Carbon Adventures: A game to teach the carbon cycle

Goal: This lesson plan is designed to introduce the complexity of the carbon cycle to students. By the end of the game, students should understand that carbon can take many forms throughout the carbon cycle, and that no set pathway exists in the cycle.

Objectives:

The students will be able to:

- describe what is carbon.
- describe the difference between organic and inorganic carbon.
- identify different carbon pools.
- identify different forms carbon takes throughout the carbon cycle.
- describe paths in which carbon can move throughout the environment.
- describe how humans influence the carbon cycle.

Background:

Carbon is an element that is essential for life. Carbon is the building block of life, as all living organisms are composed of carbon. Carbon atoms take many forms as they move through the environment. Carbon can be found as an organic molecule or an inorganic molecule. As carbon moves from one location or pool to another, many different processes can change the form of carbon. In the following game, eight major pools are identified: Vegetation, Animals, Bacteria and Fungi, Litter and Waste, Fossil Fuels, Industry and Vehicles, Atmosphere and Ocean. Of the 8 pools identified, 4 of the pools are shown as the terrestrial carbon cycle. These pools are Vegetation, Animals, Bacteria and Fungi, and Litter and Waste. The processes that take place in these pools on land also take place in similar fashion in aquatic environments such as the ocean. This game does not separate out the biotic processes in the ocean to retain the simplicity of the game, but students should be notified that these processes also occur in aquatic environments. This game can be especially useful to emphasize that nutrient cycles do not occur in a fixed pattern, and that a single atom of carbon may never visit some carbon pools.

Once students have a grasp of the processes that occur in each carbon pool and the transformations that can take place, emphasis can then be placed on human alterations of the carbon cycle during recent history. The largest disturbance to the global carbon cycle has been ongoing since the Industrial Revolution. This disruption is the large-scale use of fossil fuels for energy. By removing fossil fuels from below the ground surface, humans are reintroducing carbon to the global carbon cycle that has been out of circulation for millions of years. When fossil fuels are burned to produce energy, the carbon in them is converted to carbon dioxide. This carbon dioxide then enters the atmosphere and has been building up in the atmosphere since the Industrial Revolution. The level of CO_2 in the atmosphere is not as high as we would expect it to be. Scientists have been looking for the "missing carbon" and have discovered that most of the missing carbon is being utilized by forests in the northern hemisphere and dissolved by oceans.

Terminology:
Combustion – burning of carbon-based materials (e.g. wood, gasoline, coal) to obtain energy to do work, releasing CO_2 as a byproduct
Humification – the alteration of organic matter that is too complex to be broken down by bacteria and fungi. This carbon becomes part of the matter in the soil.
Inorganic – molecules that are not of biological origin (e.g. CO_2, bicarbonate)
Organic – molecules that are of biological origin (e.g. wood, leaves, sugars, starches)
Organic Matter – various molecules and pieces of dead tissue that are of biological origin
Photosynthesis – the conversion of carbon dioxide into sugars by plants using the sun as an energy source
Respiration – the conversion of sugars into carbon dioxide to release energy used by organisms

Level: Grade 6 – College

Time:
This lesson should take 2-3 class periods of 50 minutes each. One period to play the game and one to discuss results.

Materials:
- One copy of the game board and game cards for each group of 5 students (best if printed on card stock, or laminated)
- 5 different colored small nuts and bolts for each game board(Can be colored using spray paint)
- Dice
- Game Worksheet, Carbon Cycle Worksheet and Comprehension Worksheet
- Game Instructions

Procedure:
1. Print one game board and game card set for each group of 5 students. If printed on a large format printer, game boards can be laminated. If printed on a letter-sized printer, print on card stock and tape sections of game board together. Print game cards on card stock and cut out. Place one die with each game board. Paint 5 nuts and bolts for each game board 5 different colors. These will be the game pieces.
2. Explain the game instructions to the students. Students should enter the locations they visit on the game board on the location blank on the Game worksheet. More advanced students can use the Advanced Game worksheet and also enter the process and form information on their worksheets.
3. Allow students to play the game for the rest of the class period. If you want to continue playing the game the next day, students can start at the last pool location they entered on their worksheet. It is best if most students make it back to vegetation once before stopping the game.
4. Once the game is stopped, have students draw their paths using arrows on the Carbon Cycle worksheet.

5. Discuss the carbon cycle. Questions that can be asked are:
    - What is carbon?
    - Where is carbon found?
    - How does carbon move from one pool to another? Ask for specific processes such as photosynthesis, respiration, combustion, etc.
    - What are some of the different forms carbon can take in the carbon cycle?
    - Sometimes carbon is in an organic form. What does that mean?
    - Does a carbon molecule always take the same path, or visit every pool?
6. Have the students remove all game cards where humans alter the carbon cycle. These game cards have a star in the upper right-hand corner of the card. The students can play the game again with the cards removed, and/or discuss how removing these cards would affect the carbon cycle. The students should be asked, "Which carbon pools are most influenced by human activity?"

Evaluation:

1. Students can be rated on their participation.
2. Students can also be assessed using the Comprehension worksheet.