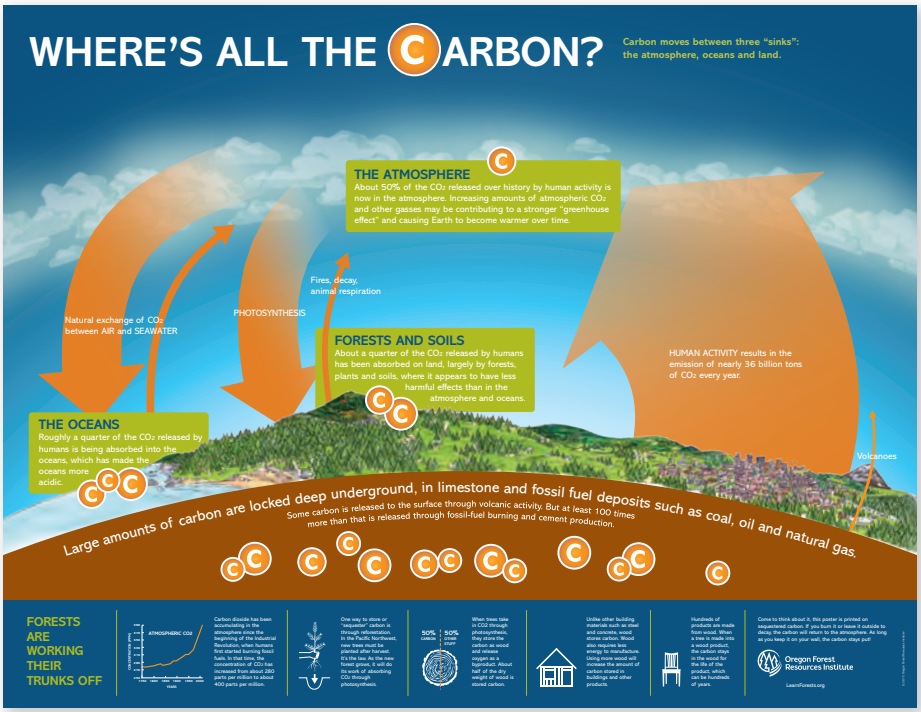
WHERE'S ALL THE CARBON?

Instruction Guide

Grades 6-12

The *Where's All the Carbon?* poster was created by the Oregon Forest Resources Institute (OFRI) to show the relationship between Oregon's forests and the carbon cycle.

This instruction guide is designed to help you use the *Where's All the Carbon?* poster in your middle school or high school classroom. It provides background information to support you in presenting this topic to your students, and suggests discussion questions and learning activities to help bring the carbon cycle alive for your students. This guide also identifies standards connections to assist you in making the necessary links with your school curriculum. We invite you to add your own creative ideas, and hope you will enjoy exploring *Where's All the Carbon?* with your students.



EQUATION FOR PHOTOSYNTHESIS:

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

(carbon dioxide) (water) (with sunlight) (glucose) (oxygen)

BACKGROUND

The carbon cycle is the movement of carbon in its many forms among Earth's organisms (biosphere), the gas surrounding Earth (atmosphere), water (hydrosphere), and soils and rocks (geosphere). The global carbon cycle can be divided into two parts: the geological carbon cycle, which operates over a time frame of millions of years; and the biological carbon cycle, which operates at a shorter time frame of days to thousands of years.

Forests are an important part of the biological carbon cycle. Through photosynthesis, trees absorb carbon dioxide, transform it into carbohydrates (sugars), release oxygen into the atmosphere, and store the carbon in their woody structures as cellulose.

Forests, soil, oceans, the atmosphere, fossil fuels and carbonate rocks are important stores or reservoirs of carbon. Carbon is constantly moving between these different reservoirs by means of a number of processes known as carbon fluxes. Some of the more important carbon fluxes are photosynthesis, respiration, decomposition and combustion.

Natural events such as volcanic eruptions and forest fires release carbon dioxide into the atmosphere, as do human activities such as burning fossil fuels and deforestation. Increased levels of carbon dioxide in the atmosphere – primarily due to human activities – are resulting in warmer global temperatures and affecting our global climate.

Carbon sequestration is the removal and capture of atmospheric carbon in plants, soils or oceans. A place where carbon is sequestered is often referred to as a "carbon sink." Trees in forests, as well as forest products, are primary carbon sinks.[1] Forests store or sequester significant amounts of carbon, reducing the presence of carbon dioxide in the atmosphere. The U.S. Forest Service estimates that U.S. forests sequester from 10 to 20 percent of U.S. fossil fuel emissions each year.[2]

When carbon is absorbed by trees through photosynthesis, it is stored in the wood as cellulose. Even after a tree is harvested and made into wood products such as furniture or building materials, the carbon remains stored within the wood. In addition, wood products typically require less energy to produce and create less carbon dioxide during manufacture than similar products made from other materials. For these reasons, wood products can reduce atmospheric carbon and help mitigate global climate change.

Questions for Discussion

You may use the poster to spark a discussion about the carbon cycle and the role of trees and forests in the cycle, using questions such as:

What is the carbon cycle?

What are the various components of the carbon cycle?

What are the carbon reservoirs (places where carbon is stored), and what are the carbon fluxes (processes that move carbon from one reservoir to another)?

What is the relationship between the carbon cycle, forests and global climate change?

In what ways do Oregon's forests and Oregon-made wood products help reduce global climate change?

OREGON FOREST LITERACY PLAN CONCEPTS

The *Oregon Forest Literacy Plan*, developed by a diverse statewide stakeholder group, identifies critical concepts for K-12 students in understanding Oregon's forests. Concepts relevant to the *Where's All the Carbon?* poster include:

- Theme 1, C.3. Forest ecosystems include processes such as photosynthesis, energy flow and the cycling of nutrients, water, carbon and other matter.
- Theme 2, B.4. Forests sequester carbon from the atmosphere and are an essential component of the global carbon cycle. Forest products made from wood also store carbon.
- Theme 2, D.3. Forest products are an important component of Oregon's "green" economy. They come from a renewable resource and store carbon, and most are also reusable and recyclable.

Activity: Model the Carbon Cycle

In this activity, after studying the *Where's All the Carbon?* poster, students create a model of the carbon cycle depicting where carbon is stored and how it moves through the cycle.

Materials: *Where's All the Carbon?* poster, copies of the "Carbon Reservoirs and Fluxes" student page.

Procedure:

1. Share the poster with students, asking them what they think it represents. As necessary, explain that the poster depicts the carbon cycle. Point out how it shows different carbon reservoirs where carbon is stored, and that the arrows represent carbon fluxes or processes that move carbon from one reservoir to another.
2. Have students work in pairs to identify the carbon reservoirs and fluxes presented on the poster, using the "Carbon Reservoirs and Fluxes" student page as a guide.
3. Challenge students to create a model of the carbon cycle using the information they have gleaned. It may be an illustration, flow chart, graphic organizer, three-dimensional model or other visual representation of the carbon cycle (but should not copy the poster). You might specify what components their model should include, such as:
   - At least four carbon reservoirs
   - At least four carbon fluxes
   - At least three ways carbon is added to the atmosphere through natural means
   - At least three ways carbon is added to the atmosphere by human activities
4. Invite students to present their models to the class.

[1] While the exact chemical composition of wood varies by species, wood is made up of approximately 50 percent carbon, 44 percent oxygen and 6 percent hydrogen, with trace amounts of metal ions.

[2] "Forests and Carbon Storage." U.S. Forest Service. www.fs.usda.gov/ccrc/topics/forests-carbon.

More Activity Suggestions

Choose one or more activities to deepen your students' understanding of the connection between the carbon cycle and forests:

- Have students research a variety of resources to calculate how much carbon is in each of Earth's carbon sinks, and how much flows each year from the carbon sources.
- Instruct students to write a story of a carbon molecule, describing where it goes as it journeys through the carbon cycle.
- Share the two-minute video *Forest Fact Break: Carbon Capture* (see Resources), and then invite students to write a report or make a presentation on how trees help reduce levels of atmospheric carbon.
- Guide students in making a list of forest management techniques that could increase carbon sequestration in forests and reduce carbon emissions. See "Forests Reduce Climate Change" in Resources for some ideas.
- Assign students to use evidence and reason to write an argument for the advantages of a wood chair, construction beam or other wood product over the same product from a different material.
- Have your students calculate their "carbon footprint," an estimate of the impact of daily activities on carbon emissions, using the "Carbon Footprint Calculator" listed in Resources. Discuss which activities impact the results the most, and have students identify ways they might reduce their carbon footprint.

Oregon Forest Resources Institute

LearnForests.org

RESOURCES

Forest Fact Break: Carbon Capture. This two-minute video from OFRI introduces the concept of forest carbon capture. It is available at LearnForests.org.

Inside Oregon's Forests: A High School Forestry Curriculum. This 37-lesson stand-alone module from OFRI provides an in-depth exploration of Oregon's forests and forestry. Available at LearnForests.org.

"Forests Reduce Climate Change." The American Forest Foundation offers information about how forest management can increase carbon sequestration in forests. Available at forestfoundation.org/forests-reduce-climate-change.

"Carbon Footprint Calculator." This student-friendly calculator from the U.S. Environmental Protection Agency estimates the impact of daily activities on carbon emissions. Available at epa.gov/carbon-footprint-calculator.

STANDARDS CONNECTIONS

NEXT GENERATION SCIENCE STANDARDS

Performance Expectations

- MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
- HS-LS2-5. Ecosystems: Interactions, Energy, and Dynamics. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.

Disciplinary Core Ideas

- MS.LS2.C. Ecosystem Dynamics, Functioning, and Resilience. Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.
- HS.LS2.B. Cycles of Matter and Energy Transfer in Ecosystems. Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.

Science and Engineering Practices

- Developing and Using Models. Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

COMMON CORE STATE STANDARDS – LITERACY/ELA

- W.6.2, W7.2, W8.2. Writing. Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
- WHST.9-10.7, WHST.11-12.7. Writing History, Science, and Technical Subjects. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

COMMON CORE STATE STANDARDS – MATHEMATICS

- MP.4. Mathematical Practice. Model with mathematics.

STUDENT PAGE

NAME _____

DATE _____

Carbon Reservoirs and Fluxes

Almost everything around us contains carbon, including plants, animals, soil, oceans and even the air we breathe. The amount of carbon in, on and around Earth is always the same. But carbon is constantly cycling from one place to another.

The carbon cycle is the movement of carbon between Earth's organisms, bodies of water, soil, rock and fossil fuel deposits, and the atmosphere. The cycle involves different **carbon reservoirs** that store carbon over time and **carbon fluxes**, the processes that move carbon from one reservoir to another.

1. Using the *Where's All the Carbon?* poster, identify different carbon reservoirs and carbon fluxes in Earth's carbon cycle, and describe how carbon moves from place to place.

Carbon reservoir	How does carbon get there?	Carbon flux	How does carbon move?

2. A carbon sink is a reservoir that takes up more carbon than it gives off, and a carbon source is one that gives off more carbon than it takes up. Which of the reservoirs you've listed above are carbon sinks? Which are carbon sources?