THE SCIENCE OF
Global
Atmospheric
Change

Fossil Fuels and the Carbon Cycle

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

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BioEd[SM]

Teacher Resources from the
Center for Educational Outreach at
Baylor College of Medicine

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Energy and the Atmosphere

Physical Science Basics

THE SPECTRUM

Radiation travels in waves. The wavelengths that we see as visible light represent a small portion of the entire electromagnetic spectrum.

Light usually is measured in nanometers (one nanometer equals 0.000,000,001 meters). Wavelengths that we can see fall between 400 and 700 nm. During photosynthesis, green plants capture energy from wavelengths in this range.

Some kinds of radiation are listed below, from longest to shortest wavelengths.

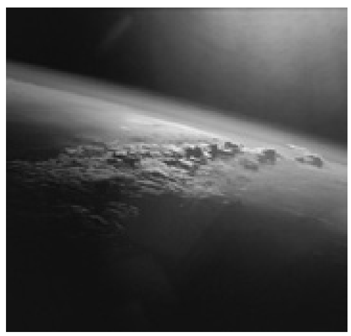
- Long wave radio
- Short wave radio
- Radar
- Microwave
- Infrared
- Visible light
- Ultraviolet light
- X-ray
- Gamma ray
- Cosmic ray

FOSSIL FUELS

Fossil fuels — coal, oil and natural gas — consist of the remains of ancient plants, animals and one-celled organisms that have been buried under intense pressures and high temperatures for millions of years. The resulting substances deliver much more useful energy than raw plant materials, such as wood.

The sun is the source of Earth's energy. Every second, approximately five million tons of matter within this relatively small star are converted into energy, which is sent outward into space. We feel part of this energy as heat and see another part as light. Heat and light that we can detect, however, represent only a small portion of the radiation emitted by the sun.

Radiation travels in waves, similar in some ways to waves on the surface of a lake. The distance between the peaks, or crests, of two successive waves is known as the wavelength. The longest wavelengths—between 1 and 1,000 meters—correspond to television and radio signals. The shortest wavelengths, those of cosmic rays, are only 0.000,000,000,000,01 meters long!



Radiation traveling toward Earth passes through a thin layer of gases called the atmosphere. Without this protective layer, life on Earth would be impossible. Earth's atmosphere consists primarily of nitrogen and oxygen, along with other argon, carbon dioxide and water vapor. The atmosphere keeps the planet warmer than it would be otherwise; provides oxygen, moisture and carbon dioxide; and prevents most harmful radiation from reaching the surface.

Green plants and algae (related plant-like organisms that usually grow in water) are able to absorb energy from the sun and use it to combine carbon dioxide (CO_2) from the atmosphere with water to make energy-rich molecules, such as sugars and carbohydrates. Green plants and their products form the base of almost all food webs on Earth. They also are the source of our most common fuels.

Fuels such as wood, coal, oil and natural gas all are composed of matter originally produced by plants and other organisms. Each holds energy, originally trapped during photosynthesis, in the chemical bonds of carbon-containing molecules. When these substances are burned, they release heat energy that can be used for many purposes.

Our use of fossil fuels has grown dramatically since the 1800s. During the Industrial Revolution, coal was used to power steam engines in mines, factories, locomotives and ships. Later, it was used to generate electrical power. The discovery of large deposits of petroleum led to widespread use of fuels for transportation, heating and production of electricity. When fossil fuels are burned, carbon-containing molecules combine rapidly with oxygen. This chemical reaction releases energy in the form of heat. It also releases CO_2 into the air. Many other chemical substances also are produced by the burning or incomplete burning of fossil fuels.

Photo courtesy of NASA.

Fossil Fuels and the Carbon Cycle

Physical Science

In the United States, more than 75% of the energy used in homes and businesses, and for transportation comes from coal, oil or natural gas. These fuels are known as "fossil" fuels because they are the remnants of ancient plants and other living things buried under intense heat and pressure over millions of years. They are very efficient sources of energy. However, it is important to keep in mind that the energy in fossil fuels originally came from the sun and was trapped by plants and similar organisms during photosynthesis. During this process, plants also consumed carbon dioxide (CO_2) from the atmosphere. So when fossil fuels are burned, trapped carbon is released back into the atmosphere, principally as CO_2.

- **Petroleum**, or crude oil, is a thick, gooey liquid that can be found within Earth's crust on land or beneath the sea floor. It was formed principally from tiny marine organisms that were buried in layers of sediment, such as sand. In addition to containing high-energy carbon compounds, petroleum contains varying amounts of substances such as oxygen, sulfur and nitrogen. Crude oil must be heated and distilled to separate it into gasoline, heating oil, diesel oil, asphalt and other materials. Some components of crude oil are used to manufacture industrial chemicals, fertilizers, pesticides, plastics, medicines and other products.
- **Natural gas** is a mixture of methane (CH_4) and smaller amounts of related gases. It often is found above deposits of crude oil. Natural gas burns hotter and produces less air pollution than any other fossil fuel. When burned, it also releases less CO_2, relative to the amount of energy produced.
- **Coal** is a solid that is formed in several stages. It is a mixture of many different substances, with varying amounts of water, nitrogen and sulphur. Coal is formed from peat—a moist soil substance made of partially decayed plant material. When peat is subjected to intense heat and pressure, it becomes lignite—a brown coal. Lignite will become bituminous coal if it is placed under more heat and pressure. Bituminous coal often is used as fuel because it produces high levels of heat and is abundant. The most desirable form of coal is anthracite, a hard mineral that results from the transformation of bituminous coal under more conditions of very high heat and pressure. Anthracite is a very attractive fuel because it burns cleanly and produces great quantities of heat.

Unit Links

Mr. Slaptail's Curious Contraption
Story, pp. 10–12;
Science box, p. 12

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

CONCEPTS

- Fossil fuels are found within Earth's crust.
- The presence of certain layers of soil and rock helps predict the presence of oil.
- The supply of fossil fuels cannot be replenished.

OVERVIEW

Students will learn how geologists locate fossil fuels by using a straw to extract core samples from a model that has different layers.

SCIENCE, HEALTH & MATH SKILLS

- Predicting
- Observing
- Identifying patterns
- Mapping
- Drawing conclusions

TIME

Preparation: 45 minutes
Class: 30–45 minutes

MATERIALS

- 24 aluminum baking cups and a cookie sheet (see Setup)
- 2 envelopes of bran muffin mix (plus ingredients)
- 2 envelopes of corn muffin mix (plus ingredients)
- Green and red food coloring

Each student or team of 2 will need:

- Prepared GeoMuffin (see Setup)
- Cotton swab
- Crayons or colored markers
- Plastic serrated knife
- Section of plastic straw about 8 cm (3 in.) in length
- Toothpick
- Copy of "GeoMuffin Observations" sheet

One kind of fossil fuel, coal, can be found between layers of earth and rocks. The coal seam shown above (darkest layer) is in cliffs that are approximately 335 million years old. Earth has a finite amount of fossil fuels.

CARBON CYCLE

Carbon is the basic building block for many molecules in living organisms. Producers take carbon from carbon dioxide gas (CO_2) and create substances such as glucose (a kind of sugar) through photosynthesis. All other living things rely on producers for food.

When food is broken down or digested, carbon is converted back into CO_2, which is released into the atmosphere.

Other processes, such as burning and decomposition, also release CO_2 back into the atmosphere. In the oceans, some carbon is incorporated into the shells of organisms and becomes deposited in sediments.

When geologists look for fossil fuels, they often drill deep into Earth. They remove narrow cores of rock and sediments and examine them for clues about the presence of oil and other fuels. This activity lets students explore the layers in a muffin representing Earth's crust, using a straw to drill "cores."

SETUP

You will need to bake 24 GeoMuffins (see recipe, p. 6) in advance, using two envelopes of prepared bran muffin mix and two envelopes of prepared corn muffin mix, plus ingredients listed on the packages. (Other flavors may be substituted as long as they are different colors and contain no fruit or nuts.) You will need 24 aluminum baking cups on a cookie sheet or 24 paper liners and a muffin pan.

Note. Cake mixes usually are less satisfactory because the baked texture is too soft.

Cut straws into 3-in. lengths for students to use.

Students may work individually or in groups.

PROCEDURE

1. Show the muffins to the class. Point out that all of the muffins look the same on the surface. Tell students that the muffins are made of layers that look similar to those visible in a cross section of Earth's crust. Explain that they will be exploring their muffins to discover whether or not the muffins hold petroleum deposits, and where those deposits might be located. Lead the class in a discussion of how fossil fuels were formed under the ground, how they are mined and how they are used.
2. Give a muffin and a "GeoMuffin Observations" sheet to each student or team of students. Ask, *What do you think the inside of the muffin looks like?* Without touching or removing the baking cup, instruct students to draw their predictions on their student sheets. They also should predict whether or not they will find oil (see "Geomuffin Legend," right).
3. Have students insert a toothpick near the edge of their muffins to represent "North." Based on what they can observe on the top surface of the muffin, have students identify six places on the muffin to "drill."
4. Demonstrate the technique to be used. Show the students how to take a core sample by gently twisting a section of plastic drinking straw into a muffin and then pulling it back out. Use a cotton swab to dislodge the core by inserting it in the top of the straw and pushing the core out the bottom.
5. Encourage students to take at least six samples, recording each

GEOMUFFIN LEGEND

- RED = Oil
- GREEN = Predicting layer for oil
- YELLOW = Soil or rock layer
- BROWN = Soil or rock layer

sample's location on their worksheets, and then drawing and coloring the samples in order.

6. Once they have finished sampling, recording and coloring, students should evaluate their information, looking for a pattern. Based on their cores, students should draw an estimate of a side view of the muffin, showing all the layers.
7. Now instruct students to cut through the center of the muffin. They should compare their predictions with their muffins. Ask, *Did the core samples give you valuable information? Why or why not? Did you find anything that predicts the presence of oil?* Mention that geologists frequently look for certain patterns of layers in the cores. Certain patterns predict or suggest that oil might be present.
8. Have students consider petroleum as a resource. Ask, *What happens when we burn products made from oil? Does burning oil produce carbon dioxide? Do you think we could run out of oil?* Help students understand that oil and coal are resources that cannot be replaced once they have been "used up."
9. Initiate a discussion about where oil and other fossil fuels come from. Use the "Carbon Dioxide and the Carbon Cycle" page as an overhead to help students understand how photosynthesis by ancient plants and similar organisms is responsible for the carbon now found in fossil fuels. Challenge students to figure out what happens to the carbon in fossil fuels when the fuels are burned (carbon returns to the atmosphere as carbon dioxide).

VARIATIONS

- Instead of having students cut their muffins in half after making their predictions, challenge them to restore the "landscape" on the top of their muffins before proceeding with the rest of the activity.
- Encourage students to use resources in the library or on the Internet to learn about other important cycles in ecosystems. Nitrogen is another example of an atmospheric gas that cycles through non-living and living parts of ecosystems in many different forms.
- As an alternative to baking, use different colors of clay or modeling dough to make the layered GeoMuffins.

QUESTIONS FOR STUDENTS TO THINK ABOUT

How many different uses of fossil fuels are there? Have students use the library or the Internet to look for answers.

What will happen when we use up the supplies of fossil fuel? Do you think that we can get any more? Why or why not? Are there any good substitutes for fossil fuels?

How much oil and natural gas still are left on Earth? Have students look for answers in the library or on the Internet. *What might be done to ensure wise use of these resources?*

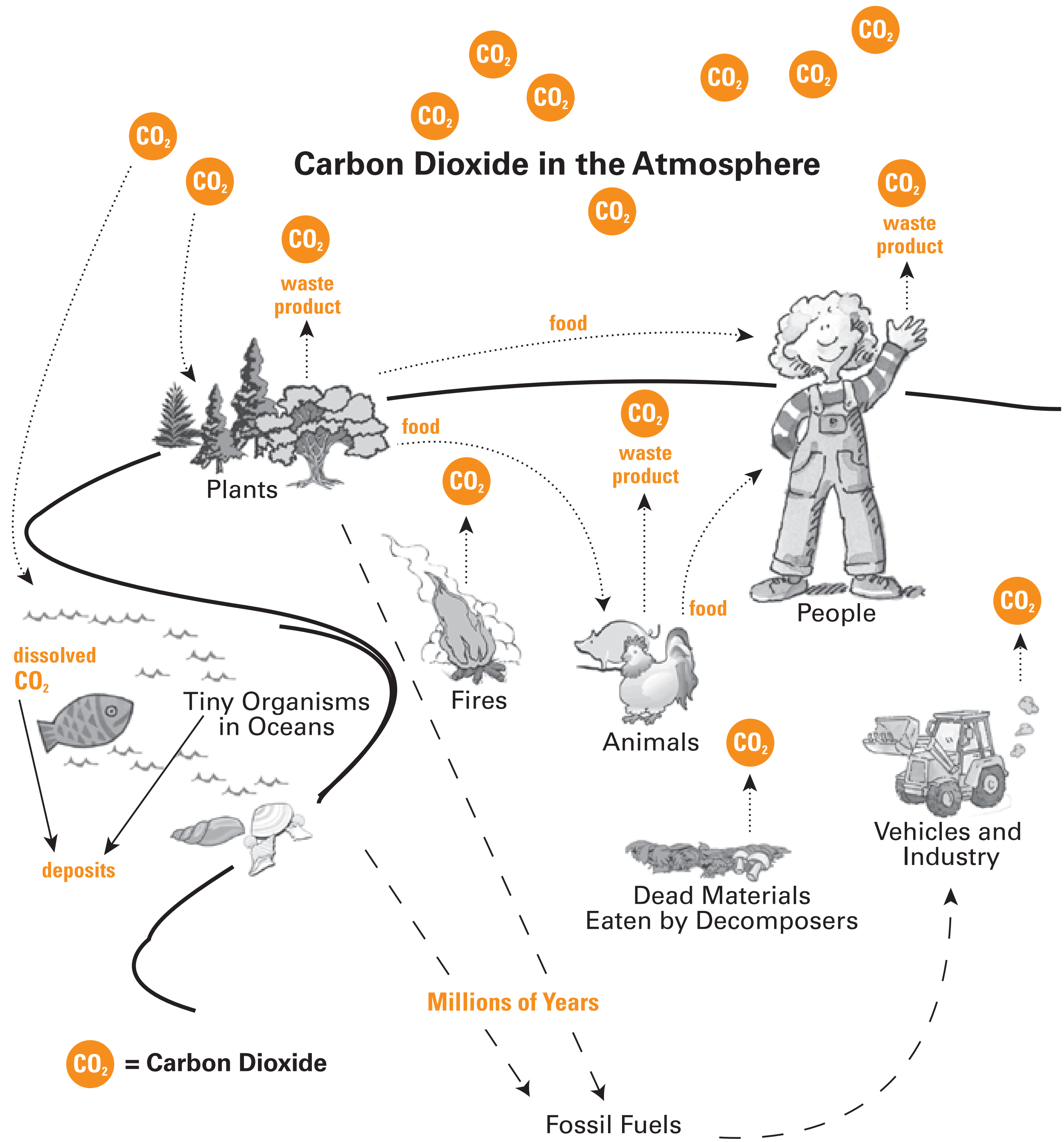
Modern society relies heavily on energy generated by burning fossil fuels—coal, oil and natural gas.

Photo courtesy of the U.S. Global Change Research Program, *Climate Literacy: The Essential Principles of Climate Science.*

LEGACY OF FOSSIL FUELS

Fossil fuels have supported unprecedented economic growth during the last century. Use of these fuels also is responsible for much of the world's air and water pollution, and has increased the levels of heat-trapping gases, such as carbon dioxide and methane, in the atmosphere.

Carbon Dioxide and the Carbon Cycle



GeoMuffin Baking Instructions

Materials and Ingredients

- 24 aluminum baking cups and a cookie sheet (or 24 paper liners and 2 muffin pans)
- 2 medium-sized mixing bowls
- 2 small mixing bowls
- 2 envelopes of bran muffin mix (plus ingredients listed on package)
- 2 envelopes of corn muffin* mix (plus ingredients listed on package)
- Green and red food coloring

* **Note:** Other types of muffin mixes without fruit or nuts may be substituted. *Do not use cake mixes.*

Baking Instructions

1. Preheat oven to temperature specified on the muffin mixes. If different temperatures are given on the two kinds of mixes, set oven to the lower temperature.
2. Set aluminum baking cups on the cookie sheet (or line muffin pans with paper baking cups).
3. **Bran muffin mix.** Combine both packages of bran muffin mix in one medium-sized bowl and prepare batter by following the instructions on the packages. If the mixture is very stiff, add additional milk or water so that the consistency of the batter is slightly runny.
4. **Corn muffin mix.** Prepare the packages of corn muffin mix in the second medium-sized bowl.
   - Remove about 1/4 cup of the corn batter to one small mixing bowl and color it deep red.
   - Remove about 1/2 cup of the corn batter to the second small mixing bowl and color it deep green.
5. Add batters in layers to the baking cups in the following order (see illustration, right).

   Layer 1: 1 Tbs of bran batter spread across bottom of the cup

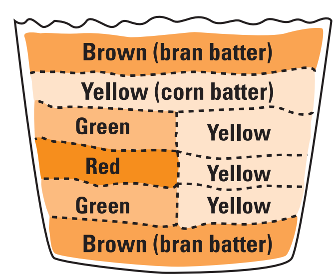
   Layer 2: 1/2 tsp of green batter on one side of muffin
   1 tsp of yellow batter next to the green

   Layer 3: 1/2 tsp of red batter spread over the green batter
   1 tsp of yellow batter next to the red

   Layer 4: 1/2 tsp of green spread over the red batter
   1 tsp of yellow batter next to the green

   Layer 5: 1 Tbs of yellow over entire muffin

   Layer 6: 1 Tbs of bran over entire muffin
6. Bake according to package instructions.
7. Cool before using with students. Muffins are firmer and easier to sample if they are baked a day in advance.



The colored layers in the muffin represent the following.

- RED = Oil
- GREEN = Predicting layer for oil
- YELLOW = Soil or rock layer
- BROWN = Soil or rock layer

GeoMuffin Observations

Name ____

1. Look at your GeoMuffin. Do not peel or eat it. Write a sentence to describe your GeoMuffin.

2. What do you think the GeoMuffin would look like if you cut it in half? Draw a cross section based on what you can observe.

3. Draw a top view of your GeoMuffin. Mark North on your muffin with a toothpick. Starting just right of your North marker, make your first core sample. Push the core out of the straw. Draw the core and color the layers. Mark it Sample Number 1.

4. Make at least 5 more samples. Draw each core in order in the space below.

5. Now, use the information from your core samples to draw what you predict a side view of your GeoMuffin would look like if you cut it in half. Then cut the muffin half and draw what you see. Compare your two drawings.

6. Do you think there is any "oil" in your GeoMuffin? Is there a pattern in the layers that predicts where oil will be?

Bizcochos Geológicos

La Buzqueda para los Combustibles Fósiles

Mi Nombre ____

1. Examina tu Bizcocho Geológico sin tocarlo o comerlo. Escribe una oración que describe tu bizcocho.

2. Como piensas que se vería si partieras el bizcocho a la mitad? Dibuja una vista de la mitad del bizcocho basado en lo que puedes observar.

3. Dibuja el bizcocho visto desde arriba. Usando un palillo marca el Norte. Empezando a la derecha del marcador del Norte, toma tu primera muestra con un popote. Saca la sección de bizcocho del popote. Dibuja la sección y colorea las capas. Márcala Muestra Número 1.

4. Toma por lo menos 5 muestras más. Dibuja cada muestra en el espacio abajo.

5. Ahora, utiliza la información de tus muestras para dibujar lo que piensas sería una vista de tu bizcocho si lo cortaras a la mitad.

6. ¿Piensas que hay "petroleo" en tu bizcocho? ¿Demuestran las capas algunas características que predicen la presencia de petroleo?