



Autumn

Middle Level Lesson Plan

Overview

QUEST: Autumn leads students to examine the many changes that occur in our northern hardwood forests as organisms make the transition from warm summer to snowy winter weather.

The changing colors and falling of hardwood leaves creates a boon for tourism-related businesses. It also provides a rich opportunity for students to consider what happens to those dead and decaying leaves – how they actually break down into materials that can be used by other organisms in the ecosystem as matter or “stuff” for growth.

The *QUEST* video includes descriptions and explanations by biologists and mushroom experts who point out the enormous amount of biomass that is cycled through an ecosystem and the kinds of decomposers that live, grow, and work in these forests.

Introduction

This lesson gives middle-level students an opportunity to visit a local “ecosystem” (a rotting log) to consider in general the kinds of organisms that live within the system. Students will then explore the cycling of matter that provides the “stuff” these organisms are composed of. (In the event of inclement weather, a Web site is provided that allows students to observe decomposition over time from an indoor perspective.)

Students will create a “biocolumn” in order to observe composting firsthand. Through information they have gathered from the *QUEST* video and by visiting several Web sites, they will accumulate a growing body of knowledge about the chemicals that make up these organisms and how that matter decomposes.

As a final challenge, students will develop models representing the components and interactions within their individual ecosystems.

Time Allotment

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



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



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Maine Forest Products Council





Accessing Prior Knowledge

In order to trace the cycling of matter through an ecosystem, students will need to understand that the food of nearly all animals can be traced back to plants; that some source of energy is needed for all organisms to stay alive and to grow; and that over the earth, organisms are growing, dying, and decaying, and new organisms are being produced by the old ones.

Before students have an understanding of atomic structures, the notion of reusable building blocks common to plants and animals is quite mysterious. For this reason, their study of the cycling of matter through ecosystems should be linked with their study of atoms. This lesson will also be more meaningful to students if they already have an understanding of photosynthesis that is focused on the transformation by plants of air and other materials into food that can be used for fuel and growth. (Even after traditional instruction, students have difficulty accepting that plants make food from water and air and that this is their only source of food. Understanding that the food made by plants is very different from other nutrients such as water or minerals is a prerequisite for understanding the distinction between plants as producers and animals as consumers.)

Concepts to Clarify

Most students see food webs and cycles as involving the creation and destruction of matter, rather than as the breakdown and reassembly of invisible units of matter. They regard various organisms as consisting of distinctly different types of matter that are not convertible into one another. For example, they generally believe that animals are composed of bone, muscle, skin, and so on; that plants are made of leaves, stems, and roots; that the nonliving environment is made of water, soil, and air; and that these substances are all unique and not transformable.

Research indicates that some students think dead organisms simply rot away. They don't realize that the matter from a dead organism is converted into other materials in the environment. Some students see decay as a gradual, inevitable consequence of time without the need for decomposing agents.

Some students pay little attention to the matter involved in processes such as plant growth or plant consumption by animals. They view these processes as involving the creation and destruction of matter rather than its transformation from one substance to another. Other students recognize one form of recycling through soil minerals but fail to incorporate water, oxygen, and carbon dioxide into matter cycles.



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CONNECTIONS TO THE STANDARDS

National Science Education Standards	Benchmarks for Science Literacy	Maine Learning Results	New Hampshire Curriculum Framework	Vermont Learning Standards
<p>Content Standards (5-8)</p> <p>C. Life Sciences: Populations and Ecosystems (pp. 157-158) – Populations of organisms can be categorized by the function they serve in an ecosystem. Plants and some microorganisms 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.</p>	<p>Chapter 5 The Living Environment</p> <p>5E. Flow of Matter and Energy (pp. 118-121); Benchmark 6-8, # 2 – Over a long time, matter is transferred from one organism to another repeatedly and between organisms and their physical environment. As in all material systems, the total amount of matter remains constant, even though its form and location change.</p>	<p>Science Content Standards</p> <p>B. Ecology; #5 – Describe various mechanisms found in the natural world for transporting living and nonliving matter and the results of such movements.</p>	<p>Life Science</p> <p>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 ... to maintain a dynamic equilibrium.</p> <p>End of Grade 10 (Secondary) 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.</p>	<p>The Living World: Organisms, Evolution and Interdependence</p> <p>7.13.cc. Describe, model and explain the principles of the interdependence of all systems that support life (e.g., food chains, webs...), and apply them to local and regional systems.</p>



Materials Needed

- TV/VCR
- *QUEST Autumn* video
- Area with decaying logs for students to observe (or access to Web site for teacher to print out handout for students)
- For Activity 2: Dead plants, other plant and animal matter, and soil; three 2-liter soda bottles of similar size and shape for each student, pair, or small group; scissors and razor blade; heat source and Pyrex™ test tube (for creating air holes in biocolumn); nylon stocking, electrical tape, and rubber band for each biocolumn; water; marking pen, and paper; thermometer; triple beam or pan balance or soda bottle scale (described on Student Handout 4); red worms
- Materials for students to use in creating ecosystem models – either computer software that can help design flow charts (such as *Inspiration*), materials for a mobile, or other appropriate material
- Student Handout 1: Cycles of Life: Observations of a Decaying Log
- Student Handout 2: Cycles of Life: Where Does All That Stuff Come From, Anyway?
- Student Handout 3: A Bottle Model of Decomposition and Decay
- Student Handout 4: Life on a Log Over Time
- Student Handout 5: It's Elemental!
- Student Handout 6: A Model of Our Forested Ecosystem
- Student Handout 7: Analyzing Our Ecosystem Models
- Student Handout 8: Quest At Home: Building a Compost

I. Introducing the Concepts

The following activity engages students in considering a local, familiar ecosystem and food web. It also will inform teachers about their students' current thinking about the cycling of matter in that ecosystem.

Activity I

Note: You will need to “scope out” an appropriate site for your class field trip ahead of time; this site should include at least one, but ideally several, dead and decaying logs for students to observe. This would also be a good time to collect a large bucketful of soil and plant and animal remains that will be used in Activity 2.

In the event of inclement weather or lack of field trip possibilities, students can visit the Decomposition Web site at <http://www.offwell.free-online.co.uk/decompos.htm>

They should record information about the decaying rabbit they can observe in a series of thumbnail sketches. By enlarging each image, they can view some of the organisms living on and in the rabbit as it decays over the course of a year.

Step 1

Explain to students that they will be learning about the organisms that live within their own local ecosystems. In particular, they will be studying what happens to these organisms as they die off.

You may wish to prepare students for this outdoor excursion by first distributing Student Handout 1 (Cycles of Life: Observations of a Decaying Log). This will help them understand the reasons – and expectations – for the excursion. At this time, you should also have students form pairs or small groups, each of which will observe one of the decaying logs.

Step 2

At the field trip site, gather the class around one decaying log. Ask the following questions: Looking at this log, can you guess how long ago this tree died? What evidence supports your guess? Discuss student responses.

Step 3

Assign each group to one specific rotting log. Then point out the data table on Student Handout 1. Remind groups to record (through sketches, labels, and/or notes) as much detail as possible about their particular log. Mention that it will be important to list as many organisms as possible in order to begin to see patterns in the ecosystem around them.

Note: Students in classes with digital cameras may choose to use the cameras to record specific features of their decaying logs and to include those images in their handout responses.



Step 4

Back in the classroom, ask each pair or group to share information about one unusual organism that they found on or in their log, providing as much detail as possible.

Step 5

Distribute Student Handout 2 (Cycles of Life: Where Does All That Stuff Come From Anyway?!). Encourage students to include everything they have learned in their responses, since this initial assessment will be instrumental in helping you determine how the rest of the lesson will be structured.

2. Exploring the Concepts

This activity will help students begin to explore the notion of conservation of matter during decomposition and decay. By the end of the activity, students will be more aware of the role and importance of agents of decomposition in the decay process.

Activity 2

Step 1

Begin by leading a general discussion based on the following question: “Where do you think the matter that makes up a leaf comes from?” Elicit students’ initial ideas. (If they have already learned about photosynthesis and respiration, they will be aware that most of the matter in a tree comes from the air, through respiration, and that it is transformed during the process of photosynthesis into the material that makes up a tree.)

Then ask, “Where does the matter that makes up an animal come from? How does that matter become available to the animal?” Discuss students’ responses.

Step 2

Now turn the discussion to the results of the previous homework (Student Handout 2). Ask students to share some of the items they have listed. Record one idea from each student team either on chart paper or on an overhead transparency that you can create using Student Handout 2 as a master.

Step 3

Tell the class that they will be exploring more about where matter comes from and where it goes in an ecosystem. In this case, they will be learning about a hardwood (broadleaf) forest in the autumn. Explain, “We will be setting up an experiment that will help us understand more about how decomposition and decay in the hardwood forest occurs.”

Step 4

Distribute Student Handout 3 (A Bottle Model of Decomposition and Decay). Follow the instructions for the Biocolumn Composting setup described on pages 2-4 of the handout.² (They should use the soil and

² From *Bottle Biology*, © Wisconsin Fast Plants, University of Wisconsin-Madison, published by Kendall-Hunt.

plant/animal matter that were gathered during the field trip in lieu of the Fast Plants and potting soil mentioned on the handout.) Have students record baseline data about their biocolumns on page 1 of Student Handout 3.

Step 5

Some students see decay as a gradual, inevitable consequence of time without the need of decomposing agents. In order to dispel this misconception, have half of the student pairs or groups add red worms to their biocolumns as described in the extension section of this activity.³ It will be interesting for students to observe the difference in decomposition rates between the bottles that contain worms and those that do not. (**Note:** Moisture levels in these columns must be checked regularly.)

In order to support understanding of the conservation of matter, have students weigh their columns at the beginning and at the end of their investigation, using a triple beam balance, pan balance, or scale made from soda bottles. Directions for constructing this latter tool are also available on the Bottle Biology Web site: http://www.fastplants.org/Library/BottleBiology_body.htm

3. Developing the Concepts

The following “think/pair/share” activity will lead students to begin to identify the components of a northern hardwood forest and to recognize how these components each play a role in the cycling of matter within this ecosystem.

Activity 3

Step 1

Begin by having students think individually about the following questions: Remember the rotting log that we saw the other day? If you were to visit that log once a month for two years, do you think that you would always see the same *kinds* of organisms living on it each time? Or, do you think that the populations would change over time? Explain your response.

Students can refer back to their notes and sketches on Student Handout 1. Next, they should discuss their answers with a partner. Finally, student pairs should share their responses with the whole class. The whole process should take about 5-7 minutes.

Step 2

Distribute Student Handout 4 (Life on a Log Over Time). Have students make a list on the front of the handout of the kinds of organisms that would live on a rotten log at each specified time of year.

³ For information about ordering red worms or other vermicomposting resources and materials, visit http://www.wormwoman.com/acatalog/Wormwoman_catalog_Redworms_Eisenia_fetida_43.html#14

Step 3

Give students about 10 minutes to draw a “storyboard” on the back of their handouts. (If they think that the log would host the same kinds of organisms each time, their storyboard should reflect this idea. However, encourage them to consider all of the different stages of log decay they have seen during forest visits.)

Step 4

Explain to students that they have been focused on one part of a forest ecosystem – the rotting log. They will now consider other components of the forest and how these, too, are cycled and contribute to the cycling process that all matter undergoes in any ecosystem. For example, ask: How many leaves do you think fall in an acre of forest during the autumn? What happens to those leaves?

Explain that they will be viewing a video that will give them some idea of the progression or “succession” of organisms responsible for decomposition in the hardwood forest. Ask students to observe and record in their notebooks (or laptop computers, if applicable) some of the other parts of the forest that are discussed in terms of decomposition and how they are recycled or decayed. Also ask them to note any of the kinds of nutrients that these organisms provide to the rest of the food web. (Through this and subsequent activities, they will begin to recognize the many types of decomposers – bacteria, fungi, worms, insects, etc. – and that they each plays a different role and does different work in a predictable progression over time.)

Step 5

Show the first half of the *QUEST: Autumn* videotape. Check to be sure that students are taking notes. Stop the video after the mushroom club segment (as the topic turns to bird and mammal changes in the autumn).

Step 6

Conclude the class by discussing what students have recorded in their notebooks (or on their laptops).

Activity 4

The purpose of this activity is to help students recognize that the cycling of matter in an ecosystem actually involves breaking down animals and plants into their basic elements; this enables them to be recombined to form the “stuff” or matter that makes up other organisms.

Note: This research-based activity requires two class periods to complete. The end of the first class period would be a perfect time for students to spend about 10 minutes doing the second observation of their biocolumns. Be sure that they record their observations on the data tables set up previously.

Step 1

Introduce the activity by distributing the three-page “Decomposition” article that can be downloaded from <http://www.offwell.free-online.co.uk/decompos.htm>. Read the article aloud to the class, pointing out

and discussing the key sections describing how organisms are broken down into their constituent chemicals, which can then be used by other creatures. Another point of interest is the photograph of a student holding the hyphae of mushrooms; this was mentioned in the *QUEST* video shown during Activity 3.

Step 2

Clarify for students that the section at the end of the article does not mean that the nutrients that support plants in the process of photosynthesis will actually become the majority of the matter in those plants. In fact, most of that matter actually comes from the air in the form of carbon (from carbon dioxide).

Step 3

Tell students that in a couple of days, they will begin a task in which each student (or pair or small group of students, if you prefer) will create a model that shows how matter is cycled in a typical hardwood forest ecosystem. Distribute Student Handout 5 (It's Elemental!) and review with students. Stress that their models will need to include:

- the kinds of organisms that are found within the ecosystem
- how each organism is decomposed (eaten by which decomposers?)
- some kinds of materials the decomposers will contribute to the new organisms that will be born and will grow after their death

Explain that, in order for students to complete this task, they will need to research other Web sites and/or library materials to discover more information and details about decay and the cycles of life.

Step 4

Let students know precisely when they should wrap up their work on the first day if you want them to make observations of their biocolumns. (The observation will probably take 10-15 minutes.)

4. Synthesizing the Concepts

The following activity pulls together students' understanding about the organisms that live within a forested ecosystem, the interactions of these organisms within a food web, the decomposers within the ecosystem's food web, and the cycling of matter that those decomposers are responsible for within the system.

Activity 5

Step 1

Decide whether you prefer students to work individually, with partners, or in groups of four. Arrange students so that they can work well within the organizational structure you have chosen.

Organize the materials that your students will need to complete their models, including materials to create a mobile, diorama, computer-generated flowchart, Hyperstudio product, PowerPoint presentation,

or any other model that demonstrates the flow of matter in a forested ecosystem. (See the Resources section for links that may help you locate some of these materials.)

Step 2

Introduce the activity by distributing Student Handout 6 (A Model of Our Forested Ecosystem.) Review the assignment together; have students discuss and specify aloud for their classmates the “products” that will be required for this culminating task. Check to be sure that they understand the assignment.

Step 3

Allow students the rest of the period to complete their work. Let them know that they will be sharing their models with the rest of the class during the next lesson. (They will apply their new conceptual understanding during Activity 6, in which they debrief the results of Activity 5.)

Note About Proficiency: To demonstrate proficiency in this assignment, a student’s model should provide specific and accurate examples of interactions within the hardwood forest ecosystem. Organisms should be linked to one another and to their physical setting through the transfer and transformation of matter. Models should perform the following functions:

- Provide an accurate example of a food web that could exist within this ecosystem.
- Show how some matter that results from decomposition is used immediately by other organisms to support their growth, while other matter may be broken down so that it becomes part of the soil, the atmosphere, or the water within the ecosystem, then eventually is taken in by other organisms.
- Include reference to at least three different interactions at the molecular or atomic level -- mentioning elements that are passed from one organism to another. (Knowing the specific elements is not the critical concept here; rather, understanding that each organism is composed and is later broken down into basic elements is the key idea.)

5. Applying the Concepts

The next activity allows students to apply their conceptual understanding of the transfer and transformation of matter within a forested ecosystem.

Activity 6

Note: This activity may take two class periods in order for all teams to present their models.

Step 1

Begin by having students get back together with their partners or with the small groups with whom they completed their models from Activity 5.



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Explain that each group will have an opportunity to share their model. (**Note:** If your class has not done so already, this is an appropriate time to generate a list of standards that define a “quality audience.” Record these on chart paper and keep them posted throughout the presentations.)

Step 2

Ask students to take out Student Handout 6. Review the components that they were asked to include in their ecosystem models.

Discuss the concept of “models”— that they are tools for learning about the things they are meant to resemble. Tell students that one thing they will be considering as they listen to each presentation is how the model both does and does not represent the real hardwood forest ecosystem. (Be sure that they understand that no model can totally imitate a living, real-world system.)

Step 3

Distribute Student Handout 7 (Analyzing Our Ecosystem Models). Ask students to record their observations about each presentation.

Step 4

After every presentation, have students within each pair or small group “put their heads together” to come up with three comments to share with the presenting team:

- Something about the model that helped them to understand forest ecosystems
- Something about the model that **is like** a real hardwood forest ecosystem
- Something about the model that **is not like** a real hardwood forest ecosystem

(If time is an issue, you may choose to have groups in the “audience” report just their first comment, then hand in their written results so that you can check for understanding.)

Note About Proficiency: To demonstrate proficiency in this assignment, the majority of a student’s notes (for at least five different presentations) must mention accurate examples of components of the model and of the hardwood forest ecosystem that are alike. The majority of their notes (for at least five presentations) must also make accurate mention of ways in which the model and the hardwood forest ecosystem are not alike.

Activity 7

To apply their learning to the world beyond school, students can perform the following activity at home with family members.

Step 1

Distribute copies of Student Handout 8 (Quest At Home: Building a Compost). Read the handout together, and encourage students to work with other family members to develop their own home composting project.

Note that the Vermont Agency for Natural Resources Web page (<http://www.anr.state.vt.us/dec/wastediv/compost/backyard2.html#GeneralWhy>) is especially rich in information about composting: what to compost, how to compost, and what to do with the composted soil that results from this process. You may choose to invite students to share the results of their home composting efforts with classmates. Participating students can keep a log of the materials that make up the “input” and “output” of this process.

6. Extending the Concepts

Community Connections

- Students can visit their community’s transfer station to learn about the extent to which composting occurs there or is encouraged. (Some communities collect and compost roadside collections of autumn leaves, for example.)
- Many adult education programs offer short workshops on composting. Have students explore those opportunities within their school system, then encourage families to attend and to begin to compost their household food waste.
- New Hampshire’s Hubbard Brook Experimental Forest is located in the heart of the White Mountains. It provides a wonderful opportunity for visitors to learn about short-term and long-term research projects that have been designed to study how ecosystems work. (What happens when all of the trees are cut down? How do plant nutrients cycle in the soil, water, and air? Are bird populations increasing or decreasing? Is acid rain a problem?) The U.S. Forest Service routinely gives tours, including slide shows and field trips. Tours can be geared toward specific interests of visitors and are flexible with respect to age and education level of the group. Contact the forest at: 603-726-8902 or <http://www.hubbardbrook.org/education/Introduction/Intro2A.htm>

Career Opportunities

- Have students visit the Invisible Forest Web site at <http://www.conservation.state.mo.us/conmag/1999/06/1.html> for a delightful first-person account of a multiyear study examining the effects of different logging practices on plants, animals, and nutrient cycles of the forest. Just a small excerpt from the site demonstrates its appropriateness for middle-level students: “I count...37, 38, 39... I look up and blink and then focus on the beetle poster across the room. Once my eyes have adjusted, I turn to the paper next to my microscope and write 39 @ 2 mm on the line for species number 362. I am halfway through the leaf litter sample I collected last summer from a shady slope, deep in the Ozark forest ...”
- Provide students with the following prompting questions. Then have them visit the Hubbard Brook Experimental Forest Web site at <http://www.hubbardbrook.org/education/Introduction/Intro6.htm> to seek answers. (The site includes a virtual tour for students, which would be very helpful in their search.)

- Do scientists work individually or do they sometimes work with other scientists?
- Why do collaboration and cooperation help scientists do better research?
- If you were studying a certain part of the forest to find out certain information (for example, How long it takes trees to decompose?), how long would you want to conduct your research?

Resources

Content Background

Helpful Web sites on decomposition and decay in a forested ecosystem include:

- **Decomposition:** <http://www.offwell.free-online.co.uk/decompos.htm>

This British Web site includes excellent information about decomposition in the forest.

- **The Magic Habitat:** http://www.insights.co.nz/magic_habitat_fe.asp

This site describes a typical pine forest ecosystem and explains which organisms eat and help to decay which other organisms.

- **Gardener's Bookshelf:** <http://www.fulcrum-gardening.com/html/compost.html>

How Composting Works discusses the components that make up the forest floor and points out one of the important nutrients that become available for plants to use.

- **Fun Facts About Fungi:** <http://www.herb.lsa.umich.edu/kidpage/Decay.htm>

Fungi as Decomposers is the subheading of this article, which describes their role in breaking down organic matter. It also explains what "organic matter" is.

- **Food for Worms:** <http://www.hartwick.edu/pinelake/ecotone/num10/fw.html>

This site describes some basic forest food webs. It also describes some research that was done to compare the rate of decomposition between a hardwood and a hemlock (softwood) forest.

- **Coarse Woody Debris:** <http://www.fs.fed.us/r6/olympic/ecomgt/unecosys/woody.htm>

Fallen logs and branches form the base of many food webs in the forest. This site describes some of those interactions.

Quest Pedagogy

The Learning Cycle model that forms the foundation on which these lessons are designed is based on the belief that students construct conceptual understanding gradually, through active engagement in a series of coherent experiences. Of equal importance to the activities is the opportunity to have time and support for reflecting on the meaning of these new ideas.

For background on this model, visit one of the following Web sites:

- www.coe.ilstu.edu/scienceed/lorsbach/257lrcy.htm
- www.mdki2.org/practices/good_instruction/projectbetter/science/s-26-28.html
- www.aenc.org/ABOUT/Philosophy-Learning.html



National Science Standards Documents

There are two major standards documents at the national level for K-12 science:

- Benchmarks for Science Literacy were created by the American Association for the Advancement of Science (Oxford University Press, 1-800-222-7809). <http://www.project2061.org/tools/benchol/ch5/ch5.htm>
- National Science Education Standards were developed by the National Research Council (National Academy Press, 1-800-624-6242). <http://www.nap.edu/catalog/4962.html>



Student Name _____

Cycles of Life: Observations of a Decaying Log

Let's begin our study of a local ecosystem by considering what happens to things in the forest after they have died. Record detailed information about all of the organisms that you see on or in your decaying log; use both notes and sketches with labels.

Organism Observed	Description/Sketches with Labels



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Student Name _____

Cycles of Life: Where Does All That Stuff Come From, Anyway?!

A friend and I were hiking in the woods one day when we noticed a huge log lying on the ground.

We sat down on a rock and began to watch all of the different kinds of things that were living on and in the log. (Yes, I must admit that we took a couple of large sticks and used them to peel off layers of the log so we could see what was going on inside!) We saw bugs, wormholes, mushrooms, little plants and even some scratch marks that probably were made by a skunk looking for grubs.

My friend told me that her class was studying about “food chains” and that everything we could see in and on that log was going to be lunch for something else. I had heard about food chains before, but the part that I wasn’t really sure about was where all of that “stuff” came from that the different plants, mushrooms, bugs, and worms are made of. And, how does that material get into them as they grow bigger?

Can you help me and my friend out? We’d like to know where the “stuff” in each different kind of living thing comes from. Please answer in as much detail as possible – tell everything that you know about the matter that makes up each of the organisms in the chart below.

Kind of Organism	Where Its “Matter” Comes From
log/woods	
bugs/insects	
worms	
mushrooms	
small plants	
skunk	



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Student Name _____

Cycle of Life: A Bottle Model of Decomposition and Decay

This model of a hardwood ecosystem will let you watch what happens during the decomposition of organisms and other organic matter over time. In order to understand how changes happen, it will be very important that you keep careful and detailed records of all that you observe. Use the chart below to keep your data organized.

Circle One: Includes red worms / Does not include red worms

Table with 6 columns: Date, Weight of Column (units), Temperature of Column (units), Odor, Decay Organisms (sketches and/or names), Appearance (of each organism and of decaying matter). The table is currently empty.

Reminder: Observe your column approximately once per week for several weeks.

Additional Notes and Observations: _____



When is the end a beginning?

Decomposition Column

The U.S. generates 190 million tons of solid waste a year – enough to fill a bumper-to-bumper convoy of garbage trucks halfway to the moon. So why aren't we up to our necks in garbage?

The key is staying on top of the garbage heap is recycling, by people and nature. People are just beginning to recycle some of the metal, glass and plastic that fill up a quarter of America's garbage pails.

Nature recycles garbage all the time, and this recycling is essential to the availability of nutrients for living things. Nature's recyclers are tiny bacteria and fungi, which break down plant and animal waste, making nutrients available for other living things in the process. This is known as decomposition.

Decomposition involves a whole community of large and small organisms that serve as food for each other, clean up each other's debris, control each other's populations and convert materials to forms that others can use. The bacteria and fungi that initiate the recycling process, for example, become food for other microbes, earthworms, snails, slugs and flies, beetles and mites, all of which in turn feed larger insects and birds.

You can think of the Decomposition Column as a miniature compost pile or landfill, or as leaf litter on a forest floor. Through the sides of the bottle you can observe different substances decompose and explore how moisture, air, temperature and light affect the process.

Many landfills seal garbage in the earth, excluding air and moisture. How might this affect decomposition? Will a foam cup ever rot? What happens to a fruit pie, or tea bag? Which do you think decomposes faster, banana peels or leaves? If you add layers of soil to the column, how might they affect the decomposition process? What would you like to watch decompose?

Connections: *microbial ecology, decomposition, food chains, carbon and nitrogen cycles, recycling, landfills. Scientific process skills – observing, predicting, asking questions, recording data, describing.*



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Build: Decomposition Column

Materials:

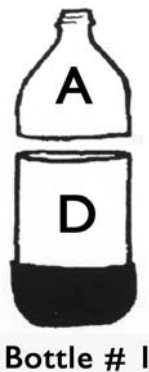
- three 2-liter soda bottles,
- Bottle Biology Tool Kit,
- kitchen scraps, leaves, newspapers... you decide!



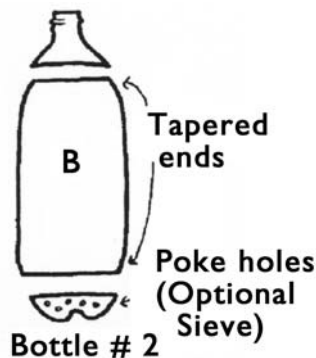
1. Remove labels from all 3 bottles. Remove bases from 2 of them if they have bases.



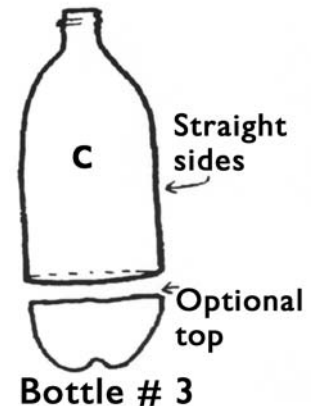
2. Cut top off Bottle # 1, 2 to 3 cm below shoulder so that cylinder has straight sides.



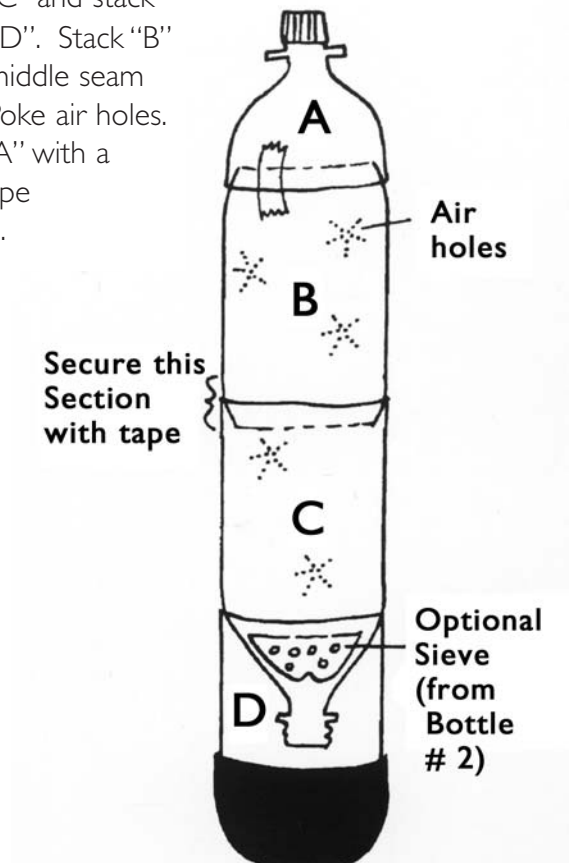
3. Cut top off Bottle # 2, 2 to 3 cm above shoulder. Cut bottom of 2 to 3 cm below hip. The resulting cylinder will have two tapered ends.



4. Cut bottom of Bottle # 3, 2 to 3 cm above hp, so cylinder has a straight end.



5. Invert "C" and stack into base "D". Stack "B" and tape middle seam securely. Poke air holes. Add top "A" with a piece of tape for a hinge.



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Choosing ingredients: Decomposition Column ingredients can include leaves, grass and plant clippings, kitchen scraps, newspapers, animal manure and soil. If you are interested in how fast things decay, try building two identical columns, but fill them with leaves from two different species of trees. Try adding fertilizer to your column, or water from a pond or river. How do you suppose differences in temperature, light, or moisture will affect the decomposition process?

The time it takes: You'll begin to see mold and other evidence of decomposition within the first few days after filling your column.

Two or three months is plenty of time to see soft **organic** material such as leaves, fruits, vegetables and grain products decompose dramatically. (The term organic applies to something that is derived directly from a living organism.) Bark, newspapers and wood chips all take longer to decompose, though they still undergo interesting changes in two to three months.

How wet?: Keep your column moist in order to observe more rapid decomposition. Avoid flooding your column or it will become waterlogged. This can create an **anaerobic** environment, or one completely lacking oxygen, in which certain microbes create particularly vigorous odors.

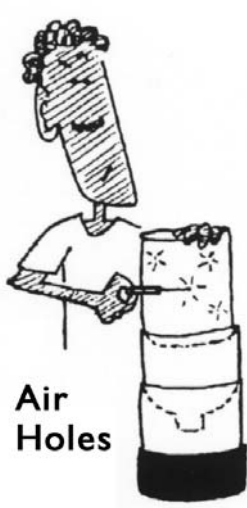
Using your nose: Odor is a by-product of decomposition, and can tell you a lot about the materials in your columns. Odors may be strong at first, but can mellow and become musty with time. Classrooms full of odorous Decomposition Columns, however, have been known to try the patience of colleagues and building supervisors. The strongest odors



arise from animal products such as meat and dairy products. Grapefruit rinds and grass cuttings can also produce strong odors. Why is this so? If you use food scraps, mix in plant matter such as leaves, twigs and dried grass to temper odors. Layering soil on top of contents also lessens the odor.

Recording data: Once you've decided how to fill your column, carefully observe what you put inside. In a notebook, describe the color, texture, smell and shape for everything you put in the bottle. Weigh everything before it goes into the column.

Schedule column checks for at least once a week to record changes. Note changes in the column contents' height, color,



Air Holes

Increasing the number and size of air holes in your column will increase air exchange. How do you think this will affect decomposition? Keep holes small so fruit flies stay inside.

INVESTIGATING OUR WORLD

shape, texture and odor. Hold a ruler next to the column to record changes in the height of the contents. Insert a thermometer from the top of the column to determine temperature changes. Can you figure out the rate of change? You can also test the pH of the leachate (the solution that drips through the column) or use it in a bioassay.

Is anything moving? Look for the appearance of any “critters,” such as flies, beetles, slugs, millipedes, or snails. Decomposition Columns offer good opportunities for observation and description. Try using photographs or drawings to record changes. Write a story about what is going on in your column. What do you predict will happen during decomposition?

“On Top”

All this new stuff goes on top
Turn it over turn it over
wait and water down.
From the dark bottom
Turn it inside out
Let it spread through, sift
Down, even.
Watch it sprout.

A mind like compost

Gary Snyder, *Axe Handles*
1983





Student Name _____

Cycles of Life: Life on a Log Over Time

On this side of your paper, make a list or “diary” of the kinds of organisms that you would expect to find during each of the observation times described below. On the back of this sheet, show what the log would look like *during each observation*.

April 2003

(Tree has just fallen down and is now a log on the ground.)

Organisms living on or in it:

July 2003

Organisms living on or in it:

October 2003

Organisms living on or in it:

April 2004

Organisms living on or in it:

July 2004

Organisms living on or in it:



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INVESTIGATING OUR WORLD

On this side of your paper, draw a “storyboard” that shows all of the organisms you listed on the front. Be sure that your sketch shows *how the log itself* would look at each point during the year:

April 2003

July 2003

October 2003

April 2004

July 2004



Student Name _____

Cycles of Life: It's Elemental!

When you watched the *QUEST* video called *Autumn*, you may have heard about the “more than 100 pounds of nitrogen, phosphorus, potassium, calcium, and magnesium that are returned to the soil each year” through the work of mushrooms that decompose trees and other organisms. It is important to remember that each living organism (including mushrooms!) is made of these “building blocks.” Each organism gets broken back down into these elements through decomposition. This allows the other organisms that are just beginning to grow to make use of these same “building blocks” for their own growth.

In order to complete the task that will end this unit of study, you will need to have more information about the different organisms in a hardwood forest, about the food webs that they are a part of, and about the building blocks, or elements, of which they are made.

You will need to answer these questions:

- Which parts of the forest contribute which different chemicals to the food web?
- Which organisms are responsible for the breakdown or recycling (decay) of different kinds of organisms?

Now you will do some Internet and library research to discover answers to these questions. Use the table on the second page of this handout to help you organize the information you collect. You may want to do a Web search on your own, or you may choose to use some of the following Web sites for your research:

The Magic Habitat (http://www.insights.co.nz/magic_habitat_fe.asp)

This site describes a typical pine forest ecosystem and explains which organisms eat and help to decay which other organisms.

Gardener's Bookshelf (<http://www.fulcrum-gardening.com/html/compost.html>)

“How Composting Works” discusses the components that make up the forest floor and points out one of the important nutrients that become available for plants to use.

Fun Facts About Fungi (<http://www.herb.lsa.umich.edu/kidpage/Decay.htm>)

“Fungi as Decomposers” is the subheading of this article, which describes their role in breaking down organic matter. (It also explains what “organic matter” is.)

Food for Worms (<http://www.hartwick.edu/pinelake/ecotone/num10/fw.html>)

This site describes some basic food webs in the forest. It also describes some research that was done to compare the rate of decomposition between a hardwood and a hemlock (softwood) forest.

Coarse Woody Debris (<http://www.fs.fed.us/r6/olympic/ecomgt/unecosys/woody.htm>)

Fallen logs and branches form the base of many food webs in the forest. This site describes some of those interactions.



INVESTIGATING OUR WORLD

Use this table to record the information you find in your research. You may find that writing your notes in this table format helps you to combine similar information from many different articles. Please note that you may not find information for the third column in every article, but you should find that information for at least two organisms.

Kind of Organism Found in the Forest Ecosystem	How It Is Decomposed (Who eats it?)	Materials – Chemicals, Elements, etc. – That the Organism Contributes or Needs		Source of This Information (Web site, article, etc)
		Materials it Contributes	Materials it Needs	



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Cycles of Life: A Model of Our Forested Ecosystem

After studying about cycles of life, death, decay, and decomposition, you have become something of an expert on the interactions that go on within the hardwood forests of northern New England. Your task now is to create a model that will help other people understand some of these complicated processes.

A. You first need to decide what kind of **model** will be most helpful in sharing your information. It might be a computer-generated flowchart, a mobile, a diorama, a poster, a Hyperstudio or PowerPoint presentation, or even some other format that will make these processes clear. (Keep in mind that one of your challenges will be to show the progression of time that occurs between the different interactions within your ecosystem. Your model must show that passage of time.)

You may choose your model type first, or you may make a decision after thinking about the questions that follow -- after considering what information you want to share and what is the best way to share that information.

B. Next, create a picture in your mind of all of the components of your model:

- Which organisms will you include to demonstrate a typical food web within a hardwood ecosystem?
- How will you demonstrate the interactions among the organisms within this food web? For example, what eats what, and what happens to the matter that gets passed along from one to the other?
- How can you include at least three examples of specific chemicals or elements that are broken down and used by some of the different organisms within your food web? (It is important that the people who see your model understand that this matter is constantly reused by different living things.)
- How will you include the nonliving components of the ecosystem -- the soil, the air, and the water that have been recycled from some of the decayed living material once it is broken down, and which, in turn, contribute elements to the food web?
- How will you help others see the amount of time that this process requires?

C. Finally, design your model! You will put together the components and show how they all interact with one another. Your model may end up being a combination of types – flowcharts, drawings, descriptions, and so on.

Resources

Your best resource will be the notes that you have been collecting over the course of this unit. You may refer to any of the information you have already collected, whether through direct observation (examining a log, setting up a biocolumn) or through your reading (articles, Web sites, etc.).

Good luck!



Student Name _____

Cycles of Life: Analyzing our Ecosystem Models

For each presentation, record at least one way in which the model helped you to deepen your understanding of a hardwood forest ecosystem. You must also list at least one way in which the model does a good job of representing a real ecosystem, and at least one way in which the model is *not* like a hardwood forest ecosystem.

Group	Observations of the Models	
	Thing that helped my understanding	
	Way the model was like a forest ecosystem	
	Way the model was <i>not</i> like a forest ecosystem	
	Thing that helped my understanding	
	Way the model was like a forest ecosystem	
	Way the model was <i>not</i> like a forest ecosystem	
	Thing that helped my understanding	
	Way the model was like a forest ecosystem	
	Way the model was <i>not</i> like a forest ecosystem	
	Thing that helped my understanding	
	Way the model was like a forest ecosystem	
	Way the model was <i>not</i> like a forest ecosystem	
	Thing that helped my understanding	
	Way the model was like a forest ecosystem	
	Way the model was <i>not</i> like a forest ecosystem	
	Thing that helped my understanding	
	Way the model was like a forest ecosystem	
	Way the model was <i>not</i> like a forest ecosystem	
	Thing that helped my understanding	
	Way the model was like a forest ecosystem	
	Way the model was <i>not</i> like a forest ecosystem	



Building a Compost

You're on a Quest!

What would autumn be like in northern New England without the opportunity of raking leaves? What do you do with all of those leaves? Instead of burning them, you can turn them into wonderful material that can enrich family gardens in the coming year. This activity will guide you on composting and utilizing leaves as a valuable waste resource!

Investigate with your family!

- Do you or other relatives have a garden? A lawn? Trees and shrubs? Planter boxes? These can all have a use for compost!
- What is composting? What is the right amount of air and moisture for composting?
- Why are worms important in a compost? Are there particular types of worms that are best? Why?

Materials needed:

- Fallen leaves
- Grass clippings
- Garden soil
- Shovel
- Computer with Internet access
- Pen and paper for notes

Build Your Own Compost

Step 1

Identify a location in the yard that would be good to build a compost pile. You might want to be sure there is a lid or some type of cover to protect the pile from rain and snow – and where you can control the amount of moisture, air or ventilation in the pile.

Step 2

Start with a 6-inch layer of chopped leaves set on top of soil. Add 4-inches of damp grass clippings, then add another 6-inches of damp leaves. Finish it with one-inch of garden soil.

Step 3

Before adding another layer to the pile, mix the layers of leaves to the pile. This will speed up the composting process.

Step 4

Turn the pile, adding water. You will notice that your compost will be warm (and it should reach about 110°F). After one week, using a shovel, continue to turn, moving the material on the top and sides of the pile to the center. Shovel the pile and loosen any compacted material. Let it set.

Step 5

After the second week, turn the pile again. Check the moisture in the pile. Squeeze a handful of compost and check to see if you need to add extra water.

QUEST: Investigating Our World is a regional public television series seen on Maine PBS, Vermont Public Television, and New Hampshire Public Television

The compost is complete when the pile cools off and is about one-third of the original volume you started with. The color will be dark, crumble in your hands, and have a soil-like odor. Record your results for each of your steps. Describe your process and determine whether you think you ended up with a rich, dark composting soil that can be used for gardens!

- Step 1 _____
- Step 2 _____
- Step 3 _____
- Step 4 _____
- Step 5 _____

Worms in my garden!

Find out which worms are best to use in composts. Do you "feed" worms? What types of food scraps might be appropriate to feed the worms? What food scraps shouldn't you use, and why? How do you avoid smell problems and flies in a compost pile?

<p>List of food scraps for worms</p> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/>	<p>List of food scraps not for worms</p> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/>	<p>Add worms to your compost and, after one week, describe what you find!</p> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/>
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Here are some terrific Web sites that will help you determine how to design, fill, and "feed" your compost!

Maine Department of Environmental Protection: In Our Backyard

Compost Your Soil and the Earth http://www.state.me.us/depl/iob/iob_76.htm

Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln

<http://www.ianr.unl.edu/pubs/horticulture/g810.htm>

Environmental Fact Sheet, Municipal Composting of Yard Waste

<http://www.des.state.nh.us/factsheets/sw/sw-3.htm>

Urban Agriculture Notes, published by City Farmer, Canada's Office of Urban Agriculture

Composting with Red Wiggler Worms <http://www.cityfarmer.org/wormcomp61.html>

The Green Lane, Environment Canada

Composting: Getting down to paydirt <http://www.ns.ec.gc.ca/udo/paydirt.html>



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Maine Forest Products Council

