



Name: _____

Date: _____

Student Exploration: Carbon Cycle

Vocabulary: atmosphere, biomass, biosphere, carbon reservoir, carbon sink, fossil fuel, geosphere, greenhouse gas, hydrosphere, lithosphere, photosynthesis

Prior Knowledge Questions (Do these BEFORE using the Gizmo.)

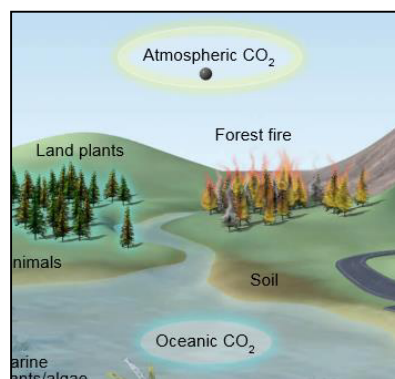
In the process of **photosynthesis**, plants take in carbon dioxide (CO_2) from the atmosphere and water (H_2O) from the soil. Using the energy of sunlight, plants build molecules of glucose ($\text{C}_6\text{H}_{12}\text{O}_6$) and oxygen (O_2).

1. How do plants on Earth affect the amount of carbon in Earth's atmosphere? _____

2. Animals eat plants and produce carbon dioxide and water. How do animals affect the amount of carbon in Earth's atmosphere? _____


Gizmo Warm-up

The *Carbon Cycle* Gizmo allows you to follow the many paths an atom of carbon can take through Earth's systems. To begin, notice the black carbon atom in the **Atmospheric CO_2** area, highlighted in yellow. The glowing blue areas represent possible locations the carbon atom could go next.



1. From Earth's atmosphere, where can the carbon atom go next? _____
2. Click on **Land plants** and read the description. How did the carbon atom get from the atmosphere to a plant? _____
3. Select **Land animals**. How did the carbon atom get from land plants into the animal? _____
4. Select **Atmospheric CO_2** . How did the carbon atom get from land animals back to the atmosphere? _____



Activity A: Carbon pathways	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> Click Reset. 	
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Introduction: Earth can be divided into four systems. The **atmosphere** is the air above Earth's surface. The **hydrosphere** is composed of all of Earth's water. The **geosphere** is the rocky, non-living part of Earth. The **biosphere** consists of all living things, including people. Some scientists use the term "anthroposphere" to describe everything made or modified by humans.

Question: How does carbon move between the atmosphere, hydrosphere, biosphere, and geosphere?

1. **Explore:** Use the Gizmo to create a path for carbon that begins and ends in the atmosphere. Fill in the steps in the path below. Then, label each location with the system it represents. Finally, summarize very briefly how the carbon atom got to that location.

Carbon path	System	How it got there
Atmospheric CO ₂ ↓	Atmosphere	Atmospheric CO ₂ comes from volcanoes, burning fossil fuels, and other sources.

2. **Create:** Click **Reset**. Use the Gizmo to create a path in which the carbon atom goes from the atmosphere to the hydrosphere, biosphere and geosphere. Describe each transition briefly.

Atmosphere	Hydrosphere	Biosphere	Geosphere
Atmospheric CO ₂ →	→	→	
Volcanoes, burning fossil fuels, and other sources.			

(Activity A continued on next page)

Activity A (continued from previous page)

3. Explore: Use the Gizmo to create three more carbon paths, each starting and ending in the atmosphere. Label each location with A for atmosphere, B for biosphere, G for geosphere, or H for hydrosphere. (You can also use P for anthroposphere if you like, or just include it in the biosphere.)

Path 1:

Path 2:

Path 3:

4. Explain: Based on the Gizmo, explain how the following transitions might take place:


A. Describe at least two ways that carbon can get from a land plant to the atmosphere.

B. Describe at least two ways that carbon can get from the atmosphere to the hydrosphere. _____

C. Can you find two ways that carbon can get from the ocean to the **lithosphere**? (The lithosphere is the rigid layer of the Earth, including the crust and part of the mantle.)

D. Describe at least two ways that carbon can get from seashells to the atmosphere.



Activity B: Human activities	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> Click Reset. 	
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Introduction: **Fossil fuels**, such as coal, oil, and natural gas, formed over millions of years from the remains of ancient plants and animals. The burning of fossil fuels, as well as other human activities, increases the amount of carbon dioxide in the atmosphere.

Question: How does human activity affect the carbon cycle?

1. Describe: Using the Gizmo, determine how coal and petroleum (oil) are formed. Describe the steps required to form each fuel from atmospheric CO₂.

Coal: _____

Petroleum: _____

2. Explore: Natural gas is a mixture of methane (CH₄), ethane (C₂H₆), and other gases. Find two ways that natural gas forms. List the steps of the two carbon pathways below:

Path 1:

Path 2:

How is the formation of natural gas related to the formation of coal and petroleum? _____

3. Describe: Fossil fuels are used in many ways. Using the Gizmo, describe the main use for each fuel.

Coal: _____

Petroleum: _____

Natural gas: _____

In each case, what is the end product of burning the fossil fuel, and where does it go?

(Activity B continued on next page)

Activity B (continued from previous page)

4. Explore: Another major contribution to atmospheric carbon dioxide is the cement industry. Using the Gizmo, find a carbon atom path from the atmosphere to the cement plant. (Hint: One of the ingredients in cement is limestone.)

Path:

How is carbon dioxide produced in a cement plant? _____

5. Analyze: Click **Reset**, then navigate to the **Land animals**. Select **Atmospheric CH₄**.

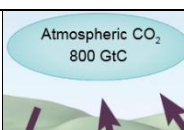
A. How do land animals create methane? _____

B. Humans raise large numbers of cattle for food. How will these herds of cows affect Earth's atmosphere? _____

6. Analyze: In many tropical rainforests, people clear land by cutting down trees and burning them. After a few years, the soil runs out of nutrients and cannot be farmed any longer. How does this practice of "slash and burn agriculture" affect Earth's atmosphere?

7. Draw conclusions: In general, how do many human activities influence the carbon cycle?



Activity C: Modeling the carbon cycle	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> Select the MODEL tab. 	
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Introduction: Humans have been burning fossil fuels rapidly for the past 250 years. As a result, the amount of atmospheric CO₂ has increased by about 40% since the year 1800. By measuring how much carbon moves into and out of the atmosphere, scientists can predict the change in the amount of atmospheric carbon dioxide every year.

Question: How can we model changes in atmospheric carbon over time?

- Observe: The MODEL tab shows a simplified model of the carbon cycle. The ovals represent **carbon reservoirs**, where carbon is stored. The unit “GtC” stands for gigatonnes of carbon, where one GtC is equal to one trillion kilograms of carbon. The arrows represent how much carbon moves from one reservoir to another each year, in gigatonnes per year.

A. Look at the arrows pointing toward atmospheric CO₂. What are the two major sources of atmospheric carbon? _____

B. A **carbon sink** is a location that stores carbon for a long period of time. Which two carbon sinks remove carbon from the atmosphere? _____

C. Without changing the Gizmo, list the carbon reservoirs from largest to smallest.

Note: The largest carbon reservoir is actually Earth’s lithosphere, which contains about 80,000 GtC. However, there is not much exchange between the lithosphere and the other reservoirs on short time scales.

- Experiment: If necessary, click **Return to original settings**. These settings approximate present-day conditions, but should not be taken as exact values.

A. What is the total amount of carbon removed from the atmosphere each year by the ocean and land plants? _____

B. What is the total amount of carbon added to the atmosphere from soil and the burning of fossil fuels? _____

C. How much will atmospheric carbon change in one year? _____

In 10 years? _____ In 100 years? _____

(Activity C continued on next page)

Activity C (continued from previous page)

3. Calculate: Carbon dioxide is a **greenhouse gas** that helps to trap heat in Earth's atmosphere. We need some CO₂ in the atmosphere to maintain a warm planet, but excess carbon can cause considerable warming of the planet.
- A. What fossil fuel usage will result in no change in atmospheric CO₂ each year? _____
- B. What percentage decrease in fossil fuel usage is required to achieve this goal? _____
4. Experiment: Using the Gizmo model, explore the following questions:
- A. How does increasing plant **biomass** (amount of plants) affect atmospheric CO₂?

- B. How does increasing oceanic CO₂ intake affect atmospheric CO₂ and oceanic CO₂?

- As carbon dioxide is absorbed by the ocean, the ocean becomes slightly more acidic. This could make it harder for many organisms to build their shells and skeletons. The consequences of ocean acidification are not yet fully understood.
5. Infer: Click **Reset** and **Return to original settings**. Suppose we completely stopped burning fossil fuels immediately. How many years would it take to return to atmospheric CO₂ levels from the year 1800, about 600 GtC? Use the Gizmo to find the answer.

6. Think about it: Since hard-shelled organisms evolved about 550 million years ago, billions of tons of limestone rock have been produced from their shells. Limestone is made of calcium carbonate, with the formula CaCO₃.

Based on this, how do you think the amount of atmospheric CO₂ has changed in the last 550 million years, and how has this affected Earth's climate? Explain your answer.

