

Carbon Cycle Adventure Story: A self-guided tour through the carbon cycle

Purpose

- To explore a system – the carbon cycle.
- To learn that carbon is one of the most important and abundant elements on Earth and can be found everywhere.

Overview

This activity provides an introduction to the carbon cycle and systems thinking. It could also be used as an introduction to biogeochemical cycling, the greenhouse effect and climate change. During the activity, students read about a carbon atom that begins in the atmosphere as part of carbon dioxide. Students choose where the atom will travel next, i.e. into a leaf via photosynthesis or dissolve into the ocean. Students keep track of the carbon pools they visit, and the process that takes their carbon atom on to the next pool.

Content Questions

Where is carbon stored (pools)?

What are some ways that carbon moves (fluxes) between pools?

Can systems contain sub-systems?

How can we represent systems?

Student Outcomes

Students will be able to:

- List the major pools and fluxes of the carbon cycle
- Diagram the carbon cycle using box and arrow models
- Describe what components of the carbon cycle make it a system

Science Standards

9-12

Life Science

- The atoms and molecules on the earth cycle among living and non-living components of the biosphere.
- As matter and energy flows through the system chemical elements are recombined in different ways.

Earth and Space Science

- The earth is a system containing essentially a fixed amount of each stable chemical atom or element.
- Movement of matter between reservoirs is driven by the earth's internal and external sources of energy.

Science in Personal and Social Perspectives

- Natural ecosystems provide an array of basic processes that affect humans.
- Materials from human societies affect both physical and chemical cycles of the earth.

Time

60 – 90 minutes

Level

Secondary (Middle & High School)

Materials and Tools

- *Carbon Cycle Adventure Story Booklet* (per individual or student pair)
- *Carbon Atom Journey Table* (per individual or student pair)
- *Carbon Cycle Adventure Story Map of Flows* (separate – for use by teacher)
- White board, chalk board, large paper or overhead projector & markers/chalk
- Pencil or pen for each student

Preparation

- Print/copy *Carbon Atom Journey Table* & *Carbon Cycle Adventure Story Booklet*
- Make a classroom example of the Carbon Atom Journey Table (on overhead, white or blackboard)
- Write essential, unit, and content questions somewhere visible in the classroom.

Pre-requisites

None required. However a basic understanding of atoms and elements may be helpful, but the introduction pages of the booklet may suffice. An introduction to the concept of pools and fluxes might also be useful (perform *Paperclip Factory Analogy*).

Background

All systems consist of a set of interacting components that, together, form a more unified entity. As an example, an engine, wheels, brakes, transmission and chassis interact together to form a system we identify as a car. In the environment, systems tend to be very intricate because the number of components is often large and the ways in which they interact are complex. To deal with this complexity, scientists often simplify environmental systems by lumping multiple components together and treating them as individual 'pools' and treating the transfer of materials between them as 'fluxes.'

Pools, also known as stocks or reservoirs, represent any place where a given substance can reside. In the carbon cycle, examples of individual pools might include soils, leaves, wood, whole trees and ecosystems or the entire biosphere. Note that these examples overlap and that carbon pools can be grouped together or treated separately. Carbon in trees can be considered a single pool, or it can be divided into leaves, wood and roots. If necessary, these pools can be further subdivided into sugars, starches, and other compounds. Alternatively, trees can be grouped with crops, grasses and shrubs to form a single global plant pool. How scientists make these decisions depends on the questions being asked and the scale of a particular study.

The movement of material from one pool to another is known as a flow, or flux. For example, in the global carbon cycle, carbon moves from the atmosphere to the plant pool through the process of photosynthesis. Hence, photosynthesis represents a flux and is, in fact, one of the most important fluxes in the carbon cycle. The flux of carbon out of this plant pool occurs through the transfer of leaves and other dead plant materials to soils (a process known as litterfall) and through respiration, which releases carbon dioxide back into the atmosphere. These examples are just a few of the pools and fluxes that make up the entire global carbon cycle.

As we proceed, we should keep in mind that no system occurs in complete isolation. Because all things in the universe are in some way interconnected, scientists studying any system must draw artificial boundaries around what they believe are the most important components for a particular study. Although we can view an automobile as a discrete system, its function relies on external inputs in the form of fuel, parts and other materials, as well as outputs in the form of exhaust and

heat. Each of these is affected by processes that occur outside the normal boundaries of what we view as a car. If needed, we could capture these processes by treating cars as subsystems that act within larger systems of transportation, energy and environment. How we draw the boundaries depends on what we are trying to achieve. In the investigations we're about to embark on, we can treat the carbon cycle as a single system, a series of interacting subsystems, or as just a part of the overall Earth system (which also includes the nitrogen cycle, the energy cycle, the water cycle and more).

To learn more about systems, the Earth system and teaching about systems see the Resources section below. To learn more about the carbon cycle see the *GLOBE Carbon Cycle Teacher Background*.

What To Do and How To Do It

ENGAGE	Student Grouping: Whole Class	Time: 10 minutes
	<ul style="list-style-type: none"> • *Note: Students may have completed this engagement exercise if they participated in the <i>Carbon Travels Game</i>. If so, move on to Explore. • Tell students that you want to begin teaching about carbon today, but you can't seem to find it. Ask students if anyone saw carbon today on their way into class. <ul style="list-style-type: none"> ○ This will help start generating ideas about where carbon is found and how prevalent it is in the world around us. ○ Record the ideas of where carbon is found on the board. • Solicit additional ideas about the carbon cycle. What is carbon? Where is it found? How does carbon move from one place to another (the processes)? What forms does it take (C, CO₂, CH₄, CaCO₃, glucose)? • Tell students carbon and the carbon cycle will be the subject for the next few class periods (or more) and they will begin by reading an adventure story where they follow Mr. Carbon, a carbon atom through the global carbon cycle. 	
EXPLORE	Student Grouping: Individual/Small groups	Time: 20-30 minutes
	<ul style="list-style-type: none"> • Students follow a carbon atom through the carbon cycle by reading the choose your own adventure story • Students begin by reading aloud pages 1 through 3 of the <i>Carbon Cycle Adventure Story</i>. • Show students the Glossary of Terms (on the last page) as a reference for any terms (bold and italic) they don't understand. • Instruct students to read the Adventure Story and record their journey in the Journey Table. <ul style="list-style-type: none"> ○ Students will record: 1) the pools where carbon currently resides, 2) the flow or process chosen within the booklet which will take the carbon atom to another pool, 3) the pool where carbon moves to. ○ Students should also record any questions that come to mind or terms they do not understand (and are not listed in the glossary) • Note: The adventure can be run as long or as short as time allows, providing that students/student groups have experienced at least 5 pools during their journey. 	

EXPLAIN	Student Grouping: Whole Class	Time: 15 minutes
	<ul style="list-style-type: none"> • After a Journey is completed ask students for any questions they may have. Record questions on a class list and tell students you will not answer these questions now, but they will be answered through classroom activities and individual student investigations. • Define any vocabulary terms that students need clarification on. • Introduce or review the concept of basic systems. <ul style="list-style-type: none"> ○ Review: If students performed the <i>Paperclip Simulation</i> or another systems activity. Review box and arrow diagrams and systems terminology (stock/pool and flow/flux). <ul style="list-style-type: none"> ▪ Show students one example of how to create a multi-box and arrow diagram from their story data. ○ Introduce: If this is students' first experience with systems. <ul style="list-style-type: none"> ▪ Ask students to look at their Journey Table and give a few examples of where carbon is found - where they traveled to during their journey. Record these on the board and explain to students that places where carbon is stored are called pools, stocks or reservoirs. ▪ Now ask students to share the processes by which carbon left these pools and entered other pools. Tell students that the movement of material from one pool to another is called a flux, flow or transfer. ▪ Tell students that an easy way to represent the interaction of pools and fluxes is through the use of box and arrow diagrams. Where boxes represent pools and arrows represent fluxes (Figure 1). <ul style="list-style-type: none"> • Show an example of a one-box diagram using some of the pools and fluxes written on the board (Figure 2). • Expand the one box diagram into a two-box diagram. 	
	<p>FIGURE 1</p> <p>FIGURE 2</p>	
ELABORATE/ INVESTIGATE	Student Grouping: Partners/Small Groups – Whole Class	Time: Varies
	<ul style="list-style-type: none"> • Develop the classroom carbon cycle diagram based on each student's journey • Tell students to form partners/small groups and create a multi-box and arrow diagram by combining their journeys through the carbon cycle. • When all students have added their own pools and flows to the group carbon cycle diagram have a representative from each group come to the board and add a few pools and fluxes to the <u>class diagram</u> (start by writing the Atmosphere at the top of the board). • Use the <i>Carbon Cycle Adventure Story Map of Flows</i> to assist students if necessary. 	

EVALUATE/ WRAP-UP	Student Grouping: Individual	Time: 15 minutes
	<ul style="list-style-type: none"> • Discuss the complexities of the carbon cycle. <ul style="list-style-type: none"> ○ Ask students to share one thing they learned about the carbon cycle from this activity. ○ Did students find themselves returning to one pool or another more often than others? • What does that indicate about systems in general? (systems within systems) • Are there ways that one could simplify the carbon cycle flow created during your adventure to better understand the carbon cycle at a global scale? (Lead in to <i>Getting to know the Global Carbon Cycle</i>.) 	

Assessment

- Completion of a *Journey Table*
- Group diagram of journey using the box and arrow method

Adaptations

- For younger or special education students, create a blank diagram on the board, which includes all the boxes and arrows. Have students suggest how to fill it in.
- For advanced students, begin to discuss pool size and flux (process) speed. Alter the class diagram to include larger boxes for larger pools and larger arrows for faster fluxes.

Extension

- Students develop their own carbon cycle game based on their reading from the *Carbon Cycle Adventure Story* (see *Carbon Travels Game* for ideas).

Resources

Systems:

GLOBE Carbon Cycle – Paperclip Simulation (An introductory activity to systems)

GLOBE Earth System Activities – GLOBE Website, Teacher Resources, Earth System:
http://www.globe.gov/fsl/html/templ.cgi?earth_system&lang=en

Dr. Art's Guide to Planet Earth – Book and Website: <http://www.planetguide.net/index.html>The
 Creative Learning Exchange: <http://www.clexchange.org/>

A Waters Foundation Project – Systems Thinking in Schools: <http://www.watersfoundation.org/>
 iSee Systems – Systems Thinking Software: <http://iseesystems.com>

Carbon Cycle:

EPA Climate Change Kids Page – Flash Animations:

<http://epa.gov/climatechange/kids/animations.html>

Windows to the Universe – The Carbon Cycle Game (Flash):

http://www.windows2universe.org/earth/climate/carbon_cycle.html

Dr. Art's Guide to Planet Earth – The Carbon Cycle:

http://www.planetguide.net/cool/carboncycle_activity.html

Environmental Literacy Council – Carbon Cycle:

<http://www.enviroliteracy.org/article.php/478.html>

Northeast Science Center Collaborative – Climate Change Backpack:

<http://sciencecentercollaborative.org/backpack.php>

Name: _____ Date: _____

Carbon Cycle Journey Table

Instructions: As you read the Adventure Story, record your journey in the table. If you encounter anything you do not understand including new vocabulary record your questions below.

Where is carbon now?	How did carbon leave? (The process)	Where did carbon arrive?

Vocabulary and Questions: