Louisiana Public Broadcasting

Enviro♦Tacklebox™

Teacher's Guide

Module 5: Environmental Cycles and Processes

Carbon: The Element of Surprise

The Aggravation of Accumulation

Behind the Numbers

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Rotten But Not Forgotten

Enviro♦TackleBox™

Module 5

Environmental Cycles and Processes

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Enviro-Tacklebox™

Module 5

Environmental Cycles and Processes

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SERC More Power to You

LPB Louisiana Public Broadcasting

Star Schools U.S. Department of Education

Enviro-Tacklebox™ Overview

Enviro-Tacklebox™ Project Overview

Background Information

What is the Enviro-Tacklebox™ Project?

The Enviro-Tacklebox™ is a program directed toward middle school students that focuses on environmental education topics. The project is being developed by Louisiana Public Broadcasting working as a sub-grantee of the Satellite Education Resource Consortium. Enviro-Tacklebox™ is funded through a five year U. S. Department of Education Star Schools grant.

The goals of the project are to:

- Develop thematic modules that focus on environmental issues and promote student interest and the attainment of critical thinking skills that will support decision making;
- Enhance student learning by using the environment as an integrating theme;
- Engage and support community outreach efforts through workshop presentations at science conferences at the state, regional and national level; and
- Increase the level of awareness and understanding of K-12 teachers about environmental education issues.

The Enviro-Tacklebox™ includes the following components:

1. A series of five thematic modules, each of which consists of five tele-lessons and accompanying teacher guides with student activities. An interactive web site complements each module.

2. Professional development teleconferences, delivered by satellite, that address topics of national interest to all formal and informal educators involved in environmental education.

3. Workshops presented at professional conferences, in school districts and other appropriate educational settings to raise the awareness of the Enviro-Tacklebox™ project.

Topics for each module were selected in response to a national survey of middle school teachers and were developed by a curriculum design team of educators. Materials from each module have undergone extensive review at the state and national levels. All materials reflect the ***National Science Education Standards*** and the North American Association for Environmental Education's ***Excellence in Environmental Education-Guidelines for Learning (K-12).***

There are five student video lessons in each module, with the exception of Module II, which has four student video lessons and one teacher professional development video. This "how to" video for educators is not for student viewing but instead provides the instructor with a model for teaching decision-making strategies.

For information concerning purchase of the Enviro-Tacklebox™ materials contact:

GPN
P.O. Box 80669
Lincoln, NE 68501-0669
1-800-228-4630
http://gpn.unl.edu

Louisiana teachers interested in broadcast dates or purchasing information should contact:

Louisiana Public Broadcasting
7733 Perkins Road
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225-767-4206
http://www.lpb.org

Module 5

www.envirotacklebox.org

Carbon: The Element of Surprise

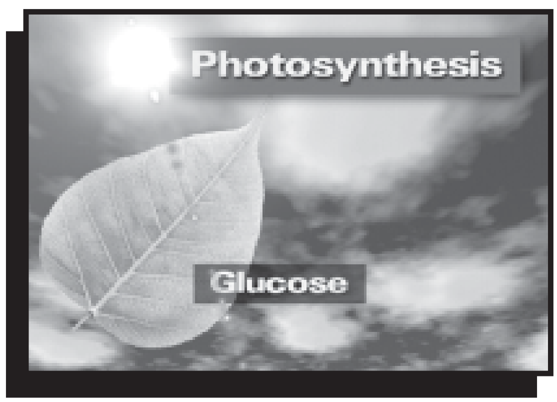
ACTIVITY GUIDE

CARBON:
The Element of Surprise

Background Information

The delicate balance of chemical changes involved in recycling carbon between living and nonliving parts of the biosphere is the pervasive theme of this module. With the dependence of life on carbon and the ongoing debate over global warming and the greenhouse effect, it is essential that students have a basic understanding of the impact of these chemical processes on their environment and life itself.

Most middle school students know that **photosynthesis** is the process used by plants to make food, but they do not understand or realize the profound impact that it has on the rest of the biosphere. The chemical reactions that are part of the carbon cycle either remove carbon dioxide gas from the atmosphere, the soil, or aquatic ecosystems or add it back to them. Through photosynthesis **producers** such as plants, algae, and some bacteria remove carbon dioxide, an **inorganic compound**, and convert it into glucose for use by themselves and other living things. Glucose is the simplest **organic compound** and contains carbon, hydrogen, and oxygen. Glucose, often referred to as food, is used by cells and tissues in the plant as a source of chemical energy and as a source of molecules with which to build other needed compounds that make up the structure of living things. For example, some of this glucose is changed to cellulose and used to build plant tissues; some is changed to starch and stored in leaves, stems, or roots as an energy reserve. Other glucose molecules combine with nitrogen from the soil to form amino acids, proteins, or nucleic acids.

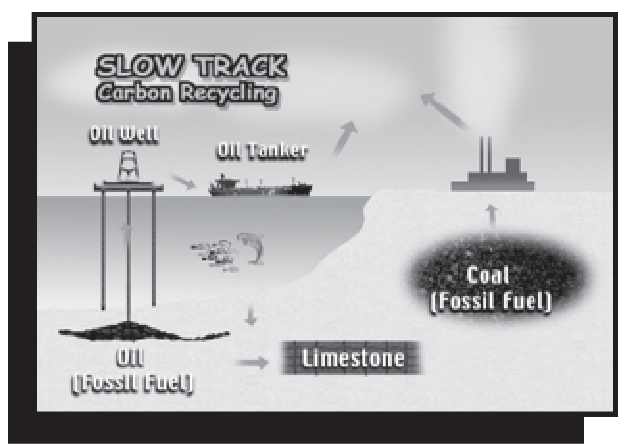


Understanding photosynthesis requires some knowledge of where and how the process occurs in plants. Producers have their own mini carbon cycle. A key element of photosynthesis is the chemical **chlorophyll**. Most chlorophyll is located within the leaf inside cellular structures called **chloroplasts**. Chlorophyll is a green pigment molecule that absorbs energy from sunlight. This energy removes hydrogen atoms from water that enters through the plant roots and releases carbon from carbon dioxide. The carbon dioxide enters the leaves through small openings called **stomata**. The carbon is then trapped within the plant by energy-rich chemical bonds and, along with hydrogen, combines to form glucose. Light energy from the sun has now been transformed into chemical bond energy. Upon its release from the water molecules, **oxygen** exits the leaves through the stomata.

Plants, animals, and most other living things combine oxygen with glucose during **aerobic respiration**, another group of important chemical reactions. These chemical reactions return carbon dioxide to the atmosphere or aquatic systems. Because carbon dioxide is a gas that moves from one place to another throughout the atmosphere, the carbon cycle is global. The carbon dioxide that a plant takes in may have been released by an organism's respiration in another location far away.

On a larger scale, carbon cycles by way of many individual organisms as it moves through food chains and food webs. This **fast track** can take minutes to years to complete. Carbon moves from the soil, water or atmosphere through living things by photosynthesis, respiration, and decomposition and back to the soil, water, or atmosphere. The demand for carbon is great but only producers can convert carbon dioxide gas into carbon compounds through photosynthesis. **Producers** form the basis of terrestrial, marine, and aquatic food chains and food webs. **Consumers** and **decomposers** that are unable to use carbon dioxide depend on producers and/or other consumers for their carbon compounds. **Decomposers** break down the carbon compounds when organisms die and release carbon back into the atmosphere as carbon dioxide. Once carbon compounds are inside the organism other chemical reactions can change them into a variety of carbon compounds. Living things also use atmospheric oxygen during the process of respiration to break down carbon compounds for energy, and in the process, release more carbon dioxide. The same carbon atoms are used over and over in an endless cycle. Respiration and photosynthesis are opposite reactions and are the key recyclers of carbon through living things. Photosynthesis traps carbon into compounds and respiration releases it from compounds.

But most of the carbon on Earth is recycled through a **slow track** that can take millions of years. As marine organisms die, their shells and skeletons become buried under layers of silt on the ocean floor and their carbon becomes part of sedimentary rock. When sediments covered marine organisms before they decomposed, the resulting heat and pressure caused huge deposits of petroleum (oil) to form. Millions of years ago the remains of plants became buried in sediments under swamps where they were compacted into coal. Today, these fossil fuels are the major energy source used by humans. Burning these fuels releases carbon back into the atmosphere as carbon dioxide that is then available for the fast track. Carbon dioxide is also released from rock through weathering and erosion and as volcanoes erupt into the air. The atmospheric carbon dioxide can then be channeled through the fast track carbon cycle.



Humans can impact the fast and slow tracks of the carbon cycle in both positive and negative ways. An awareness and understanding of the cycle and its interrelationships with living things can help us act in more responsible ways. Slight seasonal changes in atmospheric concentrations of carbon dioxide occur because plants remove more carbon dioxide during the summer when photosynthesis is greater than they do in winter. When it is summer in the Northern Hemisphere (which has more land), there are more plants removing carbon dioxide. This results in a decrease of global concentrations of carbon dioxide. The opposite occurs during winter in the Northern Hemisphere. Globally, carbon dioxide removal by photosynthesis is balanced by its release through respiration. However, humans increase the amount of carbon dioxide in the atmosphere by burning wood and fossil fuels. Deforestation removes trees that could absorb some of the carbon dioxide from the atmosphere. Because carbon dioxide is one of the greenhouse gases that absorbs radiant energy (heat) from the sun, many scientists argue that human actions have caused the amount of atmospheric carbon dioxide to steadily increase, resulting in warming temperatures. These increases in temperature may be causing climate changes, which can upset the delicate balance between carbon removal and carbon release. Oceans play a major role in the carbon cycle by absorbing carbon dioxide. Carbon dioxide dissolved in water forms an acid that dissolves limestone (CaCO3). These chemical reactions help absorb carbon dioxide and regulate some of the carbon dioxide in the atmosphere. Many scientists argue that the oceans cannot regulate carbon dioxide levels fast enough and that humans must help preserve this ecosystem. Other scientists report that planting trees, restoring habitats, and burning less fossil fuel have helped remove carbon dioxide from the carbon cycle and restore the balance so that a global warming problem is not occurring.

The formulas for **photosynthesis**

$$6\mathbf{CO_2} + 6H_2O + \text{radiant energy} \rightarrow \mathbf{C_6H_{12}O_6} + 6O_2$$

and **respiration**

$$\mathbf{C_6H_{12}O_6} + 6O_2 \rightarrow 6\mathbf{CO_2} + 6H_2O$$

CARBON: THE ELEMENT OF SURPRISE

Lesson 1 Activity: Carbon Dioxide Heats It Up

Lesson Overview:

Atmospheric carbon dioxide has been called the Earth's thermostat because of its ability to absorb radiant energy (infrared radiation) from the sun and help keep the Earth warm. This is called the **greenhouse effect**. Unfortunately many scientists report that the amount of carbon dioxide gas in the atmosphere has been steadily increasing since 1958 when measurements were first made. There is tremendous debate about whether increasing carbon dioxide concentrations are trapping heat within the atmosphere, thus resulting in a global warming effect. In this activity students will investigate the potential of carbon dioxide to act as a greenhouse gas and absorb heat.

National Science Education Standards:

Content Standard A: Science as Inquiry
Understanding about Scientific Inquiry
Content Standard C: Life Science
Populations and Ecosystems

Excellence in EE — Guidelines for Learning:

Strand 1: Questioning and Analysis Skills
C. Collecting Information
Strand 2: Knowledge of Environmental Processes and Systems
4. Environment and Society

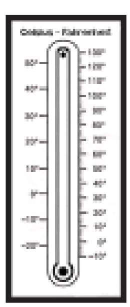
Key Concepts:

1. Carbon dioxide is a greenhouse gas that absorbs infrared energy from sunlight.
2. Higher concentrations of carbon dioxide in an area will increase the ambient air temperature.
3. Vegetation in an area will remove carbon dioxide during photosynthesis and help regulate the ambient air temperature.

Objectives:

Students will

- design an investigation to test whether vegetation in an area helps regulate the ambient air temperature.
- make comparisons between the investigation and global changes in climate.



Lesson 1 Activity: Carbon Dioxide Heats It Up

Cross-Curricular Connections:

Language Arts

- Write a formal lab report of their findings and report their conclusions to the class.

Mathematics

- Construct terra/aqua columns and measure temperature changes over time. Data is recorded in tables and in histograms.

Social Studies

- Read about Charles Keeling and his studies of atmospheric carbon dioxide concentrations on Mauna Loa in Hawaii.

Process Skills:

Observing
Inferring
Analyzing
Communicating

Materials:

Per Class

Eight 2-liter clean soda bottles plus eight additional footed bottoms.
One extra base from another bottle
Clear tape, awl, razor in safety holder, silicone sealant, scissors, metric ruler
Sand or gravel; soil; small-leaved, slow-growing plant (begonia, ferns, mosses) or cacti (for a drier environment); Elodea, or other water plant; distilled water
Watch with second hand
Ring stand with clamp
Lamp with reflector and 150-watt bulb
0.25 percent sodium hydrogen bicarbonate (baking soda) solution

Suggested Time Frame:

Several 45 minute class periods at the discretion of the teacher

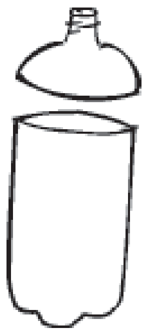
Procedure:

1. Introduce students to the issue of global warming by having students read about Charles Keeling's research (http://gcmd.nasa.gov/Learning) and gather information regarding the source of the extra carbon dioxide. Lead a class discussion about this information and have students interpret graphs: 1) Keeling's data and 2) a comparison of carbon dioxide levels and Earth's surface temperatures.

2. Assign eight groups of students to investigate the effects of vegetation on ambient air temperature in a terrestrial and an aquatic ecosystem. Models will be set up following a procedure adapted from Bottle Biology (Kendall/Hunt Pub., 1993). Assign one group each to construct: 1) a control terra column, 2) a control aqua column, 3) a treatment terra column, and 4) a treatment aqua column. These can be done in duplicate for a total of eight groups.

3. Instruct the groups to construct their columns.

Terra Ecosystem Column



1. Remove the labels from the bottles by adding very warm water to the bottle, capping it, and laying it on its side so that the water is over the label. Within a few minutes the label should peel off easily.
   Caution — overheating the water will warp the bottle.
2. Cut off the bottle top 1 to 2 cm above the shoulder.
3. Cut off the base of a 2L bottle about 2 inches from the bottom. It will have a diameter of 14 inches. Invert this base and use as a top over the column.
4. Use the awl to poke 4 or 5 air holes in the top.
5. Cut an opening in the top through which a thermometer can be inserted to measure the temperature of the air above the plant.
6. Pour rocks or sand in the bottom for drainage. Then cover with soil. Add the plants and water. The distance from the edge of the top of the column to the soil surface should be 10 centimeters.
7. Insert the thermometer and attach it to a clamp and a ring stand to hold it in place. Make sure the thermometer is turned so that you can read it through the bottle. Be careful that the thermometer does not touch anything inside the column. Seal the opening around the thermometer with sealant to keep air from leaking out.
8. Place the top on so that it hangs down over the edge of the bottle.
9. Allow one day for your terra column ecosystem to equilibrate.
10. Place a light with reflector and a 150-watt bulb close to the bottle so that it shines on the plants.
11. Measure the temperature at various time periods (for example, every minute) for a total of at least 10 minutes. Record the data in a table.

Terra Control Column

1. Construct a similar column for the control but omit the plant. Keep all other factors the same (constant).
2. After allowing the column to equilibrate, measure and record the temperature as in the Terra Treatment Column.

Aqua Ecosystem Column

1. Construct a column similar to the Terra Ecosystem Column, but instead of soil fill with distilled water or pond water until there is a 10 cm air space between its surface and the edge of the top.
2. Add some of the 0.25 percent sodium hydrogen bicarbonate solution. It will serve as a source of carbon dioxide for the water plant.
3. Add 3 - 4 sprigs of Elodea to the water.
4. After allowing the column to equilibrate, measure and record the temperature.

Lesson 1 Activity: Carbon Dioxide Heats It Up

Aqua Control Column

1. Construct a column similar to the Aqua Ecosystem Column, but do not add the water plant.
2. After allowing the column to equilibrate, measure and record the temperature.

4. Groups should construct a histogram of the data. Then they should analyze the data and draw conclusions about the relationships between photosynthesis, atmospheric carbon dioxide levels, and ambient air temperature changes.

5. Each group will write a formal lab report to turn in and explain its findings to the rest of the class.

Suggested Discussion Questions:

- What comparisons can you make between the terra ecosystem, the aqua ecosystem and the controls?
- What factors do you think affect the temperature in each column?
- Describe how these events might occur on a larger scale on Earth.
- What changes in temperature would you expect if animals were added to the columns?
- Describe the relationships between plants, carbon dioxide and ambient air temperature.

Further Investigations:

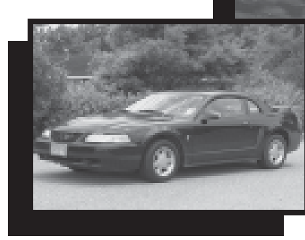
- Students write a short story or poem describing what their environment would be like if the Earth's temperature were to rise at least 2° C by the year 2050. Include the plant and animals that would live there.
- Students list ways in which their individual actions add carbon dioxide to the atmosphere and remove carbon dioxide from the atmosphere.
- Students access real time NASA (or other) data about carbon dioxide levels and how the carbon cycle is affected.

Career Opportunities:

Environmental Scientist
Climatologist

Assessment Procedures:

- Use a rubric to assess the formal lab report.
- Students should keep a log of all measurements and observations.



Additional Resources:

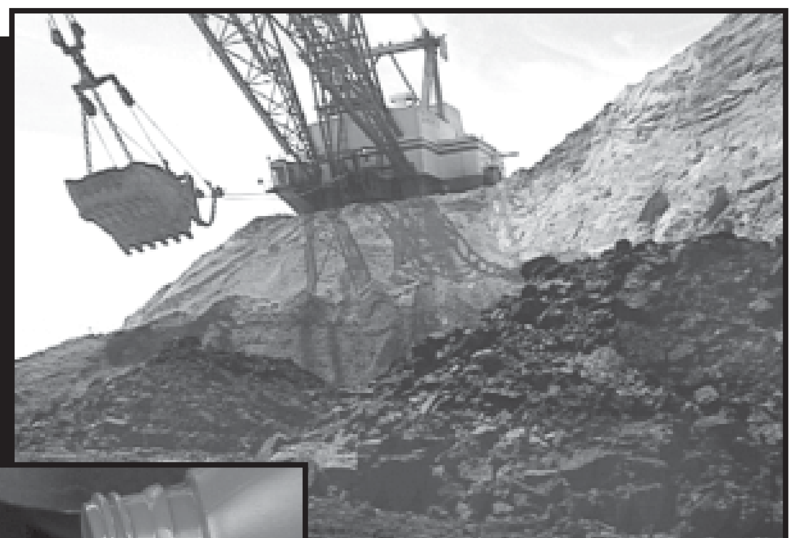
Arms, Karen. (1996) ***Environmental Science.*** Orlando, Florida: Holt.

Schachter, M. (1999) ***Environmental Science.*** New York, New York: Amsco Shool Publications, Inc.

U. S. Global Change Research Information Office http://www.gcrio.org/index.shtml (accessed August, 2003)

USGCRP Carbon Cycle Science Program http://www.carboncyclescience.gov/ (accessed August, 2003)

Carbon Dioxide Information Analysis Center http://cdiac.esd.ornl.gov/ (accessed August, 2003)

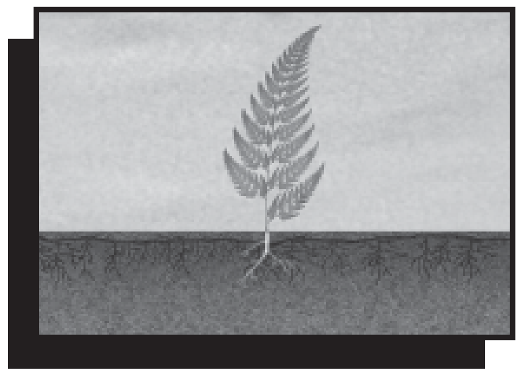


CARBON: THE ELEMENT OF SURPRISE

Lesson 2 Activity: Cycling Carbon in Your Neighborhood

Lesson Overview:

The ***Carbon: Element of Surprise*** video will introduce students to carbon cycling and the general chemistry concepts involved in the process. Students will investigate how neighborhood trees recycle carbon through the fast track by making observations throughout the school year. (The activity can instead be adapted to observe native plants or plants grown in the classroom, such as Wisconsin Fast Plants.) Students will plant a seedling or select a young tree to examine for changes such as growth, leaf production, flower production, area covered by shade, leaf mass, or leaf area and make inferences about the carbon cycle. They will use data tables and graphs to display and analyze their data and draw conclusions about changes in the carbon cycle occurring throughout the year.



National Science Education Standards:

Content Standard A: Science As Inquiry
Abilities Necessary to do Scientific Inquiry
Content Standard C: Life Science
Matter, Energy, and Organization in Living Systems

Excellence in EE — Guidelines for Learning:

Strand 1: Questioning and Analysis Skills
B. Designing Investigations
Strand 2: Knowledge of Environmental Processes and Systems
2.2 The Living Environment
C. Systems and Connections

Key Concepts:

1. Scientists design and conduct investigations to test hypotheses based on their observations, their prior knowledge, and their understanding of the process of scientific investigations.
2. During photosynthesis, producers (such as trees) use chlorophyll, water, and energy from the sun to split carbon from inorganic carbon dioxide molecules.
3. Producers then trap the carbon into organic compounds (such as glucose) that producers, consumers, and decomposers can use for energy and building blocks for growth, releasing oxygen into the atmosphere.
4. Producers, consumers, and decomposers use aerobic respiration and/or decomposition to recycle carbon by releasing carbon dioxide from organic compounds and putting it back into the atmosphere.

Objectives:

Students will

- design and conduct an investigation to measure long-term changes in a selected tree and make inferences about the fast track carbon cycle.
- reach conclusions about how changes in the fast track carbon cycle are affected by environmental factors such as location, weather, and seasonal changes.

Lesson 2 Activity: Cycling Carbon in Your Neighborhood

Cross-Curricular Connections:

<u>Language Arts</u>

- Communicate their findings orally and in written reports.

<u>Mathematics</u>

- Measure changes in indicators of tree growth, such as trunk diameter, and correlate these changes with environmental factors.
- Organize and graph data.

<u>Visual Arts</u>

- Illustrate, using a time line, the changes in the carbon cycle that occur during a period of observation.

Process Skills:

Observing — Inferring
Analyzing — Communicating

Materials:

Per Group

Measuring instruments such as meter sticks, string, weather thermometer, tape measures, balance scales
Rain gauge
Fertilizer

Suggested Time Frame:

Several 45 minute class periods throughout the year

Procedure:

1. Introduce the concepts of the carbon cycle by showing the ***Carbon: Element of Surprise*** video.

2. Assign groups of students to design a long-term investigation of the effects of different environmental factors on the carbon cycle. They will compare input and output of the system. Example — input is increase in mass while output is serving as a food source for squirrels or loss of leaves. The design should include measuring and comparing the effects of environmental factors selected by the students such as weather, rainfall, temperature, and fertilizer on photosynthesis several times throughout the school year. The tree's response to these factors might be measured as changes in leaf number, trunk diameter, leaf mass, leaf area, area covered by shade, and height. Ideally, measurements would be taken once a month, recorded in tables, and graphed.

More qualitative observations including leaf color, use of the tree by animals for food and/or shelter, and date of spring leaf out should also be made and recorded.

Students should be able to make inferences about events in the carbon cycle comparing the measurements over time. After careful analysis conclusions can then be drawn and shared during class discussions and oral presentations.

Depending on the number of trees on the school grounds options include: 1) each group can select its own tree of a designated species and investigate several factors, averaging the results from all groups 2) the class can select one individual tree and each group can measure a different factor each time.

3. Students will illustrate a food chain that includes their tree and a time line showing the changes in their tree. These changes can be correlated with chemical changes that occur in the carbon cycle. For example, many trees shed their leaves during times of drought to conserve water loss. If there are fewer leaves students may infer that photosynthesis has decreased. Therefore less carbon dioxide is being used by the tree to make glucose.

Suggested Discussion Questions:

- Which factors seem to influence the chemical changes the most? The least?
- What effect would additional fertilizer have on the tree in relation to the chemical changes of the carbon cycle?
- How can a tree compensate for a lack of rainfall?
- Describe how the rate of the carbon cycle changed in your tree throughout the year.

Further Investigations:

- Groups can email ecology pen pals at other schools who are also monitoring trees and exchange data and ideas.
- The class can participate in an online phrenology data exchange with other schools by participating in online projects such as Journey North at http://www.learner.org.
- A local forester can present information to the class about local tree species and how they are adapted to recycle carbon in efficient ways.

Career Opportunities:

Arborist
Botanist
Forester
Land Management

Assessment Procedures:

- Use a rubric to assess the food chain illustration.
- Students should keep a log of all measurements and observations.

Additional Resources:

Information Unit on Climate Change. (1995) ***Greenhouse Effect.*** Chatelaine, Switzerland.

Nakatani, H. (1988) ***Photosynthesis.*** Burlington, North Carolina: Carolina Biological Supply Company.

Wittwer, S. (1988) ***The Greenhouse Effect.*** Burlington, North Carolina: Carolina Biological Supply Company.

Newton's Apple Show 907, Lesson 9 - Photosynthesis
http://www.ktca.org/newtons/9/phytosy.html
(accessed August, 2003)

Chemical Carousel: A Trip Around the Carbon Cycle
http://www.thinkquest.org/library/lib/site_sum_outside.html?tname=11226&url=11226/
(accessed August, 2003)

ASU Photosynthesis Center
http://photoscience.la.asu.edu/photosyn/
(accessed August, 2003)

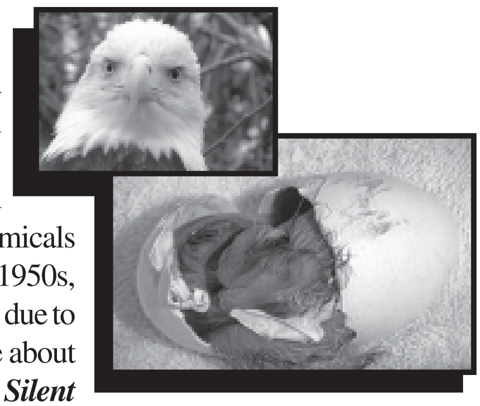
The Aggravation of Accumulation

ACTIVITY GUIDE

THE AGGRAVATION OF ACCUMULATION

Background Information

Bioaccumulation is the increase in the concentration of a chemical in a biological organism over time. Compounds accumulate in living things when they are absorbed and stored faster than they are metabolized or eliminated. Understanding bioaccumulation is important in protecting humans and other organisms from exposure to chemicals that may cause harm.



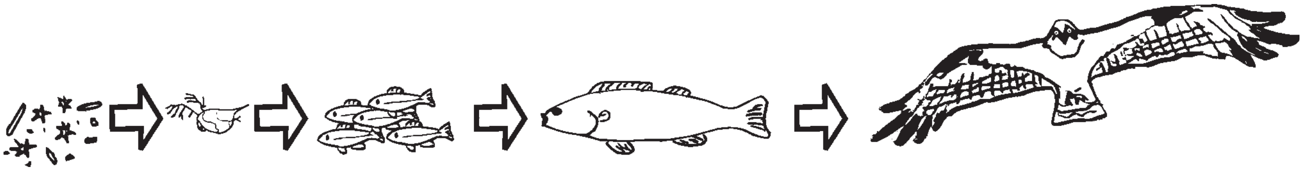
History

The production and release of synthetic chemicals began at the end of WW II. The chemicals were primarily used to control diseases, such as malaria and yellow fever, and to increase food production. However, in some cases, the release of these chemicals into the environment had negative affects on biodiversity and human health. One of the first chemicals found to have harmful affects on the environment was DDT. By the 1950s, DDT was linked to the decline in bald eagle and other bird populations due to the thinning of eggshells. In 1962, the biologist Rachel Carson, wrote about the impacts of pesticides on wildlife and human health in her book, ***Silent Spring***, a landmark for the environmental movement.

Terms used in conjunction with bioaccumulation.

Uptake occurs when an organism ingests a substance by breathing, swallowing, or absorbing it through the skin. **Storage** refers to the presence of a chemical in a body tissue or an organ. **Bioconcentration** is when there is a net accumulation of a chemical in an organism as a result of intake and elimination. **Biomagnification** is the increased accumulation in the concentration of a chemical as it moves up through the food chain.

For example, the following graphic illustrates a typical food chain:



Algae is eaten by the water flea eaten by a minnow eaten by a trout and finally consumed by an osprey.

Examples of Chemical Bioaccumulation

Persistent Organic Pollutants (POPs) are synthetic chemicals that resist the normal processes of degradation. They are carbon-based chemical compounds that share four characteristics: high toxicity, persistence, fat solubility, and ablility to evaporate and travel long distances. There are 12 top POPs (called "the Dirty Dozen" by environmental groups) targeted for banning by an international community of governments, scientists and environmental groups. They include: 8 pesticides (aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, mirex, and toxaphene); 2 types of industrial chemicals (polychlorinated biphenyls or PCBs and hexachlorobenzene); and 2 types of by-products of the manufacture, use, and/or combustion of chlorine and chlorine-containing materials (dioxins and furans).

Some of these POPs, such as DDT, aldrin, dieldrin, toxaphene, chlordane, and heptachlor, have been banned or restricted in the U. S. and some other countries. However, because they are persistent and do not break down for a long time, scientists are still finding them in high concentrations. Many developing countries are still using such POPs as DDT, and because of their ability to travel far distances, these chemicals are still being spread globally.

Focus on Pesticides

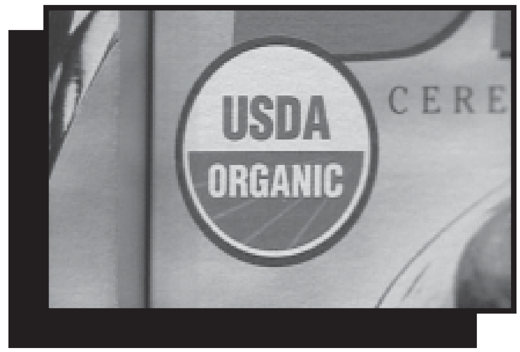
A **pesticide** is any chemical used to repel, kill or control fungi, animals, or plants. Pesticides are divided into different categories depending on the kinds of organisms they are used to control. **Insecticides** are used to control insect populations. **Fungicides** are used to kill fungal growths. Mice and rats are killed by **rodenticides** and unwanted plants are controlled with **herbicides**. Since many of the POPs have been banned in the U. S., the chemical industry has developed new pesticides called **organophosphates** and **carbamates**. These pesticides, while toxic to humans and other vertebrates, are short-lived and break down into less harmful products in a few hours or days so they do not bioaccumulate. These new pesticides do have some side effects. They are not species-specific and can kill beneficial species too. Since they do not last long in the environment, more frequent applications must be performed, increasing the overall cost. Common types of organophosphates are malathion, parathion, and diazinon. Sevin, aldricarb and propoxur are examples of carbamates.

WHAT CAN BE DONE

International Negotiations to Phase out POPs

The phasing out of the use of POPs on a global scale began at the 1992 Earth Summit in Rio de Janeiro. Over 170 governments agreed to stop using synthetic chemicals that accumulate in the environment. The United Nations Environment Programme took the lead in developing a plan for the phase-out of a number of different chemicals. Banning harmful chemicals works! In 1972, DDT was banned in the United States. Since then, the recovery of impacted species such as the Bald Eagle and the Brown Pelican have been well documented.

Alternatives to pesticide use on farms



In order to eliminate the use of synthetic chemicals, some farmers are returning to the traditional methods of farming now called "organic farming." While they do experience smaller yields than farms that use synthetic chemicals, on an average organic farms use only 40% of the energy used on conventional farms. This reduces costs and raises the profit margin. Often organic produce is more expensive to the consumer because the demand is not great enough to influence pricing. Organic farming uses methods such as crop rotation and planting a mixture of crops to prevent pest problems. To replace the use of synthetic chemicals, organic farmers, as well as many traditional farmers, also use Integrated Pest Management (IPM) methods that take into consideration the entire ecological aspects of the crop and the particular pest to which it is susceptible. When chemicals must be used, technology can assist the farmer in not overusing them. For example, GPS (Global Positioning Systems) can help farmers target the areas that most need chemicals (instead of spraying the entire field).

Personal use of synthetic chemicals

Each person can do his or her part to reduce the use of synthetic chemicals. Organic methods for plant and lawn care can be substituted for pesticides. If organic methods are not feasible, the proper use of chemicals is recommended. Many times people do not use the prescribed amount called for on the directions of the chemicals. For example, they may think that more is better and use 3 times the recommended amount, though that is often not the case. (Refer to **Additional Resources** listed in this activity plan for more information.)

Civic involvement

Students can get involved in their schools and communities to eliminate or reduce the use of synthetic chemicals. See Lesson 2 on page 26.

NOTE:

To help students better understand bioaccumulation/biomagnification, refer to the following sources:

- Enviro-Tacklebox™ Video on ***The Aggravation of Accumulation***
- Project WILD's "Deadly Links" activity.

Lesson 1 Activity: How Does Your Garden Grow?

Lesson Overview:

Students will learn how to use natural fertilizers and pesticides by growing an organic vegetable garden.

National Science Education Standards:

Content Standard A: Science as Inquiry
Abilities Necessary to do Scientific Inquiry
Content Standard C: Life Science
Structures and Functions in Living Systems

Excellence in EE—Guidelines for Learning:

Strand 2: Knowledge of Environmental Processes and Systems
2.2 The Living Environment

Key Concepts:

1. The misuse of synthetic chemicals can negatively impact the health of the environment.
2. Using natural fertilizers and pesticides can reduce pollution to the environment.
3. Organically grown produce is safe to eat.

Objectives:

Students will:
- determine which types of vegetables are best to grow in their area.
- select a suitable site for their vegetable garden.
- decide on the proper soil mix.
- understand the plant growth process by planting and caring for the garden.

Cross Curricular Connections:

Language Arts:
- Keep a journal in which students record their observations and the progress of their garden.

Mathematics:
- Measure proper amounts and mixtures of soil, fertilizer, etc.

Process Skills

Experimenting	Observing	Predicting
Modeling	Measuring	Controlling Variables

Lesson 1 Activity: How Does Your Garden Grow?

Materials:

Per Classroom (inside garden)

Long, flat pots (length and depth will depend on plant chosen and amount of classroom space available)
Seeds or transplants of chosen vegetables and flowers
Proper soil mixture (depends on plants chosen)
Water and watering can
Fish meal fertilizer or manure
Insecticidal soap
Grow lights

Suggested Time Frame:

One growing season (depends on plants chosen)

Procedure:

1. If possible, take a field trip to a local garden center. If this is not possible, contact the local Cooperative Extension Service agent (there are agents in urban areas) to come to the class and help plan the garden.
2. Select plants resistant to insects and diseases.
3. Select the proper soil mixture for the plants chosen.
4. Plant the seeds or transplants according to instructions on the packets.
5. Use natural fertilizer such as fish meal. Fertilize at intervals according to packet directions.
6. Don't forget to water. Don't under-water or over-water. Read watering instructions on seed packets.
7. Remove dead plant material that could harbor insects or diseases.
8. Pull weeds before they bloom.
9. Spray plants with insecticidal soap to kill soft-bodied insects such as aphids and grubs.
10. Try natural insecticide such as Bacillus thuringiensis (Bt), which has been shown to be effective against caterpillars and beetles without harming humans or wildlife.
11. Plant a variety of crops that flower throughout the season (such as some marigolds) to deter pests (such as rabbits).
12. Once the plants are ready to harvest, do so as soon as possible.
13. Give each student some vegetables and flowers to take home.

NOTE: *If it is possible to have a garden on the school grounds, pick a proper spot for the beds, depending on the plants chosen (i.e., what amount of sunlight is required). Build the beds above the ground using untreated wood as boundaries. Add proper soil mixture and proceed as above. To keep insects away from outside gardens, try physical barriers such as cheese cloth, netting and row covers. Surround developing plants with tin can collars to protect against insects that feed or lay their eggs at a plant's base.*

Lesson 1 Activity: How Does Your Garden Grow?

Suggested Discussion Questions:

- What is the feasibility for organic gardening to feed large numbers of people?
- What type of plant grew the best and why?
- What happened to plants that did not grow well?
- Would it have been easier to use chemicals?

Further Investigations:

- Students can research organic methods used on a large scale and compare them with chemical methods on a large scale.
- Students can investigate the cost differential between organically grown and chemically grown produce.
- Students can research recipes to cook vegetables.

Career Opportunities:

Agricultural Engineer
Farmer
Extension Service Agent
Organic Food Store Owner / Manager

Assessment Procedures:

- Student participation in creating the garden.
- Journals recording progress of garden.

Additional Resources:

Bradley, Marshall et al. (1978, 1993). ***Rodale's All-New Encyclopedia of Organic Gardening: The Indispensable Resource for Every Gardener.*** PUB.

Cox, G. W. (1997). ***Conservation Biology.*** Wm. C. Brown Publishers

Enger, E. and B. Smith. (1995). ***Environmental Science: A Study of Interrelationships.*** Wm. C. Brown Publishers.

Fryer, Lee et al; (1989). ***A Child's Organic Garden.*** PUB.

Mader, Sylvia S. (1996). ***Biology***. Wm. C. Brown Publishers

Project WILD. (1986). Western Regional Environmental Education Council.

World Wildlife Federation
http://www.worldwildlife.org/toxics
(accessed August, 2003)

Women Environment and Development Organization
http://www.wedo.org/ehealth/popsprimer.htm
(accessed August, 2003)

Marietta College Biology Department
http://www.marietta.edu/~biol
(accessed August, 2003)

Pesticide Information Project of Cooperative Extension Offices at several major universities
The EXtension TOXicology NETwork
http://ace.ace.orst.edu/info/extoxnet
(accessed August, 2003)

North Dakota State University Extension Service
http://www.ag.ndsu.nodak.edu/
(accessed August, 2003)

Pesticide Watch
http://www.pesticidewatch.org/Html/Schools/Schools.htm
(accessed August, 2003)

Organic Gardening Magazine
http://www.organicgardening.com
(accessed August, 2003)

THE AGGRAVATION OF ACCUMULATION

Lesson 2 Activity: Pesticides in Schools

Lesson Overview:

Students will investigate the practices their school uses for pest control. Depending on their findings, students may suggest alternative, non-chemical methods.

National Science Education Standards:

Content Standard F: Science in Personal and Social Perspectives
Personal Health
Risks and Benefits
Science and Technology in Society

Excellence in EE—Guidelines for Learning:

Strand 3: Skills for Understanding and Addressing Environmental Issues
3.1 Skills for Analyzing and Investigating Environmental Issues

Key Concepts:

1. The use of certain pesticides in schools can be a health hazard to students and teachers.
2. Alternatives to using pesticides are included in the Integrative Pest Management Program (IPM).

Objectives:

Students will:

- investigate the use of pesticides in their schools.
- determine alternative measures to reduce the use of pesticides.
- present a pest control plan to school officials.

Cross Curricular Connections:

Language Arts:
- Write their findings in report form.

Process Skills:

Classifying	Interpreting	Observing
Communicating	Investigating	Inferring

Lesson 2 Activity: Pesticides in Schools

Materials:

Per Student

School Pesticide Inventory Sheet

Suggested Time Frame:

One semester

Procedure:

1. Have students research the types of pesticides used in their school. Record this information on the School Pesticide Inventory sheet. ***NOTE:*** *Teacher may have to go to the school administration with the students to get permission to undertake this project. Also, the administration may not have this information and may refer the class to maintenance, a contractor, or the school board.*
2. Once students complete the inventory, have them research the health risks associated with each pesticide used. Record this information on the Inventory sheet also.
3. Have students create a pest management plan for your school that:

a) Bans the use of most hazardous pesticides (i.e. those listed under EPA's Toxic Category I & II: http://www.epa.gov/pesticides/).
b) Uses least-toxic Integrated Pest Management (IPM) from U.S. EPA's ***Pest Control in the School Environment: Adapting IPM.*** Office of Pesticide Programs. August 1993.
c) Encourages school officials to notify students, teachers and parents three days in advance of pesticide application.
d) Sets a goal that reduces the use of pesticides to as close to zero as possible.

4. Once the plan is complete, have the students present it to the PTA, school officials and student body.

Suggested Discussion Questions:

- Which pesticides used in the school are considered most toxic?
- What are the health effects related to these pesticides?
- What alternatives can be used in the place of pesticides?
- How effective are these alternative methods in pest management?

Further Investigations:

- Students can ask their local government department about the methods used for weed control and pest control and recommend alternative methods if synthetic chemicals are used.
- Students can ask their parents to use organic methods of weed and pest control at their homes.
- Students can investigate what type of pest management is used at their recreation areas, such as ball fields, parks, etc.

Career Opportunities:

Chemical Engineer
Environmental Scientist
Environmental Lawyer
School Health Administrator

Lesson 2 Activity: Pesticides in Schools

Assessment Procedures:

- Use the School Pesticide Inventory
- Use the Pest Management Plan
- Rate student presentations.

Additional Resources:

Cox, G. W. (1997). ***Conservation Biology***. Wm. C. Brown Publishers

Enger, E. and B. Smith. (1995). ***Environmental Science: A Study of Interrelationships***. Wm. C. Brown Publishers.

Mader, Sylvia S. (1996). ***Biology***. Wm. C. Brown Publishers

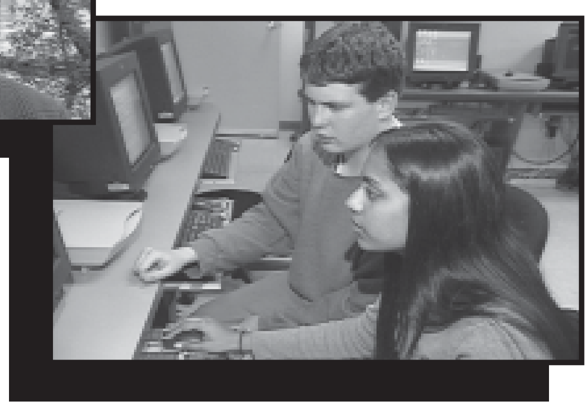
World Wildlife Federation
http://www.worldwildlife.org/toxics
(accessed August, 2003)

Pesticide Information Project of Cooperative Extension Offices at several major universities
The EXtension TOXicology NETwork
http://ace.ace.orst.edu/info/extoxnet
(accessed August, 2003)

Pesticide Watch
http://www.pesticidewatch.org/Html/Schools/Schools.htm
(accessed August, 2003)

Northwest Coalition for Alternatives to Pesticides
http://www.pesticide.org
(accessed August, 2003)

U.S. EPA Office of Pesticides Program
http://www.epa.gov/pesticides/
(accessed August, 2003)



School Pesticide Inventory

(Based on the questionnaire of the Northwest Coalition for Alternatives to Pesticides)

Name of Interviewer: ____

Name of Interviewee: ____

Title of Interviewee: ____

Name of School or District: ____

1. Does the school or school district have a written pesticide use policy? ______ If so, please attach.

2. Who applies the pesticides and how are they trained?

   ____

   ____

3. What pests are targeted and what methods are used to control them?

   ____

   ____

4. If pesticides are used, what kind of records are kept of applications? Include insecticides, herbicides (weed killers), fungicides, rodenticides, wood preservatives, moss-killers, soil sterilants, repellants, bait and lure, or other products licensed to kill, control, or repel living organisms. Do not include disinfectants or cleaning products.

   ____

   ____

   ____

5. What pesticides are used? Please list.

   ____

   ____

   ____

6. When and how often are pesticide applications done (on a schedule, or only when a pest problem is present)?

____

____

7. What time of day and week are applications made?

____

____

8. Are preventative and non-chemical control methods considered, tried, and documented before pesticides are used? Please explain.

____

____

____

9. If pesticides are used, what is the school's / district's notification policy to parents, teachers and other staff?

____

____

10. Does the school's / district's emergency management plan address possible pesticide accidents or exposures due to on-site pesticide use or use on adjacent properties?

____

____

____

Behind the Numbers

Activity Guide

Behind the Numbers

Background Information

Populations within an ecosystem are constantly increasing and decreasing (**population fluctuations and cycles**) in numbers based on the amount of food, clean water available, weather and natural disasters that have occurred. The numbers within a species in an ecosystem population change over time. From time to time new species appear while others disappear, depending upon the resources available. **Carrying capacity** describes the ability of the biotic and abiotic resources in an ecosystem to support life.

Within the environment of an ecosystem, **organisms** interact constantly with both the **biotic** (living) and **abiotic** (nonliving) elements. In an ecosystem different **species** of plants and animals interact with one another. For example, honey bees seek food from flowering plants and also pollinate the flowers as they go from plant to plant.

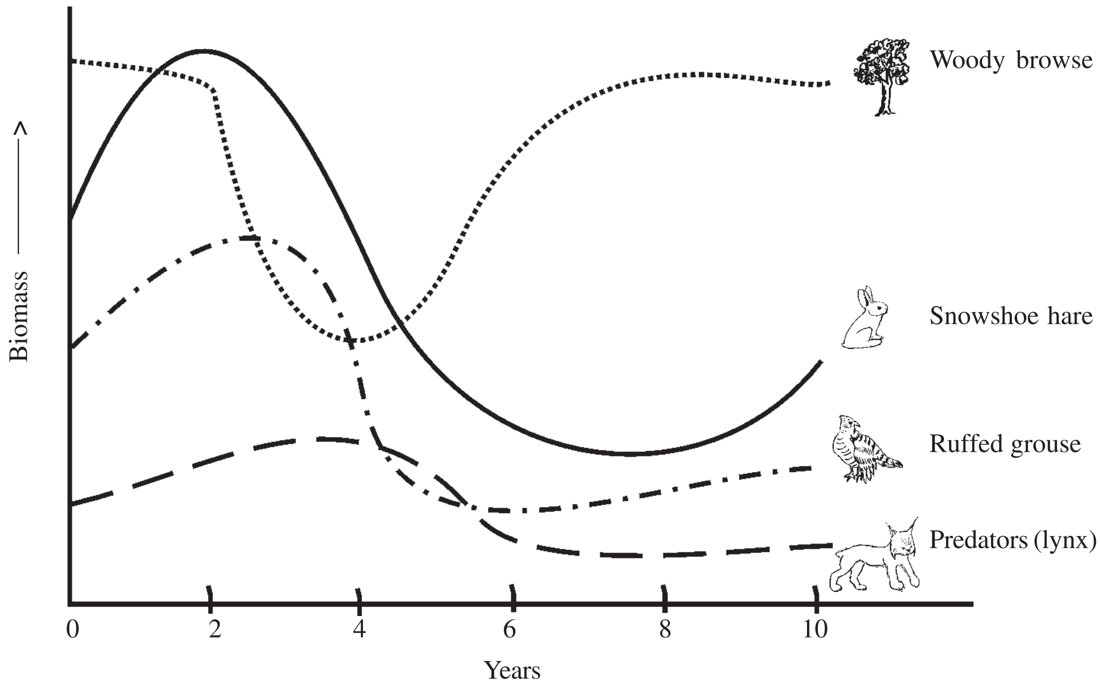
If the amount of resources in an ecosystem changes dramatically for some reason, then the **carrying capacity** changes and the plants and animals either adapt, move, or die out. For example, the northern areas of Alaska and Canada can sustain large numbers of birds during the summer due to the quantity of summer plants and animals available as food sources. As Fall begins, the carrying capacity of these northern climates decreases, causing the birds to fly south looking for areas where food is available. Another example of a change in carrying capacity can be illustrated in the southwestern U.S. Here there are geologic signs that as little as a 1000 years ago the land in northern New Mexico was at a lower elevation or there was a lot more water available from rain and in the rivers. American Indians in that area farmed crops and the animals and plants present were similar to what is found in fertile river valleys. The area of northern New Mexico shows signs of a great uplift. After the uplift the land became a much drier climate. This change in the climate dramatically changed the carrying capacity of the land for the types of plants and animals that could survive.

Population Fluctuations, Cycles, and Carrying Capacity

In an ecosystem, population fluctuations and cycles are natural and constant as populations are dynamic. The number of organisms of a species in an ecosystem changes naturally due to birth rates, death rates, numbers of predators, amount of food, clean water, shelter available, and other environmental factors. If the number of trees and brushes in a forest increases there becomes more food and shelter available. The size of small animals and bird populations might also increase over a number of years. Local predators will have more food so their population numbers might increase as well.

The size of the population may decrease, at some point, due to over population of a species, disease, lack of food, water, cover for breeding and shelter, or extreme weather (prolonged drought or severe temperatures). During a period of low rainfall, the number of trees, brushes, and grasses available might decline, making it more difficult for small animals to find food and shelter. Limited shelter enables predators to identify and catch these food sources more easily. Population cycles have been documented in the grouse and hare populations.

L. Keith and Associates (Meadows and Keith, 1968; Keith and Windberg, 1978) studied snowshoe hare populations in a particular area through two periods of decline and one period of increase. The study took 15 years and showed that the full population cycle for the woody browse (trees and brush), grouse, snowshoe hare, and the lynx was about 10 years. These cycles can be interrupted by natural disasters or any dramatic change in the land or climate.



Bottomland Hardwood Forests of the Southeastern United States

One ecosystem that has dramatically decreased and been altered over the past 200 years is the bottomland hardwood forest of North America. These forests are found along the banks of most large rivers in the southeastern and south central U.S. where annual flooding occurs during the late winter or spring of each year. This flooding provides needed water and nutrients to the trees and other vegetation, which in turn become habitats for large numbers of species of animals.

Bottomland hardwood forests are an important renewable forest resource as well as a wetland. These forests are ecologically significant as a habitat for thousands of plants and animals (as spawning grounds, nesting areas and food resources) that help make up the great diversity of life on the North American continent. The bottomland hardwood forests are home to: hardwood trees, smaller vegetation, insects, fish, amphibians, reptiles, deer, birds (native and migrating) and many other animals.

Population sizes in ecosystems, such as bottomland hardwood forests, have been fluctuating and sustaining themselves for thousands of years. In the past, population size has been effected by changes in the weather, land and natural disaster. Humans have been developing these forest areas and changing the resources needed by plants and animals. This has resulted in a decrease in the carrying capacity of these bottomland hardwood forests. Of the 25 million original acres of forested wetlands or bottomland hardwood forests in the Mississippi River alluvial floodplain, more than 80% of the these acres have already been cleared and drained, leaving only about 5 million acres of bottomland hardwood forest as a habitat for many native species of animals and plants. Most of the 20 million acres has been put into croplands, while some of it has been used for housing and roadways.

BEHIND THE NUMBERS

Lesson 1 Activity: Surveying an Environment / Ecosystem

Lesson Overview:

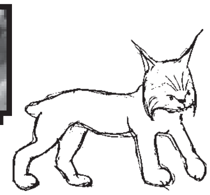
Students will visit a local ecosystem to survey the plants and animals present and identify interactions between organisms.

National Science Education Standards:

Content Standard C: Life Science
Structure and Function in Living Systems
Regulations and Behavior
Populations and Environment / Ecosystems
Content Standard F: Science in Personal and Social Perspectives
Populations, Resources, and Envrionments

Excellence in EE —Environmental Guidelines for Learning:

Strand 2: Knowledge of Environmental Processes and Systems
1. *Energy*
2. *The Living Environment*
4. *Environment and Society*



Key Concepts:

1. Organisms must interact with other living and nonliving elements in the environment in order to sustain life in an ecosystem.
2. An ecosystem has a limit to the number of organisms it can support. This is called its carrying capacity.

Objectives:

Students will:
- identify living organisms in the ecosystem.
- identify interactions that occur between living organisms and their ecosystem.
- describe how an ecosystem can be sustained.

Cross-Curricular Connections:

Language Arts
- Record information and assess the results.
- Discuss and report the results of research.

Mathematics
- Construct data tables of the numbers of living organisms in an environment/ecosystem.

Social Sciences
- Detail the impact of natural disasters or human activities on an environment/ecosystem.

Lesson 1 Activity: Surveying an Environment / Ecosystem

Process Skills:

Investigating	Communicating	Inferring
Estimating	Modeling	

Materials:

Per Group

Paper and pencil for recording data

Meter stick(s) or 25 meter tapes (a string or yarn measured to desired lengths can be used)

Field guides for identification of plants and animals (if available)

Per Class

One environment or ecosystem to study

Field guides for identification of plants and animals (if available)

Suggested Time Frame:

One or two 50 minute class periods

Procedure:

Surveying an environment/ecosystem

Call a local environmental agency or just chose an example of an environment that is part of a larger ecosystem that will include different species of trees, plants, and animals.

1. Have students make a list of what they expect to find when they visit the site.
2. Transport students to the site to be studied. Assign each pair of students a square meter to study. You may want to consider assigning a larger area (10 square meters) to groups of 4 to 8 students. Students should record all of the plants and animals they find in their assigned area.
3. Have students gather as a group and on a large sheet of paper list all of the organisms they have recorded.
4. Bring students together to make additions of new animals or plants other students have found in their assigned areas. Then have students think of plants or animals that they infer are present in the ecosystem. Students can use evidence they can see, or from past experiences in the ecosystem, to make these inferences.
5. Assign each pair of students an organism and have them make a list of all of the interactions that organism may have in the ecosystem.
6. Have students share their possible interactions with another group with a similar organism.
7. Have the class make a list of things that all of the organisms need to sustain life in this ecosystem.
8. Have the class draw a list of things that need to happen over the next 50 years for the ecosystem to sustain itself in its current state.

As a concluding activity, after returning to school, have students describe what they observed that they had not expected to be in the ecosystem.

Lesson 1 Activity: Surveying an Environment / Ecosystem

Suggested Discussion Questions:

- Describe an ecosystem.
- Identify the ecosystem in which you live.
- Describe what is meant by carrying capacity.
- Describe what is meant by a sustainable ecosystem.

Further Investigations:

- Have students study an additional environment or ecosystem if available.
- Using Internet resources, have students investigate other ecosystems with which they have had little or no contact.

Career Opportunities:

Ecologist
Botanist
Zoologist
Park Ranger
Wild Life Manager

Assessment Procedures:

- Students describe an ecosystem, the interactions within the ecosystem, and what the carrying capacity of the ecosystem might be for a particular species.
- Students compare and contrast different ecosystems.
- Students explain what the needs are for an ecosystem to be sustainable.

Additional Resources:

Smith, Robert L. (1980). ***Ecology and Field Biology.*** New York: Harper and Row.

Gribbin, J. & Gribbin, M. (1996). ***Fire on earth.*** New York, N.Y.: St Martin's Press.

Schachter, M. (1998). ***Environmental Science.*** New York: Amsco School Publications, Inc.

Exploring Our Living Planet. (1983). National Geographic Society, Washington, DC.

ENN The Environmental News Network
http://www.enn.com
(accessed August, 2003)

NASA's Bigelow Laboratory: Web or Chain?
http://www.bigelow.org/foodweb/chain2.html
(accessed August, 2003)

NASA's Bigelow Laboratory: Shipmates Educational
http://www.bigelow.org/shipmates/curricular.html
(accessed August, 2003)

AAAS: Population and ecosystems
http://www.ourplanet.com/aaas/pages/eco01.html
(accessed August, 2003)

The Franklin Institute: Neighborhoods: Ecosystems, Biomes, and Habitats
http://www.fi.edu/tfi/units/life/habitat/habitat.html
(accessed August, 2003)

BEHIND THE NUMBERS

Lesson 2 Activity: Ecosystem Interactions Web

Lesson Overview:

Students will pick an ecosystem (forest, desert, coral reef, open ocean, grassland, mountain, savanna, etc.) and design an interaction web for their chosen ecosystem. This should contain at least three types of each of the following: abiotic elements, plants, herbivores, carnivores, and omnivores. Organism numbers must have the necessary resources in the ecosystem to maintain its carrying capacity.

National Science Education Standards:

Content Standard C: Life Science
Structure and Function in Living Systems
Regulations and Behavior
Populations and Ecosystems
Content Standard F: Science in Personal and Social Perspectives
Populations, Resources, and Environments

Excellence in EE — Guidelines for Learning:

Strand 2: Knowledge of Environmental Processes and Systems
1. *Energy*
2. *The Living Environment*
4. *Environment and Society*

Key Concepts:

1. There are many types of interactions within an ecosystem.
2. To sustain life in an ecosystem requires organisms to interact with other living and nonliving elements in the environment.

Objectives:

Students will
- identify interactions that occur between living organisms and their ecosystem.
- identify living organisms in the ecosystem and why they can sustain life.

Cross-Curricular Connections:

Language Arts
- Record information and assess the results.
- Discuss and report the results of research.

Mathematics
- Construct data tables for the numbers of living organisms in an ecosystem.

Social Sciences
- Detail the impact of natural disasters or human activities on an ecosystem.

Lesson 2 Activity: Ecosystem Interactions Web

Process Skills:

Investigating	Communicating	Inferring
Estimating	Modeling	

Materials:

Per Group

One ecosystem selected
Large sheet of paper to draw the interactions chart
Different color markers for writing on the chart

Suggested Time Frame:

One or two 50 minute class periods

Procedure:

Allow students to choose an ecosystem (savannah, desert, tropical rain forest, coral reef, bottomland hardwood forest, etc.) to study. Students identify key biotic and abiotic elements in the ecosystem.

1. Students make a list of the abiotic elements in their ecosystem of choice.
2. Students make a list of the plants and animals (herbivores, carnivores, omnivores) in their ecosystem of choice.
3. Have students use a minimum of at least 3 abiotic elements, 3 plants, 3 herbivores, 3 omnivores and 3 carnivores in their ecosystem and design an interactions web. Draw lines between the elements to show there is interaction between the two elements. Use arrows to show who is the consumer between the two elements. Write the type of interaction that is occurring on each line.

   Example:

   ```
               breathe
   air ----------------> deer
   ```

4. After the groups have completed their interaction webs, have each group share its web with another group and allow the groups to modify their webs.
5. Have groups share their webs with more groups and allow those groups to modify their webs.
6. Post interaction webs for a few days in the classroom. Allow students to review the different webs and ecosystems.
7. Have a discussion of the different ecosystems and their interactions, during which students draw conclusions about the importance of interactions within ecosystems and how these interactions allow the ecosystems to sustain their carrying capacities.
8. Have groups remove one abiotic or biotic element from their interactions web and describe how it would effect the carrying capacity of the ecosystem.

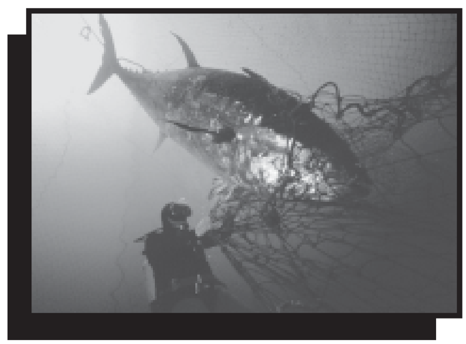
Lesson 2 Activity: Ecosystem Interactions Web

Suggested Discussion Questions:

- Do animals and plants really need to interact with the abiotic elements in their ecosystem?
- How important are interactions to the carrying capacity of a particular species within an ecosystem?
- Would bears and wolves interact within an ecosystem?
- Name the abiotic factors (in a forest and in a desert ecosystem) in which a mouse might interact.
- How would a natural disaster affect the carrying capacity of an ecosystem?
- How would human activities affect the carrying capacity of an ecosystem?

Further Investigations:

- As a whole class activity, have students pick one ecosystem and illustrate interactions within that ecosystem.
- Have students study an ecosystem near their home and write about the interactions in that system. They should describe how the carrying capacity of the ecosystem might be altered.



Career Opportunities:

Ecologist
Botanist
Zoologist
Park Ranger
Wild Life Manager

Assessment Procedures:

- Students draw an interactions chart for any ecosystem when given specific elements.
- Students compare and contrast the interactions of the same species in different ecosystems.
- Students describe how the carrying capacity of an ecosystem might be changed.

Additional Resources:

Smith, Robert L. (1980). ***Ecology and Field Biology.*** New York: Harper and Row.

Gribbin, J. & Gribbin, M. (1996). ***Fire on earth.*** New York, N.Y.: St Martin's Press.

Schachter, M. (1998). ***Environmental Science.*** New York: Amsco School Publications, Inc.

Exploring Our Living Planet. (1983). National Geographic Society, Washington, DC.

ENN The Environmental News Network
http://www.enn.com
(accessed August, 2003)

NASA's Bigelow Laboratory: Web or Chain?
http://www.bigelow.org/foodweb/chain2.html
(accessed August, 2003)

NASA's Bigelow Laboratory: Shipmates Educational
http://www.bigelow.org/shipmates/curricular.html
(accessed August, 2003)

AAAS: Population and ecosystems
http://www.ourplanet.com/aaas/pages/eco01.html
(accessed August, 2003)

The Franklin Institute: Neighborhoods: Ecosystems, Biomes, and Habitats
http://www.fi.edu/tfi/units/life/habitat/habitat.html
(accessed August, 2003)

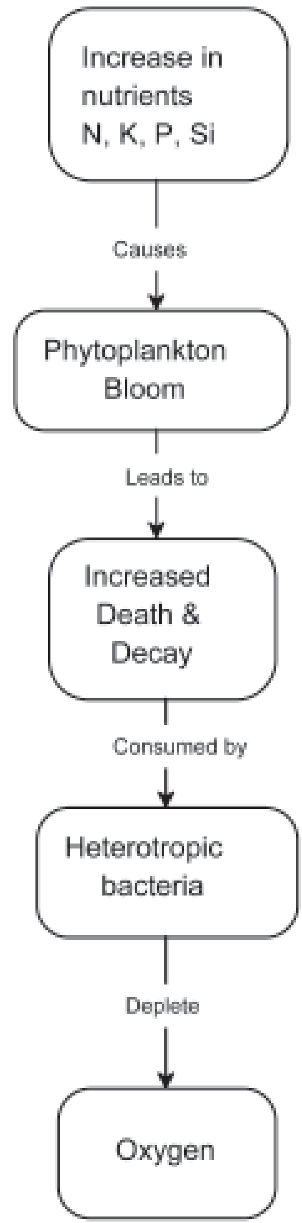
Hypoxia: The O_2 Blues

ACTIVITY GUIDE

HYPOXIA: THE O_2 BLUES

Background Information

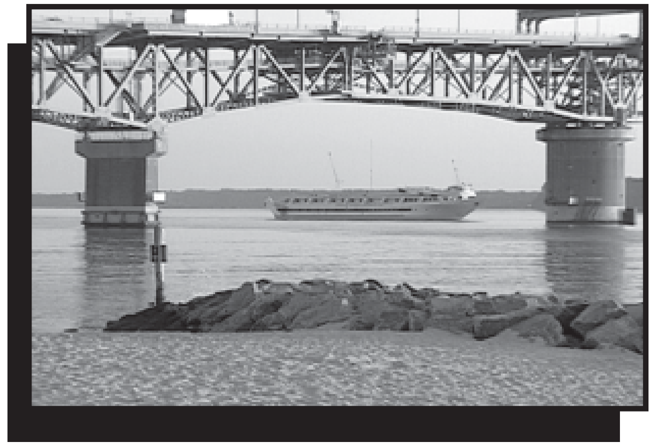
Eutrophication is the process of nutrient enrichment in aquatic ecosystems. The term **nutrient** refers to any one of the chemical elements that are necessary for plant growth. For example, in a garden or on farm crops, fertilizers are used to facilitate plant growth. The most common chemicals in fertilizers are nitrogen (N), phosphorus (P), and potassium (K). Examine the labels on fertilizers as well as on containers of household plant food and you will see the percentages of these chemicals used in each product. When these chemicals, which are essentially fertilizers, enter an aquatic ecosystem they stimulate the growth and reproduction of algae and bacteria. These algae, bacteria, and other microscopic plant-like life are known as **phytoplankton**. Phytoplankon are responsible for what is called the primary production in an aquatic ecosystem. **Primary production** is the result of photosynthesis (see video lesson on the carbon cycle). In most aquatic ecosystems there is a balance or equilibrium between primary production, consumption by consumers, and decay processes. When excessive nutrients from natural or human sources enter an aquatic ecosystem phytoplankton production increases. The increase may be rapid and is called a phytoplankton **bloom** or an algal bloom.



A bloom or population explosion increases the numbers and total biomass of the phytoplankton population well beyond the capacity of predators or consumers to graze it down to the normal balanced level. The microscopic organisms that make up the phytoplankton have a short life span. After they die and decay bacteria consume them. These bacteria are consumers, technically called **heterotrophs,** and are organisms unable to make their own food. Organisms that make their own food are called **autotrophs**. An important part of the process is that heterotrophic bacteria consume oxygen. During a bloom, there is a large number, beyond the normal balance, of dead and decaying organisms, and thus, there is an increase in the population of heterotrophic bacteria. These bacteria can consume most of the available oxygen in the water, creating a low oxygen situation called **hypoxia**. When all the available oxygen is depleted it is called **anoxia**. Since most life needs oxygen, low oxygen conditions create considerable stress on organisms in the ecosystem, such as fish and invertebrates.

The nutrients or chemicals that set the eutrophication process into motion come from many sources. There are natural sources of nutrients such as soil runoff. However, human or cultural activities tend to be major sources of nutrients that accelerate the eutrophication process. Cultural sources of nutrients include storm drain runoff, fertilizer, sewage, industry, and farm waste. You may recognize these sources as components of what is referred to as nonpoint source pollution.

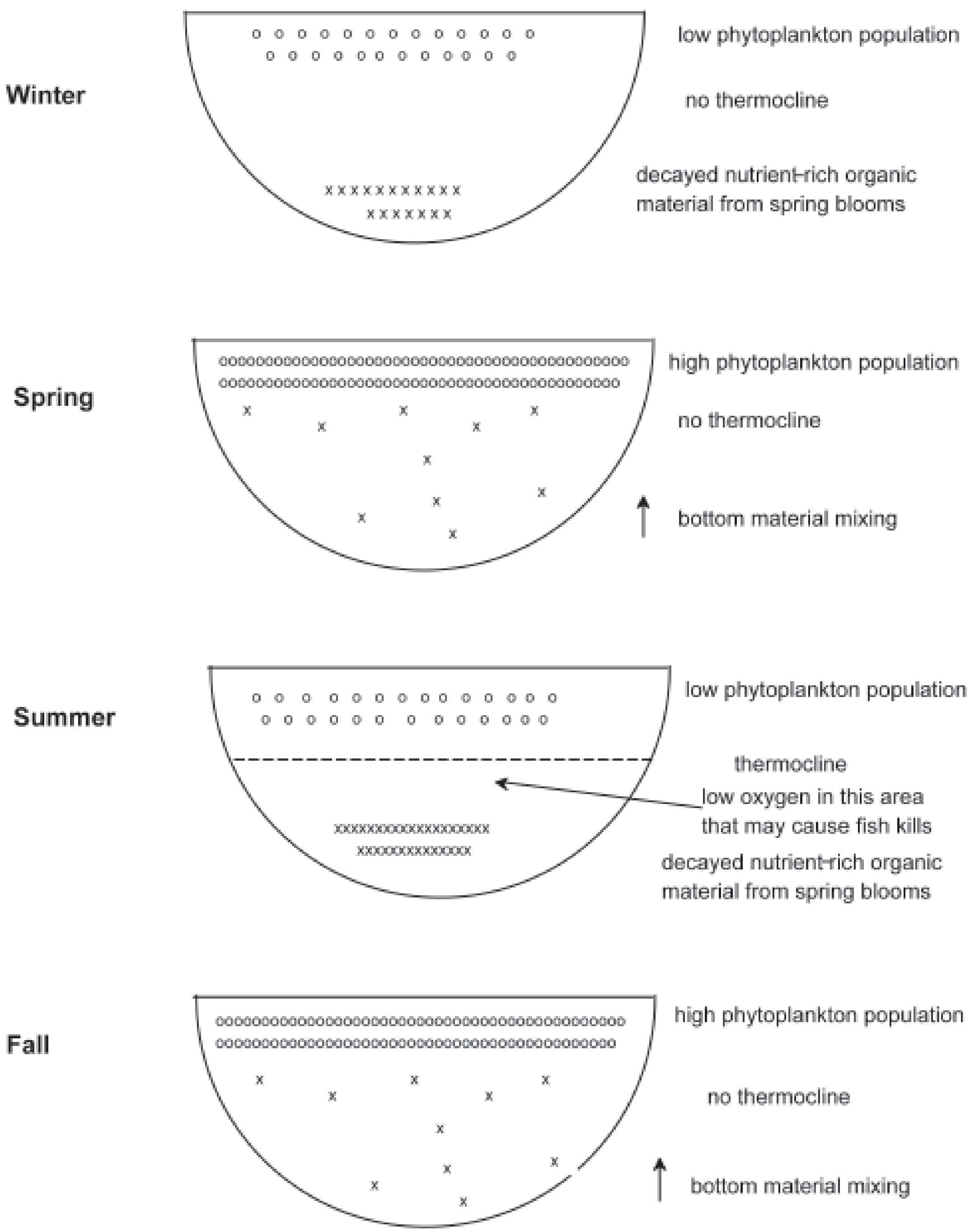
Eutrophication may occur in a small pond, a large lake such as Lake Erie, or a coastal marine ecosystem such as the Gulf of Mexico. Eutrophication may play a major role in the process of a pond or small lake eventually filling itself up with organic material and becoming a bog or marsh. The bog or marsh may eventually become dry land. Recall that excessive amounts of organic materials are created by eutrophication with subsequent loss of oxygen. Without oxygen there is no decay. The organic material simply builds up over time and can fill up a small lake or pond.



These small aquatic ecosystems undergo a phenomenon known as **overturn**. Overturn is one complete cycle of top to bottom mixing of stratified or layered water masses. This phenomenon may occur in spring or fall, or after storms, and results in uniformity of chemical and physical properties of water at all depths. Pond overturn involves many of the same processes of eutrophication, such as nutrient enrichment and population blooms. In order to understand overturn we must incorporate physics principals to the chemical and biological understandings we have developed related to eutrophication. An important point here is that ecological systems and processes are the result of geological, chemical, physical, and biological interactions.

Overturn in a pond or lake generally occurs in the spring and in the fall. Let's follow the process by starting with winter conditions. In the winter there is a minimum of biological activity. The water temperature is cold from top to bottom. These conditions change with the onset of spring. Spring winds cause a stirring up of the organic and nutrient-rich bottom water which then mixes with the nutrient poor surface water. The warm conditions, along with the influx of nutrients, cause a phytoplankton bloom. The bloom stimulates the growth of the consumer populations, such as small crustaceans, that then graze down the phytoplankton population. This cycle does not go on forever. The phytoplankton uses up all the available nutrients (limiting factors) and are reduced in numbers. Here again we see nature's tendency to establish a balance or equilibrium in ecosystems. As summer approaches, biological activity is reduced because of reduced primary productivity. The nutrients that would be recycled through the death and decay process are locked into the bottom waters by the presence of a strong thermocline. A **thermocline** is a boundary between warm surface waters and cooler waters below. The thermocline acts as a density barrier preventing bottom and surface waters from mixing. The fall season brings about the breakdown of the thermocline, along with some mixing created by winds, which sets into motion another brief bloom, thus completing the cycle.

Pond Overturn



HYPOXIA: THE O_2 BLUES

Lesson 1 Activity: Your Blooming Pond

Lesson Overview:

The students will model a pond system that becomes enriched with nutrients (fertilizer). They will manipulate variables, make observations over time, and draw conclusions that may lead to further inquiry.

National Science Education Standards:

Content Standard A: Science as Inquiry
Abilities Necessary to do Scientific Inquiry
Content Standard F: Science in Personal and Social Perspectives
Populations, Resources, and Environments

Excellence in EE—Guidelines for Learning:

Strand 3: Skills for Understanding and Addressing Environmental Issues
1. Skills for Analyzing and Investigating Environmental Issues

Key Concepts:

1. Natural systems can be modeled for experimental purposes.
2. Excessive nutrients in an aquatic system can lead to a bloom of microorganisms.

Objectives:

Students will:
- model a pond ecosystem.
- conduct an investigation using nutrients as a variable.

Cross-Curricular Connections:

Language Arts:
• Communicate student observations and results.
Mathematics:
• Plot data changes over time.
Social Studies:
• Discuss how algal blooms affect people's lives (such as fishing).
Visual Arts:
• Create color-coded models of different layers in the water columns of ocean or lakes.

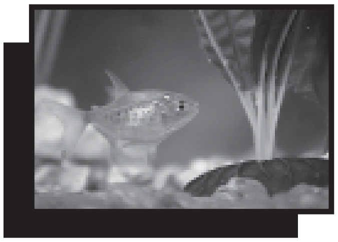
Process Skills:

Controlling Variables	Hypothesizing
Modeling	Experimenting

Materials:

Per Group

Three 10-gallon tubs or aquariums
Tap water dechlorinator
Liquid plant fertilizer



Suggested Time Frame:

One 30-minute set up, ten 5-minute observations (over 10 days), 30-minute conclusions

Procedure:

NOTE: For safety purposes, it may be necessary for the teacher to collect pond water or at a minimum supervise students as it is collected.

1. Give each cooperative group three small tubs. These will represent ponds.
2. Have each group fill each tub 3/4 full of water.
3. Most municipal and community water systems chlorinate their water. Each group should dechlorinate their water by using a chemical product designed for setting up aquariums. Concentrated dechlorinator can be found in a pet store or the aquarium section of large department stores. The recommended treatment only requires a few drops, so one bottle will last a long time or will supply several classes.
4. Have the students collect water from local ponds or from standing water in a ditch. You will need 500ml of pond water cup per tub.
5. The students should combine all the collected water into a large bucket and stir to make a homogenous mixture.
6. Each group should place 250ml of the collected pond water mixture into two of their tubs and label the tubs as such. This will inoculate the tubs with the microorganisms that typically grow in a pond.
7. Each group should add 10ml of liquid plant food to one of the two treated tubs and label as such. (This may be mixed up ahead of time).
8. Have each group make predictions about what they think may be observed over the course of time and why. (Note: predict for each of the three set-ups: 1) tub with water only, 2) tub with pond water added, and 3) tub with pond water and liquid fertilizer added.
9. Instruct the groups to make and record daily observations for a two week period. Observations may include but are not limited to clarity, color, or smell of the water in the tub.
10. Have each group analyze and discuss their observations. What explanations are possible for the observed results? Compare with the other groups. Were there similar or different results?
11. Design another experiment that may test or verify claims made in step #10.

Suggested Discussion Questions:

- What would be the source of excessive nutrients in a natural system?
- If any odor was detected, what caused it?
- What tub was considered the control? Why was it necessary to have a control tub?
- What kind of microorganisms are found in pond water?

Further Investigations:

- Conduct further experiments that manipulate variables such as the inoculate and fertilizer.
- Explore the history and reasons for the production of phosphate-free detergents.
- Conduct experiments testing the effect of nutrients and aquatic plants.
- Aquarium stores also sell denitrifying chemicals. Conduct experiments to see if you can keep a test-pond from becoming eutrophic.

Career Opportunities:

Limnologist
Water District Supervisor

Assessment Procedures:

- Using a rubric students should be assessed on:
    - hypothesis development
    - experimental procedures
    - record keeping
    - conclusions based upon evidence

Additional Resources:

Cooper, S. R., & Brush, G. S. (1991). ***Long-term history of Chesapeake Bay anoxia.*** Science 254(5034), 992-997.

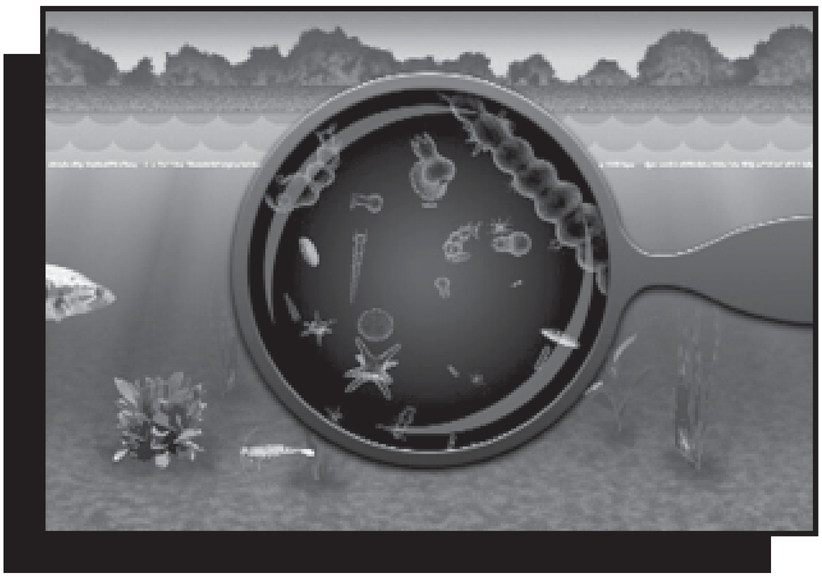
Cherfas, J. (1990). ***The fringe of the ocean - under siege from land***. Science 248(4952), 163-166.

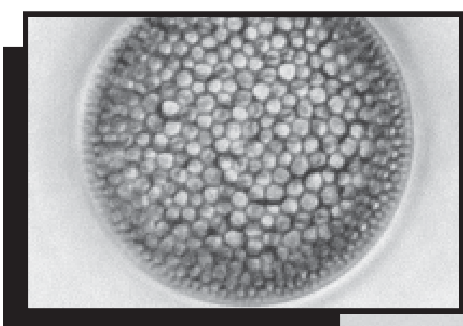
Glausiusz, J. (2000). ***Dead Zones: Pollution killing off ocean life.*** **Discover** 21(3), 22.

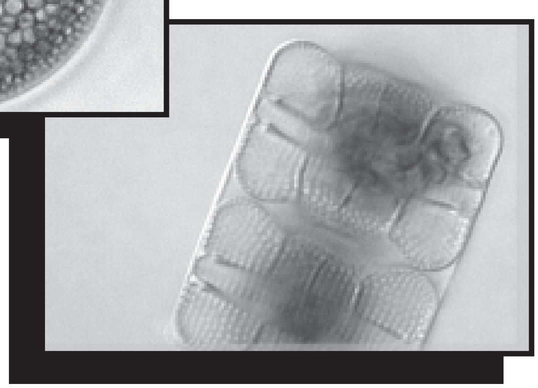
Gulf of Mexico Program
http://www.epa.gov/gmpo/
(accessed August, 2003)

National Centers for Coastal Ocean Science
Gulf of Mexico Hypoxia Assessment
http://nos.noaa.gov/products/pubs_hypox.html
(accessed August, 2003)

EPA Addresses Hypoxia in the Gulf
http://www.epa.gov/msbasin/hypoxia.htm
(accessed August, 2003)







HYPOXIA: THE O_2 BLUES

Lesson 2 Activity: Water Density Boundaries

Lesson Overview:

Students will create observable layers in water that represents a separation based upon density differences. Students will model density boundaries using differences in temperature and salinity.

National Science Education Standards:

Content Standard A: Science as Inquiry
Abilities Necessary To Do Scientific Inquiry

Excellence in EE—Guidelines for Learning:

Strand 3: Skills for Understanding and Addressing Environmental Issues
1. Skills for Analyzing and Investigating Environmental Issues

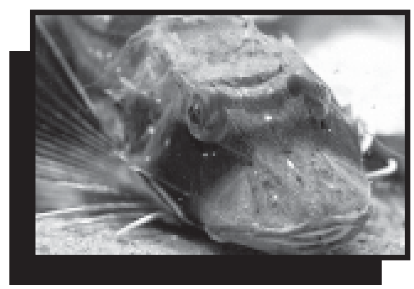
Key Concepts:

1. An understanding of phenomena associated with eutrophication, such as **dead zones** and **overturn,** requires an understanding of how water can layer due to density differences.
2. Water layers can create boundaries or zones that prevent vertical mixing of the water column.

Objectives:

Students will:

- compare various water samples for density differences.
- model a thermocline.



Cross Curricular Connections:

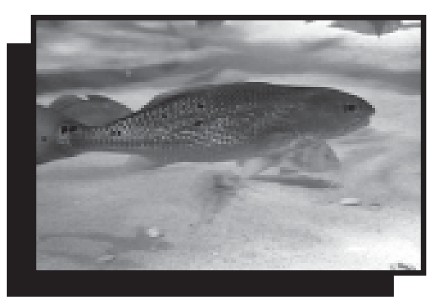
Language Arts:
- Communicate student observations and results.

Mathematics:
- Plot data changes over time.

Visual Arts:
- Create color-coded models of different layers in the water columns of ocean or lakes.

Processes and Skills:

Controlling Variables	Hypothesizing
Modeling	Experimenting



Lesson 2 Activity: Water Density Boundaries

Materials:

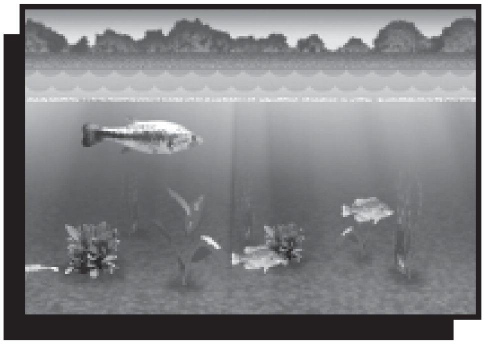
Per Group

Clear plastic containers (The 1 quart containers that you get at the deli section of a grocery store are great for this. You may also use recycled plastic soft drink bottles)

Salt

Red and blue food coloring

Spoon



Suggested Time Frame:

One 50-minute class period

Procedure:

1. Assign students into cooperative groups of 4.
2. Each member of the group should prepare the following in quantities suitable for the containers being used.
   a. a saturated salt solution
   b. freshwater with blue food coloring
   c. hot tap water with red food coloring
   d. cold tap water
3. A member of the group should fill a container one third full making a layer of freshwater.
4. Have each group member predict what will happen when saltwater is mixed with the freshwater and what will happen when the freshwater is mixed with the saltwater.
5. Have a group member slowly add the saltwater to raise the volume up another one third of the container. Pour the water slowly over a spoon to prevent turbulence.
6. Have each student make and record observations.
7. Reverse the procedure in step #5 and make and record observations.
8. Repeat steps 3 - 7 using cold and hot water.

Suggested Discussion Questions:

- Is saltwater higher or lower in density than freshwater? Why?
- Is hot water higher or lower in density than cold water? Why?
- Explain your observations in light of the equation for density (D=M/V).
- Where in natural ecosystems do we find saltwater and freshwater mixing or layering?
- Where in natural ecosystems do we find cold water and warm water mixing or layering?

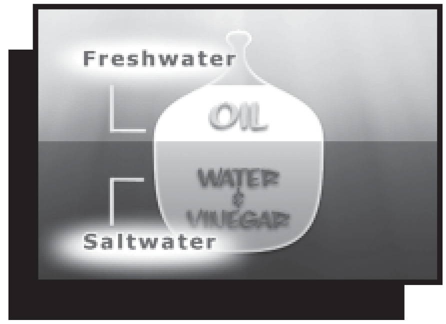
Further Investigations:

- Recreate one of the setups above that formed a visible layer and let it set for an extended period of time. How long does it take for mixing to occur?

Lesson 2 Activity: Water Density Boundaries

Career Opportunities:

Water Quality Expert
Oceanographer
Coastal Planner



Assessment Procedures:

Using a rubric students should be assessed on:

- hypothesis development
- experimental procedures
- record keeping
- conclusions based upon evidence

Additional Resources:

Cooper, S. R., & Brush, G. S. (1991). ***Long-term history of Chesapeake Bay anoxia.*** Science 254(5034), 992-997.

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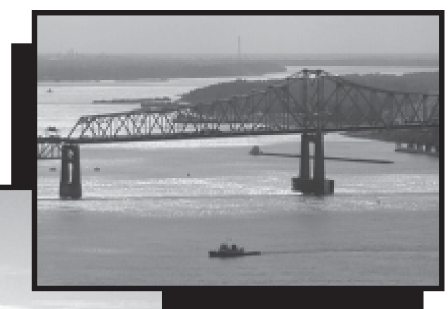
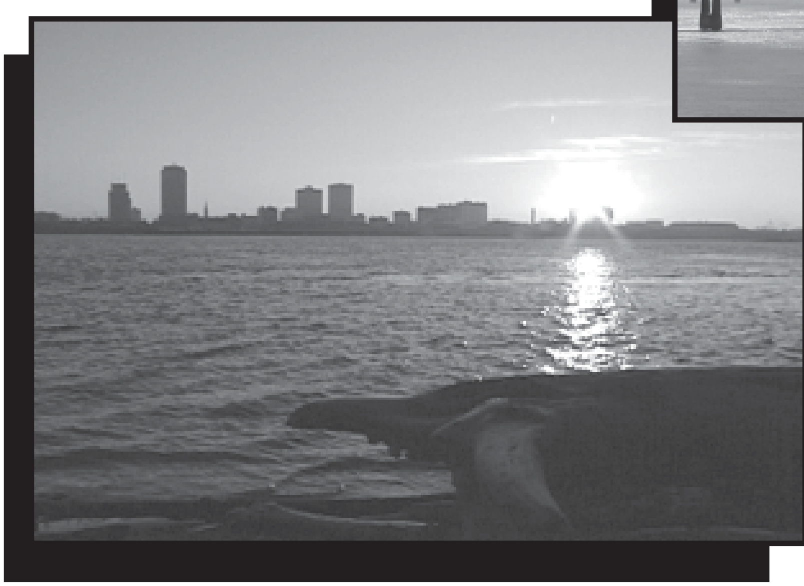




Rotten But Not Forgotten

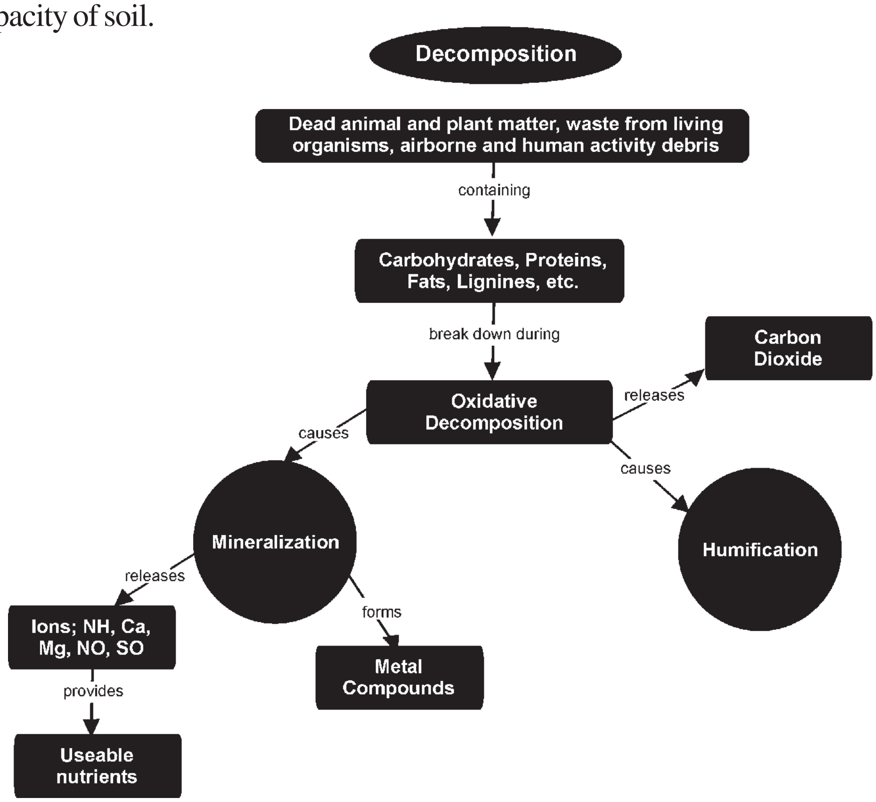
ACTIVITY GUIDE

ROTTEN
BUT NOT FORGOTTEN

Background Information

Decomposition is the process of breaking down organic matter into basic chemical components of carbon, hydrogen, nitrogen, phosphorus, oxygen, etc. Decomposition is a complex process and serves many functions, including the formation of soil, the recycling of nutrients stored in the organic materials, and the reduction of high energy carbon compounds. Carbon, the basic building block of all living things, is recycled back into the environment when it is no longer a part of a living organism and decomposition takes place. During decomposition, nutrients that were used for the growth of plants and animals are discarded. Other organisms, known as decomposers, feed upon these nutrients, grow, die and become food for others. The process is cyclical, but the rate of decomposition is dependent upon the chemical composition of the various components, which are degraded at widely different rates.

The following graphic uses plant material as a decomposition model. Two concurrent processes are involved in decomposition: mineralization and humification of complex carbohydrates by soil organisms. Mineralization is when organic compounds are converted into inorganic forms and made available to meet the nutritional needs of organisms. Humification is the result of the activity of soil organisms upon residues. Humus resists further decomposition and, while it is not nutritional, it enhances the water holding, nutrient-supplying capacity of soil.



The decomposers responsible for this process include the following:

Bacteria are simple, microscopic organisms that begin the chemical stage of the decomposition process by secreting enzymes. They appear as rods, spheres or chains when viewed under a microscope. They live almost everywhere: in water, soil, and even the bodies of other organisms. They are the most numerous of all the decomposers and are capable of generating significant amounts of energy as heat. Millions of bacteria may be present in just a small sample of decomposing matter. All living things depend upon bacteria to maintain a healthy balance in nature and sustain life. Many plants need bacteria in the soil to survive. Some bacteria take nitrogen out of the air and change it into nitrates the plants can then use.

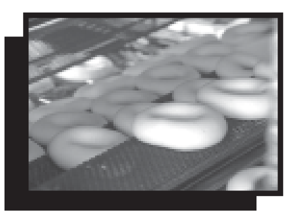
Fungi are organisms that produce networks of root-like structures and continue the chemical breakdown process. Fungi lack chlorophyll so they are unable to manufacture their own food from the raw materials around them. Instead, they get their nutrition from other plants or animals. Fungi are called parasites when their food is derived from living plants or animals, and saprophytes when the food comes from dead plant or animal matter. Their root structures, called mycelium, dissolve and collect nutrients. As mycelium spread throughout an area, they meet and form fruiting bodies. Fruiting bodies contain spores which produce the next generation. Mushrooms are an example of a fruiting body.

Actinomycetes are higher forms of bacteria and share many of the same properties. Their role in the decomposition process is similar to that of bacteria. They produce the thick "earthy" smell of decaying matter. Actinomycetes look something like spider webs, with long, thick filaments branching out.

Arthropods, physical decomposers, serve many purposes in the decomposition process. Some feed directly on bacteria, while others continue to break down the material into small sizes. Arthropods are larger and more complex than bacteria or fungi, and range in size from microscopic to relatively large. Beetles, sow bugs, centipedes and praying mantises are examples of arthropods.

Earthworms enter the decomposition process as the decaying matter becomes soil-like. They eat bacteria, fungi, protozoa and decaying organic matter. They enrich the humus by passing the matter through their bodies and producing castings. Castings, the waste of the earthworms, are rich in nutrients.

The microscopic organisms, bacteria, fungi, and actinomycetes do the majority of the work of decomposing matter, while the arthropods, earthworms and other small animals provide the finishing touches.



Bioremediation

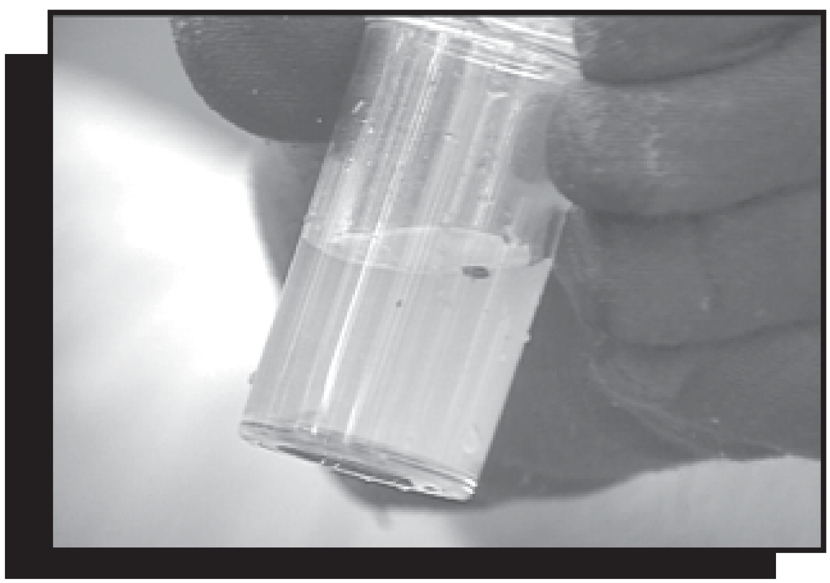
Bioremediation is the use of microorganisms to remove environmental pollutants from soil, water or gases. The current implementation rate for bioremediation is 5-10% of all pollution treatments, but there is evidence to suggest that as research continues and advancements are made this percentage will increase significantly.

In a natural setting microorganisms decompose organic compounds using enzymes. Enzymes are protein molecules that control metabolism. Some of these enzymes can break down pollutants. Exploitation of this ability to biodegrade pollutants can greatly enhance the effective treatment of wastes from a variety of sources — hazardous, industrial, agricultural — and has applications for municipal solid wastes as well.

Bioremediation is most effective when used on natural carbon-rich substances called **hydrocarbons.** Hydrocarbons and the bacteria that are capable of degrading them are found in abundance in the environment. For example, there are bacteria found in soil that can degrade gasoline. Scientists can culture these bacteria to produce enough to effectively clean up a large gasoline spill and lessen the environmental impact caused by the cleanup process.

While bioremediation is often used to remove dispersed pollutants that have inadvertently entered the environment, industries have utilized bioremediation very effectively in treating wastewater and other industry by-products. There are also indications that bioremediation can assist in agriculture by removing toxins from soil.

The process does not work with every pollutant, i.e. the organisms are unavailable in large enough quantities to be useful or have not been identified, yet the possibilities of bioremediation are limitless. Some scientists are advocating genetically engineering microorganisms to be more effective, but there is much controversy surrounding the issue of genetic engineering and its long-term effects on the environment.



ROTTEN BUT NOT FORGOTTEN

Lesson 1 Activity: Decomposers at Work! It's a Happenin' Thing!

Lesson Overview:

Students design and conduct investigations that illustrate the process of decomposition.

National Science Education Standards:

Content Standard F: Science in Personal and Social Perspectives
Population, Resources, and Environments

Excellence in EE—Guidelines for Learning:

Strand 2: Knowledge of Environmental Processes and Systems
2.1: The Earth as a Physical System

Key Concepts:

1. The process of decomposition involves changes in matter.
2. Microbes that enhance decomposition are found in the air, water and soil.

Objectives:

Students will:

- design and conduct investigations to identify the effect that temperature, soil, water and air have on the process of decomposition.
- observe and record the effect of decomposers on several types of organic matter.
- develop graphic representations of data collected during the investigations.

Cross-Curricular Connections:

Language Arts:
- Record and organize information, discuss experimental design, and share results.

Mathematics:
- Construct graphs and other representations of data collected during investigations.

Social Studies:
- Discuss how the process of decomposition affects their everyday lives.
- Practice group consensus in making decisions.

Process Skills:

Observing	Communicating	Comparing
Investigating	Inferring	Applying

Lesson 1 Activity: Decomposers at Work! It's a Happenin' Thing!

Materials:

Per Student

Research Journals

Per Group

Minimum of 4 disposable petri dishes, labeled according to contents
Garden soil
Spray bottle filled with water (rainwater, or pond water; preferably not treated water)
Small pieces of fruit, vegetables, bread
Other types of materials determined by students
Hand lenses
Microscopes
Measurement tools
Thermometer
Chart paper
Markers

Suggested Time Frame:

One introductory class period and one final class period, with daily 5 minute observations/recordings; expected completion within approximately 3-4 weeks.

Procedure:

1. Describe the purpose of the investigation (to determine the effect temperature, water, soil and air have on the rate of decomposition) and elicit student input in designing investigations that allow for cross class comparisons of data. Collecting and analyzing the data is a key component, so students should set guidelines on how to structure data collection.
2. Students determine the best methods for the investigations, get approval to proceed, and prepare petri dishes according to established class criteria. How will the measurement of decomposition be determined? Will mass be considered? How should the investigation be carried out? For example, each group of four may choose one type of food to investigate and set up petri dishes as follows: Each dish would have the same type and amount of food, but the medium would be different. Dish 1 may contain only the food with exposure to the air, Dish 2 only the soil and food, Dish 3 soil, water, and food, while Dish 4 may have only water and food. Temperature, keeping the dishes sealed or unsealing them periodically to add water, etc., are other considerations. There are numerous ways this investigation could be designed that would provide information, and it is important that the students are given the opportunity to determine the variables and work through the process.
3. Students predict and record what will happen to the food in the dishes and set the dishes aside in the same general area of the classroom where they would be exposed to the conditions congruent to their designs.
4. Students follow their procedures, observe the dishes and record their observations on the data collection table over a specified period of time.
5. Students analyze their data, graphically represent their findings, and present the information to the class.

6. Use the students' information to lead the discussion to bring closure to the activity and develop the concept of decomposition and its effects:
   What changes were observed during the investigation? Why do you think these changes have occurred? Which food began changing first? Which took the longest to decompose? Were there any differences in the decomposition rates of the food in the various dishes? What were the variables? Were all of the dishes and food exposed to air at some point? Would that make a difference in the rate of decomposition? Did temperature effect the rate of decomposition? What are some reasons for the differences in decomposition rates? Is any food still recognizable? Were you able to draw reasonable conclusions based on the data you collected?
7. Properly dispose of petri dishes.

Suggested Discussion Questions:

- Do you think there may have been a better way to design your investigation? What might you have done differently?
- How does this investigation relate to you in your life?
- Have you ever thought about what happens to leaves that fall off trees or trees that fall in the forest? What about the bodies of dead animals? Do they just lie where they fall forever?
- What do you think decomposition of matter does to the composition of soil?
- What are some ways to inhibit/encourage decay?

Further Investigations:

- Investigate the contents of a rotting log — one that has been on the ground for a period of time — and determine what kinds of processes have been taking place. Locate and identify any "critters" that may be present. Discuss the chemical and physical decay processes that are taking place.
- Interview the school cafeteria staff to determine how they handle food to inhibit decay.
- Determine ways decay of matter affects health, i.e., tooth decay, gangrene, etc.
- Determine ways decay of matter is beneficial, i.e., disposing of harmful materials, composting to divert waste from the landfill, etc.
- Research food preservation methods and their effectiveness in inhibiting decay, i.e., refrigeration, drying, canning, etc.

Careers Opportunities:

Market Research Analyst
Regulatory Affairs Specialist
Manufacturing Engineer
Environmental Engineer
Food Service Manager
Waste Management Engineer

Assessment Procedures:

- Investigations should be monitored and judged according to a rubric produced, in part, with student input.
- Design a home or school composting program.

Additional Resources:

National Science Foundation. (1999). ***Meet the Microbes through the Microbe World Activities.*** National Association of Biology Teachers. Ruston: VA.

The U.S. Composting Council
http://www.compostingcouncil.org/
(accessed August, 2003)

Newton's Apple. Mummies.
http://www.ktca.org/newtons/13/mummy.html
(accessed August, 2003)

Digital Learning Center for Microbial Ecology.
http://commtechlab.msu.edu/sites/dlc-me/whatis.html
(accessed August, 2003)

ROTTEN BUT NOT FORGOTTEN

Lesson 2 Activity: Bioremediation

Lesson Overview:

Students design and conduct investigations that illustrate the effect bioremediation has on organic matter and determine environmental applications.

National Science Education Standards:

Content Standard F: Science in Personal and Social Perspectives
Population, Resources, and Environments

Excellence in EE—Guidelines for Learning

Strand 2: Knowledge of Environmental Processes and Systems
2.1 The Earth as Physical System

Key Concepts:

1. The process of decomposition involves changes in matter.
2. Microbes can be cultured in large quantities.
3. Bioremediation can greatly increase decomposition rates of organic matter and assist in removing contaminants from water and soil.

Objectives:

Students will:

- design and conduct investigations to identify the effect bacteria and enzymes have on food samples.
- make observations during their investigations, keep accurate records, and report findings.
- use graphic representations of data collected during the investigations.

Cross-Curricular Connections:

Language Arts:
- Record and organize information, discuss experimental design and share results.

Mathematics:
- Construct graphs and other representations of data collected during investigations.

Social Studies:
- Discuss how the process of decomposition can be greatly enhanced through bioremediation.
- Investigate various real world applications for bioremediation.

Process Skills:

Observing	Communicating	Comparing
Investigating	Inferring	Applying

Lesson 2 Activity: Bioremediation

Materials:

Per Student

Research Journals

Per Group

Goggles

Gloves

4-6 quart-sized freezer baggies

Lab tray or shoebox (something to hold the baggies intact without disturbing them)

1-2 slices of bread (other types of organic material may be used, but bread provides a highly visible example of the effects within a few hours)

RID-X Septic System Treatment, 16 oz (available in grocery/hardware stores. Cost approximately $5.00.) RID-X must be dissolved in water to activate microbial action. Suggested minimal amount to get results within a short period of time: 1 tablespoon per cup of water) aquarium dechlorinator (use as directed, removes chlorine which may adversely affect microbial action.)

Water

Spoon

Measurement tools

Hand lenses

Microscopes

Chart paper

Markers

Suggested Time Frame:

One introductory class period and one final class period, with daily 5 minute observations/ recordings in between. Observable changes will be noticeable within a few hours. Dramatic change is observable after 24 hours, allowing the lesson to be completed in 2-3 days. (Experiment using ¼ piece of whole wheat bread and 1 cup of water per baggie with varying amounts of RID-X added initially to warm water and then kept at 80° F — varying amounts: no RID-X, ½ tablespoon RID-X, 1 tablespoon RID-X, 2 tablespoons RID-X, etc. Visible results after 24 hours show the bread simply waterlogged in the baggie without RID-X, and there should be progressive evidence of decomposition in the RID-X baggies, with the greater amount of RID-X added showing the greater rate of decomposition.)

Procedure:

1. Describe the purpose of the investigation; (1) to determine the effect, if any, that bacteria and enzymes have on the rate of decomposition and (2) determine conditions that inhibit or enhance the rate of decomposition. Elicit student input in designing investigations. Discuss the need for controls and variables to provide accurate information. Variables may include differences in temperature, amount of RID-X, amount of water, exposure to sunlight, exposure to air, etc.
2. After listing the possible categories of designs, each group chooses one variable to investigate to ensure that there is variety, and designs the investigation accordingly. Prior to preparing the baggies, review their designs to provide an embedded assessment of their knowledge of experimental design and to allow for the possible redirection of their efforts.

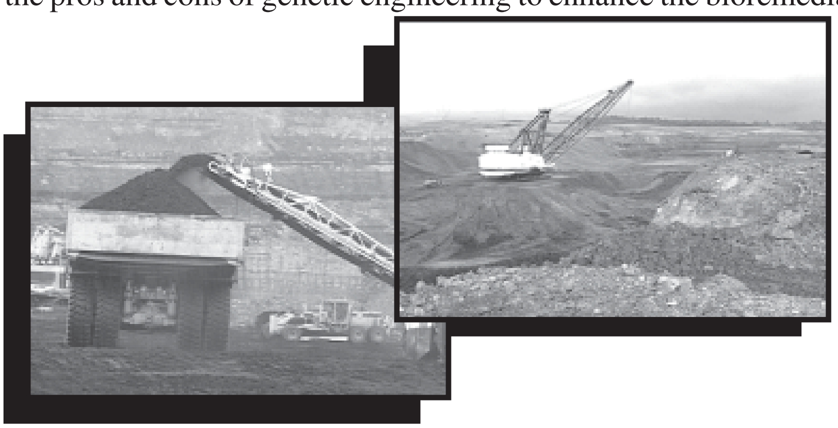
3. Students predict and record what will happen to the bread in each baggie, and then prepare their baggies.
4. Students follow their procedures, observe the baggies and record observations in their journals over a specified period of time.
5. Students analyze their data, graphically represent their findings, and present the information to the class.
6. Use the students' information to lead the discussion and bring closure to the activity. Develop the concept of bioremediation and its real world applications (see Suggested Discussion Questions below).
7. Properly dispose of experimental materials.

Suggested Discussion Questions:

- What changes were observed during the investigation?
- Why do you think these changes occurred?
- Were there any differences in the decomposition rates of the bread exposed to RID-X, and bread that was placed in plain water?
- What were the variables and how did they effect the decomposition rate?
- What are the benefits/risks to using bioremediation processes to clean up contaminants in water or soil?
- Do you think there may have been a better way to design the investigation?
- What would you have done differently?
- How does this investigation relate to you in your life?
- Do you have a septic tank? Do you believe using a product like RID-X may have some beneficial effects on the microbial action in the septic tank?

Further Investigations:

- Interview the city wastewater treatment manager to determine if the city adds microbes in their water treatment process.
- Research benefits and risks of using bioremediation.
- Contact local industries to determine if they use microbes or plan to in the future.
- Locate additional information about bioremediation on the Internet.
- Contact local environmental agencies/universities for information on bioremediation and their recommended uses of the technology.
- Debate the pros and cons of genetic engineering to enhance the bioremediation process.



Lesson 2 Activity: Bioremediation

Career Opportunities:

Environmental Engineer
Waste Management Engineer
Chemical Engineer
Biologist
Biotechnology Researcher
Quality Control Analyst
Biostatistician
Clinical Data Programmer
Patent Agent

Assessment Procedures:

- Investigations should be monitored and judged according to a rubric produced, in part, with student input.
- Have students individually design an investigation that would answer a question posed during the investigation to determine if they understand experimental design.

Additional Resources:

National Science Foundation. (1999). ***Meet the Microbes through the Microbe World Activities.*** National Association of Biology Teachers. Ruston: VA.

The U.S. Department of Energy/Natural and Accelerated Bioremediation Research
http://www.lbl.gov/NABIR/
(accessed August, 2003)

Digital Learning Center for Microbial Ecology.
http://commtechlab.msu.edu/sites/dlc-me/whatis.html
(accessed August, 2003)

Excellence Excellence, National Health Museum sponsored by Genetech
http://www.accessexcellence.org/
(accessed August, 2003)

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