

Endeavor

STEM Teaching Certificate Project



Sphere Lesson 1: Moving through the Carbon Cycle

Grade(s): 9-12

Lesson Duration: Class 90minutes

Course Name(s): Biology I/Sheltered Biology

Lesson Author: Nashville, TN

The premises behind this lesson in the exploration of the cycling of matter and the flow of energy through Earth's systems are given keen attention. Students play a crucial role in this exploration, focusing on how carbon moves among the atmosphere, biosphere, hydrosphere, and geosphere. Their active participation will lead to a deeper understanding of the impact that biotic entities have on these cycles and the further influences they exert in each sphere.

Students' investigation of how carbon moves among these three spheres will lend itself to the use of specific NASA resources, such as MOPITT (Measurements of Pollution in the Troposphere), which tracks carbon monoxide as a tracer for carbon movement, and the NASA Earth Observations (NEO) portal, which provides visualizations of atmospheric CO₂ concentrations and vegetation indices.

With the overall goal of having students examine datasets, they can analyze and disaggregate the cause-and-effect relationships within the carbon cycle. The real-world relevance of their learning, including processes such as photosynthesis, respiration, decomposition, and combustion, will keep students engaged and interested in the lesson.

EDUCATION STANDARDS

Science Performance Expectations (or state Science standard): HS-LS2-5 *Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.*

Science and Engineering Practices:

Disciplinary Core Ideas:

Crosscutting Concepts:
Systems and System

<p>Developing and Using Models Modeling in grades 9–12 builds on K–8 experiences. It progresses to using, synthesizing, and developing models to predict and illustrate how relationships among variables within systems and their components in the natural and designed worlds.</p> <p>Develop a model based on evidence to illustrate the relationships between systems or components of a system.</p>	<p>LS2.B: Cycles of Matter and Energy Transfer in Ecosystems</p> <ul style="list-style-type: none"> Photosynthesis and cellular respiration are critical components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. <p>PS3.D: Energy in Chemical Processes</p> <ul style="list-style-type: none"> The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. (secondary) 	<p>Models</p> <ul style="list-style-type: none"> Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.
<p>Common Core State Standards:</p> <p>Math:</p> <p><i>Mathematics -</i></p> <p><u>Reason abstractly and quantitatively.</u> (HS-PS1-5),(HS-PS1-7)</p> <p><u>Model with mathematics.</u> (HS-PS1-4),(HS-PS1-8)</p> <p><u>Use units as a way to understand problems and to guide the solution of multi-step problems;</u></p>		

choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)

Define appropriate quantities for descriptive modeling. (HS-PS1-4),(HS-PS1-7),(HS-PS1-8)

Select a level of accuracy that is appropriate to the limitations of measurement when reporting quantities. (HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)

ELA:

ELA/Literacy -

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3),(HS-PS1-5)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2),(HS-PS1-5)

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3),(HS-PS1-6)

WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3)

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4)

State Math or ELA Standards: N/A

ITEEA Standards: N/A
Other Standards: N/A

MEASURABLE STUDENT LEARNING OBJECTIVES

Students will construct and analyze models using data from NASA systems, such as MOPITT and NEO, to demonstrate how carbon moves through the atmosphere, including photosynthesis, respiration, and other biogeochemical processes that sustain life.

EL Focus Support: Students will use evidence from NASA datasets (MOPITT and NEO) to explain in writing or orally how carbon movement and photosynthesis interact within Earth's biogeochemical systems.

MATERIALS NEEDED

Digital and Data Tools

The NASA MOPITT data portal for analyzing atmospheric CO and CO₂ as tracers of carbon movement.

<https://www.earthdata.nasa.gov/missions/mopitt>

NASA NEO (Earth Observations) to visualize vegetation index, CO₂ concentrations, and global temperature changes.

<https://neo.gsfc.nasa.gov/>

Hands-on Lab

Clear plastic bottles, aquatic plants, aquatic snails, and CO₂ sensors, or bromothymol blue, to model carbon exchange.

Digital thermometers for small-scale simulations.

Soil samples and mineral test kits

Instructional Materials

Student Data sheets for graphing and recording observations.

Modeling Worksheets to map CO₂, photosynthesis rate, temperature, and soil health

Student computers.

ENGAGING CONTEXT/PHENOMENON/ REAL-WORLD CONNECTIONS FOR STUDENTS

Students will watch how carbon moves through the air over North and South America using NASA satellite data. They'll notice how carbon levels change with the seasons and connect what they see to how plants, animals, and the atmosphere interact through the carbon cycle.

<https://youtube.com/shorts/HqMueYOLilo?si=IXE9NjmtnVktz5jZ>

DATA INTEGRATION

Students will integrate data using real-world NASA datasets to explore the movement of carbon and its relationship to life

processes and climate systems. Through analyzing authentic satellite data, students develop an evidence-based understanding of how carbon cycles through Earth's systems and how human activities can alter this balance. With hands-on experience, students will create their own comparable data sets to validate the correlation.

TEACHER'S BACKGROUND KNOWLEDGE

The teacher needs to be familiar with the previous standards/instructions, as students will be engaging with biogeochemical cycles, which include understanding HS-PS1 Matter and its interactions, MS-PS3 Energy, and MS-LS1 From Molecules to Organisms: Structures and Processes.

DIFFERENTIATION OF INSTRUCTION

This lesson is designed to be inclusive, accessible, and engaging for diverse learners through multiple means of representation, engagement, and expression. To enhance the experience for content comprehension, multimodal representations of data from NASA datasets and visualizations (MOPITT, NEO, SPHERES) will be used, incorporating interactive maps, graphs, and short videos. This will enable students to identify patterns rather than relying solely on text-heavy data tables.

Pre-teaching vocabulary with the use of sentence stems and using cognates and sentence frames for Multilingual Students, EE students, and those who lack background knowledge. Another accommodation is using language objectives aligned to ELPA 21 standards and offering graphic organizers for students to make connections between content and phenomena.

POSSIBLE PRIOR or MISCONCEPTIONS

With the varied science experiences and content knowledge, some common misconceptions may be encountered throughout the duration of the lesson.

Misconception	Clarification/Strategy
Carbon only exists in living things.	Using data from NEO and SPHERE, map the movement of carbon in these abiotic systems.
Plants only take in oxygen and release CO ₂	Reinforce that during photosynthesis, plants take in CO ₂ and release O ₂ , but during respiration, they also release CO ₂ . Use graphic organizers and models to illustrate movement.
Human activities do not significantly change global carbon levels	Utilize historical data from NASA's NEO to demonstrate the measurable human impact over time.

LESSON PROCEDURE

5E	Details of 5E Lesson Implementation (Visit BSCS to learn more about the 5E instructional model)
Engage	<p>Lesson Objective HS-LS2-5: Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere</p> <p>Standards Addressed LS2.B: Cycles of Matter and Energy Transfer in Ecosystems: Photosynthesis and cellular respiration are critical components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.</p>

	<p>Materials & Resources: https://youtube.com/shorts/HqMueY0Lilo?si=IXE9NjmtnVkTz5jZ</p> <p>Procedure: Students will work in partner groups to analyze and determine how and why the carbon is moving in the direction over the western hemisphere. They will use thinking maps (flow maps to identify the cause.</p> <p>Formative/Summative Assessments: This will be a formative assessment of students' knowledge and understanding. Using Mentimeter to record responses, we will then create a word cloud to identify patterns in student thinking.</p> <p>Modifications: Thinking Maps for organizing thoughts, probing questions specifically designed for students at varying performance levels. Intentional grouping, sentence frames, and starters.</p>
<p>Explore</p>	<p>Lesson Objective: Develop a model based on evidence to illustrate the relationships between systems or components of a system.</p> <p>Standards Addressed: HS-LS2-5 <i>Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.</i></p> <p>Materials & Resources: Clear plastic bottles, Aquatic plants(elodea), Aquatic Snails CO₂ sensors or bromothymol blue to model carbon exchange.</p> <p>Digital thermometers for small-scale simulations.</p> <p>Soil samples and mineral test kits</p> <p>Procedure: The students will build a physical model and monitor how Carbon Dioxide moves through the spheres, specifically the exchange between the atmosphere and other spheres, and the interaction between biotic and abiotic sources.</p> <p>Formative/Summative Assessments This will function as the first portion of the summative assessment for this two-step endeavor. The data sheets that students will use to monitor the change in the CO₂ levels when different elements are either added or subtracted. They will use the data collected here as a comparative measure for the historical data they will obtain from NASA websites.</p> <p>Modifications are like those used in the first step of engagement, with the addition of labeled visual charts to help students connect the tools of discovery to anticipated actions.</p>
<p>Explain</p>	<p>Lesson Objective: Students will construct and analyze models using the data from NASA systems such as MOPITT and NEO to demonstrate how carbon moves</p>

through the atmosphere, photosynthesis, respiration, and other biogeochemical processes that sustain life.

Standards Addressed: HS-LS2-5 Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.

LS2.B Cycles of Matter and Energy Transfer in Ecosystems (Photosynthesis and cellular respiration are critical components of the carbon cycle.

Materials & Resources: Modeling Worksheets to map Carbon, photosynthesis rate, temperature changes, and soil. Students will need data sheets for graphing and recording observations on their student computers.

Procedure: During this phase of the lesson, the teacher will facilitate a class discussion. The teacher will guide students to compare their data (from the aquatic plant/snail models in Explore) to the real-world concentration data from the NASA NEO portal.

The teacher will prompt students to use their modeling worksheet to formally label and define the processes (photosynthesis, respiration, decomposition, combustion) and map the movement of carbon among the four spheres.

Formative/Summative Assessments: Students will scan or take a picture of their completed data and upload it to the school's learning platform as a Summative Assessment. As another formative assessment, there will be a quick write. Explain how photosynthesis and respiration act as opposing forces in regulating levels in the atmosphere."

Modifications: Provide a graphic organizer (such as a flow chart or concept map) for students to trace the path of carbon, connecting their model observations to formal terminology. Use sentence starters for the Quick Write for Multilingual Students.

Elaborate

Lesson Objective: Students will use evidence from NASA data sets (MOPITT and NEO) to explain in writing or orally how carbon movement and photosynthesis interact within Earth's biogeochemical systems.

Standards Addressed HS-LS2-5: Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere

Materials & Resources: NASA MOPITT data portal to analyze atmospheric and trace gases *for carbon movement*. NASA NEO visualizations. Student Computers.

Procedure: The teacher will introduce the NASA program, which tracks carbon movement as a tracer. The instructor will provide students with historical data from NEO and compare it to vegetation indices or global temperature.

Students will investigate the following concept: "Human activities do not significantly change global carbon levels" by utilizing historical data from NASA's NEO.

	<p>Formative/Summative Assessments Research Project (WHST.9-12.7): Students write an argumentative paragraph or short essay using evidence from multiple authoritative sources (NASA data and text) to support the claim that Human activities significantly impact the carbon cycle</p> <p>Modifications: Provide a scaffolded outline for the argumentative paragraph. Pre-teach vocabulary and key concepts for the NASA datasets. Intentional grouping to <i>promote peer collaboration</i></p>
<p>Evaluate</p>	<p>Lesson Objective: Students will construct and analyze models... to demonstrate how carbon moves through the atmosphere, photosynthesis, respiration, and other biogeochemical processes</p> <p>Standards Addressed HS-LS2-5: Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the four spheres</p> <p>Materials & Resources: Digital media and presentation tools. Student Data Sheets and Modeling Worksheets from previous phases</p> <p>Procedure: The teacher will provide a rubric for the final product, which should integrate data and model development.</p> <p>Students synthesize their learning into a final presentation or model. This could be a physical model with a narrative explanation, a digital presentation (SL.11-12.5), or a comprehensive, labeled diagram (RST.9-10.7). The model must illustrate the role of photosynthesis and cellular respiration in the cycle of carbon and explicitly show how carbon moves among all four spheres using evidence from both their hands-on lab and the NASA datasets</p> <p>Formative/Summative Assessments</p> <p>The final Model/Presentation. The model's key components will be evaluated: 1) Accuracy in showing carbon movement (e.g., photosynthesis uptake, respiration release). 2) Correctly labeling all four spheres. 3) Evidence-based analysis using their collected lab data and the NASA datasets.</p> <p>Modifications: Allow students to choose their mode of presentation (digital slide deck, narrated video, poster, or written report) to address different learning styles and strengths. Offer a tiered rubric for students at varying performance levels.</p>

REFERENCES

