THE SCIENCE OF
Global
Atmospheric
Change

Fuel for Living Things

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

Written by
Nancy P. Moreno Ph.D.
Barbara Z. Tharp, M.S.
Judith Dresden, M.S.

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Authors: Nancy P. Moreno, Ph.D., Barbara Z. Tharp, M.S., and Judith H. Dresden, M.S.
Editor: James P. Denk, M.A.
Designer and Illustrator: Martha S. Young, B.F.A.

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BCM
Baylor College of Medicine

Center for Educational Outreach
Baylor College of Medicine
One Baylor Plaza, BCM411
Houston, Texas 77030
713-798-8200 | 800-798-8244 | edoutreach@bcm.edu
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ALAN E. WHEALS, PH.D., UNIVERSITY OF BATH
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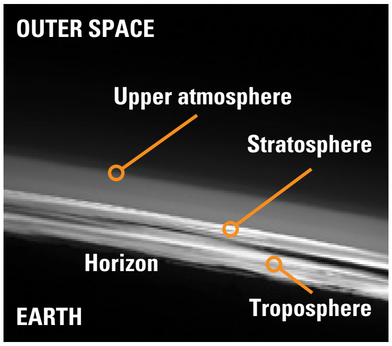
Solar Energy and Living Things

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.

Fuel for Living Things

Life Science

Some living things, especially plants and algae, are able to build all the materials they need from very simple substances. Using energy from light, carbon dioxide and water, these organisms, known collectively as producers, are able to make carbohydrates, which serve as fuel and raw material for the processes of life. All other organisms (consumers) rely on producers for food. Food provides energy and needed raw materials.

Unit Links

Mr. Slaptail's Curious Contraption
Story, pp. 16–20

Explorations
Lief Sigren, p. 7

When organisms consume food, it is broken down to release energy and to obtain building blocks for other molecules. During this process, oxygen is consumed and some carbon is given off as carbon dioxide. This can be compared to the burning of fuels, which also uses oxygen and releases carbon dioxide. When something burns, most of the energy released is given off as heat. Inside living things, some of the energy is used to maintain the body and conduct reactions necessary for life.

All organisms (with a few exceptions) release carbon dioxide when they use food. In mammals, the released carbon dioxide is carried through the bloodstream to the lungs, where it is given off when we breathe out (exhale).

In this activity, students observe how carbon dioxide gas is given off by yeast cells, when the cells use sugar as food. Red cabbage "juice" will serve as an indicator for the presence of carbon dioxide. Cabbage "juice" turns bright pink in the presence of acids, such as the carbonic acid produced by dissolved carbon dioxide in water.

SETUP

The indicator can be made in advance by the teacher or by student groups of 4. Session 2 is a teacher demonstration, followed by the investigation by student groups in Session 3. Consider having students read part of *Mr. Slaptail's Curious Contraption* or this unit's *Explorations* magazine between observations.

PROCEDURE

Session 1: Making the indicator (can be done in advance)

1. Have Materials Managers collect the materials for their groups.
2. Have students place the sliced red cabbage in the plastic bags, along with 1/2–1 cup warm water, and seal the bags tightly. Direct students to take turns gently rubbing the cabbage inside the bags until the water becomes dark purple (usually about 10–15 minutes). This is the indicator solution.

CONCEPTS

- All organisms need a source of energy.
- Plants and some other organisms (producers) take in energy from the sun.
- All other living things rely on producers for energy and raw materials.
- Carbon dioxide usually is given off when living things use food.

OVERVIEW

Students will observe what happens when yeast cells are provided with a source of food (sugar).

SCIENCE, HEALTH & MATH SKILLS

- Predicting
- Making qualitative observations
- Drawing conclusions

TIME

Preparation: 10 minutes
Class: 15 minutes to make indicator solutions; 15 minutes for demonstration; 30–60 minutes to conduct experiment

MATERIALS

- Tsp of baking soda
- Vinegar, a few drops

Each group will need:

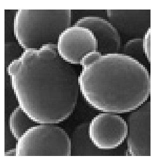
- 2 cups, 9-oz clear plastic
- 2 spoons or coffee stirrers
- 1/2 to 1 cup warm water
- Clear, resealable plastic bag, 4 in. x 6 in.
- Handful of raw, finely sliced red or purple cabbage
- Tsp of dry yeast
- Tsp of sugar

ACIDS AND BASES

ACIDS taste sour, conduct electricity and are corrosive. Common acids include vinegar, lemon juice, eyewash solutions (boric acid) and carbonated soft drinks.

BASES have a bitter taste and feel slippery when dissolved in water. Like acids, they can be very corrosive. Examples of bases include antacids, household ammonia and baking soda.

DECOMPOSERS



Baker's yeast *(Saccharomyces cerevisiae)* is used in food production. Yeasts are members of the same Kingdom as mushrooms and toadstools. Known as Fungi, members of this Kingdom are vital as decomposers. They obtain energy and nutrients by breaking down the bodies of dead organisms.

SEM image courtesy of Alan E. Wheals, Ph.D. © University of Bath.

FUEL FOR BODIES

When sugar is used for energy inside living things, CO_2 is released. This is comparable to what happens when fuels are burned for energy.

Students can observe how they exhale CO_2 by blowing vigorously with a straw into the cup of indicator solution for 5–10 minutes.

Session 2: Demonstration of cabbage juice indicator

1. Tell students that they will be using an indicator to look for the presence of an acid. If students are not familiar with things that are acidic, list some common examples, such as lemon juice and vinegar. Explain that the indicator will be used to test for the presence of carbon dioxide (CO_2), which becomes a weak acid in water.
2. Pour some indicator liquid into a clear cup. Ask, *What color is the liquid? What do you think will happen if I put something acidic into the water?* Add a few drops of vinegar to the solution until it turns pink. You also may show how the indicator solution reacts to bases by adding about 1/2 teaspoon (or more) of baking soda (the solution will turn pale blue or green).
3. Explain to students that they will be using the indicator to test for the presence of carbon dioxide (CO_2), a gas that is given off when living things use food for energy.

Session 3: Conducting the investigation

1. Talk about yeast with students. Ask, *Did you know that yeast is a living thing?* Explain that yeast is a living, microscopic single-celled organism. Under the right conditions, yeast begins to grow and multiply.
2. Direct the students to label two cups as "no food" and "food." Have them add about 1/2 cup of warm water and 1/2 teaspoon of yeast to each cup. Ask, *Do you think the yeast cells have very much to eat in the cup now?* Help students understand that all living things need food to survive and grow. Ask, *What do you think will happen if we add yeast food to one of the cups?* Have students record their predictions.
3. Have one person in each group add one teaspoon of sugar to one cup. He or she should swirl or stir the contents of the cup gently.
4. Direct the groups to set the cups side-by-side and to observe both cups at 5–10 minute intervals. The yeast in the cup with sugar will begin to produce CO_2 (making the liquid foamy) after a short period of time. Students should stir the cups (with separate stirrers) each time they make their observations.
5. After 30–45 minutes, instruct students to pour small, equal amounts of cabbage "juice" into both cups and to stir the mixture. Ask them to observe the colors. Have students record their observations. (The cup with sugar will be pinker in color than the other cup.)
6. Ask, *What happened when you fed the yeast?* Point out that the gas given off by the yeast is the same as that given off when wood, coal or oil is burned. Help students understand that the yeast cells were using the sugar as a source of energy.
7. Assess student understanding by having the members of each group write a paragraph describing its investigation and results.