LESSON 10: THE AMAZING ADVENTURES OF CARBON
How Carbon Cycles through the Earth

TEACHER BACKGROUND
Overview:
This activity provides an introduction to the carbon cycle and systems thinking. It could also be used as an introduction to the carbon cycle and, more broadly, 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.

All systems consist of a set of interacting components that, together, form a more unified entity. 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 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. 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

Preparation:
- Copy and create Carbon Cycle Adventure Story books-enough for every two or three students.
- Each student needs the Carbon Atom Journey Table
- For the Explain you will need to create a large display that shows a landscape image. See example.

Helpful Hints:
- Modeling your expectations for the Explore activity both academically and behaviorally will be important to the success of the activity.

GRADE LEVEL
5-8

TIME TO COMPLETE
1.5 -1.75 hours
To be split up to meet the needs of the class

PREREQUISITE KNOWLEDGE
Students should have basic knowledge of what carbon is, that it cycles through the Earth system, and is essential to life.

LEARNING OUTCOMES
- Explore a system using the carbon cycle model.
- Carbon is one of the most important and abundant elements on Earth.
- Carbon can be found everywhere.
Lesson 10: The Amazing Adventures of Carbon
How Carbon Cycles through the Earth System

**ENGAGE**

<table>
<thead>
<tr>
<th>Student Grouping - Whole Group</th>
<th>Time: 20 min</th>
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</table>

**Essential Question:**
A. After reading pages 1-3 explain why you feel carbon is an important atom and element. Give at least 3 reasons.

**Directions:**
1. 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. This will help start generating ideas about where carbon is found and how prevalent it is in the world around us.
2. Record ideas of where carbon is found on the board/smart board/chart paper.
3. Read pages 1-3 in the Carbon Cycle Adventure Story. Have students answer the essential question in their science notebook.
4. Solicit additional ideas about the carbon cycle. *NOTE* Your questioning and leading will depend upon the grade level you teach. What is carbon? Where is it found? How does carbon move from one place to another (the processes)? What form does it take (C, CO$_2$, CH$_4$, CaCO$_3$, glucose)?
5. Let students know that they next few class periods will be spent learning about carbon and the carbon cycle through as they follow Mr. Carbon, a carbon atom, through the global carbon cycle.

**EXPLORE**

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<thead>
<tr>
<th>Student Grouping - Individuals/Pairs</th>
<th>Time: 30 min or Groups of Three</th>
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**Essential Question:**
B. Where is carbon stored or pooled?
C. What are some ways that carbon moves or fluxes between pools?

**Directions:**
1. Students follow a carbon atom through the carbon cycle by reading then choosing their own adventure story.
2. Each pair or group of students will need a Carbon Cycle Adventure Story Booklet and the Carbon Atom Journey table.
3. Show students the Glossary of Terms (on the last page of the story booklet) as a reference for any terms (bold and italic) they don’t understand.

**STUDENT OBJECTIVES**

Students will -
- 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

**MATERIALS**
- Science Notebook
- Carbon Cycle Adventure Story Booklet (per student pair)
- Table: Carbon Atom Journey (per student pair)
- Large chart paper

**ACADEMIC VOCABULARY**
Carbon pool, carbon flux, environmental system, cycle, carbon, carbon dioxide

**LESSON LINKS** can be found under Web References unless otherwise noted.

- Carbon Cycle Adventure Story - found as a pdf. in the Lesson 10 folder
- Carbon Atom Journey Table - found on page 6
- Class Carbon Cycle Diagram example - found on page 7
- Story Map of Flows (Fluxes) - found on page 5
- Student Carbon Cycle example - found as PowerPoint in the Lesson 10 folder
Lesson 10: The Amazing Adventures of Carbon  
How Carbon Cycles through the Earth System

<table>
<thead>
<tr>
<th>EXPLORE CONTINUED</th>
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<tbody>
<tr>
<td>4. Instruct students to read the Carbon Cycle Adventure Story and record their journey in their table.</td>
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<tr>
<td>a. Model the process.</td>
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<td>b. Students choose where they want to go on their journey.</td>
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<td>c. On their Carbon Atom Journey Table students will record-</td>
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<td>i. the pools where carbon currently resides,</td>
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<td>ii. the flow or flux (process) chosen within the booklet which will take the carbon atom to another pool,</td>
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<td>iii. and the pool where carbon moves to.</td>
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<td>d. Students should record any questions that come to mind or terms they do not understand.</td>
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*NOTE* The adventure can be run as long or as short as time allows, providing that students have experienced at least 5 pools during their journey.

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<th>EXPLAIN</th>
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<td>Student Grouping-Pairs or Groups of Three</td>
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<td>Time: 20 min.</td>
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**Essential Question:**  
D. Can systems contain sub-systems? Explain.

**Directions:**  
1. The class will create a carbon cycle diagram based on each pair or group’s journey using the landscape diagram you created. Each pair or group will need a different color marker/crayon to track their journey on the class diagram.  
2. Allow pairs or groups to come up, a couple at a time, to trace out their journey. Refer to Class Carbon Cycle Diagram example under Lesson Links.  
3. Once everyone’s journey is on the map have a discussion-  
   a. Ask students to share one thing they’ve learned about the carbon cycle from this activity.  
   b. Did students find themselves returning to one pool or another more often than others? Why reasoning can they provide?  
   c. What does this indicate about systems in general? (systems within systems)  

*NOTE* Student’s journeys will overlap-meaning colors will overlap. This is perfectly acceptable and will demonstrate to the students the complexity of the carbon cycle. You can also show students the Story Map of Flows found under Lesson Links.

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<th>ELABORATE</th>
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<td>Student Grouping-Individual with Peer Support</td>
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<td>Time: 15 min. to start and finish for homework.</td>
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**Essential Question:**  
E. How can we represent systems? Give examples and explain your reasoning.  
F. What’s the importance of carbon cycle on plant and animal life?

**Directions:**  
1. Students will create their own carbon cycle journey diagram (in their science notebook) using their pools and fluxes during their journey. Using the Journey Table is the best way to translate their table into a diagram. This task shouldn’t be difficult since you worked together to create a class diagram with multiple pools and fluxes. If needed see Student Carbon Cycle example found under Lesson Links.

*NOTE* This diagram will allow students to see that the carbon cycle does not function in a cyclical pattern as shown in most diagrams but weaves in and out of various Earth systems at all times.
Lesson 10: The Amazing Adventures of Carbon
How Carbon Cycles through the Earth System

EVALUATE

Student Grouping-Individual

Directions:
Grades can be taken from the Carbon Cycle Journey Table, the individual student created diagram, and from responses to the Essential Questions. For the following assessment pieces you may choose what best fits your student’s needs or you may allow your students to choose their assessment.

a. Concept Quiz – found on pages 8-11
b. Essay – found on page 12

*NOTE* Utilize the Science Notebook Rubric for assessing your students work within their notebooks.

Web References

Further Learning Resources
EPA Climate Change Kids
http://www.epa.gov/climatechange/kids/index.html

Windows to the Universe – The Carbon Cycle Game
http://www.windows2universe.org/earth/climate/carbon_cycle.html

Carbon Dioxide Concentration Data
http://climate.nasa.gov/keyIndicators/index.cfm#co2

Other Content Connections
Carbon cycles through all the Earth systems as well as living and dead plants and animals.

- Study of landforms
- Movement of air and ocean currents
- What happens when carbon pools are destroyed due to natural or man-made causes, such as fire, deforestation and urbanization?
- Relationship between decomposition and the carbon cycle
Lesson 10: The Amazing Adventures of Carbon
How Carbon Cycles through the Earth System

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.

<table>
<thead>
<tr>
<th>Where is carbon now?</th>
<th>How did carbon leave? (The process)</th>
<th>Where did carbon arrive?</th>
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Vocabulary and Questions:
Lesson 10: The Amazing Adventures of Carbon
How Carbon Cycles through the Earth System

Class Carbon Cycle Example

Global Carbon Cycle

You just need something simple. Use this picture as a guide to quickly sketch a blank diagram on chart paper, projection system, or chalkboard.
Lesson 10: The Amazing Adventures of Carbon
How Carbon Cycles through the Earth System

Name: ________________________________  Date: ____________

Science Concept Quiz
Lesson 10: Carbon Cycle Adventure Story
How Carbon Cycles through the Earth System

Global Carbon Cycle

Legend
Units: Petagrams (Pg) = 10^15 gC
- Pools: Pg
- Fluxes: Pg/year

Copyright 2010 GLOBE Carbon Cycle Project, a collaborative project between the University of New Hampshire, Charles University and the GLOBE Program Office.
Data Sources: Adapted from Houghton, R.A. Balancing the Global Carbon Budget. Annu. Rev. Earth Planet. Sci. 007, 30.313-347. Updated emissions values are from the Global Carbon Project. Carbon Budget 2009.
Lesson 10: The Amazing Adventures of Carbon
How Carbon Cycles through the Earth System

Using the diagram on page one to answer the following question. In order to understand how carbon is cycled and how atmospheric CO\textsubscript{2} will change in the future, scientists must carefully study the places in which carbon is stored (pools), how long it resides there, and processes that transfer it from one pool to another (fluxes). Identify two pools and two fluxes from the choices below.

A. Burning fossil fuels, plant respiration, photosynthesis, and volcanoes
B. Burial of sediment, oceans, earth’s crust, and fossil fuels
C. The Global Carbon Cycle is too complex a system to identify pools and fluxes.
D. Litterfall, burning fossil fuels, plants, and soils

_____ points out of 20
I. Answer
   A. ○  B. ○  C.○  D. ○  E. ○

_____ points out of 15
II. What is the main concept behind the question?
   1. Changes over time
   2. Making Predictions
   3. Carbon storage and transfer
   4. Understanding the definition of a cycle

_____ points out of 25
III. Provide the reasoning for choosing your answer in part II.
Lesson 10: The Amazing Adventures of Carbon
How Carbon Cycles through the Earth System

_____ points out of 40

IV. Why are the other responses in part I not the best answer choice?

1.

2.

3.

4.

Use the rest of this page if more room is needed to fully communicate your thoughts.
Lesson 10: The Amazing Adventures of Carbon
How Carbon Cycles through the Earth System

Teacher Answer Key

1. D

2. 3

3. Answers will vary. The legend states that red identifies carbon fluxes and blue identifies carbon pools.

4. Answers will vary.
   A) This list identifies carbon fluxes only.
   B) This list identifies carbon pools only.
   C) Yes the Global Carbon Cycle is a complex system, but scientists have identified many pools and fluxes to help us understand how carbon travels through the earth system.
   D) Litterfall and burning fossil fuels are both fluxes and plants and soils are both pools for carbon storage.
Lesson 10: The Amazing Adventures of Carbon
How Carbon Cycles through the Earth System

Explain what you understand about the carbon cycle now that you did not know before this activity.