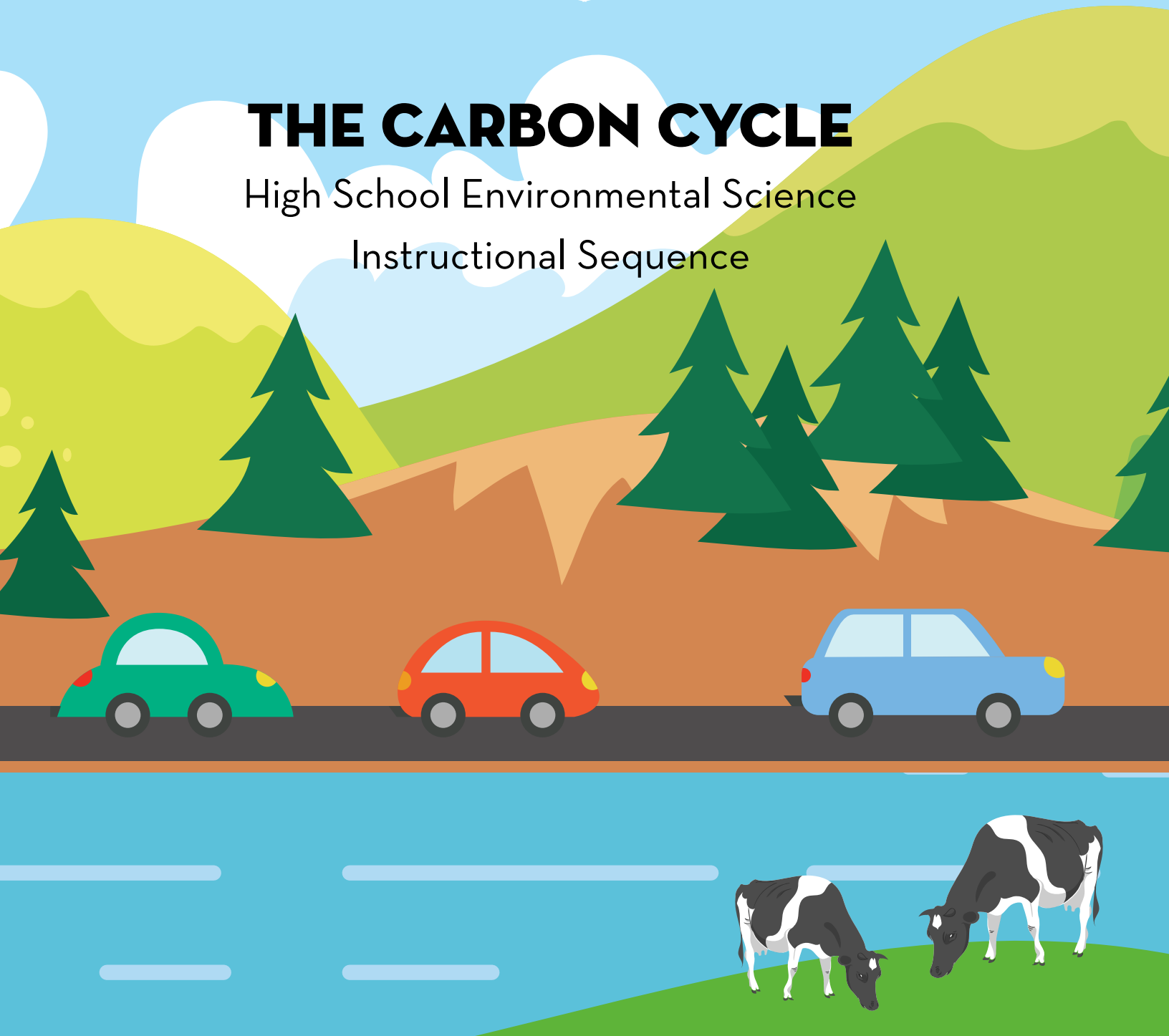
District of Columbia
Office of the State Superintendent of Education

THE CARBON CYCLE

High School Environmental Science Instructional Sequence



This high school environmental science instructional sequence was created to support teaching the Next Generation Science Standards through the Biological Sciences Curriculum Study (BSCS) 5E instructional model. Developed by District of Columbia teachers, these lessons include real-world contexts for learning about environmental science through a lens that encourages student investigation of local issues.

The lessons also support Scope and Sequence documents used by District local education agencies: Unit 1: Ecosystems: Interactions, Energy and Dynamics Advisory 1 and 2

Acknowledgements:
Charlene Cummings, District of Columbia International School

This curriculum resource can be downloaded online:
https://osse.dc.gov/service/environmental-literacy-program-elp

Overview and Goal of the Lesson: In this sequence of lessons, students will go into depth via investigations about what processes drive the carbon cycle. Students are first introduced to the carbon cycle in an interactive game that triggers prior knowledge and touches on how carbon moves through Earth's interconnected spheres. Students then investigate and gather evidence of the carbon transformation that carbon atoms encounter throughout the cycle. Since carbon is seen in students' everyday lives, they will calculate their carbon footprint, calculate ways to deduct their carbon footprint, and trace carbon interaction throughout a typical school day.

Essential Question(s): How are the cycles of matter and energy transferred in ecosystems? What processes drive the carbon cycle?

NGSS Emphasized and Addressed in this Lesson Sequence: Carbon Cycle

PERFORMANCE EXPECTATIONS	SCIENCE AND ENGINEERING PRACTICES	DISCIPLINARY CORE IDEAS	CROSSCUTTING CONCEPTS
HS-LS2-3. Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions. **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.	**Developing and Using Models** • Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show how relationships among variables between systems and their components in the natural and designed worlds. • Develop a model based on evidence to illustrate the relationships between systems or components of a system.	**LS2.B. Cycles of Matter and Energy Transfer in Ecosystems** • Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. **PS3.D. Energy in Chemical Processes** • The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis.	**Systems and System Models** • Models (e.g., physical, mathematical, computer model) can be used to simulate systems and interactions - including energy, matter, and information flows-within and between systems at different scales. Evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Materials

ITEM	QUANTITY	PURPOSE
Dice	7	Carbon Cycle Game (Engage)
Station Signs	7	Carbon Cycle Game (Engage)
Station Movement Directions (before)	7	Carbon Cycle Game (Engage)
Station Movement Directions (after)	7	Carbon Cycle Game (Engage)
Data Record Sheets	1 per student	Carbon Cycle Game (Engage)
Carbon Cycle Game Discussion Questions	1 per student	Engage
Carbon Cycle Graphic Organizer	1 per student	Explore/ Explain
Carbon Footprint Activity Worksheet	1 per student	Elaborate
Colored Pencil (any color)	1 per student	Elaborate
Green Marker	1 per student	Elaborate
Carbon Cycle Storybook Requirements	1 per student	Evaluate
Peer Review Document	2 per student (different depending on student groups)	Evaluate

5E Lesson Sequence

TOTAL DURATION: *14 CLASS PERIODS*

5E MODEL STAGE	DURATION	TEACHER AND STUDENT ACTIONS		NOTES
Engage ***The Carbon Cycle Game***	*One class period*	What Teacher Does	1. Teacher says that today they will play a game in which they will take on a role of how a carbon atom moves. 2. Teacher facilitates the carbon cycle game using the following resource: The Carbon Cycle Game.[1]	Supporting Document 1: Background Information. Teacher can reference this document for background information and other source material about the carbon cycle. Carbon Cycle Game: Students play a game in which they take on the role of a carbon atom moving through the carbon cycle. They will follow their atom randomly through the various levels of the food chain, and through biotic and abiotic processes that make up the carbon cycle. They then answer *discussion questions* based on their experiences in the game. The carbon cycle game option 2 is another option for a stationary carbon cycle game that can be played in groups.[2] This resource contains the procedure for the carbon cycle game, copies of individual board games, discussion questions, and background knowledge of the carbon cycle. Worksheets and documents may need to be modified for student use. Teacher should ensure that students are keeping track of: who visited the most organisms, who completed the most cycles, who completed the longest/shortest cycle, who spent the most time in the atmosphere, etc.

5E MODEL STAGE	DURATION	TEACHER AND STUDENT ACTIONS		NOTES
		What Students Do	1. Students will participate in carbon cycle game and record their progress through the cycle as a carbon atom. 2. Students will answer discussion questions about the game. This can be done with questions adapted as a worksheet or as a whole class discussion.	Supporting Document 2: *Carbon Cycle Game Discussion Questions.* This document includes possible discussion questions that can be modified as a reflection via a worksheet or whole class discussion.
Explore ***Investigating Carbon Transformations***	*Five class periods*	What Teacher Does	1. Teacher asks students to think back to the carbon cycle game and recall as many steps of the cycle that they can. Teacher has students brainstorm examples of carbon transformation in each of those steps. 2. Teacher will pass out the *Carbon Cycle Graphic Organizer* and explain how it will be used to record notes and information about the investigations, readings, and/or videos used to explain the carbon transformations. 3. Teacher will facilitate *investigations* to demonstrate carbon transformations.	Supporting Document 3: *Carbon Cycle Investigations.* In this explore/explain collection of investigations, teachers can choose from the following investigations to demonstrate how carbon transforms as it moves throughout the cycle. This can be done as stations, demonstrations, or whole class investigations, videos, informational texts. Supporting Document 4: *Carbon Cycle Graphic Organizer.* Teacher can modify carbon cycle graphic organizer for student use.
		What Students Do	1. Students will refer back to the carbon cycle game and recall steps. 2. Students will brainstorm examples of carbon transfer in each of the steps. 3. Students will engage in investigations about carbon transfer, record observations, data, and chemical reactions. 4. Students will fill in *graphic organizer* with required information.	
Explain ***What is the carbon cycle*?**	*Five class periods*	What Teacher Does	1. Teacher will facilitate investigations to demonstrate carbon transformations. Investigations are categorized in Supporting Document 3: *Carbon Cycle Investigations*. 2. Teacher will direct students to complete the *Carbon Cycle Graphic Organizer* once applicable investigations have been completed. 3. Teacher will facilitate class discussion of findings for the carbon transformation investigations. 4. Teacher will post chemical formulas of carbon transformations once applicable investigations have been completed.	This portion of the learning cycle alternates with the exploration investigation that the teacher chooses. Once the investigations have been completed, students are to use the *Carbon Cycle Graphic Organizer* to organize information about each step of the carbon cycle. Once each transformation has been investigated, teacher can choose to post chemical formula model and keep a running list along with vocabulary posted. In addition to resources in Supporting Document 1, teacher can reference this resource for background information and chemical formulas for carbon transformations.[3] Short videos that can be used to understand the carbon cycle: NASA's Earth Observatory and ClimateBits.[4, 5]

5E MODEL STAGE	DURATION	TEACHER AND STUDENT ACTIONS		NOTES
		What Students Do	1. Students will engage in carbon transformation investigations as directed. 2. Students will record observations, data, and answer analysis/discussion questions for each carbon transformation investigations. 3. Students will use their observations, background knowledge, and analysis of the investigations for each portion of the carbon cycle and fill in the Carbon Cycle Graphic Organizer. 4. Students will participate in whole class discussion.	
Elaborate ***Calculating my Carbon Footprint***	*One class period*	What Teacher Does	1. Teacher will show short video about how carbon can affect climate: Carbon Footprint Whiteboard animation.[6] 2. Teacher will facilitate turn-and-talk for students to discuss the video that was shown. 3. Teacher will facilitate *Carbon Footprint Classroom Activity*.	Supporting Document 5: *Carbon Footprint Classroom Activity*. This document can be modified for student needs, and includes a student worksheet. Teacher should reinforce that humans can play a positive and negative role in the carbon cycle. Also go over what a carbon footprint is. Teacher can provide discussion questions for turn-and-talk portion of the lesson in order to focus conversation. For the carbon footprint activity if students need to visualize CO_2 emissions this video about New York City can be shown.[7] CO_2 emissions are the most plentiful greenhouse gas emissions caused by human activities. Additional video to provide greater understanding: Geography4Kids.[8] Additional activity: Students can calculate their carbon footprint virtually[9] or with this worksheet.[10] Students can then compare their footprint with the carbon footprint of other nations.[11]
		What Students Do	1. Students will participate in the turn-and-talk discussion about the video. 2. Students will calculate their carbon footprint (part 1) following the provided worksheet. 3. Students will calculate their modified carbon footprints (part 2) following the protocol on the provided worksheet. 4. Student will answer discussion questions on worksheet and share out with the class their observations and findings.	

5E MODEL STAGE	DURATION	TEACHER AND STUDENT ACTIONS		NOTES
Evaluate *Carbon Cycle Story book*	*Two class periods*	What Teacher Does	1. Teacher will say, "Today we are going to check for understanding of the carbon cycle." 2. Teacher will review the protocol for the *Carbon Cycle Storybook* assignment and its requirements. 3. Teacher will divide students into groups to participate in a round robin discussion to present the peer editing review sheets for the storybook. 4. Teacher will circulate around the classroom to help facilitate discussion and peer review document.	Supporting Documents 6 and 7: *Carbon Cycle Storybook* and P*eer Editing Review worksheet*. Teacher should emphasize to students the importance of using learned vocabulary, build from investigations and if necessary, additional research can be conducted to provide greater understanding. This assessment can be modified for students by creating a comic strip or modifying the required amount of carbon interactions. After peer editing round robin session, teacher can have students revise work based on feedback before final submission. The "Praise, Question, and Polish" strategy helps focus student feedback to be constructive. Students provide positive feedback, offer suggestions for revision, and make recommendations intended to improve the quality of text.[12]
		What Students Do	1. Students will draw from experiences, graphic organizer, and research to create a story book that details the carbon cycle via a day in their life. 2. Students will be divided into groups of four and present their story books via a round robin. 3. Students who are not presenting will peer review student presenter's storybook using the peer editing review sheets provided by teacher.	

Footnotes

1 www2.research.uky.edu/pimser/p12mso/pub/LeaPS%20STM%20Units/8th/The%20Carbon%20Cycle%20Game.pdf
2 www.chicagobotanic.org/downloads/nasa/Unit_1_Grades_10-12_Activity_1.1_TheCarbonCycle.pdf
3 www.columbia.edu/~vjd1/carbon.htm
4 https://earthobservatory.nasa.gov/Features/CarbonCycle/
5 www.youtube.com/watch?v=D7ujMCzcVCk
6 www.youtube.com/watch?v=R-pponP15P0
7 www.youtube.com/watch?v=v9cT-tHoXdI
8 www.geography4kids.com/files/cycles_carbon.html
9 http://coolclimate.berkeley.edu/calculator
10 www.teachengineering.org/content/cub_/lessons/cub_whatkindoffootprint/cub_footprint_lesson01_worksheet_v3_tedl_dwc.pdf
11 http://environment.nationalgeographic.com/environment/energy/great-energy-challenge/global-footprints/
12 https://ndhsliteracylinks.wikispaces.com/file/view/PraiseQuestionPolishStrategy.pdf

SUPPORTING DOCUMENTS

Name:_____ Date:_____
Class: _____

Background Reading about the Carbon Cycle

Adapted from: http://on.ny.gov/2Fti7bn

There are many sources of energy in our world. Most energy comes to us either directly or indirectly from the Sun. Solar energy is the original source of most of the energy on Earth. Energy from the Sun heats Earth's surface and the air above it. Sometimes this causes winds. Water evaporated by the Sun forms clouds and rain to give us flowing rivers and streams. Both wind and flowing water are sources of energy.

Through photosynthesis, organisms containing chlorophyll (plants and algae, along with some bacteria and protozoans) convert light energy into chemical energy. This is not a single-step process. During the first part of the reaction, light energy absorbed by chlorophyll is used to split water into hydrogen and oxygen. Most of the oxygen is released into Earth's atmosphere.

water + light energy —> hydrogen + oxygen

During the second phase of the reaction, carbon dioxide from the atmosphere is combined with the hydrogen from the split water molecules. The carbon, oxygen, and hydrogen are combined in the correct proportions to form a simple sugar—glucose.

hydrogen + carbon dioxide —> glucose

The Sun's energy can be stored. Organisms that carry out photosynthesis store energy from the Sun. They do so as long as they produce more food than they need to grow and carry on life processes. Fruits, vegetables, and wood from trees, for example, all contain stored solar energy. This is called biomass energy, from *bio* for "life" or "living." Biomass energy is referred to as renewable because it is produced quickly and is constantly being replaced. However, it takes longer to grow a tree than it does to make use of energy from the Sun directly, as wind and flowing water do.

You need energy to move and think. You also need energy to synthesize new molecules. Some of these molecules are used for growth and repair, while others are used to fight off disease. Every moment of every day, your body needs energy. This energy comes from food molecules such as glucose. Your food can actually be thought of as fuel for your body. In the cells of your body, oxygen from the atmosphere is used to break down food molecules and release the energy stored in them. This process is known as respiration. As the food, such as sugar, is broken down, carbon dioxide and water are released.

oxygen + sugar —> carbon dioxide + water + energy

Plants also respire. At night (during darkness), just like animals, plants use oxygen and release carbon dioxide as they break down sugar for their energy needs. During the day (in sunlight), photosynthesis is going at a faster rate than is respiration. So, during the day, plants release much more oxygen than carbon dioxide. Yet they are still respiring and releasing energy from sugar. Photosynthesis, however, is producing more oxygen than plants require for respiration.

When energy is stored in a material, we refer to that substance as a fuel. Food and wood are biomass fuels. When biomass fuels are old—really old—and have become concentrated through natural events, they are called "fossil fuels." Fossil fuels (coal, oil, and natural gas) are found deposited in rock formations that are millions of years old. Coal was formed from the remains of ferns, trees, and grasses that grew in vast swamps 345 million years ago. When the plants died, they sank below the water and became concentrated at the swamp bottom in layers under conditions that prevented them from reacting with oxygen.

The exact processes that resulted in the formation of coal, oil, and natural gas are not completely understood. It is known that fossil fuels cannot be replaced quickly. In fact, in terms of our lifetimes, they cannot be replaced at all. For that reason, fossil fuels are referred to as nonrenewable resources. It is also known that the energy stored in fossil fuels came originally from the Sun and was captured by plants through photosynthesis. Thus, these fuel molecules contain carbon and oxygen from carbon dioxide and hydrogen from water taken in by plants millions of years ago. When we burn coal, oil, and natural gas, we are putting back into the ecosystems

carbon dioxide and water that were removed from circulation millions of years ago. We are also removing from the atmosphere oxygen that was put there when plants in the ancient swamps split apart water molecules during photosynthesis.

It is important to life on Earth that an appropriate balance of oxygen and carbon dioxide be maintained. The plants provide oxygen and sugars (fuel) for the ecosystems. Both plants and animals provide carbon dioxide and water for the ecosystems. The processes of photosynthesis and respiration support one another. The movement of carbon through photosynthesis and respiration is called the carbon cycle. The burning of fossil fuels and wood is a very important part of the carbon cycle.

References For Background Information

Miller, Kenneth and Joseph Levine. *Biology.* Pearson Education, Inc., Upper Saddle River, NJ, 2003.

Smith, Leo. *Ecology and Field Biology.* 4th edition. HarperCollins Publisher, New York, 1990.

Wright, Richard T. and Bernard J. Nebel. *Environmental Science: Toward a Sustainable Future.* Pearson Education, Inc., Upper Saddle River, NJ, 2002.

www.oaerre.napier.ac.uk/users/p.tett/Env/Ocycle.html provides information about the oxygen cycle.

http://home.nyu.edu/~pet205/biogeochem1.html provides some information about biochemical cycles including both the oxygen and carbon cycles.

http://telstar.ote.cmu.edu/environ/m3/s4/cycleCarbon.shtml supported by Carnegie Mellon as part of their "Environmental Decision Making, Science, and Technology" Web site. This URL links to pages that provide extensive background information on the carbon cycle. There are links to information about the oxygen cycle and energy use.

www.barc.usda.gov/psi/vl/bpdkids/page2.html#oxygen provides information appropriate for use with younger students. A cute illustration of the oxygen cycle and the role of plants is included.

Name:_____ Date:_____
Class: _____

Carbon Cycle Game Discussion Questions

(Adapted from: http://bit.ly/2FEjaIQ*)*
Directions: *Answer questions in complete sentences using your notes and experiences from the carbon cycle game.*

1. What parts of the carbon cycle game did you find surprising? What did you learn from playing the game that you didn't know before? _____
_____
2. In the course of the carbon cycle, are carbon atoms themselves ever created or destroyed? Are carbon atoms ever changed into other kinds of atoms? Are they ever changed into other compounds? Explain. _____
_____
_____
3. What phase changes occur in the state of carbon atoms in the course of the cycle? When are carbon atoms part of a solid, liquid, or gas. _____
_____
_____
4. When are carbon atoms part of something living (biotic)? When are they part of something non-living (abiotic?)? _____
_____
_____
5. Much of the food ingested by each organism is metabolized in cell respiration. Why is this so? _____
_____
_____
6. What happens to carbon atoms as a result of respiration? _____
_____
_____
7. Why is a natural ecosystem not polluted by built up wastes from the various organisms? _____
_____
_____
8. Do you think all possible pathways of carbon were included in this diagram? _____
_____
_____
9. What role did chance play in the carbon cycle game? What role do you think chance plays in the actual carbon cycle? _____
_____
_____

Name:_____ Date:_____

Class: _____

Carbon Cycle Classroom Investigations

1. http://bit.ly/2FBToVe - Students examine the Carbon Movement question and discuss how the balance between photosynthesis and cellular respiration impact the exchange of carbon between the organic biomass pool and the inorganic atmosphere pool.
2. http://bit.ly/2FqnEiG - Students examine fossil fuels in three different ways. The first is through introduction to the Carbon Pools Question, where they examine the different Carbon Pools in the unit. They then zoom in to the fossil fuels pool specifically to learn about (a) the molecular structure of fossil fuels, and (b) how fossil fuels were formed. This provides the foundational information for understanding why fossil fuels burn (they are constructed from organic molecules).
3. http://bit.ly/2FseYbs - Students are introduced to the concept of organic and inorganic carbon pools and review carbon transforming processes that connect the pools.
4. http://bit.ly/2FmgFv7 - Students model the oxidation of glucose ($C_gH_{12}O_6$) to carbon dioxide and water using molecular model kits. They describe this chemical change in two ways: molecular models, and a chemical equation.
5. http://bit.ly/2Icha8Z - Students investigate changes in mass and CO_2 concentration for soda water fizzing. Then they explain results using molecular models and chemical equations to answer the Movement Question and the Carbon Question.
6. http://bit.ly/2p1sonV - Students investigate changes in mass and CO_2 concentration for burning ethanol. Then they explain results using molecular models and chemical equations.
7. http://bit.ly/2DazJGQ - In Part A, students trace the pathway of carbon from the atmosphere into trees where carbon can be stored for hundreds to thousands of years. In Part B, students go outdoors and measure the amount of carbon in a local tree. In Part C, students use molecular model kits and Jmol images to explore how carbon compounds are built and how they are transformed into new carbon compounds as carbon moves through the carbon cycle. In Part D, students learn about combustion, a carbon cycle process that burns fossil fuels. Students analyze graphs and videos to determine if the human activity of burning fossil fuels is changing the chemical composition of the atmosphere.
8. http://bit.ly/2G6pHcS - Students focus initially on a sub-section of Earth's natural carbon cycle related to the biosphere involving the cycling of carbon through the processes of photosynthesis, respiration, and decay. Following that, they study an annotated representation of the full carbon cycle with reservoirs and the processes that drive carbon from one reservoir to others. Finally, students learn about the interconnectedness of the Earth system, feedback loops, and how changes in the carbon cycle lead to other changes in the system.
9. http://bit.ly/2G6pHcS - Students investigate the role of dinosaurs in the carbon cycle and the eventual storage of carbon in the form of chalk. Students discover how the carbon cycle has been occurring for millions of years and is necessary for life on Earth.
10. http://bit.ly/2Flolht - Play this interactive to learn how changing conditions in soil may affect the carbon cycle. Carbon's movement through the environment modifies the temperature of our atmosphere and oceans, provides the structure and fuel for all living organisms, and contributes significantly to the living skin of our Earth. This investigation of soil's role in the carbon cycle illustrates the importance of soil to our ecosystems, and demonstrates how human interactions with soil may affect the carbon cycle.

Informational Texts

- www.cpalms.org/uploads/resources/164528/Article_CarbonCycle.pdf
- www.ck12.org/biology/Carbon-Cycle/lesson/Carbon-Cycle-BIO/?referrer=featured_content
- www.ck12.org/biology/carbon-cycle/lesson/Carbon-Cycle-Basic/?referrer=concept_details
- https://newsela.com/read/lib-nasa-carbon-cycle/id/28120

Videos

- https://youtu.be/syGhnXsx89s
- www.youtube.com/watch?v=KmyBazI1JAQ
- www.youtube.com/watch?v=MFl6PjkAFR4
- www.youtube.com/watch?v=5RAJzjidx80
- www.youtube.com/watch?v=jY4INQCQhoc

Name:_____ Date:_____
Class: _____

Carbon Cycle Graphic Organizer

Steps of the Carbon Cycle	Investigation Description/ Example	Chemical Reaction	How humans impact this part of the cycle in a bad way (include resources used)	How humans impact this part of the cycle in a good way (include resources used)
Respiration				
Combustion				
Photosynthesis				
Death and Decomposition				
Carbon Dioxide in the Atmosphere (CO_2)				
Fossil Fuels				
Food				

Name:_____ Date:_____
Class: _____

Carbon and Water Footprint Classroom Activity

Adapted from: http://bit.ly/2oTMYY1

Overview:

An interactive classroom activity designed to introduce and convey the concept of carbon footprints and environmental consequences to everyday actions.

Goal:

To help students conceptualize resource use and encourage them to take steps to reduce their carbon footprints.

Objectives:

1. Introduce the concepts of water and carbon footprints.
2. Allow students to consider their habits and see for themselves the varying impact their choices have on the environment.
3. Give students the chance to make pledges to change their habits.
4. Engage the students and start a conversation about resource use and conservation.

Materials:

Printouts of the worksheets (Questionnaire, Graph Paper, Block Values, and Reductions)

Colored pencils

Markers (green)

Instructions:

1. Teacher explains instructions and introduces concepts to the class.
2. Students break into groups of two.
3. Students take turns reading each other the questions and recording the answers.
4. Teacher hands out the page with corresponding blocks for each question (Block Values).
5. Students fill out their paper accordingly and compare results with their partners. Carbon blocks are represented by color pencil of choice. (Part 1)
6. Teacher explains the value represented by each block. Next, teacher hands out Reductions page, and partners take turns committing to different reductions and adjusting their paper accordingly (reductions are indicated by green marker drawn over the colored pencil). (Part 2)
7. Students compare and reflect.

Explaining the Concept

Consider all the different "things" you use in your daily life. What you eat for breakfast, the clothes you wear, the desks in the classroom, the car you drive to school—they all come from earth's resources. They're powered and transported by earth's resources, too. An environmental footprint is an annual measure of how much land and water it takes to provide the things we use and consume.

In this activity, we will be focusing on the carbon components of your environmental footprint. It does not attempt to estimate a student's total carbon footprint. Rather, it highlights the impact of certain key lifestyle choices, most of which students can take an active role in changing.

Carbon footprint: In this activity, "carbon footprint" refers to the amount of CO_2 emitted annually from the lifestyle choices included in the questionnaire. Each carbon block represents 200 pounds of atmospheric CO_2. Ten of these blocks equals one ton of atmospheric CO_2. This measurement can be portrayed to students as a large sphere 33 feet in diameter, full of CO_2. This representation comes from this video (http://bit.ly/2DaMmBM), which might help to visualize CO_2 emissions. CO_2 emissions are the most plentiful greenhouse gas emissions caused by human activities.

The instructor may find it necessary to explain the importance of CO_2 emissions as it relates to climate change. Basically, greenhouse gases such as carbon dioxide, methane, and others, are released into the atmosphere at rates far exceeding those of the pre-Industrial era. This influx increases the concentration of greenhouse gases, bulking up the greenhouse effect, which prevents the earth from turning into a ball of ice by trapping in some of the heat from the sun. With too many greenhouses gases, however, more and more heat is trapped, warming the planet and disrupting delicate climatic balances. Scientists believe that once certain temperature thresholds are exceeded, chain reactions (known as "feedback loops") will be set in motion that have far-reaching and sometimes irreversible consequences. The moral of the story is that human-caused greenhouse gas emissions contribute to climate change, which can effect everything from habitat loss and species extinction to rising sea levels, increased intensity of catastrophic weather events, collapse of food systems, and more.

Throughout this activity, there are opportunities for partners to discuss with each other their habits, their impressions of block values and fun facts, and their goals for reductions. Reflection time after the activity can be constructive as well.

Questionnaire

Directions: Mark whichever answer best fits your habits

Does the person who picks you up from school leave the car engine running while they wait?

- ☐ Yes
- ☐ No

How often do you eat red meat (beef, lamb, pork) as the main course?

- ☐ More than once a day
- ☐ Once a day
- ☐ A few times a week
- ☐ Once or twice a week
- ☐ Never

Does your family purchase bottled water?

- ☐ Yes
- ☐ No, I use a reusable water bottle

Do you leave the tap running when you brush your teeth?

- ☐ Yes
- ☐ No

What kind of bags do you use when you go shopping?

- ☐ Plastic bags from the store
- ☐ We bring our own

Which do your family recycle?

- ☐ Plastic
- ☐ Glass
- ☐ Paper
- ☐ Metal
- ☐ None

Block Values (Part 1)

How big are your carbon footprints? Think about how much CO_2 you use each year, only from the activities in these questions. And still, this isn't even close to the size of your actual footprint!

Directions: Follow the instructions given for each choice that you selected.

- Does the person who picks you up from school leave the car engine running while they wait?
  - Yes (+4 carbon blocks)
  - No(0 carbon blocks)

  Leaving your car engine on without driving (this is called "idling") gives off as much CO_2 as when you are driving.
- How often do you eat red meat as the main course?
  - More than once a day(+8 carbon blocks)
  - Once a day (+7 carbon blocks)
  - A few times per week (+5 carbon blocks)
  - Once or twice a week (+4 carbon blocks)
  - Never (0 carbon blocks)

  Meat, especially red meat, uses a lot of water! Eating six fewer hamburgers has the same water footprint impact as choosing not to shower for the whole year. Also, methane gas from cows and pigs make up 18 percent of the world's greenhouse gas emissions, more than all car and plane emissions combined!
- Does your family purchase bottled water?
  - Yes (+1 carbon block)
  - No, use reusable water bottle (0 carbon blocks)

  Plastic water bottles don't have the biggest effect on carbon or water footprints, but they impact the environment in other ways. About 35 billion water bottles are thrown out each year, which would stretch from the East Coast to the West Coast and back 800 times. These bottles often end up in the ocean, where they are toxic to turtles, fish, and other sea creatures.
- What kind of bags do you use when you go shopping?
  - Plastic bags from the store (+3 carbon blocks)
  - We bring our own (+1⁄2 carbon block)

  Yep, plastic bags are made of oil. Even some reusable bags have oil as an ingredient, too. But bringing your own is always better than using plastic ones!

- Which ones do your family recycle? *(start with +3 1⁄2 blocks and subtract from there)*
    - Plastic (-½ carbon block)
    - Glass (-½ carbon block)
    - Paper (- ½ carbon block)
    - Metal (-1 carbon block)
    - None (-0 carbon blocks)

One carbon block = 200 pounds of atmospheric CO_2. Ten carbon blocks is equal to a sphere 33 feet high and as heavy as a car. That's big enough to burst through your classroom and the one above it.

Reductions (Part 2)

Now, think about the difference your reductions made. You can save huge amounts of CO_2 and fresh water each year by making some of these changes. The world needs people to step up and fight against climate change, habitat destruction, pollution, and wasteful water use. You always have a choice—what do you want your world to look like?

Directions: Check off whichever pledges you want to commit to and use a green marker to cross out the carbon blocks that match your reductions. Remember not to pledge to do something that you already do.

I pledge to:

- ☐ Ask the person who picks me up if they can turn off the car engine while the wait for me (reduce 4 carbon blocks)

I pledge to: (*pick one)*:

- ☐ Go one more day a week without red meat (reduce 1 carbon block)
- ☐ Go two more days a week without red meat (reduce 2 carbon blocks)
- ☐ Go three more days a week without red meat (reduce 3 carbon blocks)
- ☐ Go four more days a week without red meat (reduce 4 carbon blocks)

I pledge to:

- ☐ Bring own reusable bags to the store (reduce 2 ½ carbon blocks)

I pledge to:

- ☐ Recycle plastic (reduce ½ carbon block)
- ☐ Recycle glass (reduce ½ carbon block)
- ☐ Recycle paper (reduce 1 ½ carbon blocks)
- ☐ Recycle metal (reduce 1 carbon block)

Discussion/Conclusion Questions

Adapted from: http://bit.ly/2G7NCsC

What changes can you make in your life to reduce your carbon footprint? Try to make some of these changes in the next week.

Directions: Use the space below to engineer a plan to reduce your carbon footprint.

Things I will turn off: _____

_____

How I will get to school:

_____

_____

What I will eat:

_____

_____

How much I will use electronics:

_____

_____

What I will recycle:

_____

_____

Other things I will do:

_____

_____

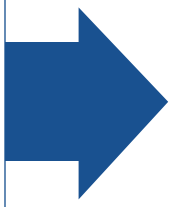
Name:_____ Date:_____
Class: _____

Carbon: A Day in My Life Carbon Cycle Storybook Assignment

Objective: Your task is to write a short story titled, "Carbon: A Day in My Life." It will be a narrative essay that follows your interaction with carbon throughout a typical day in your life. For each carbon encounter (must describe at least five) you must explain where that carbon could have come from at least two steps in the cycle. You are required to demonstrate your understanding of the following processes:

Requirements

- **Photosynthesis**
- **Respiration**
- **Decomposition**
- **Fossil Fuel formation**
- **Combustion**
- **Carbon Dioxide in the Atmosphere**



These processes should be described using student notes and student creativity. Vivid details should be used to explain each.

Name:_____ Date:_____
Class: _____

Praise: What do you like about my story? What works well? What are some specific examples of things that you thought were done well?

Question: What are some things that you did not understand in my story? Are there questions that you have about why I wrote the story the way I did? What are some parts of my story that you felt were left unfinished or not fully explored?

Polish: What could I do specifically to make this a better story? What parts would you change and how?

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