



What is The Carbon Cycle?

Middle School Grades

Lesson Summary

Students will learn about the carbon cycle and learn to identify carbon sources, sinks and release agents. They will then create their own path for a carbon atom.

Prior Knowledge & Skills

- Knowledge of greenhouse gasses
- Research skills

AAAS Science Benchmarks

The Physical Setting

Processes that Shape the Earth

The Living Environment

The Flow of Matter and Energy

Human Society

Global Interdependence

Common Themes

Systems

NSES Science Standards

Life Science

Populations and Ecosystems

Earth and Space Science

Structure of the Earth System

NCGE Geography Standards

Physical Systems

Standard 7

Teaching Time: 2 – 2.5 hours

Materials

- Magazines and newspapers
- Tagboard or poster board for collages
- Blank paper

Advanced Planning

Preparation Time: ~30 minutes

1. Review the instructions
2. Gather the necessary supplies.

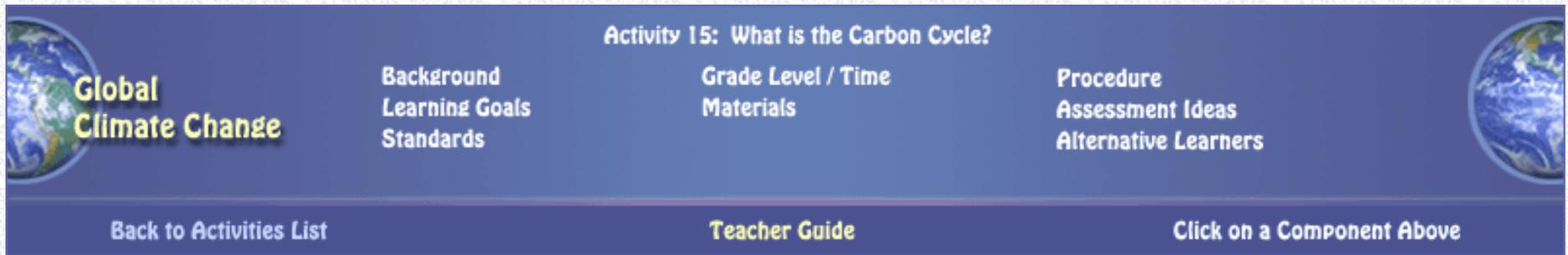
Recommended Reading: (attached)

- Background

University Corporation for Atmospheric Research

Learn: Atmospheric Science Explorers

<http://www.ucar.edu/learn/>



Global Climate Change

Activity 15: What is the Carbon Cycle?

Background Learning Goals Standards

Grade Level / Time Materials

Procedure Assessment Ideas Alternative Learners

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What is the Carbon Cycle?

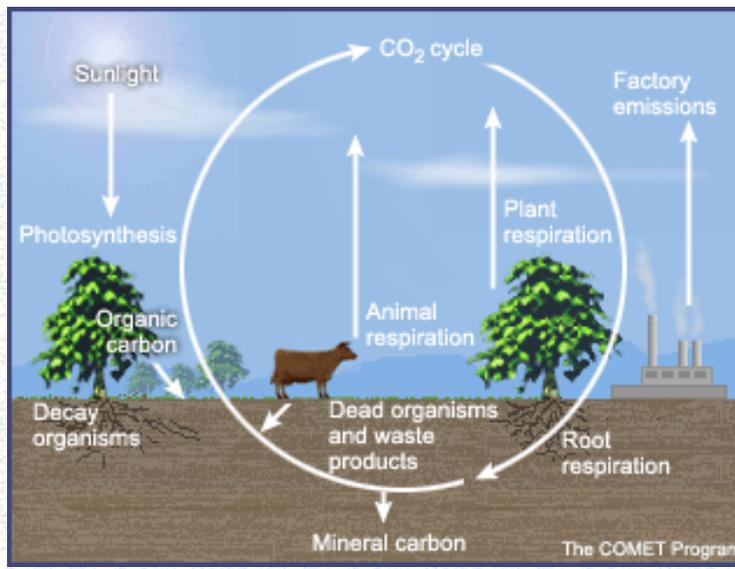
Modified with permission from Global Climates - Past, Present, and Future, S. Henderson, S. Holman, and L. Mortensen (Eds.). EPA Report No. EPA/600/R-93/126, U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC. pp. 59 - 64.

In this exercise, students will explore the carbon cycle and be able to identify carbon sources, sinks, and release agents.

Background

All living organisms are based on the carbon atom. Unique among the common elements of the earth's surface, the carbon atom has the ability to form bonds with as many as four other atoms (including other carbon atoms) and to form double bonds to itself. Carbon compounds can be solid, liquid, or gas under conditions commonly found on the earth's surface. Because of this, carbon can help form solid minerals (such as limestone), 'squishy' organisms (such as plants and animals), and can be dissolved in water or carried around the world through the atmosphere as carbon dioxide gas. The attributes of the remarkable carbon atom make possible the existence of all organic compounds essential to life on earth.

Carbon atoms continually move through living organisms, the oceans, the atmosphere, and the crust of the planet. This movement is known as the carbon cycle. The paths taken by carbon atoms through this cycle are extremely complex, and may take millions of years to come full circle.



Consider, for example, the journey of a "typical" carbon atom that existed in the atmosphere as part of a carbon dioxide molecule some 360 million years ago, during the Carboniferous Period. That CO₂ molecule drifted into the leaf of a large fern growing in the extensive tropical swamp forests of that time.



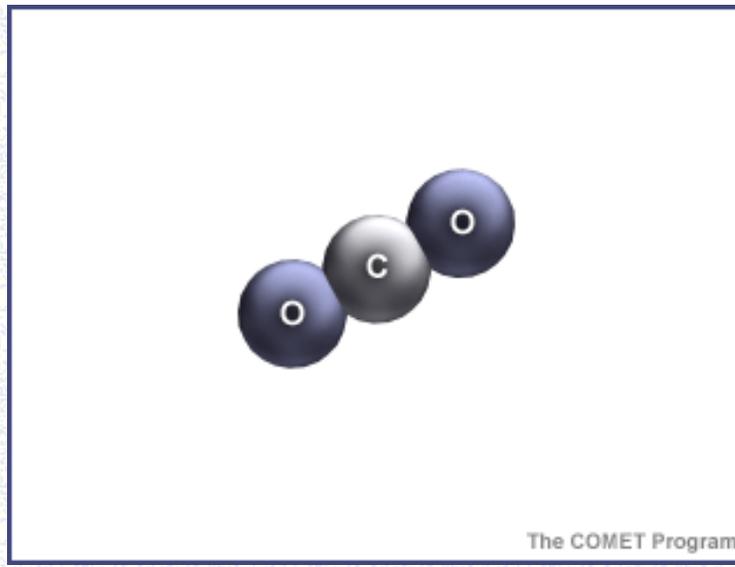
Through photosynthesis, the oxygen from the CO₂ molecule was released back into the air and the carbon atom was removed from the CO₂ molecule and used to build a molecule of sugar.

The sugar could have been broken down by the plant at a later time to release the energy stored inside, but this particular sugar molecule was transformed instead into a long-lived structural part of one of the plant cells. Soon after, the fern died and the remains sank into the muck at the bottom of the swamp. Over thousands of years, more plants grew in the swamp and their remains also sank into the swamp, forming a layer of dead plant material many meters thick. Gradually, the climate changed, becoming drier and less tropical. Sand, dust, and other materials slowly covered the ancient swamp and sealed the decaying vegetation under an ever-thickening layer of sediment. The sediment hardened, turning to sedimentary rock. The carbon atom stayed trapped in the remains of the long-vanished swamp while the pressure of the layers above slowly turned the material into coals.

Some 360 million years later, in the 1900s, the coal bed was mined by humans and burned to fuel industrial civilization.



The process of burning released the energy stored in the carbon compounds in the coal and reunited the carbon atom with oxygen to form CO_2 again.



The CO_2 was released to the atmosphere through the smokestack and the journey continues. Many other paths are possible, some taking only hours or days to trace, others, like the one above, many millions of years.

The aggregation of the possible paths of carbon, where it may be stored for extended periods (the "sinks"), where it is likely to be released to the atmosphere (the "source"), and what triggers those sources (the "release agents"), together defines the carbon cycle.

Carbon sinks include long-lived trees, limestone (formed from the carbon-containing shells of small sea creatures that settle to the ocean bottoms and build up into thick deposits), plastic (a modern invention, but very long-lived), and the burial of organic matter (such as those that formed the fossil fuels we use today). **Carbon sources** include the burning of fossil fuels and other organic matter, the weathering of limestone rocks (which releases CO_2), and the respiration of living organisms. **Release agents** include volcanic activity, forest fires, and many human activities.

In this activity, students will use resources provided by the teacher to construct the essential elements of the global carbon cycle. Students may work alone or in small groups, but should discuss their findings with the whole class. The goal is to develop a class consensus on the important elements of the cycle. Your role is to encourage and question, but not to give away answers or suggest that there is only one right way of looking at the issue.

Learning Goals

1. Students will understand that carbon is critical to the biosphere and must continue cycling to support life on earth.
 2. Students will understand and be able to identify carbon sources, sinks, and release agents in the carbon cycle.
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Alignment to National Standards

National Science Education Standards

- Life Science, The Interdependence of Organisms, Grades 9 to 12, pg. 186, Item #1: "The atoms and molecules on the earth cycle among the living and nonliving components of the biosphere."
- Earth and Space Science, Geochemical Cycles, Grades 9 to 12, pg. 189, Item #1: "The earth is a system containing essentially a fixed amount of each stable chemical atom or element. Each element can exist in several different chemical reservoirs. Each element on earth moves among reservoirs in the solid earth, oceans, atmosphere, and organisms as part of geochemical cycles."
- Earth and Space Science, Geochemical Cycles, Grades 9 to 12, pg. 189, Item #2: "Movement of matter between reservoirs is driven by the earth's internal and external sources of energy. These movements are often accompanied by a change in the physical and chemical properties of the matter. Carbon, for example, occurs in carbonate rocks such as limestone, in the atmosphere as carbon dioxide gas, in water as dissolved carbon dioxide, and in all organisms as complex molecules that control the chemistry of life."

Benchmarks for Science Literacy, Project 2061, AAAS

- The Physical Setting, Processes That Shape the Earth, Grades 9 to 12, pg. 74, Item #1: "Plants alter the earth's atmosphere by removing carbon dioxide from it, using the carbon to make sugars and releasing oxygen. This process is responsible for the oxygen content of the air."
- The Living Environment, Flow of Matter and Energy, Grades 6 to 8, pg. 120, Item #2: "Over a long

time, matter is transferred from one organism to another repeatedly and between organisms and their physical environment. As in all material systems, the total amount of matter remains constant, even though its form and location change."

- The Living Environment, Flow of Matter and Energy, Grades 9 to 12, pg. 121, Item #1: "At times, environmental conditions are such that plants and marine organisms grow faster than decomposers can recycle them back to the environment. Layers of energy-rich organic material have been gradually turned into great coal beds and oil pools by the pressure of the overlying earth. By burning these fossil fuels, people are passing most of the stored energy back into the environment as heat and releasing large amounts of carbon dioxide."

Grade Level/Time

- **Grade level:** 6 to 9
- **Time:**
 - Teacher introduction: 20 minutes
 - Student brainstorming: 20 minutes
 - Student preliminary carbon cycle: 15 minutes
 - Student research time: 45 minutes to 60 minutes
 - Discussion/assessment: 30 minutes

Materials (for extension activity)

- Magazines and newspapers
- Tagboard or poster board for collages
- Blank paper

Procedure

1. Distribute blank paper to students.
2. Using class discussion, brainstorming, or question and answer methods, have students try to trace the movement of a carbon atom. You may wish to record while students come up with ideas. The result should be a version of a simplified carbon cycle, including at least eating and respiration in animals and photosynthesis in plants. It is common for the students to get stuck on the animal-to-plant-to-animal cycle because most have been exposed to the concept several times. You may need to move the cycle development along by encouraging them to think about oceans and whether CO_2 plays a role in them. Have them consider rocks and minerals – do they contain carbon? When you feel that they have at least several important elements of the cycle, have them work with a partner to illustrate their version of the carbon cycle.
3. Next, have students compare their cycle with more elaborate ones illustrated in texts, encyclopedias, or on-line. Have them list the differences and modify their own cycle if they think it necessary. Through class discussion, students can share what they have discovered.
4. Introduce the concepts of 'sink,' 'source,' and 'release agents.' Challenge students to label these factors on their modified cycles. Why might these be important factors to identify?
5. Have students respond to the discussion questions below.

Initial Discussion

1. What gas do humans and animals exhale? Write the formula for this exhaled gas. (CO_2)
2. Can humans be considered carbon sinks? If so, for how long? What living organisms are better long-term sinks than humans?
3. List two important 'sinks' (things that store carbon), two important 'sources' (things that release carbon), and one important 'release agent' (things that trigger sources) for carbon.
4. We are currently worried that CO_2 sources are out of balance with CO_2 sinks. If sources produce

more CO_2 than sinks can remove, CO_2 in the atmosphere increases, possibly leading to global warming. What might happen if the reverse were true and sinks took up more CO_2 than sources? (Answers will vary but students may note that less CO_2 would be available for plant growth or that less atmospheric CO_2 might result in a slightly cooler atmosphere.)

5. Explain how understanding the carbon cycle helps atmospheric scientists understand and prepare for global climate changes.

EXTENSION (Highly recommended): Divide the class into small groups. Ask each to develop a collage using magazines and newspapers that illustrates the carbon cycle. They should label the sinks, sources, and release agents. Each group should present its collage to the class.

Assessment Ideas

- Consider using the last two discussion questions as a short quiz. Thoughtful answers to these should indicate that the students met the learning goals.

Modifications for Alternative Learners

- English Language Limited (ELL) students should be able to grasp the concepts in this activity as long as they can express them in graphic form and are not forced to rely entirely on text resources for their information. They may be paired together and given selected ELL-appropriate reading material, if available, or paired with students who will help explain the readings.

When you're finished with the activity, click on Back to Activities List at the top of the page to return to the activity menu.

