Lesson 6: Carbon Cycle and Life

Scientist conferring with field guides on research trip to Cross Bayou in Southeast Louisiana; NASA

Students explore the steps in the carbon cycle and draw conclusions about the importance of the carbon cycle in the planetary temperature system.

Main Lesson Concept:
The movement of the crust and mantle allows carbon to be cycled in and out of the atmosphere, stabilizing the surface temperature.

Scientific Question:
What role does Earth's geology play in regulating the amount of carbon dioxide in our atmosphere?

Objectives	Standards
• Students will draw and explain the steps in the carbon cycle. • Students will perform two skits that show the carbon cycle process and what would happen if carbon were no longer released into the atmosphere by volcanoes. • Students will explain how Earth's geological structure is important to the carbon cycle and the importance of the carbon cycle for life.	**Partially meets:** 2061: 4C (6-8) #1 NSES: D (5-8) #1.4

Assessment	Abstract of Lesson
Carbon cycle diagrams, answers to Astro Journal questions, and skit performances and/or scripts.	Students review the Geology Training module to observe how Earth's geology affects carbon dioxide levels. Students create a diagram of the carbon cycle and conclude that the carbon cycle maintains a balance of carbon dioxide in Earth's atmosphere, thus helping to maintain a moderate surface temperature. They then create and act out two skits of how the carbon cycle works and what would happen if carbon were not released into the atmosphere.

Prerequisite Concepts	Major Concepts
• The type of star and the distance of a planet from the star affects two major parts of the system that controls the surface temperature of a planet (planetary temperature system). (Astronomy Lesson 9) • The atmosphere of a planet affects the planetary temperature system, which determines the temperature of that planet. (Astronomy Lesson 10) • No matter how substances within a closed system interact with one another, or how they combine or break apart, the total weight of the system remains the same. The idea of atoms explains the conservation of matter: If the number of atoms stays the same no matter how they are rearranged, then their total mass stays the same. (2061: 4D (6-8) #7. Atmosphere Lessons 3 and 4) • The following geologic characteristics allow Earth to remain habitable to humans (Geology Lesson 1): – Liquid outer core (coupled with the planet's rotation) and a thick atmosphere – Viscous mantle (slow motion) – Slow motion of crust and upper mantle (lithosphere) of 3 to 5 centimeters per year • The crust and top part of the mantle that is solid are called the lithosphere (sphere of rock). (Geology Lesson 4) • The lower part of the upper mantle that is composed of partially molten or melted rock is called the asthenosphere. (Geology Lesson 4) • Plate tectonics involves the lithosphere moving over the asthenosphere. (Geology Lesson 5) • Volcanoes occur where plates collide or move apart, and in areas known as "hot spots." (Geology Lesson 5)	• Volcanoes release carbon dioxide (a greenhouse gas), which can raise the Earth's surface temperature. • Carbon dioxide in the air interacts with rain to form acid rain that reacts with rocks and is eventually deposited into the oceans. • Sea creatures, like coral and clam, take the carbon out of the water to build their bodies/shells. • When these sea creatures die, their bodies form limestone, which is eventually subducted under a continental plate and released again as volcanic gas. • This process is part of the carbon cycle. • No matter is created or destroyed in this process. It only changes form and location. • Humans and other life forms require a balance of carbon dioxide in the atmosphere to maintain a moderate surface temperature. The carbon cycle provides this balance. • Volcanoes can also release ash, which can block the Sun's light from reaching Earth's surface, therefore decreasing the surface temperature.

Suggested Timeline (45-minute periods):

Day 1: Engage and Explore sections
Day 2: Explain section
Day 3: Extend section
Day 4: Evaluate section

Materials and Equipment:

- A class set of Astro Journal Lesson 6
- Carbon Cycle Diagram Transparency with sticky notes or cards to cover each step
- A wet paper towel
- A chalkboard
- Materials to make props for Carbon Cycle Live Activity skits
- 1 to 30 computers with Internet browser, Internet connection and the Flash 6 Player installed*
- LCD projector or TV connected to a computer with video card (if you only have 1 or few computers)
- Overhead projector
- Chart paper

You may want to have the following materials on hand when describing the carbon cycle (optional):

- Club soda
- Limestone
- Seashells
- Baking soda
- Vinegar
- Carbonate rocks
- Water
- Salt
- Volcanic ash
- Clear glasses or jars

Preparation:

- Duplicate a class set of Astro Journals.
- Prepare Carbon Cycle Diagram Transparency and cover steps with sticky notes or cards.
- Gather materials.
- Download and install Flash 6 Players on computers from: http://www.marcromedia.com/downloads.
  Test these at http://astroventure.arc.nasa.gov by clicking "Geology Training."
- Prepare classroom. (Make sure there is enough room for the Carbon Cycle Live Activity skits in Extend and Evaluate sections.
- Prepare chart paper with major concept of the lesson to post at the end of the lesson by clicking "Biology Training."
- Prepare chart paper with major concept of the lesson and human survival needs to post at the end of the lesson.

*System Requirements to Run Biology Training Module

Operating System	Browser
Windows 95 Windows 98 Windows Me	Internet Explorer 4.0 or later (Internet Explorer 5.0 or later is recommended), Netscape Navigator 4 or later, Netscape 7.0 or later (Netscape 6 is not recommended)
Windows NT Windows 2000 Windows XP or later	Internet Explorer 4.0 or later, Netscape Navigator 4 or later, Netscape 7.0 or later, with standard install defaults (Netscape 6 is not recommended)
Macintosh: System 8.6 System 9.0 System 9.1 System 9.2	Netscape 4.5 or later (Netscape Communicator 4.7 or Netscape 7.0 are recommended), Netscape 7.0 or later (Netscape 6 is not recommended), Microsoft Internet Explorer 5.0 or later
Macintosh OS X 10.1 or later	Netscape 7.0 or later (Netscape 6 is not recommended), Microsoft Internet Explorer 5.1 or later

RAM
The minimum requirement for RAM is 32 MB; however, the animations will run slowly and it will be slow sending the Astro Journal and Certificate to the printer at the end of the module. We recommend a minimum of 64 MB.

Sound
Astro-Venture uses narration and some sound effects. Computers will require a sound card and either headphones or speakers. Pairs of students using the same computer can use a y-cable to connect two pairs of headphones to one computer.

Differentiation

Accommodations
For students who may have special needs:
Have them work with a partner on their Astro Journal writing or report orally to the teacher.

Advanced Extensions
For students who have mastered this concept:
Have students research and report on other ways that carbon is cycled in and out of the atmosphere through living things. Alternatively, students could research how carbon dioxide levels have changed over time in Earth's history, the causes of these changes, and whether these have correlated with Earth's surface temperatures at the time.
Two Web sites that might help with this second exploration are:
http://www.forestry.uga.edu
http://www.yourplanetearth.org

Engage

(approximately 15 minutes)

Pumping saline ground into evaporation ponds at Pyramid Salt Company; Victoria Museum, Australia

1. Draw on students' prior knowledge of natural recycling processes.

- Wet a piece of paper towel and wipe it across the chalkboard.
- Have students observe the section of the chalkboard that the wet paper towel was wiped on.
- Question: What observations can you make about the water on the board?
- *Answer: Students should observe that the wet spot is getting smaller and beginning to disappear.*
- Question: Where is the water going?
- *Answer: The water is going into the atmosphere.*
- Question: What is the process called when water goes into the atmosphere?
- *Answer: When water goes into the atmosphere, it is called evaporation.*
- Question: When water evaporates, does the amount of water on the Earth change? Explain your answer.
- *Answer: No, the amount of water on the Earth does not change because water is recycled through the water cycle.*
- Question: What are other things on Earth that are naturally recycled? Explain your answer.
- *Answer: (Allow students to share their ideas. Students may respond that living things are naturally recycled when they die.)*
- Say: In cycles such as the water cycle or the cycle of life, the amount of matter does not change throughout the cycle.

2. Review conservation of matter from Atmosphere Lesson 4.

- Say: In Atmosphere Lesson 4, you learned about chemical reactions.

- Question: What is an example of a chemical reaction?
- *Answer: (Accept all correct answers. One chemical reaction that students learned about in Atmosphere Lesson 4 was that hydrogen gas and oxygen gas combine to make water vapor.)*

- Question: When a chemical reaction takes place, does the amount of matter change?
- *Answer: The amount of matter does not change during a reaction. The number of atoms stays the same, but they change location and recombine to form new substances.*

- Say: You can see that during a chemical reaction, just like during the water cycle, the amount of the substances involved does not change. Today we will be looking at another cycle that is important to human survival.

3. Review the planetary temperature system from Astronomy Lessons 9 and 10 and the role of greenhouse gases from Atmosphere Lessons 1 and 3.

- Question: We've talked about how important a moderate temperature is for human survival. Let's discuss what we know about the planetary temperature system. In Astronomy, what did we learn were three factors that determine the surface temperature of a planet?
- *Answer: We learned that a star's type, a planet's distance from its star, and the amount and composition of its atmosphere all work together to determine the surface temperature of a planet.*

- Question: How does Earth's atmosphere affect the planet's temperature?
- *Answer: The atmosphere maintains heat.*

- Question: Do all of the gases in the atmosphere help maintain heat?
- *Answer: No, all of the gases in the atmosphere do not help maintain heat.*

- Question: Which gases in the atmosphere help maintain heat?
- *Answer: Greenhouse gases help maintain heat.*

- Question: What were the two greenhouse gases that we studied in Atmosphere Lesson 3?
- *Answer: The greenhouse gases that we studied were carbon dioxide and water vapor.*

- Question: What role do greenhouse gases like carbon dioxide and water vapor play in the temperature of the Earth's surface?
- *Answer: Greenhouse gases like carbon dioxide and water vapor absorb heat that is radiated from Earth's surface and release some of the heat back towards the Earth, increasing the surface temperature.*

- Question: How does this affect human life on Earth?
- *Answer: By trapping heat, greenhouse gases help to maintain a stable temperature for human survival.*

- Question: What happened in the Atmosphere Training module when the carbon dioxide level was too high?
- *Answer: When the carbon dioxide level was too high, Earth's temperature rose.*

- Question: What happened in the Atmosphere Training module when the carbon dioxide level was too low?
- *Answer: When the carbon dioxide level was too low, Earth's temperature decreased.*

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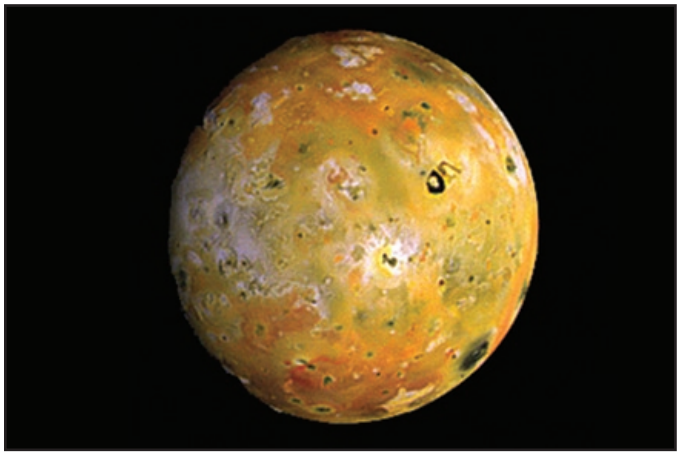
4. Introduce the purpose of the lesson and the Scientific Question.

- Say: Carbon exists in many forms and is transferred in different forms between different reservoirs on both short and long time scales. Today, we are going to learn about the long-term carbon cycle. We are going to explore how Earth's geology affects carbon dioxide levels and thus impacts human survival.

- Say: The Scientific Question we will be investigating is: How does plate tectonics affect Earth's ability to support human survival?

Explore

(approximately 30 minutes)



Jupiter's moon, Io, the most volcanically active body in the Solar System; NASA

1. Draw on students' knowledge of plate tectonics and volcanoes from Geology Lesson 4 and previous experiences.

- Question: What is plate tectonics?
- *Answer: Plate tectonics is the theory describing how the lithospheric plates move over the asthenosphere.*

- Question: What is the relationship between plate tectonics and volcanoes?
- *Answer: Two of the places that volcanoes occur are where plates collide and where plates move apart.*

- Question: How do you think volcanoes might affect human survival?
- *Answer: (Allow students to share their ideas. Students will likely identify the destructiveness of volcanoes.)*

2. Discuss with students how they think Earth's geology might affect carbon dioxide levels.

- Question: How do you think Earth's geology might affect carbon dioxide levels? Why?
- Have students record their hypothesis/prediction in their Astro Journals.
- Have students share their hypotheses/predictions about how they think Earth's geology affects carbon dioxide levels.
- Say: In the next activity, you will look at how Earth's geologic structure affects carbon dioxide levels.

3. Have students review the Geology Training module focusing on how Earth's geology affects carbon dioxide levels.

- Question: If you look at the Earth from a compositional viewpoint, what are the layers that make up the interior of the Earth?
- *Answer: The compositional layers that make up the interior of the Earth are the crust, mantle, and core.*
- Say: In the Geology Training module, you saw the effects of the crust, mantle, and core being changed. Today, you are going to review the module a second time focusing on how Earth's geology affects carbon dioxide levels.
- Have students work individually, in small groups, or as a class to review the Geology Training module.
- As students review the Geology Training module, have them complete the Review of Geology Training Module Questions in their Astro Journals.

Explain

(approximately 45 minutes)

Taking air samples at South Pole Station; Scripps Institution of Oceanography, NOAA

1. Discuss with students their observations from reviewing the Geology Training module.

- Question: What observations did you make when reviewing the Geology Training module in terms of how Earth's geology affects the amount of carbon dioxide in the atmosphere?
- *Answer: (Accept all reasonable answers. Student observations may include that the amount of movement of the crust and mantle affects the amount of carbon dioxide and thus the temperature, and that there appears to be a cycle of carbon in and out of the atmosphere affected by plate movement.)*

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2. Discuss the carbon cycle in more detail using the Carbon Cycle Diagram.

- Put up the overhead transparency of the Carbon Cycle Diagram and cover up each step. Reveal each step as it is talked about.

- Throughout this discussion, it would be helpful for students to correct or add to their diagram of the carbon cycle.

Note to Teacher: This is what is known as the carbon-rock cycle and is only part of the complete carbon cycle, as carbon also cycles through vegetation, soil, and in fossil fuel burning. You may want to make students aware of this.

- Say: We're going to look at the carbon cycle in detail to understand how the Earth regulates the amount of carbon dioxide in the atmosphere. Add to and correct the diagram in your Astro Journal, as you will be asked to write a script and act out this carbon cycle later.

Step 1: Release of carbon dioxide into the atmosphere

- Question: In the module, where was carbon dioxide released?
- *Answer: Carbon dioxide was released from volcanoes.*

Step 2: Removing carbon dioxide from the atmosphere

- Question: In the module, where was carbon dioxide taken out of the atmosphere?
- *Answer: (Allow students to share their ideas. From viewing the module, students may respond that carbon dioxide eventually forms limestone. The following discussion will help them understand the carbon cycle in more detail.)*

Note to Teacher: Carbon dioxide is also removed from the atmosphere during photosynthesis. As a part of the geological carbon cycle discussed in this lesson, you could have a discussion or have students investigate the carbon that is stored in all living things. Plants and other producers remove carbon dioxide from the atmosphere during photosynthesis. They use this carbon to build their bodies. This could be used to address the misconception that plants are mainly made of water and substances in the soil. You could trace the carbon from the atmosphere to the plants (stored as part of the plant and as food) to the consumers that eat the plants until it is eventually returned to the Earth during decomposition or added back to the atmosphere during respiration. The burning of fossil fuels like oil and gasoline returns the biological carbon stored in the Earth back into the atmosphere. The biological cycle is considered the "short-term" cycle. The geological cycle is considered "long-term." The biological and geological carbon cycles are actually two parts of the same cycle.

- Say: Carbon dioxide does form limestone rock, but there are steps that must occur in order for it to get to this point.

- Question: How does water get from the atmosphere to the surface of Earth?
- *Answer: Water gets from the atmosphere to the surface of the Earth through rain.*

- Question: Do you think that rain can carry other substances with it?
- *Answer: (Allow students to share their ideas. Many students will respond that rain can carry other substances with it.)*

- Say: Carbon dioxide released from volcanoes interacts with rain to form acid rain.

- Question: What do you know about acid rain?
- *Answer: (Allow students to share their ideas. Students may respond that they have heard of acid rain, but they may not know much information about it.)*

Note to Teacher: You may want to discuss acid rain in more detail with your students. Acid rain can be defined as rain containing acids. These acids form in the atmosphere when gas emissions combine with water. Students may associate acid rain with something harmful. You can explain to students that there are different types of acid rain. Sulfuric acid rain, for example, could be considered a harmful acid rain. The acid rain we are studying is carbonic acid rain. This is a helpful acid rain, and it is essential for our carbon cycle to continue. A carbonic acid that students may be familiar with or that you could use to show as an example to your students is club soda.

- Question: What happens when you combine vinegar and baking soda?
- *Answer: Students will most likely respond that the vinegar and baking soda react to create a gas.*

- Say: Vinegar is an example of a very weak acid. In acid rain, the acids also cause reactions when they interact with other substances.

Step 3: Breaking down rocks

- Question: The acid rain will fall on to the surface of Earth. What do you think happens when acid rain falls on to rocks?
- *Answer: (Allow students to share their ideas. Students may understand that the acid in the rain will react with the rocks.)*

- Say: The acid in the rain will react with the rocks. When this happens, the rocks are slowly dissolved in a process called weathering. When the rocks are weathered, dissolved bicarbonate (baking soda is a type of bicarbonate) is released.

Step 4: Transfer of dissolved materials

- Question: If the rocks located near streams or rivers are slowly dissolved, what do you think will happen to the dissolved materials?
- *Answer: (Allow students to share their ideas. If students don't understand the concept of materials dissolving, adding salt to water might be an example they are familiar with. Students may respond that the materials will be carried by the stream or river.)*

- Question: Into what do streams and rivers eventually run?
- *Answer: Students should understand that streams and rivers eventually run into oceans.*

Step 5: Becoming a part of sea creatures

- Say: Some of the dissolved materials found in rivers and streams include carbon and calcium.

- Question: What do you know about calcium?
- *Answer: (Accept all reasonable answers. Students will most likely respond that calcium makes up their bones.)*

- Say: You used calcium in foods to build up your bones. Some sea creatures, like coral and clam, use the carbon and calcium to build up their bodies and shells.

Step 6: Forming limestone

- Question: What do you think happens to these sea creatures when they die?
- *Answer: (Allow students to share their ideas.)*

- Say: When the sea creatures die, if they are not eaten, their bodies sink to the bottom of the ocean. Depending on the water chemistry at the bottom of the ocean, their skeletons may be preserved to form limestone.

Note to Teacher: You can explain to your students that limestone is calcium carbonate.

- Say: Remember from the Geology Training module that you saw limestone being built up. The calcium and carbon from the sea creatures' skeletons form limestone after they die.

Step 7: Subducting limestone to be released again

- Question: Do you think that this is the end of the carbon cycle? Explain your answer.
- *Answer: (Allow students to share their ideas. Hopefully students will use their knowledge of cycles to explain that this is not the end of the carbon cycle. To have a cycle, the process must make a full circle.)*

- Question: Where did our discussion begin in the carbon cycle?
- *Answer: Our discussion started with carbon dioxide being released from volcanoes.*

- Question: A cycle is a process that repeats. For this process to repeat, what must happen?
- *Answer: (Allow students to share their ideas. Students may understand that the carbon must get back to the volcanoes and be released as carbon dioxide.)*

- Question: How could the materials in limestone become the materials released as volcanic gas?
- *Answer: (Allow students to share their ideas.)*

- Say: In Geology Lesson 5, we used our hands to represent plates.

- Question: You had your hand out in front of you, and your fingertips were touching. What happened when you pushed your fingertips together?
- *Answer: Students should explain that the denser hand/plate went under the less dense hand/plate.*

- Say: The same type of movement occurs in the carbon cycle. The denser oceanic crust (that has limestone formations on top of it) goes under the continental plate. This is called subduction.

- Question: What do you think happens when the limestone subducts under the continental plate?
- *Answer: Students should understand the interior of the Earth is hot, and that the limestone will get hot and release gases when it goes under the continental plate.*

- Question: What are two materials that you know make up limestone?
- *Answer: Two materials that we know make up limestone are calcium and carbon.*

- Say: The carbon from the limestone will eventually be released again as volcanic gas.

- Question: What will carbon combine with before it is released as a volcanic gas?
- *Answer: Students should understand that carbon dioxide is one of the gases released by volcanoes. Using this information, they should be able to determine that carbon must combine with oxygen to form carbon dioxide.*

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3. Discuss with students how the balance of carbon dioxide occurs.

- Question: How do you think a balance of carbon dioxide occurs?
- *Answer: (Allow students to share their ideas.)*

- Say: Think back to our discussion on cycles at the beginning of this lesson. Carbon dioxide is part of the cycle called the carbon cycle.

- Question: What do you think the carbon cycle does for the amount of carbon dioxide in the atmosphere?
- *Answer: (Allow students to share their ideas. Students should conclude that carbon dioxide must be both trapped and released in order to keep the level of carbon dioxide in the atmosphere balanced.)*

- Question: Does the amount of carbon change during the carbon cycle? Explain your answer.
- *Answer: No, the amount of carbon does not change during the carbon cycle. The carbon changes form and location, but it is not created nor destroyed.*

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4. Review with students the importance of carbon dioxide and the effects of too much or too little carbon dioxide from the Geology Training module.

- Question: What would happen if the carbon dioxide in Earth's atmosphere increased?
- *Answer: Surface temperatures would increase.*

- Question: How might this affect life on Earth?
- *Answer: If temperatures increased too much, humans (and other forms of life) might not be able to survive.*

- Question: What would happen if the carbon dioxide in Earth's atmosphere decreased?
- *Answer: Surface temperatures would decrease.*

- Question: How might this affect life on Earth?
- *Answer: If temperatures decreased too much, humans (and other forms of life) might not be able to survive.*

- Question: What might cause a decrease in carbon dioxide in the atmosphere?
- *Answer: (If the plates stopped moving, then the carbon couldn't get subducted under another plate to be released by volcanoes.)*

- Say: Earth's geology is very important to maintaining the balance of carbon dioxide that is vital to the habitability of Earth.

- Question: Why do you think the balance of carbon dioxide is vital to the habitability of Earth?
- *Answer: Students should understand that a balance of carbon dioxide is vital to having a moderate surface temperature on Earth.*

- Question: What do you think would happen if somehow carbon dioxide was only released into the atmosphere and not taken out of the air?
- *Answer: Students should explain that the level of carbon dioxide in the atmosphere would rise greatly resulting in an increase in the temperature of Earth.*

- Question: Volcanoes can also release ash. What affect do you think volcanic ash would have on the Earth?
- *Answer: (Allow students to share their ideas. Students may focus on the effect that ash would have on humans, as far as breathing in ash or areas of the Earth being covered by ash.)*

- Question: If volcanic activity increased and more ash was released into the atmosphere, would the level of carbon dioxide be higher or lower?
- *Answer: Students should understand from this lesson that the level of carbon dioxide would be higher.*

- Question: What affect would high levels of carbon dioxide have on Earth's surface temperature?
- *Answer: High levels of carbon dioxide would cause an increase in Earth's surface temperature.*

- Question: What affect would volcanic ash in the atmosphere have on the amount of sunlight we receive?
- *Answer: (Allow students to share their ideas. Students may understand that the ash would block out sunlight.)*

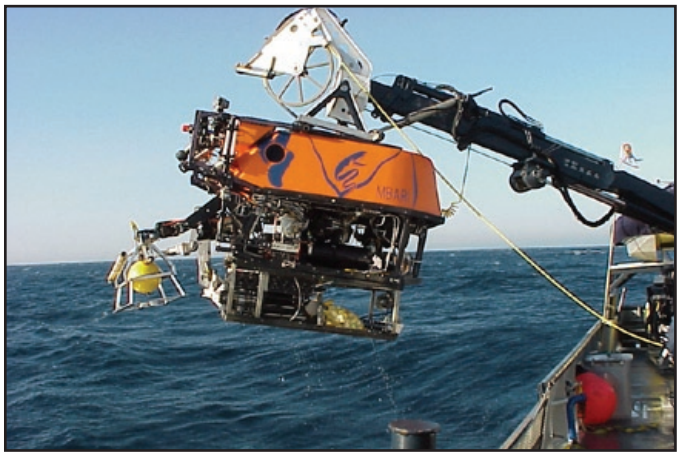
- Question: Volcanic ash would block out sunlight. How would this affect Earth?
- *Answer: The temperature of Earth would decrease greatly because sunlight could not reach the surface of Earth.*

- Say: An increase in volcanic activity would cause ash and carbon dioxide levels to be higher. But, because the ash would block sunlight from reaching Earth's surface and prevent carbon dioxide from trapping any heat energy from the Sun, the temperature of Earth's surface would decrease greatly. When the volcanoes stop, the ash would eventually settle out of the atmosphere and the carbon dioxide left would start to warm the planet again.

Note to Teacher: You might review with students the model they used in Astronomy Lesson 10 and Atmosphere Lesson 3 using plastic wrap to model the greenhouse gases in our atmosphere that trap heat compared with an open box or glass jar with no plastic wrap. Ask students what they might use to model the effect of excessive volcanic ash in the atmosphere. Students might suggest placing an opaque piece of paper over the plastic wrap. This could be compared with a box or jar with plastic wrap. Ask them what they predict the temperature of each model would be and why. You might consider carrying out this experiment so that students can see that because less light from the lamp can reach the "ground" of the box or jar with opaque paper, less heat can be trapped, thus reducing the temperature, even though both models have plastic wrap symbolizing greenhouse gases.

Extend/Apply

(approximately 45 minutes)



Ocean submersible being used to test carbon sequestration strategies to address the global warming problem; Lawrence Livermore National Laboratory, USDOE

1. Introduce students to the Carbon Cycle Live Activity.

- Say: Today you are going to develop a skit for the carbon cycle.

- Have students look at the directions in their Astro Journals.

- Explain the directions for this activity and answer any questions.
- Break students into small groups.

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2. Have students develop their skits for the Carbon Cycle Live Activity.

Note to Teacher: To ensure that students include all of the necessary parts in their skits, you could have them create a script. You could then check this script for thoroughness and accuracy.

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3. Have students present their skits.

- Question: Did the amount of carbon in your cycle change during your skit?
- *Answer: No, the amount of carbon did not change. It only changed form and location.*

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4. Discuss with students what would happen if the process of removing carbon from the atmosphere stopped.

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5. Have students work in their small groups again to develop a second skit that shows what would happen if the plate movement stopped and the process of releasing carbon dioxide into the atmosphere stopped.

Evaluate

(approximately 45 minutes)

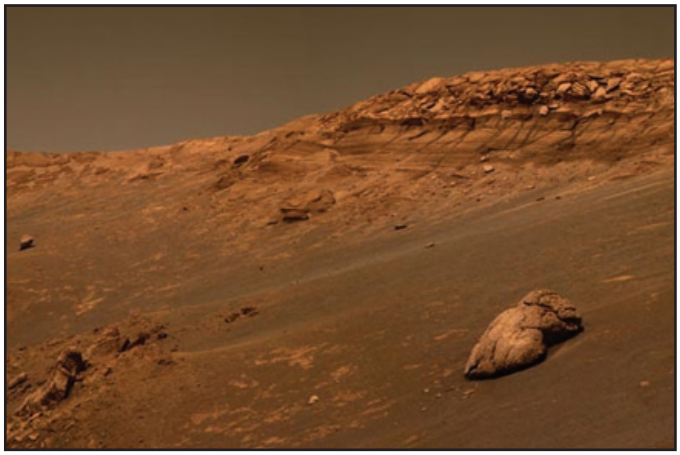

Photo of lumpy rock formation on the lower slopes of Endurance Crater, Mars; NASA

1. Have students present their second skits.

Note to Teacher: To ensure that students include all of the necessary parts in their skits, you could have them create a script. You could then check this script for thoroughness and accuracy.

- Say: There are planets in our solar system where this has occurred. Mars is an example, and its surface temperature is very cold.

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2. Have students answer the Carbon Cycle questions in their Astro Journals and finalize their drawing and explanation of the carbon cycle.

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3. Discuss students' responses to their Astro Journals to ensure they have mastered the major concepts.

- Question: Where was carbon dioxide released in the module?
- *Answer: Carbon dioxide was released from volcanoes.*

- Question: What happens to carbon dioxide once it is released from volcanoes?
- *Answer: Carbon dioxide in the air interacts with rain to form acid rain. The acid rain reacts with and slowly dissolves rocks. The dissolved materials eventually end up in the ocean. Sea creatures, like coral and clam, use carbon and calcium to build their bodies/shells. When these sea creatures die, their bodies form limestone, which is eventually subducted under a continental plate and released again as volcanic gas.*

- Question: Why do you think the balance of carbon dioxide is vital to the habitability of Earth?
- *Answer: A balance of carbon dioxide is vital to having a moderate surface temperature on Earth.*

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4. Collect students' Astro Journals and evaluate them to ensure they have each mastered the major concepts.

- Volcanoes release carbon dioxide (a greenhouse gas), which can raise the Earth's surface temperature.
- Carbon dioxide in the air interacts with rain to form acid rain, which reacts with rocks and is eventually deposited into the oceans.
- Sea creatures, like coral and clam, take the carbon out of the water to build their bodies/shells.
- When these sea creatures die, their bodies form limestone, which is eventually subducted under a continental plate and released again as volcanic gas.
- This process is called the carbon cycle.
- No matter is created or destroyed in this process. It only changes form and location.
- Humans and other life forms require a balance of carbon dioxide in the atmosphere to maintain a moderate surface temperature. The carbon cycle provides this balance.
- Volcanoes can also release ash, which can block the Sun's light from reaching Earth's surface, therefore decreasing the surface temperature.

5. Bridge to next lesson.

- Say: Today, we learned how movement of the plates affects human survival. In the next lesson, we will learn how movement of the liquid outer core affects human survival.

Note to Teacher: After each lesson, consider posting the main concept of the lesson some place in your classroom. As you move through the unit, you and the students can refer to the "conceptual flow" and reflect on the progression of the learning. This may be logistically difficult, but it is a powerful tool for building understanding.

Astro Journal Geology Lesson 6: Carbon Cycle and Life

Name _____ Date _____ Class/Period _____

Scientific Question:
What role does Earth's geology play in regulating the amount of carbon dioxide in our atmosphere?

1. Hypothesis/Prediction: How do you think Earth's geology might affect carbon dioxide levels? Why?

Review of Geology Training Module Questions
2. Using the Geology Training module, what observations can you make about how Earth's geology affects the amount of carbon dioxide in the atmosphere?
3. Which speed of movement in the crust produced conditions for a habitable Earth? What information did you use to come to this conclusion?
4. Which speed of movement of the mantle produced conditions for a habitable Earth? What information did you use to come to this conclusion?

Astro Journal Geology Lesson : Carbon Cycle and Life

Name _____ Date _____ Class/Period _____

5. Use your knowledge from the Geology Training module to draw the carbon cycle in the space below. Label where the carbon can be found at each stage of the cycle. Include an explanation of how the carbon cycle affects carbon dioxide levels, temperature, and ultimately human survival.

Carbon Cycle Live Activity

Skit 1 Directions:

Develop a skit that shows all of the parts of the carbon cycle.

Your skit must include information on:

- Where carbon is released into the atmosphere.
- How carbon is deposited into the oceans.
- How carbon is used once it is deposited into the oceans.
- How carbon is cycled back to volcanoes.
- Why humans and other life forms require a balance of carbon dioxide in the atmosphere.
- How the amount of carbon in the cycle never changes.

Skit 2 Directions:

Develop a skit that shows what would happen if plate movement stopped and the process of releasing carbon dioxide into the atmosphere stopped.

Your skit must include information on:

- Where carbon is released into the atmosphere.
- What would happen if the process of releasing carbon into the atmosphere stopped.
- How humans and other life-forms would be affected if carbon were no longer released into the atmosphere.

Your skit will be evaluated using the following rubric:

4 Expectations Exceeded	• Skits clearly and accurately explain the carbon cycle. • Skits have all required parts and use excellent reasoning to create an exceptionally powerful and detailed explanation.
3 Expectations Met	• Skits clearly and accurately explain the carbon cycle. • Skits have all required parts and use good reasoning in explanations.
2 Expectations Not Quite Met	• Skits are not completely clear or accurate in explaining the carbon cycle. • Skits have most required parts and use some good reasoning in explanations.
1 Expectations Not Met	• Skits are not clear or accurate in explaining the carbon cycle, are missing several parts, and use little or no good reasoning.

Carbon Cycle Transparency