

## TEACHER LESSON KEY

The purpose of this lesson is to highlight the importance of the Carbon Cycle in the natural cycles of photosynthesis and respiration. It also models how human activity can alter the carbon cycle. The animation, which runs for 2:56 minutes total time, covers a large amount of information that students may or may not be familiar with. Here is one suggestion for working your students through the animation. By actively taking notes during the animations, students can engage in a dialogue with the model and better increase their understanding of the material. The instructions read as if each student has their own computer, but this can be modified for a whole class activity with one computer.

Suggested vocabulary words/phrases:

atomic number, mass number, element symbol, greenhouse effect, climate, carbon cycle, photosynthesis, respiration, plant litter, decompose and decomposition, soil organic matter, global carbon cycle, land use change, greenhouse gas emissions, reservoir, infrared radiation, positive feedback loop

Have the students turn on the captions. This will help address the different learning styles, and encourage them to slow down and pause the animation as needed to take notes and fill in the blanks in the following section.

### I. Carbon , the Element

Pause as the animation begins: "Carbon is one of the most important elements on Earth"

1. What is the square that is pictured called?

**Element symbol**

2. Copy the symbol and label each bit of information given here (atomic number, atomic mass, element symbol, and name)

**Atomic number: 6**

**Atomic mass: 12.0107**

**Symbol: "C"**

**Name: Carbon**

Resume the animation, answering the following questions as it runs:

3. What element is an important component of all living things? **Carbon**
4. Besides living things, what other things is carbon found in?

**fuels that humans use for energy, food that humans**

5. What gas made from Carbon plays an important role in regulating climate?  
**CO<sub>2</sub>, Carbon Dioxide**
6. "Biological activity causes carbon to be constantly **converted** among different **forms** and **locations**. These movements of carbon are referred to as the **carbon cycle**."

## II. The Carbon Cycle

1. Pause the animation at this point (~:27), and draw the Carbon cycle depicted here. Fill in the labels as you learn the material. **Students should draw the picture; labeling trees, oxygen, plants and other living organisms, leaf section image, decomposing microbes, carbon dioxide, and the factory. They also should include the arrows.**

2. Once you have drawn and labeled the Carbon cycle, study it for a minute or two to familiarize yourself with it. Think about such things as: Where does the Oxygen in the cycle come from? What are two pathways transforming the Carbon Dioxide? Write several sentences in the space below to answer these questions.

**The oxygen in the cycle comes from the photosynthesis process of plants, represented here by the trees. Fossil fuels, from once living material, burned in the factory results in CO<sub>2</sub> emissions. Oxygen is taken up by living things and as they live and decay they release CO<sub>2</sub> through the processes of respiration. These biological activities are constantly converting carbon in the cycle into different forms and locations.**

3. The Global Carbon Cycle describes the exchanges of carbon between the atmosphere, terrestrial vegetation, soils and organic matter, oceans and fossil fuels. These exchanges are continually changing and not in perfect balance. Human activities are converting oil, coal, natural gas, plant and soil organic carbon into carbon dioxide.

4. Describe the changes that have occurred in the images from the green field and mountains to the end image (at ~:55 seconds).

**The image of the meadows and mountains transforms with added images of clouds representing the atmosphere, trees representing terrestrial vegetation, soils and organic matter of the field, the blue water of an ocean, and roots and underground layers representing fossil fuels. Next, a car and road, house with landscaping and a swimming pool, a factory, and a tractor plowing the field are added to represent human activities which convert various forms of carbon into carbon dioxide, which is accumulating in the atmosphere, enhancing the greenhouse effect.**

5. Using your resources, define the greenhouse effect and why it is a concern.

**The greenhouse effect results from gases in the atmosphere trapping heat as it re-radiates off of Earth. This keeps Earth at a habitable temperature. However, too much greenhouse gas can cause the atmosphere to retain too much heat and get too warm. An excellent reference resource for this information can be found at The Greenhouse Effect, [http://www.ucar.edu/learn/1\\_3\\_1.htm](http://www.ucar.edu/learn/1_3_1.htm)**

### III. Atmospheric Carbon

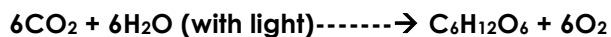
1. "The atmosphere is a relatively small reservoir of carbon, containing less than **1%** of the Earth's total carbon pool".

2. Write down or draw and label the analogy of the pool and glass of water and how it models the effect of increased atmospheric carbon dioxide.

**For equal size portions of carbon, the added carbon makes a bigger difference in the glass of water than it does the larger swimming pool. This is analogous to the addition of CO<sub>2</sub> into the atmosphere; although it is a relatively small reservoir of carbon, a little extra added to it can make a significant difference.**

3. The amount of carbon in terrestrial vegetation is **comparable** to the amount of carbon in the atmosphere. Vegetation takes CO<sub>2</sub> out of the atmosphere through **photosynthesis**.

What is the equation for photosynthesis? You may use words or symbols.



**Carbon dioxide plus water react (with light) to form sugars and oxygen.**

4. What do you notice about the two arrows in the image and what do they tell you?

**The arrow is larger for the emissions one...showing an imbalance of carbon dioxide emissions to the atmosphere due to human activity. This adds more carbon than plants can use, causing carbon in the atmosphere to increase.**

### IV. Carbon Dioxide cycling

1. What happens to the CO<sub>2</sub> that plants are able to use? Ultimately, where does it wind up and how does that happen? **It becomes new plant tissue which will die and fall to the ground, eventually to decompose or be transformed into soil organic matter. It can then be stored in the soil carbon pools.**
2. How does carbon end up accumulating in soil carbon pools? **It accumulates faster than it decomposes, adding to soil carbon pools.**

3. "Within the **soil**, there is more than **twice** as much carbon locked up in organic material than there is carbon in the **atmosphere**".
  4. What are two examples of human activities that accelerate the conversion of soil carbon to CO<sub>2</sub>? **Land use changes and greenhouse gas emissions.**
  5. Give an example of land use change due to human activities, besides the example given here. **Deforestation**
- v. So What? Why is this important?

1. Explain the important role of carbon dioxide as a major greenhouse gas. Describe the process of how heat is retained by this gas using the words radiation, infrared radiation, absorb, and re-emit. You may draw and label a diagram if you wish.

**Carbon dioxide in the atmosphere causes heat to be retained between the Earth and the atmosphere. Some radiation leaving the earth is trapped by the greenhouse gases, causing heat to be retained. The carbon dioxide radiates the escaping heat in all directions, including back down toward Earth.**

2. What is the significance of the arrows in the drawing of this occurrence?  
**The arrows show the direction of heat radiation.**
3. "This leads to **increased** temperatures in the **lower** atmosphere, which in turn can **increase** the rate of decomposition, which **further increases** the amount of **CO<sub>2</sub>**." This creates a magnifying cycle of increased warming and increased atmospheric circulation. This is an example of a **positive** feedback loop.

As you review what you have learned, what can affect the balance of the overall exchanges of carbon? In a short paragraph, summarize what you have learned from this animation.

**Emissions from human activity including energy uses, releasing soil carbon from stored pools, and changes in decomposition rates are factors that can affect the balance of the overall exchanges of carbon.**

**Students might discuss the importance of carbon as a greenhouse gas, the effects of added human emissions due to energy uses, the effects of land use change on releasing soil carbon locked in the organic material, the natural flux of carbon among the different pools, the effect of adding excess carbon to the atmospheric pool of carbon, the effects of photosynthesis or respiration on the carbon cycle, or the important role of decomposition of plant material in the carbon cycle.**

LESSON PLAN: **ANIMATED** LESSONS FROM I-MOLD

Part One: The Carbon Cycle <http://imold.utoledo.edu/carbon.html>

\*During this animation, what has the thermometer done? (beginning at time 2:33)

**It increased.**