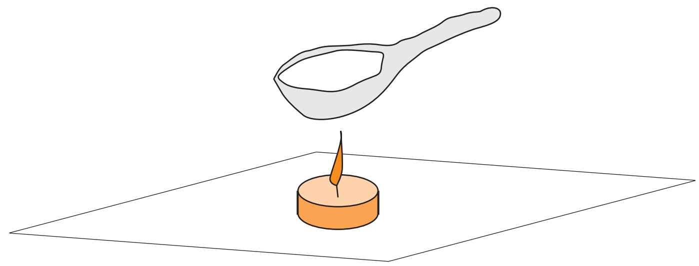
All plants make sugar during photosynthesis. *Which plants are used to manufacture sweeteners, such as table sugar and syrups?*

Sugar as Fuel

Name ___________________________________

You will need:

1/2 teaspoon white sugar
candle
square of aluminum foil
wet paper towels



To carry out your investigation:

1. Mold the foil into a spoon with a long handle. Make sure that the bowl of the spoon is made of only one layer of foil.

2. Put the sugar into the bowl of the spoon.

   What do you think will happen to the sugar if you heat it for a long time over a candle flame? Write your prediction in the space below.

   ____
   ____
   ____

3. Hold the spoon by the handle and heat the sugar over a candle. For safety, place the candle on a wet paper towel, and follow your teacher's instructions.

4. Observe the changes in the sugar. Write your observations in the space below.

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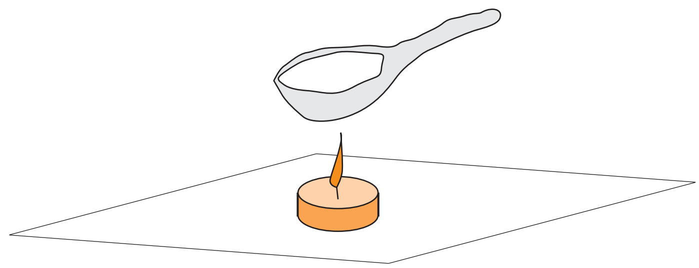
El Azucar como Combustible

Mi Nombre ____

Vas a necesitar:



1/2 cucharadita de azucar
una vela
un cuadrado de papel de aluminio
toallas de papel mojadas

Para hacer la investigación:

1. Usa el papel de aluminio para formar una cuchara con una asa larga. La parte honda de la cuchara debe hacerse de una sola capa de papel de aluminio.

2. Pon el azucar en la parte honda de la cuchara.

   ¿Que crees que pasará al azucar si lo calientas por mucho tiempo? Escribe tu predicción en el espacio abajo.

   ____

   ____

   ____

3. Toma la cuchara por el asa y calienta el azucar sobre una vela. Para mayor seguridad, pon la vela encima de unas toallas de papel mojadas.

4. Observa como cambia el azucar. Escribe tus observaciones en el espacio abajo.

   ____

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