Lesson 10: Teacher Reference 2

Carbon Dice Game Instructions and Station Cards

Guidance

Prior to the lesson:

- Decide where each "reservoir" will be located in the classroom. Assuming that the fossil fuel reservoir will be the largest reservoir, consider having students remain at their desk if they are in the fossil fuel reservoir to start.
- Tape the station cards in the appropriate location or have tape on hand to tape the station cards when you give instructions to students.

During the lesson:

- Provide each student with their own dice. Provide each student with a Quick Reference Card as needed.
- Give students instructions about how they will roll their own dice and move within the carbon system according to the number rolled. Each station will have guidance on where to move next based on the roll of their dice.
- This version of the dice game is designed to be a quick, whole-group activity with no recording of data or information, but rather focusing students on observations of where carbon atoms are flowing in and out of the system components (or carbon reservoirs). If you choose to add a more structured activity for students to record their experience, consider having students record:
    - tally marks on a sheet of paper at each location and/or
    - their movement through the reservoirs (e.g., starting location, next location, next location, and so on).
- Arrange students in their starting location following the breakdown below. Have students in the fossil fuel reservoir remain in their seats.

Starting Location	Amount of Carbon in gigatons	Percent of students	Number of students for class size of 30	Number of students for class size of 20
Atmosphere	750-800	15%	5	4
Land plants and animals	600-650	10-15%	4	3
Soil and decomposers	1500-1600	30%	9	5-6
Fossil fuels	2,000* (lowest possible recoverable estimates)	40%	12	8
Totals	~5000	~100%	30	20-21

Start the game

- Begin the the first round BEFORE human activity of fossil fuels. Roughly about ⅔ of the class will be actively moving through the system, while the other third will be "locked" in the fossil fuel reservoir.
- Have some students pause at each roll and share where they moved, why they moved there, and why they did not move.
- Have students complete roughly 10-15 rolls.

Modify the game to include combustion of fossil fuels

- Then introduce the change to the system with the addition of combustion of fossil fuels. Now the students who began in the fossil fuel reservoir are "unlocked" and can roll their way into the system.
- Allow students 5-6 minutes to roll their dice and move through the system. Pause as needed when you start to notice a buildup in any of the reservoirs or a depletion in reservoirs, such as fossil fuels.
- If you need to adjust the game, "reset" the students to the starting locations and make adjustments. If you do this, take a minute to share how this simulation of the system is based on "chance" with the roll of the dice. In the real world, the system is much more predictable.

ALTERNATE ACTIVITY

If you want to include oceans: This activity is inspired by other versions of the activity developed and used by Project Wet. The original activity includes surface and deep ocean reservoirs, so if your model includes these reservoirs, consult the original activity and modify the stations and dice roll directions as needed. You can locate the original activity at the following website: *The Carbon Cycle Game*: https://pages.mtu.edu/~raman/SilverI/MiTEP_ESI-1/Day_7_Core_and_the_subsurface_files/Carbon%20Cycle%20Game_JCevensCredited.pdf.

If you are in remote learning: The CarbonTIME project from Michigan State University offers a Tiny World activity that is done individually with "counters" and a follow-up simulation.

- Website: CarbonTIME Fossil Fuels and Carbon Pools: https://carbontime.bscs.org/human-energy-systems/lesson-4
    - Tiny World Modeling Activity 4.3 is an individual counter activity that simulates the flow of carbon atoms. Modify this activity to exclude the seasonal variation. Complete Scenarios #1 and #3.
    - Global Computer Model Activity 4.4 is a computer model based on the Tiny World counter activity. Consider using this after the counter activity to facilitate a discussion of the flow of carbon through components and processes before and after combustion is added to the system.

Atmosphere

Number on Dice	What to do
1	**Stay in the atmosphere**. Carbon dioxide can stay in the atmosphere for as little as 30 years or up to thousands of years.
2	**Stay in the atmosphere**. Carbon dioxide can stay in the atmosphere for as little as 30 years or up to thousands of years.
3	**Stay in the atmosphere**. Carbon dioxide can stay in the atmosphere for as little as 30 years or up to thousands of years.
4	**Stay in the atmosphere**. Carbon dioxide can stay in the atmosphere for as little as 30 years or up to thousands of years.
5	**Go to the plant and animal reservoir.** You are used by a plant in photosynthesis and may be eaten by an animal.
6	**Go to the plant and animal reservoir.** You are used by a plant in photosynthesis and may be eaten by an animal.

Plants & Animals

Number on Dice	What to do
1	**Stay in the plant and animal reservoir**. You become part of a plant as it grows.
2	**Stay in the plant and animal reservoir**. You become part of a plant as it grows.
3	**Stay in the plant and animal reservoir.** You are eaten by an animal and become part of an animal.
4	**Stay in the plant and animal reservoir.** You are eaten by an animal and become part of an animal.
5	**Go to the atmosphere**. A plant or animal reacts you with oxygen for energy and gives you off as a CO_2 molecule back to the atmosphere.
6	**Go to the soil reservoir.** You are a dead plant or animal that has started to decompose.

Soil & Decomposers

Number on Dice	What to do
1	**Stay in the soil reservoir**. You are decomposed and become carbon in the soil.
2	**Stay in the soil reservoir**. You are decomposed and become carbon in the soil.
3	**Stay in the soil reservoir**. You are decomposed and become carbon in the soil.
4	**Stay in the soil reservoir**. You are decomposed and become carbon in the soil.
5	**Go to the atmosphere**. A decomposer reacts you with oxygen for energy and gives you off as a CO_2 molecule back to the atmosphere.
6	**Go to the atmosphere**. A decomposer reacts you with oxygen for energy and gives you off as a CO_2 molecule back to the atmosphere.

Fossil Fuels

Number on Dice	What to do
1	**Stay in the fossil fuels reservoir**. You are ancient plant and animal matter trapped underground.
2	**Stay in the fossil fuels reservoir**. You are ancient plant and animal matter trapped underground.
3	**Stay in the fossil fuels reservoir**. You are ancient plant and animal matter trapped underground.
4	**Stay in the fossil fuels reservoir**. You are ancient plant and animal matter trapped underground.
5	**Go to the atmosphere**. A person reacts you with oxygen for energy and gives you off as a CO_2 molecule back to the atmosphere.
6	**Go to the atmosphere**. A person reacts you with oxygen for energy and gives you off as a CO_2 molecule back to the atmosphere.

Quick Reference Cards

Atmosphere	Plants and Animals
1. **Stay in the atmosphere**. Carbon dioxide can stay in the atmosphere for as little as 30 years or up to thousands of years. 2. **Stay in the atmosphere**. 3. **Stay in the atmosphere**. 4. **Stay in the atmosphere**. 5. **Go to the plant and animal reservoir.** You are used by a plant in photosynthesis and may be eaten by an animal. 6. **Go to the plant and animal reservoir.**	1. **Stay in the plant and animal reservoir**. You become part of a plant as it grows. 2. **Stay in the plant and animal reservoir**. You become part of a plant as it grows. 3. **Stay in the plant and animal reservoir.** You are eaten by an animal and become part of an animal. 4. **Stay in the plant and animal reservoir.** You are eaten by an animal and become part of an animal. 5. **Go to the atmosphere**. A plant or animal reacts you with oxygen for energy and gives you off as a CO_2 molecule back to the atmosphere. 6. **Go to the soil reservoir.** You are a dead plant or animal that has started to decompose.
Fossil Fuels	**Soil and Decomposers**
1. **Stay in the fossil fuels reservoir**. You are ancient plant and animal matter trapped underground. 2. **Stay in the fossil fuels reservoir**. 3. **Stay in the fossil fuels reservoir**. 4. **Stay in the fossil fuels reservoir**. 5. **Go to the atmosphere**. A person reacts you with oxygen for energy and gives you off as a CO_2 molecule back to the atmosphere. 6. **Go to the atmosphere**.	1. **Stay in the soil reservoir**. You are decomposed and become carbon in the soil. 2. **Stay in the soil reservoir**. 3. **Stay in the soil reservoir**. 4. **Stay in the soil reservoir**. 5. **Go to the atmosphere**. A decomposer reacts you with oxygen for energy and gives you off as a CO_2 molecule back to the atmosphere. 6. **Go to the atmosphere**.