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Instructors Guide: Carbon Fluxes in Arctic Headwater Streams

Part I introduces key concepts related to Arctic carbon fluxes, including permafrost's role, headwater streams' importance, and the significance of this topic in climate change research. It includes background information, a section on stream classification using Strahler numbers, and challenge questions to encourage critical thinking. This section also features a "Meet the Scientist" segment, highlighting the work of researcher Macall Hock.

Part II consists of a lab activity where students analyze hydrological data from different Arctic seasons (snowmelt, Arctic summer, and late season). Students are asked to graph data on stream flow rates, photosynthetic light levels, and temperature fluctuations. They then interpret this data to understand how these factors influence carbon fluxes in Arctic streams. The lab concludes with a structured analysis and a CER (Claim, Evidence, Reasoning) exercise to reinforce scientific thinking and writing skills.

Part III - In this part of the lesson, students are asked to create a visual representation that captures the key concepts about carbon fluxes in Arctic headwater streams. The goal is for students to demonstrate their understanding of the complex processes occurring in these unique environments. The sketch is meant to be a conceptual drawing, not a scientific illustration. Students should focus on conveying the main ideas about carbon fluxes in an informative and visually appealing way.

The reflection questions encourage students to consider how their visualization helps explain the concept of carbon fluxes, what challenges they faced in representing the complex interactions, and how they might modify the sketch to show the potential impacts of climate change.

Overall, this part of the lesson allows students to synthesize their understanding of Arctic carbon dynamics through a creative visual representation.

This resource offers a blend of theoretical knowledge and practical application, aiming to engage students in understanding complex environmental processes while developing their analytical and scientific reasoning abilities.

Procedure: This is based on a 45-minute class period. Modify as needed.

Day 1: Introduction to Carbon Fluxes in the Arctic

1. Hook/Engage Students
   - Start with an engaging question: “How can the Arctic, one of the coldest places on Earth, influence global climate change?”
   - Show a short video clip or series of images about the Arctic's rapid environmental changes due to global warming. Highlight permafrost thaw and its role in carbon emissions.
   - Ask students to brainstorm how carbon in the Arctic could affect the rest of the world. Write their ideas on the board.

2. Introduce Key Vocabulary and Concepts:
Distribute the handouts or display them digitally. Using the "Background" section of the handout, guide students through key vocabulary terms (carbon fluxes, permafrost, methane, feedback loops, etc.).
- Have students annotate these terms in their notebooks as they read through the first section of the handout.

3. Discussion of Carbon Fluxes:
- Lead a class discussion on how carbon moves through the environment (terrestrial to aquatic systems) and how climate change can accelerate these processes in the Arctic.
- Use the challenge question: “How do carbon fluxes in Arctic headwater streams illustrate feedback loops in the global climate system?”
- Ask students to reflect on their answers and jot down initial thoughts in their notebooks.

Day 2: Meet the Scientist and Start Data Analysis
1. Meet the Scientist:
- Introduce students to Macall Hock (featured in the handout). Share her research focus on Arctic carbon cycling and watch the short video linked in the handout.
- Discuss the importance of scientific research in understanding climate change and its applications to global conservation strategies.

2. Data Analysis Introduction:
- Explain that students will now analyze real-world data about carbon fluxes from Arctic headwater streams. This data will help them understand the seasonal changes affecting carbon dynamics.
- Introduce the three seasonal periods (Snowmelt, Arctic Summer, Late Season) and the key variables: stream flow rates, photosynthetic light levels, and temperature fluctuations.

3. Graphing Activity Part I:
- Distribute the provided data sets (either printed or digital) on stream flow rates, photosynthetic light levels, and temperature.
- Instruct students to create a multi-line graph comparing these variables across the three seasons.
- Homework/Extended Activity: Students complete their graphs at home or in small groups if they don’t finish during class.

Day 3: Graphing Analysis and Discussion
1. Graphing Activity Part II:
- Have students finalize their graphs, using either Google Sheets, Excel, or graph paper.
- Ensure students use different colors for each season and label their X and Y axes accurately.

2. Graph Analysis Discussion:
- Guide students through interpreting their graphs. Use the following questions to prompt discussion:
  - “How do stream flow rates vary across the seasons?”

- "What trends can be observed in photosynthetic light levels, and how do they affect carbon fluxes?"
- "How do temperature fluctuations influence the carbon movement in Arctic streams?"
- Students should jot down their observations and begin answering analysis questions from the handout.

3. Group Analysis:
- Have students form small groups to compare their graphs and discuss the conclusions they've drawn so far. Each group can share insights with the class.

Day 4: Conclusion and CER Writing
1. CER Writing:
- Instruct students to write a Claim-Evidence-Reasoning (CER) statement based on their graph and data analysis. The prompt: "What are the key factors influencing carbon fluxes in Arctic headwater streams?"
  - Claim: A statement identifying the main factor(s) that influence carbon fluxes.
  - Evidence: Use specific data points from their graph and analysis to support the claim.
  - Reasoning: Explain how and why these factors affect the carbon fluxes, referring to both the data and scientific principles learned.

2. Share and Critique CER:
- Have students swap their CERs with a peer for review. They can offer feedback on whether the evidence supports the claim and if the reasoning is logical.
- Allow students to revise their CER statements based on feedback.

Day 5: Carbon Flux Sketch and Final Reflection
1. Sketch Activity:
- Guide students in creating a visual representation (sketch) of carbon fluxes in Arctic headwater streams, as described in Part III of the handout.
- The sketch should include:
  - A headwater stream, the surrounding tundra, permafrost layers, and the atmosphere.
  - Arrows showing the movement of carbon between these components.
  - Representations of the three seasons (Snowmelt, Arctic Summer, Late Season) with stream flow rates, sunlight intensity, and temperature variations.
- Allow students to work independently or in small groups.

2. Reflection and Conclusion:
- Ask students to reflect on the following questions:
- "How does your sketch help explain carbon fluxes in the Arctic ecosystem?"
  - "What were the biggest challenges you faced in representing the complex interactions in the system?"
  - "How might climate change further affect these carbon fluxes?"
- Conduct a class discussion, or have students write a brief reflection in their notebooks.

3. Optional Gallery Walk:
- Organize a gallery walk where students display their sketches around the room and observe

others' work. Encourage students to leave comments or questions on sticky notes.

Assessment and Reflection:
- Assess students based on their:
  - Graphs and data interpretations
  - CER writing and reasoning
  - Carbon flux sketches
  - Participation in discussions and group work
- Use the rubrics provided in the handout to evaluate scientific accuracy, labeling, and presentation.

Student Reflection on Learning:
Exit Tickets:
"What are the most important things you learned about carbon fluxes in Arctic headwater streams?"
"How has your understanding of the Arctic's role in global climate change changed?"
"What challenges did you face during the graphing or sketching activities, and how did you overcome them?"
"How do you think you could apply the skills you learned in this lesson to real-world environmental issues?"
"What's one key concept you learned today, and how does it connect to the real world?"

Assessment of Learning Objectives:
Graphing Activity: Review the students' graphs for accuracy. Did they correctly interpret the data on stream flow, photosynthetic light, and temperature across the seasons? Check for proper scaling, labeling, and the use of different colors for each season.
CER Statements: Assess students' CER statements to determine whether they can make a strong claim based on evidence from their data analysis. Evaluate how well they connect their evidence to the claim using scientific reasoning.
Carbon Flux Sketches: Use the rubric in the PDF to assess the accuracy and detail of the students' sketches. Do the sketches correctly understand carbon movement in Arctic headwater streams? Are the seasonal variations and feedback loops represented?