Autumn

High School Lesson Plan

Overview

The high-school lesson plan for *QUEST: Autumn* explores the many behavioral and structural adaptations that wildlife undergo in order to survive the changing seasons of New England. As the amount of daylight shortens, biochemical triggers bring about thicker coats on mammals, the migration of birds, changing colors, and the falling of leaves. Soon the forest floor is covered with a deep layer of duff, animals have stored their winter food caches, and the cold rains and early snows dampen the leaves – giving off that familiar dank smell of late fall. Slowly, the moist fallen leaves are recycled by the actions of mushrooms, worms, arthropods, and nematodes to create a nutrient-rich soil that will support a burst of new forest vegetation the following spring.

The recycling of nutrients through a forest ecosystem is a key to the long-term survival of its plants and animals. Carbon is one of the key elements that passes through the forest food web. Beginning with the carbon dioxide trapped by plants in the process of photosynthesis, carbon is transferred between the atmosphere, biosphere, and geosphere, continuously forming new molecules of carbon dioxide, glucose, or protein. This underlying flow of matter can encourage or inhibit the productivity of an ecosystem.

Introduction

This lesson for ninth- through twelfth-graders focuses on students' gaining understanding about the cycling of nutrients in the forest. All matter in the forest is composed of a few essential elements. Plants and animals recycle these, using them over and over again as organisms live, grow, die, and decompose. One key element is carbon. In this unit, we will look at the cycling of carbon through a forest community.

Time Allotment

This lesson requires six to eight 45-minute class periods to complete.

Accessing Prior Knowledge

Students should have some basic understanding of forest ecology and the interactions among predator, prey, and decomposers. Some knowledge of chemistry is also helpful, including a basic understanding of elements

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QUEST lessons are developed in partnership with Maine Mathematics and Science Alliance

Maine Public Broadcasting Network · New Hampshire Public Television · Vermont Public Television · PBS

Major funding for Quest is provided by the National Science Foundation. Additional funding is provided by the Maine Department of Inland Fisheries and Wildlife, Maine Forest Products Council, and Irving Woodlands LLC.

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and chemical bonding. Students should also be able to describe, in basic terms, the processes of photosynthesis and respiration.

Concepts to Clarify

Many students think that the basic building blocks of trees come from the soil, not from carbon dioxide in the atmosphere. Most students can understand the distinct changes that carbon goes through as it moves through the carbon cycle. However, few understand that the same element of carbon moves through all of these stages. Students tend to see each stage as independent – not part of a true cycle, where the carbon is continually recycled.

CONNECTIONS TO THE STANDARDS

National Science Education Standards	Benchmarks for Science Literacy	Maine Learning Results	New Hampshire Curriculum Framework	Vermont Learning Standards
Content Standards (9-12) C. Life Sciences: The Matter, Energy and Organization in Living Systems --As matter and energy flow through different levels of organization of living systems – cells, organs, organisms, communities – and between living systems and the physical environment, chemical elements are recombined in different ways …. Matter and energy are conserved in each change.	**Chapter 5: The Living Environment** 5E. Flow of Matter and Energy, #3 --The chemical elements that make up the molecules of living things pass through food webs and are combined and recombined in different ways.	**Science and Technology** B. Ecology, #1 -- Illustrate the cycles of matter in the environment and explain their interrelationships.	**Life Science** 3c. Students will demonstrate an increasing ability to understand that organisms are linked to one another and to their physical setting by the transfer and transformation of matter and energy to maintain a dynamic equilibrium. Construct models that demonstrate which chemical elements make up the molecules of substances found in living organisms and how these elements pass through food webs.	**The Living World: Organisms, Evolution and Interdependence** 7.13 Describe, model and explain the principles of the interdependence of all systems that support life (e.g., flow of energy, ecosystems, life cycles, cooperation and competition, human populations' impacts on the world ecological system), and apply them to local, regional, and global systems.

Materials Needed

- TV and VCR
- *QUEST Autumn* video:
- Poster board or chart paper
- Markers of varied colors
- Computers with Internet access for student use
- Textbooks, trade books, and other sources of information about the carbon cycle
- Mini-marshmallows
- Toothpicks
- Student Handout 1: Video Viewing Guide
- Student Handout 2: A Letter from Sam
- Student Handout 3: Quest at Home – Does Greenhouse Rock?

1. Introducing the Concepts

Activity 1

Begin by asking students the following question: "Where have your carbon molecules been before?" In small groups, have students discuss their responses and diagram where they think the carbon molecules that compose their bodies have come from.

Explore with the class whether they think these molecules have always been in humans, whether they are remnants that have been passed from cell to cell, and other possibilities. This is a good time to explore students' misconceptions. Do not judge or correct them at this point; just encourage them to voice their thoughts.

Step 2

Create a list of questions that students may have about carbon. Keep the list posted in the classroom so that it can be referred back to during discussions throughout this teaching unit. Try to answer these questions as information arises during the course of the activities that follow.

Step 3

Explain that in this unit, students will be exploring some of the cycles that occur in nature. Be sure that they understand the concept of cycle rather than web. A cycle is a repeating pattern that occurs over time. Some cycles are short-term and some are long-term. Some occur daily, some monthly, some yearly, some occur over millions of years. Have students brainstorm a list of cycles in nature for each category. (Examples: daily cycle – rotation of earth; monthly cycle – orbit of moon around earth; yearly cycle – orbit of earth around sun; millennial cycle – climatic cycle of the ice ages).

2. Exploring the Concepts

Activity 2

Step 1
Tell students that they will be watching a video that describes a number of types of cyclic events in nature. Ask them to make a list of all the different types of natural cycles they can think of.

Step 2
Distribute copies of Student Handout 1 (Video Viewing Guide). Ask students to use this viewing guide sheet while watching the video so that they can keep their information organized.

Step 3
Show the *QUEST* video to the class. Ask students to jot down the names of some of the cycles that are shown in the video. From these lists, students should then select two cycles to examine in more detail. Tell them that you will show the video again so that students can watch more closely and take notes on the phases of the particular cycles they have chosen.

Step 4
After showing the video for a second time, have students draw diagrams of each of the two cycles they have individually examined. Have them identify whether each cycle is behavioral or biological. Next, ask them to try to identify the specific factor(s) that have triggered the changes in their selected cycles. Some examples of behavioral cycles include birds migrating from wintering grounds to nesting grounds (triggered by changing temperatures), moose and deer looking for mates, or small mammals caching food or storing up body fat (also triggered by temperature changes); biological cycles include leaves budding, growing, changing color, and falling (triggered by day length) or feathers molting after mating and nesting are complete (also triggered by day length). Have the students share their ideas.

Step 5
If none of the students identify the food web as a cycle, discuss it now, using mushrooms as an example. Explain how matter moves between organisms. Identify this movement as the nutrient cycle. (Recycling of nutrients is depicted in the video as leaves falling, decomposing, becoming absorbed in the soil, and providing nutrients which are drawn out of the soil for plant growth.)

Step 6
Arrange students in teams of three. Ask them to consider the carbon atom in a forest ecosystem. Have teams discuss what they know about carbon as it appears in various parts of the ecosystem. They should consider what carbon comprises in the atmosphere, in plants, in animals, in decomposers, and in soil. Now ask each team to diagram in general terms how carbon might move from the atmosphere to a producer, then to a consumer, then to a decomposer, and back to the atmosphere. Have each team member select one of these three levels of interaction: (1) atmosphere to producer (carbon dioxide to

starch in plants), (2) producer to consumer (starch in plants to protein in animals), (3) consumer to decomposer (protein in animals to protein in organisms), and (1) producer back to atmosphere (respiration of carbon dioxide from organisms into atmosphere). Individual team members should research the particular form that carbon takes in their trophic level and how it changes.

3. Developing the Concepts

In the following activity, students will further explore carbon and the molecular forms it can take on as it moves through each trophic level.

Activity 3

Step 1

Have student teams do their research on carbon and its molecular forms. Allow them to use the Internet, textbooks, trade books, and knowledgeable individuals as resources. Explain the level of technical description you expect, based on their prior knowledge of chemistry and metabolism. You may choose to accept simplified explanations if your students have not had exposure to this information before.

Step 2

Provide student teams with the materials they will need to create a poster and model(s) of the carbon molecule they have researched. Ask each team to prepare a poster and model of their findings about carbon – in other words, they should illustrate the specific chemical changes that occur during photosynthesis as carbon moves from a carbon dioxide molecule into a starch. Models should depict the chemical structure(s) that carbon takes in each trophic level (mini-marshmallows, color-coded for each element, can be used with toothpicks to make the models). Teams should use their posters to summarize their findings about the entire carbon cycle for class presentations. A great Web site for students to use is titles Chemical Carousel: A Trip Around the Carbon Cycle *(http://library.thinkquest.org/11226/index.htm)*.

Step 3

When all teams have had adequate time to create their posters and models, have each team of students present their creations to at least one other team. Encourage students to ask each other questions to probe for understanding.

Step 4

To conclude this portion of the lesson, ask each student to respond individually to the following writing prompt: "Can the same molecule of carbon travel through all of the trophic levels and become part of a sugar, a carbohydrate, the soil, and so on? Explain you answer." Allow time (either in class or as a homework assignment) for all students to produce written responses to the prompt. Review responses as needed.

4. Synthesizing the Concepts

Activity 4

Step 1
Have students gather in the team arrangements established earlier. Distribute to each student a copy of the letter from Sam Neighbor (Student Handout 2).

Step 2
Have teams review the letter from Sam, discuss their responses, and agree on a position to present to the rest of the class. Ask each team to prepare a presentation of their ideas, using the models they have already created from their carbon cycle presentation (Activity 3) as evidence to justify their position. Give teams time to prepare their presentations.

Step 3
Have each team present their position. Allow the other teams to question any points they doubt or that need further explanation. Then ask the class as a whole to decide what their preferred explanation is.

Step 4
As a wrap-up assignment, ask each student to write a letter to Sam Neighbor describing, in the clearest possible terms, the class's final response to Sam's question.

5. Applying the Concepts

The flow of carbon naturally occurs throughout the earth. Students have studied how the carbon element combines with other elements to form various molecules as it moves from the atmosphere (carbon dioxide) to plants (starch) to animals (proteins) and back to the atmosphere.

Earth system scientists study this carbon flow. One reason for their interest is the current world climate change (global warming), which they believe is being caused by an increase in carbon dioxide in the earth's atmosphere, caused by the burning of fossil fuels. The following activity demonstrates for students and their families the far-reaching effects of greenhouse gases. (Note: This activity must be done in the early fall or in the spring.)

Activity 5

Step 1
Distribute a copy of Student Handout 3 Quest at Home: Does Greenhouse Rock? to each student. Review the handout with the class, and instruct students to take the handouts home for completion with family members.

Step 2

Check periodically with students to find out what they are observing in their greenhouse experience. When enough time has elapsed for seedlings to grow and for students to record temperatures in the plant-filled trays for several weeks, have students bring their written findings into class for discussion. Encourage them to extrapolate from their home-based experiment to the more widespread problem of greenhouse gases and global warming.

6. Extending the Concepts (Optional Activities)

Community Connections

Gathering information on the cycles and population changes of species in your community can provide valuable knowledge for your students. Many organizations track the migrations of bird species, for example. Many state and private nature centers sponsor bird walks at various seasons. Some also offer walks to identify mushrooms, which are particularly plentiful in the fall. The National Audubon Society has chapters in each state which conduct Christmas Bird Counts, Birdathons, Breeding Bird Surveys, and/or Hawk Watches *http://www.audubon.org/bird/birdathon/index.html*. Other links for birding in New England can be found at *http://home.att.net/~plastereddragon/birdlink.html*

Career Opportunities

Share the following information with students who might be interested in further exploring how some of the concepts they have learned about in this lesson may be applied in the workplace:

■ This lesson examines some aspects of the carbon cycle – just one type of cycle depicted in the video. There are also other kinds of cycles referred to in the video, which are discussed by a number of professionals. Ornithologist, for example, study patterns of bird migration. Foresters study the cycling of nutrients in forest ecosystems. Mycologists study mushrooms as decomposers in the forest.

■ Many of the experts mentioned above work together to study changes that are occurring in the earth's environment. These changes are called *global change*s. The carbon cycle is being examined for its relationship to global change issues. Scientists are examining how carbon is distributed throughout all of the earth's systems – atmosphere, hydrosphere, and geosphere.

■ Many scientists believe that much more carbon is now in the atmosphere because of the relatively modern practice of burning fossil fuels (particularly oil and coal) to make electricity. These fossil fuels are actually the ancient remains of plants. As students have already learned from Student Handout 2, when fossil fuels (plants) are burned, they release carbon into the atmosphere. Thus, reservoirs of carbon that have been stored as oil, coal, and gas over many thousands of years have now moved from the earth (geosphere) to the air (atmosphere). This is generally believed to be the leading cause of global warming.

■ Also discussed on Student Handout 2 is the greenhouse effect on earth, caused by gases like carbon dioxide. As carbon dioxide increases in the atmosphere, it traps heat from the sun, thus warming the earth to a greater degree. This is thought to be leading to many changes around the world such as melting of the polar ice caps, rising sea levels, decreasing biodiversity, and more dramatic weather patterns. Many organizations are studying these phenomena in order to determine with certainty the origin of the problem and its potential impact. Such researchers include earth systems scientists, climatologists, biologists, geologists, chemists, foresters, and computer programmers.

Resources

The Carbon Cycle: http://www.woodrow.org/teachers/esi/1998/p/carboncycle/index.htm

The Carbon Cycle: http://www.ultranet.com/~jkimball/BiologyPages/C/CarbonCycle.html

Global Warming Kids Site, EPA: http://www.epa.gov/globalwarming/kids/carbon_cycle_version2.html

Video Viewing Guide

While watching the *QUEST* video in class, use this viewing guide sheet to help you organize your notes.

(A) Some natural **cycles** mentioned in the video:

_____

_____

_____

(B) **Two cycles** you will examine in more detail:

Cycle #1 _____ **Cycle # 2** _____

(*Check one*) Behavioral _____ (*Check one*) Behavioral _____

Biological _____ Biological _____

Diagram of this cycle

Diagram of this cycle

(C) **Specific factors** that trigger these changes:

Cycle #1	**Cycle #2**
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

A Letter from Sam

Dear Students,

I work downtown at the hardware store. I was in there the other day when somebody came in and asked me a very interesting question.

Although his question seemed simple, this person told me that he had spoken to graduates from Harvard University who did not know the correct response! So, I did some research on my own, and I have found out what I think the correct answer is. This answer really is pretty simple, but it is hard to believe.

I heard that you were doing research on plants and the carbon cycle, so I would like you to confirm my response.

So, here is the question:

> **If you have a little acorn, and a great big oak tree, where did all the matter that makes up the cells of the oak tree come from?**

To come up with my answer, I had to do research on how plants grow – which I think your class has been doing. If you could tackle this question and decide what the right answer is, I would really like to hear what you find.

Thanks so much,

Sam Neighbor

Does Greenhouse Rock?

You're on a Quest!

Explore the natural phenomenon of the greenhouse effect. Just by looking at daily rising temperatures, changing climate conditions, and the changes in our ecosystems, we are finding out more about the warming of our planet Earth.

Materials needed:

- 2 seed trays
- Soil to fill seed trays
- Flower seeds of several varieties
- Water
- Plastic food wrap
- 2 thermometers
- Large rubber band
- Wooden skewers or ice-cream sticks
- Pencil and notebook for record keeping

Investigate with your family!

■ We are finding that the earth's atmospheric levels of carbon dioxide (CO_2) have increased dramatically over the years, making it harder for this heat to escape. Why do scientists consider carbon dioxide a greenhouse gas? How does the Earth's heat get trapped?

■ Why so much carbon dioxide? Talk with family, neighbors, friends, and community members about what they do to conserve energy with their cars, their homes, and their businesses?

Here is a list of helpful Web sites on global warming and the greenhouse effect:

United States Environmental Protection Agency *http://www.epa.gov/globalwarming/kids/index.html*
Union of Concerned Scientists *http://www.climatehotmap.org/*
Center for the Study of Carbon Dioxide and Global Change *http://www.co2science.org/*

Conduct this simple experiment with your family to illustrate how the greenhouse effect works. It's best to conduct this experiment in the early fall or in the spring.

Procedure

1. Fill the seed trays with soil. Plant a variety of seeds in each tray. Water the soil after planting; be certain that the soil is moist.

2. Place a thermometer in each tray.

3. Cover one tray with plastic wrap, and secure it with the large rubber band.

4. Place both trays in an outside location. Shelter them from rain, but expose the trays to the sun.

5. As the seedlings grow taller, insert the skewers/ice-cream sticks so that they are upright in the corners of the wrapped tray. This will help to keep the plastic from touching the plants. Then replace the plastic wrap.

Record the temperatures of both trays as well as any of your weekly observations.

Week 1 _____ Week 2 _____

_____ _____

Week 3 _____ Week 4 _____

_____ _____

Conclusion

What do you notice about the closed environment (the plastic-wrapped tray)?

_____

_____

_____

_____

What do you notice about the open environment (the unwrapped tray)?

_____

_____

_____

_____

Electronic Quest!

Take a global change quiz to check your understanding! Ask your family and friends to complete the Environmental News Network quiz on global warming:

http://www.enn.com/enn-news-archive/2001/03/03302001/globalwarming_42749.asp

When everyone has had a chance to take the on-line quiz, ask if any of the answers have been surprising. Record everybody's score. Compile the data. What do you find?

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