The Carbon Cycle and its Role in Climate Change: Activity 1

Grade Level(s): 5-8

Time Required: One 45-minute class period

Focus Question(s):
- What is the carbon cycle?
- How do atoms combine and recombine?

Learning Objectives:
- The students will be able to explain that all things are made of atoms and that atoms can be re-arranged in whole number ratios to make different materials and that photosynthesis and respiration are reverse processes.

Materials:
- Several different colors of construction paper
- Several different colors of chalk or ribbon

Background:

- The students have heard about global warming, but most do not yet have the chemical background to understand what is happening. This activity is designed to give them a basic chemical understanding of the carbon cycle and thereby giving them an understanding of why healthy plants are essential to a healthy habitat. While other greenhouse gases (besides carbon dioxide) are also important, carbon is the example covered here. It is also important for the students to understand that there are other greenhouse gases.

  The story of Democritus' definition of the atom can be used to set a basic understanding. Using cheese as a prop as you talk will maintain the student's curiosity. The story, in brief, is as follows: Democritus stated that if you take a piece of cheese and cut it in half, you still have cheese. If you take that half and cut it again, the smaller piece is still cheese. If you take that tiny piece and cut it again the tinier piece is still, cheese. If you could continue cutting the cheese into tinier and tinier pieces you would eventually come down to the most basic of all particles that still have all the qualities of cheese. Democritus called that fundamental particle the atom.

  We now know that cheese is not a fundamental particle, but we still use his word for the fundamental particle, the atom. There are 108 different atoms. They are the fundamental particles or building blocks from which all matter is made. In this lesson we are going to look at only a few of them. What does this have to do with our indicator species? Animals are made of atoms, just like us and just like the plants that it eats. The atom that is found in all living things on earth is carbon. In the upcoming activities keep your eye on where the carbon atoms are going.

Procedures/Instructional Strategies:

1. Use construction paper to create paper "atom" signs to be pinned to each student. You will need:
   - 6 black carbon atoms
   - 12 white hydrogen atoms
   - 18 red oxygen atoms
   - 1 big yellow energy sign
   - Several black $C_6H_{12}O_6$ (sugar) signs. On the reverse side of these signs write: oil, gas, or coal

2. Write the name and symbol of the appropriate atom on each sign. These will be used to act out the processes of photosynthesis and respiration. Post the equations of these processes where the students can see them. The equations are as follows:
   - Photosynthesis: $6CO_2$ + 6 H_2O + energy -> $C_6H_{12}O_6$ +$6O_2$
     Carbon dioxide plus water plus energy yields sugar and oxygen
   - Respiration: $C_6H_{12}O_6$ +$6O_2$ -> $6CO_2$ + 6 H_2O + energy
     Sugar plus oxygen yields carbon dioxide plus water plus energy

3. Make a large circle on the floor with green chalk or a green piece of ribbon. The circle needs to be large enough for the student groups to step into. This will represent a plant.

4. Make a second large circle on the floor with brown chalk or with a brown piece of ribbon. The circle needs to be large enough for the student groups to step into. This will represent an animal.

5. Give each student one sign to wear. Since there are 36 different atoms and the energy sign, some students may have an extra atom that gets passed along during the activity to make the equations work.

6. Have students group themselves into six carbon dioxide molecules and six water molecules by holding hands or linking arms to form the chemical bonds. Show them how the carbon and oxygen have to be in the center of the group.
   - Have the water molecules pretend that they are being drawn into the plant through the roots.
   - Have the carbon dioxide molecules pretend that they are being drawn into the plant through the leaves.
   - Once they are all in the plant, have the yellow energy person come in to break the bonds by pulling their hands apart. Make the point that it takes energy to break the bonds.
   - Energy stays in the plant circle while the atoms regroup themselves into sugar and oxygen molecules, holding hands or linking arms to show that new bonds have formed.
   - Have the oxygen molecules drift off into the air, as the plant does not need it.

7. Now explain that an animal, such as a human, is going to eat the plant. Have the students pretend they are eaten by stepping as a molecule (with hands still held), along with the energy, into the brown ribbon that represents an animal.
    - Have the students who are the oxygen molecules pretend they are being breathed into the animal.
    - Now have everyone regroup into carbon dioxide and water. The energy will be released as “heat” when the CO_2 and H_2O bonds form and those students who represent energy will leave the animal by stepping outside the circle.
    - Tell the students that the energy is used by the animal to live and that is why the animal ate the plant. They can feel their own body heat as evidence. Warm hands mean more energy is leaving their body, cold hands mean that less energy is leaving their body.
    - Have them pretend that the water is released as sweat or urine, the water student molecules step out of the brown circle, and the carbon dioxide is breathed out, the carbon dioxide student molecules step out of the circle.

8. Repeat the cycle about two more times until the students can do it without help. For advanced students you can lead to the understanding that plants both photosynthesize and respire.

9. Have the students stop the activity long enough to write a summary of their understanding of what they have just practiced by answering the questions for Lesson 1 on the Data and Analysis page.

10. Evaluate students with the following questions:
    - What is an atom?
      (An atom is the smallest particle that can exist and still have the properties of the parent material. A material made of all of one kind of atom is called an element.)
    - Use the reactants in photosynthesis as an example to explain how atoms combine to make molecules. What are the elements in the molecules? How many of each atom are in each molecule?
      (The reactants in photosynthesis are carbon dioxide, CO_2 and water, H_2O. The carbon dioxide is made of one carbon atom between two oxygen atoms. The water is made of one oxygen atom between two hydrogen atoms)
    - Use the products of photosynthesis to explain how atoms recombine to make other molecules. What happened to the reactant molecules? Where did the atoms go? How many of each atom are the new product molecules?
      (The reactants molecules came apart into their component atoms. Those atoms recombined to form sugar. No atoms were lost or gained in the process.)
    - Is it atoms or molecules that break into pieces to form new things?
      (It is molecules that break apart into individual atoms.)
    - Where did the plants get the carbon from?
      (The plants get the carbon from the carbon dioxide in the air.)
    - Explain how a plant, a solid, can be made from the gas, carbon dioxide.
      (When the atoms recombine into a different molecule the new material has different physical and chemical properties than the original molecule. So an atom

of carbon in carbon dioxide has the molecular properties of a gas, but the same atom in a sugar molecule has the molecular properties of a solid.)

- What happened to the energy trapped by the plants?
  (The energy was stored in the plant until the plant decomposed or was eaten. Then as the respiration process began, the energy was released. This is why compost piles become warm and animals have body heat.)

National Science Education Standards:

Physical Science

- Substances react chemically in characteristic ways with other substances to form new substances (compounds) with different characteristic properties. In chemical reactions, the total mass is conserved. Substances often are placed in categories or groups if they react in similar ways; metals is an example of such a group.
- Chemical elements do not break down during normal laboratory reactions involving such treatments as heating, exposure to electric current, or reaction with acids. There are more than 100 known elements that combine in a multitude of ways to produce compounds, which account for the living and nonliving substances that we encounter.
- The sun is a major source of energy for changes on the earth's surface. The sun loses energy by emitting light. A tiny fraction of that light reaches the earth, transferring energy from the sun to the earth. The sun's energy arrives as light with a range of wavelengths, consisting of visible light, infrared, and ultraviolet radiation.
- Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways.
- In most chemical and nuclear reactions, energy is transferred into or out of a system. Heat, light, mechanical motion, or electricity might all be involved in such transfers.

Life Science

- Populations of organisms can be categorized by the function they serve in an ecosystem. Plants and some micro-organisms are producers--they make their own food. All animals, including humans, are consumers, which obtain food by eating other organisms. Decomposers, primarily bacteria and fungi, are consumers that use waste materials and dead organisms for food. Food webs identify the relationships among producers, consumers, and decomposers in an ecosystem.
- For ecosystems, the major source of energy is sunlight. Energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis. That energy then passes from organism to organism in food webs.

Earth Science

- The atmosphere is a mixture of nitrogen, oxygen, and trace gases that include water vapor. The atmosphere has different properties at different elevations.
- Living organisms have played many roles in the earth system, including affecting the

composition of the atmosphere, producing some types of rocks, and contributing to the weathering of rocks.
- The sun is the major source of energy for phenomena on the earth's surface, such as growth of plants, winds, ocean currents, and the water cycle. Seasons result from variations in the amount of the sun's energy hitting the surface, due to the tilt of the earth's rotation on its axis and the length of the day.

Science and Technology

- Perfectly designed solutions do not exist. All technological solutions have trade-offs, such as safety, cost, efficiency, and appearance. Engineers often build in back-up systems to provide safety. Risk is part of living in a highly technological world. Reducing risk often results in new technology.
- Technological solutions have intended benefits and unintended consequences. Some consequences can be predicted, others cannot.

Science in Personal and Social Perspectives

- Natural environments may contain substances (for example, radon and lead) that are harmful to human beings. Maintaining environmental health involves establishing or monitoring quality standards related to use of soil, water, and air.
- Human activities also can induce hazards through resource acquisition, urban growth, land-use decisions, and waste disposal. Such activities can accelerate many natural changes.
- Natural hazards can present personal and societal challenges because misidentifying the change or incorrectly estimating the rate and scale of change may result in either too little attention and significant human costs or too much cost for unneeded preventive measures.
- Internal and external processes of the earth system cause natural hazards, events that change or destroy human and wildlife habitats, damage property, and harm or kill humans. Natural hazards include earthquakes, landslides, wildfires, volcanic eruptions, floods, storms, and even possible impacts of asteroids.
- Risk analysis considers the type of hazard and estimates the number of people that might be exposed and the number likely to suffer consequences. The results are used to determine the options for reducing or eliminating risks.
- Students should understand the risks associated with natural hazards (fires, floods, tornadoes, hurricanes, earthquakes, and volcanic eruptions), with chemical hazards (pollutants in air, water, soil, and food), with biological hazards (pollen, viruses, bacterial, and parasites), social hazards (occupational safety and transportation), and with personal hazards (smoking, dieting, and drinking).
- Individuals can use a systematic approach to thinking critically about risks and benefits. Examples include applying probability estimates to risks and comparing them to estimated personal and social benefits.
- Important personal and social decisions are made based on perceptions of benefits and risks.
- Science influences society through its knowledge and world view. Scientific knowledge

and the procedures used by scientists influence the way many individuals in society think about themselves, others, and the environment. The effect of science on society is neither entirely beneficial nor entirely detrimental.

- Societal challenges often inspire questions for scientific research, and social priorities often influence research priorities through the availability of funding for research.
- Technology influences society through its products and processes. Technology influences the quality of life and the ways people act and interact. Technological changes are often accompanied by social, political, and economic changes that can be beneficial or detrimental to individuals and to society. Social needs, attitudes, and values influence the direction of technological development.
- Science cannot answer all questions and technology cannot solve all human problems or meet all human needs. Students should understand the difference between scientific and other questions. They should appreciate what science and technology can reasonably contribute to society and what they cannot do. For example, new technologies often will decrease some risks and increase others.
- Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement in principle, for most major ideas in science, there is much experimental and observational confirmation. Those ideas are not likely to change greatly in the future. Scientists do and have changed their ideas about nature when they encounter new experimental evidence that does not match their existing explanations.
- In areas where active research is being pursued and in which there is not a great deal of experimental or observational evidence and understanding, it is normal for scientists to differ with one another about the interpretation of the evidence or theory being considered. Different scientists might publish conflicting experimental results or might draw different conclusions from the same data. Ideally, scientists acknowledge such conflict and work towards finding evidence that will resolve their disagreement.
- It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists. Evaluation includes reviewing the experimental procedures, examining the evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations. Although scientists may disagree about explanations of phenomena, about interpretations of data, or about the value of rival theories, they do agree that questioning, response to criticism, and open communication are integral to the process of science. As scientific knowledge evolves, major disagreements are eventually resolved through such interactions between scientists.

References:

1. National Research Council, *Learning to Think Spatially*, The National Academies Press, Washington, DC, 2006.