Carbon's Adventures Around The Forest

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Engineering Challenge:

Carbon is found nearly everywhere on Earth. Explore where and how carbon travels in an ecosystem, and make a model of carbon cycling in a forest. Explore how certain events in a forest can change the timing and routing of carbon.

Activity List for Lesson

Activity 1 (Engage):

- Adapted from *What Contains Carbon?* from California Academy of Sciences
- See link below for original materials, background, and lesson plan.
- *https://www.calacademy.org/educators/lesson-plans/what-contains-carbon*
- Extra object ideas: Bag of Sugar, Jar of Air, Stuffed Animal, Fruit or Vegetable

Activity 2 (Explore and onward):

- Adapted from *The Forest Carbon Cycle Journey,* from Boulder Lake Environmental Learning Center
- Explore the carbon cycle in a single ecosystem.
- See link below for original materials, background, and lesson plan.
- *http://www.boulderlake.org/epaschoolforest/curriculum/forestcarboncycle.pdf*

Materials for TEAM-E Activity

Activity 1 (at least 5 of the following):

- seashell
- piece of wood
- piece of plastic
- carbonated beverage
- bag of sugar
- jar of air
- stuffed animal (like a teddy bear or fox; representing a real animal)
- fruit or vegetable

Activity 2:

- Carbon Station Signs
    - Make these yourself with notecards, photos, or anything else. Or make stations around your school yard.

    - Stations: Living Tree, Understory Vegetation, Standing Dead Tree, Down Dead Wood, Forest Floor, Soil, Animal, and Atmosphere
- Set of Version A Station Movement Sheets
- Set of Version B Station Movement Sheets
- Dice (at least one die per station)
- Carbon Atom Travel Log & Map Copies – one per student or group
- Writing Utensils
- White/Chalkboard or Butcher Paper and Markers

Key Words/ Concepts:

carbon: an element found in all living things; individual particles of carbon are called atoms

carbon dioxide: a chemical compound composed of two oxygen atoms bonded with a carbon atom (CO_2); usually found in gas form on Earth

atmosphere: the gases surrounding the Earth

decomposition: how dead leaves and branches become soil ; the breakdown of organic material physically and chemically by bacteria, fungi, animals, plants, water, etc.

photosynthesis: the process by which plants use carbon dioxide and energy from the sun to build sugar

respiration: the processes by which plant and animal cells, including bacteria, break down sugar, which results in carbon dioxide

carbon sink: a carbon storage area that holds more carbon than it releases

5-E Activity Plan

Engage – Activity 1

- Explain to students that carbon is a particle we usually cannot see but is all around us. Carbon can exist on its own – like in diamonds or graphite in pencils – but it likes to bond with other *elements*. It bonds so well and is so important that it is part of all living things. Carbon is also in some but not all non-living things.
- Divide students into groups and give each group an object from the materials list. Ask each group to discuss and decide if their item contains carbon, and why they think it does or does not. Have each group explain their decision aloud.
- Explain to students that carbon is in *all* of their items.
    - All living things contain carbon. Some non-living things contain carbon too.
    - Sugar is made of carbon – we eat it and turn carbon into our bodies' energy. Plants produce it through photosynthesis.
    - Carbon is in the air – in several kinds of gases in the atmosphere, like carbon dioxide and methane. We and other animals exhale carbon dioxide.

    - Seashells were once part of living things like snails and oysters, and the animals that live in those shells make their shells by secreting calcium carbonate, or calcite. Calcite is the same mineral that limestone is made of.
    - Plastic is made from a carbon-rich source called *hydrocarbon*, a compound that is made of hydrogen and carbon. Oil, natural gas, and coal are a kind of *hydrocarbon* called fossil fuels.
    - Carbonated beverages are fizzy, and the bubbles in their fizz are made of carbon dioxide, a gas made of carbon and oxygen. Most sodas also contain sugar, and their plastic bottles are made of carbon too.
- Carbon is in all of these things and more. Carbon can be found all over the Earth and moves around over time. Tell students that they are going to explore how carbon is found and moves around in one kind of ecosystem: a forest.

Explore – Activity 2

- Brainstorm all of the places carbon is found in a particular ecosystem: a forest.
    - Be specific – what kinds of plants? Do living *and* dead trees contain carbon?
    - Introduce forest canopy structure – forest floor, understory, overstory.
- Set up Carbon Stations in a large room or school yard, with a sign for each station: Atmosphere, Plants, Animals, Surface Ocean, Deep Ocean, Soil, and Rocks & Fossil Fuels. Set a matching Station Movement Sheet from *The Forest Carbon Cycle Journey* at each Carbon Station, along with a die or several dice.
- Pass out a Carbon Station Worksheet to each student or group. Assign each student/group a starting place and tell them that they are now carbon particles, or atoms, in that station.
- They will roll a die and use the Station Movement Sheet to determine where their carbon moves to next. Each time they roll a die and stay or move, they record this on their sheet. After students roll 10 times, students can stay where they are or return to their seats.
- Ask a few students to explain their Carbon atom's travels and how they moved from station to station. Don't forget the mechanism – the "what happened"!
    - Define new terms with students.
    - Ask questions like, where didn't Joe go? Why do you think Jane stayed there for four turns?

Explain

- Use your Carbon Travel Log to create a map of carbon atom movement.
    - Tell students to draw arrows to show how they moved from station to station for their 10 steps. If they stay at the same station on a roll, they should add an O or X inside the circle for that station.
- Explain that each Carbon Station is a storage area for carbon in the forest, and carbon particles or atoms can move from one carbon storage area to another over time.
    - As each student moved from station to station and mapped out their carbon particle's paths, they created a model of a single atom in a forest's carbon cycle.
- Carbon atoms are everywhere all at once though, with multiple atoms moving around to different carbon areas at the same time.

    - With everyone in the class moving at the same time, the class acted out a model of carbon cycling in the forest.
- Combine the entire class' individual atoms' models to make a whole-system model of the forest carbon cycle.
    - On a large white/chalk board or butcher paper create a large Station Map with lots of room between the carbon stations.
    - Ask students to come up in small groups to add their individual carbon atom's map to the larger carbon cycling map, or model.
        - Draw arrows and Xs or Os to show how each atom cycled. If a student followed an arrow pathway that is already drawn, either thicken the existing arrow or add another arrow next to the existing arrow.
        - You could also use a cork board, yarn, and stickers or pins to create the larger model.
- Ask students to look at patterns on the board. Ask questions such as:
    - Where do most of the carbon atoms that started in the atmosphere go?
    - What are all of the sources for carbon in soil? (Where do the arrows pointing to soil come from?)
    - How do the sources of carbon differ for different living things? Where does an animal obtain its carbon from compared to a tree?
    - Are there Carbon Stations with lots where carbon stayed for more than one turn? Why is that? These stations may be *carbon sinks* that hold more carbon than they release.

Elaborate (And Starter Ideas for Evaluate)

- How Big Events Can Change Carbon's Travels

    - Use Version B of the Station Movement Sheets to look at how natural events like a forest fire can change the normal forest carbon cycle.
        - One die-roll number on each sheet except Atmosphere now reads: "Go to Atmosphere. You were burned in a forest fire and released into the atmosphere." Living Tree also has one more Standing Dead Wood roll number.
    - Repeat the dice-rolling activity and have students fill out a new 10-step Carbon Travel Log & Map.
    - Repeat combining everyone's maps on another piece of butcher paper or the other side of the white/chalkboard.
        - Individually students may not notice a difference in their own atoms; maybe a meadow prevented the small fire from spreading. But overall there should be more atmospheric carbon pathways and stay-overs.
    - Work in groups to compare the old carbon cycle model's results with the new carbon cycle pathways. Are there more arrows or Os anywhere? Less arrows or X/Os anywhere? Ask the students to explain why this change occurred.
    - Wildfires release high levels of carbon into the atmosphere in a small amount of time, and other effects of forest fires include habitat loss and increased soil erosion. However forest fires are historically a natural occurrence and can be

healthy for forests, by thinning trees, allowing more understory growth, and even helping some plants like sequoias reproduce.
    - Pose to students, if you were are forester, what kinds of decisions would you make to keep a forest healthy?
    - Foresters are trying to prevent catastrophic fires by managing the forests differently, with smaller, systematic, *controlled or prescribed burns* in forests. This also releases carbon into the atmosphere, but it releases a smaller amount of carbon over a longer time than a wildfire.
    - Discuss and/or research controlled burns with your class, and the benefits and limitations of this forest management decision.
  - Think with your class about how other events could affect the carbon cycle in a forest – drought, flood, clear cutting, warming climate, species introduction?

- Zooming out to the Earth's Carbon Cycle

  - Forests contain many storage areas, but the carbon system of a forest is part of a bigger carbon system on Earth. Forests, the atmosphere, soils, rocks, and oceans all store carbon. And carbon moves within and between each of these in a continuous cycle. On a projector or poster, show an image of the Earth's carbon cycle. NOAA or NASA's websites in Additional Resources can be helpful.
  - Zoom out from an ecosystem and model the Earth's broader carbon cycle, including oceans, rocks, and human activity.
  - Explore more with lessons on global carbon cycling and human activity included in Additional Resources.

- Managing Atmospheric Carbon Output

  - Use the NASA Gallery of Carbon's Travels and other research tools to discuss our society's carbon output, or footprint. Explain to students the importance of understanding our own and our society's atmospheric carbon output, or *carbon footprint*: as more carbon dioxide is added to the atmosphere, the Earth's climate is changing.
  - Brainstorm ways we can reduce our carbon footprints. Some idea-sparking questions listed below:
    - What is the carbon footprint of the banana you buy from the grocery store compared to a peach grown in California?
    - What is the carbon footprint of eating eggs with a side of fruit salad? What about with a side of bacon?
    - How can we get from place to place and emit less carbon?
    - What can you do with a paper grocery bag besides hold groceries?
  - Working in groups, research and present one way that humans can reduce their own or society's carbon footprint. Students should explain how their carbon reduction method works. How does it fit into the carbon cycle? Does the carbon disappear, reroute itself, or stay somewhere for a longer time?

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Supports National Next Generation Science Standards:

Disciplinary Core Ideas

- LS1.C: Organization for Matter and Energy Flow in Organisms
- LS2.A: Interdependent Relationships in Ecosystems
- LS2.B: Cycles of Matter and Energy Transfer in Ecosystems
- LS2.C: Ecosystem Dynamics, Functioning, and Resilience
- ESS2.A: Earth Materials and Systems
- ESS3.A: Natural Resources
- ESS3.B: Natural Hazards
- ESS3.C: Human Impacts on Earth Systems
- ESS3.D: Global Climate Change
- ETS1.B: Developing Possible Solutions

Science & Engineering Practices:

- Asking Questions and Defining Problems
- Developing and Using Models
- Planning and Carrying Out Investigations
- Analyzing and Interpreting Data
- Constructing Explanations and Designing Solutions
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information

Crosscutting Concepts

- Patterns
- Cause and Effect
- Systems and System Models
- Energy and Matter
- Structure and Function
- Stability and Change

Additional Resources:

1. What Contains Carbon? from California Academy of Sciences
   - *https://www.calacademy.org/educators/lesson-plans/carbon-cycle-poster*

2. *The Forest Carbon Cycle Journey*, from Boulder Lake Environmental Learning Center
   - *http://www.boulderlake.org/epaschoolforest/curriculum/forestcarboncycle.pdf*

3. *Carbon Cycle Game, from Jennifer Ceven (pages 1-11 in link)*
   - *http://oceanservice.noaa.gov/education/pd/climate/teachingclimate/carbon_cycle_game.pdf*

4. *Carbon Cycle Game* (before & after human activity), from Connecticut Energy Education

- https://www.windows2universe.org/earth/climate/carbon_cycle.html

5. *Carbon Cycle Role-Play*, from California Academy of Sciences
   - https://www.calacademy.org/educators/lesson-plans/carbon-cycle-role-play

6. *Carbon Cycle Poster*, from California Academy of Sciences
   - *https://www.calacademy.org/educators/lesson-plans/carbon-cycle-poster*

7. NOAA Education Resources: Carbon Cycle, from NOAA
   - http://www.education.noaa.gov/Climate/Carbon_Cycle.html

8. NASA Photo Gallery of Carbon's Travels
   - http://climatekids.nasa.gov/carbon-gallery/