

Cassandra Williams- Socioscientific Issues Unit plan Climate Science Summer 2022

Topic and Background Information:

Prior to this unit based on the carbon cycle simulation and connection to climate change, students have learned about the hydrologic cycle as the intro to biogeochemical cycles. This follows ecosystems, which includes the flowing of energy through abiotic and biotic factors beginning with the sun

We begin the year introducing carbon as an element in the Periodic Table. Most students already have the knowledge that we breathe out carbon dioxide but cannot quite connect it to the element carbon. We spend the first part of the year using the periodic table to work toward the Law of Conservation of Matter. Next, students learn about ecosystems and thus how energy flows and matter cycles. This lasts most of the year for us so we are able to look at how energy flows using photosynthesis and cellular respiration. This leads to the components of ecosystems. Then we look at the Earth as an interconnected system of spheres. Finally, biogeochemical cycles allow us to look at how both the Law of Conservation of Energy and the Law of Conservation of Matter work in ecosystems. We begin with the hydrologic cycle as students have basic prior knowledge of its processes. This helps introduce the terms “reservoirs or sinks” and “flows” The carbon cycle comes next and leads us into human influence on the spheres and thus climate change.

I have taught the carbon cycle as part of the biogeochemical cycles (big idea- matter cycles and energy flows) the past three years in a middle school 6th grade comprehensive science class. Each year I have improved the lesson however, it is still missing so much and needs to be a mini-unit within the larger BGC cycles and Spheres. Using what we have learned in this class thus far, I am excited to have this opportunity to deepen, refine, and improve the carbon cycle lessons I have done previously. My goal is to connect all the learning from the year to climate change. This unit plan assignment will help me tie all these pieces together to form a socioscientific lesson.

Two areas I was not able to fit in or flow well with the below mini-unit would be the carbon footprint and developing the skill of argumentation. I would thus use those as my next two lessons/activities. I have found the carbon footprint often difficult for sixth graders and have not had success finding a link that would be able to accurately calculate their footprint. This year I made it extra credit to facilitate discussion with adults at home. This year it will be an assignment. I have placed the calculator we used in week 4 on part of this unit, but it will be best to have its own lesson. I can then provide more explicit instruction on what it is, how we compare to other countries and time for reflection on lifestyle choices.

Further, in reading about SSI lessons and teaching kids how to speak to each other for different purposes, I want to develop a lesson using argumentation. I understand argumentation about climate change to be persuasive in nature and not debating over it. I will develop a cumulative assessment lesson on BGC cycles. I am still brainstorming the specifics but the desired outcome would be for students to have the choice of one of the BGC cycles (we mostly only get to hydrologic and carbon, but some years nitrogen too) and develop a persuasive/argument for climate change. In seeing how difficult it must be to bridge these topics with younger students, I believe I would make the product that students would design be a book (paper or book creator, etc..) or podcast explaining carbon and its cycle to an audience of elementary students, 2-4th grades. An example of a video that would be an example for them would be Mark Rober and Bill Gates exploring non-meat products [linked here.](#)

Data/Resources/Sources Integrated:

Source showing an example of Thomas's demo from this class as inspiration for the engage phase- <https://youtu.be/VYw2csiBngY>

Carbon demos (carbon dioxide in soda and burning ethanol) with video derived from <https://carbontime.create4stem.msu.edu/systems-and-scale/activity-3.1>

Week 4 text on misconceptions Page Keely

Week 4 links to videos

Source from class discussion week 5 used to refine carbon cycle game- <https://mare.lawrencehallofscience.org/curriculum/climate-data-aclipse-activities>

Source of carbon cycle games from Kesler Science, Science lessons that rock, and Chalkduster via teachers pay teachers over the past couple years. I designed the sheet linked in the Explore phase of this plan, but have used pieces of the above lessons to put together the cards at each station/reservoir. Each sink is labeled and has six options for carbon movement within it.

Carbon Cycle Raft Rubric I developed using information and rubric examples in the book: Wiggins, G. & McTighe, J. (2011). The understanding by design guide to creating high-quality units. Alexandria, VA: ASCD. ISBN: 9781416611493

Conceptual model idea from week 5 text

[https://www.aft.org/ae/winter2019-2020/shepardson_hirsch?
_ga=2.49938147.41113087.1591593300-594186060.1591241193](https://www.aft.org/ae/winter2019-2020/shepardson_hirsch?_ga=2.49938147.41113087.1591593300-594186060.1591241193)

and NGSS SEP 2 student actions <https://ngss.sdcoe.net/Dimensions-of-the-NGSS/Scientific-and-Engineering-Practices/SEP2-Developing-and-Using-Models>

Standards identified from NGSS. Then copied and pasted from JeffCo Public Schools Intranet (Bridge to Curriculum) for Middle school Science.

Anchoring Ideas/Statement of Purpose:

- Matter (carbon) cycles through Earth's system of interconnected spheres.
- Matter cannot be created or destroyed, only changed. Where does it go and how does carbon change as it cycles?
- Carbon is essential for energy, from the micro to the macro level of ecosystems.
- Humans affect the carbon cycling through the spheres and thus climate change.

Standards: From the state of Colorado (JeffCo Intranet Curriculum and NGSS)

Disciplinary Core Ideas:

MS.LS2.A: Interdependent Relationships in Ecosystems and MS.LS2.B Cycles of Matter and Energy Transfer in Ecosystems

How do organisms obtain and use the matter and energy they need to live and grow? How do food and fuel provide energy?

Students will understand that matter and energy flow through different organizational levels — organisms, populations, communities, and ecosystems—of living systems, and that chemical elements are recombined in different ways to form different products. The result of these chemical reactions is that energy is transferred from one system of interacting molecules to another. (Boundary: Further details of the photosynthesis process are not taught at this grade level.)

How and why do organisms interact with their environment and what are the effects of these interactions?

Organisms and populations of organisms are dependent on their environmental interactions both with other living things and with nonliving factors. Growth of organisms and population increases are limited by access to resources. In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.

How do matter and energy move through an ecosystem? What happens to ecosystems when the environment changes?

Transfers of matter into and out of the physical environment occur at every level. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. Also, ecosystems are dynamic in nature; their characteristics can vary over time and its biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. Ecosystems with a wide variety of species—that is, greater biodiversity—tend to be more resilient to change than those with few species.

Standard 2: Life Science

- GLE 3: Sustaining life requires substantial energy and matter inputs.
 - o EO a: Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. (MS-LS1-6) (*Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.*) (*Boundary Statement: Does not include the biochemical mechanisms of photosynthesis.*)
 - o EO b: Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. (MS-LS1-7) (*Clarification Statement: Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.*) (*Boundary Statement: Assessment does not include details of the chemical reactions for photosynthesis or respiration.*)

- GLE 5: Organisms and populations of organisms are dependent on their environmental interactions both with other living things and with nonliving.
 - o EO a: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. (MS-LS2-1) *(Clarification Statement: Emphasis is on cause - and - effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.)*
 - o EO b: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. (MS-LS2-2) *(Clarification Statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.)*

GLE 6: Ecosystems are sustained by the continuous flow of energy, originating primarily from the sun, and the recycling of matter and nutrients within the system.

- *EO a: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. (MS-LS2-3) (Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.) (Boundary Statement: Assessment does not include the use of chemical reactions to describe the processes.*
- GLE 7: Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem.
 - o EO a: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. (MSLS2-4) *(Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.)*

MS.ESS2.A: Earth's Materials and Systems, MS.ESS3.C: Human impacts on Earth's Systems, MS.ESS3.D: Global Climate Change

- Standard 3: Earth and Space Science
 - o GLE 10: Human activities have altered the biosphere, sometimes damaging it, although changes to environments can have different impacts for different living things.
 - EO b: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. (MS-ESS3-4) *(Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources [such as freshwater, mineral, and energy]. Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.)*

Science and Engineering Practice: Interpret and Analyze Data, Constructing Explanations and Designing Solutions • Developing and Using Models

Crosscutting Concepts:

- Cause and Effect: Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.
- Scale, Proportion, and Quantity: In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system’s structure or performance.
- Systems and System Models: Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.
- Energy and Matter: Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems’ possibilities and limitations.

Ocean Literacy Principles

3.E: The ocean dominates Earth’s carbon cycle. Half of the primary productivity on Earth takes place in the sunlit layers of the ocean. The ocean absorbs roughly half of all carbon dioxide and methane that are added to the atmosphere.

3.F: Changes in the ocean-atmosphere system can result in changes to the climate, that in turn, cause further changes to the ocean and atmosphere. These interactions have dramatic physical, chemical, biological, economic, and social consequences

Essential Questions:

- What is Carbon?
- What does carbon have to do with the following?
 - o The Periodic table-
 - o Photosynthesis and cellular respiration
 - o Ecosystems
 - o Earth’s interconnected system of spheres
- What are some of the different places that carbon (in any form) can be found or stored on Earth?
- What are some processes involved in moving atmospheric CO₂ (and other forms of carbon) around Earth?
- What does carbon and the carbon cycle have to do with climate change?
- How can we model carbon movement in our local region or area? What can we do to bring awareness to others about what we have learned

Learning Activities Procedures/Materials/Time Needed:

ENGAGE- Day 1 (one 50 minute class period)

Teacher	Students
1. Bell work task presented: Please get out your notebook and turn to the next open page. Divide it into three sections.	1. Students get their notebooks and complete the bell

<p>1. For each section write the following:</p> <ul style="list-style-type: none"> • Observations • Questions (I wonder...) • Where is the carbon? <p>2. The teacher presents the first of three demos/investigations. Materials: petri dish with ethanol, petri dish with bromothymol blue, digital scale, clear cover that goes over the petri dishes. The teacher lights the ethanol and then covers both petri dishes.</p> <p>3. The teacher has set up materials for the students to complete the next two investigations</p> <ol style="list-style-type: none"> Using the activity Thomas did in Climate Science class zoom June 7th, 2022, present students with the bicycle pump or just the straw and bromothymol blue water in a beaker. Using a modified version of the original activity located at https://carbontime.create4stem.msu.edu/systems-and-scale/activity-3.1, provide students with two petri dishes, soda (one dish is fresh soda and one is flat) and a digital balance. <p>During each activity, the teacher walks around to each group to listen for student discussion (assessing prior knowledge and guiding students with hints.)</p> <p>4. The teacher brings back the initial demo (burning ethanol with BTB present) to see if there are additional observations or questions from those at the beginning of class. (Students most likely at this level do not have the answer to the third question for this one.)</p> <ol style="list-style-type: none"> Show the video linked here (from CarbonTime resource linked above.) Teacher stops video at the prompted times for discussion. When students are finished independently answering the questions and sharing, the teacher facilitates a class discussion using probing questions to assess knowledge and misconceptions. (see misconceptions article from week 4 class discussion for question stems.) 	<p>work task.</p> <p>2. In the first section of their notebooks, the students record their thoughts to the bullet points. No discussion yet on this demo.</p> <p>3. With the provided materials, students are to work with their groups to brainstorm the answers to the three bullets from bell work for each demo/investigation in sections two and three on their notebook page.</p> <p>4. Students first copy the following three questions in their notebooks:</p> <ul style="list-style-type: none"> • Where are the atoms moving? • What is happening to the carbon atoms? • What changes in energy are taking place? <ol style="list-style-type: none"> Before students answer anything, they make additional observations and questions. Students watch and discuss the video with the teacher and class.
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	<p>c. Students answer the above three new questions in the notebooks then pair share with partners and groups.</p>
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EXPLORE- (1-2 50 min class periods)

Teacher	Students																																
<p>1. Presents guiding questions for students to copy as bell work:</p> <ul style="list-style-type: none"> • What is Carbon? • What do we know about carbon from the periodic table? • Where is carbon in Photosynthesis and cellular respiration? • What does carbon have to do with energy in Ecosystems? • What are some of the different places that carbon can be found or stored on Earth? • How does carbon move around Earth? • How do we use carbon in our lives? <p>a. Teacher uses large sticky paper posted around the room (or shared google doc) to write the questions above for all students to see)</p> <p>b. Once all students have copied the chart and written the questions, the teacher reads them aloud as the students listen.</p> <p>2. Teacher directs students to a list of links for research. Doc of links here. (Teacher has flexibility here for differentiation: teacher can assign each student 20 min to work on this</p>	<p>1. Students set up four columns in their science notebooks like below.</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 15%;">Question</th> <th style="width: 15%;">Your guess/ answer</th> <th style="width: 15%;">Final group answer</th> <th style="width: 15%;">What did you add or wonder after the carousel walk?</th> </tr> </thead> <tbody> <tr><td>1.</td><td></td><td></td><td></td></tr> <tr><td>2.</td><td></td><td></td><td></td></tr> <tr><td>3.</td><td></td><td></td><td></td></tr> <tr><td>4.</td><td></td><td></td><td></td></tr> <tr><td>5.</td><td></td><td></td><td></td></tr> <tr><td>6.</td><td></td><td></td><td></td></tr> <tr><td>7.</td><td></td><td></td><td></td></tr> </tbody> </table> <p>Once students have questions written and table constructed, they listen as the teacher reads the questions aloud. Students write answers/guesses in the second column if they can,</p> <p>2. Students are to navigate through the links to finalize their answers in the second column of the table.</p>	Question	Your guess/ answer	Final group answer	What did you add or wonder after the carousel walk?	1.				2.				3.				4.				5.				6.				7.			
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<p>individually, in partners or in groups. It can also be divided up between students or even completed together as a class. The teacher can start this way to model how to watch a link and then see if it has any info to write in the chart.</p> <p>3. When allotted time is up, students pair and share their answers.</p> <p>4. Provide directions for the last steps. All members of the groups share and they work together to develop ONE answer for each question. After time is up, the teacher randomly assigns group members to write their group answers on the large sticky papers or doc. Students are then directed to carousel walk (if on large papers around the room) to read all the groups' answers.</p> <p>5. Directions for students to complete the final column of the chart in their notebooks. If time, choose random students to share how their answers changed or did not change from the beginning of class to the end of class.</p>	<p>3. Students pair and share. They add to their answers in column two if needed.</p> <p>4. Groups now share and must come up with one answer to each question. Students write that answer in their notebooks and one member from each group takes turns to write the group answers on the large sticky papers or google doc for each of the seven questions. Students carousel walk to read all the other groups' answers.</p> <p>5. Students complete the final column "End of class answers."</p>
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EXPLAIN- (2-3 50 min class periods)

Teacher	Students
<p>1. Bellwork question-</p> <ol style="list-style-type: none"> 1. Find your hydrologic cycle in your notebook and identify the sinks and flows with your partner. 2. Next, talk about what forms water has as it moves through the cycle. <p>Teacher uses class discussion to assess knowledge (we covered reservoirs/sinks and flow in the hydrologic cycle</p>	<ol style="list-style-type: none"> 1. Get notebooks and find the hydrologic cycle info. Begin discussing with their partners the two questions.

but need to make sure students remember them.)

–Provide explicit instruction to connect the carbon cycle to the hydrologic cycle by identifying the sinks and flows as well as reminders of the law of conservation of matter. Finish by discussing the different forms of carbon we know of.

2. Explain that we will now use a model simulation to help answer more of our essential questions about carbon. Explain the directions for the carbon cycle game.
 - a. Students are given a recording sheet ([linked here via Google Doc](#)) and a dice. Teacher circulates throughout the game.
 - b. Near the end of the game, the teacher makes a chart on the board (or a shared doc) for students to record their tally marks (how many times they ended up in each station)
 - c. Teacher provides the next step, the game sheet data analysis ([linked here via Google Doc](#).) The purpose of this is first-to practice graphing from real data and secondly for students to see how much time is spent on average in each carbon sink. Teacher facilitates discussion when all class data can be viewed (end of class or next day) so students see that most carbon ends up in our oceans (atmosphere is a close second or tied)
 - d. Teachers provide students with the exit slip questions.
 - In which sink/reservoir did most of your class carbon end up the most?
 - Were you surprised by this? Why or why not?
 - How does the carbon enter the cycle or get out of it?

2. Students listen to directions, help pass out materials, ask questions before they start, etc.
 - a. Students begin at the station that is on their desks. They roll the dice. There are six choices for what happens to the carbon at each of the stations. They record what the directions say happened to their carbon atom at that station.
 - b. When everyone has finished the game, each student records with tally marks on the board how many times they were at each station.
 - c. Students complete graphs for each class that go with the game sheet analysis.
 - d. Exit slip at end of class or following

	<p>data analysis- students answer the following questions, then pair and share.</p>
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ELABORATE- (2-4 50 min class periods)

Teacher	Students
<p>Assigns RAFT assignment to conclude the carbon cycle simulation game. Shows examples and non-examples of assignment expectations in all formats.</p> <p>RAFT assignment Rubric link for RAFT assignment</p> <p>R= Role: Imagine you are the carbon in your story. You have just gone on an adventure.</p> <p>A= Audience: You are telling a story to the other carbon from the Periodic table about your journeys.</p> <p>F= Format: You are going to create a comic, cartoon strip or a travel journal to tell the story of your journey.</p> <p>T= Topic: You are going to explain the processes you experienced as you moved through the cycle.</p>	<ul style="list-style-type: none"> • Review the assignment and rubric with the teacher. • Brainstorm with partners and groups. • Independent work time (1 block or two regular periods.)