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ACTIVITY : 1 HR 15 MINS

Tracking Down the Carbon

Students sort everyday objects into carbon and non-carbon categories to learn that almost all objects contain carbon. Then students are introduced to the carbon cycle and create a simple model to diagram their understanding of carbon's movements through Earth's four major reservoirs: biosphere, lithosphere, hydrosphere, and atmosphere. Students use labels and arrows to represent processes that move carbon from one reservoir to another.

GRADES

6 - 8

SUBJECTS

Earth Science

CONTENTS

3 PDFs

OVERVIEW

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For the complete activity with media resources, visit:
http://www.nationalgeographic.org/activity/tracking-down-carbon/

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DIRECTIONS

This activity is part of the Carbon Trackers unit.

1. Engage students by asking, "*Where do you think the carbon is stored on Earth?*" before students sort objects into carbon and non-carbon categories.

- Divide students into pairs or groups of three and give each group a collection of 6-10 everyday objects.
    - Examples of objects include: a rock, bottle of water, piece of plastic, shell, feather, carbon dioxide in a can of soda (tell them to classify the bubbles, not the can), leaf, flower, a piece of cotton fabric, piece of coal or Vaseline or other fossil fuel-based product, a piece of limestone, chert, marble, and a piece of wood. You could also ask them in which category would their finger, foot, or other body part belong.
    - Instruct each group to take about 10 minutes to categorize the objects into two groups: those that contain carbon and those that don't contain carbon.
- As a class, have each group briefly share and justify what they put in each category. Record these on the board to note themes and items that groups agreed or disagreed on.
- Use this sharing/discussion to help students determine that nearly all the objects provided contain carbon. Explain that they will be digging more thoroughly into how carbon moves through these objects.
    - Define the carbon cycle: the series of processes by which carbon compounds are converted from one form to another in the environment. Explain that carbon is the basis of life on Earth and critically important to living and nonliving things, and also makes up all three fossil fuels.

2. Introduce the concept of systems thinking to students to prepare them for Step 3.

- Start by introducing the term "systems" (an entity composed of diverse, but interrelated parts that function as a complex whole) and help students understand two important terms related to systems: reservoirs and processes.
- Reservoirs are a place where matter or energy resides (synonyms: pool, stock, storage); processes are things that move matter or energy between reservoirs (synonyms: flux, flow, transfer).

- Illustrate a simple system on the board to show that reservoirs can be depicted as circles or squares, and processes can be shown as arrows between the reservoirs.

    - An example could be an individual student's financial system. Use a circle or square labeled "Money in Wallet" to symbolize money and explain to students that is a reservoir. Ask students what processes would remove money. "Spending" is the process that removes money from the reservoir; draw an arrow labeled "Spending," pointing out from the reservoir.
    - Ask for examples of reservoirs that money might go into. It could be anything they would spend money on. For example, if students want to buy ice cream, draw a square or circle labeled "Ice Cream Store" touching the tip of the "Spending" arrow.
    - Ask what process might put money into the "Money in Wallet" reservoir. One answer might be "Earning," which would be illustrated as an arrow pointing to the "Money in Wallet" reservoir. Ask for examples of reservoirs that would be the source of the earned money (e.g., a job, a neighbor or parent that paid the student for a chore). Before moving to the next step, review again with students which parts of the example are processes and which are reservoirs.

3. Challenge students to create a simple model of the carbon cycle based on prior knowledge and activate thinking on this topic.

- Task each student pair or team to collaboratively identify the major reservoirs on Earth that all carbon objects come from: biosphere, lithosphere, hydrosphere, and atmosphere.

    - Distribute the *Cycle Diagram* handout or direct students to design their own on blank paper.
    - Instruct students to label each circle as a reservoir on Earth: biosphere, lithosphere, hydrosphere, and atmosphere. Guide students to write the label outside each circle to leave room inside the circles for other notes. Briefly explain what each term means and then connect each reservoir back to the objects sorted, showing which reservoir each object would come from.

- Ask students to brainstorm how carbon might move from one reservoir to another.

    - To help get them started, elicit a few initial ideas from the class. (Sample response: Burning coal moves carbon from rock into the atmosphere. This could be recorded on the chart as an arrow labeled "Burning," pointing from the lithosphere to the atmosphere.)

- Have students, in the same pairs or teams, record their initial ideas on a piece of scratch paper first.
- When they have a clear set of one to three processes in and out of each reservoir, they should then record them on their *Cycle Diagram*.
- Ask them to draw arrows between the various reservoirs and label the arrows with the name of the process(es) that allows carbon to move from one form in one reservoir to another form in another reservoir.

4. Lead a class "Snowball Discussion" to refine students' models into a consensus model representing what the class knows currently and identify questions that require investigation.

- Students begin in pairs or teams of three, with their first draft of the *Cycle Diagram*. Set a timer to give them three minutes to decide if the cycle is as complete as possible, based on their current knowledge.
- When the time is up, the pair or team joins another pair or team, creating a larger group. Set a timer for five minutes for each pair or team to share their diagram with their new teammates, justifying their choices and responding to the other group's probing questions. Each team will edit their diagram as necessary, based on new information from their new teammates.
- After 10 minutes (five minutes for each team to present to their partner team), prompt groups to rotate to join with another group to repeat this ten-minute process, until all groups have met with each other.
- Direct the class to reconvene in one large group and distribute fresh *Cycle Diagram* handouts (or blank paper if students have generated their own models). Instruct the class to generate a second draft that represents their collective knowledge about the carbon cycle and highlight areas they need to learn more about. Frame this as an activity that requires everyone to share their ideas to create the strongest class consensus model.

    - Students should record their own and the classes' ideas from the Snowball Discussion on their paper while the teacher does the same on a projected diagram to ensure the whole group comes away with the same diagram.
    - Begin with recording the names of the four reservoirs: biosphere, lithosphere, hydrosphere, and atmosphere. If students have done so in their discussions, break these into more specific smaller reservoirs. For example, the biosphere could be broken into land plants, ocean plants, land animals, and ocean animals. Query students to see how they might break them down.

- Ask student volunteers to share some of the processes that move carbon from one to another, building vocabulary by connecting the proper scientific terms to their responses. For example, replace “burning” with combustion. Present the correct vocabulary in a way that confirms their ideas but gives them the scientific term, versus implying that their simpler term was incorrect. This process is intended to teach vocabulary through building on what they already understand. Processes include the words listed below, though students are not expected to know all of these at this point:

    - Respiration
    - Litter fall, decay, and decomposition
    - Soil respiration
    - Ocean-atmosphere exchange (dissolution and diffusion)
    - Photosynthesis or chemosynthesis
    - Sedimentation
    - Fossil fuel combustion
    - Forest burning
    - Volcanism
    - Decomposition and oxidation of soil
    - Rock weathering

- Now use guiding questions to highlight missing pieces or further “need to know” pieces. Remind students that there is a finite amount of carbon on Earth. The atoms are not created or destroyed via natural processes on Earth, only moved around, so there must be a way to cycle it from one reservoir to another to get the Earth in balance.

    - For example, if students don’t have a process for moving carbon from the atmosphere to the ocean or back, ask them how that might happen. (Answer: This happens due to air-sea exchange where carbon dioxide gas is dissolved into seawater or released back into the atmosphere.) If no one knows, add a question mark there to flag that further class research is needed.

- Finish up this discussion by highlighting the question marks as “need to know” items that they will investigate further and asking if they know the names of any sub-cycles that move matter or energy around within or between reservoirs.

    - Although students may not have identified the exact names, highlight their ideas related to the hydrosphere-atmosphere cycle via the hydrologic cycle, the lithosphere

cycle of the rock cycle, and the biosphere-atmosphere cycle of photosynthesis and respiration.

- Inform students that while there are many other important matter and energy cycles on Earth, this unit will focus on these three cycles along with the broader carbon cycle.
- They will explore the missing pieces in the *Matter and Energy Cycles Research* activity.

5. Use the *Cycle Diagram Quiz* to assess students' understanding of the main concepts covered in the *Tracking Carbon to Understand its Flow* lesson.

- Distribute the *Cycle Diagram Quiz* to each student. Students should complete this assessment individually, but they can use their model cycle diagram for help.

Tip

Step 2: *InTeGrate* is a great resource for information about teaching systems thinking.

Tip

Step 3: Allow students creative freedom in this step. Their models don't necessarily need to include circles; they could divide the paper into quadrants or any other creative way to show the four reservoirs that makes sense to them. The goal is to help them create an effective mental model. Let them try a free-form creative approach.

Note that the biosphere is not entirely based on land but also includes living things in the ocean, and that the hydrosphere is not entirely located in the ocean but also includes water on land and in the atmosphere.

Informal Assessment

Collect and review the *Cycle Diagram Quiz* to assess students' understanding of the main concepts covered in this lesson. The *Cycle Diagram Quiz Answer Key* is provided.

Extending the Learning

Useful readings to help students cement and expand their understandings about the topics discussed in this activity are the *Earth's Systems* article, and the *Carbon Cycle*, *Biosphere*, *Hydrosphere*, *Atmosphere*, and *Lithosphere* encyclopedic entries.

You could assign these readings as homework or use additional class time to include them.

OBJECTIVES

Subjects & Disciplines

Earth Science

Learning Objectives

Students will:

- Utilize the skill of information modeling to help determine their current understanding of a complex process and highlight remaining questions.
- Understand that Earth's systems can be represented in one way with four major reservoirs: the lithosphere, hydrosphere, biosphere, and the atmosphere.
- Understand that carbon moves through these reservoirs via many different processes.

Teaching Approach

- Project-based learning

Teaching Methods

- Brainstorming
- Discussions
- Inquiry

Skills Summary

This activity targets the following skills:

- 21st Century Themes
  - Environmental Literacy
  - Global Awareness
- Critical Thinking Skills
  - Applying
  - Creating
  - Evaluating
  - Remembering
  - Understanding
- Science and Engineering Practices
  - Developing and using models

National Standards, Principles, and Practices

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

• **CCSS.ELA-LITERACY.SL.7.1:**
Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on Grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly.

NEXT GENERATION SCIENCE STANDARDS

• **Crosscutting Concept 4:**
Systems and system models
• **Crosscutting Concept 5:**
Energy and matter: Flows, cycles, and conservation
• **ESS2.A: Earth Materials and Systems:**
All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. This energy is derived from the sun and Earth’s hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth’s materials and living organisms.   The planet’s systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth’s history and will determine its future.
• **MS-ESS2-1:**

Develop a model to describe the cycling of Earth’s materials and the flow of energy that drives this process.

- **Science and Engineering Practice 1:**

Asking questions and defining problems

- **Science and Engineering Practice 2:**

Developing and using models

Preparation

What You'll Need

MATERIALS YOU PROVIDE

- Colored markers or pencils
- A set of 6-10 carbon-containing common objects for each student pair or team. Examples include: a rock, bottle of water, piece of plastic, shell, feather, carbon dioxide in a can of soda (tell them to classify the bubbles, not the can), leaf, flower, a piece of cotton fabric, piece of coal or Vaseline or other fossil fuel-based product, a piece of limestone, chert, marble, and a piece of wood.

PHYSICAL SPACE

- Classroom

SETUP

Overall

Ideally, tables or desks should be grouped together to help facilitate collaboration with the physical objects and on the visual diagram.

Step 1

- Each group does not need to have the exact same objects, but each group should have sufficient diversity of objects to convey that most common objects contain carbon.
- Depending on students' prior knowledge, they may or may not need a reminder of or introduction to what carbon is (an element from the Periodic Table, a non-metal, a building

block of life) and that, due to the law of conservation of matter, there is a finite amount of carbon on Earth.

GROUPING

- Small-group work

BACKGROUND & VOCABULARY

Background Information

Carbon is one of the most abundant elements in the universe and, on Earth, it is contained in the biosphere, the atmosphere, the hydrosphere, and the lithosphere. Carbon moves through these four reservoirs in slow and fast cycles, and many Earth systems keep it all in balance, preventing too much carbon from being moved from one reservoir into another. This complex system is impacted by human activities, which in turn impacts the functioning of various systems on Earth, creating a feedback loop which alters the carbon cycle as well.

Prior Knowledge

["Students should be familiar with the fact that carbon is an element on the Periodic Table, an atom that bonds with other atoms to form various compounds.","Students should understand the law of conservation of matter and the idea that atoms and, in this case, carbon atoms are not created or destroyed on Earth under normal conditions. Thus the amount of carbon on Earth is finite."]

Recommended Prior Activities

- Putting the "Fossil" in Fossil Fuels
- Researching Fossil Fuels

Vocabulary

Term	Part of Speech	Definition
atmosphere	*noun*	layers of gases surrounding a planet or other celestial body.
biosphere	*noun*	part of the Earth where life exists.

Term	Part of Speech	Definition
carbon cycle	*noun*	series of processes in which carbon (C) atoms circulate through Earth's land, ocean, atmosphere, and interior.
hydrosphere	*noun*	all the Earth's water in the ground, on the surface, and in the air.
lithosphere	*noun*	outer, solid portion of the Earth. Also called the geosphere.
process	*noun*	continuous action, operation, or series of changes taking place in a defined manner.
reservoir	*noun*	large, concentrated supply or reserve.
system	*noun*	collection of items or organisms that are linked and related, functioning as a whole.

For Further Exploration

Articles & Profiles

- NASA Earth Observatory: The Carbon Cycle
- National Geographic: Atmosphere
- National Geographic: Biosphere
- National Geographic: Hydrosphere
- National Geographic: Lithosphere