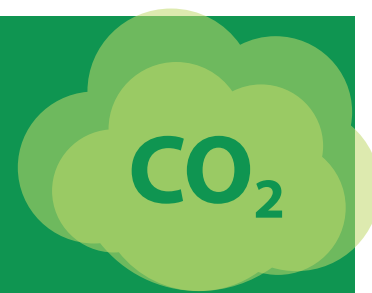


7

Carbon on the Move

Students imagine they are a carbon atom and take part in a simulation that allows them to cycle through biological and physical systems. Group work and class discussions allow students to better understand global carbon pools, quantities, fluxes, and residence time—with an emphasis on how human activities can affect where carbon goes.



Subjects

Agriculture, Biology, Chemistry, Earth Science, Environmental Science

Skills

Determining Cause and Effect, Identifying Relationships and Patterns

Materials

Student pages, answer keys, and presentations (see [Activity Webpage](#) link below); eight dice; large paper; markers

Time Considerations

Part A: One 50-minute class
Part B: One 50-minute class

Related Activities

This activity introduces the carbon cycle. It can be preceded or followed with information about climate change (Activity 2) and followed with Activity 8, which applies this information to understanding carbon sequestration across the landscape. This activity also provides helpful background to Activity 12, which explores the life cycle of wood products.

Research Connection

Scientists are studying the amount of carbon that is stored in different carbon pools, how carbon moves between different pools, and the length of time that carbon resides in these pools. This information is key to understanding how carbon dioxide emissions affect the carbon cycle on Earth.

Activity Webpage

Find online materials for this activity at <https://sfcc.plt.org/section3/activity7>



Objectives

By the end of this activity, students will be able to

- illustrate the carbon cycle, including carbon pools and carbon fluxes;
- explain how the biological carbon cycle is “in balance,” and
- predict how releasing carbon stored in fossil fuels affects other carbon pools.

Assessment

- Use the group carbon cycle diagram to assess students’ understanding of the major carbon pools and carbon fluxes.
- Instruct students to write a summary of what they learned during the carbon cycle exercise and subsequent group work and discussion. Ask them to address the following: What is the biological carbon cycle, and how does it differ from the geological carbon cycle? What are potential effects of releasing carbon stored in geological pools?

Background

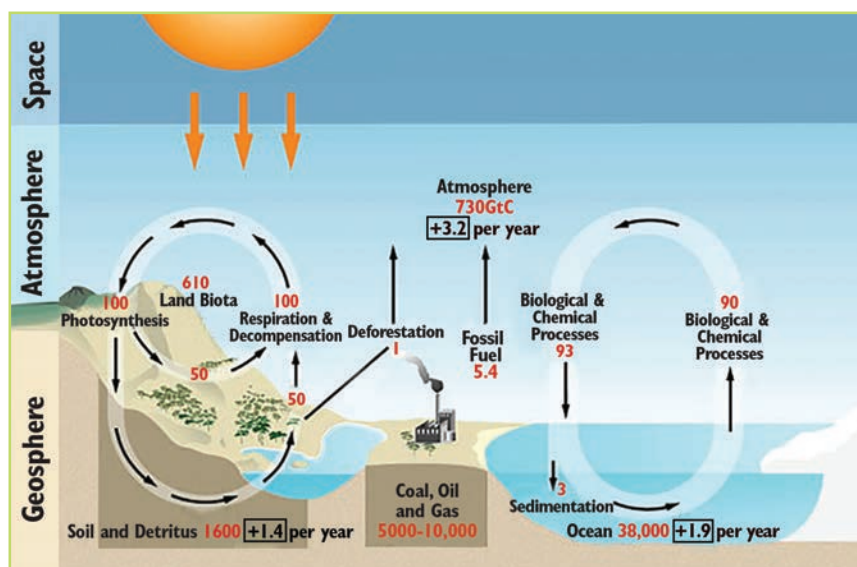
Carbon flows through biological, physical, and geological **systems** with different processes and at different timescales. The **carbon cycle** refers to the movement of carbon, in its various forms, from one pool to another (figure 1). A **carbon pool** is any place where carbon can be found, such as plants, the **atmosphere**, or soil. Carbon pools can also be called **stocks** or reservoirs. **Carbon flux** is the process by which carbon moves from one pool to another. For example, carbon moves from the atmosphere to plants through **photosynthesis** and can move back from plants to the atmosphere through plant or soil **respiration** during the **decomposition** process, or during a **wildfire** when trees and plants are burned. When a pool absorbs more carbon than it releases, it is a **carbon sink**. For example, the ocean and soil are carbon sinks. Forests can also be carbon sinks. Alternatively, when a pool releases more carbon than it absorbs, it is a **carbon source**. Because **fossil fuels** cannot be created as fast as we are extracting and combusting them, they are considered a carbon source.

Additional background information can be found in the **Section 3 Overview**.

Biological Carbon Cycle

In the biological system, carbon cycles through living organisms, land, water, and the atmosphere by processes including photosynthesis, respiration, and decomposition. Different quantities of carbon reside in each pool, and the carbon moves at different rates among the pools. Some of these processes occur very quickly, while others can take hundreds to thousands of years. For example, some carbon atoms may cycle daily through plant photosynthesis and respiration, while other atoms may be trapped in a tree trunk for hundreds of years through carbon sequestration. Soil can also trap carbon for long time periods, up to thousands of years.

Carbon sequestration is the process of transferring atmospheric **carbon dioxide** into other pools, such as plant **biomass** via photosynthesis or into soils from decaying plant and animal matter.



COMMONWEALTH OF AUSTRALIA, BUREAU OF METEOROLOGY

Figure 1. The global carbon cycle, with amounts of carbon in carbon pools noted in gigatons (GtC) and carbon flux and accumulation rates noted in GtC/year.

WHAT IS A GIGATON?

It is a measure by weight, of one billion metric tons, which is the weight of one cubic kilometer of water. A metric ton is 2,200 pounds. One gigaton is about the amount of CO₂ emitted by all American adults driving 15,000 miles in average cars. For examples to visualize carbon dioxide emissions, go to www.carbonvisuals.com and www.carbonquilt.org.

Carbon storage in plant biomass is relatively easy to visualize as plants and trees are comprised largely of carbon that they have obtained from atmospheric carbon dioxide through photosynthesis. During photosynthesis, plants convert carbon dioxide and water into sugar in the presence of sunlight. Some of the sugars are used as building blocks to form plant biomass, such as cellulose, lignin, bark, and leaves. Through this process, carbon moves from the atmosphere and is stored in plant cells. Building and maintaining these complex structures requires energy, which the plants convert by metabolizing sugars

made during photosynthesis to form **ATP (adenosine triphosphate)**. ATP is created through the process of respiration, which releases some carbon dioxide back into the atmosphere.

Many people do not realize how important soils are in carbon sequestration. Carbon is a major ingredient of soil, and as figure 1 indicates, soil contains well over twice the carbon found in all the terrestrial plants and animals. As plants and trees grow, die, and decay, some of their carbon is stored in soils in “recalcitrant” forms that decay slowly. This carbon can build continuously over long periods of time and will likely play a significant role in carbon sequestration efforts. The deep ocean and soils represent significant carbon pools, where carbon can stay for hundreds to thousands of years. On the other hand, the exchange of carbon between the atmosphere and plants, along with the exchange between the atmosphere and the ocean’s surface, occurs continuously. The amount of carbon flowing through the biological system without human impact (through plants and animals to soil and atmosphere) is fairly stable and is considered to be “in balance.” In figure 1, the biological fluxes in terrestrial and marine systems account for all their carbon.

To distinguish between the mineral and organic components of soil, we refer to the decomposing, organic components as **soil carbon**.

Geological Carbon Cycle

The geological carbon cycle occurs over millions of years and includes processes such as rock formation, large-scale land shifts (plate tectonics), weathering, dissolution, volcanic eruptions, and fossilization. Fossil fuels—petroleum, natural gas, and coal—are created over hundreds of millions of years as layers of rock, soil, and **sediment** cover the remains of dead plants and animals. As this organic matter becomes compacted, pressure and heat turn the carbon into

long chains of **hydrocarbons**. Without human intervention, the carbon would mostly remain trapped far beneath Earth's surface—making fossil fuels a long-term carbon sink. **Limestone** is another long-term carbon sink. Limestone forms when ocean sediments, which contain the shells of marine animals, are compressed and buried under the ocean floor. Some of this carbon is released back to the atmosphere through volcanic eruptions and ocean vents or seeps that release gas (known as outgassing). If limestone rock is lifted to the surface of the planet, precipitation and lichen can dissolve it (weathering) and release carbon.

Be sure to point out the different time scales on which these flows take place. For example, the answer key (see Activity 7 webpage) to the Biological and Geological Carbon Cycle Diagram shows arrows from soil and ocean sediments down to fossil fuels. This is because the generation of new fossil fuels is an ongoing process. However, it is a process that takes place on a time scale of hundreds of millions of years. Contrast this to the burning of fossil fuels (represented by the arrow from fossil fuels to atmosphere), which began emitting large quantities of carbon in the 1800s and continues to grow.



LARRY KOHNIAK, UNIVERSITY OF FLORIDA



Systems Thinking Connection

If you have been using the Systems Enrichment Exercises (particularly the **Bathtub Dynamics** exercise from Activity 2), then your students are familiar with the systems concepts of **stocks** and **flows**. These terms are synonymous with the “pools” and “fluxes” discussed in this activity. As you work through the discussion questions with your students, be sure to emphasize the relationship of stocks and flows. If you didn't use this exercise earlier, you may wish to do so now.

Recall that there are two ways of reducing a stock: (1) reducing the flow into the stock and (2) increasing the flow out of the stock. Have students identify the flows into the stock of atmospheric carbon in this activity (e.g., respiration, burning). Then have them identify the flows out of the atmospheric stock of carbon (e.g., photosynthesis, dissolving into the ocean). Discuss ways to decrease flows of carbon into the atmosphere and increase flows of carbon out of the atmosphere.

Soils play an important role in the carbon cycle.





ANNIE OXART, UNIVERSITY OF FLORIDA

You can set up stations for this activity by printing the **Illustrated Station Cards** on the Activity 7 webpage.

Teaching This Content

This activity engages students by having them imagine they are carbon molecules traveling through different carbon pools. Students will likely enjoy and remember this part of the activity. However, it is equally important that students are given adequate time to apply and reflect upon the information they learn during the simulation. This is particularly important because the geological carbon cycle is not included in the simulation conducted in Part A. We strongly recommend that you complete both Part A and Part B of this activity so that students are exposed to the full carbon cycle and apply that information as they answer questions.

Getting Ready



The Activity 7 webpage provides **Teacher Tools** that you can use to become more familiar with this activity's background and procedure (<https://sfcc.plt.org/section3/activity7>).

If you would like to provide a short presentation on carbon and the carbon cycle, you can use the Introducing Carbon presentation on the Activity 7 webpage. If students need more background regarding biological or geological carbon cycle processes, see the Additional Resources for websites, readings, and videos.

Download and print one copy of the Illustrated Station Cards available on the Activity 7 webpage. You can also use the information provided on the Station Cards student page to create your own cards with images that reflect your local environment or surroundings.

Make copies of the Carbon Pathway and Mapping Carbon student pages (one for each student).

Set up eight stations, each with one die. The Station Cards should be visible from any place in the room, and the die should be placed on a table or desk. Students need enough space between classroom furniture to gather at each station and move between them.

Doing the Activity

Part A: The Biological Carbon Cycle

I. To introduce the topic of the carbon cycle, ask students to brainstorm what they already know about carbon and to provide examples of places carbon can be found. If needed, remind students that carbon is an element on the periodic table, is the fourth most abundant element, and can be found in different forms everywhere we look. You can use the Introducing Carbon presentation on the Activity 7 webpage to provide a brief overview of carbon and the carbon cycle. In addition, you might find these discussion questions helpful:

- Is there a fixed amount of carbon on the planet?
Yes. Like water, there is a relatively constant amount of carbon on the planet. Also like water, carbon constantly moves through different states and pools.

- Do you have any carbon in you?
Yes, in the carbohydrates, fats, proteins, enzymes, and tissues of your body.
- How is photosynthesis related to the carbon cycle?
During photosynthesis, plants convert carbon dioxide and water into sugar in the presence of sunlight. This process moves carbon from the atmosphere to sugar in plant cells. Then, the sugars are either metabolized into energy in the form of ATP through the process of respiration or used as building blocks to form starch, cellulose, lignin, wood, leaves, or roots. Energy in the form of ATP is used to construct these complex molecules. This process, where carbon is removed from the atmosphere and stored in plant biomass, is known as sequestration.

2. Explain to students that they are about to become a carbon atom and move through the carbon cycle.

- The purpose of the activity is to help students better understand the variety of places that carbon can be found and how it moves from location to location.
- While carbon cycles geologically over millions of years, this part of the activity only focuses on the biological component of the carbon cycle that happens on a much shorter timeframe. In this cycle, carbon moves between different pools such as living organisms, land, water, and the atmosphere.
- Make sure students understand the terms *soil carbon, carbon pool, carbon flux, carbon cycle, and carbon sequestration.*
- Some students might get stuck in some parts of the carbon cycle or move back and forth between two carbon pools. Let students know in advance that this may happen, and that this mimics the real carbon cycle. If a student seems frustrated or upset by getting stuck, it is okay for them to move to another appropriate pool.

3. Give each student a copy of the Carbon Pathway student page and provide instructions

for how they should use this worksheet to record their journey through the carbon cycle. Modeling what students should do when they arrive at their first station and how to move to subsequent stations helps the simulation move smoothly. Ask them to count off by eight and move to their first stations. Tell students they will complete eight rounds and record their journeys through the carbon cycle. If you have a small class, you may wish to have students complete additional rounds to increase chances that they will experience diverse outcomes and visit all the stations; which can lead to richer discussion after the activity.

- Students should write their first station on the first row in the table, roll the die, read the outcome from the card at that station, write down the next destination and the process that took them there, and move to that station.
- Even if some students end up staying at the same location after a roll of the die, they should write down the station name again and the process that led to them staying in place.

4. When everyone is finished, discuss the following questions as a class:

- Who visited the most pools? Who visited the least?
Responses will vary. Some students may have visited all the stations, but many probably moved between the atmosphere and the forest or the ocean.
- Did anyone get stuck at one station or between two stations? Why do you think that happened?
Point out that there are many different ways to enter and leave most carbon pools. The time carbon atoms spend in each pool varies. For example, some atoms might cycle very quickly between the atmosphere and forests through photosynthesis and respiration, while others may get sequestered in a tree for hundreds of years. This is built into the exercise through the number of options that keep the carbon molecule at the same station.

TEACHERS SAY ...

I loved this activity, especially to introduce the terms carbon pool, carbon sink, and carbon flux.

—Biology Teacher, Florida





Students work together to draw a carbon cycle that includes both biological and geological components.



JESSICA IRELAND, UNIVERSITY OF FLORIDA

Part B: The Full Carbon Cycle

1. Remind students that the simulation focused on the *biological* portion of the carbon cycle. Ask students if there are other places that carbon is stored and other ways that carbon moves?

Carbon is also stored in rocks, fossil fuels, and in sediments on the ocean floor and includes fluxes like weathering, compaction, combustion, and volcanic eruptions.

2. Introduce the geological portion of the carbon cycle, including how fossil fuels are created (see Additional Resources for more background information if needed). Carbon atoms in the geological portion of the cycle will be stuck for millions of years. Ask students to imagine how long it takes for carbon to move from ocean and terrestrial sediment to rock and fossils. Discuss how carbon is naturally released through weathering and volcanic eruptions in small amounts over very long periods of time. When fossil fuels are burned for energy, however, large amounts of carbon are released into the atmosphere in a very short time period.

3. Show the class the global carbon diagram (in Background Information and available for download on the Activity 6 webpage).

- Point out the major carbon pools and fluxes that are shown on the diagram. Ask students to list the carbon pools that they experienced during the simulation that are missing on this diagram (e.g., animals, wood products, marine life).
- Reinforce that the amount of carbon flowing through the biological portion of the cycle is fairly stable and that carbon is constantly moving from the atmosphere to plants or oceans and back to the atmosphere.
- Explain that human use of fossil fuels has added carbon to the atmosphere that previously had been locked in fossils for millions of years. This “old” carbon is changing the balance of carbon in the atmosphere and ocean. Carbon from fossil fuels contains a different isotope (i.e., a variation of a chemical element, differing in the number of

neutrons found in each atom) from that found in trees and other living things. This allows the atmospheric contribution from fossil fuels to be tracked.

4. Discuss potential effects of releasing additional carbon to the system.

5. Form groups of four to five students and give each student a copy of the Mapping Carbon student page. Instruct students to work together to draw a carbon cycle that includes both biological and geological components. When the groups finish, ask a representative from each group to share the group's diagram and responses to the questions on the student page.

- According to your diagram, what are the two ways carbon is removed from the atmosphere? List the pools and the fluxes.

Forests through photosynthesis; oceans through dissolving.

- How might each of these pools be affected by increased amounts of carbon dioxide in the atmosphere?

More atmospheric carbon dioxide allows plants to grow and develop more quickly. However, several other factors may influence the amount of forested land and forest health, such as land use changes, weather events, forest disturbances, as well as water and nutrient availability. An ocean with more carbon is more acidic; acidic oceans may alter coral reefs and other organisms.

- How could we change these pools to remove more carbon from the atmosphere? What might be the limitations of managing these pools in this way?

Plant more trees; grow trees longer; increase carbon in the soil; make long-lasting products out of wood. These options may be limited by the following: amount of land on which trees will grow; wood will eventually decay; a warmer ocean will hold less carbon; a more acidic ocean will dissolve coral reefs and negatively impact marine life that use carbon to build shells and skeletons.

- What are the implications of removing the trees from a piece of land and developing it so that trees no longer dominate the landscape?

The carbon from a forest could go into wood products or into the atmosphere if the forest is burned. Whichever way trees are removed, as long as they are not replanted, the result will be an area of land that will not be able to sequester as much carbon as it did when it was forested.

- **Systems Reflection:** How can thinking about the atmospheric greenhouse gases in terms of stocks and flows enable people to understand the system more clearly?



Thinking in terms of stocks and flows can help people understand the climate change mitigation actions and policies in terms of the physical system. Efforts to reduce emissions from fossil fuels can be seen as attempts to reduce the flow of carbon into the atmospheric stock. Reforestation efforts can be seen as attempts to increase flow of carbon out of the atmospheric stock. Using both types of strategies concurrently provides the best chance of successfully addressing the challenge of climate change.

6. Summarize this activity by reminding students that the carbon cycle consists of both biological and geological pools and fluxes, which operate on different timescales. Through human activities, such as fossil fuel combustion and land development, carbon is being released from geological carbon pools. The carbon activities in this module focus on the ways trees and wood products can be used to remove carbon dioxide from the atmosphere or prevent future emissions. A variety of other classroom activities and programs can be used to explore other strategies for reducing atmospheric carbon dioxide. See the Additional Resources listed at the end of this activity.

TEACHERS SAY ...

I enjoyed this activity. The students were engaged and working well individually and with others.

—AP Environmental Science Teacher,
Florida

Ask student groups to share their carbon cycle diagram and responses to the questions on the student page.



MARTHA MONROE, UNIVERSITY OF FLORIDA

Modifications

Younger students will benefit from “seeing” Part A of the activity in action, as you or another student model the instructions by rolling the die, selecting the flux, and moving to the next station.

Part B of this activity can be completed as a class discussion rather than in small groups, which can help you provide guidance and answer questions.

Enrichment

Ask students to research carbon-neutral energy sources that might replace fossil fuels. Why is using biomass, such as wood or corn, to produce energy considered carbon neutral? What factors determine neutrality? How could land-use changes impact biomass carbon neutrality?

Have students investigate how technology might be used to reduce carbon in the

atmosphere. For example, people around the world are working to remove carbon from the atmosphere and store it underground and to reduce the amount of carbon that we add to the atmosphere by saving energy and reducing our dependence on fossil fuels. Ask students to write a report explaining one solution and to discuss its advantages and disadvantages.

Have a discussion with students on the relationship between the carbon cycle and other cycles that students are familiar with, such as water or nitrogen cycles. How are these cycles similar and how are they different? What are the key events in carbon cycle, water cycle, and nitrogen cycle?

Additional Resources

All about Carbon Dioxide, A Student's Guide to Global Climate Change
U.S. Environmental Protection Agency

<http://epa.gov/climatestudents/basics/today/carbon-dioxide.html>

This website contains a video describing the carbon cycle and how humans are changing its natural balance.

Global Warming: It's All about Carbon

Robert Krulwich, National Public Radio, 2007

<http://www.npr.org/news/specials/climate/video/>

As part of the Climate Connections Special Series, these five short videos teach basic concepts about carbon and its role in climate change.

GLOBE Carbon Cycle

University of New Hampshire

<http://globecarboncycle.unh.edu/index.shtml>

This education unit focuses on bringing cutting edge research and research techniques in the field of terrestrial ecosystem carbon cycling into secondary classrooms. It includes several activities to help students understand the carbon cycle, including a “choose your own adventure story.”

Climate Science Info Zone

London Science Museum

<http://www.sciencemuseum.org.uk/ClimateChanging/ClimateScienceInfoZone/ExploringEarthsclimate>

This interactive website has a series of animations and videos related to the global climate, the carbon cycle, and climate change.

Steroids and Baseball

University Corporation for Atmospheric Research (UCAR)

<https://www2.ucar.edu/atmosnews/attribution/steroids-baseball-climate-change>

This two-minute video uses steroids in baseball as an analogy to carbon dioxide in climate and provides reflective comments on the purpose and value of the video.

The Carbon Cycle

Holli Riebeek, NASA's Earth Observatory

<http://earthobservatory.nasa.gov/Features/CarbonCycle>

The six sections of this online article provide a comprehensive look at the geologic carbon cycle, historical changes in the carbon cycle due to climate change, contemporary changes in the carbon cycle due to human activities, effects of these changes, and how the carbon cycle is studied. The article includes helpful photos, diagrams, graphs, and maps. A previous version of the article is available in PDF format at http://earthobservatory.nasa.gov/Features/CarbonCycle/carbon_cycle2001.pdf.

The Carbon Cycle: Forestry Never Looked So Cool

The Forest Foundation

<http://www.calforestfoundation.org/pdf/carbon-poster.pdf>

This poster (also available as a handout) provides a colorful depiction of the carbon cycle and highlights the role of forests and wood products.

The Carbon Cycle: What Goes Around Comes Around

John Harrison, Visionlearning, National Science Foundation, 2003

http://www.visionlearning.com/library/module_viewer.php?mid=95

This online module provides basic information about the carbon cycle including human influences. The module also includes an interactive quiz and section with links to other resources.

The Carbon Quilt

Carbon Visuals Ltd

www.carbonquilt.org

This website provides images and animations to help people better understand carbon emissions.



TEACHERS SAY ...

This activity was one of my favorites and one of my students' favorites.

—Ecology Teacher, Virginia



Carbon Pathway

NAME _____

DATE _____

Instructions: Imagine you are a carbon atom in one of many places that carbon is found. Write your starting location on the first line, roll the die, and determine your next location. Follow the instructions for the number you roll to move to another station or stay where you are. What process was responsible for moving you from one carbon pool to another? Repeat this eight times and record in the table below what happens during each round. Make sure to record what happens, even if you have to stay at one station for more than one turn.

Round	Starting Location (Carbon Pool)	What happened? (Carbon Flux)	Ending Location (Carbon Pool)
Example	Atmosphere	Photosynthesis	Forest
1			
2			
3			
4			
5			
6			
7			
8			

CO₂

Station Cards (1 of 2)

Atmosphere

1. You continue to circulate through the atmosphere. **Stay at Atmosphere.**
2. You continue to circulate through the atmosphere. **Stay at Atmosphere.**
3. In a forest, a pine tree needle absorbs and uses carbon dioxide during photosynthesis. **Go to Forest.**
4. In a forest, a pine tree needle absorbs and uses carbon dioxide during photosynthesis. **Go to Forest.**
5. Near the East coast, you dissolve into the waters of the Atlantic Ocean. **Go to Surface Ocean.**
6. Near the East coast, you dissolve into the waters of the Atlantic Ocean. **Go to Surface Ocean.**

Wood Products

1. The lumber where you are sequestered is used to build a house. **Stay at Wood Products.**
2. The lumber where you are sequestered is used to build a house. **Stay at Wood Products.**
3. After many years, the lumber gets thrown in a pile of old wood and begins to rot and break down. **Go to Soil Carbon.**
4. You are eaten by termites. **Go to Animals.**
5. After many years, the lumber where you are sequestered gets burned for firewood. **Go to Atmosphere.**
6. After many years, the lumber where you are sequestered gets burned for firewood. **Go to Atmosphere.**

Forest

1. Through respiration, a tree uses your sugar molecule for energy. **Go to Atmosphere.**
2. The pinecone where you have been stored is eaten by an Eastern fox squirrel. **Go to Animals.**
3. You become sequestered in a tree's trunk. After several years, your tree gets cut down. **Go to Wood Products.**
4. You become sequestered in a tree's trunk. After several years, your tree gets cut down. **Go to Wood Products.**
5. You become sequestered in a tree root, which dies and decays. **Go to Soil Carbon.**
6. A fire moves through the forest and burns the tree where you have been stored. **Go to Atmosphere.**

Surface Ocean

1. Through wave action, you mix with air and come out of the water—leaving solution as carbon dioxide gas. **Go to Atmosphere.**
2. Through wave action, you mix with air and come out of the water—leaving solution as carbon dioxide gas. **Go to Atmosphere.**
3. You continue mixing in water near the surface of the ocean. **Stay at Surface Ocean.**
4. Water currents and ocean mixing send you deeper within the ocean. **Go to Deep Ocean.**
5. An algae plant takes you in during photosynthesis. **Go to Marine Life.**
6. An algae plant takes you in during photosynthesis. **Go to Marine Life.**



Station Cards (2 of 2)

Soil Carbon

1. As the organic matter decomposes, you become carbon dioxide through [soil respiration](#). **Go to Atmosphere.**
2. As the organic matter decomposes, you become carbon dioxide through [soil respiration](#). **Go to Atmosphere.**
3. An insect [eats](#) the rotting material where you are located. **Go to Animal.**
4. An insect [eats](#) the rotting material where you are located. **Go to Animal.**
5. You become buried in layers of leaf litter and soil. **Stay at Soil Carbon.**
6. You become buried in layers of leaf litter and soil. **Stay at Soil Carbon.**

Deep Ocean

1. [Ocean mixing](#) and water currents send you toward the surface. **Go to Surface Ocean.**
2. [Ocean mixing](#) and water currents send you toward the surface. **Go to Surface Ocean.**
3. [Ocean mixing](#) and water currents send you toward the surface. **Go to Surface Ocean.**
4. [Ocean mixing](#) and water currents send you toward the surface. **Go to Surface Ocean.**
5. Water currents send you deeper within the ocean. **Stay at Deep Ocean.**
6. Water currents send you deeper within the ocean. **Stay at Deep Ocean.**

Animals

1. A bird eats you for dinner. **Stay at Animal.**
2. You are stored in animal fat cells. **Stay at Animal.**
3. You get released as carbon dioxide during [respiration](#). **Go to Atmosphere.**
4. You get released as carbon dioxide during [respiration](#). **Go to Atmosphere.**
5. When the animal [produces waste](#), you find yourself on the forest floor in a pile of poop. **Go to Soil Carbon.**
6. The animal dies and begins to [break down](#) on the forest floor. **Go to Soil Carbon.**

Marine Life

1. You are eaten by tiny marine animal, called zooplankton. **Stay at Marine Life.**
2. You are eaten by tiny marine animal, called zooplankton. **Stay at Marine Life.**
3. You are exhaled through [respiration](#). **Go to Surface Ocean.**
4. You are exhaled through [respiration](#). **Go to Surface Ocean.**
5. The organism you are part of dies. You [break down](#) and sink through the waters of the Atlantic Ocean. **Go to Deep Ocean.**
6. The organism you are part of dies. You [break down](#) and sink through the waters of the Atlantic Ocean. **Go to Deep Ocean.**



Mapping Carbon (1 of 2)

NAME _____

DATE _____

- I. Use a large sheet of paper and markers to create a carbon cycle that combines the path that each group member experienced during the simulated carbon cycle. Use ovals or circles to represent the **carbon pools**. Use arrows to show how you moved from pool to pool, and label each arrow with the **carbon flux** that took you to the next pool.

For example, one or more students in your group probably went from the atmosphere to the forest through photosynthesis. This means you would draw one oval labeled “atmosphere” and one oval labeled “forests.” Then you would connect them with an arrow labeled “photosynthesis.”

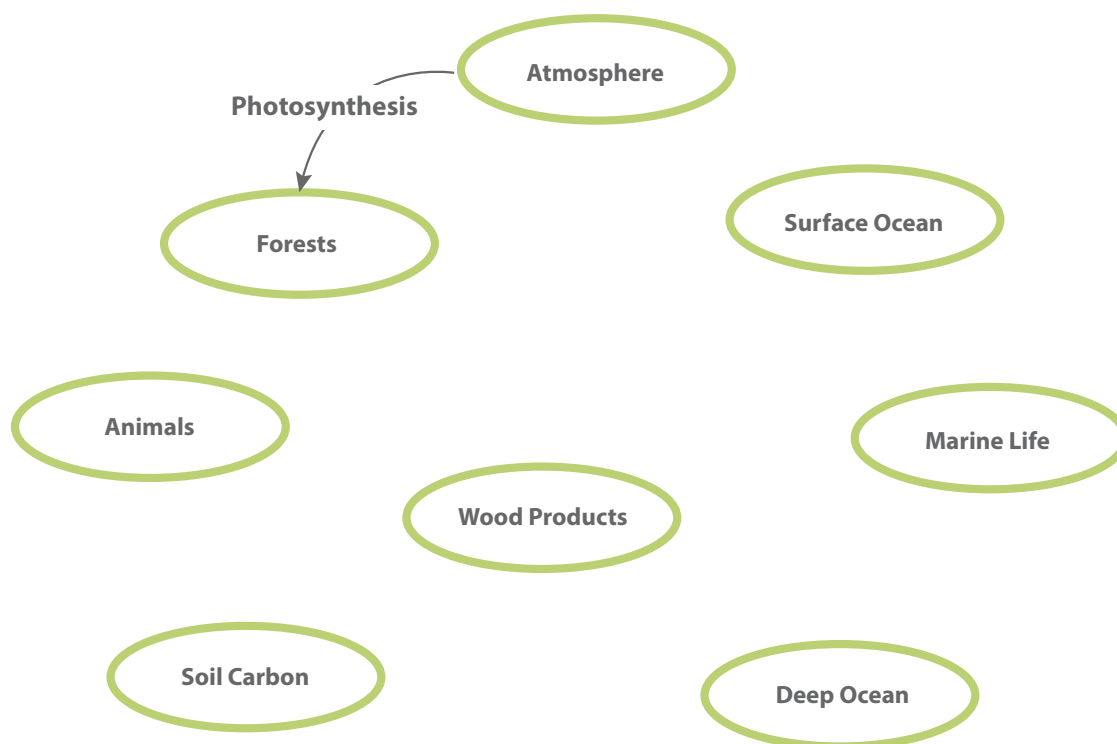
Carbon fluxes that you may have experienced include:

Breaks Down
Burns (Combustion)
Dissolves
Eaten (Consumption)

Leaves Solution
Ocean Mixing/Circulation
Photosynthesis

Respiration (Plant, Soil, Animal)
Sequestration
Waste Production

Example Diagram for Biological Carbon Cycle





Mapping Carbon (2 of 2)

NAME _____

DATE _____

2. If needed, add additional arrows to represent any realistic pathways (fluxes) between pools that were not experienced by your group members. This diagram represents the **biological part** of the carbon cycle.
3. Add three new carbon pools to the bottom of your group diagram to represent the **geological part** of the carbon cycle: Fossil Fuels, Ocean Sediments, and Carbonate Rock / Limestone. Then use the following fluxes to describe how carbon moves between the new and existing carbon pools: Heat and Compression, Burning (Combustion), Volcanism (Outgassing), Weathering, Rock Formation, and Sinking.
4. According to your diagram, what are two ways carbon is removed from the atmosphere? List these fluxes and the pools.
5. How might each of these pools be affected by increased amounts of carbon dioxide in the atmosphere?
6. How could we change these pools and also remove more carbon from the atmosphere? What might be the limitations of managing these pools in this way?
7. What are the implications of developing a piece of land that used to be forested, so that trees no longer dominate the landscape?