Learning Through Legacy

Alabama's Environmental Education Guide
for Grades 9-12

Produced for
Alabama Educators

By
Legacy, Partners in Environmental Education

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Legacy, Inc., Partners in Environmental Education
P.O. Box 3813
Montgomery, AL 36109
Phone: 334-270-5921 or 800-240-5115 (In Alabama)
FAX: 334-270-5527
E-mail: info@legacyenved.org
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Project Staff
Legacy, Inc. Staff
Paige Moreland, Executive Director
Toni Bruner, Programs Coordinator
Stacey Little, Marketing Manager

and

Brenda Litchfield, Educational Concepts
Clint Orr, Graphic Designer
Chuck Higginbotham, Graphic Designer
Rick Van Eck, Layout and Design

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TABLE OF CONTENTS

Chapter 3 - Waste Management

Chapter 4 - Natural Resources

Resources

9-12 Correlation with Alabama Course of Study(rev 4/2013)

B-Biology E-Environment Science C-Chemistry P-Physics PS-Physical Science

Activity Ecology Chapter 1	Page #	Content Standard Number
Deer Populations and Carrying Capacity	3	B – 12, 16 ES – 1, 12
Over Hill, Over Dale, Over Plants, Over Animals	7	B – 16 ES – 1, 11, 12
Life Cycle Assessment	13	E – 1, 4, 12
Cooler By Design	17	B – 10, E – 1, 3, 12 P -8, , PS - 8
Growing Globally	19	B – 16, ES – 1, 12
A Mock Council	21	B – 16, E – 1, 7, 9, 12
Ext. Activity: Are You Willing to Trade (Off)?	23	B – 16, E – 1, 7, 9, 12
A Futurist's Writer's View on The Environment	27	B – 16, E – 1, 4, 7, 9, 12 P -1, 7
Don't Flush It Away	31	E – 1, 6, 8, 12
In Hot Water	37	E – 1, 2, P – 5, 6, 9 PS – 6, 8, 9, 12
The "Oh No Ozone"	41	B – 16, E –1, 2, 4, C - 3
Population Dynamics of the Zebra Mussel: Case Study	49	B – 11, 12, 14, 16 ES – 1, 12
Classification of the Marine Environment	51	B – 5, 9, 11, 12, 13, 14, 16, ES – 1, 7, 12
Using Duckweed to Examine Population Dynamics	57	B – 5, 9, 10, 13, 16, ES -1, 7, 12
Wetlands – A Bad Rap	61	B – 5, 13, 14, ES – 1, 7, 8, 10, 12
Wonderful Wetlands and Watersheds	65	B – 5, 13, 14, ES – 1, 7, 8, 10, 12
Chapter 2 – Pollution Prevention		
Bacterial Growth from Three Common Pollutants	73	B – 9, 13, 14, 16, ES – 1, 4, 5, 6, 7, 8, 12
Don't Sag Behind	77	B – 9, 12, 13, 14, 16, ES – 1, 5, 6, 7, 8, 12, PS - 2
The Effects of Pollutants on Algae Productivity	83	B – 9, 12, 13, 14, 16, ES – 1, 5, 6, 7, 8, 12, PS - 2
Mutant Colonies	85	B – 1, 4, 8, 9, 16, ES – 1, 8, 12
To Clean or To Glean	87	E – 1, 4, 5, 6, 7, 8, 12, C – 4, PS -2,
Plants and Sulfur Dioxide Air Pollution	91	B – 14, E – 1,2, 4, 12,
Manure Nuisance	97	B – 1, 4, 9, 14 ES – 1, 6, 8, 12
The Routes of Radon	99	B – 1, ES – 1, 4, 9, 10, 12, C – 1, 9
Enlightened and Reformed – Hazardous Substances	109	ES – 1, 4, 5, 6, 8, 10, 12, C – 4, PS - 2
Are Those Fish Safe to Eat?	119	B – 9, 11, 12, 13, 14, ES – 1, 5, 6, 7, 8, 12, C - 1
Cleanup Up	127	B – 1, 2, 13, 14, 16 ES – 1, 5, 6, 8, 12
Eutrophication: Nutrients and Algae Growth	131	B – 1, 10, 13, 14, 16, ES – 1, 5, 6, 7, 8, 12
Modeling Groundwater Pollution	135	B- 14, ES – 1, 5, 6, 8, 10, 12, C - 2
Particulate Pollution and Emissions Testing	139	ES – 1, 2, 4, 12, C – 2, 5, 7, 8, PS -2, 5
Particulate Producers	143	ES – 1,2, 4, 12, C – 2, 5, 7, 8, PS -2, 5
Particulate Survey	145	ES – 1, 2, 4, 12, C – 2, 5, 7, 8, PS -2, 5
Pollution and Osmosis	147	B – 1, 2, 4, 10, 13, 14, ES – 1, 2, 4, 5, 6, 7, 8, 12, C – 4, PS- 2
Who's Been Sleeping In My Stream?	151	B –1, 2, 4, 5, 9, 11, 12, 13, 14, 16, ES – 1, 2, 4, 5, 6, 7, 8, 12
Chapter 3 – Waste Management		
Classroom Compost	165	B – 2, 9, 13, 14, E – 1, 9, 10, 12, C – 8
Closing The Waste Loop	173	B – 1, 14, E – 1, 3, 6, 8, 9, 12, C - 8
Deciding What To Do	179	B – 1, 14, E – 1, 3, 6, 8, 9, 12
Generating Methane From Waste	191	B – 1, 9, 14, E – 1, 2, 3, 4, 6, 8, 9, 12, C – 8

9-12 Subject Correlation

	Page #	Biology	Environmental Science	Chemistry	Physics/Physic	Marine Biology	Geology	Zoology	Aqua Science	Botany	Earth/Space Science	History/Social Studies	Geography	Life Skills Science	Economics	Home Economics	Language Arts	Mathematics	Computer Science	Art	Health
ECOLOGY - CHAPTER 1																					
Deer Populations and Carrying Capacity	3	x	x														x	x			
Over Hill, Over Dale, Over Plants, Over Animals	7		x					x		x		x					x				
Life Cycle Assessment	13			x	x																
Cooler By Design	17		x														x				
Growing Globally	19	x										x			x			x			
A Mock Council	21		x									x									
Are You Willing To Trade (Off)?	23		x																		
Extension Activity: A Futurist Writer's View on the Environment	27		x														x				
Don't Flush It Away	31		x															x			
In Hot Water	37	x	x	x	x						x										
The "Oh No Ozone"	41	x	x	x					x		x							x			x
Population Dynamics of the Zebra Mussel: A Case Study	49	x	x		x				x									x			
Classification of the Marine Environment	51	x				x			x												
Using Duckweed to Examine Population Dynamics	57		x	x						x								x			
Wetlands - A Bad Rap	61		x																		
Wonderful Wetlands And Watersheds	65		x																		
POLLUTION PREVENTION - CHAPTER 2																					
Bacterial Growth From Three Common....	73	x	x	x																	
Don't Sag Behind	77	x	x											x				x			
The Effects of Pollutants on Algal Productivity	83	x	x						x												
Mutant Colonies	85	x	x																		
To Clean Or To Glean	87	x	x	x										x		x					
Plants and Sulfur Dioxide Air Pollution	91	x	x	x																	

9-12 Subject Correlation

	Page #	Biology	Environmental Science	Chemistry	Physics/Physic	Marine Biology	Geology	Zoology	Aqua Science	Botany	Earth/Space Science	History/Social Studies	Geography	Life Skills Science	Economics	Home Economics	Language Arts	Mathematics	Computer Science	Art	Health
Manure Nuisance	97	x	x															x			x
The Routes of Radon	99	x	x		x								x			x					x
Enlightened And Reformed - Hazardous Substance	109	x	x	x											x	x					
Are Those Fish Safe To Eat?	119	x	x			x			x				x			x		x			x
Cleaning Up	127	x	x						x								x				
Eutrophication: Nutrients and Algal Growth	131	x	x						x												
Modeling Groundwater Pollution	135		x	x																	
Particulate Pollution and Emissions Testing	139	x	x	x																	x
Particulate Producers	143	x	x	x																	x
Particulate Survey	145	x	x															x			
Pollution and Osmosis	147		x			x			x												
Who's Been Sleeping In My Stream	151	x	x			x															
WASTE MANAGEMENT - CHAPTER 3																					
Classroom Compost	163	x	x								x										
Closing The Waste Loop	171		x	x								x			x	x					
Deciding What To Do	177		x									x		x							
Generating Methane From Waste	189		x	x			x														
Making Landfill Models	193		x	x														x			
Myths of Solid Waste Crisis - Facts Or Opinions	199	x	x		x																x
Nuclear Energy	205		x		x																
Oil Spills	209	x	x		x																
Packaging Alternatives (Waste Reduction)	213		x											x	x					x	
Rural Water	217	x	x	x					x					x							
Spill It - NOT!	223		x	x																	

9-12 Subject Correlation

	Page #	Biology	Environmental Science	Chemistry	Physics/Physic	Marine Biology	Geology	Zoology	Aqua Science	Botany	Earth/Space Science	History/Social Studies	Geography	Life Skills Science	Economics	Home Economics	Language Arts	Mathematics	Computer Science	Art	Health
Are You Down In The Dumps?	225		x									x		x							
Plastic Numbers	229	x	x	x										x		x	x	x			
Sewage Treatment Plant Model	223	x	x										x				x	x			
NATURAL RESOURCES - CHAPTER 4																					
S*PARK*S	239	x	x				x			x		x	x							x	
The Water Facts Of The Matter	243								x				x								
Alabama's Public Lands	247		x									x						x			
Chain Gang	253	x	x																		
Check It Out	257		x									x	x								
Designer Streams	261	x	x						x				x							x	
Journey To The Center Of A Tree	265		x							x		x						x			
Lakes And Dams Of Alabama	267								x			x						x			
Name That Mineral	271		x		x		x														
Threatened And Endangered Species of Alabama	275	x	x									x							x	x	
Treeless City	281	x	x									x	x								
Developed A Stream Of Consciousness	283											x	x				x			x	
Water Woebegone	285										x				x			x			
What A Watershed	287		x								x	x									

INTRODUCTION TO ECOLOGY

Ecology deals with the relationships living things have with each other and with their environments (surroundings). Scientists who specialize in studying these relationships are called ecologists.

No living thing—plant or animal—lives alone. Every living thing depends in some way on certain other living and nonliving things. Animals and plants that live in the same area, or community, depend on each other in some way. For example, an elephant must have plants for food. If the plants in its environment were destroyed, the elephant would have to move to another area that had plants, or it would starve to death. Plants depend on such animals as the elephants for the nutrients (nourishing substances) they need to survive. Animal wastes and the decaying bodies of dead animals and plants provide many of the nutrients that plants need.

The study of ecology increases people's understanding of the world and all its creatures. This is important because humanity's survival and well-being depend on relationships that exist on a worldwide basis. Change in distant parts of the world—even outer space—affect us and our environments.

One goal of ecologists is to intelligently manage and control the living and nonliving things in the world. Many ecologists study air and water pollution and how dirty air and water affect life. Ecologists try to foresee possible environmental problems, such as crop losses or losses in animal life that building a dam or straightening a river channel may cause. They study such things as insect pests, including the beetle that carried the Dutch elm disease from Europe to the United States where it killed millions of trees.

Ecologists are concerned about the rate at which people are using up such natural resources as coal, gas, and oil. Along with many other scientists, they are searching for ways to use sunlight and atomic energy for fuel and power. Ecologists also are concerned about the world's increasing population and its decreasing food supply. For example, along with marine biologists, they are trying to find new ways of producing food from the sea.

Ecologists use knowledge from many different fields of study including physics, chemistry, mathematics, and computer science. They also rely on other sciences, such as climatology, meteorology, geology, and oceanography, to learn about air, land, and water environments.

Adapted from *World Book Encyclopedia*

Deer Populations and Carrying Capacity

OBJECTIVES:

Students will be able to:

1. Calculate expected increases in population of a deer population in the absence of predation.
2. Prepare bar and line graphs of population growth.
3. Explain how a deer population is adapted to heavy predation.
4. Describe how unchecked population growth affects carrying capacity.

Grades:
9-12

Subjects:
Biology, Ecology, Math

Time Needed:
One class period (50-60 minutes)

Materials:
graph paper
calculators
colored pencils
rulers
teacher handouts

BACKGROUND:

Deer have survived on the North American continent for millions of years. As the vast virgin hardwood forests of the 16th century were cleared and farmed by early settlers, the deer population probably increased as edge habitat with browse plants increased. Certainly deer were plentiful by all accounts in the mid 1800s. However, by 1900, unrestricted year-round hunting and loss of habitat had reduced the number of deer in Alabama to very low levels. State laws were passed for protection of wildlife but couldn't be enforced because of lack of public support. Finally, large landowners interested in conservation and U.S. Forest Service officials began buying and releasing deer from other states to restock Alabama lands. It has been estimated that current deer populations exceed one million. For every deer in Alabama in 1935, we now have 70.

Deer are prolific breeders. A population of deer in an uncrowded habitat is capable of doubling itself within two years. This was adaptive behavior when deer were subjected to high predation by coyotes, wolves, bears, and bobcats, but is not now an advantage since people have displaced most of the deer's normal predators. When carrying capacity is exceeded, deer get smaller, become more susceptible to disease, suffer health problems associated with malnutrition, and may starve or may encroach into populated areas with crops and gardens. Sometimes, as on the Kaibab Plateau in Arizona after all predators were removed, a population will exceed the carrying capacity to the point that the population will "crash," decimating the herd and requiring 20 years or so to rebuild a healthy herd.

Management of deer populations usually includes regulated hunting. For every 100 deer in Alabama, the normal sex (bucks=male; does=female)and age ratios are:

5 bucks, age 1+ yr., 3 or more points (antlers)
10 bucks, age 1+ yr., spikes visible above hairline
5 bucks, age 1+ yr., no visible spikes
20 bucks (fawns), age <1 yr.
40 does, age 1+ yr.
20 does (fawns), age <1 yr.

With a bucks-only hunting season, only 15 of 100 deer can legally be hunted. Typically, only a third are actually killed, a loss that doesn't harm the population. It also doesn't address the problem of 40 does each usually having 2 <u>more</u> fawns each year.

VOCABULARY:

edge habitat, browse, carrying capacity, predation, bucks, does, fawns

ADVANCE PREPARATION:

1. Gather enough graph paper for the students. If they are allowed to use calculators, remind them to bring the calculators to class.

PROCEDURE:

Setting the Stage

1. Determine what the students know about white-tailed deer. Question them about such things as life cycle, life span, habitat, predators. Don't give much information at this point.
2. Take an informal poll to see how the students feel about hunting.
3. Review bar graphs and line graphs.

Activity

1. Read aloud the following scenario:
   There is a herd of deer in a protected area with no hunting allowed. The site has wooded areas and also areas that are filling in after having been previously cleared and farmed. There is a creek on the property, not large but flowing throughout the year. The area is fenced around its perimeter, but access roads allow some passage in and out. The only predators are an occasional coyote and small packs of dogs.
2. If the area has a carrying capacity of 250 deer, how long would it take to reach carrying capacity if the area initially had 50 deer?
3. Let students write down their predictions.
4. Tell them they're going to track the population in this herd over the next 10 years. Write the following assumptions on the board and then read them aloud to the students:
   - Of the 50 deer, half are female.
   - All of the deer are two years old. Female deer are sexually mature at one year. Males are sexually mature between 1.5 and 2.0 years. Assume 1.5 fawns per year for all does older than 1 year.
   - Does have 1 fawn in their first breeding season and 2 fawns per year thereafter.
   - Predators have a minimal impact. Deer evolved in the presence of more predators and more *kinds* of predators than they now face.
- The deer die at age 10, not unreasonable in a protected habitat with ample food.
5. Make a bar graph for the 10 years. Each year should have a line for (1) beginning number (for that year); (2) number of does; (3) number of new fawns; (4) new total.

Example:

Year #1 starts with 50 deer. The 25 does have 37 fawns (25 x 1.5) and there are 25 bucks for a total of 87 deer at the end of the year.

Year #2 starts with 87 deer. The 43 does have 64 fawns and there are 43 bucks for a total of 150 deer at the end of the second year.

Year #3 starts with 150 deer The 75 does have 112 fawns and there are 75 bucks for a total of 262 deer at the end of the third year. <u>The herd reached carrying capacity at the end of three years.</u>

* Students do not have to receive all the examples; this is for you. Just let them figure from year to year until they reach carrying capacity. Then have them complete the exercise for the 10-year span, although probably something would intervene to reduce the herd before that time (starvation, disease).

6. Make a line graph to also cover the 10 years.

Follow-Up

1. Ask the students to speculate on <u>why</u> deer have such high reproductive rates. Under what conditions would this be a good or necessary adaptation? What has changed?
2. Deer management officials say that since people's activities and loss of habitat have removed most of the deer's natural predators, it is up to us to manage their numbers to maintain healthy populations. Short of bringing back wolves, coyotes, bobcats, and bears; awarding bonus points for turning deer into roadkill;

capturing and sterilizing deer in great numbers or allowing regulated hunting, what can we do? Brainstorm possible solutions.
3. See if opinions about regulated hunting have changed.

EXTENSIONS:

1. Redo the graphs with a reduced reproduction rate of 1 fawn per doe per year.
2. Redo the graphs with various percentages of loss due to predation or hunting. What percentage of loss each year would be required to maintain a stable population?
3. Review the hunting laws of Alabama available at www. dcnr.state.al.us. Make recommendations that might alleviate the overpopulation problem.

ORIGINAL DEVELOPMENT RESOURCES:

Gwin, G. (1996, Spring). The Place Alabama's Wildlife Calls Home. *Outdoor Alabama*, 4-11.

www.dcnr.state.al.us

www.buckmasters.com

ADDITIONAL RESOURCES:

Smityhsonian North American Mammals: www.mnh.si.edu/mna

Outdoor Alabama: www.outdooralabama.com/watchable-wildlife/Mammals/Ungulates/

Notes

Over Hill, Over Dale, Over Plants, Over Animals

OBJECTIVES:

Students will be able to:

1. Define and identify the impacts of Off Road Vehicles (ORVs).
2. Compare the positions of groups involved with and impacted by, ORVs.
3. Defend a position, whether or not it is the student's own personal one.
4. Compare the issue of rights of the individual versus the rights of society.

BACKGROUND:

Ownership and enjoyment of Off Road Vehicles (ORVS), as well as environmental issues, are very popular with teenagers. This activity will help them understand the impact of this recreational activity on the soil, water, and wildlife. It also will explore the concerns of different involved groups.

VOCABULARY:

Off Road Vehicles, erosion, silt/sediment/watershed, degradation

Grades:

9-12

Subjects:

Environmental Science, Science, Social Studies, Art

Time Needed:

One class period for the presentation; time for research, some class time and some individual

Materials:

Over Hill, Over Dale, Team activity sheet

Using a Futures Wheel (2 pages) activity sheets

PROCEDURE:

Setting the Stage

1. Photograph popular ORV locations in the area and bring them to class. Keep any identifiable signs out of the picture.
2. Show the pictures and discuss the environmental impacts such as compacted soil, runoff, and resultant destruction of habitat.
3. Ask the students to identify what could have caused this damage and where the pictures were taken.

Activity

1. Divide the class into three investigative teams and give each team a team assignment sheet (See "Over Hill, Over Dale" sheet). Allow time to brainstorm the areas that need filling in on this sheet.
2. Monitor the teams' work and give approval before proceeding to the next step.
3. Students are to carry out investigations.
4. Using any approved method, they are to present the information to the class.

Follow-Up

1. Explain how to use a Futures Wheel. See accompanying information.
2. Divide the class into small groups. Give each group a blank Futures Wheel and let them fill it in. It is best if the groups are separated so that students cannot hear what is being suggested by other groups.
3. Let each group share its wheel and follow this with a discussion of a possible solution. It is not necessary to reach a consensus.

EVALUATIONS:

1. Grades will be based on the evidence of research, following assignment requirements, quality of presentation, and participation in class assignments.
2. Students will turn in an individually completed position paper on the rights of the individual versus the rights of society using ORV as an example. This is a graded assignment.

EXTENSIONS:

1. Divide students into two groups. Have one group develop a Bill of Rights for ORV users and the other group develop a Bill of Rights for watershed citizens impacted by ORVs. Compare and contrast the two statements.
2. Obtain information about the Tread Lightly environmental program for 4x4s available at www.treadlightly.org or 1-800-966-9900..
3. Have students develop an educational bulletin board for ORV users and display it somewhere in the school.

ORIGINAL DEVELOPMENT RESOURCES:

ORV user magazines and groups

Science Scope, January, (1994). pages 18-19.

ADDITIONAL RESOURCES:

http://www.fort.usgs.gov/products/publications/22021/22021.pdf

http://www.wildlandscpr.org/road-riporter/environmental-impacts-road-vehicle-races-and-events-literature-review

Over Hill, Over Dale

	Team 1	**Team 2**	**Team 3**
Group To Investigate	*ORV Users*	*Concerned Environmental Groups*	*Governmental Bodies/Agenies*
Information Needed			
Methods Used to Obtain Information			
Presentation Plans			

Using A Futures Wheel*

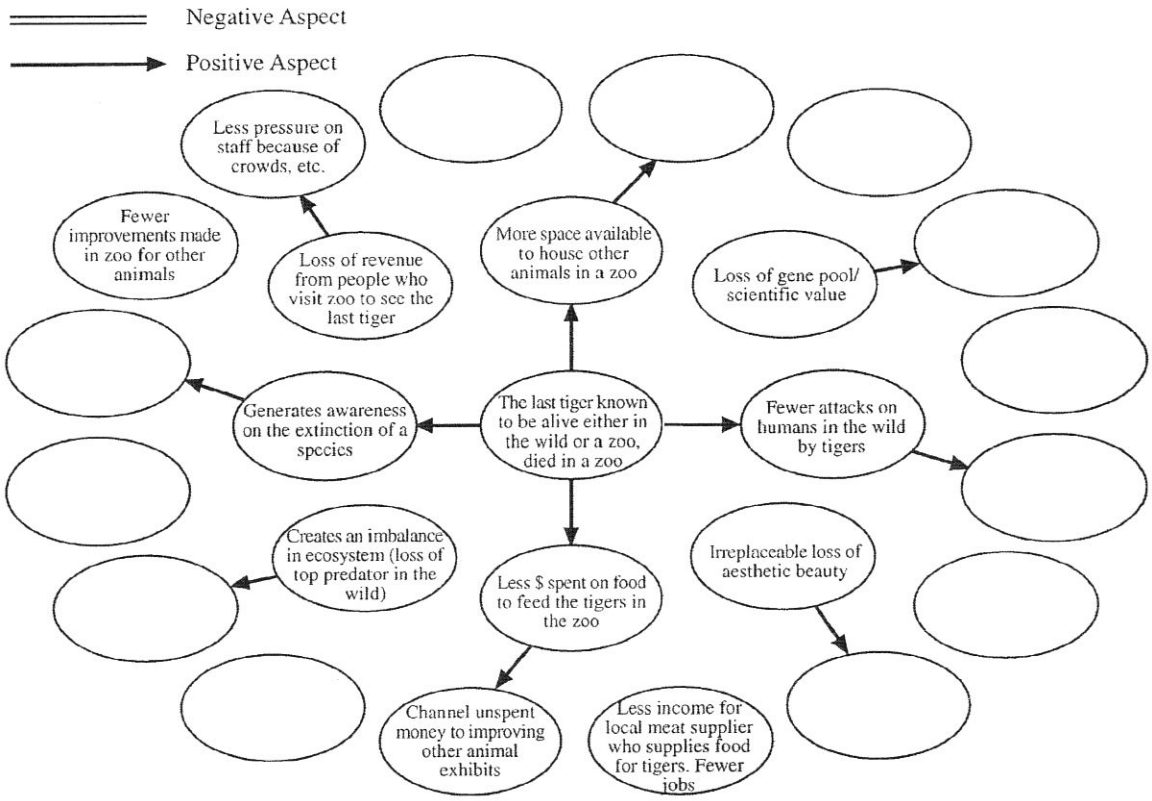
Time: Students need about 20-25 minutes to complete the wheel and additional time for class discussion. Monitor their progress the first few times. One this method becomes familiar to them, it can be used for any issue without much teacher intervention.

A futures wheel is a graphic toll to assist students with productive brainstorming. Using the wheel guides students in seeking both sides to issues and helps them to "see" where their thinking is progressing.

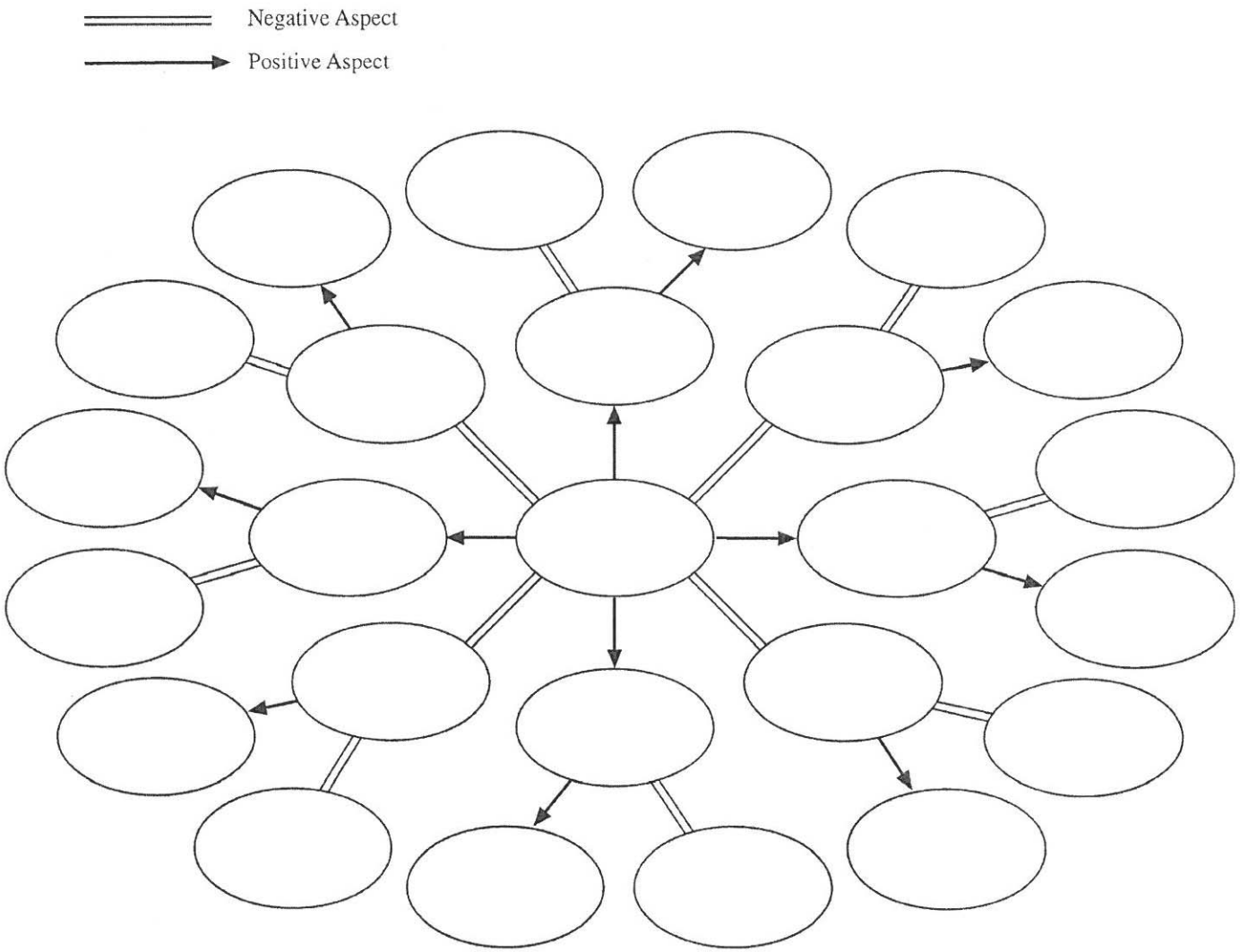
Directions: Divide students into very small groups (three to four is best) and give each groups a blank futures wheel. In the center oval have them write the problem they are trying to solve. In each of the closest surrounding ovals connected with an arrow, they are to add (after discussion within their group) four positive aspects of this problem. In each of the closest surrounding ovals connected with a double line, they are to add (after discussion within their group) four negaitve aspects of the problem. Next, following the same pattern, they are to complete each of the additional ovals. Remind the students that they must address the statement in the closest adjoining oval, not return to the center each time. Also, once a response has been agreed upon by the group, it should not be changed even when it is hard to think of a corresponding response. Forcing critical and open-minded thinking is the value of using the wheel.

*Adapted from: Puls, Dan and O'Brien Pamela. "What's a Zoo to do?" *Science Scope*, January, 1994. p 17-20

Futures Wheel Example



Futures Wheel



Notes

Life Cycle Assessment

OBJECTIVES:

Students will be able to:

1. Research the Life Cycle Assessment (LCA) of certain market items.
2. Compare the LCAs of Europe with those of Alabama.

Grades:
9 - 12

Subjects:
Biology, Chemistry,
World History, Environmental Science

Time Needed:
50-minute class period (allow one week for researching European LCAs)

Materials:
materials gathered from research

BACKGROUND:

All products have environmental impacts over the course of their existence from extraction/procurement of raw material to manufacturing, distribution, use, and disposal. Life Cycle Assessment (LCA) is a holistic evaluation of all direct and indirect, pre-market and post-market, and recycle/disposal aspects of a product. Other names for Life Cycle Assessment are ecobalance, cradle-to-grave analysis, and environmental profile analysis.

Determinations of what is environmentally preferable are complex processes; and Life Cycle Assessment is growing rapidly, especially in Europe where 130 LCAs were done in 1994. In the United States, LCAs have been done since 1969 for the products listed in Table 1.

A model for an LCA (Figure 1) consists of inputs (raw materials and energy); life cycle stages (raw materials acquisition, manufacturing, use/reuse/maintenance, and recycle/waste management); and outputs (atmospheric emissions, waterborne wastes, solid wastes, coproducts, and other releases).

Many conclusions can be reached using data inputs to the model. For example, is it less energy/environmentally demanding to recycle or dispose; can a product be re-configured to lessen its energy/environmental impact; are there preferable pollution control steps to minimize environmental impact?

LCA is not yet a regulatory requirement in the United States, as in Europe; but leading corporations and business organizations have voluntarily adopted the concept as a business principle.

VOCABULARY:

LCA, ecobalance, cradle-to-grave analysis, holistic, environmental profile analysis

PROCEDURE:

Setting the Stage

1. Discuss Life Cycle Assessment and what it means in terms of our environment.

Activity

1. Ask the students their opinions as to why Europe has regulated LCA and the United States has not.
2. Using the LCA model provided, have the students construct their own LCA for common consumer products. For example, they might construct an LCA for an aluminum can or plastic soft drink bottle.
3. Using Figure 1, discuss any packaging changes that may have occurred in certain grocery store or fast-food products as a result of an LCA of the product.

4. Have the students make a list of companies in the U.S. that they think are LCA sensitive and state the reasons upon which they base their opinions. The students also could make a list of companies that they think are not LCA sensitive and explain why they feel these companies are not sensitive.

EXTENSION:

1. Students could choose roles of people in these companies and their communities and could debate the issues of LCA in Alabama.

ORIGINAL DEVELOPMENT RESOURCES:

Broad-Based Environmental Life Cycle Assessment. (1993, March). *Environmental Science and Technology*, 430.

Learning to Live with Life Cycle Assessment. (1994, May). *Environmental Science and Technolog*y. 236a.

www.life-cycle.org

www.quantis-intl.com/life_cycle_assessment.php

http://environment.nationalgeographic.com/environment/national-geographic-sustainability/magazine-life-cycle-assessment/

Table 1

Life Cycle Assessments in the United States

Client	Practitioner	Product	Year
Coca-Cola	MRI	Beverage containers	1969
EPA	MRI	Beverage containers	1974
SPI	MRI	Plastics	1974
Unknown	MRI	Beer containers	1974
Goodyear	Franklin	Soft drink containers	1978
Procter & Gamble	Franklin packaging	Laundry detergent	1988
Procter & Gamble	Franklin	Surfactants	1989
Unknown	Franklin	Softdrink delivery systems	1989
Council for Solid Waste Solutions	Franklin	Foamed polystyrene and bleached paperboard	1990
American Paper Institute	Franklin	Cloth and disposable diapers	1990
Council for Solid Waste Solutions	Franklin	Grocery sacks	1990
Vinyl Institute Systems	Chem	Vinyl packaging	1991
National Association of Diaper Services	Lehrbergerr & Jones	Diapers	1991
Council of State Governments	Tellus	Packaging	1991
Procter & Gamble	Franklin	Hard surface cleaners	1992
Procter & Gamble	A. D. Little	Cloth & disposable diapers	1990

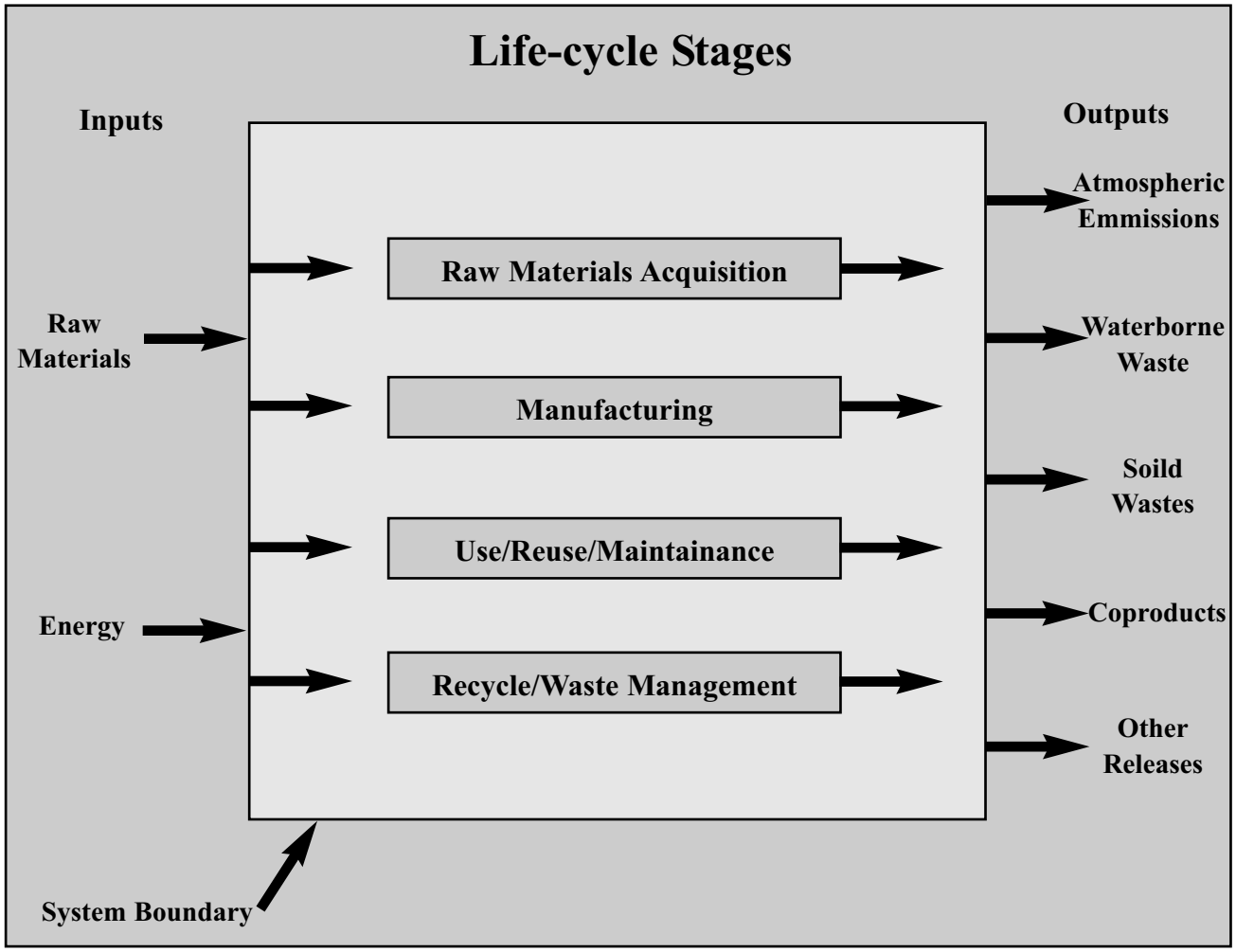


Figure 1. Model for a Life Cycle Assessment

Cooler By Design

OBJECTIVES:

Students will be able to:

1. Investigate the role of trees in energy conservation.
2. Compare and contrast the inside temperatures of model houses painted black and white.

Grades:

9-12

Subjects:

Physics, Environmental Science, Geometry, Architectural Arts

Time Needed:

Four to five 40-minute class periods.

Materials:

- four 20x20 inch sheets of white or light-colored foam core or cardboard
- scalpel or artist's knife (such as an X-Acto knife)
- black paint
- paper or other "surfacing" material
- outdoor thermometers
- glue
- sturdy tape such as masking or duct tape

BACKGROUND:

One important way to save energy is by landscaping with trees and other vegetation around the home. Landscaping provides an effective, natural way to prevent heat loss and heat gain in the home. When the home stays cool in the summer and warm in the winter, the air conditioner and heater are used less frequently. Consequently, energy is saved.

Deciduous (leaf losing) trees placed on the west and east sides of a house are the most effective at shading and cooling because they block the morning and afternoon sun, especially in the summer. Because they are bare in the winter, the trees allow the winter sun to warm the house.

If one lives in a large apartment building or an area that does not have space for trees, one still can receive the cooling and shading benefits of trees. Trees planted along streets and around schools, churches, and office buildings also help to conserve energy.

Another energy-saving measure that goes hand-in-hand with landscaping is light-colored surfacing. If a person has ever stepped barefoot on asphalt in the summertime, he/she probably ran as fast as possible to the light-colored sidewalk or, even better, to a shady spot on the grass.

The street is much hotter than surrounding areas because dark surfaces absorb solar radiation while light-colored surfaces reflect it. By lightening the colors of buildings, parking lots, and pavements, communities can reduce the amount of energy required for cooling by as much as 50 percent. A combination of trees and light-colored surfaces can make a significant difference in temperature.

VOCABULARY:

deciduous, solar energy, absorption, reflection

PROCEDURE:

1. Construct three model houses out of foam or cardboard. The structures can be as simple or as complex as the students wish, but the dimensions and features of each must be consistent (a good size is 9" wide x 6" deep x 10" tall). The roof of each house must be removable. Build each on a base slightly larger than the house. The entire outer surface of one house must be black, and the entire outer surface of the other two must be white.

2. On a clear day, remove the roof and place a thermometer in each house, making sure its position is consistent in all three houses. Secure the thermometers with tape and replace the roofs. Place the houses

outside. Put the dark-surfaced house and one of the light-surfaced houses together in a spot that will get sun all day. Place the other light-surfaced house in an area shaded by trees or other vegetation. Leave the houses outside for several hours.

3. After several hours, touch the roof and exterior walls of each house. Is there a significant difference in temperature?
4. Remove the roofs and check the internal temperature. Record the temperatures and compare them.
5. Discuss these questions as a class, in groups, or in journal entries:
   - Is there a difference in temperature among the three houses or just between the light and dark ones?
   - What can be concluded from the outcome of the experiment?
   - How is the model similar to "the real thing?" How is it different?

EVALUATION:

1. The students should keep records of their experiment and should use graphs or charts to explain the outcome of their experiments. The teacher should make sure that students have carefully answered any questions associated with the lesson.

EXTENSIONS:

1. Students could study the seasonal angles of the sun and then locate trees around the built houses. The prior experiment could be performed again after trees have been placed around the houses. Data from the first "Cooler by Design" experiment could then be compared to data from the second experiment.
2. Have students investigate the school grounds to determine if, and where, trees could be planted to help save energy.

ORIGINAL DEVELOPMENT RESOURCE:

Adapted from *Growing Greener Cities*. Used with permission.

http://forestry.usu.edu/htm/city-and-town/tree-selection/planting-trees-for-energy-conservation-the-right-tree-in-the-right-place

http://www.arborday.org/globalwarming/summerShade.cfm

Growing Globally

Grades:
9-12

Subjects:
Social Science, Biology, Civics, Economics, Science

Time Needed:
Two or three class periods of 1 hour each

Materials:
research materials

OBJECTIVES:

Students will be able to:
1. Define carrying capacity.
2. Explain how population size is related to quality of life.

BACKGROUND:

Carrying capacity refers to the ability of a habitat to sustain a population. Technology is the ability of a population to adapt to new circumstances by inventing new tools and ways of managing resources.

VOCABULARY:

technology, carrying capacity, population

PROCEDURE:

1. Define carrying capacity (See "Background"). Emphasize the fact that carrying capacity is in a constant state of change as populations, availability of resources, and technological skills are always changing.
2. Define technology as a way that people adapt to new conditions and solve problems.
3. Read this to the students:

   On July 7, 1986, the Associated Press reported that sometime during that day, the five billionth person would be added to the Earth. The following letter was written to the editor of the newspaper in response:

   To the editor: In *The Oregonian* (July 7), Associated Press reported the imminent birth of this planet's 5 billionth person, casting it as 'a sobering symbol' with 'staggering consequences' of overpopulation. Yet, if all 5 billion people were placed on the land area of Canada (+) 3,560,238 square miles, every man, woman and child would have 19,851 square feet of space, with the rest of the continent and the rest of the planet empty.

   All the space and resources we need are here. It's for us to learn how to use them.

4. Ask the students these questions:
   - Do you agree or disagree with the letter? Why?
   - Do you think that this individual would agree with the theory of carrying capacity as applied to human populations?
   - What enables the human population to exceed limiting factors such as food scarcity?
5. Tell students that the modern human population of the world today is more than six billion and projected to be greater than ten billion by 2025. What might this mean for resources, technology, and society?
6. Have the students research and find:
   - The current population of Alabama.
   - The current population of their city.
   - The square feet of space each Alabamian has.

EVALUATION:

1. Have students write an essay on technology, population, and resources.

EXTENSION:

1. Students could write letters to the local or student newspaper about this issue.

ORIGINAL DEVELOPMENT RESOURCES:

Adapted from *American Forests Global Releaf*. Used with permission.

www.worldgame.org (current world population counter)

A Mock Council

OBJECTIVE:

Students will be able to:

1. Synthesize specific aspects of environmental issues by acting out the roles of the people impacted by these issues.

BACKGROUND:

Students frequently deal with environmental issues, but it is only from a superficial viewpoint. Rarely do they have the opportunity to view an issue from the perspective of real involvement. Role playing gives students the chance to put their feelings into a specific situation. When this happens, their views about an issue may change. They may realize that many issues have no clear-cut, "easy answers." This case study can be about any real issue taken from the newspaper or from various news periodicals, researched by the students, and debated in class.

VOCABULARY:

This can vary depending upon the issue(s) to be debated.

PROCEDURE:

1. Have the students select and research an environmental issue. *Note*: The student is not allowed to argue from the way he/she truly feels but must assume the role of one of the people involved and must be able to argue in favor of that position.
2. Have the students, either individually or in small groups, assume the role of various players on all sides of the issue. Typical roles will depend on the issue to be debated. This example assumes the issue of water pollution:
   - Homeowner with polluted water or other environmental problem.
   - Homeowner with clean water but whose water bill will double to help cover the costs of a new water system.
   - Company president whose job is to keep the company financially sound.
   - Stockholder of the company.
   - Federal EPA or environmental official.
   - Alabama Department of Environmental Management.
   - Mayor or city council person.
   - Consumer who buys products made by the company.
   - Lawyer representing a homeowner or another player in the scenario.
   - Environmental scientist.
   - (The rest of the class can be the "voting public.")
3. Students should read the periodical(s) containing the issues to be debated. As they read the story, have them focus on the questions that develop in the story. Give them time to formulate answers to those questions in preparation for classroom discussion. If possible, have them get in a circle and start discussing the questions based on the role each has assumed.
4. Once the students are familiar with this approach, the teacher can let the students go with their arguments representing the views of the roles they have assumed. Sometimes the teacher may need to act as a mediator or may need to clarify some of the points a group has made.

Grades:

9-12

Subjects:

Environmental Science, Social Studies

Time Needed:

About a week of in-class time or can be done as an outside assignment. Time is needed for the students to gather the materials on the issue and to research the people impacted by the issue. The actual town/world council will take about two hours for presentation or two individual class periods.

Materials:

list of roles of various people or companies impacted by the issue to be debated
news periodicals on the issue
place cards for role identification

5. Typically, students cannot reach closure on the day of the debate. Assign a period of time, possibly three days, for the groups to debate on their own; and have them report their decisions to the class.

EVALUATION:

1. Teacher may evaluate research and clarity in voicing opinions based on fact.

EXTENSIONS:

1. A typical issue might be the water wars between Alabama and Georgia. Invite the people involved in the issues to speak to the class during the post-debate period.
2. Do "Are You Willing to Trade (Off)?" extension activity. (See next activity.)

ORIGINAL DEVELOPMENT RESOURCES:

Alabama Department of Ecomonic and Community Affiars - Office of Water Resources; 334-242-5499, 1-877-252-9283, water@adeca.alabama.gov, www.adeca.state.al.us

Extension Activity:
Are You Willing To Trade (Off)?

OBJECTIVES:

Students will be able to:
1. Define "trade offs" and give at least two specific examples.
2. Compare the impacts, both positive and negative, for at least one local industry.
3. Identify appropriate resource material.
4. Develop and analyze survey results (extension).

BACKGROUND:

This activity will help students focus on both sides of an issue. Students are often passionate in their beliefs without thinking through all of the consequences of what they are assuming. Students need to understand that most solutions involve accepting the best compromise. To gain benefits, we usually also give up other benefits.

The teacher should determine the local industries to select so that materials and information are readily available. Depending on the age and ability of the students, the teacher may wish to have the information in the classroom for students to use.

Grades:
9-12

Subjects:
Environmental Science

Time Needed:
Research time both in and out of class; 30 minutes to present the activity; total presentation time based on the number of groups presenting

Materials:
handouts/one per group
example to post on bulletin board

VOCABULARY:

trade offs

PROCEDURE:

Setting the Stage
1. Write the words "TRADE OFFS" on the board and ask the students what thoughts come to their minds when they read this. Solicit as many responses as possible. Guide their thoughts to cover such things as "give and take," and "compromise."
2. Ask for examples of trade offs they make at home, at school, and in the use of their time. continue this until they have a good working feeling for the idea of trade offs.

Activity
1. Divide the class into groups and assign each group a local industry. (Use specific local industries or businesses.)
2. Give each group a copy of the Industry Investigation survey form, and assist students in filling out the top portion.
3. Explain the instructions (see form). Answer questions about the assignment.

EVALUATION:

Student projects will be graded on the following:
1. Did they follow the assignment and complete the work on time?
2. Were facts gained from accurate sources, and were they properly cited?
3. Were presentations well planned and ready on time? Did they show evidence of understanding and research?
4. Did all group members participate equally?

EXTENSIONS:

1. Arrange for a field trip for the class or groups of students to tour one of the industries.
2. Bring in a speaker from one of the industries to talk with the class about the environmental changes they are making within the industry.
3. Let the students develop and take a survey of the general public to assess their impression of the industry in relation to environmental issues, and compare this to the class reaction before and after this activity. Graph and analyze the results. (Caution: surveys of human subjectrs must be structured carefully and with adult supervision. The methodology and questions to be asked in the surveys should be chosen carefully and should be approved by the teacher.)
4. Rather than selecting industries, choose an environmental issue to investigate.

ORIGINAL DEVELOPMENT RESOURCES:

Local chamber of commerce, governments, and media environmental reporters.

Environmental and industry groups and professional organizations. Refer to links on Bama Environmental News website at www.bamanews.com.

Industry Investigation Survey

Industry To Be Investigated: _____

Date Due: _____ Class Period: _____

Group Members: _____

_____

As a group, you are to investigate your assigned industry in regard to its impact on the community. For each of the areas investigated, you will need to support your comments with specific facts. To locate information, you may use any source (always remember to cite your source). Good sources could include the public library, interviews, the chamber of commerce, specific businesses within the industry, and community members. Remember, you are seeking information about the industry in general, not a specific example. Keep good records and accurate facts.

Impacts on the Community	
Benefits to Society	Environmental Consequences

Notes

A Futurist Writer's View on the Environment

OBJECTIVES:

Students will be able to:
1. Interpret written social theories and support or dispute them.
2. Discuss the meaning and implications of social theories.

Grades:
9-12

Subjects:
Social Science, Literature, Civics, Environmental Science

Time Needed:
One or two class periods of 50-60 minutes each

Materials:
Toffler excerpts from appropriate books

BACKGROUND:

Alvin Toffler, one of the world's best-known social thinkers as well as a contributor to management literature and a member of the American Academy of Science, wrote a trilogy of international best-selling books about the world's movement into the 21st century. The first, *Future Shock*, originally published in 1970, looked at the process of change and how change affects people and organizations. The second, *The Third Wave* (1980), focused on the directions of change and where today's changes are taking us. The third in the trilogy, *Power Shift* (1990), dealt with the continued changes still to come, who will shape them, and how they will accomplish that.

In another book following the trilogy, *War and Anti-War* (1995), he discussed the future of global military and political conflicts, with the term "national security" broadened to include ecological components.

VOCABULARY:

thermopollution, social overhead, life cycle assessment, exploitation of nature, diversity, defoliant, vector, laser

PROCEDURE:

Advance preparation: Review the attached excerpts of Toffler's books and assign them to students for an essay, debate, point-counterpoint discussion, or analysis of events that corroborates or does not corroborate Toffler's theories.
1. Explain the background of Toffler's books, the reason they were written, the times in which they were written, and the environmental status of the world at each of those times.
2. Assign the environmental excerpts to students as a theme to support, expound upon, or dispute Toffler's theories.
3. Use the excerpts as the basis for debate or reading comprehension exercises, or discuss their value as a guide into the 21st century.
4. Assign an out-of-class paper, oral presentation, or class debate for students to further examine Toffler's theories through real-world examples.
5. Analyze the excerpts relative to their time of publication; hypothesize about the environment's status in each era represented by the books, about public attitudes about the environment in each era, and about present environmental values, attitudes, and directions.

ORIGINAL DEVELOPMENT RESOURCES:

Toffler, A. (1970). *Future Shock*.

Toffler, A. (1980). *Third Wave*.

Toffler A. (1990). *Power Shift*.

Toffler, A, & Toffler, H. (1995). *War and Anti-War*.

Toffler excerpts (see attached)

www.maslowtoffler.com

Toffler Excerpts

Toffler, *Future Shock*, 1970, pp. 429-430.
Environmental Stewardship
Our technological powers increase but the side effects and potential hazards also escalate. We risk thermopollution of the oceans themselves, overheating them, destroying immeasurable quantities of marine life, perhaps even melting the polar icecaps. On land we concentrate such large masses of population in such small urban-technological islands, that we threaten to use up the air's oxygen faster than it can be replaced, conjuring up the possibility of new Saharas where the cities are now. Through such disruptions of the natural ecology, we may literally, in the words of biologist Barry Commoner, be "destroying this planet as a suitable place for human habitation."

Toffler, *Future Shock*, 1970, p. 442.
Who Pays Environmental Costs?
The costs of air pollution are similarly borne by taxpayer and community even though, as is often the case, the sources of pollution are traceable to individual companies, industries, or government installations. Perhaps it is sensible for de-pollution costs to be borne by the public government as a form of social overhead, rather than by specific industries. There are many ways to allocate the cost. But whichever way we choose, it is absolutely vital that the lines of responsibility are made clear. Too often no agency, group or institution has clear responsibility.

Toffler, *Power Shift*, 1990, p. 79.
The Concept of Life Cycle Assessment
We are, in fact, discovering that "production" neither begins nor ends in the factory. Thus, the latest models of economic production extend the process both upstream and downstream, forward into aftercare or "support" for the product even after it is sold, as in auto-repair warrantees or the support expected from the retailer when a person buys a computer. Before long, the conception of production will reach even beyond that to ecologically safe disposal of the product after use. Companies will have to provide for post-use cleanup, forcing them to alter design specs, cost calculations, production methods, and much else besides. In so doing they will be performing more service, relative to manufacture, and they will be adding value. "Production" will be seen to include all these functions.

Toffler, *Power Shift*, 1990, pp. 369, 373, 378.
The Green Movement
[The Green Movement has two sides.] on one side: those who favor technological economic advances within stringent environmental constraints. Unwilling to give up on imagination and intelligence, they believe in the power of the human mind, and therefore in our ability to design technologies that will use smaller amounts of resources, emit less pollution, and recycle all wastes into valuable resources....Oriented toward tomorrow, these are the mainstream environmentalists.

Battling them for ideological control...are self-described "fundamentalists," who wish to plunge society into pre-technological medievalism and asceticism. What the eco-medievalists normally do not tell us is the political price. They seldom point out that democracy was conspicuously absent from those bucolic villages they hold up for emulation, villages ruled by the cruelest patriarchy, religious mind-control, feudal ignorance, and force. Governments controlled or heavily influenced by extremists who put their particular brand of religion, ecology, or nationalism ahead of democratic values do not stay democratic for long.

Toffler Excerpts (con't)

Toffler, *The Third Wave*, 1980, pp. 8, 16, 301, 342, 383, 416, 421.

Patterns of Change

The First Wave of human progress was the development by man of agriculture, cultivated land and a new way of life, lasting until about 1750. With the coming of the Second Wave (1750-1955), civilization once found capitalist industrialists gouging resources on a massive scale, pumping voluminous poisons into the air, deforesting whole regions in pursuit of property, without much thought about side effects or long-term consequences. The idea that nature was there to be exploited provided a convenient rationalization for shortsightedness and selfishness.

Shortly after 1955 white collar workers outnumbered blue collar workers for the first time, the computer, commercial jet travel, the birth control pill and many other high-impact innovations appeared. National borders that can no longer contain economic flows are now even less defensible against environmental forces. The Third Wave represents a shift to higher diversity in society, a faster pace at which change occurs, and requires a change in leadership direction to one of the depending upon, and listening to others.

Second Wave thinking opposes change, pooh-poohs environmental concerns and opposes the move to a fairer world economic order. Third Wave thinkers favor more individualization in the schools, place higher priority on environmental problems, and have a lack of confidence in the present political framework.

The responsibility for change, therefore lies with us. We must begin with ourselves, teaching ourselves not to close our minds permanently to the novel, the surprising, the seemingly radical. This means fighting off the idea-assassins who rush forward to kill any new suggestion on grounds of its impracticability, no matter how absurd, oppressive, or unresolvable it may be. If we begin now, we and our children can take part in the exciting reconstitution of not merely our absolute political structures, but of civilization itself.

Toffler, *War and Anti-War*, 1995, pp. 286, 183, 143.

Ecological Militarism

Few words are more loosely thrown about today than the term "global." Ecology is said to be a "global" problem. The very notion of "national security" is being broadcast to include not simply military but economic, diplomatic, and even ecological components. [One proponent] argues that to head off trouble before it explodes, the United States should use its intelligence and its military forces to help the world deal with problems like hunger, disaster and pollution that can throw disparate populations into violent conflict.

And then there is ecological weaponry [as] when Saddam Hussein torched the Kuwaiti oil fields...the Romans salted the fields of Carthage...during World War II the Russians pursued their "scorched Earth" policy to deny food to the Nazi invaders...and what the United States did with the use of defoliants in Vietnam.

[Modern day] possibilities of sophisticated ecological weaponry...[include] triggering earthquakes or volcanic eruptions at a distance by generating certain electromagnetic waves; deflecting wind currents; sending in a vector of genetically-altered insects to devastate a selected crop; using lasers to cut a custom-tailored hole in the ozone over an adversary's land; and even modifying weather.

Don't Flush It Away

OBJECTIVES:

Students will be able to:
1. Compute the amount of water used to flush a toilet.
2. Describe ways to reduce the amount of water used to flush a toilet.
3. Define and compute mean and range.

Grades:
9-12

Subjects:
Environmental Science, Math

Time Needed:
Two class periods

Materials:
"How Do You Measure Up?" quiz
small dishwashing or laundry plastic bottle
several pieces of gravel
checklist to record the number of flushes in a two-day period

BACKGROUND:

Did you know there is the same amount of water on Earth today as there was three billion years ago? This amounts to approximately 326 million cubic miles of water covering 71 percent of the Earth. Nearly one-half of the world's population lacks access to clean water for sanitation, drinking, and other human needs. One could survive about a month without food but only five to seven days without water.

In some parts of the world, saving water is a necessity; but in Alabama it is a responsibility. It saves money, helps protect the environment, helps prevent water pollution, and helps preserve our water resources. Conservation by homeowners can be achieved by simply reducing the amount of water used to flush a toilet. Each time the toilet is flushed, it uses five to seven gallons of water. To reduce this by 15 to 40 percent, a displacement device can be used in the tank.

VOCABULARY:

displacement, mean, range

PROCEDURE:

Setting the Stage

1. Using background information and data from current publications, the teacher can relate facts about the amount of water available on the Earth and the quality of this water.
2. Have each student complete a "How Do You Measure Up?" quiz (attached).
3. After totaling the score, students can determine how they "measure up" in taking care of the Earth's water supply by referring to the scale at the end of the quiz.
4. Have students share their results with the class, and have them discuss how they can become better caretakers of the Earth's water supplies.

Activity

1. Give each student a flush frequency chart (attached), and explain that each flush should be recorded on the chart. This should be done for a period of four days covering Thursday, Friday, Saturday, and Sunday.
2. Place a few pieces of gravel in the bottom of the plastic bottle. Fill the bottle with water, and place it in the tank of the toilet. Be careful that the bottle does not interfere with the proper flushing of a toilet. This becomes a displacement device resulting in less water being used for each flush.
3. Using data from the flush frequency chart, calculate the following amounts of water saved in:
    - One day.
    - One week.
    - One year.

EVALUATION:

1. A flush frequency chart must be completed.

EXTENSIONS:

1. Use this information to determine the amount of money saved over the period of one year. One gallon of water costs $.004.
2. Have the students devise another means of conserving water.
3. Students can collect data for one week or longer.
4. Have students determine the sources of water in their communities or homes.

ORIGINAL DEVELOPMENT RESOURCES:

Buchanan, P.; Carter, P.; McSwean, S.; & Wilson, C. (1992). *Discover Alabama III* Activities Booklet, Alabama Commission on Higher Education.

Water Quality and Pollution Control Handbook Circular, ANR-790, Alabama Cooperative Extension System.www.aces.edu

Water in Alabama, (current year), Geological Survey of Alabama.

"Alabama Water Resources" poster, Legacy, Inc. P.O. Box 3813, Montgomery, AL 36109, www.legacyenved.org, 1-800-240-5115.

Alabama Cooperative Extension System website, www.aces.edu.

Worksheet

Don't Flush It Away

How Do You Measure Up?
A Water Awareness Test

Every day we do things that positively or negatively affect the amount of water we use and the condition or "quality" of the water we dispose. Here's an opportunity for you to consider what your contribution is to the problem and to the solution. Take a few minutes to complete this checklist. Add up the numbers you circled as answers in each column to find your total. Then use the "How Did You Score?" section at the end to determine what your score means.

Part 1: Do you	**Never**	**Sometimes**	**Often**
1. Leave the tap water running as you brush your teeth or shave?	1	2	3
2. Throw used containers of paint, solvents, or harsh cleansers into the trash?	1	2	3
3. Empty leftover paint solvents or cleansers into house drains?	1	2	3
4. Run the washing machine with small loads?	1	2	3
5. Use lots of fertilizer and lawn feeder to help the lawn recover from winter?	1	2	3
6. Leave the shower running to heat up the bathroom?	1	2	3
7. Wait to repair a dripping faucet until it turns into a steady leak?	1	2	3
8. Wash the car every weekend in the summer?	1	2	3
9. Change the oil in the street or use storm drains to dispose of used oil?	1	2	3
10. Use the toilet to dispose of ordinary waste around the house?	1	2	3
11. Attend public hearings on water issues?	3	2	1
12. Consider the impact of land-use and zoning decisions on your water resources?	3	2	1
13. Volunteer to help clean up a body of water or promote water quality awareness in your community through a program such as "Adopt a Stream"?	3	2	1

Part 2: Do You	**Yes**	**No**
Know where your tap water comes from?	1	3
Know where your waste water goes?	1	3
Know who operates your water utilities?	1	3
Know the name and location of your watershed?	1	3
Know how much it costs to purify your drinking water and to clean your wastewater?	1	3
Operate the dishwasher only for full loads?	1	3
Fill the tub to a high level when you take a bath?	3	1

Add Part I_____ +Part II _____
Total score =_____

Worksheet

Don’t Flush It Away

How Did You Score?

If your total score was:

24 or less
You are to be complimented on your knowledge of water resource issues and your commitment to practicing sound conservation and pollution prevention measures.

25-44
You are generally aware of the need to conserve water and to protect surface and groundwater from pollution, but you need to be more consistent in your habits. Remember, even small leaks result in huge losses, and small quantities of pollutants can contaminate large bodies of water.

45-60
Unfortunately, like too many others, you may be contributing to severe water supply and pollution control problems in your community. You need to think about the many ways you can modify your habits to become part of the solution.

Worksheet

Flush Frequency Chart

Anyone who flushes the toilet should place a check mark on the line next to the day of the week under the proper column each time a flush is made. Average number of gallons per flush = five. Multiply number of flushes by 5 to get gallon used per day.

Day One (Thursday) _____x 5 = Day One Total _____gallons

Day Two (Friday) _____x 5 = Day Two Total _____gallons

Day Three (Saturday) _____x 5 = Day Three Total _____gallons

Day Four (Sunday) _____x 5 = Day Four Total _____gallons

Lowest number of flushes per day _____

Highest number of flushes per day _____

Range _____

Daily Average (weekday) _____

Daily Average (weekend) _____

Daily Average (total)_____

With the use of a simple displacement device, a savings of 1.5 gallons of water is made with each flush. Complete the chart below to determine how much water could be saved in one year at your home.

One day = _____
(use the daily average number of flushes x 1.5)

One week = _____

One month (30 days) = _____

One year = _____

Notes

In Hot Water

OBJECTIVES:

Students will be able to:

1. Set up and conduct a controlled experiment by exploring the heating potential of solar energy.
2. Measure and record the temperature of water each minute for a 20-minute period.
3. Graph the results and describe their results in paragraph form.

BACKGROUND:

In many homes, the water heater is second only to the heating system in total energy consumption. To heat their water and homes, most people use fossil fuels: coal, oil, or natural gas.

In Alabama, electricity is typically produced by power plants that burn coal, but hydroelectric dams and nuclear power plants also are used to produce electricity.

Advances in solar technology enable people to harness the sun's power and use it successfully to heat their water and to cool and heat their homes. Today, a family has the option of using a solar water heater to reduce monthly utility bills while helping to conserve rapidly diminishing fossil fuel reserves. More than 1.7 million Americans use some form of solar energy in their homes. in 2001, and more than 350 megawatts of commercial capacity are operating today, according to the Solar Energy Industry Association.

There are more than 1 million American susing solar watrer heaters; more than 1/2 million using solar to heat their swimming pools; more than 1/4 million homes using solar electric (PV) technology.

Grades:

9 - 12

Subjects:

Physical Science, Biology, Chemistry, Earth Science

Time Needed:

Two class periods of approximately 60 minutes each

Materials:

paper cups holding 150 milliliters of water at room temperature
thermometers
aluminum pie pans
pieces of cardboard on which to set the pans
clear plastic bags
colored plastic bags
pie pans painted black
pie pans of smaller diameter
plastic containers
activity sheets for recording results
watch or clock
graph paper
flat black spray paint

A basic understanding of the uses for, and potential of, solar energy continues to become increasingly relevant because of "global warming" posssibly caused by the dependence of industrialized nations on fossil fuels.

Solar water heaters need to be located in direct sunlight. To increase the absorption of heat, the water storage container should have a large surface area, a transparent or translucent glazing, and a dark bottom surface (a flat black paint is often used). The container also should be tightly sealed so that it benefits from the "greenhouse" effect.

The greenhouse effect is best demonstrated by a car left in the sunlight with its windows rolled up. The inside of the car soon becomes uncomfortably hot. This happens because sunlight consists mostly of visible light, which passes easily through clear glass or plastic windows, and energy such as infrared, which is blocked by a clear window. Inside the car, the visible light is absorbed by the dashboard, seats, and flooring, warming them and, in return, re-radiating at longer wavelengths, i.e., infrared. Because the infrared radiation cannot easily escape through the window glass, heat keeps accumulating inside the car. That's the reason we roll down car windows to cool off a car quickly to let in fresh air, which replaces the previously trapped hot air.

VOCABULARY:

greenhouse effect, controlled experiment, global climate change, fossil fuel, visible radiation, infrared radiation

PROCEDURE:

Day One:

1. Begin the activity by explaining to students that they are going to experiment using the sun to heat water. Using aluminum pie pans, they are going to test how fast the sun heats the water. This experiment will work best on a sunny day; but even on a cloudy day, they'll get interesting results.
2. Demonstrate setting a pan without water on a level surface on top of a piece of cardboard, which helps insulate the pan. Caution students to make sure all pans have the same amount of water by adding the water after the pan is in its experimental position in the sunlight. Moving the pan around may spill the water. Show students the paper cup that holds 150 milliliters and demonstrate using the cup to measure and add water to the pan. Then demonstrate how they should carefully immerse the thermometer in the water.
3. Divide the class into groups and give each group the supplies it will need. Have students set up their equipment on level surfaces. Before students measure out and pour a full paper cup of water into their pie pans, have them feel with their fingers how cold or warm the water is. Ask: How can we determine what is the change in water temperature? Hand out the activity sheets and explain how students should use the sheets to record their data and calculate the change in water temperature.

Day Two:

1. As a class or in groups, decide which variables students will test. Ask: How should we set up the supplies so the test is fair and can be compared with our results in the first heaters we tested? Make sure that the class understands the concept of a fair test (controlled experiment) and that they need to use the same amount of water they tested on Day One (150 milliliters).
2. Give each group several activity sheets, and tell them to use those sheets to record and graph their results. Have the student groups set up and test their experiments. Have them also set up a control water heater, the same pie pan set up in Day One, so they can compare their results against it. Graph all results on one large graph.

EVALUATION:

1. Accuracy in carrying out laboratory procedures may be checked; completed activity sheets may be graded.

EXTENSIONS:

1. Locate willing teachers in other parts of Alabama/United States/world, and ask them to let their students conduct similar experiments on the same day. Let the classes share results electronically by fax, e-mail, or the Internet. They may note variations and hypothesize about reasons. Make sure that all experiments use the smae temperature scales (Fahrenheit or Centigrade).
2. Allow individual students to do library research and report on areas in which solar energy is abundant and on areas in which it is not. (This could be an optional exercise available for extra credit.)

ORIGINAL DEVELOPMENT RESOURCES:

Explore, a booklet published by the National Science Foundation encouraging teachers to recognize National Science and Technology Week, 1995.

America's Solar Energy Potential www.americanenergyindependence.com

Solar Energy Potential www.energy.gov/maps/solar-energy-potential

Data Collection

Directions: List the equipment in each of the set-ups. Record the temperature each minute for 20 minutes.

Minutes

Equipment	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
1.																				
2.																				
3.																				

Notes

The "Oh No Ozone"

OBJECTIVES:

Students will be able to:

1. Determine how the ozone is formed and destroyed.
2. Determine the importance of the ozone layer and the environmental problems if there is too much or too little ozone.
3. Calculate data to determine if a hole is forming in the ozone layer.

Grades:
9-12

Subjects:
Atmospheric Science, Environmental Science, Biology, Chemistry, Earth Science

Time Needed:
40 minutes

Materials:
graph paper

BACKGROUND:

Ozone is composed of three oxygen atoms as compared to diatomic oxygen molecules, which are composed of two oxygen atoms. About 90 percent of the total atmospheric ozone is located in a layer between approximately 15 and 50 kilometers above the Earth's surface (the ozone layer) in the atmospheric region known as the stratosphere. (See Figure 1.) This upper-level ozone layer is different from the ground-level ozone that causes pollution and respiratory problems.

Upper-level ozone is quite rare. The stratosphere contains from 0.1 to 10 parts per million of ozone with much lower amounts closer to the ground. (See Table 1.) In contrast, the atmosphere contains more than 20 percent of diatomic oxygen, hundreds to thousands of times as much as the ozone. The ozone forms in the stratosphere by the sun's rays hitting oxygen. The ozone is easily destroyed by the sun's rays breaking down (photo-dissociation) various chemicals, including human-made chlorofluorocarbons (CFCs) such as Freon (used in air conditioners and Styrofoam) and propellants (used in aerosol cans). (See Figures 2, 3, and 4.) In addition, near the ground, the sun reacts with auto exhaust to make ozone a part of photochemical smog. In the classroom, ozone can be formed by a flint sparker.

Ozone is very important to human health. The upper-level ozone layer stops much of the ultraviolet radiation from the sun from reaching the Earth's surface. These rays can cause skin cancer, mutations, and reduced crop yields. They also can harm plankton. Therefore, a decrease in the amount of stratospheric ozone could lead to human health problems. Conversely, too much ozone near the ground can lead to smog, such as is seen on summer days in many large cities, and can irritate the eyes and lead to respiratory problems. Concentrations of ozone near the ground are much lower than in the ozone layer, even in smoggy cities. While the concentration of ozone in the ozone layer is important to human health, an increase in concentration near the ground or a decrease in concentration in the ozone layer should be evaluated for possible environmental problems. It has been scientifically determined that a "hole" in the ozone layer is forming and growing over the polar regions of the Earth due to the release of CFCs and other gases (see Figure 5).

VOCABULARY:

ozone, stratosphere, photo dissociation, chlorofluorocarbons (CFCs), Freon, propellent, aerosol can, smog, ultraviolet radiation

PROCEDURE:

1. Students should make a bar graph of ozone concentrations versus altitude above Antarctica for 1987. (Use the data table in Table 2.)
2. Repeat Step 1 for 1993.

3. Students should identify the ozone layer on their bar graphs.
4. Calculate whether there has been an increase or decrease in ozone concentration in the ozone layer. Calculate the total change for the interval 1987-1993 and the percent change per year.
5. Discuss the environmental implications if this trend continues.
6. Compare data included in this activity with newer data from NOAA, located at www.ozonelayer.noaa.gov.

EXTENSIONS:

1. Students can compare maps of the ozone layer from the 1970s, 1980s, and 1990s. Older students can calculate rates of change. Maps can be obtained from sources listed in the resources section.
2. Students can compare historical photos of major Alabama cities to see if smog has gotten worse.
3. Students can contact the U.S. Environmental Protection Agency and/or the Jefferson County Department of Public Health to obtain information on ozone and smog levels in Alabama over the last 25 years.

ORIGINAL DEVELOPMENT RESOURCES:

The U.S. Environmental Protection Agency. www.epa.gov

The Alabama Department of Environmental Management. www.adem.state.al.us

The Jefferson County Department of Public Health www.jcdh.org

Alabama Partners for Clean Air: www.alabamacleanair.org

NOAA: Stratopsheric Ozone monitoring and research website: www.ozonelayer.noaa.gov

Table 1. Major and Selected Trace Gases in the Atmosphere

Gases	Concentration
Nitrogen (N_2)	78.08 percent by volume
Oxygen (O_2)	20.95 percent by volume
Argon (Ar)	00.93 percent by volume
Water Vapor (H_2O)	0 to 1 or 2 percent by volume
Carbon Dioxide (CO_2)	350 ppmv
Ozone (O_3)	
in troposphere	0.02 to 0.1 ppmv
in stratosphere	0.1 to 10 ppmv
Methane (CH_4)	1.7 ppmv
Nitrous Oxide (N_2O)	0.31 ppmv
CFC-12 (CF_2Cl_2)	0.5 ppbv
CFC-11 ($CFCl_3$)	0.3 ppbv
Halon-1301 ($CBrF_3$)	2.0 pptv
Halon-1211 ($CBrClF_2$)	1.7 pptv
Hydroxyl (OH)	
in troposphere	0.015 pptv
in stratosphere	0.02 pptv to 0.3 ppbv
Nitric Oxide (NO)	
in troposphere	0 to 1 ppbv
in stratosphere	Up to 0.02 ppmv

Note: The concentrations of atmospheric gases are given in either percentage by volume (which is the same as parts per hundred by volume), parts per million by volume (ppmv), parts per billion by volume (ppbv), or parts per trillion by volume (pptv).

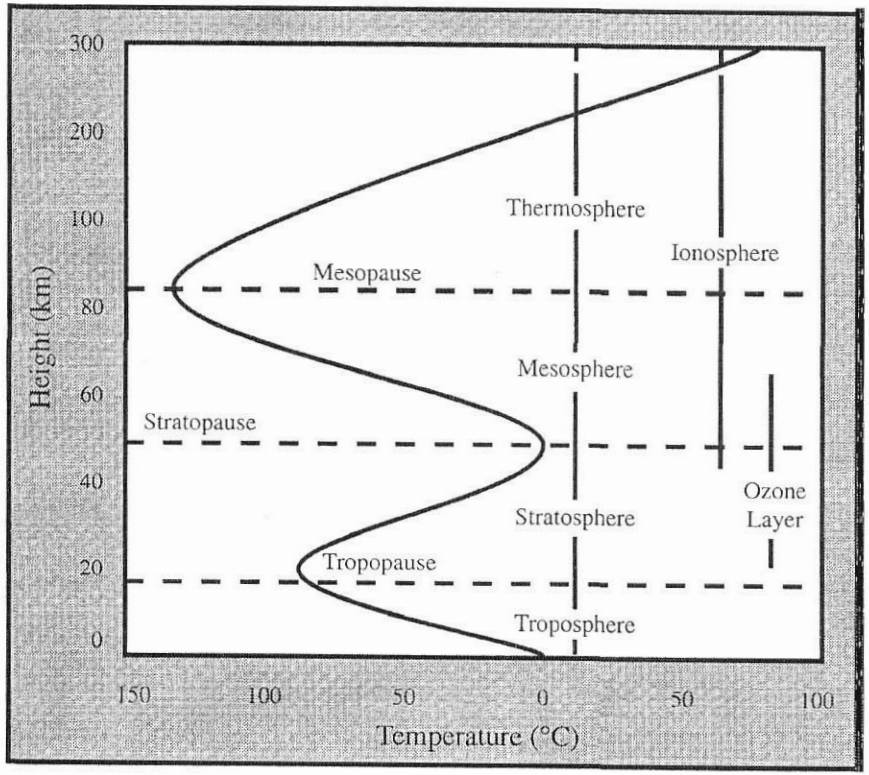


Figure 1 The structure of the Earth's atmosphere illustrating the various regions. Each region is defined by its temperature gradient. *(Earth Systems Sciences Committee, NASA, 1988)*

Table 2

AVERAGE OZONE	CONTENT	
	1987	1993
Altitude (km):		
0-5	27	26
5-10	19	20
10-15	60	54
15-20	152	136
20-25	64	47
25-30	38	33
30-35	31	29
35-40	26	26

Figure 3 Schematic diagram for absorbtion of solar radiation by ozone with the creation of the stratosphere (temperature increase with increasing altitude).

SOLAR U.V. CREATES OZONE, 0_3

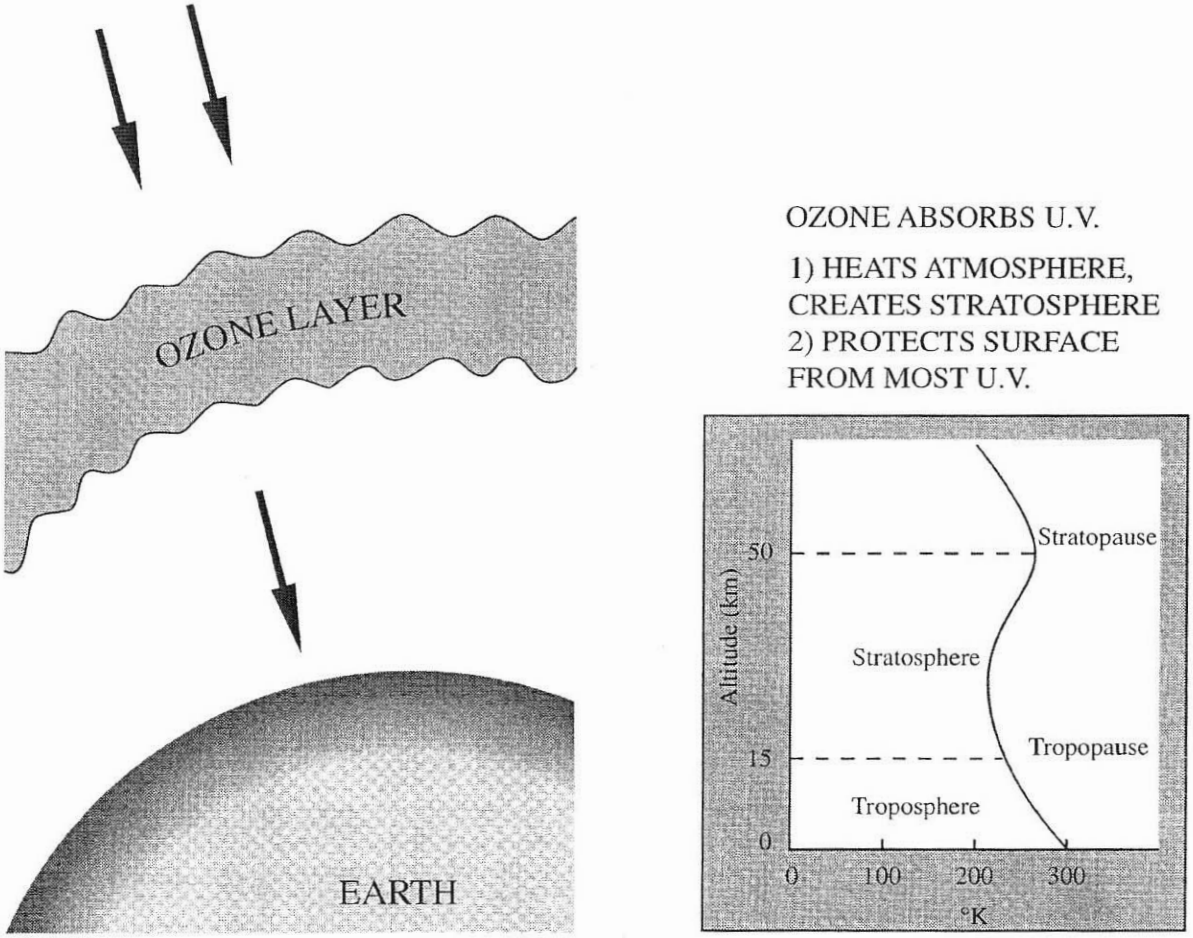
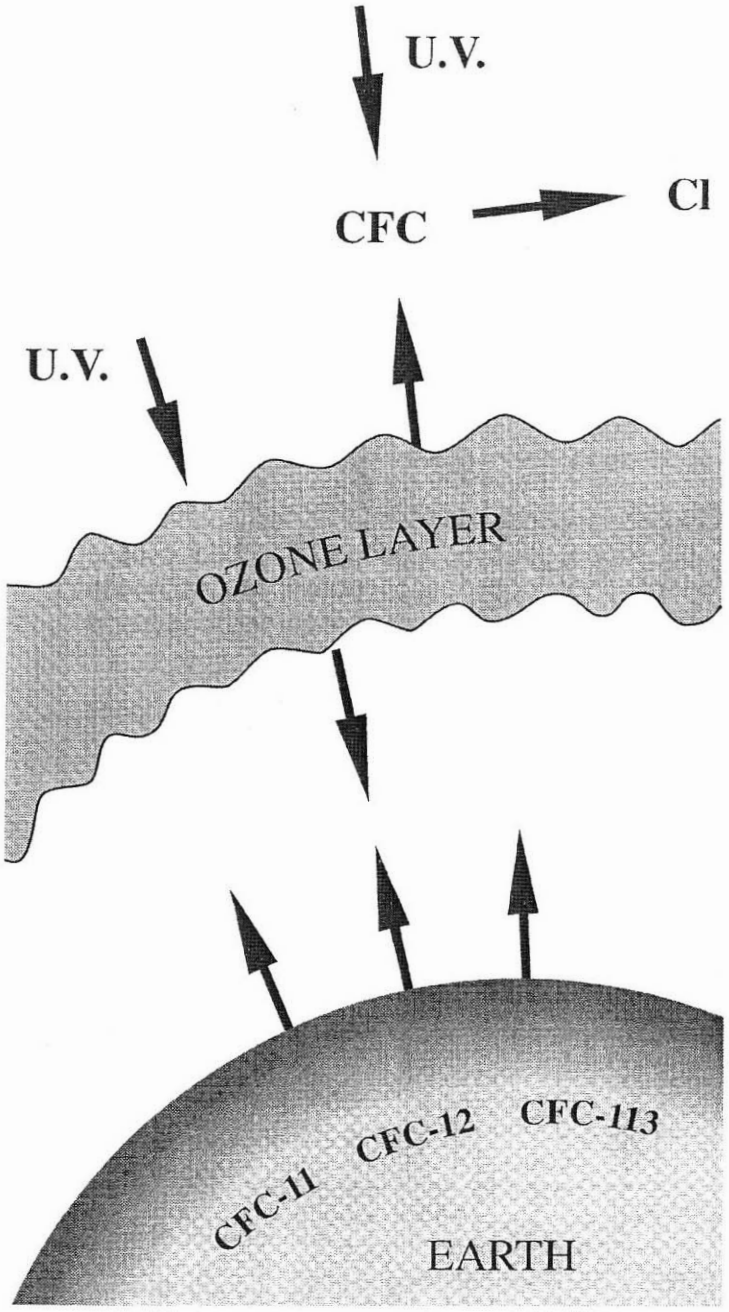


Figure 4 Schematic diagram for release of CFC gases at the surface, their photolysis above the ozone layer, and the chlorine chain reaction for removal of ozone.



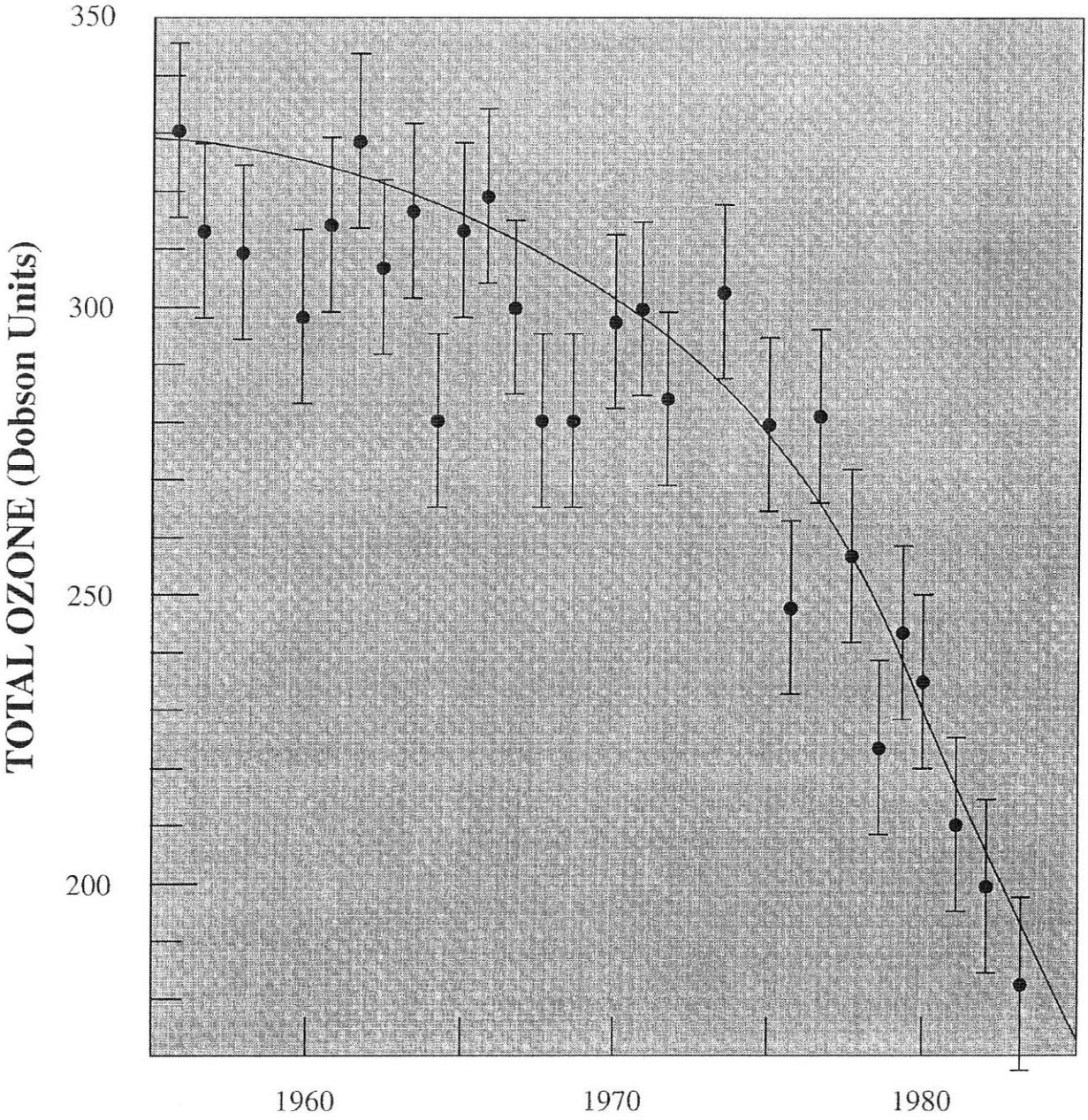
CHLORINE ATTACKS OZONE IN ClO_x CHAIN

$$Cl + O_3 \rightarrow ClO + O_2$$

$$ClO + O \rightarrow Cl + O_2$$

$$O + O3 \rightarrow O2 + O2$$

Figure 5 Average ozone concentrations above Halley Bay, Antarctica, for the month of October, showing the sharp decline since the mid-1970s. Data of J. Farman and colleagues from British Antarctic Survey.



Notes

Population Dynamics of the Zebra Mussel: A Case Study

OBJECTIVES:

Students will be able to:

1. Discuss the impact that the importation (intended or accidental) of non-native species can have on ecosystems.
2. Discuss the potential impact of Zebra Mussels in Alabama.
3. Estimate the rate of growth of Zebra Mussels from available data.

Grades:
9-12

Subjects:
Biology, Ecology, Physical Science, Math

Time Needed:
30 minutes

Materials:
a map of Alabama showing the major waterways as well as the Gulf of Mexico (1cm=32km)

BACKGROUND:

Zebra Mussels (scientific name: *Driessena polymorpha*) are an exotic, introduced species. They look like small clams with wavy, zebra-like black or brown and cream-colored stripes. The mollusks are native to the Caspian Sea in Eastern Europe. It is believed that Zebra Mussels came to North America in the middle of the 1980s as "stowaways" in the ballast water of ships and oceanliners. Since their appearance, first in Lake St. Clair near Detroit, Michigan, Zebra Mussels have created serious ecological as well as economic damage. As Zebra Mussels "colonize," they accumulate in large masses. These can ultimately block a pipe designed to take water out of a lake or river or force other species out of an area. About the only positive thing the Zebra Mussel has done for the environment in the United States, is that, in areas infested with the Zebra Mussel, the filtering action of the mollusk cleans the water so that the water quality itself may be better than in non-infested areas.

Zebra Mussels cluster in large colonies, up to several hundred per square foot. They can attach to almost any firm surface by using a tuft of fibers called *byssal threads.* These threads act like "Superglue" and allow the mussel to attach to solid underwater objects such as boat hulls and propellers, buoys, clam and turtle shells, drinking water plant intake structures, and industrial pipes and condensers. The adult Zebra Mussel can grow to a length of two inches and can survive for up to five years. Zebra Mussels reproduce rapidly. Females can bear from 10,000 to 1,000,000 eggs per year. The fertilized eggs develop into free-floating larvae that can travel great distances during the next 10-30 days, thus spreading in freshwater lakes or streams. After 30 days, they settle and attach to a suitable hard surface. Zebra Mussels have no natural enemies in the waters of the United States. They, therefore, are extremely difficult to control. The use of chemicals is often the only way to prevent damage from the Zebra Mussel.

VOCABULARY:

Zebra Mussel, population, Caspian Sea, colonies, byssal threads, larvae, ballast water, exotic species, mollusks

PROCEDURE:

1. Assume a Zebra Mussel has hatched as a free-floating larvae in the Tennessee River. It floats freely in the river for 15 days and attaches on a barge hull that is moved to the Tennessee/Tombigbee Waterway and is used in that waterway. (See Legacy's Alabama Water Resoures poster.) The barge stays for a year until the following summer when the barge is moved to travel on the Alabama River. If the Zebra Mussel bore eggs once during the year that the barge stayed in the Tennessee/Tombigbee Waterway, what is the estimated population of the Zebra Mussel after five years in the Tennessee/Tombigbee Waterway, assuming that only one Zebra Mussel arrived there originally, that all eggs survived, and that the mussel takes one year to reach sexual maturity?

2. Why is it a poor assumption that all eggs survive?
3. How many Zebra Mussels could cover a football field in a single layer, assuming a population of 700 Zebra Mussels per square foot? (Assuming one football field = 100 yards x 30 yards, 3 feet = 1 yard.)
4. Once the single Zebra Mussel is in the Tennessee/Tombigbee Waterway and travels on a boat moving at the speed of 15 km/hr, how long will it take to reach the mouth of Mobile Bay? Scale on map: 1 in. = 60 miles.
5. Name some ways to prevent the spread of the Zebra Mussel from the Tennessee River to other Alabama water bodies.

ANSWERS TO THE QUESTIONS:

1. See below:
    - First year sexually immature.
    - Second year: 10,000–1,000,000
    - Third year: $1 \times 10^4 \times 10^4 = 1 \times 10^8$
    - Fourth year: $1 \times 10^8 \times 10^8 = 1 \times 10^{16}$
    - Fifth year: $1 \times 10^{16} \times 10^{16} = 1 \times 10^{32}$
2. Some will die or be eaten.
3. 100 yds. x 30 yds. = 3000 sq. yds. x 9 sq. ft. = 27,000 sq. ft. x 700 per foot = 18,900,000 mussels
4. Approximately 14 hours (Distance is about 200 km ÷ 15 = 13.3 hr.)
5. Explain the concept of natural predators; non-chemical treatments such as ultra-violet radiation, electrostatic fields, temperature, and magnetic treatments; and surface protection such as non-fouling coatings.

EVALUATION:

1. The teacher can evaluate on the basis of participation and correct answering of the questions.

EXTENSIONS:

1. Have the students do research on the spread of the Zebra Mussel in Alabama. This could be an ongoing project.
2. Have the students do research on other exotics such as kudzu, starling, pheasants, and nutria that have been introduced into Alabama.

ORIGINAL DEVELOPMENT RESOURCES:

"Alabama Water Resources " poster, Legacy, Inc. P.O. Box 3813, Montgomery, AL 36109, www.legacyenved.org, 1-800-240-5115.

Water Impacts. (1996, January). *Institute of Water Research, Michigan State University,17*(1).

Website: www.iwr.msu.edu

http://www.outdooralabama.com/watchable-wildlife/what/inverts/mollusks/mussels/list/v/z/

http://nas.er.usgs.gov/queries/factsheet.aspx?speciesid=5

Classification of the Marine Environment

OBJECTIVES:

Students will be able to:

1. Categorize marine organisms based on mode of life, habitats, and light zones.
2. Design a model of the marine environment on graph paper illustrating categories of marine life, distribution of marine life as related to habitats, and light zones.
3. Illustrate the vocabulary terms by showing their relationships effectively on graph paper.

BACKGROUND:

The marine environment can be studied in areas that include the marine organisms and the habitats in which they interact. Classification can be based on mode of life, distribution as related to the sea bottom and ocean water, and division of marine life distribution as related to light penetration. This ecosystem should be viewed in its entirety in order for these relationships to be appreciated.

Grades:

9-12

Subjects:

Science, Marine Science

Time Needed:

90 minutes

Materials:

audiovisual of the ocean
pictures of organisms: plankton, benthos, nekton
graph paper (per student)
colored pens/pencils

Classification of marine life *as related to mode of life* includes three great categories. **Plankton** consists of communities of floating, drifting organisms carried about primarily by the movement of water rather than by their own swimming activity. The bulk of these organisms consists mostly of microscopic plants and animals that vary from bacteria to minute yellowish microscopic plants called coccolithophores to copepods several millimeters in length. Many invertebrate larval stages can be found. Larger drifters, such as Sargassum weed and jellyfishes, are present. **Benthos** includes organisms that live on or in the bottom of the ocean floor. They may be demersal organisms, like flounder and certain scallops, that alternate between swimming near and resting on the bottom. Epifauna, such as the seastar, sea anemone, and mussel, live on the substrate. Tube worms and clams are identified as infauna because they live within the substrate. **Nekton** includes larger animals that control the direction and speed of their own movements rather than drifting with the water. This group includes mainly of fish, whales, seals, sea turtles, and a few invertebrates like squid and shrimp.

Classification of marine life distribution as *related to the sea bottom (benthic)* includes the part of the ocean floor beginning from high-tide zone to the greatest depths. The **littoral region** borders continents and extends from high tide out to the edge of the continental shelf (about 200 meters deep). This region is divided into two zones called the eulittoral and sublittoral. The **eulittoral** starts from high tide level to a depth of 40 to 60 meters. This is the lowest limit at which plants will usually grow. This area is characterized by strong tide and wave action. The **sublittoral** extends from 60 to 200 meters deep and the edge is the **continental shelf**. This gentle seaward-sloping surface has an average width of 50 to 100 km. Life found at this level depends on light penetration. The deep sea floor system begins at the edge of the shelf. Extending from the shelf, the **bathyal** goes from 200 to 4000 meters in depth. This bottom may be rocky or muddy. Many organisms vary in color and migrate to the rich upper level at night. The **abyssal** extends from 4000 to 6000 meters in depth. This is a very stable environment with almost no change. Organisms are probably carnivores feeding on the debris that falls from the upper levels. The **hadal** zone goes from 6000 meters to the deepest areas of the ocean floor called trenches. One of the deepest spots recorded is the Marianas Trench near Guam at 36,198 feet (11 km).

Classification of marine life distribution *as related to the ocean water* includes all water above the ocean floor. The **Pelagic Division** refers to all ocean waters and is divided into the neritic and oceanic provinces. The **neritic province** embraces the open water affected by continental influences. It receives much inland drainage and extends out to the edge of the continental shelf. Included is all the open water within a depth of 200 meters extending shoreward over most of the littoral. The **oceanic province** includes a vertical series of open sea referred to as "blue water." The **epipelagic** is a relatively thin illuminated zone from the surface to 200 meters in depth. From 200 to 1000 meters, the **mesopelagic** is referred to as the "twilight" zone. The **bathypelagic** begins from 1000 meters and goes to 4000 meters. No solar light may ever penetrate this zone. The **abyssopelagic** continues to the greatest depths. A significant feature of these last three zones is bioluminescence. Ninety-nine percent of higher forms of mid-water marine animals contain photophores. Some examples are squid, anglerfish, viperfish, dragonfish, and hatchet fish.

Classification of marine life distribution *as related to the distribution of light* includes the photic and aphotic zones. The **photic** zone is the place where 70 percent of the world's photosynthesis takes place. It consists of the **euphotic** that starts at the surface to 80 meters deep and the **disphotic** that goes from 80 to 200 meters in depth (edge of the continental shelf). Most of the light is contained in the euphotic. Few plants are produced in the disphotic that is referred to as the "demarcation line of plant life." The **aphotic** zone is a lightless region extending from 200 meters to the bottom. No plants are produced, and life is limited. The aphotic occupies over 90 percent of the ocean.

VOCABULARY:

mode of life, benthos, nekton, plankton, habitat, substrate (ocean floor), littoral , eulittoral, sublittoral, continental shelf, bathyal, abyssal, hadal, habitat (ocean water), pelagic division, neritic province, oceanic province, epipelagic, mesopelagic, bathypelagic, abyssopelagic, light penetration, photic zone, euphotic, disphotic, aphotic zone

ADVANCE PREPARATION:

1. Introduce the concept of the marine ecosystem.
2. Discuss the types of organisms found and the environmental factors with which they interact.
3. Show pictures of plankton, benthos, and nectonic organisms. Have students describe their living conditions.
4. Show appropriate audiovisuals relating to the ocean environment.

PROCEDURE:

Setting the Stage

1. Give students an opportunity to acquire information about the terms to be used in the activity by supplying them with the content material directly through lecture or reading material from a text.
2. Identify terms through concept mapping.
3. Show an example of a finished diagram on a transparency, such as the the "Classification of Marine Environments" included with this activity.

Activity

1. Students will illustrate the terms related to the classification of the marine environment by showing their relationships effectively on graph paper. (See example on next page.)
2. Depths on the diagram should be expressed in meters, and terms should correspond to the appropriate depth.
3. Color code each area of terms, for example, Mode of Life—green; Ocean Floor—brown; Ocean Water—blue; and Light Penetration—yellow.
4. Print all words. (Include number with word.)
5. Draw appropriate pictures illustrating mode of life terms (plankton, benthos, nekton). These should be placed at appropriate depths and areas. Label with the appropriate term.

EVALUATION:

1. Have the students label these areas on a prepared diagram (teacher-made).

EXTENSIONS:

1. As a class, design a mural illustrating these areas of the marine environment.
2. Show actual examples of organisms (specimens) and discuss in which areas they may be found.
3. Using an aquarium, design a marine environment relating to the prepared diagram.
4. Research organisms that live deep in the ocean in areas with no light penetration.
5. Research the equipment used to explore the deep ocean.
6. Research hydrothermal vents and the animal life surrounding them.
7. Research the chemical composition of the environment around the hydrothermal vents and compare it with the chemical composition of the rest of the ocean areas.
8. Invite a marine geologist or biologist to talk to the class.

ORIGINAL DEVELOPMENT RESOURCES:

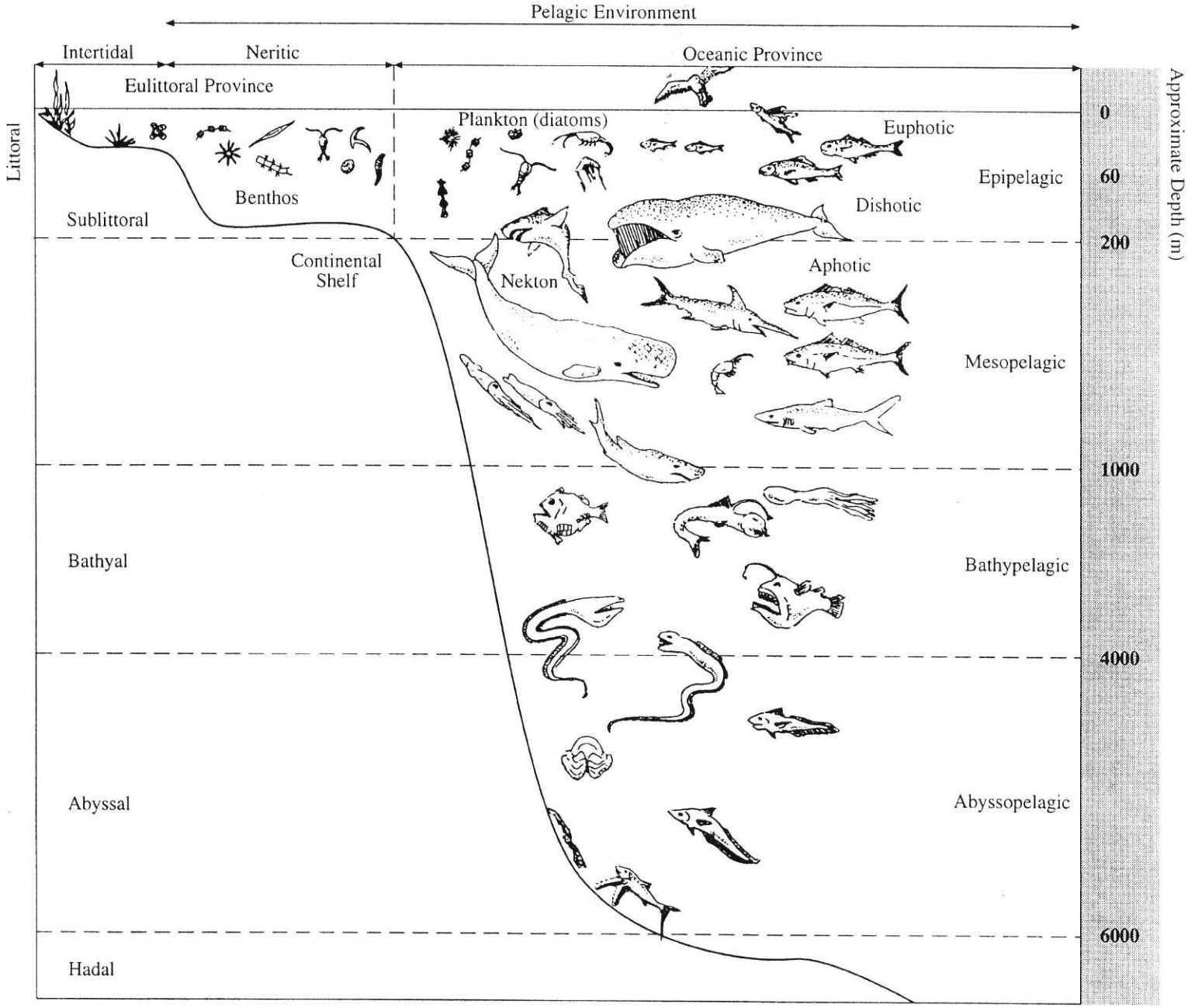
Lerman, M. (1986). *Marine biology.* New York, NY: Addison-Wesley Publishing Co, Inc.

Gross, M. G. (1990). *Oceanography.* Columbus, OH: Prentice Hall.

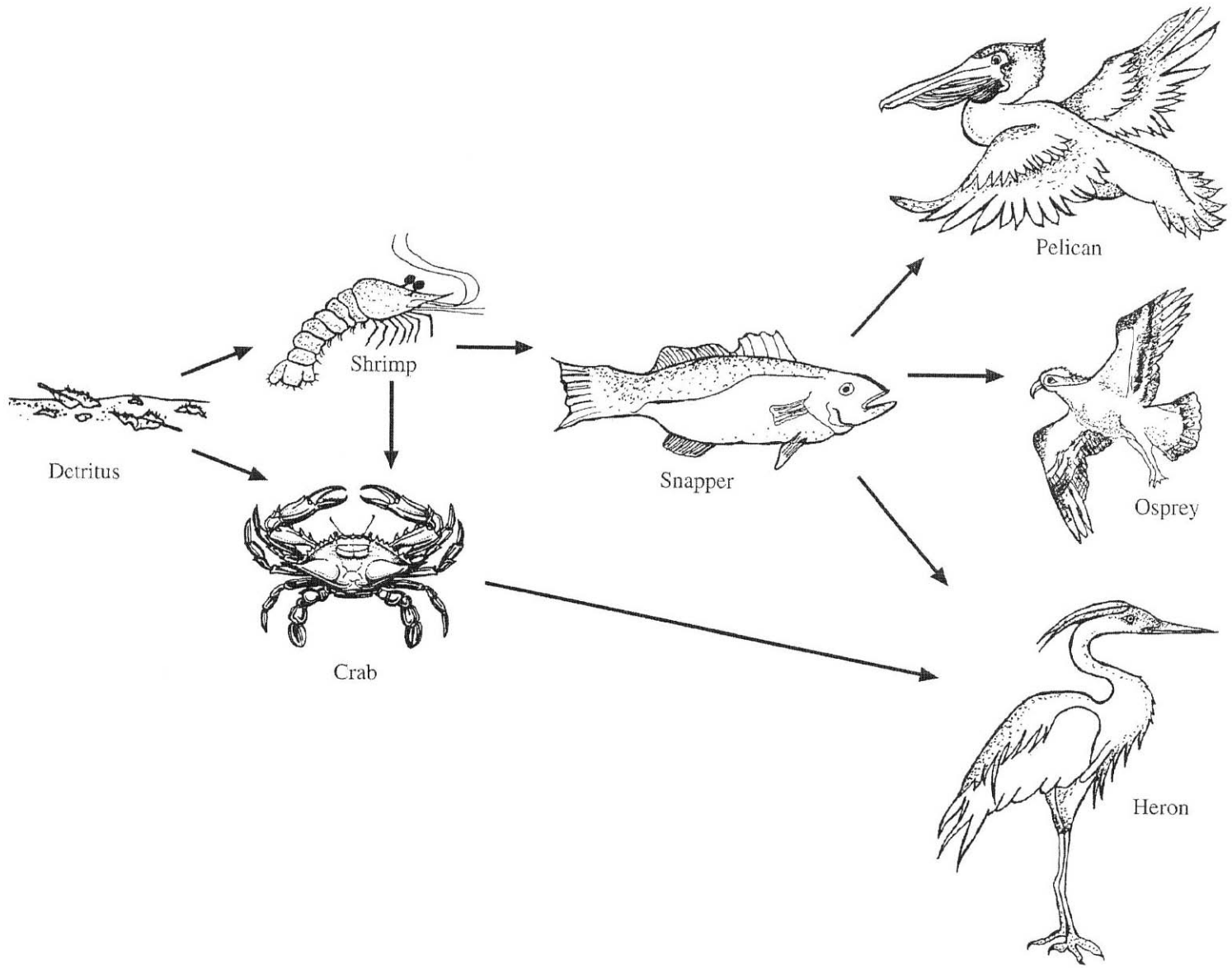
Stowe, K. (1987). *Essentials of ocean science.* Toronto, Canada: John Wiley & Sons.

Websites: www.disl.org (Dauphin Island Sea Lab)
www.onr.navy.mil/focus/ocean
http://fins.actwin.com/index.php (useful photographs of marine life)
www.aquanet.com

Classification of Marine Environments



Food Chain



Notes

Using Duckweed to Examine Population Dynamics

OBJECTIVES:

Students will be able to:

1. Measure the increase of duckweed present in a closed ecosystem over a one-month period.
2. Determine the initial number of plants, number of leaves, and biomass of the initial culture of duckweed.
3. Hypothesize the effects of continued, uncontrolled growth of duckweed on the overall sustainability of the environment.

Grades:

9-12

Subjects:

Environmental Science, Math

Time Needed:

First day: 45 minutes
Data collection : 25 minutes once a week for four weeks
Analysis and discussion: 45 minutes

Materials:

duckweed culture sufficient for groups of four to six (sold by Carolina Biological Supply - or similar suppy houses - as *Lemna minor*, listed under floating plants)
containers, such as one-gallon milk cartons or other small containers or aquariums for each group
fresh, dechlorinated water for each container
student data sheet for each student
balance for measuring mass
hand lens for observing the plants

BACKGROUND:

The ecosystem of a freshwater habitat is dependent on the quality of the water and the ability of the biotic and abiotic factors to remain in balance. Many biological species are capable of reproducing faster than the rate needed to maintain the species number. This ability to reproduce allows organisms to replace a population after natural disasters, disease epidemics, or other population declines.

A population consists of all the members of a particular species occupying a given area. By determining the population of a particular plant, such as duckweed, the health of an ecosystem can be determined. Indicator species, such as duckweed, serve as early warnings that a community or an ecosystem is being damaged.

Duckweed is a rapidly reproducing plant that floats on the surface of the water. The duckweeds belong to the family Lemnaceae. They are the smallest flowering plants known, with the genus *Wolffia* being less than 1.5 mm in size. The body of duckweeds is composed of a simple floating disc of photosynthetic tissue often with roots attached. It is not differentiatied into stem and leaf tissue. All species of duckweed supposedly produce minute flowers, but these flowers are seldom observed.

One of the common species of duckweed found floating on the surfaces of shallow ponds is *Lemna minor*. *L. minor* is 2-4 mm in size. Duckweed is an important food for water fowl, fish, and humans. It contains all the essential amino acids needed for growth and is an excellent food for herbivores. The world's smallest flowering plant also has one of the most rapid rates of vegetative reproduction. The Indian species, *Wolffia microscopica*, can produce a smaller daughter plant in its basal reproductive pouch by budding every 30-36 hours. One plant could theoretically give rise to about one nonillion plants (1 followed by 30 zeros) in four months. This represents a spherical volume of plants roughly equal to the size of the Earth. In mid to late summer, ponds often become covered with huge populations of duckweed.

VOCABULARY:

population, biomass, indicator species, sustainability, biotic factors, abiotic factors, ecosystem, habitat, limiting factors, population density

ADVANCE PREPARATION:

1. Order duckweed (*Lemna sp*) from a biological supply house or collect samples from lakes or ponds. Local universities often can supply small quantities.
2. Prepare an appropriately-sized aquarium and allow to filter with dechlorinated water several days prior to beginning the laboratory. Small cartons or other similar containers can be used in place of an aquarium. **Caution:** Do not run filter while plants are in aquarium.

PROCEDURE:

Setting the Stage

1. Have students write a hypothesis stating what changes in population will occur in the duckweed over a four-week period and write the hypothesis on the student worksheet.
2. Discuss the possible effects of overpopulation in the duckweed culture.

Activity

1. Divide the class into groups of four to six students. Each group is responsible for one culture of duckweed. Provide each group with an initial culture of 25 plants (or have each group count out 25 plants). Each group will measure the mass of the 25 plants, count the number of leaves, and describe the overall appearance of the culture. This data is then recorded on the data sheet.
2. Discuss the variables that can affect the changes in growth and overall appearance during the four-week period. List all the variables on the worksheet.
3. Data will be collected by each group at the end of each week for a four-week period.
4. Each group will analyze the data collected by determining the increase in number of plants, number of leaves, and overall mass of the culture.
5. Each group will discuss the data collected and will present a final report to the class.

Follow-Up

1. The class will discuss the data collected by each group and hypothesize how the population will increase over a longer period of time if given optimum growth conditions.
2. Have the students research the effects of overpopulation on a different species of organism and report to the class.

EVALUATION:

1. The students will fill out the Student Data Sheet to be discussed with the class.

EXTENSIONS:

1. Assign each group a varied amount of nutrient fertilizer to be used in the duckweed culture.
2. Provide various types of pollutants and determine the effects on the duckweed population. After a period of time, test the water to see if the duckweed cleaned any polluntants from the water.
3. Ask the students to design an experiment to test the various effects of chemicals, fertilizers, light, warmth, or other variables on the duckweed population.
4. Graph all data collected from the class on graph paper and display for future reference.

ORIGINAL DEVELOPMENT RESOURCES:

Cadogan, A. & Best, G. (1992). *Environment and ecology.* Glasgow: Blackie & Sons, Ltd.

Radford, A. E., Ahles, H. E., & Bell, R. C. (1968). *Manual of the vascular flora of the Carolinas.*Chapel Hill, NC: The University of North Carolina Press.

Towle, A. (1989). *Modern biology.* Austin, TX: Holt, Rinehart, and Winston.

Carolina Biological Science and Math Catalog 66, 2700 York Rd, Burlington, NC 27215, (800) 334 5551, www.carolina.com.

Student Data Sheet

Name: _____

Using Duckweed to Examine Population Dynamics

1. Write a hypothesis stating what changes will take place in the population density of the duckweed culture over the one-month period.

_____

2. Record the data collected by your group. Each member of the group is responsible for recording all data on the data sheet.

Date	# of Plants	# of Leaves	Biomass	Appearance
Initial				
Week 1				
Week 2				
Week 3				
Week 4				
Percent Change				

3. Describe what changes occurred over the four-week period.

_____

4. Was your hypothesis correct? Explain.

_____

5. Predict the number of duckweed plants that would be produced over a longer period of time (two months, six months, or longer).

_____

6. If uncontrolled growth were allowed to continue, what might happen to the population?

_____

7. How might uncontrolled population growth affect the quality of life for other species such as humans? Explain.

_____

8. How did the data from the other groups compare with the data collected in your group? Explain.

_____

Wetlands - A Bad Rap

OBJECTIVES:

Students will be able to:

1. Observe how different soil components—peat, sand, gravel, and potting soil—vary in their capacity to absorb and hold water.
2. Describe why peat is exceptional at absorbing large quantities of water.
3. Describe how wetlands affect their daily lives.
4. Explain the importance of wetlands for wildlife and humans.

Grades:
9-12

Subjects:
Science, Ecology

Time Needed:
two to three class periods

Materials:
peat moss
sand
gravel
potting soil
several sieves
cheesecloth or coffee filters
measuring cups
bowls for catching water
scales
student data sheets
pictures, photographs, or slides of wetlands

BACKGROUND:

Wetlands traditionally have received a "bad rap"—they have been thought of as wastelands, as buggy, mucky places fit only for monsters and other unsavory creatures. Wetlands perform a number of critical functions. They moderate impacts from flooding, control erosion, purify water, and provide habitat for fish and wildlife. They also provide a unique natural habitat for people to enjoy outdoor recreational activities.

Wetlands located along the shores of oceans, lakes, rivers, and streams protect surrounding properties from flooding by acting as a "sponge," temporarily storing flood water and slowly releasing it back into the system. As storm water enters a wetland from surface runoff or adjacent water bodies, it is slowed down by trees, shrubs, reeds, rushes, and other wetland plants. Slowing the flow of water allows more time for it to percolate through the soil rather than going directly into the water body. Wetlands also act as large sinks, diffusing large flows over a greater land area and slowing the momentum of rushing water. In this way, wetlands help protect adjacent and downstream property from flood damage.

During a storm, the effects of rushing water can be destructive. Rapidly flowing water can carry a large load of soil particles from the land, which are then washed into lakes, rivers, and streams. Excessive sediment in water is considered both a chemical and physical pollutant; it can carry bacteria and toxic particles and alter the habitat of the receiving water for plants and animals. Wetland vegetation reduces the erosive effect of rushing water by slowing the velocity of floodwaters. Coastal wetlands protect shorelines from erosion by dissipating the energy from waves and currents.

Wetlands are good water filters because of their location between land and open water. This allows them to intercept and eliminate many pollutants before the water enters rivers, streams, and lakes. However, wetlands alone can't solve pollution problems since every wetland has a limited capacity to absorb nutrients, metals, and sediments.

Water flowing into wetlands slows down as it comes into contact with wetland vegetation. Suspended soil particles or sediments will settle out of the water and will bind to the stems and roots of plants. Wetlands play a role in trapping excess sediments and preventing them from entering river and lake systems. Research has shown that as much as 90 percent of sediments in water can be removed as it moves through wetlands.

VOCABULARY:

erosion, estuary, purification, runoff, sediment, wetland

ADVANCE PREPARATION:

1. Show magazine pictures, slides, and photographs of wetland areas.
2. Show pictures, slides, and photographs of different wetland soil types (good ones on EPA's web site: www.epa.gov/owowwtr1/ - look for wetlands photo contest).
3. Have students find an area in their neighborhood, city, or town that they suspect is a wetland area. Have them collect (with permission) a few wetland soil samples and bring them to class. Have students describe in their own words how their soil sample looks, feels, and smells.
4. Arrange a classroom display of the collected soil samples. Have the students attempt to identify the different types of soil.
5. Discuss the importance of wetlands to the health of our planet. Have the students brainstorm the benefits of wetlands and the reasons they are important. List the ideas on the chalkboard.

PROCEDURE:

Setting the Stage

1. Read the background information on wetlands, focusing on the many benefits we get from wetlands. Emphasize the fact that one important benefit of wetlands is the capacity to absorb large amounts of water during rainstorms and to release it slowly over time into rivers, lakes, and groundwater. This function prevents extreme flooding during storms and maintains a base level of water during dry spells. This water storage capacity is due in part to the presence of organic matter in wetland soils.

Activity

1. Divide the class into cooperative groups.
2. Give each group four sieves and a dry sample of each of the purchased soil types (peat, potting soil, sand, gravel). Put samples in the bowls and place cheesecloth or a filter in each sieve and fill each with a different soil type.
3. Have the students weigh out the filled sieve with the bowl on a scale and record this on the student data sheet.
4. Instruct the students to fill the measuring cup with exactly one cup of water. Pour the water into the sieve and let it soak in the bowl for 30 minutes. Do this for each bowl with soil types.
5. Lift the sieve out and slowly pour the remaining water out of the bowl. Have the students reweigh the sieve, wet material, and bowl and record the weight on the Student Data Sheet.
6. Using the Flood Storage Data Sheet, have students calculate the percent of water absorbed by each material by subtracting the dry weight (A) from the wet weight (B) to yield (C). C/A x 100 = water absorbed. Have each group record its results on the chalkboard and discuss the results. Have the students prepare graphs of their results.
7. Have the students discuss the following questions:
   - Which of the materials—peat, soil, sand, or gravel—retained the most water?
   - What factors influence a soil's capacity to hold or drain water?
   - What determines how much water a substance can hold?
   - What would happen to rain water if there were mainly poorly absorbing soil types in the watershed?

Follow-Up

1. Have the students look through newspapers for articles about flooding. Have them do a comparison study to see if any of the flooding was related to wetland loss.
2. Prepare a classroom display of commercial products harvested from wetlands.

EVALUATION:

1. Have the students write an opinion paper on how our lives are linked to the health of the environment.
2. In the paper, have the students focus on what would happen if wetlands disappeared.

EXTENSIONS:

1. Hold a mock town meeting where students take the roles of neighbors, developers, town officials, and environmentalists to discuss options involved in a proposed development project impacting wetlands.
2. Have students develop a "wetland protection directory" of local, state, and federal officials who make land use decisions affecting wetlands.

ORIGINAL DEVELOPMENT RESOURCES:

Lynn, B. (1988). *Discover wetlands: A curriculum guide*. Washington State Department of Ecology. http://www.epa.gov/gmpo/education/pdfs/DiscoverWetlandsI.pdf

National Wildlife Federation, (1986). *Ranger Rick's naturescope: Wading into wetlands*. Washington, D.C., Vol. 2, No. 5. www.nwf.org

Slatterly, B. (1995). *WOW! The wonder of wetlands: An educator's guide*. St. Michaels, MD: Environmental Concern, Inc.; www.wetland.org.

http://water.epa.gov/type/wetlands/outreach/education_index.cfm

Flood Storage Data Sheet

Name:_____ Date: _____

Material	**Dry Weight**	**Wet Weight**	**B-A=C**	**Percent (%) water absorbed = (C/A) x 100**
Peat				
Soil				
Sand				
Gravel				

Wonderful Wetlands And Watersheds

OBJECTIVES:

Students will be able to:
1. Describe the concept of a watershed.
2. Explain how wetlands function within a watershed.
3. Illustrate how human impacts can alter wetlands.

Grades:
9-12

Subjects:
Science, Ecology

Time Needed:
90 minutes

Materials:
10–gallon aquariums or clear basins
spray bottle with water
newspaper
waterproof magic markers
plastic sheets
miniature houses (game pieces)
pictures of different types of wetlands
United States and Alabama maps showing wetland areas
potting soil, peat, sand, clay

BACKGROUND:

Did you know that every state in the United States has at least one "wetland" in it? (See Figure 1.)You've probably even visited one, or at least seen one, as you rode down the highway! Wetlands are part of our lives, and that's a great reason to start learning all you can about them. Wetlands are often referred to as swamps, bogs, moors, fens, and marshes. Wetlands are often transitional areas located between dry lands and deeper aquatic systems like rivers and lakes. Wetlands can be shallow water habitats, where the soil is covered by water, or saturated areas, where the soil is wet at or near the surface but not necessarily covered by water.

Some wetlands develop in low-lying areas in the landscape where water drains and collects. Others border salt or fresh bodies of water such as oceans, rivers, or ponds; while still others are isolated in forests and urban areas. As the transitional zones between upland and aquatic areas, wetlands often support both terrestrial and aquatic species, contributing to the diversity of plants and animals they support.

Wetlands vary considerably in their appearance and size. Regional and local differences in vegetation, hydrology, water chemistry, soils, topography, and climate contribute to the variety of wetland types found around the world. Some wetlands are inundated with water year round, while others are only seasonally flooded; and the depth and duration of flooding can vary widely. Still others are only saturated at or near the surface of the soil. Wetlands may occupy just a few hundred square feet or may cover thousands of acres.

Why are wetlands valuable?
- flood control and traps for sediments
- storm protection
- temporary homes for migrating birds
- homes and nesting sites for animals, fish, and birds (including 1/3 of America's threatened and endangered wildlife) and specialized plants
- water purification
- source of economic income
- recreation sites for humans

Now our wetlands are disappearing. We lose approximately 300,000 acres every year, at a rate of over 32 acres per hour.

VOCABULARY:

hydrology, infiltrate, percolate, precipitation, watershed, wetland

ADVANCE PREPARATION:

1. Introduce the terms hydrology, infiltrate, percolate, watershed, and wetland.
2. Show the students a U.S. map indicating areas designated as wetlands.
3. Show the students a map of Alabama indicating areas designated as wetlands.
4. Show the students magazine pictures, photographs, and slides of various types of wetlands.
5. Have the students make comparison maps showing U.S. wetland areas in 1780 compared to 2002.
6. Have the students design a wetland display, either a mural or a three-dimensional one for the classroom, showing the importance of wetlands to the health of our planet.

PROCEDURE:

Setting the Stage

1. Read the background information on the characteristics of wetlands. Have the students brainstorm where the water in wetlands comes from and why it is important.
2. Have the students prepare a "wetland" journal recording each day's activities relating to wetlands. Ask them how they use water in their daily lives. Also, have them record how much water they use in one day's time. Compare the class results and list on the chalkboard.
3. Using the responses above, have the students discuss where the water originated (a well, a town reservoir, a river, rain water) and where it goes (to septic tanks and waste water treatment plants). Emphasize the importance of water and how our uses impact upon its quality and quantity.
4. Discuss that water is always moving from high areas to low areas due to gravity. Any piece of land belongs to a very small watershed that is part of a much larger watershed.

Activity

1. Have students experiment with the movement of water through different gradients by constructing terrariums using potting soil, peat, rocks, sand, and clay. Have each group of students build the most absorbent, the most erosive, and the fastest draining gradients through which the water might travel.
2. To demonstrate and illustrate watersheds and the effects that changes in land use have on watershed areas, students will build a watershed model (see Figure 2) using the following procedure:
   - Divide the class into cooperative groups and give each group a 10–gallon aquarium or a clear plastic basin and the necessary supplies.
   - Have the students crumple three sheets of newspaper and place them in the aquarium. Drape the plastic sheet over the paper, fitting it between the three pieces to form two valleys with a ridge in the middle. Tape the plastic to the walls of the aquarium to prevent water from running down the sides. The water should generally flow towards the valleys and the front side of the aquarium.
   - The students should now have a model of three hills and two valleys.
   - Ask the students to describe what they think will happen when it "rains." Have them draw a channel through the valleys on the plastic sheet, placing a few of the houses alongside the river. Have the students color in a lake where they expect the water to pool.
   - The students should gently spray some water into one half of the aquarium so that only one of the two watersheds gets wet. Point out how the water runs off the high points and forms a stream in the valley. This is how rain and melted snow run off the land. Explain to students that all of the land that drains into a stream is called a watershed.
   - Have the students spray water so it hits the ridge between the two valleys. Some of the water will run into one stream, and some will run into the other. The ridge between these streams is called the watershed divide. It's the highest point of land between two bodies of water.

Follow-Up

1. Talk about the Continental Divide in the Rocky Mountains, where water to the west flows toward the Pacific Ocean and to the east toward the Atlantic Ocean.
2. Tour a wetland site and observe the topography.

EXTENSIONS:

1. Invite a Water Department or Board of Health officer to visit the class for a discussion on drinking water.
2. Manipulate the Wetland Watershed Model to demonstrate how human impacts alter watersheds.
3. Have the students participate in the Adopt-a-Wetland Program. Contact the regional Environmental Protection Agency office in the area for information.

ORIGINAL DEVELOPMENT RESOURCES:

(1987). *Aquatic project wild.* Western Regional Environmental Education Council.

Lynn, B. (1988). *Discover wetlands: A curriculum guide*. Washington State Department of Ecology.

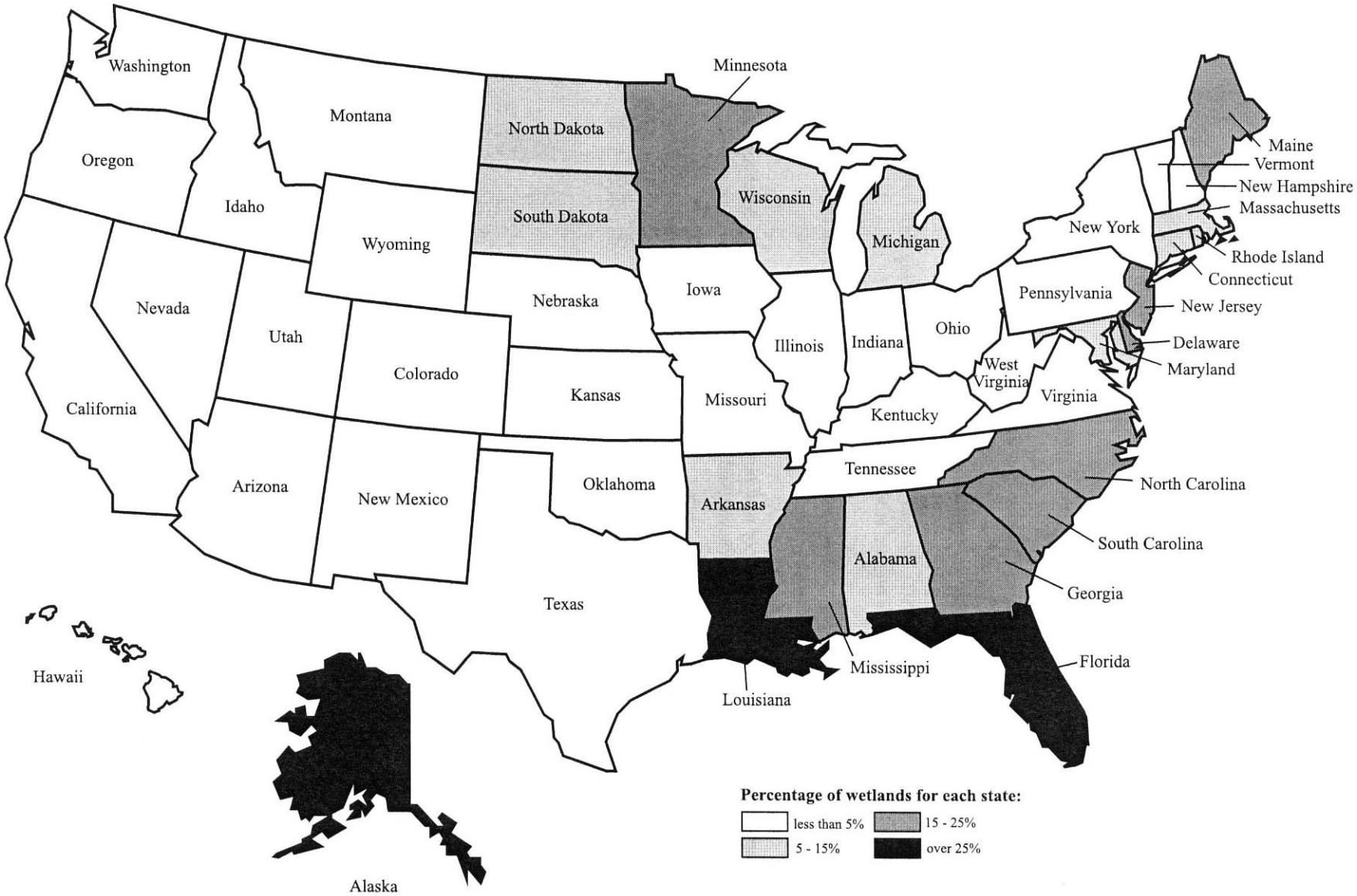
National Wildlife Federation. (1992). *Ranger Rick's naturescope: wading into wetlands*. Washington, D.C., Vol. 2, No. 5. (available to order on-line at www.nwf.org).

River Network (1994). *Starting up: a handbook for new river and watershed organizations:* Portland, OR. (available through www.rivernetwork.org.)

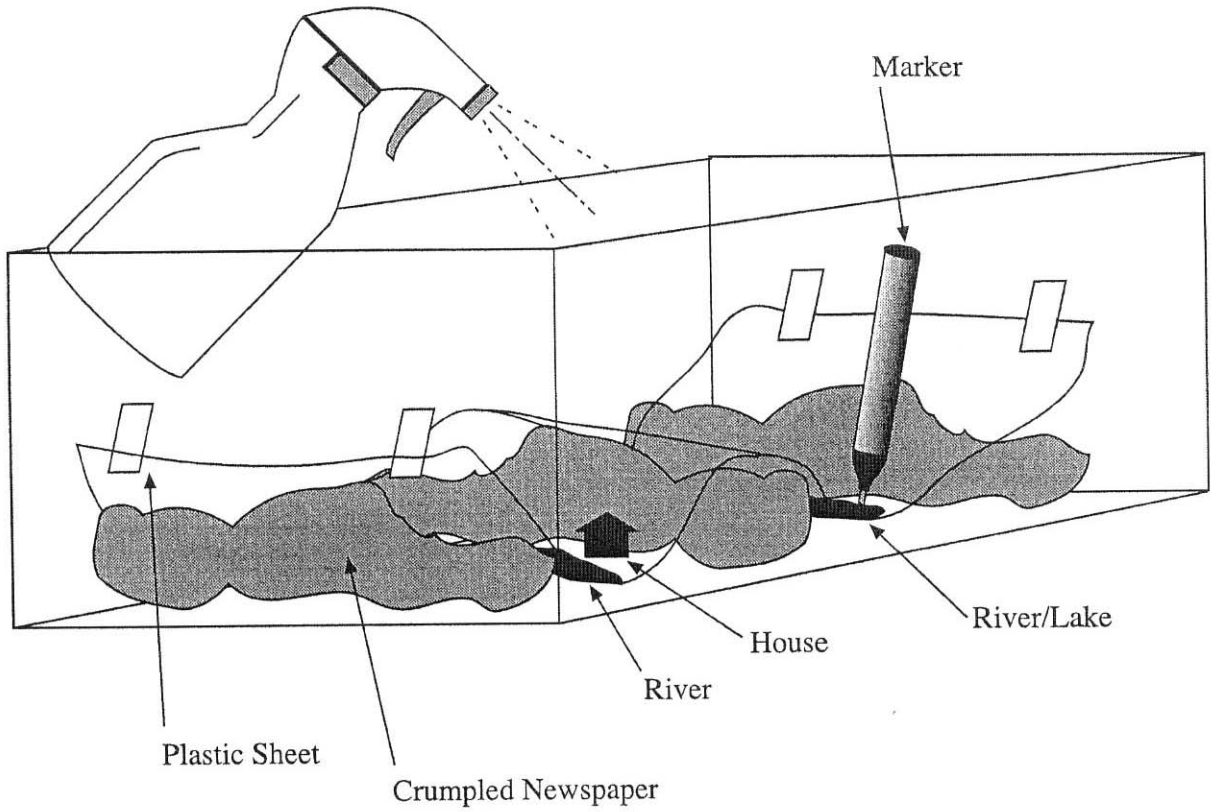
Slatterly, B. (1995). *WOW! The wonder of wetlands: An educator's guide*. St. Michaels, MD: Environmental Concern, Inc.; web site: www.wetland.org

Websites with information about wetlands and watersheds:

www.wetmaap.org (includes slide show)
www.ducks.org
www.nwf.org


Washington
Oregon
California
Nevada
Idaho
Montana
Wyoming
Utah
Arizona
Colorado
New Mexico
North Dakota
South Dakota
Nebraska
Kansas
Oklahoma
Texas
Minnesota
Iowa
Missouri
Arkansas
Louisiana
Wisconsin
Illinois
Michigan
Indiana
Ohio
Kentucky
Tennessee
Mississippi
Alabama
Georgia
Florida
South Carolina
North Carolina
Virginia
West Virginia
Pennsylvania
New York
Maine
Vermont
New Hampshire
Massachusetts
Rhode Island
Connecticut
New Jersey
Delaware
Maryland
Hawaii
Alaska
Percentage of wetlands for each state:
less than 5%
5 - 15%
15 - 25%
over 25%

Watershed Model



Notes

INTRODUCTION TO POLLUTION PREVENTION

Many satellites put in orbit by the United States and other countries have included geographic image surveys as part of their missions. The images from those satellites have illustrated the beauty and diversity of the planet's surface and the fact that it is isolated and self-contained. Although enormous in scale, the Earth is not infinite nor are its resources. While the planet can support an abundance of life and even can absorb some level of pollution, its carrying capacity (the amount of life supportable through resource allocation and use) is fixed. Because of this, the combination of natural and human-made detrimental effects, including pollution, must be considered to ensure that the carrying capacity is not exceeded.

The effect of natural or human-made change on Earth is often difficult to determine and is speculative on a worldwide scale, although studies of individual ecosystems and smaller geographic areas prove less difficult to measure. Instances of pollution can be investigated to determine effects and risks posed. Environmental studies and analyses have received increasing attention in past decades. Only through education can we as citizens become informed enough to make accurate and responsible decisions about our environment. The focus of this chapter is environmental pollution, either occurring naturally or human-made. There are two fundamental reasons for our concern with environmental pollution: (1) human health, welfare, and resource needs and (2) concern about the rest of nature.

Human Health, Welfare, and Resource Needs

Our personal concern with environmental pollution mainly revolves around health problems from natural, as well as human-made, pollutants. Human health and well-being can be impacted by environmental pollution in two distinctly different ways: (1) on a personal level by detrimental health due to contamination or depletion of water, air, and other needed resources or (2) by reduced social and economic benefits or degradation in a geographic, ecosystem, or global context through slow deterioration of our habitat or decreasing availability of resources.

The cost of control and remediation measures for pollutants sometimes is reflected in health-care costs to treat afflictions caused by pollution. Reduced or eliminated mental well-being or recreational benefits often are overlooked and are underestimated because of the difficulty in quantifying costs. The cost of the inability to fish a stream segment because of aquatic pollution, to stay outdoors for extended periods because of elevated ozone levels, or to play in areas contaminated by pollution is difficult to determine economically. Maintaining a healthy and sustainable environment for these activities often runs contrary to human and economic needs for population, urban, agricultural, and manufacturing growth and development.

Concern for Nature

Concern for nature other than that readily identified as healthful or economically beneficial has been a part of human existence for centuries. For example, there are many things about the balance of nature that we don't know. The loss of some species may throw off that delicate balance in ways that we cannot foresee at the time. This is a major theme of the modern environmental movement. Although many concerns mainly address human enjoyment, nature has value simply in its existence. Consider, for example, the number of people who place value in the protection of endangered species and the national park system, even though they have never seen an Indiana Bat or visited Little River Canyon. This protection of nature does not come without a price to all of us. Some resources have to be left unclaimed, some land has to be left undeveloped, and funds must be spent on protection and preservation of the delicate balance of nature.

Cultural Change

One of the major factors in the creation of environmental pollution stems from the consumption of resources, production and manufacture of goods, and disposal of wastes. Demand from citizens for a ready supply of goods increases as the population increases. Technology offers more products to make our lives better and easier, and our purchasing power increases.

The controversy over the creation of pollution traditionally has focused on finger pointing and pitting economic matters versus environmental concerns. Industry, government, and public groups have not always realized that environmental protection and economic growth do not have to be mutually exclusive. Government regulation, industry initiative, and public demand have caused great improvements to be made in the area of environmental protection. Better process design, control measures, and pollution prevention activities to reduce or eliminate pollutants at the source have reduced much pollution. Although great successes have been achieved, much more must be done in order to protect human health and the environment from pollutants.

A cultural change continues in the way many Alabamians work and play. Businesses, industry, agriculture, and other activities continue to make improvements in their operations. Collectively, they are trying to make a difference, as are public environmental groups and government agencies who keep watch over the environment and who encourage progress. These collective actions are important to success, but what can we do individually? We must all consider our activities, taking into consideration the environmental impact they may have. The idea of "throwing it away" is a myth. Wastes do not "disappear" when we "throw it away." All waste must be disposed of somewhere, and consumption of most materials creates at least one form of pollution from solid waste or from discharges in water or emissions into the air.

When purchasing materials and services, we must consider questions such as "What will happen to it after I use it? Can it be recycled? Can I purchase goods with less packaging? Is there a better alternative?" and finally, and most importantly, "Do I really need it?" Unfortunately, we often must act and make decisions without complete information. Educating ourselves, taking the time to get accurate information, and considering the consequences of our actions collectively and as individuals are important first steps in solving the problems created by environmental pollution.

From *World Book Encyclopedia*

Bacterial Growth From Three Common Pollutants

OBJECTIVES:

Students will be able to:

1. Compare the effects of three different pollutants on bacterial growth.
2. Graph the percent turbidity of bacterial growth versus the percent pollution for each pollutant.
3. Graph the comparison of percent bacterial growth versus percent pollutant.
4. Calculate the percent pollution in a water sample starting with a 1 percent stock solution.

Grades:

9-12

Subjects:

Science, Chemistry, Biology

Time Needed:

Two class periods of approximately 50 minutes

Materials:

250 mL flasks (4 per group)
20 mL test tubes (9 per group)
50 mL flasks (3 per group)
100 mL 0.85 percent NaCl
graph paper and pencil
bacteria nutrient broth (150 mL per group)
soil
detergent, fertilizer, motor oil

BACKGROUND:

Nitrates and phosphates are essential nutrients for plants and animals. Nitrates and other nutrients can be found in relative abundance in a balanced aquatic ecosystem. This means that, in any system, phosphates are usually the limiting reagent. Phosphates and/or nitrates are found in fertilizers (synthetic and natural) and detergents, both of which are deposited into Alabama's rivers, lakes, and streams each year through human activity. An excess of these substances can cause an increase in bacterial growth. This bacterial increase subsequently can deplete the system's oxygen levels. The population of oxygen-dependent species will be reduced dramatically. This can lead to the premature death or eutrophication in the system. The purpose of this activity is to demonstrate how bacterial growth is affected by three different pollutants commonly found in Alabama's aquatic ecosystems. It will compare detergents, fertilizers, and motor oil.

VOCABULARY:

pollutant, turbidity, nitrate, phosphate, limiting reagent, eutrophication, supernatant, stock solution, aquatic ecosystem, reagent

PROCEDURE:

1. Separate the students into groups of 4 to 5 each. Have them place 10 g of soil plus 100 mL 0.85 percent NaCl (normal saline) in a 250 mL flask.
2. Shake and leave for half an hour.
3. While waiting half an hour for the soil solution to settle, label nine test tubes #1 through #9. Then take 250 mL flasks and label them Detergent-D1%, Fertilizer-F1%, and Motor Oil-M1%. Add 1g solid or 1 mL of each pollutant to its corresponding flask. Add 9 mL of bacterial nutrient broth to each flask.

4. Take test tubes #1 through #9 and prepare them according to the following chart:
Using the indicated quantities of the pollution solutions (prepared in previous step), nutrient broth, and bacteria:

Test Tube	1% Pollution (mL)	Nutrient Broth (mL)	Bacteria (mL)
1	0-D1%	10	5
2	1-D1%	9	5
3	5-D1%	5	5
4	0-F1%	10	5
5	1-F1%	9	5
6	5-F1%	5	5
7	0-M1%	10	5
8	1-M1%	9	5
9	5-M1%	5	5

5. Gently swirl each test tube, and let sit for 24 hours. Clean up and continue the next day.
6. Rate the percent turbidity* according to the following chart:

%Turbidity*	Description
0	completely clear
25	less than half cloudy
50	half cloudy
75	more than half cloudy
100	completely cloudy

* The percent turbidity is directly proportional to the percent growth of bacteria in the medium.
7. Calculate the percent pollution (X%) in each test tube.
   Example: Test Tubes #2, #5, and #8.

   X% / 15 mLs = 1% / 1 mL

   (X%)(1 mL) = (1%)(15 mL)

   X% = (1%)(15 mL) / (1 mL)

   X% = 0.15%

Therefore test tube #2 has 0.15 percent detergent pollution in it.

8. Do the same for all the test tubes.
9. Record your results on a data chart similiar to the one below:

Test Tube	Pollution Source	% Pollution	% Bacterial Growth (% Turbidity)
1	Detergent	0	_____
2	Detergent	0.15	_____
3	Detergent	_____	_____
4	Fertilizer	_____	_____
5	_____	_____	_____
6	_____	_____	_____
7	_____	_____	_____
8	_____	_____	_____
9	_____	_____	_____

10. Graph the percent bacterial growth versus the percent pollution for each of the three pollution sources on three separate graphs.
11. Average each group's data with the rest of the class and graph the percent bacterial growth versus the percent pollution on a class graph. Use a different color marker for each pollution source.
12. Analyze the graphs in a class discussion. Ask the students for possible ways to control these types of pollution problems.

EVALUATION:

1. What effect did each pollution source have on the growth of bacteria?
2. Which pollutant affected bacterial growth the most?
3. If you added 25 mL of a 10 percent pollution solution to 225 mL distilled water, what would be the final concentration (%) of the pollution?
4. What is eutrophication? Include the effect of too much bacteria in an aquatic ecosystem in your answer.

EXTENSION:

1. Spec-20's can be obtained through the Science In Motion program that currently serves several Alabama school systems. Measure the absorbance of each test tube at 540-550 nm. The conversion of absorption to concentration can be found with the manuals accompanying this equipment. Any high school or freshman college chemistry book will also have this information.

ORIGINAL DEVELOPMENT RESOURCES:

Bernstein, L. (1990). *Globe biology*. Englewood Cliffs, NJ: Globe Book Company.

FAX: Solving biology problem by sharing ideas. (1995). Vol. 95-2, p.3. Flinn Scientific Inc.

Notes

Don't Sag Behind

OBJECTIVES:

Students will be able to:

1. Explain Dissolved Oxygen (D.O.) Sag Point and the factors that contribute to variable readings.
2. Organize aquatic macroinvertebrates in corresponding groups and sort different pollution tolerances.

BACKGROUND:

Dissolved oxygen (DO) is only sparingly soluble in water. It is essential, however, to clean water and fish survival and reproduction. It is critical to the survival and reproduction of many aquatic organisms.

Wastewater impacts in a stream, even after treatment, are very pronounced with their impacts determined by wastewater quantity, stream flow, stream velocity, number of discharges, and sediment and photosynthetic effects.

Macroinvertebrate types or diversity and abundance concentration changes if the DO stays below 5.0 mg/l DO at the low point. Should this happen, stream macroinvertebrate diversity declines from the discharge and recovers as DO levels recover. Game fish numbers are usually reduced in low DO areas of the stream. Pollution intolerant macroinvertebrates occur in the higher DO ranges and pollution tolerant organisms occur at the lower values.

For the above reasons, stream standards are set at 5.0 mg/l DO levels to maintain high quality water and greater diversity in macroinvertebrates, both of which will lead to a greater fish presence.

Grades:

9-12

Subjects:

Biology, Math, Environmental Science

Time Needed:

A two-hour block or one half-day field trip to a local stream

Materials:

Dissolved Oxygen (DO test kit)
Benthic Macroinvertebrate Sample Site Field Sheet Instructions
Team Field Sheet
Macroinvertebrate Picture Keys
Collecting jars for macro-invertebrate samples
Thermometers
Tape measure or string marked in 1" intervals
Yard stick
Orange (fruit)
Waders
Stopwatch or watch with second hand
Clipboard

VOCABULARY:

benthic, macroinvertebrate, Sag Point, pollution-tolerant, pollution-intolerant, Dissolved Oxygen

ADVANCE PRREPARATION:

Before you go into the field, calibrate your thermometer by immersing it in ice water and taking a reading. (It should read approximately 32 F or 0 C.)

PROCEDURE:

1. Review with students the information found in the background, reminding them that most wastewater is not completely clean when it is put into a local stream. The class will visit a stream to collect data on its characteristics (see stream characteristic section - instructions). Upon completion of the DO Sag Point discussion, ask the following:
   • What life forms could be discovered above 5.0 mg/l? Below 5.0 mg/l? (Refer to Picture Key Groups I, II, and III for answers.)
   • Would day or night be the best time to collect DO levels? Why? (Answer: Day, because photosynthesis does not occur at night; DO levels are at a peak during the day.)

EVALUATION:

1. Before visiting the stream, divide students into teams. Using cooperative learning, designate a leader, a writer, and collectors of data, giving importance to all assignments. Teams will be responsible for completing the Team Field Sheet. Macroinvertebrates will be collected by teams to be researched in the classroom at a later date.

EXTENSIONS:

1. Determine the effect on DO of temperature, algae growth, and reducing chemicals such as meta bisulfide. A lab exercise could be to aerate a sample of water at 40 degrees F and then test for DO levels at 60, 80, and 100 degrees F. How might heated water affect life in streams?
2. Do all fish species require the same level of DO to survive? Can trout, bass, and catfish all live at 5mg/l? Does this indicate why trout do not thrive in warm water?
3. Visit the same stream during evening hours to compare dissolved oxygen levels.

ORIGINAL DEVELOPMENT RESOURCES:

Water Division (ADEM) Alabama Department of Environmental Management, www.adem.state.al.us

Guide to Macroinvertebrate Sampling. Adapted from: *Layperson's Guide to Streams or River Water Quality–Biological Monitoring* by Steve Fiske, Vermont Department of Water Resources, June 1987.

Bio-Assess, Alabama Water Watch Program, 1993 Auburn University, Contact Dr. Bill Deutsch, 334-844-9119, www.alabamawaterwatch.org

Benthic Macroinvertebrate Sample Site Field Sheet Instructions

These instructions are meant as guidance for those filling out the field sheet and collecting Macroinvertebrate sample sites should be located in "riffle" areas (fast moving, surface broken by small waves or rocks) with a current velocity between .4 and 2 feet per second. This is a pretty strong current but not so strong that you can't easily maintain your balance in two feet of water.

Equipment and materials needed (for field sheet only): thermometer, tape measure (50' preferable) or string marked in 1 foot increments, yard stick, orange (the fruit), waders, watch (stop watch or second hand), clipboard. A USGS topographic map would be helpful.

Basic Site Information

Fill in the information requested. Most is self-explanatory. For the **site** location, try to describe it so that someone who has never been there would recognize it. **Weather** observations are important. They may explain some of your subsequent observations. For **estimated elevation,** use a topo map. For **sample type,** check the type of collection method you're using.

Stream Characteristics Section:

1. **Water temperature:** Measure this at least twice <u>from the exact spot you'll be collecting</u> and average the two results. Leave the thermometer in the water for three minutes. If you get very different readings, measure until they are within a couple of degrees.

2. **Air temperature:** You can use the same thermometer.

3. **Average width:** Measure or estimate across the stream where you'll be collecting. Use a tape measure or visual estimate.

4. **Average depth:** Measure depth in three places at the collection spot and average the result. Use a yard stick.

5. **Average velocity (in ft./sec.):** Have two people measure off ten feet, standing in the stream at the collection spot. Drop a float (preferably an orange) into the current at the upstream point and, using a stop watch if available, note the time it takes to travel the ten feet. Try to pick an open path where the float will not encounter rocks or other stream obstructions. Do this three times and average the results.

6. **Relative flow:** Is the present flow (the amount of water flowing usually expressed in cubic feet per second) high, average, or low compared with your estimate of the average flow during the course of a year? If you have seen the stream in the previous two days, was that flow high, average, or low compared with your estimate of the average flow during the course of a year? This is a subjective estimate, but it will give an idea of whether the stream flow is higher, average, or lower than "normal" (year round average). If you don't know what the average year-round flow looks like, look for visual clues, such as aquatic plant growth, that might show the channel where water is flowing most of the time.

7. **Sediment deposits:** Is the bottom covered with material other than the natural stream bed? Check the type that applies.

8. **Does the water smell of:** Check the one(s) that apply.

9. **Water color:** Check the one(s) that apply.

10. **Algal growth:** What percent of the stream bottom is covered with algae? Algae is brown to green in color and has a fine threadlike or cotton ball appearance.

11. **Does the river appear to be straightened or channelized?:** Evidence of this would be a uniform depth, uniform rock-lined banks, and a suspiciously straight channel. This is usually done near roads or houses to keep floodwaters out of those areas.

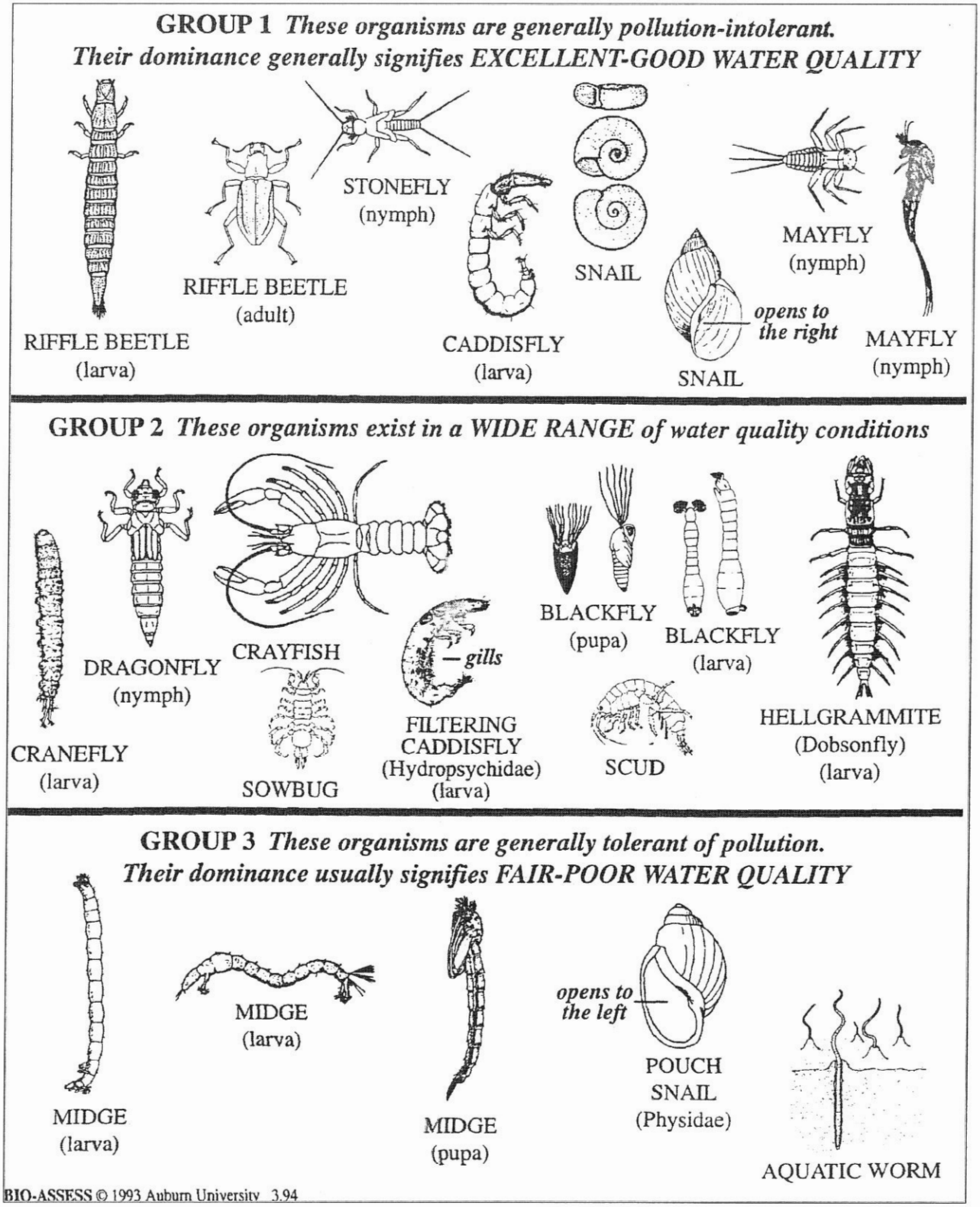
12. **Upstream dam:** Fill this in if you know of upstream dams, even if they are quite a distance upstream.

13. **Are there wastewater treatment plant discharges upstream?:** Fill this in if you know of upstream discharges, even if they are quite a distance upstream.

14. **Do you see pipes emptying directly into or near the water?**

Notes: Use this space to record any other observations.

MACROINVERTEBRATE GROUPS
Beginner's Protocol PICTURE KEY



Benthic Macroinvertebrate Sample Field Sheet
Team Field Sheet
Team Number _____

Sample site should be in riffle area with stream velocity between .4 and 2 ft./sec.

River :_____ Town:_____
Site #:_____ Site Location (be specific):_____
_____
Name(s):_____ Date:_____Time:_____
Weather: today:_____ prev. 2 days: _____
Sample Type (choose one) Kick Net___ Artificial Substrate:___ Dredge:___

Stream Characteristics (taken at the sample site)

1. Water Temp: _____ (Sample 2x and take average) (Sample 1x) a._____ b._____
2. Air Temp: _____ Sample 1x)
3. Avg. Width: _____ Sample 3x
4. Avg. Depth: _____ and take average) a._____ b._____ c._____
5. Avg. Velocity in ft./sec. (Sample 2x and take average) *time it takes a float to travel 10 ft.*
   a. 10 ft / sec _____ = v1_____
   b. 10 ft /sec _____ = v2_____
   average [(v1+v2) /2] Average
6. Relative Flow: (circle) *relative to your estimate of year round average*
   present flow: High Avg. Low
   prev. 2 days: High Avg. Low
8. Does the water smell of: Sewage___ Oil___ Chlorine___ Rtn eggs___ Other___
9. Water color: green___ tea___ milky___ cloudy___ muddy___ clear___ other___
10. Algal Growth: >75%___ 50%-75%___ 25%-50%___ 0%-25%___ none___
11. Does the river appear to be straightened or channelized? Y or N Describe:_____
12. Upstream Dam? Y or N How far?_____
13. Are there wastewater treatment plant discharges upstream? Y or N Distance:_____
14. Do you see pipes emptying directly into or near the water? Y or N How Many?_____

Notes: _____
_____

The Effects Of Pollutants On Algae Productivity

OBJECTIVES:

Students will be able to:

1. Compare the effects of three different pollution sources in varying concentrations on the productivity of algae.
2. Analyze and record experimental results in data chart and graph form.
3. Describe what an algal bloom is and how it can affect an aquatic ecosystem.

Grades:
9-12

Subject:
Environmental Science, Biology

Time Needed:
Two weeks

Materials:
3000 mL (3 liters) freshwater algal growth medium (per student group)
graph paper
3-1000 mL flasks
250 mL flasks (9 per student group)
100 mL graduated cylinders
funnels
filter paper
balance
cotton

BACKGROUND:

There are many different types of algae. Some are single-celled while others live in colonies containing many cells. Among the single-celled algae are fire algae, golden-brown algae, and euglenoids. In normal amounts, these organisms are an important source of nutrition for fish and other aquatic organisms. When conditions are adverse, such as excessively high levels of nitrates or phosphates, algae will undergo an exponential growth spurt called an algal bloom. Fire algae can be fatal to humans who eat the shellfish that co-exist with this type of algae. Green algae and brown algae are examples of multi-celled colonies. Green algae is common to freshwater systems such as lakes and ponds. When nitrates and phosphates are deposited in large quantities through sources such as detergents and fertilizers, an algal bloom can result. Lack of algae reduces the fish food supply, but too much algae will deplete the oxygen needed by fish. The purpose of this activity is to observe the effects detergents, fertilizers, and motor oil have on the growth of algae in a freshwater environment. These pollutants are commonly found in many freshwater lakes and ponds in Alabama due to boating activities and improper disposal of used motor oil by individuals on the ground or in the storm sewer.

VOCABULARY:

fire algae, green algae, brown algae, golden-brown algae, algal bloom, euglenoids, single-celled, multi-celled, aquatic ecosystem, biomass

PROCEDURE:

1. Prepare the soil slurry by adding 20 mL of topsoil to 100 mL of tap water. Swirl it around just before using it.
2. Before the lab begins, prepare a 1 percent pollution solution by adding 10 g dry or 10 mL liquid fertilizer to a 1-liter flask. You should have one for detergent, one for fertilizer, and one for motor oil. Fill the flask to the 1-liter mark with algal growth medium Add 5 mL of soil slurry (containing the bacteria to break down pollutants) and leave in a dark place for one week.
3. Separate the students into groups of four or five. Give each group nine 250 mL flasks and label them #1 through #9.
4. Have the students set up the nine flasks as follows using the indicated quantities of the pollution solutions and the soil slurry prepared in the first two steps:

Flask (mL)	1% Pollution Solution (mL)	Algal Growth Medium (mL)	Soil Slurry (mL)	Calculated Biomass Weight (Step 7)
1	0- detergent	100	5	_____
2	10- detergent	90	5	_____
3	50- detergent	50	5	_____
4	0- fertilizer	100	5	_____
5	10- fertilizer	90	5	_____
6	50- fertilizer	50	5	_____
7	0- motor oil	100	5	_____
8	10- motor oil	90	5	_____
9	50- motor oil	50	5	_____

5. Plug the flasks with cotton and place them in the window for one week.
6. After one week, give each group of students nine pieces of filter paper and a large funnel and flask.
7. Place the filter paper in the funnel and place it in the mouth of the flask. When all the water is filtered through the filter paper, let it sit for one minute and then weigh it on the balance. Record the wet biomass weight on your data chart. Repeat this for each flask.
8. Have each group of students graph the biomass weight results for each type of pollution on the same graph paper so they can compare them. The class should average its results for each condition (flask number) and prepare a class data chart and graph.

EVALUATION:

1. Which pollutant was the most harmful to the productivity of the algae?
2. Did any of the pollution solutions cause an increase in algae growth? If so, what would the result be if an aquatic ecosystem were contaminated by this type of pollution?
3. Name three types of single-celled algae and two types of multi-celled algae.
4. What can happen if there is an overabundance of fire algae in a given area?
5. Explain how you obtained the wet biomass of your algae growth.

ORIGINAL DEVELOPMENT RESOURCES:

Bernstein, L. (1990). *Globe Biology.* Globe Book Company, Englewood Cliffs, NJ. pp.113-119.

Water Shed Worlds. (1990). *Pollutants, Algae and Eutrophication*. Thames Science Center

Dobson, C. and Beck, G.G.(1991). *Watersheds: a practical handbook for healthy water*. Firefly Books.

Mutant Colonies

OBJECTIVES:

Students will be able to:
1. Define mutation.
2. Identify the sources of mutagenic agents.
3. Compare the effects of possible mutagenic agents from chemical contaminants–alcohol, tar, and nicotine.
4. Use the Ames test to confirm mutagenic agents.

BACKGROUND:

Mutagenic agents found in water may come from a variety of chemical contaminants. These agents cause tumors and cancer in aquatic animals and even in humans. Through recreational activities, people unknowingly add mutagenic agents, chemicals, or bacteria to natural waters. The Ames test is used throughout the scientific community. Dr. Ames used a bacterium, *Salmonella typhimurium*, that must mutate in order to grow on a minimal nutrient agar. If exposed to an agent that causes a mutation, the bacteria reverts and then can grow in colonies on a minimal nutrient medium.

VOCABULARY:

Salmonella typhimurium, mutation, mutagenic agent, media, incubator, autoclave, agar, mutagenicity, reliable, valid

PROCEDURE:

1. Obtain four sterile petri dishes containing glucose minimal agar media and label each dish as follows:
   - #1 control–distilled water
   - #2 control–acetone
   - #3 beer–preservatives
   - #4 cigarettes–tar and nicotine
2. Onto each dish, swab or spread *Salmonella typhimurium* (completely covering agar).
3. Control #1: Soak filter paper in distilled water, remove, allow to dry, and place in petri dish.
4. Control #2: Soak filter paper in acetone, remove, allow to dry, and place in petri dish.
5. Variable #3: Soak filter paper in beer, allow to dry, and place in petri dish #3.
6. Variable #4: To obtain chemicals from cigarette butts, remove filter and cigarette paper and place in acetone. Allow to sit for 10 minutes. Soak filter paper in the liquid, remove, allow to dry, and place in petri dish #4.
7. Preheat oven or incubator to 35-37°C. Invert petri dishes and incubate for at least 48 hours.
8. Count the number of colonies, and record on the following data sheet:

Grades:

9-12

Subjects:

Science, Environmental Science, Biology

Time Needed:

One 50 minute class period for labwork; 48 hrs. later a second 50-minute class period for the results

Materials:

culture of *Salmonella typhi-murium* mutant (requires histadine in medium for growth)
sterile cotton-tipped swabs or Q-tips
incubator or oven (35°C-37°C)
sterile filter paper (place in autoclave or pressure cooker)
autoclave or pressure cooker
sterile petri dishes containing glucose minimal agar
10 cigarette butts (any brand)
acetone
sterile distilled water
1 beer (any brand)

	Control #1	Control #2	Variable #3 (Beer)	Variable #4 (Cigarettes)
Colony #				
Colony #				

9. If bacteria colonies appear, the substances in beer/cigarette butts contain mutagenic agents.

EVALUATION:

1. Which petri dish had the most number of colonies? Why do you think this happened?
2. What controlled variables may affect the outcomes?
3. Do you think the results of this activity are reliable? Valid?
4. What other substances do you think may cause a mutation to occur on *Salmonella typhimurium?*
5. "U.V. rays from the sun can be a mutagenic agent." Explain.
6. Predict the ecological impact on aquatic animals if these contaminants continue to reach our water supplies.
7. The mutating pollutants are common in the aquatic environment. Why are the observed mutations not observed in higher species?

EXTENSIONS:

1. Explain physical and chemical mutations.
2. Adapt this to test other recreational pollutants for mutagenic effects.
3. Obtain current Toxic Release Inventory (TRI) report from ADEM in which data are organized by causal category. One category is mutagenic. Compounds, source, and amounts released are available from ADEM.

ORIGINAL DEVELOPMENT RESOURCES:

Cunningham, W., and Saigo, B. (1995). *Environmental Science*. Third Edition. Dubuque, IA: Wm C. Brown Cummunications Inc.

Alabama Department of Environmental Management , www.adem.state.al.us

2000 TRI Report released in May 2002, www.epa.gov/triinter

To Clean Or To Glean

OBJECTIVES:

Students will be able to:
1. Evaluate recipes for non-toxic common household cleaning supplies.
2. Compare the cleansing capability and safety of cleaning alternatives with their brand-name, toxic counterparts.

BACKGROUND:

If a person reads the labels of commonly used household cleaners, he/she will discover that many can be extremely toxic to humans as well as to other living things. Review the "Home Safe Home" resource sheets from the Tennessee Valley Authority and the "Hazardous Waste Wheel" from Waste Management, Inc. (see resources section) to inform students of the extent of toxicity in products. Refer to "Enlightened and Reformed" in Learning Through Legacy (9-12).

VOCABULARY:

toxicity, borax, cornstarch, baking soda

PROCEDURE:

1. Divide the class into groups.
2. Assign specific cleaning tasks to each group.
3. After preparing identical "dirty" surfaces, students should prepare non-toxic recipes and test their efficiencies in comparison to the brand-name products.
4. As students report their findings to the class, discuss which products were most effective.
5. Discuss making environmentally sound decisions when choosing products for the home.

Grade:
9-12

Subjects:
Home Economics, Environmental Science, Chemistry, Biology

Time Needed:
Two to five hours

Materials:
white vinegar
borax
washing soda (sold in supermarkets)
olive or vegetable oil
lemon juice
baking soda
cornstarch
salt
vanilla
cream of tartar
toothpaste

EVALUATION:

1. Discuss the long-term effects of using toxic versus non-toxic versions of cleaners.

EXTENSION:

1. Compare purchase costs of non-toxic recipes and brand-name products. Share the results and discuss with class.

ORIGINAL DEVELOPMENT RESOURCES:

Mason Hunter, L. *The Healthy Home: An Attic-to-Basement Guide to Toxic-Free Living*. Pocket Books.

Dadd, D. L. *The Nontoxic Home*. Tarcher.

Dadd, D. L. *Nontoxic & Natural.* Tarcher.

"Household Hazardous Waste Wheel," Legacy, Inc. P.O. Box 3813, Montgomery, AL 36109, www.legacyenved.org, 1-800-240-5115.

Non-toxic Cleaners

MATERIALS:

white vinegar, borax, washing soda (sold in supermarkets), olive or vegetable oil, lemon juice, baking soda, cornstarch, salt, vanilla, cream of tartar, toothpaste

NON-TOXIC CLEANER RECIPES:

Glass and tile:
Mix 1 quart of water with 1-2 tablespoons of vinegar (use a spray bottle), or mix 1/2 cup of cornstarch in 2 quarts of water (warm) and apply with a sponge.

Floors:
Fill a bucket with hot water and add 1/4 to 1/2 cup of vinegar. For stains, use a mix of borax and hot water.

Tough spots:
Sprinkle a wet sponge with borax.

Counters and cabinets:
Mix 1/2 cup of borax to 1 gallon of water.

All-purpose cleaner:
Mix vinegar and salt or dissolve 4 tablespoons of baking soda in a quart of warm water.

Sinks:
Use baking soda as a powdered cleanser.

Kitchen odors:
Set a cotton ball soaked in vanilla on a saucer in the refrigerator or on the counter. Sprinkle borax in the bottom of the garbage can.

Bathroom tile walls:
Make a paste of borax and water and scrub.

Toilet bowl cleaner:
Sprinkle baking soda into the bowl. Then drizzle with vinegar and scour with a brush.

Furniture polish:
Mix 1/2 cup or more of lemon juice and 1 cup of olive oil in a spray bottle. Use for all wood.

Carpets:
To refreshen (or ward off fleas), sprinkle borax.
To clean, sprinkle baking soda, wait 15 minutes, and vacuum.

Fireplace:
Clean tiles with full-strength vinegar or 1 cup washing soda (sold in supermarkets) dissolved in 2 gallons of hot water. Rinse with clear water. Clean excess soot from the flue by throwing a handful of salt into a blazing fire.

Non-toxic Cleaners (con't)

Spray starch:
In a spray bottle, mix 1 tablespoon of cornstarch in a pint of cold water.

Grease spot remover:
Rub with a damp cloth dipped in borax, or apply a paste of cornstarch and water. Let it dry and brush off.

Shoe polish:
Polish with the inside of a banana peel and buff.

Silver polish:
Clean with toothpaste and warm water.

Copper cleaner:
Apply a paste of lemon juice and cream of tartar, leave on 5 minutes, and then wash in warm water.

Notes

Plants And Sulfur Dioxide Air Pollution

OBJECTIVES:

Students will be able to:

1. Investigate the effects of sulfur dioxide air pollution on different plants.
2. Record data.
3. Compare plants exposed to sulfur dioxide with plants not exposed.
4. Compare the sensitivity of different plants to sulfur dioxide.

BACKGROUND:

Sulfur dioxide is a major cause of air pollution. It is released into the atmosphere in smoke from factories and power plants. Sulfur dioxide causes respiratory problems in people, especially when concentrated in smog. When carried high into the atmosphere, it reacts with water to form dilute sulfuric acid, falling back to Earth as acid rain; this corrodes metals, damages building stone, acidifies lakes rendering them lifeless, cuts crop yields, and kills trees. This experiment investigates the effect sulfur dioxide has on different plants, examining whether some plants are more resistant to the effects of sulfur dioxide than others.

VOCABULARY:

sulfur dioxide, respiratory, smog, acid rain, corrodes, annotated

PROCEDURE:

Caution: Read safety warning before performing this experiment, and observe all safety precautions for chemistry lab.

Part One—Effect of Sulfur Dioxide on Seedlings
Growing the Seedlings

1. Half fill two of the small square containers with potting soil. Carefully moisten the soil with water.
2. Sprinkle the mustard or cress seeds over the soil in both containers. Place the containers on a window sill or under grow lights for two weeks, moistening the soil when it dries out.

Investigating Exposure to Sulfur Dioxide

1. Label the two containers "D" and "S." Record their appearance in words or using annotated drawings in the column marked "Seedling with damp air" (for container "D") and the column marked "Seedling with sulfur dioxide" (for container "S") of Data Table One (see attached).
2. Put each container of seedlings in a plastic bag. Using the masking tape, label the bag with container "S": "Seedlings with sulfur dioxide." Label the bag with container "D": "Seedlings with damp air."

Grades:

9-12

Subjects:

Biology, Chemistry, Environ-mental Science

Time Needed:

For each part: 20 minutes to plant seeds, seed should be left to grow for two weeks, 45 minutes to set up experiment, 10 minutes to check each experiment after 30 minutes and after 24 hours

Materials:

three varieties of seeds from gardening store or nursery: either mustard or cress seeds; either corn or cucumber seeds; either barley, carrot, lettuce, or tomato seeds
four small square containers (e.g., aluminum foil dishes) approx.15 cm x 15 cm and 5 cm deep
four small empty jars (e.g., jelly or baby food jars) without lids
potting soil
four clear plastic bags (large enough to fit over one square container and one jar)
felt-tip marker
masking tape
four twist ties
scale
sodium bisulfite ($NaHSO_3$) (approximately 15 g)
stirring rod (e.g., chopstick)
citric acid solution
water
teaspoon or spatula
250-mL beaker
100-mL measuring cylinder
rubber gloves
self-adhesive labels

3. Put on the rubber gloves; in a well-ventilated place, weigh .5 gram of sodium bisulfite using the scale; add the sodium bisulfite to the beaker.
4. Measure out 100 mL of water using the measuring cylinder. Add the water to the beaker and stir.
5. Half fill one jar with sodium bisulfite solution.
6. Add a few drops of citric acid solution to the jar. This increases sulfur dioxide production.
7. Place the jar in the bag marked "Seedlings with sulfur dioxide" and seal the bag with a twist tie.
8. Remove the rubber gloves.
9. Half fill the other jar with water.
10. Place the jar in the bag marked "Seedlings with damp air" and seal the bag with a twist tie.
11. Leave the bags for 30 minutes.
12. After 30 minutes, without opening the bags, look at the seedlings and record their appearance in Data Table One.
13. After 24 hours, look at the seedlings again and record their appearance in Data Table One.

Part Two—Resistance of Seedlings to the Effect of Sulfur Dioxide
Growing the Seedlings

1. Half fill the other two small square containers with potting soil. Carefully moisten the soil with water.
2. Label one container "A" and the other "B." Also write the identities of seedlings A and B in Data Table Two.
3. Sprinkle the corn or cucumber seeds over the soil in container A. Then sprinkle the barley, carrot, lettuce, or tomato seeds over the soil in container B.
4. Leave the containers on a window sill or under grow lights for two weeks, moistening the soil if it dries out.

Comparing Sensitivity to Sulfur Dioxide

1. After two weeks, record the appearance of both containers in Data Table tWO in the columns marked "Seedling A" (for container A) and "Seedling B" (for container B).
2. Put each container of seedlings in a plastic bag.
3. Put on the rubber gloves; in a well-ventilated place, weigh .5 gram of sodium bisulfite using the scale; add the sodium bisulfite to the beaker.
4. Measure out 100 mL of water using the measuring cylinder. Add the water to the beaker and stir.
5. Half fill one jar with sodium bisulfite solution.
6. Add a few drops of citric acid solution to the jar.
7. Place the jar in the bag with container A and seal the bag with a twist tie.
8. Repeat steps 5 through 7 with container B.
9. Leave the bags for 30 minutes.
10. After 30 minutes, without opening the bags, look at the seedlings and record their appearance in Data Table Two.
11. Leave the bags for 24 hours.
12. After 24 hours, look at the seedlings again and record their appearance in Data Table Two.

Safety Warning

Adult supervision is required when preparing and pouring the sodium bisulfite solution. Please observe the safety precautions for lab procedures working with sodium bisulfite solution.. Pour the sodium bisulfite solution when in a well-ventilated place, and be careful not to inhale sulfur dioxide gas. Wear rubber gloves when pouring sodium bisulfite solution.

EVALUATION:

Part 1

Students will answer these questions:

1. What effect did the sulfur dioxide have on the seedlings in the bag labeled “S” after 30 minutes?
2. What effect did the sulfur dioxide have on the seedlings in the bag labeled “S” after 24 hours?
3. Why was water used instead of sodium bisulfite solution in one of the bags?
4, What had happened in bag “D” (the control) after 30 minutes and 24 hours?
5. Which parts of the plant are affected by sulfur dioxide?
6. How does sulfur dioxide affect humans? Do library research.

Part 2

1. What effect did sulfur dioxide have on the “A” seedlings?
2. What effect did sulfur dioxide have on the “B” seedlings?
3. What are the implications of any differential effects you observed?

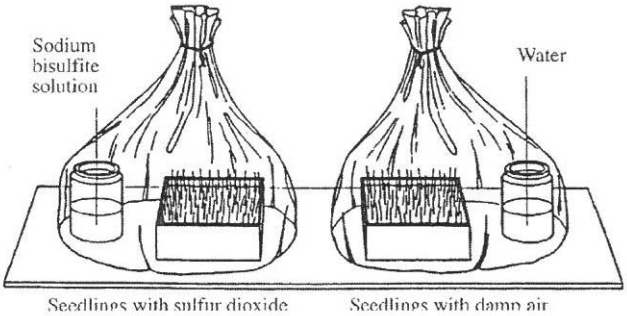
EXTENSION:

1. Students will research this question: Why might this information be important to a farmer or horticulturist growing crops near factories or a coal-fired power plant?

ADDITIONAL RESOURCES

www.epa.gov › Air & Radiation › Six Common Pollutants

PLANT RESPONSES TO SULFUR DIOXIDE POLLUTION ...
www.tandfonline.com/doi/pdf/10.1080/10643387909381667



Data Table One

Time	Seedlings with sulfur dioxide	Seedlings with damp air
At Start (At the end of first two weeks of growth outside of bags.)		
After 30 Minutes (in Bags)		
After 24 Hours (in Bags)		

Data Table Two

Time	Seedlings with sulfur dioxide	Seedlings with damp air
At Start (At the end of first two weeks of growth outside of bags.)		
After 30 Minutes (in Bags)		
After 24 Hours (in Bags)		
Seedling A was:		
Seedling B was:		

Notes

Manure Nuisance

OBJECTIVES:

Students will be able to:

1. Analyze poultry and cow manure samples for carbon, nitrogen, and phosphorus.
2. Calculate the C, N, and P ratio of each sample.
3. Observe the growth of bacteria in manure solution.

BACKGROUND:

Animal manures are typically high-volume by-products of the poultry industry or hog or cattle farms. Manures are valuable, natural soil amendments that can add nutrients and organic matter to increase soil fertility. They are also potential pollutants of surface and groundwater, if mishandled.

An environmental concern for manure contamination is in maintaining the water quality of the state. The ultimate concern is to avoid bacterial contamination and excess nutrient run off. If improperly managed, manure can become a liability by causing problems in the environment and creating hazards to human and aquatic animal health.

Manure can contaminate water by:

- Leaching into soil and groundwater.
- Running off, when incorreclty applied.
- Directly discharging into water resources.

VOCABULARY:

poultry, manure, microorganisms, contaminants, pathogen, disease, methemoglobinemia, eutrophication, supernatant, culture

PROCEDURE:

1. Measure out 10 g of poultry and cow manure each, and allow them to air dry for 24 to 48 hours before using.
2. Obtain 10 g of soil by removing top soil and going down one to two inches.
3. In a 250 mL flask, add 10 g of soil and 100 mL of 0.85 percent NaCl. Cover, shake, and allow to settle for 30 minutes. The supernatant liquid contains bacteria.
4. Label test tubes:
   a. Poultry manure 0.1 g
   b. Poultry manure 0.5 g
   c. Poultry manure 1.0 g
   d. Cow manure 0.1 g
   e. Cow manure 0.5 g
   f. Cow manure 1.0 g
   g. Poultry manure 1.0 g
   h. Cow manure 1.0 g
   i. Distilled water
   j. Distilled water

Grades:

9-12

Subjects:

Science, Math, Biology

Time Needed:

Analyzing and calculating litter, 50 minutes; setting up experiment for growth and study, 50 minutes; determine growth after 24 hours, 50 minutes

Materials:

poultry and cow manure
soil
microorganisms
balance
pipette
250 mL flask
10 g soil sample (remove top soil; go down an inch)
100 mL 0.85 percent NaCl (nor-mal saline solution)
20 mL test tubes (10 needed)
test tube rack
distilled water
field test kit capable of measuring C, N, and P in liquid

5. Add 10 mL of distilled water to each test tube.
6. Add 1 mL of supernatant to a, b, c, d, e, f, and i test tubes.
7. Add 1 mL of distilled water to test tubes g, h, and j for control study.
8. Place all the test tubes in a warm location (top of refrigerator, near heater, or under a light bulb) for 24 to 48 hours before analysis. Rank turbidity observations and record on a data table.
9. Have the students analyze the C, N, and P content of the poultry and cow manure using a field test kit. Record on data table.
10. Calculate the C, N, and P ratio in each test tube. Record on data table.
11. Compare the growth in each tube with respect to the type and amount of manure.

Refer to data table explanations and layout from

EVALUATION:

1. Students will be evaluated on field test kit use and general skill.

EXTENSION:

1. If an ultraviolet-visible spectrophotometer is available, use the control to set for 0 at 540-581 nm. Read the observation for each bacterial growth and record the data.

ORIGINAL DEVELOPMENT RESOURCES:

Dry Poultry Manure Management, Alabama Cooperative Extension Service, Manual of Practice 358.

The Routes Of Radon

OBJECTIVES:

Students will be able to:

1. Define radon and discuss why it is an indoor air pollutant.
2. Explain the process of radioactive decay and know why radiation can be harmful to your health.
3. Trace the route radon can take from bedrock and soil into air, water, homes, and eventually human bodies.
4. Conduct a home radon exposure survey.

BACKGROUND:

Radon is a colorless, odorless gas that occurs naturally. It is found in all types of rock and soil in varying concentrations. Radon results from the radioactive decay of Radium-226.

To understand radioactivity, it is essential to know something about atoms. An atom is the smallest part of an element that has all the properties of the element. Atoms are made up of protons, neutrons, and electrons. All atoms of the same element have the same number of protons. They usually have the same number of electrons; however, the number of neutrons can vary. Atoms of the same element with different numbers of neutrons are called isotopes. Unstable isotopes are also called radioactive isotopes because radioactivity is the process whereby the unstable isotopes eventually form stable isotopes. Radioactive isotopes can be thought of as rubber bands that have stretched too far. They may "break," losing energy instantly and spontaneously changing into other isotopes of the same or different elements. Eventually the daughter isotopes may be unstable too; but eventually an unstable isotope will change into a stable one, which does not decay further. During the radioactive decay, in addition to a new isotope, particles of mass and energy in the form of electromagnetic radiation are given off.

Radon occurs naturally as a gas that may be inhaled by humans. Although lung cancer is associated with high concentrations of radon gas, lung cancer is not wholly caused by radon. Since radon is a gas, it cannot lodge itself in the lung tissue. Instead, lung cancer is caused primarily by the decay products that result from the radioactive decay of Radon-222, an unstable isotope of radon. (Note: all isotopes of R_n are unstable.)

Grades:

9-12

Subjects:

Biology, Geography, Health, Physical Science, Physics

Time Needed:

Approximately five class periods

Materials:

balloons
straight pins
masking tape
9 sheets of paper (1 each labeled Radon-222, Polonium-218, Lead-214, Bismuth-214, Polonium-214, Lead-210, Bismuth-210, Polonium-210, and Lead-206)
9 chairs
rubber bands
felt-tip markers
transparencies (masters provided)
overhead projector
handful of potting soil
glass container
water
blue food coloring
"Home Radon Exposure Survey" student sheets (included)
geologic and soil maps of the area (available from Alabama Geological Survey of Alabama and Legacy)

Radon gas can convert very quickly (3.82 days) to Polonium-218, which is a solid material that can lodge in the lungs. (NOTE: This period of time, 3.82 days, is called the half-life of the isotope. A half-life is the amount of time it takes for one-half of the sample of a radioactive isotope to change into another form. Half-life varies tremendously from one isotope to another.) To cause cancer, a solid radioactive atom must be in contact with lung tissue when the atom is giving off radiation (undergoing radioactive decay). The four main decay products of Radon-222, in order, are Polonium-218, Lead-214, Bismuth-214, and Polonium-214. These four isotopes are very unstable, with half-lives ranging from fractions of a second to minutes. (See the diagram "STEPS OF

RADIOACTIVE DECAY OF RADON-222.") These four "radon daughters" are solids that can easily attach to airborne particles which can get lodged in lung tissue. The reason scientists focus attention on radon instead of the "radon daughters" is that radon is a colorless, odorless gas that can move easily from one place to another without detection.

A characteristic of radon that makes it different from many other indoor air pollutants is that it occurs naturally. Radon gas is constantly emerging from the rocks that contain it. When it emerges outdoors, it mixes with the passing air and disperses harmlessly in the atmosphere. But when it is released into the basement of a poorly ventilated home, it can accumulate in unhealthy amounts. The majority of radon that enters a building comes in through cracks and holes in the foundation from the rocks and soil. Other sources of radon include well water and building materials made of rock such as bricks and concrete. *Note:* Uranium, the parent of the radioactive decay series containing Radon-222, is not concentrated in all rock types but is concentrated mainly in igneous rocks, shales, slates, and schists.

The level of radon inside a building is determined by a number of factors. The materials used to construct the building, the building's ventilation system and/or exchange with outside air, the concentration of radon in the soil, and the permeability of the soil all play a role in the amount of radon in the air of the building. The geology of the building's location is also an important factor. (See the student sheet, "U.S. RADON LEVELS.")

Studies by the EPA indicate that as much as 10 percent of all American homes, (about 8 million homes), may have elevated levels of radon. In Alabama, the highest concentration of radon in the state is in Madison in the northern part of the state near the Tennessee border. Elevated radon levels can occur anywhere, even in an area not noted for high radon levels. To find out if radon levels exceed normal standards, homes must be tested. Two common types of detectors are available. One kind uses charcoal canisters that are exposed for two to seven days; the other uses alpha track detectors that are exposed for a month or longer. The EPA has developed a publication for each state called "EPA's Radon Measurement and Proficiency Report," which lists firms and laboratories that have demonstrated their ability to measure accurately radon in homes. It is recommended that all homes and all schools be tested!

If radon levels exceed EPA guidelines, various measures can be taken to reduce radon exposure. An action plan might include one or more of the following: sealing cracks and other openings in basement walls and floors; ventilating crawl spaces; installing sub-slab or basement ventilation; installing air-to-air heat exchanger. The EPA suggests using experienced professional help in selecting and installing radon reduction measures for all but the most skillful "do-it-yourselfers." The EPA booklet "Radon Reduction Methods: A Homeowner's Guide" offers advice on evaluating options for reducing exposure and for selecting a contractor.

VOCABULARY:

radon, half-life, radioactive, decay, isotope,atom, polonium, radiation

PROCEDURE:

Setting the Stage

1. Define the terms radon, atom, radioactive isotope, radioactive decay, and radiation.
2. Use a rubber band to demonstrate changes of energy levels in radioactive isotopes.
3. Explain why radon is a serious environmental problem. Explain how radon gas decays into four "radon daughters" and how the radiation given off by these decay products can cause lung cancer.
4. Explain to the students that they will be doing two activities. The first is a demonstration of the steps in the radioactive decay of Radon-222. The second is identification of the routes radon gas can take to get into air, homes, and water.

Activity

Select nine students to participate in a demonstration of radioactive decay. Allow 10-15 minutes for this demonstration.

1. Use separate sheets of paper labeled Radon-222, Polonium-218, Lead-214, Bismuth-214, Polonium-214, Lead-210, Bismuth-210, Polonium-210, and Lead-206 as signs to label the students. (Tape the signs to their shirts.) Note: The four main "radon daughters" that cause lung cancer are Polonium-218, Lead-214, Bismuth-214, and Polonium-214. This exercise shows the complete decay of Radon-222 to Lead-206, so it includes additional decay products.
2. Place nine chairs side-by-side in the front of the classroom and put a small piece of masking tape on the back of each chair. It should be easy for the students to remove the tape.
3. Blow up a large balloon. Do *not* overfill the balloon; it should be "squeezable" at the start.
4. Have the students sit in order, left to right, from Radon-222 to Lead-206. (See the teacher sheet "STEPS OF RADIOACTIVE DECAY OF RADON-222," included.) Tell the class the demonstration will focus on the decay products of Radon-222.
5. Explain to the class that they are going to see a demonstration of radioactive decay. Tell them the balloon is a Radon-222 atom and it is going to decay down to a Lead-206 atom. During each step, radiation is released; and the atom decreases in atomic weight. Explain to the students that in real life the changes in size occurring during radioactive decay are relatively small.
6. Give the first student a straight pin and the balloon. Ask the student to poke a hole in the balloon gently and then *immediately* cover the hole with the masking tape provided on the back of the chair. ***Note:*** You may want to practice this first with the students. Explain that the air escaping the balloon represents energy in the form of radiation. Have the remaining students repeat this process in order. As the process goes on, explain the time each "half-life" takes. A "half-life" is the amount of time it takes for "half" of the sample to convert into its daughter isotope. For example, it takes 3.82 days for Radon-222 to become Polonium-218. Remind them that after 3.82 days, only half of the Radon-222 would be converted to Polonium-218.
7. Have the Polonium-218, Bismuth-214, Lead-214, and Polonium-214 atoms stand up. Explain to the class that these are the "radon daughters." They are solid particles. When they are inhaled, they can lodge in the lungs. Radioactive atoms must decay while in contact (or at least in very close proximity) with lung tissue to do any damage to cells. Cancer may be caused when these daughters break down.

Explain to the students that radon is a gas. Discuss the characteristics of a gas that will affect radon and its movements.

1. Explain that gases will expand or move to fill a space. Blow up another balloon (or use the balloon from the demonstration). Gas (air) is filling the inside of the balloon.
2. Explain that air moves through soil slowly. Gases like radon move in the same way. When minerals decay radioactively and organic matter decomposes, the gases that are generated escape through the soil into the atmosphere.
   a. Show the class a handful of soil. Explain that the soil is like a sponge with many pores filled with air, though we cannot easily see this.
   b. Set up a demonstration to show how air moves through the soil. Water will represent the soil, and food coloring will represent the air. Gently put a glass container of water in an area where it will not be moved in any way. Put one large drop of blue food coloring into the water, and have the students check it several times during the class period to see how the color, representing air in soil, has spread.
3. Radon gas can escape through all kinds of rock fractures. Fractures in rock commonly form where different rock types are side by side. (Igneous, sedimentary, and metamorphic are the three major rock categories.) Sedimentary rocks, such as limestone and shale, also can have many cracks and fractures within the formation.

Have the students trace the routes that radon gas takes from rocks and soil into the air, homes, and water.

1. Distribute the student sheet "WHERE DOES THE RADON GO?" (included). Have the students use a colored felt-tip pen to trace the routes of radon into the air, home, or water. Allow 5-10 minutes for this.
2. Place a transparency of the student sheet on an overhead projector. Ask several students to come forward one at a time, each tracing one of the radon routes. Continue until all routes have been traced.

Have the students trace the routes of radon into homes.

1. Distribute the student sheet " RADON ROUTES IN THE HOME" (included). Have the students use colored felt-tip markers to trace the potential routes.
2. Place a transparency of the student sheet on the overhead projector. Ask several students to come forward one at a time, each tracing one of the radon routes. Continue until all routes have been traced.

Discuss the radon issue with the students using the following questions:
1. How many different ways can radon enter a home?
2. What do you think happens to the radon gas once it is in your home?
3. Can you get rid of radon gas once it is in your home? How?
4. How do you find out if your home is contaminated with radon?
5. What could you do to prevent radon from entering your home?

EVALUATION:

1. Create a short radio public service announcement about radon and have it run on the school or community station.
   - What it is.
   - Why it is an indoor pollutant.
   - Explain the process of radioactive decay.
   - Explain why radon is harmful and how to deal with the problem.
2. Using the worksheets, trace the route radon can take from bedrock and soil into air, water, homes, and eventually human bodies.

EXTENSIONS:

1. Have the students research to find out if they live in a radon-prone area. If they do, you may want to have the students conduct radon tests in their home or school. Home test kits listed by the EPA are often available for a reduced fee. Check with the regional EPA air quality division or write to the EPA Public Information Center, U.S. EPA, (PM 211B) 401 M Street, SW, Washington, D.C. 20460.
2. Have the students list ways radon potentially could contaminate their homes. The students could do a cut-away drawing, similar to the handout, to help them map possible radon routes. Also have them fill out the "HOME RADON EXPOSURE SURVEY" (included). Suggest that the students have their parents or guardians help them answer the survey questions.

ORIGINAL DEVELOPMENT RESOURCES:

"Soils of Alabama" poster, Legacy, Inc. P.O. Box 3813, Montgomery, AL 36109, www.legacyenved.org, 1-800-240-5115.

American Lung Association. (1992). "Facts about radon: The health risk indoors." pamphlet, p. 8.

Lasch, D. K. (1988). "On radon." *Virginia Minerals*, 34, pp. 1-4.

"Radon in the Northeast." (1988). Special issue of *Northeastern Environmental Science*, 7(1). [Available Northeastern Science Foundation]

Order information from the Geological Survey of Alabama at www.gsa.state.al.us

Home Radon Exposure Survey

1. Check geologic and soil maps of your area. Determine the types of bedrock and soil underlying your home.
   a. What is the main type of bedrock in your area?
   b. What types of soil do you have in your area?

2. What types of building materials are in your home?

3. Describe the foundation of your home.

4. Do you have a basement in your home?
   a. Does your basement floor have cracks?
   b. Do your basement walls have cracks?
   c. Is your basement sealed to keep moisture out?
   d. Is the basement of your home completely below ground?
   e. Does the basement have ventilation?

5. Is your home drafty or tightly sealed with insulation?

6. Is there a place for air to circulate underneath your home?

7. Does your home have an exhaust fan?
   a. Is it an all-house (attic) fan or an exhaust fan in a bathroom or over a stove?
   b. Where is it located?
   c. How often is it used?

8. Do you use fans other than exhaust fans? What kinds are they, and where are they located?

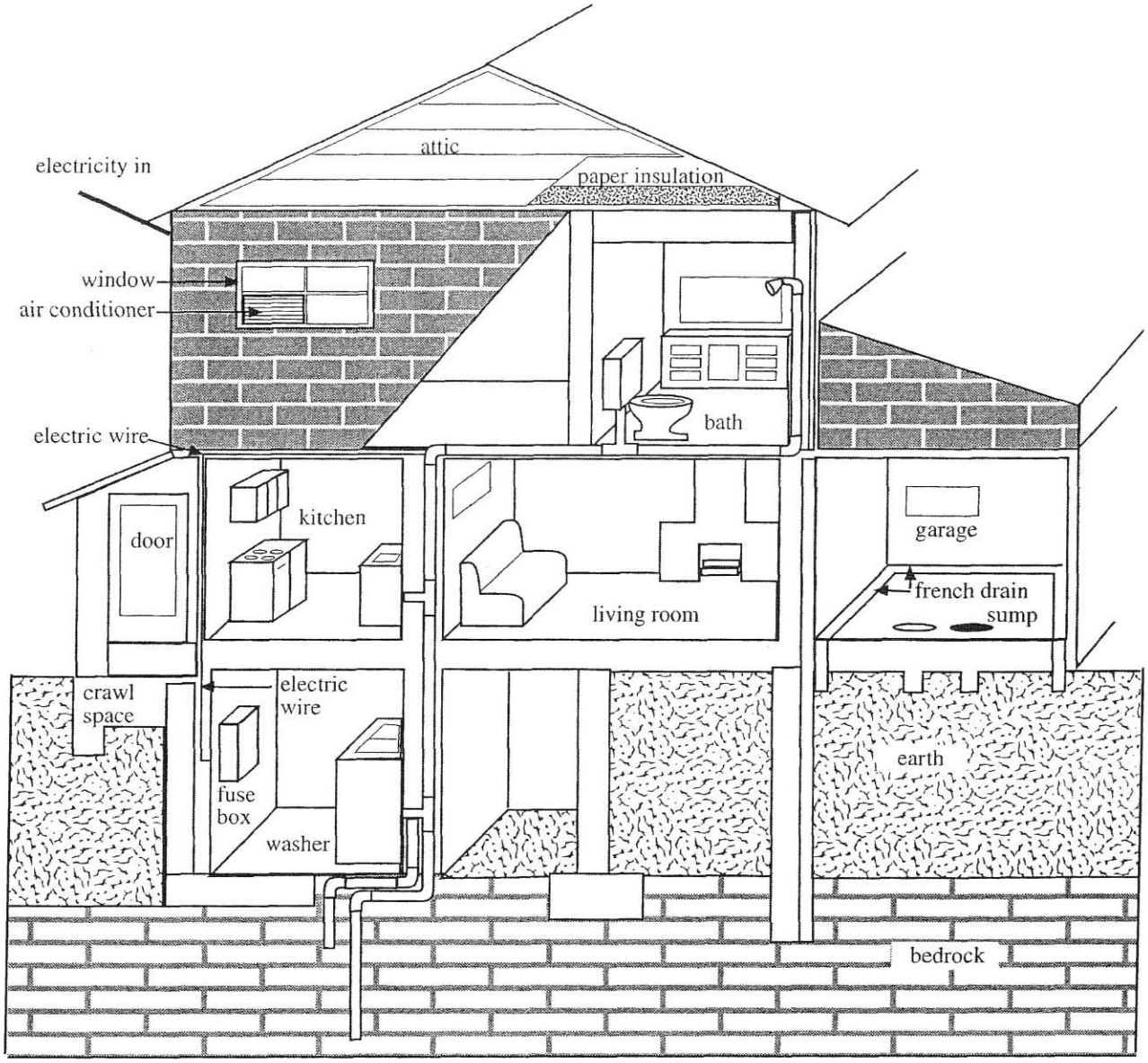
9. Do you "air-out" your home for several hours or days from time to time?

10. About how many hours do you spend in your home each day?

11. In which room(s) does your family spend most of their time when they are at home?

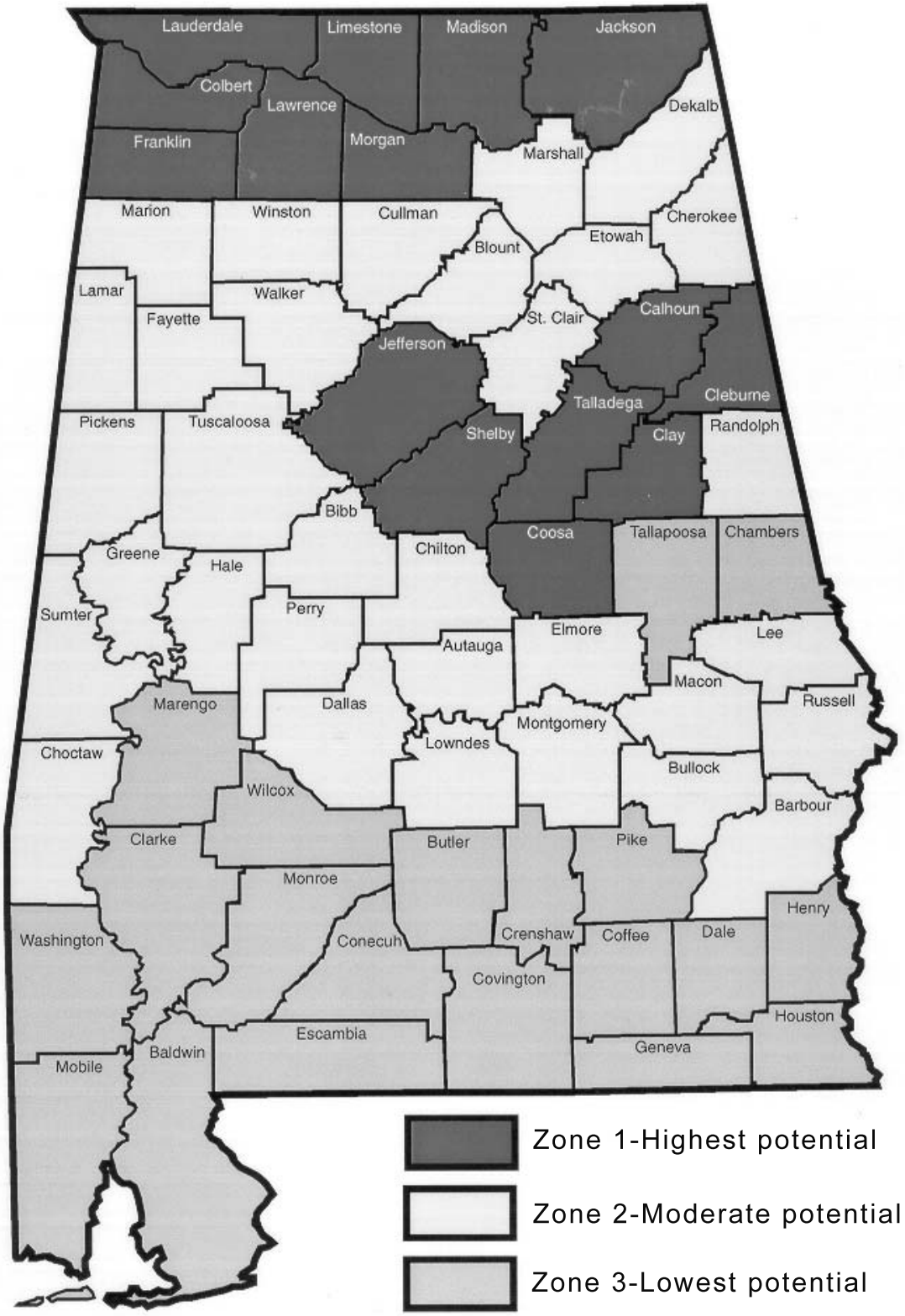
12. What is the water source for your home? If you use well water, does the well water flow through limestone or shale? (Check the soil map again.)

Radon Routes In The Home



Directions: Use a colored marker to trace all the possible routes by which radon may enter this home.

U.S. Radon Levels

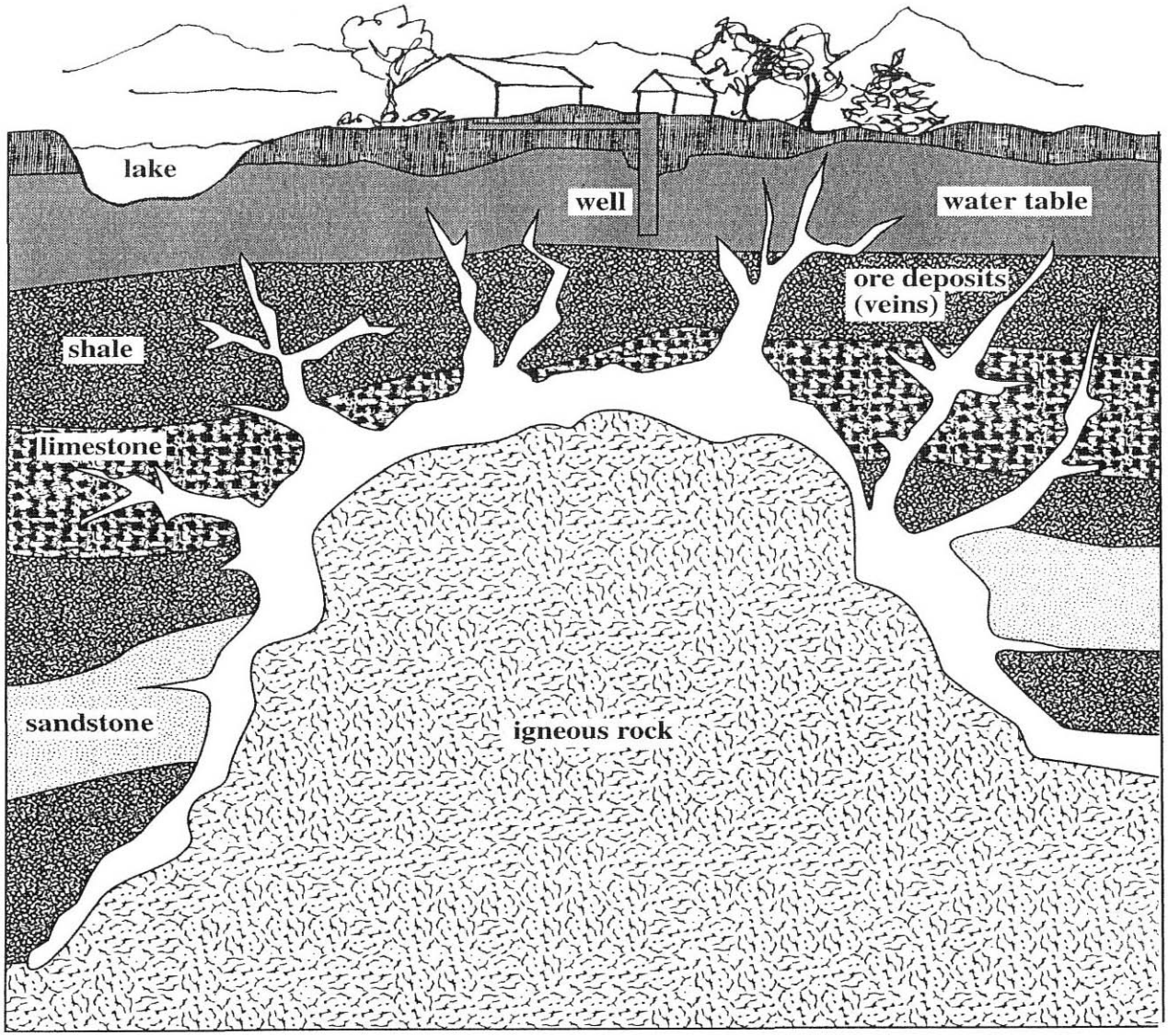


ALABAMA COOPERATIVE Extension SYSTEM

Map provided courtesy of the Alabama Radon Education Program of the Alabama Cooperative Extension System of Auburn University.

RADON IN ALABAMA

Where Does Radon Go?



Directions :

1. Using a colored marker, place a dot anywhere on the page to represent the source of radon for which you are going to trace routes.

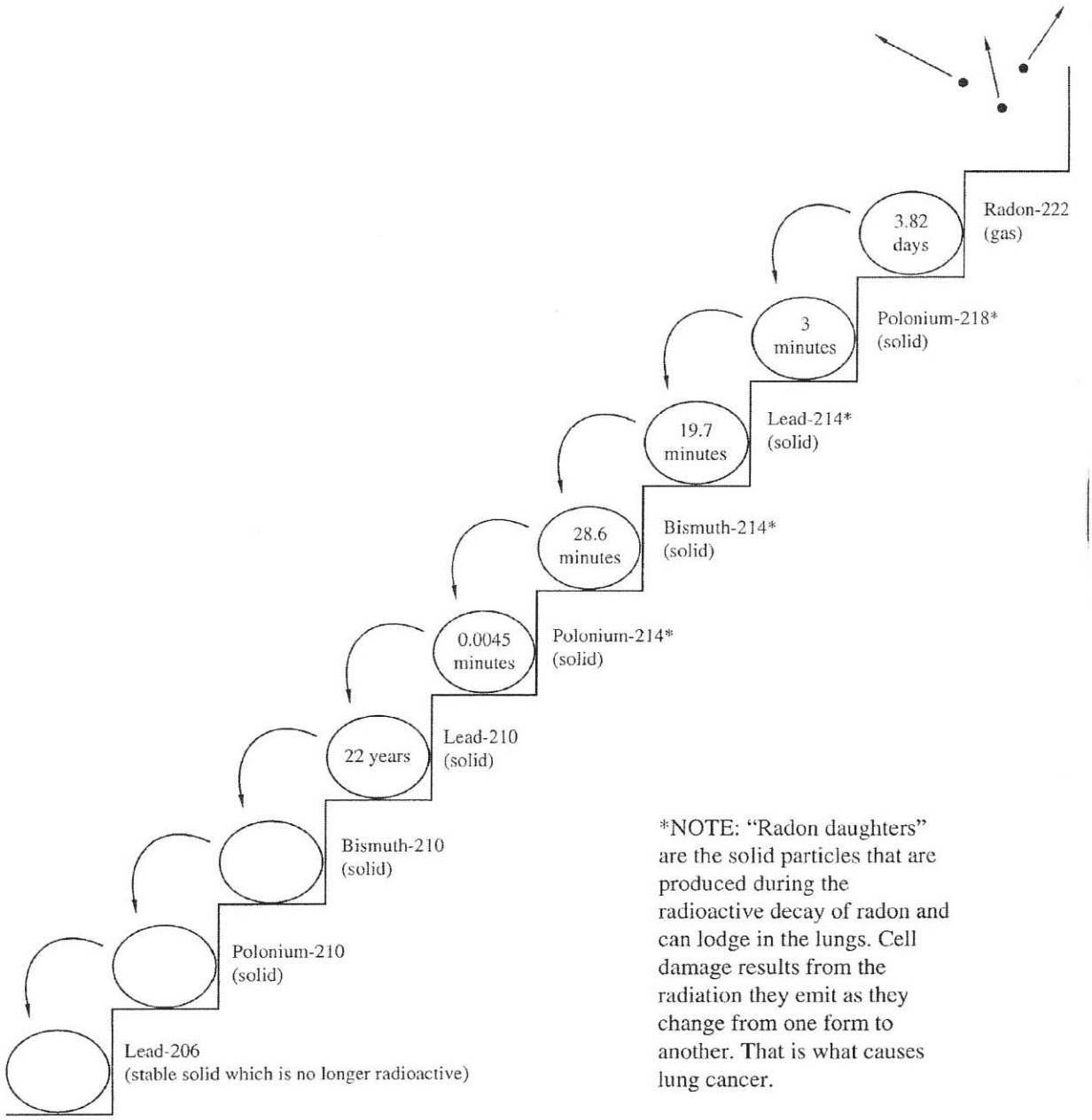
2. Trace the possible pathways of radon into the air.

3. Trace the possible pathways of radon into a home.

4. Trace the possible pathways of radon into water.

Note: *Radon may occur in all types of rocks and soil in varying amounts.*

Steps Of Radioactive Decay Of Radon-222



*NOTE: "Radon daughters" are the solid particles that are produced during the radioactive decay of radon and can lodge in the lungs. Cell damage results from the radiation they emit as they change from one form to another. That is what causes lung cancer.

Notes

Enlightened And Reformed -- Hazardous Substances

OBJECTIVE:

Students will be able to:

1. Identify hazardous substances in the home.

BACKGROUND:

The lifestyles we enjoy today in the United States would be quite different without the use of chemicals and chemical by-products. Still, our improved lifestyles create potential hazards. Many communities have established telephone hot-lines or waste alerts to be used by citizens in response to hazardous incidents. Such programs are valuable for the protection of public health and the environment by helping to enforce hazardous waste laws. Sometimes we recognize the problem, but we don't always know what to do about it. The major purpose of this activity is for students to participate actively in the identification of hazardous substances and identify sources of information, should a problem occur. See "To Clean or to Glean" in Learning Through Legacy (9-12).

Grades:

9-12

Subjects:

Economics, Home Economics, Biology, Chemistry

Time Needed:

Two to three class periods (not consecutive), plus home assignment

Materials:

student sheets (included)
home cleaning products

A*erosol sprays* may still contain cloroflourohydrocarbons (CFCs), which harm the ozone layer. This is rare now; look for "ozone friendly" on the can.

Antifreeze has a sweet taste but is harmful or fatal if swallowed because it contains ethylene glycol.

Chlorine bleach kills useful bacteria in septic tanks; chlorine is known to cause cancer.

Detergents contain phosphates that speed the growth of algae that can kill fish, plants, and other aquatic life when too much is present. *Dishwashing detergents* may even contain arsenic, which makes sewage sludge unusable as fertilizer. (Note that today's detergents mostly are phosphate-free).

Drain cleaners contain lye and hydrochloric and sulfuric acids, which are all caustic.

Floor and furniture polish contain phenol, which has caused cancer in lab animals.

Fuels, such as gasoline, propane, natural gas, lighter fluid, and charcoal briquette starter fluid, evaporate at room temperature and give off fumes that are harmful when inhaled and are flammable. They also affect our overall air quality.

Metal polishes made with ammonia, phosphoric acid, and sulfuric acid cause breathing problems.

Mothballs contain cancer-causing p-dichlorobenzene.

Oven cleaners may contain lye, which is caustic.

Pesticides are liquids and vapors that are harmful or fatal to humans and animals.

Toilet cleaners contain chlorine and hydrochloric acid, which are toxic to animals.

VOCABULARY:

hazardous waste, toxic, ignitable, corrosive, reactive, environment, EPA

PROCEDURE:

Activity, Day One

1. Initiate the discussion by defining the term "hazardous waste" (waste that poses a substantial current or potential hazard to human health or the environment when improperly stored, treated, transported, or disposed of).
2. List the Environmental Protection Agency's (EPA's) four major categories of hazardous waste: toxic, reactive, ignitable, and corrosive. (The acronym TRIC may be helpful for remembering the four categories.) Ask students to define the terms in their own words and give an example of each using the "Characteristics of Hazardous Waste" handout
3. Explain to students they will be taking an inventory of hazardous substances found in their home.
4. Give each student a copy of the student sheets "Home Safe Home Hazardous Waste Guidelines" and "Products: Potential Hazards."
5. Ask students to brainstorm all the places in the home where hazardous substances might be found such as storage rooms and closets, kitchen, bathrooms, and hobby rooms.

Home Assignment:

1. Survey your own home and bring to class a list of products with the hazardous chemicals they contain.
2. Assign each chemical to one of the four categories (corrosive, toxic, reactive, or ignitable).

***Note*:** Caution students to use care when handling potentially dangerous materials such as lye or chlorine bleach.

Activity, Day Two

1. Divide the class into five or six teams. Each team is to research and report on one of the following topics:
   - Proper disposal of products on the "Products: Potential Hazards" lists.
   - An alternative, non-hazardous product for each product on the lists.
   - Available agencies, organizations, or programs in their community to which a citizen could turn for help for problems with hazardous substances on their lists such as law enforcement agencies, hospitals, medical associations, and county health departments; fire departments and poison control centers; state information, management, compliance, and health services. Include name, full address, telephone number, and any special instructions.

EVALUATION:

1. When all assignments are complete, ask each group to compile its data and share them with the class.

EXTENSIONS:

1. Encourage students to use the data they have collected as the basis for a publication that could be made available to the school and community newspapers. The publication could include:
   - Typical products of the home and institutions (the list they compiled).
   - The hazardous category of each product together with an explanation of the hazard.
   - Recommendation for proper disposal of the hazardous substance.
   - An alternative, non-hazardous product for the hazardous substance.
   - Who to call for help for problems with hazardous substances.
2. Define and categorize hazardous substances.
3. Describe sound disposal practices for each category.
4. List one non-hazardous alternative for a potentially hazardous product in each category.

ORIGINAL DEVELOPMENT RESOURCES:

Characteristics of Hazardous Waste, 401 KAR 31:030, 1986. See Hazardous Waste Regulations handout.

"Hazardous Waste Wheel", Legacy, Inc. P.O. Box 3813, Montgomery, AL 36109, www.legacyenved.org, 1-800-240-5115.

Harte, J. et.al. *Toxics A to Z: a guide to everyday pollution hazards*. 1991. University of California Press. (ISBN 0520072243).

Dadd-Redalia, D. *Home safe home: protecting yourself and your family from everyday toxics and harmful household products in the home*. 1997. J.P Tarcher. (ISBN 0874778594).

www.epa.gov (solid waste and energy responses)

Home Safe Home Hazardous Waste Guidelines

These products, and many more that are commonly found in our homes,3 can be toxic, reactive, ignitable, or corrosive! Some products can contaminate our groundwater (including drinking water from wells), our soil (entering the food we eat), and the air we breathe.

A few guidelines will help you use chemical products safely in your home.

USE A NONHAZARDOUS PRODUCT. Choose products that are biodegradable or low in phosphates.

READ LABELS CAREFULLY. Know what you are buying.

BUY ONLY WHAT YOU NEED. Reduce amount to be discarded.

DO NOT MIX BLEACH AND AMMONIA. Reaction can be deadly!

KEEP LABELS ON THE CONTAINERS. Keep this important information available.

DO NOT STORE IN PLASTIC OR FOAM CONTAINERS. Some chemicals react with these materials.

DO NOT REUSE CONTAINERS THAT HAVE BEEN USED FOR CHEMICALS. Many chemicals are persistent.

Products: Potential Hazards

Products	Toxic	Reactive	Ignitable	Corrosive
Cleaners				
Ammonia	X			
Bleach	X			X
Disinfectant	X			X
Window Cleaner	X			
Drain Cleaner	X			X
Oven Cleaner	X			X
All-Purpose Cleaner	X			X
Rug/Upholstery Cleaner	X			X
Furniture Polish & Wax	X			
Brass Polish	X			X
Silver Polish	X		X	X
Spot Cleaner/Remover	X	X		
Cosmetics				
Nail Polish Remover	X		X	
Hair Dye	X			
Hair Spray	X		X	
Automotive Products				
Wax & Polish			X	
Antifreeze	X			
Gasoline/Kerosene	X		X	
Motor Oil	X			
Engine Degreaser	X			
Car Battery	X			X
Pesticides				
Mothballs	X			
Rodent Poison	X			
Ant, Wasp, Roach Spray	X			
Slug Bait	X			
Insecticide	X			
Herbicide	X			
Flea Powder/Spray	X			
Hobby Supplies				
Ammunition		X		X
Photo Chemical	X			
Chemistry Set	X	X	X	X

Products: Potential Hazards (con't)

Products	Toxic	Reactive	Ignitable	Corrosive
Paints/Preservatives				
Paint	X		X	
Solvent/Thinner		X		X
Drier	X		X	
Wood Preservative		X		X
Stripper	X		X	
Medicines	X			

Household Products Trace

PRODUCT:
Aerosol Spray Products, Health, Beauty and Cleaning Products.
HEALTH EFFECTS - Aerosol products release particles into the air that can be inhaled into your lungs and can be absorbed into your bloodstream. A chemical that is harmless to external parts of the body may be extremely dangerous if inhaled as an aerosol mist. Aerosol spray products have been associated with headaches, nausea, shortness of breath, eye and throat irritations, skin rashes, burns, lung irritation, liver damage, and heart problems. Aerosol products will explode if they are exposed to heat, causing burns and very serious injury.
WHAT YOU CAN DO - You can buy products in a *non*-aerosol form. Many products come in creams, solids, liquids, or pump sprays. They can save money; aerosol products are more expensive. If you do use aerosol products, **do not inhale** the fumes! Do not expose certain aerosol containers to heat. Never throw empty aerosol containers into a fire.

PRODUCT:
Chlorine Bleach
HEALTH EFFECTS - Chlorine bleach can irritate and burn the skin and eyes. The fumes from chlorine bleach irritate the eyes and nose. **Never mix chlorine bleach with ammonia, toilet bowl cleaners, or other products to make a stronger cleaning solution;** the chemicals in the products may not be compatible and could produce very dangerous gases. Look for labels warning against mixing with other products.
WHAT YOU CAN DO - Handle chlorine bleach with care! Better yet, mix baking soda in water to make a good cleaning solution.

PRODUCT:
Detergents
HEALTH EFFECTS - *Non-phosphate detergents* can be highly alkaline and can cause skin and eye irritations. They are very dangerous if swallowed. *Phosphate detergents* can pollute water systems by causing an explosive growth of algae. The phosphate acts as a fertilizer.
WHAT YOU CAN DO - Reduce the use of detergents. Use low-phospate detergents. Use soap or baking soda as an alternative.

PRODUCT:
Solvents (substances that dissolve something else) - Paint thinners, furniture strippers, dry cleaning fluids, degreasers, turpentine, and nail polish removers
HEALTH EFFECTS - Most solvents dissolve skin oils, causing skin irritation and damage. Solvent vapors or splashing of the liquid in the eye can cause severe damage. The same absorbency that allows contact lenses to retain medication also retains strong vapors from solvents. Instead of being washed away quickly by tears, chemicals are held against the eyes until the lenses are removed. The time of exposure can cause considerable eye damage or irritation. The breathing of solvents, which evaporate quickly and enter the air, can cause nose and throat irritations, can damage lung tissue, and can enter the bloodstream through the lungs. Repeated exposure to small amounts of some solvents can cause internal damage to the liver and kidneys, the first line of defense against unwanted chemicals in the blood.
WHAT YOU CAN DO - Use solvents with utmost care and respect. If possible, use solvents outdoors. When using indoors, have plenty of fresh air and good ventilation. Never transfer solvents to unlabeled containers, especially food/drink containers.

PRODUCT:
Air Fresheners
HEALTH EFFECTS - Air fresheners may interfere with the natural sense of smell by coating nasal passages with an oily film or with a nerve-deadening agent. Air fresheners don't eliminate room odors; they simply introduce a new smell and mask the offensive odor.
WHAT YOU CAN DO - Use a box of baking soda in the refrigerator to remove odors, a dish of hot vinegar to remove room odors, or a bouquet of flowers or herbs to give the room a pleasant smell.

PRODUCT:
Paints
HEALTH EFFECTS - Chemicals in paints can irritate the eyes, skin, and lungs. Fumes can cause headaches, nausea, respiratory problems, muscle weakness, and liver and kidney damage. Some paints are flammable.
WHAT YOU CAN DO - Paint items outdoors when possible. When you paint indoors, make certain there is adequate ventilation. Latex paints eliminate the need to use paint thinners that contain additional toxic chemicals.

PRODUCT:
Hobby Materials - Glues & Epoxy
HEALTH EFFECTS - Glues and epoxy are flammable. They irritate the skin and lungs and can make one more sensitive to a number of other substances. Some people have died after deliberately inhaling fumes from these products.
WHAT YOU CAN DO - Read product labels carefully. Wear gloves when you use them, and make certain you have good ventilation. Store these products away from heat and children.

PRODUCT:
Hobby Materials - Photography Supplies
HEALTH EFFECTS - Dangerous chemicals used to develop photographs are methanol, xylenol, methylene chloride, turpentine, benzene, acetates, and hydrochloric acid. Methylene chloride and benzene are associated with cancer. Many chemicals are flammable and can cause skin, eye, and lung irritations; some contain acids that can burn and blind.
WHAT YOU CAN DO - Use these materials only in a well-ventilated area. Wear goggles and gloves. Store these chemicals in unbreakable containers away from heat. Store acids in non-metal containers. Avoid products that contain benzene.

PRODUCT:
Hobby Materials - Glazes
HEALTH EFFECTS - Many heavy metals are used in glaze materials to produce beautiful colors. Uranium, lead and zinc chromate, and cadmium can cause cancer; all chromium and nickel compounds are suspected cancer-causers. Antimony, manganese, and cadmium compounds are highly toxic by inhalation.
WHAT YOU CAN DO - Use less toxic colorants, such as many iron compounds (oxides, ochres), titanium, tin, zirconium, copper, and cobalt compounds.

PRODUCT:
Rug and Upholstery Cleaners
HEALTH EFFECTS - These cleaners may contain chemicals that, when inhaled, can cause nausea, anemia, liver damage, convulsions, and possibly coma.
WHAT YOU CAN DO - Wear gloves and have adequate ventilation during the cleaning process. Clean rugs and upholstery with a non-aerosol shampoo.

Hazardous Waste Regulations

CHARACTERISTICS OF HAZARDOUS WASTE

I. Characteristic of Ignitability

Waste exhibits the characteristic of ignitability if a representative sample of the waste has any of the following properties:

A. It is a liquid and has a flash point less than 60 degrees Celsius (140 degrees F).

B. It is not a liquid and is capable, under standard temperature and pressure, of causing fire through friction, absorption of moisture, or spontaneous chemical changes, and, when ignited, burns so vigorously and persistently that it creates a hazard.

C. It is an ignitable, compressed gas.

D. It is an oxidizer.

II. Characteristic of Corrosivity

Waste exhibits the characteristic of corrosivity if a representative sample of the waste has either of the following properties:

A. It is aqueous and has a pH less than, or equal to, 2 or greater than,or equal to, 12.5.

B. It is a liquid and corrodes steel at a rate greater than 6.35 mm per year at a test temperature of 55 degrees Celsius.

III. Characteristic of Reactivity

Waste exhibits the characteristic of reactivity if a representative sample of the waste has any of the following properties:

A. It is normally unstable and readily undergoes violent change without detonating.

B. It reacts violently with water.

C. It forms potentially explosive mixtures with water.

D. When mixed with water, it generates toxic gases, vapors, or fume in a quantity sufficient to present a danger to human health or the environment.

E. It is a cyanide or sulfide-bearing waste that, when exposed to pH conditions between 2 and 12.5, can generate toxic gases, vapors, or fumes in a quantity sufficient to present a danger to human health or the environment.

F. It is capable of detonation or explosive decomposition or reaction if it is subjected to a strong initiating source or if heated under confinement.

G. It is capable of detonation or explosive decomposition or reaction at standard temperature and pressure.

IV. Characteristic of Toxicity

Waste exhibits the characteristic of toxicity if the extract from a representative sample of the waste contains any of the following contaminants: Arsenic, Barium, Cadmium, Lead, Mercury, Selenium, Silver, Endrin, Lindane, Methoxychlor, Toxaphene, 2,4-D, or 2, 4, 5.

ORIGINAL DEVELOPMENT RESOURCES:

Tennessee Valley Authority, www.tva.gov.

Notes

Are Those Fish Safe To Eat?

OBJECTIVES:

Students will be able to:

1. Identify fish advisories existing for specific locations within Alabama. (See charts.)
2. Locate the advisories on a map.
3. Explain the difference between a *limited consumption* advisory and a *no consumption* advisory.
4. Describe which toxic contaminants have caused problems in Alabama and give the history behind their use.
5. Explain what happens when fish are tested and found to be contaminated.

Grades:
9-12

Subjects:
Science, Math, Geography

Time Needed:
One to two class periods

Materials:
Alabama map
map of ADEM-ADCNR-TVA fish tissue sampling locations
copies of current Alabama Fishing advisories pamphlet
copies of current postings for different locations in the state
information from the local newspaper and magazines on fish advisories or toxic contaminants

BACKGROUND:

Water quality standards are set and enforced by federal, state, and local government agencies. The adoption of water quality standards is a state responsibility that is overseen by the Environmental Protection Agency (EPA). The Alabama Department of Environmental Management (ADEM) is the permitting authority under the National Pollutant Discharge Elimination System (NPDES) and is the agency that enforces the laws of the Clean Water Act. Under the Clean Water Act, the owner or operator of a facility covered by an NPDES permit is required to monitor effluent or wastewater quality at regular intervals, maintain complete and accurate records, and report the results. Regulators can also monitor water quality at such sites to determine compliance with permit requirements and notify the operator of any violations. Fines can be assessed for violations. (ADEM can supply a list of facilities in your county that have NPDES permits.) The Geological Survey of Alabama monitors and keeps records of water well usage, ground-water levels, and water quality.

VOCABULARY:

advisory, aquifer, carcinogen, contaminant, discharge, enforcement, regulation, risk, toxic, effluent, water quality, watershed

PROCEDURE:

1. Have students read the “Alabama Fishing Advisories” pamphlet.
2. Pass out and have students read copies of current postings.
3. Help students locate on their maps where the current posting locations are across the state.
4. Have students study the fish tissue sampling map to see the 73 locations that ADEM tests (28 major reservoirs, 26 streams and 19 ADCNR-managed public fishing lakes).
5. Have students make a list of which pollutants are listed on the chart.
6. Have students make a list of species listed on the chart.
7. Discuss the history behind contaminants, helping students to realize that current problems often result from toxic materials that were discharged years ago.
8. Discuss NPDES (National Pollutant Discharge Elimination System), which regulates discharges to prevent further water degradation.

EVALUATION:

1. Teacher may note student participation during exercise.

EXTENSIONS:

1. Have students research the Clean Water Act.
2. Have students contact their senators or congressman for current information on the Clean Water Act. Find out what they support.
3. Invite a local environmental leader to speak to the class about stream classification in the county (especially fishable/swimmable).
4. Contact ADEM or GSA for additional information on stream use classification within your watershed.
5. Assign teams of students to research the toxic chemicals and report to the class the health risks associated with each.
6. Contact GSA for information on water quality and fish species within your watershed.

ORIGINAL DEVELOPMENT RESOURCES:

Alabama Department of Environmental Management: www.adem.state.al.us (for environmental management information and information on fish and wildlife and water use classifications).

Alabama Department of Public Health, Division of Epidemiology. 1-800-338-8374, Risk Assessment Branch, 201 Monroe Street, RSA Tower Suite 1460, Montgomery, AL 36104, www.adph.org (for current Fish Consumption Advisory).

Bolton, M. (1994, March 20). "You Caught It, But Can You Eat It?" *The Birmingham News*, p.1B.

Geological Survey of Alabama. www.gsa.state.al.us., 420 Hackberry Lane, University of Alabama, Tuscaloosa, AL, 205-349-2853. (for information on biological monitoring of Alabama's fish).

Alabama Department of Conservation & Natural Resourced, Division of Wildlife and Freshwater Fisheries, 64 N. Union Street, Montgomery, AL 36130-3020, 334-242-3471, www.dcnr.state.al.us.

Rabiroff, J. (1994, July 21). New ADEM Fish-Eating Rates Mean Toxins Must Be Cut. *The Birmingham News*, p. 1C.

Mettee, M. and O'Neil P. *Fishes of Alabma and the Mobile basin*. 1996. Oxmoor House.

Alabama Fish Tissue Sampling Program

Concern: Public consumption of fish that potentially contain Hg, PCB, dioxin/furan, and other pollutants.

Response: State program combines resources of ADEM, ADCNR, and ADPH, with cooperation of TVA, to obtain statewide data.

Plan: Sample 73 frequently fished locations at recurring intervals so that information is frequently obtained and updated.

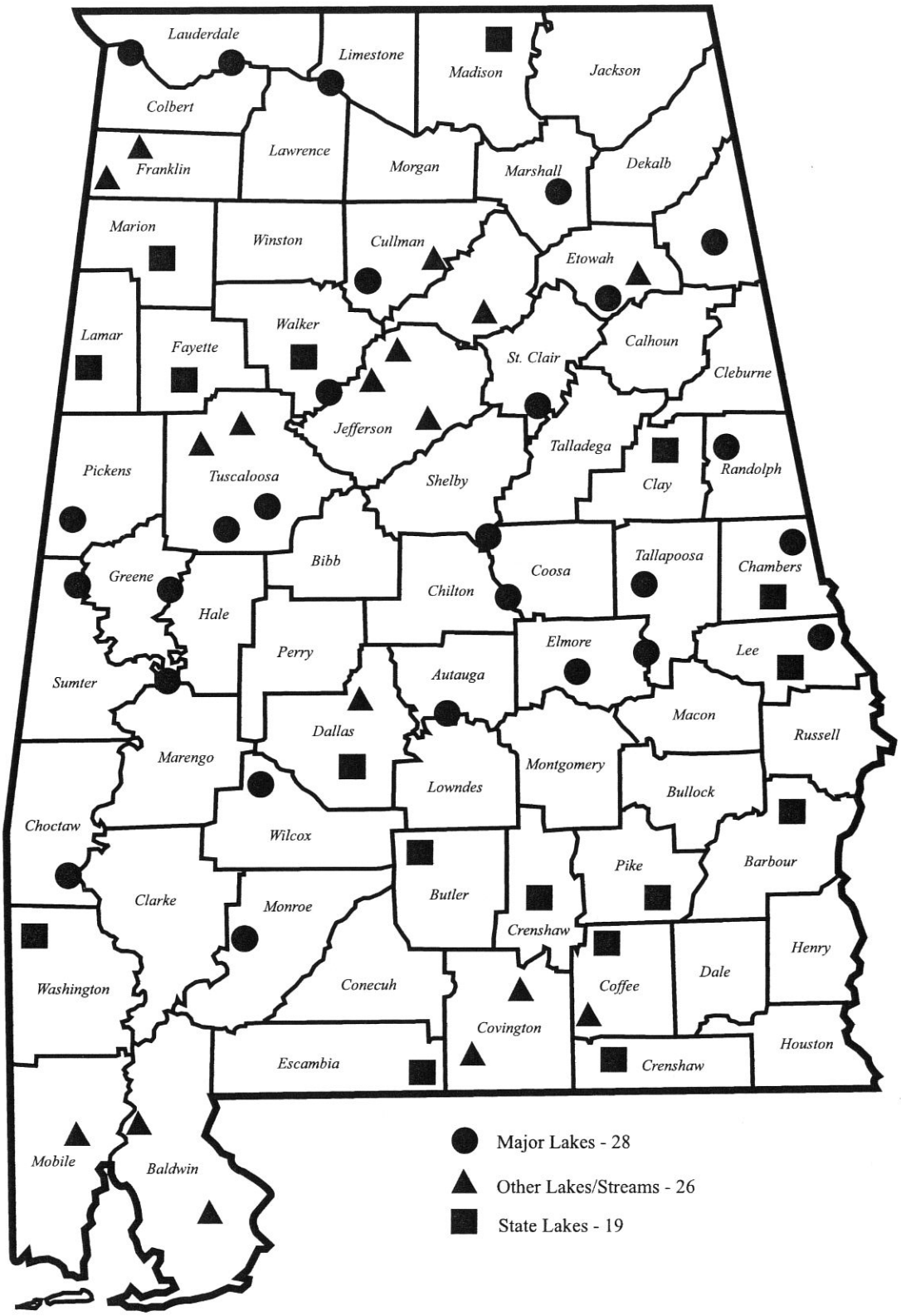
Analyze tissue for pollutants of concern and for which FDA has an action level. (1993)

Parameter	FDA Advisory Level (mg/l)
1. Chlordane	0.3
2. Chlorpyrifos (Dursban)	——
3. DDT	5.0
4. Dieldrin	0.3
5. Endrin	0.3
6. Heptachlor	0.3
7. Mercury	1.0
8. Mirex	——
9. PCB	2.0
10. Toxaphene	5.0

Fish Consumption Advisory

The Alabama Department of Public Health has issued a fish consumption advisory for Choccolocco Creek from the confluence of Snow Creek and Choccolocco Creek, south of Oxford, to where Choccolocco Creek flows into Logan Martin. The Department recommends persons avoid eating all fish caught from this area. Several species of fish were found to have levels of polychlorinated biphenyls over the Food and Drug Administration tolerance level.

ADEM - ADCNR - TVA
Fish Sampling Locations



ALABAMA FISH CONSUMPTION ADVISORIES

The State of Alabama has an abundance of clean rivers and lakes. These waters provide sport fishermen great recreation, while providing subsistence fishermen with an abundance of high quality food. However, fishermen need to understand both the benefits and the risks of their fish consumption practices, especially in areas where fish advisories have been issued.

The benefits of fishing are many. It provides stress-reducing recreational and outdoor activity needed for good health. Fish provide a high protein food, low in fat, cholesterol, and calories when prepared properly. Some components of fish, such as the omega-3 fatty acids, may enhance cardiovascular health.

Unfortunately, certain toxic chemicals have found their way into some waterbodies in Alabama. Some of these chemicals can accumulate in fish. When these chemicals reach elevated levels, they can pose health risks to people who consume these fish.

The Alabama Department of Public Health, in coordination with the Alabama Department of Environmental Management, evaluates data from the analysis of fish from Alabama waters. If these data indicate that levels of a material in fish may pose a human health concern, an advisory for consumption of the particular species of fish from a specific waterbody will be issued. These advisories are guidance. Their intent is to provide information to consumers on potential health risks. It is the responsibility of each individual to decide what risk he/she is willing to accept.

This pamphlet should help inform fishermen of particular fish species in specific bodies of water that are affected by toxic chemicals, the risks of consuming those fish, and methods for limiting risks of eating a particular catch.

DIVISION OF EPIDEMIOLOGY
RISK ASSESSMENT BRANCH

CONTAMINANTS

Fish consumption advisories have been issued for chlordane, DDT, mercury, and polychlorinated biphenyls (PCBs). **Chlordane** and **DDT** are chlorinated hydrocarbons used as pesticides. Their use was banned in the U.S. Contamination problems today result from run-off in agricultural land and other areas where it was heavily used. **Mercury** is an element and is used in a variety of products, such as barometers, thermometers, paints and batteries. Manufacturers also use mercury in the production of chlorine, caustic soda, urethane foam and other products. Such wide use has led to unintentional contamination of the environment. Naturally-occurring mercury is released into the environment when wood and/or coal are burned. Once in the environment, mercury is converted to methylmercury, which is the chemical form that is hazardous to human health. In recent years, the government has promulgated regulations to limit or ban the use of mercury in various products and industrial processes. **Polychlorinated biphenyls** (PCB's) are a class of materials, used in capacitors and transformers. They have good dielectric and fire resistance properties. In 1979, the U.S. Environmental Protection Agency (EPA) prohibited all manufacture of PCBs. All of these chemicals persist in the environment. Chlordane, DDT, and PCBs collect in fatty tissue, while mercury collects in muscle tissue of fish.

The presence of toxic contaminants in Alabama waters should decrease due to the current regulations which ban or restrict their use. Advisories are removed when their presence in the environment is reduced to levels where they pose no significant human health risk.

ADVISORIES

Advisories are to help fishermen realize and reduce the potential health risks from eating contaminated fish. When advisories are issued, fishermen can continue to catch fish and may choose to eat them; an advisory is only a recommendation.

Advisories are based on the risk of cancer or other serious illnesses that may result from eating contaminated fish. The cancer risk is usually given as 1 in 100,000 or 1 in 1,000,000 additional cancers over a lifetime of consumption. Therefore, the cancer risk from eating a few fish from the area over a few years is slight. Advisories for non-cancer causing agents are usually based on a level of a chemical below which no adverse health effects are found in animal studies. The level shown by animal studies to be safe is usually divided by 10 or more to determine a daily level of intake that is likely to be without risk of adverse health effects for humans. Women of childbearing age and children may be particularly vulnerable to the effects of toxic substances. Therefore, some advisories particularly limit consumption by these groups.

There are two types of advisories; both are for specific fish species in defined areas of lakes and streams. **A limited consumption advisory** states that women of reproductive age and children less than 15 years old should avoid eating certain fish from these areas. Other people should limit their consumption of the particular species to one meal per month. A **no consumption advisory** recommends that everyone avoid eating certain species of fish in the defined area.

ADPH-EPI-01/05-2001 (BS)

RISKS CAN BE REDUCED

Anglers who fish in an advisory area may take actions to reduce risks from contaminants in fish. Chlordane, DDT, and PCBs tend to stick to sediments; therefore, eating fish that feed on the bottom of lakes and streams (catfish, carp, buffalo fish, or sucker) should be avoided. However in waterways contaminated with mercury, game fish such as largemouth bass tend to store mercury in the muscle and should be eaten less often.

A second way to limit exposure to contaminants in fish is to keep and eat smaller fish. It's nice to catch big fish, but the longer the exposure time to a chemical, the greater the chemical level in the fish tissue. As fish grow older the conversion of food to muscle tissue changes, increasing the buildup of fat where most toxic materials are stored.

Cutting away most of the fatty tissue when cleaning fish is a third way to limit exposure to toxic chemicals. The skin, belly flap, and the fatty strip along the backbone and lateral line should be removed to reduce the amount of contaminants in the meal.

Recipes and cooking methods can be modified to provide a fourth method for reducing toxic substances in fish meals. Since most of the contaminants are stored in the fat, cook the fish in a manner that allows the juices to drip away from the meat. Broiling and grilling are recommended. Frying, chowders and stews are not recommended.

THE ALABAMA DEPARTMENT OF PUBLIC HEALTH ★ 1875 ★

Fish Consumption Advisories in Alabama

Alabama Fish Consumption Advisories
(May 2001. This list subject to change)

Water Body	County	Species	Portion	Pollutant	Type Advisory
Bay Minette Creek	Baldwin	Largemouth Bass	Entire Creek	Mercury[4]	No Consumption[1]
Chickasaw Creek	Mobile	Largemouth Bass	Entire Creek	Mercury[4]	No Consumption[1]
Choccolocco Creek	Calhoun Talladega	All Species	Entire length of Creek from South of Oxford, downstream to where Choccolocco Creek flows into Logan Martin Lake	PCBs[3]	No Consumption[1]
Cold Creek Swamp	Mobile	All Species	From confluence of Cold Creek with the Mobile River west through the swamp	Mercury[4]	No Consumption[1]
Coosa River	Cherokee	Catfish over 1 pound	Georgia state line & Weiss Dam	PCBs[3]	Limited Consumption[2]
Coosa River	Calhoun St. Clair Talladega	Catfish over 1 pound	Between Neely Henry Dam & Riverside, AL	PCBs[3]	Limited Consumption[2]
Coosa River	St. Clair Talladega	Bass: Largemouth, Spotted, Striped	Between Riverside and Vincent, including the Logan Martin Reservoir	PCBs[3]	Limited Consumption[2]
Coosa River	St. Clair Shelby Talledega	Spotted or Striped Bass, Catfish over 1 pound, Crappie	Between Logan Martin Dam & the railroad tracks crossing the Coosa River near Vincent, AL	PCBs[3]	No Consumption[1]
Coosa River	Chilton Coosa Shelby St. Clair Talladega	Striped bass, Crappie, Blue Catfish, Spotted Bass	Between Logan Martin Dam & Lay Dam	PCBs[3]	No Consumption[1]
Coosa River	St. Clair	Spotted Bass	In upper Lay Reservoir approximately two miles downstream of Logan Martin Dam and one half mile downstream from the Kelly Creek-Coosa River confluence in the vicinity of Ratcliff/Elliot Island	PCBs[3]	Limited Consumption[2]
Coosa River	Etowah	Channel Catfish	In the Croft Ferry area of Neely Henry Reservoir (Alabama Power Reservoir Mile 54)	PCBs[3]	No Consumption[1]
Fish River	Baldwin	Largemouth Bass	Entire river	Mercury[4]	No Consumption[1]
Fowl River	Mobile	Largemouth Bass	Entire river	Mercury[4]	No Consumption[1]
Gulf Coast	Baldwin Mobile	King Mackerel over 39 inches	Entire coast	Mercury[4]	No Consumption[1]
Gulf Coast	Baldwin Mobile	King Mackerel under 39 inches	Entire coast	Mercury[4]	Limited Consumption[2]
Huntsville Spring Branch & Indian Creek	Madison	Small Mouth Buffalo, Bigmouth Buffalo	From Redstone Arsenal to the Tennessee River	DDT[3]	No Consumption[1]
Mobile River	Mobile	Largemouth Bass	At and South of the confluence of Cold Creek	Mercury[4]	Limited Consumption[2]
Three Mile Creek	Mobile	Atlantic Croaker	Downstream of railroad trestle down to one mile upstream of confluence with Mobile River	Chlordane[3]	No Consumption[1]
Three Mile Creek	Mobile	Striped Bass, Speckled Trout	Downstream of railroad trestle down to one mile upstream of confluence with Mobile River	Chlordane[3]	Limited Consumption[2]
Tombigbee River	Washington	Largemouth Bass, Channel Catfish	Olin Basin at river mile 60.5	Mercury[4] DDT[3]	No Consumption[1]

[1] No consumption advisory - Everyone should avoid eating the designated species of fish in the defined area.

[2] Limited consumption advisory - Women of reproductive age and children less than 15 years old should avoid eating the designated species of fish from these areas. Other people should limit their consumption of the particular species to one meal per month.

[3] The U.S. EPA regards chlordane, DDT, and PCBs as probable human carcinogens. This indicates cancer causing ability determined in laboratory animals but not in humans.

[4] Mercury is non-carcinogenic. In extremely high levels, mercury affects the nervous system, kidney and fetus.

Cleaning Up

OBJECTIVES:

Students will be able to:
1. Discover the ways the environment is polluted.
2. Explore methods to clean the pollutants.
3. Construct a filtering apparatus.

Grades:
9-12

Subjects:
Biology, Environmental Science, Language Arts

Time Needed:
60 minutes

Materials:
clear plastic soda bottle with bottom removed
5 to 7 cm square of flexible nylon screening
rubber band
large pebbles (150 mL)
small pebbles (200 mL)
pea gravel (150 mL)
coarse sand (600 mL)
fine sand (600 mL)
"dirty water" 0.5 L (2 cups) of dirt in 4 L of water
large wide-mouth jar or 500 mL beaker

BACKGROUND:

The word *pollution* has been used often in our world. Have you ever thought about the ways you add to the pollution in your environment? The most common pollutants of water are high levels of organic matter (sewage), plant nutrients such as nitrogen and phosphorus, and suspended soil particles. Our water quality is most important. It has been estimated that we can't live without fresh water for longer than five days. Water has been cleaned by natural processes since there has been water on Earth. The water on the planet is continuously cleaned and recycled for us to use. Water treatment plants in cities and communities clean water using naturally occuring bacteria and different sizes of rocks and pebbles in a filtering system. They also add chemicals to kill disease-carrying organisms. We have been discovering ways to use plants to help remove pollutants from water. Water hyacinths are used in some water processing plants to clean pollutants from the water. It also has been determined that "dirty" water can flow through swamps; and, as it emerges, it is cleaned of pollutants. Recently, it has been discovered that hydrogen peroxide mixed with raw minced horseradish can remove chemicals from industrial waste in as little as 30 minutes. The same batch of horseradish can then be reused up to 30 times. Today we have many questions about water and pollution. The problems will become more severe as the population increases and agriculture and industry continue to develop. It is estimated that by the year 2050, at least one in four of the world's people is likely to live in countries blighted by chronic or recurring shortages of fresh water. Water quality and supply are a matter for concern. People need fresh water and a safe method of waste disposal. We will need to use our imaginations to develop and discover new ways to help our planet recycle one of the most valuable renewable resources–WATER.

VOCABULARY:

effluent, horseradish, hydrogen peroxide, pollution, recycle, renewable resource, water quality, water treatment, water hyacinth

ADVANCE PREPARATION:

1. The day before the filtration activity, the students should prepare a list which includes all chemicals and/or products that would be used in a week in their homes.
2. Prepare a copy of the Activities With Water (see attachment) to be used as a follow-up activity.
3. Obtain the necessary materials.

PROCEDURE:

Setting the Stage

1. Introduce the topic of pollution.
2. Ask for definitions of "pollution".
3. Ask the students if they add pollutants to their environment. What kinds?
4. Discuss the background information to narrow the topic to *water* pollution.
5. Ask how important clean water is to the students.

Activity

1. Group students and give instructions.
2. Attach the square nylon screen to the soda bottle mouth with a rubber band.
3. Layer fine sand next to the nylon screen and add coarse sand, pea gravel, small pebbles, and large pebbles.
4. Clean the filtering device by pouring several liters of clean water through it. Discard water.
5. Prepare "dirty wter" by adding 0.5L (2 cups) of dirt to 4L of water.
6. Smell the "dirty water" and observe. Write a description of its characteristics.
7. Carefully pour the "dirty water" through the filtering device.
8. Smell and observe the filtered water. Record your observations.

Follow-Up

1. Make a comparison of the student filtering system with that used in local water filtration plants.
2. Have the students take home the "Activities With Water" handout and obtain information on water use and additives. Students could construct their own tables.
3. Discuss how the chemicals the students listed from their homes would find their way into water as pollutants.

EXTENSIONS:

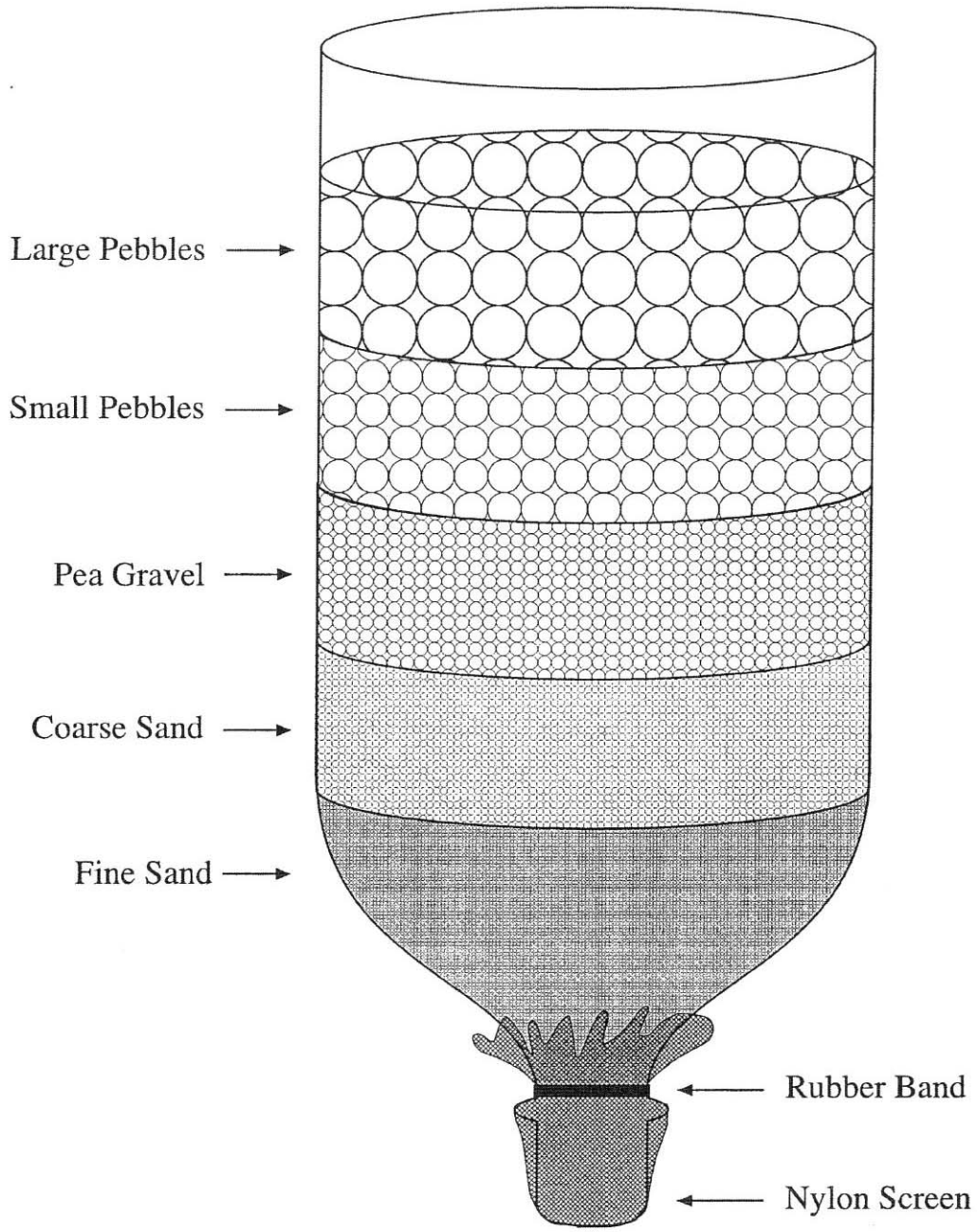
1. Research methods of water treatment.
2. How could this activity be modified or altered to consider other options of filtration?

ORIGINAL DEVELOPMENT RESOURCES:

Hogan, K. (1994). *Eco-Inquiry.* Dubuque, IA: Kendall-Hunt.

Science Briefs. (1996). Horseradish cleans up wastewater. *The Science Teacher, 63*, 12.

Figure 1. Filtering Apparatus



Activites With Water

The following is a list of common activities with the amount of water used. As you go through your daily activities, you use large quantities of water. You also add certain products to the water. When you look at the ingredients of these products, you can become aware of the vast amounts of chemicals you are adding to our water supply. In this survey, you will list your activities, the time spent, and the products you add to the water.

Some of the activities:	Showering	20 L (5 gal per minute)
	Bathing	100-150 L (30-40 gal)
	Washing dishes, hand	38-114 L (10-30 gal)
	Washing dishes, machine	38 L (10 gal)
	Washing clothes, machine	22.8 L (60 gal)
	Flushing the toilet	22.8 L (6 gal)

Source:

Roa, M.L. (1993). *Environmental science activities kit.* West Nyack, NY: Center for Applied Research in Education.

Activity	Time Spent	Products Added
Brushing Teeth		
Bathing		
Showering		
Washing Hands		
Washing Clothes		
Washing Dishes		
Drinking Water		
Cleaning Bathrooms		
Cleaning House		
Washing Cars		
Boating		

Eutrophication: Nutrients And Algal Growth

OBJECTIVES:

Students will be able to:

1. Determine the effects of fertilizers, such as nitrates and phosphates, on algae in water systems.
2. Identify the process of eutrophication and explain the effects on an aquatic ecosystem.
3. Identify ways to prevent artificial eutrophication from occurring.

BACKGROUND:

Plants depend on nutrients, such as phosphates and nitrates, to survive. However, when people release large amounts of these nutrients into rivers and lakes, eutrophication of these water systems can occur. In eutrophication, nutrients cause algae and plant life to grow rapidly and then die off and decay. When microorganisms decompose the algae and plant matter, they use up the oxygen in the water and cause the death of fish and other animals that depend on oxygen for survival. Eutrophication is commonly caused by phosphates and nitrates. Phosphates come from septic taks, runoff from feedlots and waste water treatment plants. Detergents with phosphates were a prime source before manufacturers developed phosphate-free alternatives. Nitrates are found in animal wastes and fertilizers. As nitrates increase, they act as a plant nutrient and cause an increase in plant growth. As the plant material dies and decomposes, dissolved oxygen levels decrease.

VOCABULARY:

fertilizer, eutrophication, chlorella, nitrate, phosphates

ADVANCE PREPARATION:

1. Mix phosphate and nitrate solutions (separately).
2. Write team names on the test tubes and the three quart jars.
3. Measure the volume of a test tube using the graduated cylinder. Then calculate 75 percent of this volume.
4. Obtain a sample of pond water with viable organisms.
5. Prepare the *Chlorella* culture by gently mixing.
6. Collect photos of ponds, rivers, and lakes that look clean and some that have a lot of algae and plant life. Ask students what caused the algae and plant overgrowth.

Grades:

9-12

Subject:

Environmental Science, Biology, Chemistry

Time Needed:

Preparation: 1 hour
Observation time on observation days:
15 minutes for test tubes
30 minutes when using microscopes
Total length of time: 3 weeks

Materials:

three 1-quart jars
wax pencil
distilled water
100-mL graduated cylinder
100-mL of 0.4 percent phosphate solution
100-mL of 0.4 percent nitrate solution
3 test tubes with screw caps
Chlorella culture
fertilizer containing nitrates and phosphates
stirring rod
pond water containing viable organisms
plastic wrap
fluorescent lamp
eyedropper
microscope

PROCEDURE:

Setting the Stage

1. Working in teams, use a wax pencil to label one jar "Control," the second jar "Fertilizer," and the third jar "Excess Fertilizer." Also with the wax pencil, label the first test tube "Distilled water," the second test tube "Nitrate solution," and the third test tube "Phosphate solution."

2. From the obtained pond water sample, observe a drop of pond water under the microscope. Draw at least four of the organisms that you see in the sample. Determine whether the organisms you see are algae (usually green) or consumers (usually able to move). Describe the number and type of organisms that you see on the whole slide.
3. Based on the understanding of eutrophication, make a prediction about how these pond organisms will grow in each of the three jars during the 5-6 days of the experiment.

Activity

DAY 1

1. Fill the test tube marked "Distilled water" three-quarters full with distilled water. Fill the test tube marked "Nitrate solution" three-quarters full with the nitrate solution. Fill the test tube marked "Phosphate solution" three-quarters full with the phosphate solution.
2. Gently mix the *Chlorella* culture. Using the eyedropper, place 10 drops of the culture into each of the three test tubes prepared in Step 1. Shake each tube gently to mix the contents.
3. Place the caps tightly on the test tubes and lay them on their sides in a sunny, well-lighted area such as a windowsill. (20 centimeters away from a fluorescent lamp may also be used.) Leave for 5-6 days.
4. Put 750 mL of distilled water in each of the three quart jars labeled "Control," "Fertilizer," and "Excess Fertilizer." Read the label on the fertilizer container to determine the recommended dilution of fertilizer for watering plants. To the jar labeled "Fertilizer," add the amount of fertilizer recommended for one quart of water. To the jar labeled "Excess fertilizer," add 10 times this amount of fertilizer. Stir the contents of each jar thoroughly to dissolve the fertilizer.
5. Stir the sample of pond water thoroughly to ensure that the organisms are evenly distributed throughout. Measure 100 mL of pond water into each of the three jars from Step 4.
6. Cover each jar loosely with plastic wrap. Place all three jars about 20 centimeters away from a fluorescent lamp. (Do not place the jars in direct sunlight. This may cause them to heat up too much.)

DAYS 2-6

1. Check the test tubes every day for 5-6 days. Growth of *Chlorella* can be determined by an increase in the density of the algae as well as an increase in the darkness of the green color in the test tubes.
2. Record any changes in density or color of the test tubes each day. Answer the following questions:
   - What were the changes, if any, in the test tube labeled "Distilled water"? Describe what was observed.
   - Were there any changes in the test tube labeled "Nitrate solution"? If so, describe them.
   - What occurred in the test tube labeled "Phosphate solution"? Describe the observations.

DAYS 3 to 3 weeks

1. Also check the jar samples at least once every three days for the next three weeks. Note any color, odor, and any visible presence of organisms in the jars. Record your observations in chart form.
2. When life forms begin to be visible in the jars (probably after a week or two), use an eyedropper to remove a sample of organisms from each jar and observe it under the microscope. Record the observations from each slide. (Control Jar, Fertilizer Jar, Excess Fertilizer Jar)
3. At the end of the three-week observation period, once again remove a sample from each jar and observe it under the microscope. In the space provided, sketch at least four of the most abundant organisms and describe how the number and types of organisms have changed for each jar.

EVALUATION:

1. Using the information gathered from the test tubes, have students discuss the following questions:
   - What solution contained the most algal growth? Which contained the least?
   - Why did the algae grow in the pattern that was observed?

For the labeled jars:

- After three weeks, which jar shows the most abundant growth of algae? What may have caused this growth?

• Were there any observable effects on any organisms other than the algae in the jar with the most abundant algae growth? Explain.
• Did the observations match the predictions made earlier in this experiment? Explain.

EXTENSION:

1. Write a paragraph applying the findings. What effect would phosphate and nitrate run-off from farms have on a lake or pond? How would organisms in the lake be affected? How could negative effects be prevented?
2. Write a paragraph on how artificial eutrophication can be prevented in natural bodies of water.

ORIGINAL DEVELOPMENT RESOURCES:

Arms, K. (1996). *Environmental science.* Austin, TX: Holt, Rinehart, and Winston.

Environmental science. (1996). Menlo Park, CA: Addison-Wesley Publishing Company.

Science junction: water what ifs - nitrate & phosphate lesons. (1998). www.ncsu.edu/sciencejunction.

Notes

Modeling Groundwater Pollution

OBJECTIVES:

Students will be able to:
1. Build a model of a well.
2. Demonstrate groundwater pollution and the way it gets into water systems.
3. Demonstrate the difference in the rate of movement of liquid versus solid pollutants.
4. Communicate the results of the investigation.

BACKGROUND:

In the United States, about one-fifth of our fresh water comes from underground sources. Homes that rely on wells are just one example of groundwater use. Wells are drilled down where the ground is saturated, and the stored water there is pumped up to the surface. Aquifers and other groundwater sources are replenished gradually by surface water that seeps down through the soil. Unfortunately, this water can be polluted by particulates, dissolved chemicals such as pesticides, and other substances that contaminate the groundwater.

VOCABULARY:

groundwater, particulates, pesticides, aquifer

ADVANCE PREPARATION:

Obtain a clear 2-liter soda bottle and cut off the top 1/3 of the bottle.

Grades:

9-12

Subjects:

Science, Math

Time Needed:

One hour

Materials:

2-liter soda bottles
light-colored sand
light-colored aquarium gravel
pieces of a nylon stocking
small rubber bands
spray nozzles and tubes from spray bottles
red food coloring
blue watercolor paint in solid form
500-mL beakers
paper cups
water

PROCEDURE:

Setting the Stage

Read the following scenario to the students.

Congratulations! You have just been hired by the Baldwin County Water Safety Service as a director of field research. Your first assignment is to respond to the concerns of some citizens who have recently had their well water tested. The results of the test showed contaminants that were not there during the last test. These include a trace amount of a pesticide that was used on some nearby farms many years ago as well as small amounts of several petroleum products. These citizens want to know how a pesticide that was used more than 20 years ago can affect their water systems today. They also are concerned with the trash problem that they have been having in their area lately and would like to know if some of the contamination could have come from the trash; or, if not, could it have an effect on their water supply in the future?

Your job is to construct a model of a well that will allow you to address some of the questions of these citizens. With your model, you will not only investigate the process by which groundwater sources become polluted, but you will also see how different types of pollution from the surface can end up in well water.

Activity

1. Fill the soda bottle about half full with aquarium gravel.
2. Fold the piece of nylon stocking several times and place it across the end of the sprayer tube. Secure the nylon tightly with the small rubber band. Insert the tube into the gravel along the side of the bottle with the

end of the tube about 3 centimeters from the bottom.

3. Add water until it just covers the gravel. Then add the light-colored sand to about 2 centimeters from the top of the bottle. Pump the nozzle of the spray bottle tube a few times to get the flow of water started. Spray the water into the 500 mL beaker.
4. Pump the nozzle and observe the water level in the soda bottle. Have students record their observations.
5. Using a pencil, punch a few small holes in the bottom of a paper cup. To simulate precipitation, fill the cup with water and let the water drizzle out through the holes onto the sand. Try to avoid stirring up the sand. This may cause the sand to seep down and clog the sprayer tube. Practice adding precipitation while you pump the well until you can add and remove the water at about the same rate.
6. Place 10 drops of red food coloring on top of the sand. This is to represent pollutants like pesticides and other chemicals that are dissolved in surface run-off. Begin pumping the well and adding precipitation. Count the number of squeezes of the trigger of the nozzle as you pump. As you proceed, be sure that the water level stays between the surface of the sand and the end of the tube. Watch for red coloration to appear in the discharge beaker. Have students count how many squeezes of the trigger it takes for the food coloring to pass through the well.
7. Ask students if the well is permanently polluted and explain their answers.
8. Place a few crumpled bits of blue paint on top of the sand to represent waste or other solid pollutants that contaminate groundwater by dissolving in surface water that seeps into the ground. Repeat the pumping and collecting process described in Step 6. Ask how many squeezes of the trigger it takes for the color to appear this time.
9. Put some paper into small (confetti-size) pieces, and place them on top of the sand to represent litter/trash. Repeat the pumping and collecting process in Step 6.

EVALUATION:

1. Discuss the following with the students:
   • Explain why the food coloring passed through the well at a different rate than the crumbled paint did.
   • Explain how a different rate of precipitation would affect the speed at which a pollutant shows up in the well water.
   • Using what you have learned in this experiment, explain how a pesticide that was used over 20 years ago could be found in a citizen's well water today.
   • Using what you have learned in this experiment, explain whether or not the growing trash problem in an area is a valid concern for affecting a water supply.
2. Have students complete the Report for County Water Supply Safety Service form. Remind them they are part of an investigative team.

EXTENSIONS:

1. Write a newspaper article reporting on groundwater contamination. Include how it was caused, how extensive the damage is, and what can be done to solve the problem now and in the future.
2. Invite a guest speaker from the county engineer's office or local agency which monitors groundwater to speak to the class.

ORIGINAL DEVELOPMENT RESOURCES:

Arms, K. (1996). *Environmental science*. Austin, TX: Holt, Rinehart, and Winston.

www.groundwater.org

Report For County Water Supply Safety Service

"Consulting Firm" Conducting Investigation:

Team Members:

Dates of Investigation from _____ to _____

Our team has investigated the situation and provides the following information.

1. The reasons that liquid pollution (food coloring) passes to the well at a different rate from solid pollution are the following:

2. During a time of heavy precipitation, the problem of pollution seeping into the groundwater is increased because the following things occur:

3. The reasons that a 20-year-old pesticide is just now showing up are due to the following:

4. The reasons why litter will not affect the groundwater and will not get into the wells are as follows:

5. The reasons trash on the surface may be a problem for the wells are as follows:

6. Our team suggests that the following procedures be implemented to correct the problem of groundwater contamination:

Notes

Particulate Pollution And Emissions Testing

OBJECTIVES:

Students will be able to:

1. Describe how the process of combustion gives off products that, when combined with oxygen, can be potentially harmful to the environment.
2. Explain the process of emissions testing.
3. Explain why it rains more frequently in areas of high factory emission.

BACKGROUND:

Combustion is the type of chemical change in which chemical substances are burned to produce energy. Fuels that are burned to carry out the every day processes of life, like generating electricity and starting an automobile, are made primarily of carbon, hydrogen, nitrogen, and oxygen. When these chemicals combine with oxygen to combust or burn, they then are transformed into new substances. Some of these products of combustion are invisible even though their presence in the air contributes to global warming and air pollution. Other combustion products may be clearly visible to the eye and easily discernible as air pollution.

Grades:

9-12

Subject:

Environmental Science, Chemistry

Time Needed:

One hour

Materials:

1 candle, 4-6 inches long
1-gallon glass jar with a screw-on lid
modeling clay
metal spatula
calcium carbonate solution (limewater)
matches
safety goggles

Review: All fossil fuels (petroleum, natural gas, coal) originate from living things composed of atoms of oxygen, carbon, hydrogen, and nitrogen. These atoms cannot be destroyed in chemical processes (conservation of mass), but molecules can be broken apart and recombined to make new compounds.

VOCABULARY:

pollution, limewater, particulate, suspension,emissions, fossil fuels, conservation of mass, nitrogen oxides, sulfur oxides

ADVANCE PREPARATION:

1. Use a small ball of clay to make a holder for the candle. Insert the candle into the holder and secure it to the work area so that it will not turn over.
2. Light the candle.

PROCEDURE:

Setting the Stage

1. Pretend you are the engineer for an energy plant that burns fuel containing hydrocarbons.. This energy plant has a smokestack (the candle) that is constantly emitting smoke into the air. If the smoke that is coming from the smokestack is blacker than usual, how would you determine where this black material is coming from? What should you do about it? Try some experiments to find out causes and what should be done about this type of air pollution.

Activity

1. Obtain a metal spatula. Slowly bring the spatula into the orange portion of the candle flame and leave it there for one minute. Answer questions 1, 2, and 3 on the lab sheet.
2. Blow out the candle.

3. Tiny particles that are suspended in the air are called *particulates*. These are a form of air pollution that increases the cost of keeping clothes and furniture clean. The most significant problems caused by particulates in the air are health related. Use your observations with the experiments done with the candle flame to answer question 4 on the lab sheet.
4. Part of the job of an engineer is to determine what gases are being given off by the smokestack. Secure the unlit candle in the bottom of a one-gallon glass jar by using the modeling clay.
5. Light the candle and cover the jar with the lid. Allow the candle to burn until the flame goes out.
6. Unscrew the lid and remove the candle as quickly as possible. Pour about one half inch of limewater into the bottle. Replace the lid and shake the container. Answer questions 5, 6, and 7 on the lab sheet.
7. People living near a smokestack facility complain that it rains more in their neighborhood than in other parts of the area. To determine whether any of the gases given off by a smokestack could be partly responsible for this, dispose of the mixture in the jar as directed by the teacher. Carefully dry the inside of the jar and place the candle back inside.
8. Light the candle and screw on the jar lid. Carefully observe whether any moisture forms on the inside of the jar. Answer questions 8, 9, and 10 on the lab sheet.
9. Clean up all laboratory materials in the appropriate manner as directed by the teacher.

EVALUATION:

1. Discuss the following topics:
   • A more detailed description of the chemical processes of combustion with an emphasis on the similarity between the candle and fossil fuels.
   • Alternative energy sources and the problems associated with fossil fuels that are avoided through the use of these sources.
   • The similarities between the photosynthesis/respiration process in living things and the chemical process of combustion. The disruption of the normal carbon cycle should be pointed out.

EXTENSION:

1. Another part of the job of an engineer is to order new supplies of fuel. A certain supplier can provide fuel at a lower cost. However, this fuel is not as pure and contains more nitrogen and sulfur than fuel. These elements will react with oxygen in air, giving rise to nitrogen oxides and sulfur oxides. Do some research to answer questions 11 and 12.

ORIGINAL DEVELOPMENT RESOURCES:

Arms, K. (1996). *Environmental science.* Austin, TX: Holt, Rinehart, and Winston.

www.nrdc.org/air/pollution

American Lung Association: Fact sheet on particulate matter air pollution. www.lungusa.org

Particulate Pollution And Emmission Testing Lab Sheet

Name: _____ Date: _____ Period: _____

Answer each of the following questions as you do the procedures in this activity.

1. Describe what collects on the metal surface of the spatula.

2. Where did this material come from? (Hint: What elements do all fuels contain?)

3. What happened to the flame? Why did this happen?

4. What can be done to reduce the amount of particulates given off by a smokestack?

EMISSIONS TESTING

5. What changes do you observe in the limewater?

6. When the limewater is exposed to carbon dioxide, small particles of calcium carbonate become suspended in the liquid as was just observed. What is the source of the carbon dioxide?

7. Carbon dioxide is colorless and odorless, but it is not completely harmless in the atmosphere. What is the role of carbon dioxide in the warming of the Earth's atmosphere (global warming)?

HEAVY RAIN

8. Do you observe moisture forming in the jar?

9. Where does this moisture in the jar come from? (Hint: Think about the elements that are involved in the process of combustion.)

10. What should the people living in the neighborhood of the smokestack be told about the effect that a smokestack has on the nearby climate?

EXTENSION: CHEAP FUEL

11. What effect do nitrogen oxides and sulfur oxides have on the atmosphere and the environment?

12. What factors must be considered in deciding whether or not to use the nitrogen-rich and sulfur-rich fuels that are cheaper?

Particulate Producers

OBJECTIVES:

Students will be able to:

1. Identify a correlation between the age of a car/truck and the amount of particulate pollution released into the atmosphere.
2. Describe the amount of particulate matter released into the atmosphere by cars/trucks.
3. Explain that combustion produces both visible and invisible products.
4. Identify ways to minimize air pollution.

BACKGROUND:

In the world today, there are roughly 700 million cars and trucks on the roads. More than 200 million of these are in the United States alone. In 1990 internal combustion engines propelled American vehicles over twoand a half trillion miles. Much of the exhaust from these vehicles is invisible, nontoxic water vapor plus carbon dioxide. Some of the exhaust is composed of invisible but harmful gases such as carbon monoxide and nitrous oxides. Particulates, tiny particles that are created when fuel is incompletely burned, are a major component of exhaust.

Grades:

9-12

Subject:

Environmental Science, Chemistry

Time Needed:

One hour

Materials:

a variety of cars and trucks to test
oven mitts or heavy gloves
masking tape
new, white tube socks (one for each vehicle tested)

VOCABULARY:

particulates, air pollution, carbon monoxide, nitrous oxides

ADVANCE PREPARATION:

1. Divide students into groups of 2 to 4 students each.
2. Find a variety of cars and trucks on which the test can be performed. Have as wide a variety of cars and trucks as possible (at least three different vehicles). Use older, high-polluting models (at least 10 years old) as well as recent models. If possible, include a diesel-powered vehicle.
3. Obtain the following information about each of the cars/trucks that will be tested: make and model, engine size and type (such as 2.4 L V-6), model year, number of miles driven, and number of miles since last tune-up. Assign each vehicle a different number. Record all information.
4. Using masking tape, make a label for each sock. Write the number of the vehicle you are testing on the label of the sock.
5. This activity works best on a cold day. Particulates may not be produced by a warm engine. The test should be performed on a cold engine (one that has not run for at least four hours). To ensure that particulates are collected, be sure to include some older cars in the test.
6. To avoid inhaling exhaust fumes, make sure that students stand at least 10 feet upwind of the exhaust pipes as the tests are being carried out.

PROCEDURE:

Setting the Stage

1. In this activity, a simple method will be used to observe particulates produced by a number of cars or trucks. Socks will be placed over the exhaust pipes of the vehicles, engines will be run for three minutes, and observations of what is collected in the socks will be made.

Activity

1. Before beginning the test, make a prediction about what you think testing will reveal. For example: "The larger the engine, the darker the sock will get."
2. Place a sock over the exhaust pipe of each vehicle. Make sure that you match the correctly numbered sock with the appropriately numbered vehicle. ***Caution:*** Do not touch the exhaust pipe after the car has been started. The exhaust pipe may be hot. Wear heavy gloves when working near the exhaust pipe.
3. Perform each test on a vehicle with a cold engine (has not run for 4 hours). The owner should start the vehicle engine and let it run for three minutes. After the engine is turned off, remove the sock. Make sure that you are wearing heavy gloves. Record observations on a chart. Include color, density, and dampness.

EVALUATION:

1. Review the results of the experiment with the students.
2. Describe the test results. Do they match the predictions?
3. Check to see if the socks were damp or dry when they were removed from the exhaust pipes. If damp, what could account for this?
4. Rank the vehicles that were tested from the "cleanest" to the "dirtiest."
5. Explore the correlation, if any, between a car's age, engine siae, engine type, etc. and its output of particulates. How did the other variables that were tested correlate with the output of the particulates?

EXTENSIONS:

1. Research and write a paragraph on the Clean Air Act. How has the Clean Air Act reduced air pollution from automobiles? How has it reduced industrial air pollution?
2. Research catalytic converters and the way they work.

ORIGINAL DEVELOPMENT RESOURCES:

Arms, K. (1996). *Environmental science*. Austin, TX: Holt, Rinehart, and Winston.

U. S. Department of Transportation, Federal Highway Administration, *Highway statistics*. (1999). Washington, D.C.

Particulate Survey

OBJECTIVE:

Students will be able:

1. Collect particulate samples from various areas of the community.
2. Compare the quantities of particulates found in various locations.

Grades:
9-12

Subjects:
Science, Earth Science, Math

Time Needed:
One week

Materials:
petroleum jelly
3x5 cards
city or community map
metric ruler
magnifying glass

BACKGROUND:

Our atmosphere is composed primarily of gaseous substances. Most major air pollutants are also gaseous substances; and large amounts of them concentrated in areas, such as cities, can be seen as smog. However, one easily visible air pollutant is particulate matter, especially when the surfaces of buildings and other structures have been exposed to it for long periods of time or when it is present in large amounts. Particulate matter is made up of tiny particles of solid matter and/or droplets of liquid. Natural particulate matter tends to be less of a problem to human health and the general well-being of the environment than that which is man-made. Natural sources include volcanic ash, pollen, and dust blown about by the wind. Coal and oil burned by power plants and industries and fuel burned by many vehicles are the chief sources of man-made particulate pollutants, but not all man-made sources are large-scale. The use of wood in fireplaces and wood-burning stoves also produces rather significant amounts of particulate matter in localized areas, although the total amounts are much smaller than those from vehicles, power plants, and industries.

Particulate air pollutants can be harmful to plant life and to animal and human life when the pollutants are inhaled. Discoloration of buildings and other structures also is caused by particulate pollutants; this is unsightly and quite expensive to clean up. Because particulate matter can have harmful and serious effects, it is one of the six criteria pollutants—pollutants for which the government has established laws and air quality standards.

VOCABULARY:

particulate pollution, airborne

PROCEDURE:

1. Prepare 3x5 cards by first making a grid using parallel lines 1 centimeter (cm) apart in both directions on the card forming 1 cm squares. There should be one card per student. Using petroleum jelly, smear a very thin layer over the grid.
2. Each student should take a card home and place it in an outside area, such as a window sill or table, with the sticky side up. Leave the card for a week or until a significant number of particles have stuck to the card. If the card is left for less than one week, record the date it was left and the date it was removed.
3. Have students bring the cards to school. Have each student select at random four squares on his or her card in which to count particles; and, using a magnifying glass, count the particles in each 1 cm area. Total the four squares and average.
4. Compare the averages obtained by different students.
5. Ask students what might happen if they counted eight squares and completed averages. Would the results be more or less accurate?

EVALUATION:

1. Using a community map, indicate the average number of particles reported where each student lives. Attempt to explain why some areas have more particulate than others (farming, industry, traffic). Discuss results.

EXTENSIONS:

1. Perform the same activity, using a new card for several weeks to check the initial observation. Attempt to identify the composition of the particles.
2. Repeat, placing collectors at home sites. For example, place collectors outside near the front and back of your home; place collectors in your kitchen, living room, and bedroom. Prepare a data sheet with pertinent data about your home and its inhabitants including pets, number and ages of children, fuel used for heating.
3. Repeat, placing collectors in populated and less populated areas. For example, place collectors near the following: flowering plants, a park, a factory, the city hall, a highway, a power plant.
4. Call the local city hall, health department, or air pollution office for acid rain and air pollution data.
5. Correspond with other schools who would conduct the same experiments and share your air pollution data.
6. If air pollution appears to be a problem in your area, write letters to local government officials requesting better controls. The teacher will decide whether or not they will be mailed.
7. Investigate the effects of air pollution on health problems such as emphysema and asthma.

Pollution And Osmosis

OBJECTIVES:

Students will be able to:
1. Prepare two wet mounts without assistance.
2. Explain how the process of osmosis operates.
3. Predict the effects of an intertidal environment on organisms.

Grades:
9-12

Subjects:
Marine Biology, Environmental Ecology

Time Needed:
50 minutes

Materials:
5 potatoes
Elodea (several sprigs)
salt
balance
paper towels
metric ruler
microscope and slides
cover slips
water
medicine dropper
labels
6 100 mL beakers

BACKGROUND:

Environments that are subject to tidal changes have organisms that have special adaptations. This allows them to exist in habitats that change daily as the tides change. These organisms, such as clams and mole crabs, must tolerate alternating periods of drying and immersion in sea water. Other factors subject to change are temperature, wave energy, and salinity. These organisms exhibit adaptations that reveal evolutionary solutions to dramatic environmental problems. To appreciate the stress that is experienced by these organisms, we can construct circumstances that model their environment in the laboratory. When a cell is placed in an environment and the solute (sodium chloride) outside the cell is greater than in the cell, the water will leave the cell. This causes the cell to shrink and eventually die. An example of **osmosis** is when water molecules move from an area of higher concentration to an area of lesser concentration. When the normal turgid conditions of a plant change as a result of water loss, the condition is called **plasmolysis.** In this investigation, we will vary the quantity of solute (sodium chloride) to observe the effects on the organisms. The various quantities of salt (sodium chloride) will simulate one factor in the **estuarine environment.** Organisms existing in these environments indicate their uniqueness as part of the **diversity of living organisms** on the planet. The two organisms selected for this study are *Elodea* and the white potato. *Elodea* will be used to verify cellular effects of a changing environment. The potato will permit quantifying the effects on a larger organism.

VOCABULARY:

diversity of living organisms, estuarine environment, osmosis, plasmolysis, turgid, Elodea, intertidal environment

ADVANCE PREPARATION:

1. Obtain 5 potatoes and several sprigs of *Elodea*.
2. Make salt solutions: 5 percent, 10 percent, 15 percent, and 20 percent. Place 5 grams of salt in 1 liter of water for a 5 percent solution. Follow the same pattern for the other solutions.
3. Collect all materials: balance, marking pencil or labels, paper towels, metric ruler, microscope, slides, cover slips, water, medicine dropper.

PROCEDURE:

Setting the Stage
1. Introduce terms and describe the procedure.

Activity

Potato

1. Cut the potato into 18 pieces 2 cm x 2 cm x 1 cm.
2. Place the potato pieces in 6 stacks of 3; weigh each stack and record on data table.
3. Place each stack into separate beakers with 100 mL of:
   - distilled water
   - tap water
   - 5 percent salt
   - 10 percent salt
   - 15 percent salt
   - 20 percent salt
4. Leave the potato stacks in the beakers about 25 minutes, remove and blot, and then weigh each stack. (While the potatoes are soaking, complete the *Elodea* activity.)
5. Record data on table.
6. Observe and note any changes. Explain. Did the length of time affect the potato? Why didn't the salt move into the plant cell to counteract the rapid outward movement of water?

Elodea (to be completed while waiting on potato stacks)

1. Prepare a wet mount of an *Elodea* leaf.
2. Focus to find one cell in the leaf. Switch to high power including as much of the cell as possible in the field of vision.
3. Place a drop of 5 percent salt solution on the edge of the cover slip.
4. Put a paper towel on the opposite edge to "pull" the salt solution across the slide. Another drop of solute may be used. Try reversing the process by placing water on the edge of the cover slip. Try a stronger salt solution.
5. Observe and record any changes in the *Elodea* cell when completing steps 3 through 7.

Follow-Up

1. Discuss how the natural process of osmosis acts to compromise organisms that are exposed to pollutants in their aquatic environments.

EXTENSION:

1. Research marsh communities, their types of organisms, and these organisms' special adaptations to survive in harsh habitats.

ORIGINAL DEVELOPMENT RESOURCES:

Irby, B. (1984). Intertidal organisms and their environment. *Marine and Estuarine Ecology.* Hattiesburg, MS: University of Southern Mississippi Press (currently out of print).

McLusky, D.S. (1989) *The estuarine ecosystem*. Blackie Academis & Professional; ISBN: 0470271272.

Data Table For Osmosis

	Distilled Water	Tap Water	5% Salt	10% Salt	15% Salt	20% Salt
Initial Mass of Potato						
Final Mass of Potato						
Increase						
Decrease						

Discussion:

Is there a relationship between quantity of solute and change in mass? Explain your answer.

Describe your observations about the *Elodea* leaf.

Notes

Who's Been Sleeping In My Stream?

OBJECTIVES:

Students will be able to:

1. Identify stream insects and crustaceans.
2. Identify pollutant-sensitive and pollutant-tolerant organisms found in water.
3. Categorize stream insects, crustaceans, mollusks, and worms into appropriate taxa groups.
4. Predict the quality of water based on the presence or absence of certain organisms.

BACKGROUND:

Natural waters are never very pure. Impurities may result from a variety of sources. Sometimes there can be a difference of opinion about the health of an aquatic system. Pollution of waters may result from any human-related alterations that cause a decrease or increase in the diversity of life in the system. The diversity of species within an aquatic habitat can be a measure of pollution.

Monitoring the quality of water can be done by collecting quantitative and/or qualitative data. The collection of quantitative data is done by analyzing the parameters of the water sample. Some water quality parameters that can be measured are temperature, turbidity, pH, dissolved oxygen, total alkalinity, and total hardness. Qualitative data can be gathered by doing a bioassessment using aquatic vertebrates and invertebrates. All living things have specific ranges of tolerances to physical, chemical, and biological conditions. Assessing a water sample by identifying the absence or presence of certain organisms will give one a clue as to how "healthy" or "unhealthy" a habitat is.

Grades:

9-12

Subjects:

Science, Marine Science, Environmental Science, Biology

Time Needed:

Two-three class periods

Materials:

See Resources: "Stream Insects & Crustaceans"– SAVE OUR STREAMS
Alabama Water Watch - list of Macroinvertebrate Groups - Group I, II, III
Alabama Water Watch Stream Quality Assessment Form
3 x 5 cards (approximately 30 per student)
taxonomy reference books on invertebrates

Biological assessment is a qualitative procedure that uses the identification of certain organisms to tell something about the environment. Bioassessment of lakes and streams may identify microorganisms or macroorganisms in the water column. Another area of the aquatic habitat that can be used as a primary source to investigate is the bottom substrate of the lake or stream. Common to this area is a group of organisms (benthos) that live on or in the bottom and consist mainly of benthic macroinvertebrates.

Characteristic of the benthic community are macroinvertebrates like aquatic insects, clams, snails, crayfish, and aquatic worms. This world of invertebrates can be easy to investigate because these organisms are abundant, diverse, and sedentary. They are found under sticks and stones and within the leaves on the bottom of a stream. A square meter can be "home" to a lot of macroinvertebrates. The overwhelming diversity of these macroinvertebrates is called taxa richness. As a result, biodiversity can be assessed qualitatively and then can be calculated to measure the water quality and environmental health. Another fact to consider is that these organisms are "squatters" staying in one area for days, months, and even years. According to the Alabama Water Watch Program (1994), these macroinvertebrates serve as "mini-meters" 24 hours a day, monitoring the quality of the water. All one needs to do is to figure out "who's sleeping in my stream" in order to assess the health of the environment!

VOCABULARY:

benthic, benthos, bioassessment, diversity of life, macroinvertebrates, parameters, pollution, qualitative data, quantitative data, substrate, taxa richness, crustaceans, mollusks, turbidity, pH, dissolved oxygen, alkalinity, hardness

ADVANCE PREPARATION:

1. Discuss the different types of pollution that may affect lakes and streams.
2. Discuss the parameters used to measure water quality and the way they affect the organisms that live in an aquatic environment.
3. Show pictures of macroinvertebrates that are commonly found in lakes and streams.
4. Identify organisms that range from pollution-tolerant to pollution-intolerant.
5. Group these organisms into three taxa groups.

PROCEDURE:

Setting the Stage

1. Challenge the students by forming "macro-monitor" groups; the students' major objective is to become specialists in identifying macroinvertebrates.
2. Ask the students to make a list of locations (streams) locally that might serve as places to conduct a biological assessment and determine the health of each aquatic environment.

Activity

1. Prepare a set of taxa cards based on the three major macroinvertebrate groups to be used for challenges between groups of students.
2. Using the following information and procedure in step 3, prepare a card on each of the organisms listed below:

Group l: Organisms that are generally pollution-intolerant: riffle beetle (larva), riffle beetle (adult), stonefly (nymph), caddisfly (larva), mayfly (nymph), snail—opens to the right.Their dominance generally signifies EXCELLENT-GOOD WATER QUALITY.

Group II: Organisms that exist in a wide range of water quality conditions: cranefly (larva), dragonfly (nymph), crayfish, sowbug, filtering caddisfly (Hydropsychidae-larva), scud, blackfly (pupa),blackfly (larva), Hellgrammite (Dobsonfly—larva). Note: these organisms exist in a wide range of water quality conditions.

Group III: Organisms that are generally tolerant of pollution: midge (larva), midge (pupa), pouch snail (Physidae)—opens to the left. Their dominance usually signifies FAIR-POOR WATER QUALITY.

3. Prepare a set of taxa cards using the following method (a reference sheet may be given to the student that illustrates pictures and pertinent information):
   • A drawing of the invertebrate must be neatly pasted to one side of a 3 x 5 card.
4. On the other side of the card include the following information:
   • Taxa Group Number (1, 2, or 3).
   • Common name.
   • Scientific name (phylum, order, or suborder).
   • Description (physical).
5. Conduct "flash card" challenges among teams based on picture recognition and responses with group, names, etc. information.

EVALUATION:

1. The series of "flash card" challenges between groups can be used to evaluate recognition of invertebrates and their taxa groups.
2. Have the students design streams that represent poor, fair, and good quality environments based on bioassessment.
3. As a class (or group), construct a stream on a mural that represents a stream supplied with invertebrate pictures picked at random, and predict the quality of the water.

EXTENSIONS:

1. Bring in samples of water collected for bioassessment, and identify the organisms found in the leaf litter from the pond habitat.
2. Use microscopes to investigate the organisms.
3. Construct a tally list of the organisms based on the taxa groups. (See Macroinvertebrate Tally form.)
4. Analyze and prepare a report about the health of this environment.
5. Join a water watch program (Alabama Water Watch Program) as a class or individual student involvement.

ORIGINAL DEVELOPMENT RESOURCES:

Redco Science. (1991). *Quality of water: Teacher's guide.* Oxford, CT: Ramco Enterprises, Inc.

Alabama Water Watch c/o Fisheries and Allied Aquaculture, Swingle Hall, Auburn University, AL 36849

Save Our Streams, "Stream Insects and Crustaceans", Izaak Walton League of America, 1401 Wilson Blvd., Arlington, VA 22209

Benthic Macroinvertebrate Sample Site Field Sheet Instructions

These instructions are meant as guidance for those filling out the field sheet and collecting Macroinvertebrate sample sites should be located in "riffle" areas (fast moving, surface broken by small waves or rocks) with a current velocity between .4 and 2 feet per second. This is a pretty strong current but not so strong that you can't easily maintain your balance in two feet of water.

Equipment and materials needed (for field sheet only): thermometer, tape measure (50' preferable) or string marked in 1 foot increments, yard stick, orange (the fruit), waders, watch (stop watch or second hand), clipboard. A USGS topographic map would be helpful.

Basic Site Information

Fill in the information requested. Most is self-explanatory. For the **site** location, try to describe it so that someone who has never been there would recognize it. **Weather** observations are important. They may explain some of your subsequent observations. For **estimated elevation,** use a topo map. For **sample type,** check the type of collection method you're using.

Stream Characteristics Section:

1. **Water temperature:** Measure this at least twice from the exact spot you'll be collecting and average the two results. Leave the thermometer in the water for three minutes. If you get very different readings, measure until they are within a couple of degrees.

2. **Air temperature:** You can use the same thermometer.

3. **Average width:** Measure or estimate across the stream where you'll be collecting. Use a tape measure or visual estimate.

4. **Average depth:** Measure depth in three places at the collection spot and average the result. Use a yard stick.

5. **Average velocity (in ft./sec.):** Have two people measure off ten feet, standing in the stream at the collection spot. Drop a float (preferably an orange) into the current at the upstream point and, using a stop watch if available, note the time it takes to travel the ten feet. Try to pick an open path where the float will not encounter rocks or other stream obstructions. Do this three times and average the results.

6. **Relative flow:** Is the present flow (the amount of water flowing usually expressed in cubic feet per second) high, average, or low compared with your estimate of the average flow during the course of a year? If you have seen the stream in the previous two days, was that flow high, average, or low compared with your estimate of the average flow during the course of a year? This is a subjective estimate, but it will give an idea of whether the stream flow is higher, average, or lower than "normal" (year round average). If you don't know what the average year-round flow looks like, look for visual clues, such as aquatic plant growth, that might show the channel where water is flowing most of the time.

7. **Sediment deposits:** Is the bottom covered with material other than the natural stream bed? Check the type that applies.

8. **Does the water smell of:** Check the one(s) that apply.

9. **Water color:** Check the one(s) that apply.

10. **Algal growth:** What percent of the stream bottom is covered with algae? Algae is brown to green in color and has a fine threadlike or cotton ball appearance.

11. **Does the river appear to be straightened or channelized?:** Evidence of this would be a uniform depth, uniform rock-lined banks, and a suspiciously straight channel. This is usually done near roads or houses to keep floodwaters out of those areas.

12. **Upstream dam:** Fill this in if you know of upstream dams, even if they are quite a distance upstream.

13. **Are there wastewater treatment plant discharges upstream?:** Fill this in if you know of upstream discharges, even if they are quite a distance upstream.

14. **Do you see pipes emptying directly into or near the water?**

Notes: Use this space to record any other observations.

Stream Quality Assessment Form

Monitoring Group

Name: ____________________ Stream Name: _____________

Site Location: _________________ Date:__________ Time (military):_________

County: ______________________ Town/City:________________

• •

Organic Substrate Components: ____

Canopy Cover: open partly open partly shaded shaded

Streamside Vegetation type: ____

Turbidity: clear sightly turbid turbid opaque

Water Conditions (color, odor, bedgrowths, surface scum):______________________

• •

Chemical Assessment

Please convert °F to °C (°C=[°F–32] x 5/9) & feet to centimeters (cm=ft x 30.48)

Air temp °C:_________________ Water temp °C:__________

Water depth (cm):_____________ Secchi Depth (cm):_______

Alkalinity (mg/l):_____________ Hardness (mg/l):_________

Dissolved Oxygen (mg/l):______ pH (SU):_______________

Turbidity (JTU):______________

• •

Width of Riffle:______________

Bed Composition of Riffle (%):

Silt:________

Sand:_______

Gravel (1/4" -2"):__________

Cobbles (2"-10"):__________

Boulders (>10"):___________

Macroinvertebrate Tally

Letter Code For Tally

R = Rare *(1 to 3 individuals)*
C = Common *(4 to 9)*
A = Abundant *(10 or more)*

GROUP 1 TAXA	Letter Code	GROUP 2 TAXA	Letter Code	GROUP 3 TAXA	Letter Code
Mayfly		Hellgrammite		Aquatic Worm	
Stonefly		Dragonfly		Midge	
Caddisfly		Crane Fly		Pouch Snail**	
Riffle Beetle		Filtering Caddisfly*			
Snail		Crayfish			
		Asiatic Clam			
		Sowbug			
		Water Penny Beetle			
# of Taxa =_____ X 3 =_____		# of Taxa =_____ X 2 =_____		# of Taxa =_____ X 1 =_____	

*Filtering Caddisflies are in the Family Hydropsychidae (gills on abdomen; most common caddisfly)
**Pouch snails are in the Family Physidae (shell opens to the left; air-breathing snail)

Total Number of Taxa (Sum of Number of Taxa in Each Group) ☐

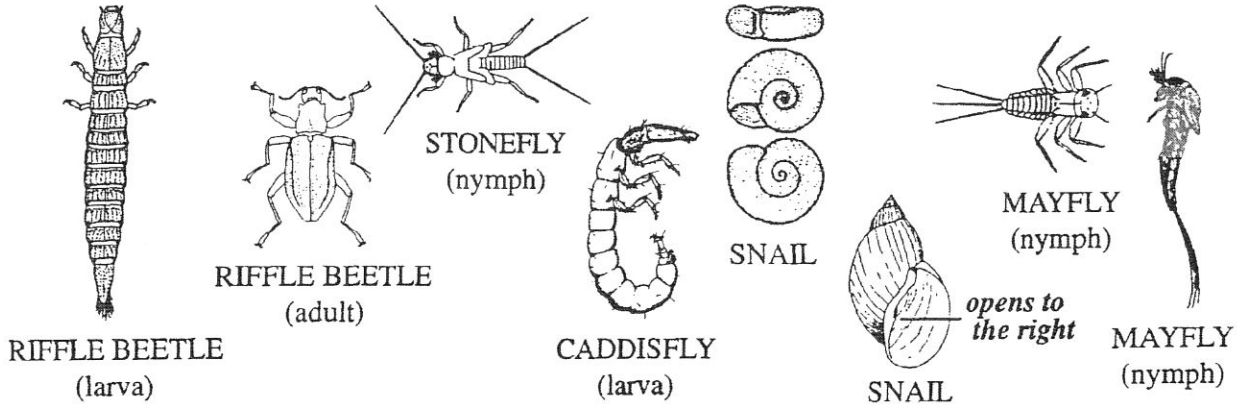
Cumulative Index Value (Sum of Index Values for Each Group) ☐

STREAM QUALITY ASSESSMENT: (Check box corresponding to Cumulative Index Value)

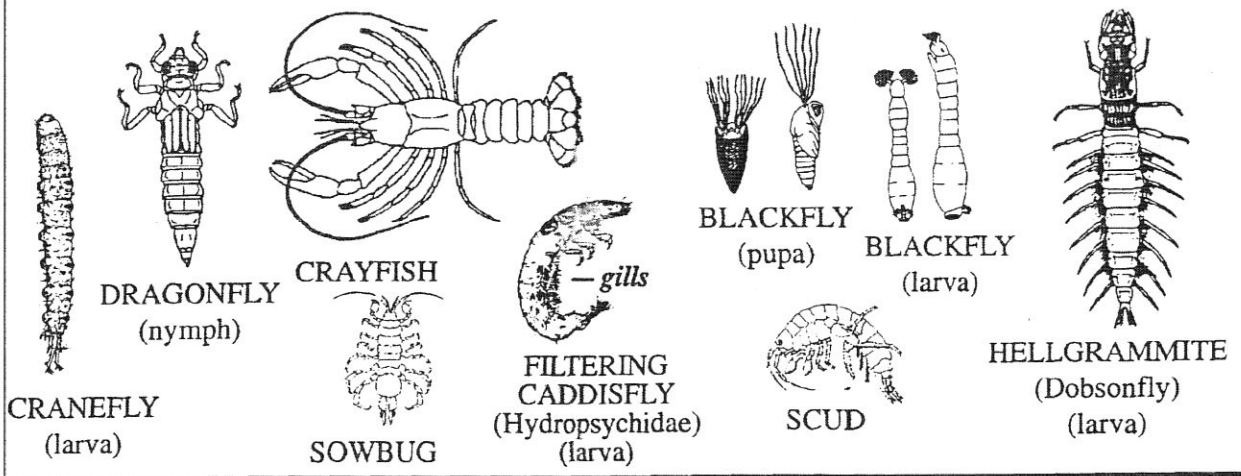
Excellent (>22)	Good (17-22)	Fair (11-16)	Poor (<11)
☐	☐	☐	☐

Macroinvertebrate Groups
Beginner Protocol Picture Key

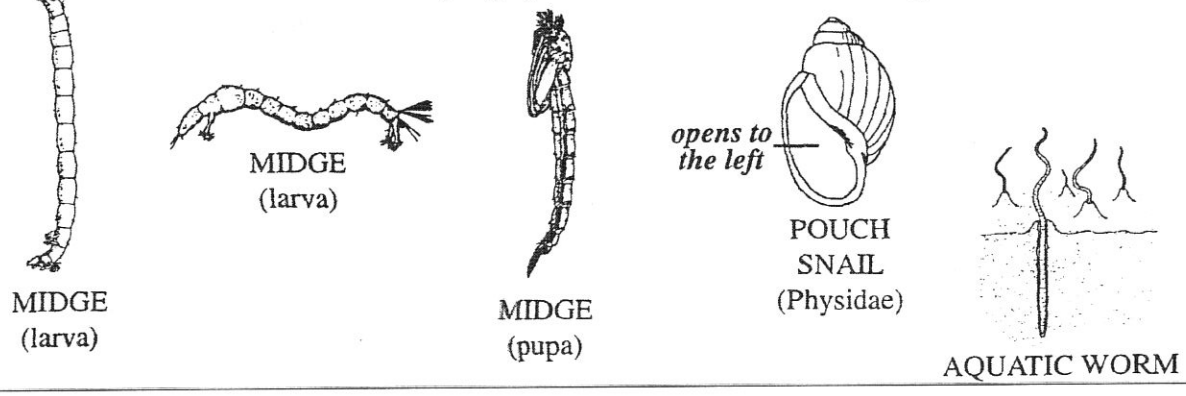
GROUP 1 ***These organisms are generally pollution-intolerant. Their dominance generally signifies EXCELLENT-GOOD WATER QUALITY***



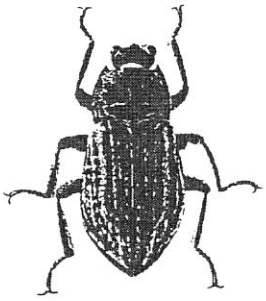
GROUP 2 ***These organisms exist in a WIDE RANGE of water quality conditions***



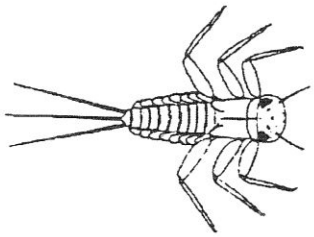
GROUP 3 ***These organisms are generally tolerant of pollution. Their dominance usually signifies FAIR-POOR WATER QUALITY***



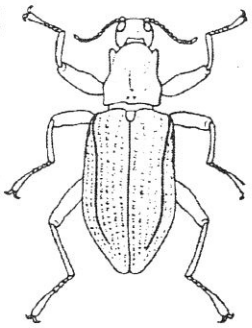
Group 1
Bugs



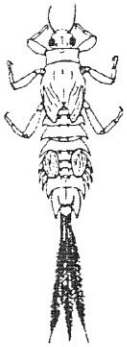
RIFFLE BEETLE
(adult)



MAYFLY
(nymph)

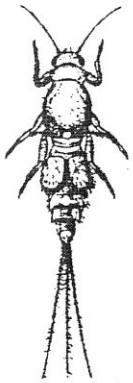


RIFFLE BEETLE
(adult)

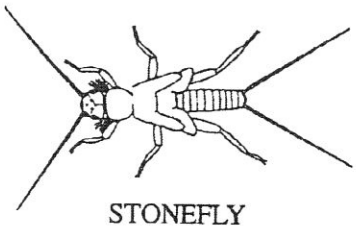


MAYFLY
(nymph)

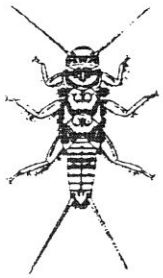
RIFFLE BEETLE
(larva)



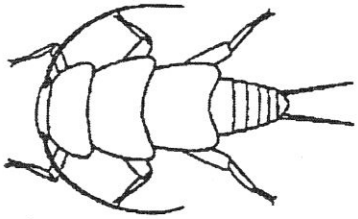
MAYFLY
(nymph)



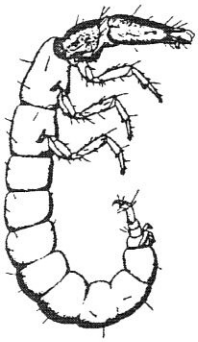
STONEFLY
(nymph)



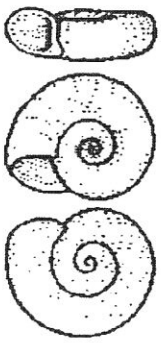
STONEFLY
(nymph)



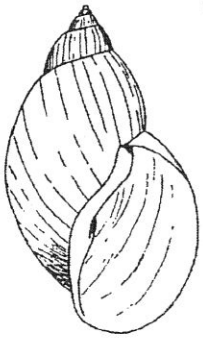
STONEFLY
(nymph)



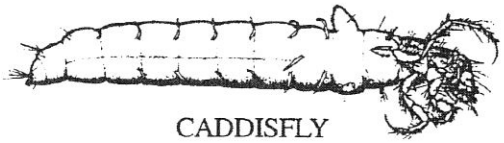
CADDISFLY
(larva)



SNAIL

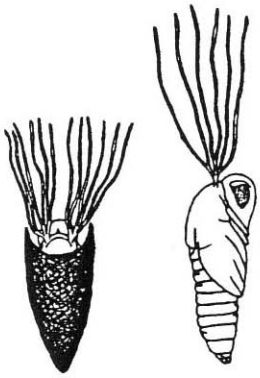


SNAIL
(shell opens to the right)

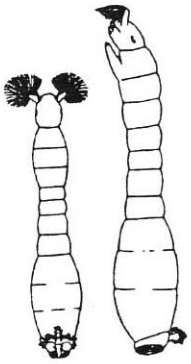


CADDISFLY
(larva)

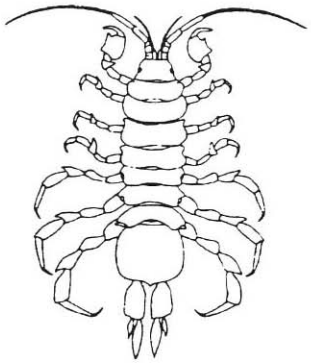
Group 2
Bugs



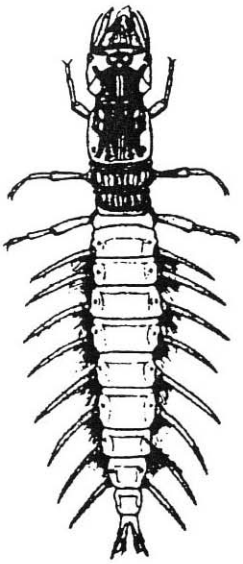
BLACKFLY
(pupa)



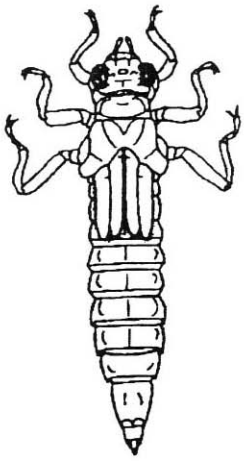
BLACKFLY
(larva)



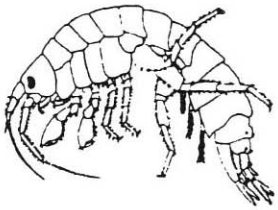
SOWBUG



HELLGRAMMITE
(Dobsonfly)
(larva)



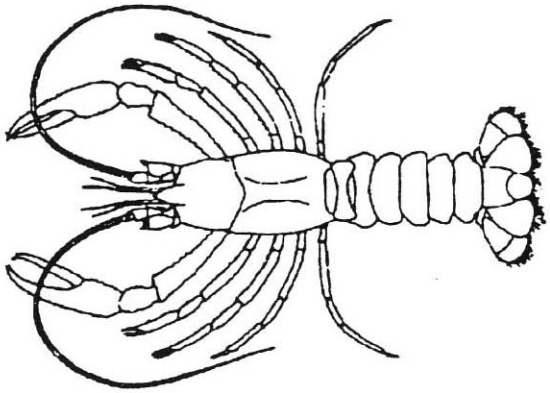
DRAGONFLY
(nymph)



SCUD

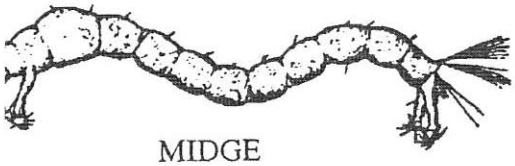
SNIPE FLY
(larva)

FILTERING CADDISFLY
(Hydropsychidae)
(larva)

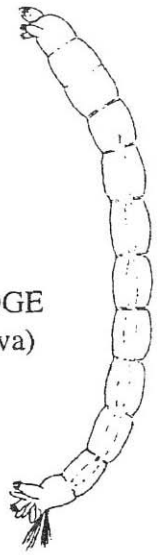


CRAYFISH

Group 3
Bugs

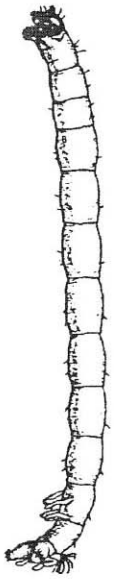


MIDGE
(Larva)



MIDGE
(Larva)

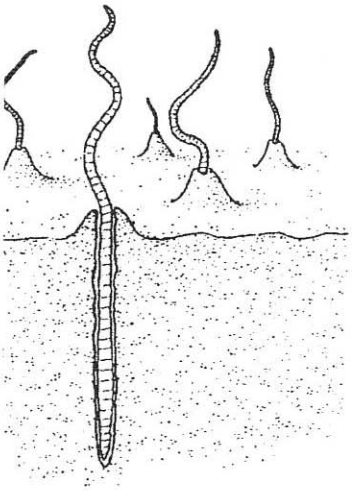
MIDGE
(Pupa)



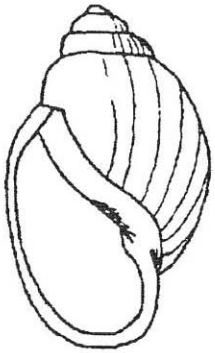
MIDGE
(Larva)

MIDGE
(Pupa)

MIDGE
(Pupa)



AQUATIC WORM



SNAIL

Notes

INTRODUCTION TO WASTE MANAGEMENT

Municipal Solid Waste Management
Waste Management in Alabama is as diverse as the state's natural resources. Municipal solid wastes are generated in homes, commercial establishments, institutions, and industries. Municipal solid waste varies from yard waste to food scraps and from construction and demolition debris to office and classroom paper. In the United States, each individual produces 2,555 pounds of garbage each year. In Alabama, each individual produces approximately 4.5 pounds of municipal solid waste a day. Local governments, waste management companies, and consumers have established methods of disposing of waste in an environmentally friendly manner.

Recycling is the process by which used items are reconditioned and are adapted to a new use or function. Recycling is a waste management method that can be a responsible, cost-effective way to help solve some of Alabama's waste disposal problems. Recycling helps preserve natural resources, reduce pollution, and save energy.

Composting is a low-cost disposal method whereby organic material is accumulated in mounds or containers to bring about decomposition by microorganisms such as bacteria or fungi. Composted items can be used as a soil conditioner in landscaping and gardening.

Incineration is a disposal method involving the burning of solid waste to reduce volume, with or without the recovery of energy.

Landfilling is the major disposal method of solid waste in Alabama. A landfill is a system of trash and garbage disposal in which waste is buried between layers of earth in such a manner that minimizes environmental hazards. New EPA regulations called subtitle D make landfilling more environmentally friendly than before, but much more expensive.

Hazardous Waste Management
In addition to municipal waste management, Alabama also must manage hazardous wastes produced in the state. *Hazardous waste* is any solid, liquid, or gaseous material that is no longer of use in its present form and would cause injury or death to living organisms and would pollute land, air, or water if improperly disposed. Some examples of hazardous wastes include oil, batteries, pesticides, and oil paints. Hazardous wastes may be managed through minimization, resource recovery such as recycling or reuse, treatment, or disposal.

The *Resource Conservation and Recovery Act* (RCRA) classifies hazardous waste into two categories: characteristic hazardous waste and listed hazardous waste. *Characteristic hazardous wastes* exhibit one or more of the following traits: ignitability, corrosivity, reactivity, or toxicity. *Listed hazardous wastes* are incorporated into lists from the RCRA rules. They exhibit one of the previously listed characteristics or contain any number of toxic constituents that have been shown to be harmful to health and the environment.

Household hazardous waste, unlike hazardous waste generated by industry, is not regulated in Alabama by the Alabama Department of Environmental Management or the U.S. Environmental Protection Agency. The best way to manage household hazardous waste is to avoid generating hazardous products.

Disposal may be reduced or eliminated by giving leftover products away, recycling materials when possible, using less hazardous alternatives when possible, and buying only the amounts of products needed.

Classroom Compost

OBJECTIVES:

Students will be able to:

1. Identify the components of an active compost pile.
2. Explain the composting process.
3. Identify current and potential markets and uses for finished compost products.
4. Describe the benefits of composting as a waste management technique.

Grades:
9 - 12

Subjects:
Biology, Ecology, Environmental Science, Earth Science

Time Needed:
Two class periods (21 days apart), plus 5 to 10 minutes per day for days 2 through 20

Materials:
wire or screen compost container for outside compost or large glass container for indoor compost
organic yard and food waste (leaves, grass clippings, wood ash, sawdust, eggshells, fruit and vegetable food waste)
lawn fertilizer that contains nitrogen, dirt, or non-sterile potting soil
thermometer
trowels or large kitchen spoons

BACKGROUND:

Composting of materials is one of the oldest forms of recycling. When dead leaves fall to the ground in wooded areas, they are broken down and decomposed over time by a combination of physical (nonliving) and biological (living) factors. Eventually the elements and compounds that were once part of the living leaves are released into the air and soil where they can be used to form new plants or other organisms in the endless cycle of life. Given proper conditions, many of the organic wastes we throw away every day also can be composted and used as a soil amendment.

Organic materials are carbon-based substances that are or were parts of living organisms. Composting is a process whereby organic material is broken down and decomposed by microscopic bacteria, or fungi, and other decomposers such as earthworms. When organic wastes, such as grass clippings, leaves, sewage sludge, and food waste, are combined and receive sufficient air and water, microorganisms, especially bacteria, proliferate. If a compost pile is constructed and operated properly, the resulting bacteriological activity significantly increases the temperature in the pile destroying unwanted pathogens and quickly breaking down the organic materials. The finished product called compost is an important source of nutrients, such as nitrogen, for plants.

The large-scale use of composting as a waste management tool could significantly reduce the volume of solid waste that communities send to landfills. At present, few Alabama communities include large-scale composting in their waste management programs. A major deterrent in developing large-scale use of composting is a lack of demand or market for the finished compost product. Several large Alabama cities have “compostin” programs for yard wastes (leaves, brush, and other plant materials). They make those composted mterials available to the general public for mulch or other re-use.

Currently, composted yard waste and sewage sludge are used for soil enhancement; for landfill cover; and as a top dressing for grassy areas, vegetable gardens, and flower beds. Current major purchasers of compost are road and park departments, landscapers, golf courses, campgrounds, airports, and hay and corn farmers. Other potential purchasers include cemeteries, state and U.S. forests, homeowners, citrus growers, horse farms, topsoil and bark companies, retail farm and garden suppliers, phosphate miners, building contractors, and the fertilizer industry.

In addition to encouraging the development of additional large-scale composting facilities, homeowners are encouraged to use yard and food waste to make their own compost for use as fertilizer and/or mulch.

VOCABULARY:

decompose, organic, compost, humus, aerate, soil amendment

PROCEDURE:

Setting the Stage

1. A few days before the activity is scheduled, ask students to bring in samples of yard and food waste from home. Instruct students not to bring in meat scraps, fats, or oils. Pre-consumer food waste also could be obtained from school cafeterias. It may be beneficial to find an outside location for storing the compostable materials. There are many ways to build a compost pile. This lesson gives you several options. If you have a suitable site outdoors, you may dig a hole to use instead of building the pile in a container.
2. Prior to class, make copies of "Striking It Rich With Compost" and "Classroom Compost."

Activity

<u>Day 1</u>

1. Introduce and define the term "compost." Ask students to identify the "ingredients" they think are essential to a good compost pile and to explain why these ingredients are necessary.
2. Distribute the "Striking It Rich With Compost" information sheet and review the nine components of an active compost pile. Next, explain the composting process and ask students what they think finished compost looks like. Explain that finished compost looks and smells like dark, nutrient-rich soil, or humus, when properly prepared.
3. As a class, design and build a mini-compost pile in the schoolyard. A suggested procedure includes the following steps:
   • Chop the food and yard waste into small pieces.
   • Alternate layers of soil (one inch), organic waste (two inches), a sprinkle of fertilizer, and a sprinkle of water.
   • Place a top layer of one inch of soil on the completed pile.
   • Add additional water as needed to make the pile moist but not soggy. (It should feel like a damp sponge.)
   • Place a thermometer into the middle of the pile.
   • DO NOT SEAL THE COMPOST PILE—AIR CIRCULATION IS CRITICAL.
   4. Explain that, if accelerated decomposition is not needed, the soil, fertilizer, and water additives are not necessary.
5. Place the completed compost pile in an appropriate area in the schoolyard and post the "Classroom Compost" data sheet nearby. Have one student record the initial temperature, odor, and texture of the compost and list the organic waste materials added to the compost pile in the appropriate boxes next to START on the data sheet.

<u>Days 2-20</u>

1. Keep the compost pile away from extreme temperatures and direct sunlight. Assign a different student to examine the compost pile and use the data sheet to record data regarding the temperature, odor, texture, and changes observed in the compost pile each day. Once each week (Days 6, 11, and 16) use a trowel or large kitchen spoon to gently turn and aerate the compost. On these days, have students make and record their observations BEFORE the compost is turned and aerated. Remind students to record the temperature of the compost pile from the same location and depth and at the same time each day.
2. Check the moisture level of the compost pile every few days and add water as needed to keep it moist.

Day 21

1. Record the final temperature, odor, and texture of the finished compost product and allow each student to feel, smell, and look at a sample of the finished compost.
2. Have students help you construct a graph of the temperature of the compost pile over time and reproduce the completed "Classroom Compost" data sheet on the board or overhead.
3. Ask students what they think happens to organic food and yard wastes when they are buried in landfills. Explain that most landfills are not exposed to air, a critical component of the natural composting process. Without adequate aeration, most decomposing organisms cannot function properly. As a result, organic wastes buried in landfills can take decades to decompose. Inorganic compounds in a landfill never decompose. In addition, without ventilation methane gas, a natural product of the decomposition process, is trapped in landfills. As methane gas builds up in landfills, it expands and has been known to "float" or lift entire landfill cells. Now, all new landfills must include systems for collection and release of methane gas. Review the benefits of composting in reducing the volume of waste sent to landfills and recycling the elements and components necessary to sustain life. Tell students that according to U.S. EPA figures, currently 10.9 percent of the solid waste generated is food waste and 12.1 percent is yard waste. This is a total of 23 percent.
4. Composting needs to continue for 2 more weeks to get finished products.
5. Have the students find places and ways to use their composted material around the school grounds.

EVALUATION:

1. List the components necessary for an active compost pile.
2. Write a paragraph explaining the composting process.
3. Identify at least two current and two potential markets/uses for finished compost products.
4. Explain the benefits of large-scale and home composting.
5. Why was it important to record the temperature of the compost pile from the same location and depth and at the same time each day?
6. How did the temperature of the compost pile change over time?
7. Why did the temperature of the compost pile change?
8. Were any odors produced during the composting process? Why does compost have an odor?
9. How did the texture of the compost change?
10. What happened to the original organic wastes added to the compost pile? Which materials were broken down and decomposed the fastest? Slowest? Why?
11. Explain that finished compost is a natural fertilizer and tell students that in natural settings, especially wooded areas, dead leaves, branches, and other organisms are naturally composted to produce humus, a nutrient-rich soil. Review the current and potential purchasers and uses of composted sewage sludge and plant and yard waste compost in Alabama.

EXTENSIONS:

1. Have small groups of students design and monitor different kinds of compost piles (one low in nitrogen, one without moisture, one without aeration, one with sterile potting soil, one with a single organic waste ingredient such as banana peel, one without earthworms). Compare the rates and effectiveness of decomposition among the piles.
2. Prepare one compost pile containing large pieces of organic waste and another containing small pieces of the same types of organic waste. Have students investigate the effect of material size on the rate and effectiveness of decomposition.
3. Collect samples of natural humus from a wooded area. Have students observe and compare the texture, odor, and color of natural humus and prepared compost and examine the humus for evidence of decomposers (fungi, earthworms, insects).
4. If the community has a municipal composting center, take a field trip to observe its operation.
5. Have students design and maintain a school or home compost pile using food and/or yard waste.

6. Have students prepare a Composting Fact Sheet and distribute it to classmates, family members, and perhaps city council members.
7. Perform soil tests on natural humus, commercially obtained humus, and compost to determine how they compare. Grow seedlings in each, under identical conditions, to see if there are any differences. If differences occur, to what could you attribute the differences?

ORIGINAL DEVELOPMENT RESOURCES:

Roest, M. (1995). *Animal tracks.* Washington, DC: National Wildlife Federation.

www.epa.gov

"*Home Composting"*. The Composting Council. www.compostingcouncil.org

Alabama Department of Economic and Community Affairs - Science, Technology and Energy Division: Waste Utility and Reuse Technology publications, www.adeca.state.al.us

Questions About Composting

Will everything in the wastestream compost?
No. About 66 percent of the typical waste stream is compostable. This includes yard and food waste, paper, and wood.

What is the best method of composting?
There are several methods of composting. Choose the method based upon the materials you want to compost and the time you have to devote to composting.

Is composting considered recycling?
Yes. The United States Environmental Protection Agency includes composting in its definition of recycling.

What's the advantage in having a community composting facility?
Composting can reduce the dependence on landfilling and/or incineration.

How does compost benefit the soil?
A high-quality compost properly applied to the soil improves soil structure and aeration as well as increases its water-holding capacity. Compost improves the permeability of clay soils and the water retention of sandy soils.

Is compost considered a fertilizer?
No. While compost can contain varying amounts of nitrogen, phosphorus, and potassium, it is considered a soil amendment, not a fertilizer.

What are typical uses for compost?
High-quality compost can be used in horticulture, landscaping, and golf courses.

Striking It Rich With Compost

Key Component	Function
1. Soil	Contains microoganisms (bacteria) that help decompose organic materials.
2. Organic wastes (leaves, fruit and vegetable scraps, egg shells, and grass clippings) containing both carbon and nitrogen	Alternating layers of high-carbon and high-nitrogen wastes create good environmental conditions for decomposition to occur. Meat scraps, fats, and oils inhibit decompositions; and their strong odors can attract dogs, rats, raccoons, and other animals. They should not be used in compost piles.
3. Fertilizer containing nitrogen (or manure) or green grass clippings containing nitrogen	Many of the organisms responsible for decomposition need extra nitrogen for rapid and thorough decomposition.
4. Water	Essential component of the decomposition process; too much water can make the compost pile soggy and can slow decomposition by reducing needed oxygen.
5. Air	Fungi, bacteria, small insects, and other decomposing organisms require adequate amounts of oxygen to survive and function.
6. Time	Decomposition takes time; stirring the compost pile every few days can speed up the decomposition.
7. Heat	Heat is a byproduct of the chemical reactions occurring during decomposition. A properly functioning compost pile can reach a temperature of 65 degrees Celsius. The high temperatures help sanitize compost by killing weed seeds, pathogens, and harmful insect larvae.
8. Mass	To generate enough heat for optimal decomposition, a compost pile should contain at least one cubic meter of organic material.

Classroom Compost

Age of Compost Pile	Temp. (C)	Odor of Compost	Texture of Compost	Changes in Organic Waste Materials (size, color)
Day 1 (Start)				
Day 2				
Day 3				
Day 4				
Day 5				
Day 6 (Stir)				
Day 7				
Day 8				
Day 9				
Day 10				
Day 11 (Stir)				
Day 12				
Day 13				
Day 14				
Day 15				
Day 16 (Stir)				
Day 17				
Day 18				
Day 19				
Day 20				
Day 21 (Finished Compost)				

Notes

Closing The Waste Loop

OBJECTIVES:

Students will be able to:

1. Explain the processes in both a one-way flow system of waste (open loop) and a cyclic system (closed loop).
2. Research local industries and report on their recycling efforts.

Grades:
9-12

Subjects:
Social Studies, Chemistry, Marketing, Consumer Education

Time Needed:
Two hours

Material:
worksheets

BACKGROUND:

Every product has a life-use cycle. The cycle begins with the design and then the manufacturing of the product. The product is then used as intended and discarded after use. The above process, common in many products, is a straight line or open loop process contributing to filling up landfills.

A preferable alternative is to close the loop and bring the discarded product into the manufacturing process again to create a new product. Another way that this concept can be explained is the 4 R's (reduce, reuse, recycle, and rebuy).

Both manufacturers and consumers can help in *reducing* the amount of waste that is generated. *Reusing* products and containers directly increases the life of products and resources, thus decreasing the rate of waste generation. Products that are *recycled* for remanufacture are removed entirely from the waste stream. The last R depends upon the consumer. When we buy recycled products, we are *rebuying* products that meet all specifications for new products. We, as consumers, get the quality of new products and, at the same time, keep waste out of landfills when we buy recycled, remanufactured products. When we purchase recycled products (re-buy), we help not only ourselves but our environment.

VOCABULARY:

one-way flow waste system (open loop), cyclic waste system (closed loop), by-product, reduce, reuse, recycle, rebuy, raw material, second generation use, networking, economic growth

PROCEDURE:

Setting the Stage

1. Show the diagrams of open loop and closed loop systems on the worksheets. Discuss examples of closed loop and open loop systems. Discuss the economic and environmental advantages of a closed loop system.
2. Discuss the process of networking with other industries to aid in the disposal of waste products by using one plant's waste as another plant's raw material. Examples are given in the following chart.

Company	By-Product Waste	2nd Generation Use
Steel Manufacturing	Naphthalene Ferric Sulfate	Mothballs Clarifying agent for drinking water
Trucking Company	Used Tires Used Oil Used Oil Filters	Asphalt blending Fuel oOl Recycled into steel products
Poultry Production	Poultry Litter	Natural Fertilizer

Activity

1. Research project: choose businesses in the local community and assign to individual students or student teams.
2. Survey company to determine what waste products it produces; how they are disposed of; and whether or not any of these are reused, recycled, or sold to other manufacturers.
3. Chart waste on either an open or closed loop diagram. (Use the appropriate one.)
4. Evaluate whether a company's waste management system is environmentally efficient or economically efficient. If both, explain.
5. Prepare a 5-minute presentation for the class to share findings of individual students.

EXTENSION:

1. Ask businesses for a cost estimate of their waste management program. Compare with other businesses.

Waste Management Survey

Company Name:

Company Address:

Contact Person:

Phone Number:

Type of Business:

List Major Waste Product	How Waste Products Are Disposed	Why This Method Of Disposal Is Used

Questions To Ask A Contact Person

1. What is it about your waste management practices that makes your company environmentally responsible?

2. How might the company become more environmentally responsible?

3. What factors prevent your company from becoming more environmentally responsible?

4. Have your waste management practices affected the economics of your business?

   Negative effects:

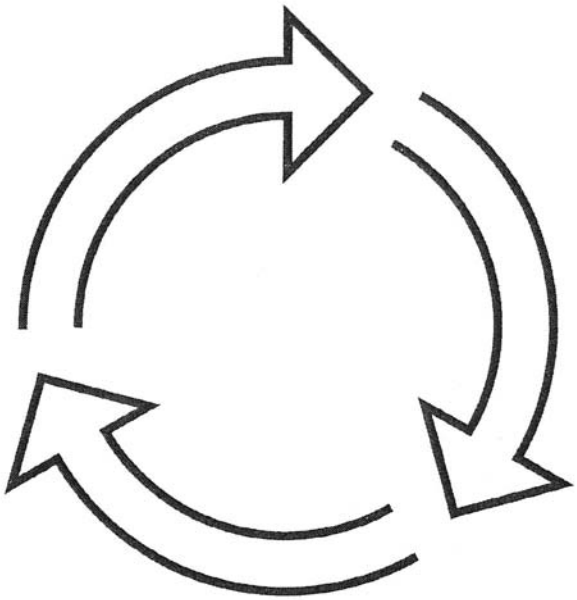
   Positive effects:

5. What are your predictions for future developments of waste management in your industry?

Closing The Waste Loop - Student Worksheet

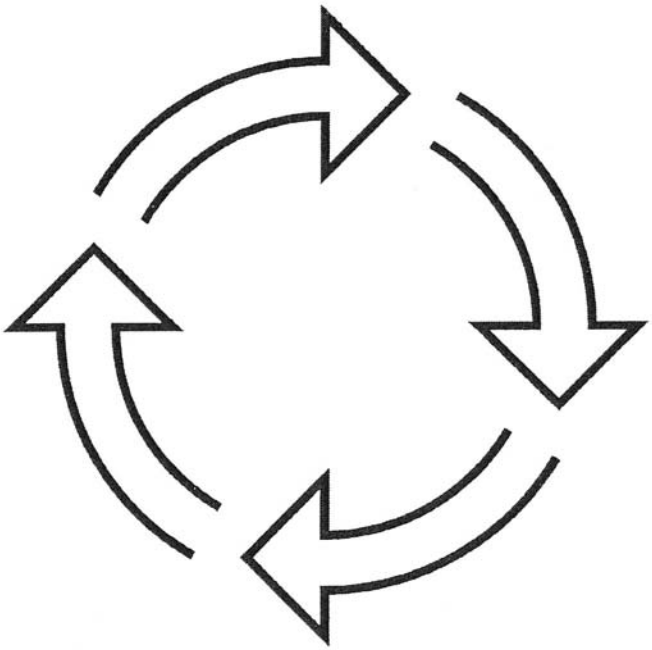
Open loop system has at least one component missing.

Closed Loop



3 arrows

or

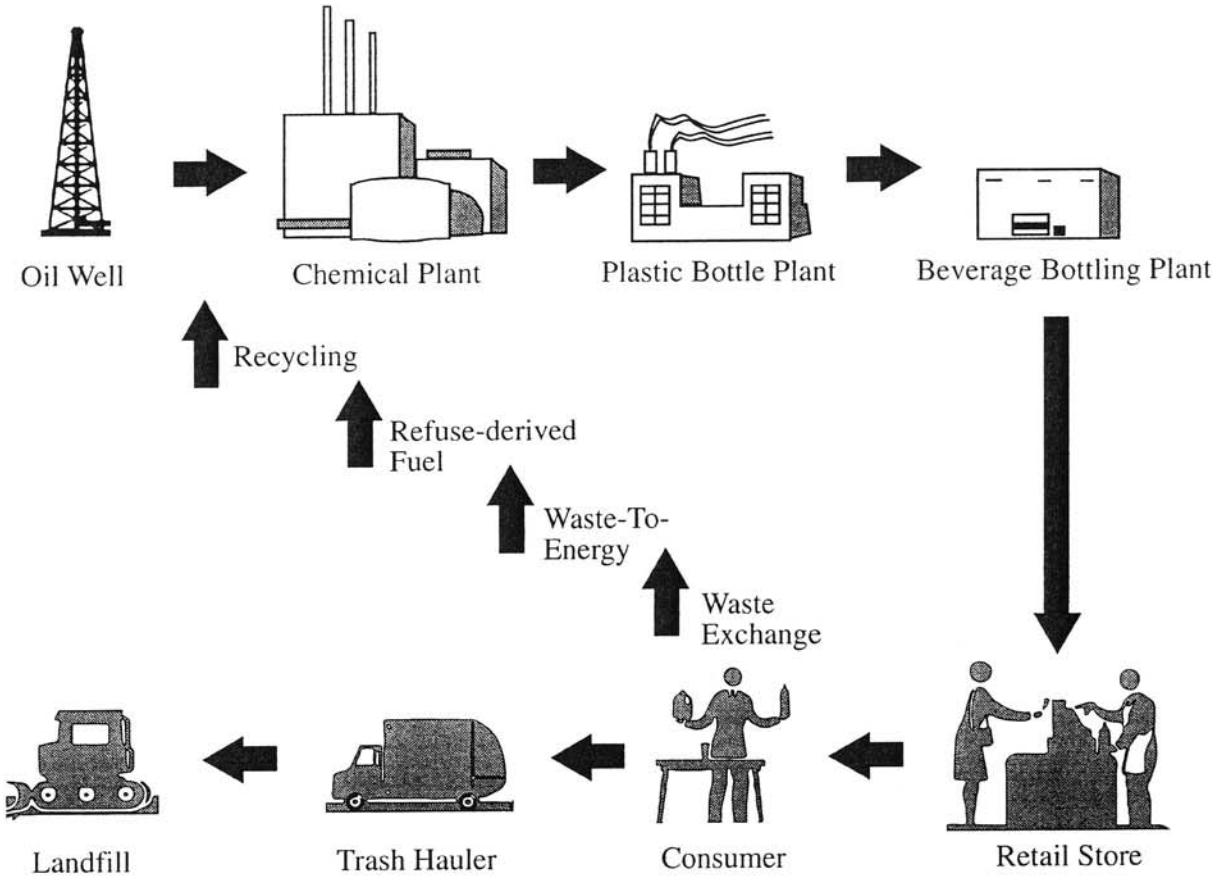


4 arrows

Industrial and Ecological Flow Systems

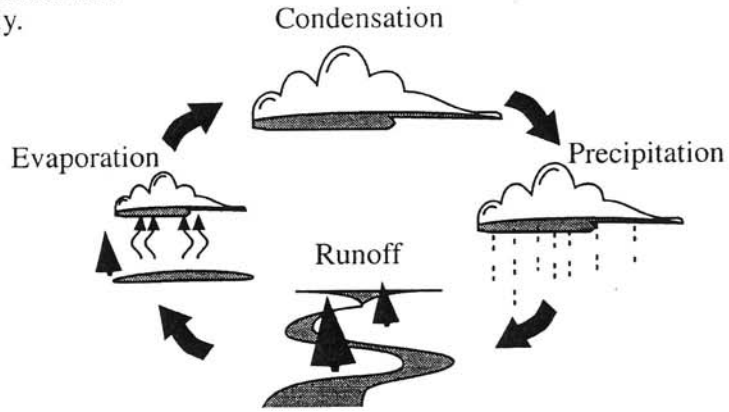
Industrial Cycle Flow Using Solid Waste Options

A cyclic system involves the potential of using materials over again at each step of the process or after final use with the intent to reuse or recover the resource or energy.



Ecological Cycle Flow

Nature provides a cyclic system that reuses and recycles natural resources continuously.



Notes

Deciding What To Do

OBJECTIVES:

Students will be able to:
1. Restate the complexities of managing solid waste.
2. Explain various agencies and legislation related to solid waste management.
3. Participate in a debate on solid waste legislation.

Grades:
9-12

Subjects:
Social Studies, Government, Environmental Science, Drama

Time Needed:
Several class periods, plus research over several weeks

Materials:
copies of the Scenario and role descriptions for students involved
sample hearing agenda
copies of the "Garbage Dictionary" for each student in the class
newspaper and magazine articles from your local area on problems in the management of solid waste

BACKGROUND:

Regulations for environmental quality usually lag behind the factors that contribute to environmental problems. Prior to World War II, there were few environmental regulatory programs. States directed their efforts to land use, not land quality. State and federal officials assumed the roles of advisors and persuaders. Only recently has government assumed a more active environmental
role.

The 1970 amendments to the Federal Solid Waste Disposal Act of 1965 were an important step toward addressing current issues in waste disposal methods. Emphasis began to shift from waste disposal to waste management and resource recovery.

The Resource Conservation and Recovery Act (RCRA) of 1976 (amended in 1984) replaced the Solid Waste Disposal Act. This law regulates the disposal of solid waste and gives strict requirements for the construction of municipal solid waste landfills (Subtitle D) and incinerators. Subtitle D landfill requirements went into effect October 1993.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) reflected changing attitudes and increasing efforts to protect the quality of the land. The Superfund legislation created a system of assessments (taxes) and provided federal funds to clean up major sites of pollution such as abandoned dumping sites.

VOCABULARY:

Solid Waste Disposal Act, RCRA, CERCLA, Superfund, NIMBY, solid waste

PROCEDURE:

Setting the Stage
To supplement these materials and to prepare students on the issues, have students collect information from newspapers, television news shows, and magazines related to citing landfills or incinerators. Review these as a class.

1. Have students research and report on the regulation of solid waste and related issues.
2. Divide the class into eight groups and explain to the students that each group is to research one of the following state and federal government agencies involved in the enforcement of solid waste legislation:
   - Environmental Protection Agency
   - Department of Energy
   - Army Corps of Engineers
   - Department of Labor

- Department of Transporation
- Department of Health and Human Services
- Interstate Commerce Commission
- Alabama Departments of Health and Environmental Management

3. Each group is to research, write, and present to the class a one- or two-page report that includes the name of the agency, its responsibilities, and the government legislation for which the agency is responsible. This will serve as a review of how government must work together to provide answers to complex solid waste situations.

   NOTE: This lesson requires students to think about the many issues surrounding solid waste disposal. For this lesson to be effective, students should have a basic understanding of solid waste, landfills, incinerators, and solid waste regulations. Management of solid waste and citing a garbage disposal facility are complex and controversial public decisions. In the decision-making process, a wide range of perspectives and values come into play.

Activity

1. The class will conduct a simulated refuse disposal citing/solid waste management hearing with class members taking the roles of various participants in the waste management decision-making process. The disposal facility under consideration includes options for an incinerator only, landfill(s) only, or both. For this exercise, students will be looking at the citing of a municipal solid waste facility. Other pertinent issues not explicitly on the hearing agenda but having direct or indirect bearing on the waste management problem as a whole are:
   - Waste prevention and reduction and what can be done to encourage it, especially in industry.
   - Recycling and the role it should play in the overall waste management plan.
   - Reducing industrial waste through the establishment of waste exchanges or treatment facilities.These issues and others are a few of the many problems facing communities and government agencies the world over as they grapple with the cumulative effects that result from our 'throwaway' culture.
2. Distribute copies of the scenario and a role description to each participating class member. For best results, use one role description for each group. Tell the students that the problem closely parallels the actual situation in a number of communities. The job of the class is to understand and discuss the solid waste problem and to come up with solutions. The emphasis should be on possible alternative solutions and not just a single answer to the problem.
3. Choose a student to serve as County Commissioner/Hearing Examiner. Then choose other students to fill the roles (see descriptions included). You may wish to assign some roles to more than one student. For example, have two journalists, one from a large newspaper and one from a smaller weekly publication, or one from the daily paper and one from a magazine. If the class is large enough, let some of the roles be assigned to two or three students who will each study and research a particular aspect of their roles' concerns about the county's disposal strategies. Not all the roles are necessary, but the 'hearing' will work best if at least the first six or seven parts are included.
4. An alternative approach is to assign the more technical and science-oriented roles, such as Scientist Expert, Toxicologist, Incinerator Vendor, to a chemistry and /or biology class while giving the other roles to a social studies class. The final hearing could be held in two sessions, one for each class.
5. Explain to the students that this simulation is not meant to represent any actual public hearing or governmental hearing process, but that many public bodies are required by law to solicit input and comment on complex projects that can affect human health and environmental quality.
6. Have students prepare to play their roles realistically and convincingly by having them contact their real counterparts in your county. Encourage students to add substance and appropriate detail to their roles. You'll notice that in the roles given, various positions and opinions are expressed. People use different terminology to describe what they agree with versus what they oppose. For example, people who oppose an incinerator may call it an incinerator while those who are for it may call it a waste-to-energy facility. This is not to say that all incinerators are waste-to-energy facilities, but it points to the fact that people's

opinions color their descriptions. Also, this example is for the siting of a municipal solid waste facility, that is, a facility to take only household and business garbage, not hazardous waste. This does not mean, however, that people won't mix issues and won't bring in their fears about dangerous wastes.

7. Hand out the sample hearing agenda or prepare a similar one of your own. Assign a specific date or dates for conducting the hearing. Encourage all the participants to come prepared with either questions or a brief presentation as indicated on the agenda. When the hearing takes place, have that part of the class not playing specific roles serve as the County Council, both questioning the hearing participants and, in the end, reaching a decision about what to do with all the solid waste.

EXTENSIONS:

1. Invite recyclers, environmental activists, solid waste engineers, garbage haulers, reporters, county commissioners to your class to describe the role each plays in dealing with your county's solid waste.
2. Invite these representatives to view your hearing and then to critique the student's arguments. How would they have handled their role in the hearing?
3. Share with the class the acronyms in the Garbage Dictionary. Have them think of others.

ORIGINAL DEVELOPMENT RESOURCES:

Adapted from the South Carolina Department of Health and Environmental Control and used with permission.

Schematic X-Section of A Solid Uaste Landfill

Deciding What TO DO
The Scenario

County population is growing rapidly. The volume of solid waste produced in the county is growing even more quickly. Federal and state regulations have outlawed open dumping, so all the old dumps have been closed. New U. S. Environmental Protection Agency guidelines for RCRA Subtitle D approved landfills are strict. In building a new landfill, Subtitle D regulations are not an option; they are the law.

To protect human health and the environment, Subtitle D landfills must have safeguards built into them, but this makes it very expensive to construct. In addition, a Subtitle D landfill must be monitored throughout its use and for many years after.

Incinerators and waste-to-energy facilities are controversial. A brief federal moratorium on these facilities puts them in the spotlight. Federal regulations on emissions are designed to safeguard the environment. These are strict and construction is expensive. People have been attracted to living in the county because of its beautiful semi-rural character and thus are very sensitive about environmental degradation or property devaluation that may possibly result from a landfill or large-volume incinerator being built nearby.

The county public work department, which has responsibility for proper disposal of all municipal waste generated within the county, is increasingly concerned about the growing amount of waste and is considering both an incinerator and/or a new landfill. The existing landfill is filling up fast; and, given the long lead time needed to site and build a replacement, a decision about what to do with the county's waste must be made soon.

ROLES

Activist
You oppose any new waste facilities. You feel strongly that more recycling could be done in the county. You think the county should require home source separation of recyclable materials such as aluminum, glass, plastic, and newspapers. Private or public garbage haulers should be required to provide separate pickup for recyclables. You'd like the county to institute a county-wide, per-can garbage collection fee schedule that allows as little as one pickup a month. You want the county to fund public education programs in recycling: programs both for citizens' groups and schools.

You oppose the construction of an incineration plant. You are concerned about the effects of incinerator emissions on air quality. You understand that an incinerator will require huge amounts of refuse to operate efficiently and thus may discourage recycling efforts, while at the same time presenting problems in disposing of the ash generated. You believe that a landfill could cause considerable environmental damage to the land, air, and water.

Garbage Hauler
You own a garbage collection company. Your company is licensed by the state and franchised by the county. Your prime concerns are providing good service to a rapidly growing number of customers and keeping costs down. You also are concerned about county and state regulations of your business.

In recent years, more of the task of running your business has been taken up with government forms and "red tape." You are concerned about the prospect of the county telling you how to set your collection fees, how the garbage itself must be picked up, and where you have to take it once it has been collected.

Commercial Recycler
You became involved in recycling a long time before concerns about environmental degradation were first voiced. Profits have never been large, and the markets for recyclables have never been particularly stable or reliable. Nevertheless, the satisfaction of knowing that your job is part of the solution and not part of the problem has always made the hard work and long hours necessary to survive more than worth it. After 20 years, you have carved out a secure market for your business, and you are looking forward to relaxing a little while letting the younger generation carry on the day-to-day work.

You are worried that an incinerator will cut the bottom out of the recycling market. Although you would like to see the city institute mandatory recycling and source separation, you recognize that your own business is probably too small to compete with the large waste management firms that the city would most likely end up contracting with for such a mandatory program. You are gratified that, at last, recycling has become a "big business" and thus respectable; but you are angry and a little bit frightened that you and your hard-earned business will get lost in the shuffle.

Spokesperson, Homeowners' Group
You are worried that the county/city may be planning to build a landfill or an incinerator near your home. You are worried about the roadway litter that may result. You also are concerned about the increase in the rat, crow, sea gull, and wild dog population that a landfill may bring, You are worried that household hazardous wastes dumped into the landfill will generate toxic leachate that could contaminate your drinking water. You are angry when you think that a landfill or incinerator may decrease the value of the house and land you've worked so hard to own.

As the co-founder of a civic organization against incinerators/landfills, you have been asked by the organization to present the group's concerns at the upcoming hearing. You realize, however, that it is not enough to protest a specific site and that appealing and feasible alternatives must be presented. For this reason, your organization has come out in favor of increased recycling.

County Public Works Engineer
Your county department has responsibility for disposing of all wastes generated in the county. You also have responsibility for meeting federal and state regulations governing the disposal of waste. Part of your job is to design and build waste facilities such as landfills and incinerators. At the same time, you are required to ensure that these disposal facilities do not create hazards for the environment or human health. A great deal of your energy goes into selecting and evaluating possible disposal sites and advising county commissioners/council members on technical aspects of solid waste management. You are becoming alarmed at the rate of growth of the county's volume of solid waste and, probably most acutely, realize the enormity of the county's solid waste problem. You ask yourself, "Where is all this stuff going to go?"

Lately, however, much more of your time has been taken up with public relations dealing with the concerns and sometimes the anger of citizens who question or challenge county solid waste policy or

decisions. You believe that citizens need to be better informed about some of the scientific and technical issues that are part of deciding what's the best option. You are especially concerned that the press is playing up some of the more sensational but remote dangers associated with incinerators and landfills. It seems that no matter how well you document the safety of a waste-to-energy incinerator or a landfill site, the papers always play up the negative aspects.

County Commissioner/Council Member
Your job is to make the final decision about how to deal with the county's growing volume of solid waste, while taking into account the needs and interests of a broad range of county citizens and businesses. You have to understand both the technical information provided you by the public works director and the anxiety of homeowners who feel threatened by the possibility of a landfill or incinerator in their area. You try to be pragmatic and fair. You also want to get re-elected to office.

Your role in the hearing is to conduct a landfill citing/solid waste management discussion by calling on and questioning the citizens who have a position or an opinion to express. It is also your responsibility to seek the input of other county commissioners/council members and interested citizens. It is your responsibility to conduct an orderly and productive meeting. This means that all participants should be treated equally and that all viewpoints are given a fair hearing.

County Citizen
You lead a busy life. You like the convenience that some packaged and processed foods give you, although you are sometimes bothered by the amount of packaging left over.

You know your county is growing rapidly; but you have been more concerned about other consequences of growth, such as crime and crowded highways, than you have been about an increase in garbage. Frankly, you'd like to throw your trash in the garbage can and forget about it, even though you know in the long run that your children or grandchildren may end up paying for it with a less healthy environment.

You're paying the garbage hauler and the county taxes to take care of trash for you. You don't feel you have enough time in your day to fool around with the trash by separating it for recycling. And you don't want anything to do with higher taxes.

Journalist
Time and time again you've been assured by elected officials that the city has its garbage problem under control only to learn later, after careful digging, that the plans made have proved to be inadequate for the mounting garbage generated daily through expanded growth. When you ask about safeguards for environmental and human health, the engineers and planners present seemingly endless numbers and graphs, all purporting to establish the safety of the sites being proposed for the disposal facility.

Your job is to ask hard questions, understand the important issues, and report accurately the decision-making process.

Incinerator Plant Vendor
You believe that incineration is the best solid waste management method available. As an engineer with many years of experience in waste management and chemical processes, you know that the

technology for safe incineration is already available; and you don't understand why some citizens are fearful and unwilling to trust your professional judgment.

If asked, you would have no qualms about having an incinerator site next to your property. You want your company to be selected for this county's contract. Your boss has promised you an especially attractive bonus if you can "land" this one. You also know that waste incinerators, under the right conditions, are good opportunities for investors.

Regulatory Agency Official
You have been assigned by your agency to carry out state law as mandated by the state legislature. Your responsibility is to write about enforcing regulations that will protect public health and the environment, yet still provide practical and economically feasible waste management facilities.

You are sensitive to the public's view of you, yet you know that there is no perfect set of regulations that will please all the parties. From your experience as a field inspector, you know that strict enforcement of the law doesn't always lead to the desired result of a safer environment. You are sometimes as frustrated as the public by the legal requirements built into the regulations as safeguards against unjust government actions but which are all too often exploited by a few "bad eggs" at the expense of the many.

It is sometimes hard to remember that most individuals and businesses are honest and want to comply with the law, especially as it relates to the environment. You have been asked to attend this hearing to explain the current state and federal regulations and to show how they affect the county's proposal for siting a disposal facility. You expect to be questioned closely by both citizen and industry groups.

Scientist Expert
You are a professor of geology at a nearby university specializing in hydrology, the study of water movement in the Earth. Your research has focused on groundwater flow and the scientific study of the problems associated with groundwater contamination from human activities.

Your publications have appeared in numerous journals, and your scholarly expertise has been acknowledged by many professional organizations throughout the world. As your reputation as an expert has grown, you have been called on to speak at a growing number of public hearings and workshops throughout the state including testimony at legal trials on the safety of various disposal options with respect to potential and actual groundwater contamination. You know as a scientist that there is no such thing as certainty, especially in a field like geology where most events are measured in millions of years, and actual experimental verification is possible only on a limited basis. Nevertheless you find yourself being asked to give "yes" or "no" answers to questions that scientific and technical knowledge can never provide. The county commissioner has asked you (for a fee) to examine the county's plans for disposal and to provide a brief report discussing the impacts that each option might have on the water supply now and in the future. At present, the data available and current scientific models can only suggest in a most sketchy fashion what these impacts might be. You are worried that, because of this, each faction will seize upon those parts of your presentation that most closely support its position and then point to you as proof of the "truth" of its claims.

Private Consultant
The county hired the firm you work for to study the various options for a garbage disposal facility. You have been part of the team that carried out the necessary research, and your particular expertise is in the area of stack emissions in incinerators and the safeguards of the new Subtitle D landfill design.

Your supervisor is out of town this week, and you have been tapped to represent the firm if any questions arise concerning the recommendations that were made to the county as part of your firm's final report. Since a landfill and/or incinerator were included as part of the recommendation, you expect to be questioned sharply on these aspects of the overall strategy your company proposed.

County Attorney
The district attorney's office reviews all the county plans to ensure that the county does not violate any of the many governmental regulations that inevitably cover any large-scale plan.

Projects with the potential for environmental harm and/or human health effects are especially complex, involving as they do both technical and political issues. You have been assigned the job of monitoring the legal aspects of the county's waste management plans. A top-notch lawyer, you welcome this assignment as the first step in your career as a public official. You have political ambitions, and you know how crucial it is to perform well on this assignment.

Your boss, the district attorney, is particularly concerned about the threat of lawsuits and other legal actions from various special interest-groups such as nearby homeowners, industry organizations, and environmental activists.

Toxicologist
You work at a federal government laboratory studying the effects of chemicals on mice and rats. Most of your research is directed toward determining whether certain chemicals can cause cancer in humans and animals. The main research tool for doing this is to expose special strains of rats and mice to substances and observe whether, or at what dosages, tumors develop. You know that many people are doubtful about relating results from mice to humans. Skeptics point out that experimental animals are exposed to high doses of substances at levels not commonly found in a normal environment. You, however, know that to extrapolate to the low dose exposures that are typical of human environments, the 50 to 100 rats and mice must ingest enough toxin to produce a statistically significant number of cancers. Estimates of cancer-causing potency are based on the extrapolation of the experimental animal results to low doses.

Several environmental organizations have expressed concern about production of dioxins by the incinerator, either as smokestack emissions in the air or as part of the flying ash that must be disposed of. Dioxins are a class of chlorinated organic compounds produced as byproducts in the production of herbicides and other products. At least one dioxin, TCDD, is the most potent carcinogen known in mice and rats. The evidence for its cancer production in humans is not established, however; and scientists disagree as to what exposure levels are safe.

Farmer/Agriculture Representative
Your family has roots in the area that stretch back to the early pioneer days more than 100 years ago. You have watched the county seat grow from a small town to a medium-sized city. You are

concerned about the rapid growth and its effects on prime agricultural land. In your view, building an incinerator or new landfill will encourage more growth, and you know that your family farm ultimately may be threatened by this growth.

Taxes continue to increase, and you have farmer colleagues who have been forced to sell their acreage due in part to rising property taxes. You feel strongly about the stewardship of the land and are worried that your family's longtime ties to the land may be broken. When it comes to new people and waste disposal, you say, "Not in my backyard."

Real Estate Developer
You believe that progress must necessarily include some environmental disruption, but that the economic growth for the area far outweighs the short-term pollution of a "few" streams or the conversion of some prime agricultural land for suburban housing and shopping centers.

If most environmentalists had their way, the county would soon stagnate from the many regulations and restrictions that stifle growth. You are convinced that the expansion now underway must not be interrupted and that desirable "high tech" industries can be attracted to the area only if they can be assured that there are adequate waste disposal facilities.

You believe that growth is inevitable and that, even if there are some minor problems now, scientists and engineers will come up with the necessary technology in the future to solve them. Sure, in the past some mistakes were made, but there are plenty of safeguards built into the law now. Besides, it's always been necessary to "break a few eggs to make an omelet." You believe that an incinerator, especially a waste-to-energy incinerator designed to produce energy while it burns trash, is necessary for the continued economic health of the county. You think that all the people who oppose progress have the NIMBY (not in my backyard) syndrome and should wake up.

Chamber of Commerce Representative/Local Businessperson
You have been a member of the local business community for 20 years. Your business has been slowly growing after a struggle to make ends meet for the first 10 years. However, the national economic situation has caused you great concern. Will you be able to meet the costs of a college education for your two teen-aged children?

A waste-to-energy incinerator would bring cheaper electrical power rates and would build an economic base in the county. Recycling efforts could bring in a few jobs, but larger companies outside the area already are prepared to initiate large-scale recycling efforts. A new landfill might cause a reduction in business opportunities, tourism, and residential growth. However, when it comes to where a facility should be located, you say, "Anywhere except my side of town."

Public Hearing On Proposed Municipal Refuse Disposal Facilities

Agenda

I. Opening Statement - County Commissioner

II. County Proposals - Public Works Engineer
   A. Combination Incinerator and Sanitary Landfill
   B. Waste Reduction/Recycling with Smaller Landfill and Incinerator
   C. Long Distance Hauling to Another Part of the State
   D. Question Period

III. Expert Reports

IV. Citizen Testimony
   A. Citizen Environmental Group
   B. Organizations

V. Industry/Business Testimony

VI. Final Summarization and Questions

VII. Conclusion and Vote - Commission Members

VIII. Report of Proceedings by the Journalists

Garbage Dictionary

excerpts from *Garbage* magazine

NIMBY— This acronym for Not In My Backyard sums up some peoples' reaction when plans for the new landfIll or incinerator are unveiled

GUMBY— Gotta Use Many Backyards. The divide-and-conquer methods of siting hazardous waste facilities and the like: You've got six sites, and you only need to use one. You try to get people to fight it out. The town offering the weakest opposition gets the facility.

YIMBY (FAP)— Yes In My Backyard (For A Price). A new siting tactic: Waste-handling firms pay fat inducements including road improvements, free disposal, and a piece of the dumping fee (which can total in the millions of dollars) to any community willing to "host" a large regional landfill or incinerator.

NIMTOF— Not In My Term Of Office. A waste-industry tag for politicians who give in to community opposition thereby leaving their successors to deal with the problem.

NIMIC—Not In My Insurance Company. When a community rises up to fight a waste site, they're branded hysterical housewives, but when an insurance executive refuses to underwrite a pollution liability policy for the same site, he's credited with sharp business acumen.

NOPE— Not On Planet Earth. When the NIMBY syndrome gets them down, this term is muttered by waste handlers convinced the "NIMBY-ites" don't want disposal facilities sited anywhere.

PICESP— Put It In Corporate Executives' Swimming Pools. In fevered moments, this term is used by radicals who think waste management executives should just keep the wastes.

NIMFY— Not In My Front Yard. If "NIMBY-ism" is taken to extreme and there are no more garbage pickups because no one will accept new recycling facilities, landfills, or waste-to-energy plants, NIMFY is what people will be crying as they watch their waste pile up.

Notes

Generating Methane From Waste

OBJECTIVES:

Students will be able to:

1. Describe the energy-producing potential of some solid wastes.
2. Examine some systems of generating methane from waste.
3. Construct a model methane generator.

BACKGROUND:

Methane gas is created naturally as a waste product of anaerobic bacteria living in water-logged soils and wetlands and also in human-produced environments such as rice paddies and landfills. The digestive systems of some animals, such as cattle and sheep, contain these bacteria and produce methane gas. A single cow produces 100 gallons of methane each day. The microbes in the intestines of termites, which digest wood, also produce methane. Methane is produced for fuel in some parts of the world and is burned in methane digesters. Methane gas is a greenhouse gas and contributes to global warming. Some scientists believe about 18 percent of global warming may be attributed to increases in methane in the environment.

The top ten sources of methane in the atmosphere are:

1. wetlands	20.2%
2. rice fields	19.4%
3. cud-chewing animals	14.0%
4. biomass fires such as burning forests	9.7%
5. oil & natural gas pipeline leaks	7.9%
6. termites	7.0%
7. coal mining	6.2%
8. landfills	6.2%
9. animal wastes	5.0%
10. sewage	4.4%

Once buried, organic wastes (food wastes, plant and animal materials) decompose anaerobically, which means that they decompose without oxygen. The speed of decomposition is highly variable and depends upon moisture, the amount of compaction, and other factors. Carbon dioxide, methane, ammonia, and hydrogen sulfide gases all are produced as microorganisms break down wastes. Note this distinction: this activity deals with organic wastes. Inorganic wastes and very stable anthropogenic organic materials, such as plastics, *may* decompose eventually if given enough oxygen, light, and time. However, they decompose only very slowly in a landfill where they are sealed off from oxygen and light.

Trapped beneath the landfill surface, the gas by-products of organic waste decomposition become potential health and safety threats if not properly vented. To avoid explosions or lateral migration of methane beneath the surface of a landfill, vents are installed to reduce pressure build-up of the gases.

Grades:

9-12

Subjects:

Chemistry, Environmental Science

Time Needed:

One class period to set up the experiment (Time needed for generating gas will depend upon the procedure used.)

Materials:

safety glasses
fume hood (if using heat source)
three Erlenmeyer flasks (one 500 mL, two 125 mL
a lubricant petroleum jelly
organic slurry of manure or ground grass clippings, etc. (from a compost pile)
balloon (blown up several times, making it easier to inflate)
three rubber stoppers (these may be pre-drilled)
one foot of glass tubing
3 feet of surgical tubing (or any flexible tubing that can be attached to glass tubing)
the nozzle from a medicine dropper
one pinch clamp
a drill to bore a hole in rubber stoppers (not needed if stoppers are pre-drilled)

Methane is the largest component of natural gas. If the landfill volume is great enough (at least one million tons), the methane produced can be captured, purified by removing carbon dioxide and water, and sold to gas utility suppliers. Capturing methane from landfills may not result in a profit, but it can help to defray the landfill's operating costs. There are many methane recovery systems operating or under construction in the United States, and there are a great many more landfills large enough to justify a methane recovery system.

In Birmingham, Alabama, the New Georgia landfill recovers methane gas that is used for fuel.

According to an article in *The Waste Age* magazine entitled "The Clean Air Act," November 1993, the United States EPA has proposed new performance standards for new municipal solid waste landfills and emission guidelines for existing facilities under Section 111(b) of the Clean Air Act. This was in response to EPA's findings that municipal solid waste landfills can be a major source of air pollution that contributes to ozone problems, air toxin concerns, global warming, and potential explosion hazards.

The EPA conducted a study of landfills to determine the methane generation rate constant and the potential methane generation capacity of the refuse. Based on these data and other assumptions, the EPA estimated that the baseline (1987) emissions from the 7,124 existing landfills in the U.S. was 15 million gallons/year of methane and 300 million gallons/year of other non-organic compounds that occur in landfill gas including trichlorofluoromethane, trichloroethylene, benzene, vinyl chloride, toluene, and perchloroethylene. The predictions do not include emissions from the 32,000 landfills closed prior to 1987.

Due to these concerns, EPA is considering more comprehensive regulation of 'municipal landfill gas emissions' in total.

VOCABULARY:

organic waste, methane, slurry, anaerobic, pyrolysis, methane digester

PROCEDURE:

Setting the Stage

1. Prior to class, make an overhead transparency of the *Methane Digester Model* or copies for each student group.
2. Review with the class the background material included with this lesson. Explain to students that they are going to create a methane generator.

Activity

1. Refer to the illustration to help with setting up the methane generation/collection apparatus. **Wear safety goggles**. This experiment must be properly constructed. Your system must be well sealed. Any leaks will result in a lack of gas pressure. (You may want to practice this experiment and have students assist you in demonstrating the experiment for the class. If enough equipment is available, you may have students set up several stations.)
2. Bore two holes in each rubber stopper, or use stoppers with two holes already in place.
3. Run a tube from the flask representing the landfill to the flask representing a gas storage container. (***Note:*** Make sure all connections are tight. Use petroleum jelly or Amogel on stopper holes. Keep tubing to a minimum. Use large diameter tubing.) The gas storage container's stopper should have two holes, one for the tube coming from the landfill flask (the large flask) and one for a nozzle and clamp. This is your flare.
4. Run a tube from the large flask representing the landfill to the third flask. This is the pressure relief system. Attach a second tube to the third flask and connect a balloon that's been blown up several times to stretch it. Make sure the tube from the landfill flask extends down into the water (see illustration; fill your pressure relief and gas storage flasks to near capacity with water). This arrangement will prevent an excess of gas from feeding back into the landfill flask.

5. Fill the large flask about three-fourths full with an organic slurry (for example, manure and ground grass clippings mixed with water until a thick, but pourable, consistency is reached). This flask will represent the landfill. Keep it warm. In the classroom, keep it away from any air conditioning. Warmth from a sunny window will help. It may be advisable to keep this set up under a fume hood.
6. It will take days or maybe even weeks before gas is produced. Keeping the slurry warm speeds production. As gas is produced, the balloon is inflated.

Optional Procedure to Speed Up Gas Production

1. Set up as before but *without* the gas storage flask.
2. Let the slurry (compost and manure) set overnight and then apply continuous heat and stirring. (Use a hot plate set to about 350 degrees C.) This should produce gas in about 20 minutes. You should see the balloon inflate.

EVALUATION:

1. What is methane?
2. How is methane produced?
3. List materials that can be used to generate methane.
4. Describe another means of using solid waste to produce fuel.

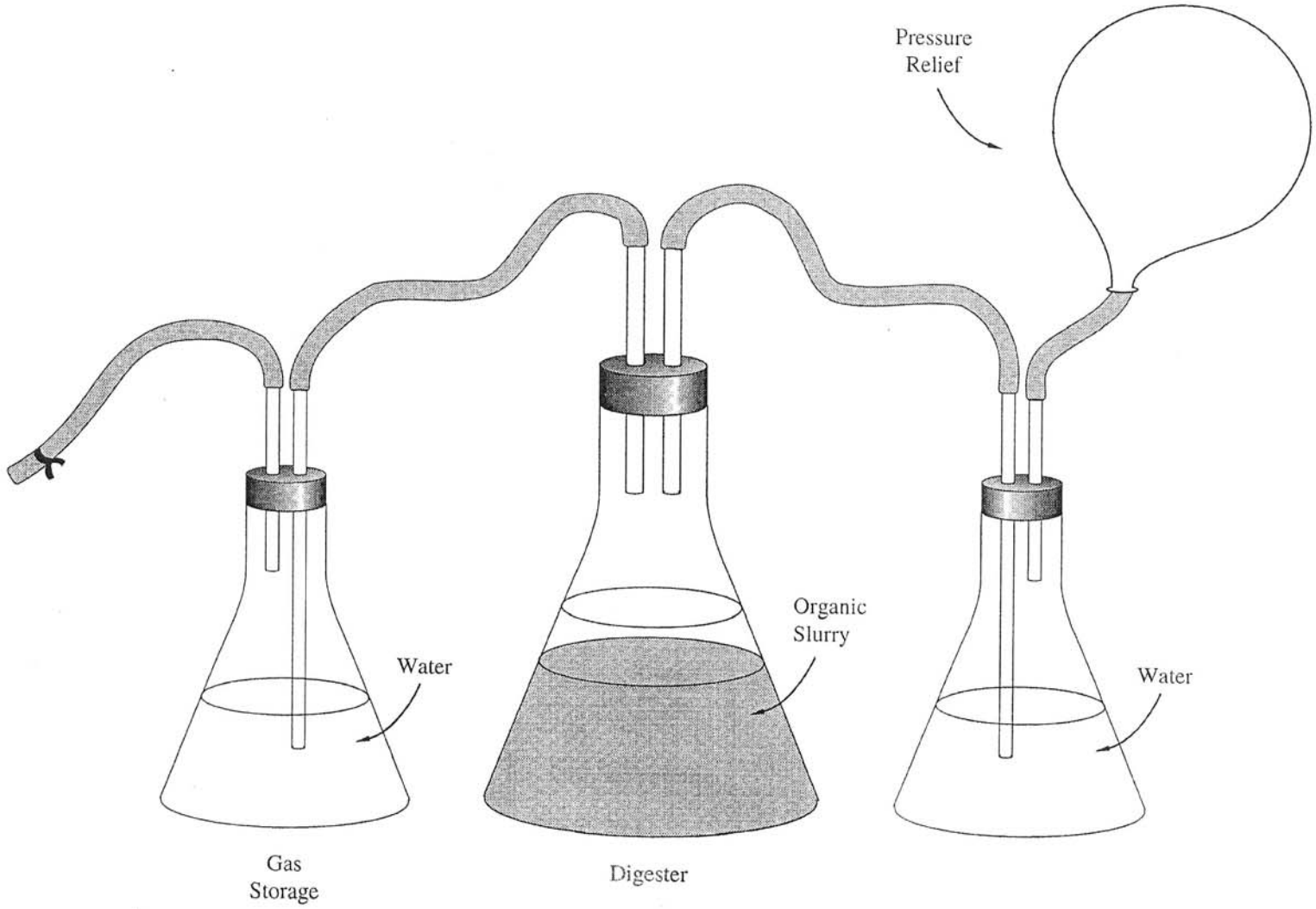
EXTENSIONS:

1. Have students research the historical uses of methane gas digesters. For example, in Holland a tarp was placed over a portion of a swamp with a hose running from under the tarp to a house to produce methane for light and heat.
2. Have students work in teams to build four or five of the three-flask methane generation/capture apparatuses. Have students test different organic wastes. Which produces the most gas the fastest? Which waste produces the best fuel?
3. Research modern methane technology.
4. Study resource recovery technology to learn how industrial fuel is created from solid waste by pyrolysis.

ORIGINAL DEVELOPMENT RESOURCES:

Environmental Literacy, the A to Z Guide. Adapted from South Carolina Department of Health and Environmental Control. Used with permission.

Methane Digester Model



Making Landfill Models

OBJECTIVES:

Students will be able to:
1. Define waste and leachate.
2. Describe a sanitary landfill in terms of its construction and function.
3. Identify some common chemical and physical properties of leachate.
4. Describe the effects of leachate on soil and groundwater.

BACKGROUND:

Landfills bury waste. An important factor in how landfills are built is how well they retain waste and prevent waste from contaminating nearby soil and water resources. The possibility of leachate contaminating soil and groundwater exists wherever wastes are buried. Leachate is formed in landfills when disposed wastes mix with water (either present at disposal or from precipitation). This water percolates through the waste, picking up a variety of suspended and dissolved materials from the waste. It collects at the bottom of a landfill.

In unlined landfills, the leachate continues to percolate through the soil. Some landfills have a simple clay liner used for containing leachate. In these landfills, which are being closed, leachate is not collected for treatment. In landfills with more sophisticated liner systems (Subtitle D landfills), leachate is collected and treated.

In this lesson, the landfill model represents the construction of a Subtitle D sanitary landfill to hold municipal solid waste.

VOCABULARY:

percolation, residue, leachate, aquifer, groundwater, leach, pH, hardness

PROCEDURE:

Setting the Stage
1. Prior to class, make copies of "Construction of a Sanitary Landfill Model" and "Student Work Sheet--How Leachate Affects Plants."
2. Discuss with the students the following questions:
   - What is waste?
   - What does the term 'biodegradable' mean? (*Note that all the elements for biodegradability (air, water, and sunlight) are not available in a landfill. Without air, water, or sunlight, there is limited or longer-term degradation.)*
   - What are the sources of waste in a landfill? Give examples.
   - What happens to the waste from our homes, schools, and businesses?
   - Why is waste disposal an important issue?

Grades:
9-12

Subjects:
Chemistry, Math, Environmental Science

Time Needed:
Three to four class periods per procedure (not consecutive), homework, one month (minimum) for leachate collection

Materials:
30-gallon plastic garbage can
5 to 10 gallons of soil (clay, loam, and sand)
screw-in plastic faucet with securing nut
two-inch square piece of screen wire
caulking compound or silicon sealer
waterproof glue for plastic
plexiglass (4" x 30")
one gallon of distilled water
(optional) Coliform bacteria test/lactose broth
laboratory thermometer
test kit for pH and hardness
egg cartons and egg shell halves
For extenstions: Daphnia (10to 20)
4 petri dishes
4 steel nails
soap
rubbing alcohol
paper towels
ammonia
vinegar
safety goggles
radish seeds
soil test kit

3. If possible, make arrangements for students to visit a landfill site, or arrange a presentation by a local waste management or public health expert. Explain to the students how a landfill is constructed. Discuss:
   • Site selection.
   Methods and operations.
   • Chemical and biological reactions occurring in completed landfills.
   • Methane gas and leachate movement and control.
   • Landfill design criteria and regulations.
4. Ask students to describe what they think the properties of landfill leachate might be (in terms of pH, bacteria, and suspended solids) and what the processes occurring in its formation might be.

Activity

1. Ask each student to bring to class a small plastic bag containing household wastes including foodstuffs (vegetable and fruit peels, NO meat or dairy products), yard trimmings or plant residue, metal, paper, plastic, and cloth. As they bring the small bags of waste, have them deposit the bags in a larger bag in the large container.
2. Have the materials and equipment gathered for constructing the landfill model. Divide the class into teams. Give the teams copies of the student sheet "Construction of a Sanitary Landfill Model" and proceed with the construction of the model and waste preparation.
3. To prepare for the simulated rainfall, determine the average annual precipitation for your geographic area. Information is available from a meteorologist or local extension agent.
4. Divide the average annual precipitation by 52 to calculate the average weekly precipitation.
5. Measure distilled water to equal the amount of the calculated average weekly precipitation and sprinkle it over the soil in the model landfill.
6. Repeat the addition of 'average weekly precipitation,' keeping a record of the number of "weeks" until water begins to collect in the bottom of the model landfill. (*The liquid that collects in the bottom is the leachate*.) Be prepared to allow several weeks of adding precipitation to obtain enough leachate to perform this activity.
7. Monitor the temperature by inserting a thermometer as far as possible into the center of the landfill model. Keep a daily record of temperature readings. This can be an excellent graphing exercise.
8. One month after the addition of the water, withdraw all of the leachate from the model and test for pH, total suspended solids (liquid weight minus the weight of solids), hardness, and coliform bacteria (optional). Then:
   • Compare qualitatively color differences in leachate.
   • Compare the results of these tests with the properties of distilled water and graph the results.
   • Discuss what we can do to prevent leachate from contaminating groundwater and surface waters.

EVALUATION:

1. Ask the students to discuss the need for monitoring streams, wells, and springs located below the elevation of landfill sites.
2. Discuss the importance of reporting unusual odors in drinking water and knowing to whom such information should be reported.

EXTENSIONS:

1. Conduct the following experiment to determine how leachate, once it has reached an aquifer, contaminates groundwater.

Materials needed:

4 petri dishes, 4 steel nails, soap, rubbing alcohol, paper towels, pH test kit, a sample of the leachate, household ammonia, household vinegar, tap water, safety goggles

a. Measure the acidity of the leachate with a test kit. Compare it with tap water, household ammonia, and

household vinegar.
b. Clean the nails with soap and water, rinse with alcohol, and dry with paper towels. Be careful not to touch the nails with bare hands after rinsing.
c. Fill each of four petri dishes about half full. Place tap water in one, leachate in another, household ammonia in the third, and vinegar in a fourth. Place one nail in each dish.
d. After a few days, when the liquid has evaporated, observe the nails. Record the observations. Have the nails changed in appearance?
e. Discuss results in relationship to landfill management. Why do we need to try to control liquid in a landfill? Under what conditions do metals leach? What other materials leach under the conditions found in a landfill?

2. Conduct the following experiment to determine how leachate can affect plants. To perform the experiment with the leachate sample, ask the students to bring to class an egg carton containing nine eggshell halves.

Materials needed:
3 different types of soil (clay, loam, sand), radish seeds, soil testing kit, copies of "Student Work Sheet--How Leachate Affects Plants"

a. Discuss soil structure and compare soils with three different structure types: heavy (clay), medium (loam), and light (sand).
b. Have the students prepare three seed beds from each of the three soil types using the eggshell halves as containers. (Have the students make tiny drainage holes in the bottoms of the eggshell halves.)
c. Have the students sow several radish seeds in each shell half and keep them moist during germination. (A plastic wrap laid on top will hold moisture in the soil.)
d. When the radish plants are one or two inches high, water one bed of each soil type with distilled water (control group), one bed of each soil type with leachate drawn directly from the landfill model, and the other bed of each type with leachate that has been passed through a column of soil. To simulate the leachate passing through a column of soik, add 99mL distilled water to 1 mL of leachate. (Discuss the movement and dilution of leachate, including how continued movement changes the degrees of dilution.) Use the same measured volume of liquid on each plant. (Be sure not to overwater.)
e. Have the students record the condition of the plants after one hour, 24 hours, and 48 hours. Observe for signs of beneficial and detrimental effects. Record the observations on the student sheet "How Leachate Affects Plants."

3. HOW LEACHATE AFFECTS LIVING THINGS

Materials needed:
1 mL of leachate, 99mL of distilled waterk 10 to 20 Daphnia-

a. Measure 1 mL of leachate in a container and add 99 mL of distilled water (to simulate the dilution of leachate due to normal movement through soil).
b. Place 10 to 20 living *Daphnia* in the container. (*Daphnia* are any of a variety of small fresh water crustaceans of the genus *Daphnia*, some species of which are commonly used as food for aquarium fish.)
c. Record any change of activity or obvious death after 1 minute, 2 minutes, and 5 minute

4. HAZARDOUS WASTES IN LANDFILLS

CAUTION: MAKE SURE STUDENTS TAKE PROPER PRECAUTIONS, SUCH AS WEARING PROTECTIVE CLOTHING, GLOVES, AND GOGGLES, BEFORE PARTICIPATING IN THE FOLLOWING SEGMENT OF THE EXPERIMENT.

Add hazardous wastes—household chemicals such as hazardous pesticides, nail polish remover, cleaning fluids—in your landfill model. Have leachate samples analyzed at a laboratory. How might this leachate affect groundwater? Should household hazardous wastes be land filled in municipal solid waste landfills? If not, what should we do with them?

Student Worksheet

Control Soil Samples

Soil Type #1	pH_____	P_____
	K _____	NO_3 _____
Soil Type #2	pH_____	P_____
	K _____	NO_3 _____
Soil Type #3	pH_____	P_____
	K _____	NO_3 _____

Pure Leachate on Soil Samples

Soil Type #1	pH_____	P_____
	K _____	NO_3 _____
Soil Type #2	pH_____	P_____
	K _____	NO_3 _____
Soil Type #3	pH_____	P_____
	K _____	NO_3 _____

Leachate Through Soil on Soil Samples

Soil Type #1	pH_____	P_____
	K _____	NO_3 _____
Soil Type #2	pH_____	P_____
	K _____	NO_3 _____
Soil Type #3	pH_____	P_____
	K _____	NO_3 _____

Student Worksheet
How Leacheate Affects Plants Experiment

Control Soil Samples	**Plant Condition After:**		
	1 hour	**24 hours**	**48 hours**
Soil Type #1			
Soil Type #2			
Soil Type #3			

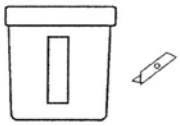
Pure Leachate on Soil Samples	**Plant Condition After:**		
	1 hour	**24 hours**	**48 hours**
Soil Type #1			
Soil Type #2			
Soil Type #3			

Leachate through Soil on Soil Samples	**Plant Condition After:**		
	1 hour	**24 hours**	**48 hours**
Soil Type #1			
Soil Type #2			
Soil Type #3			

Construction Of A Sanitary Landfill Model

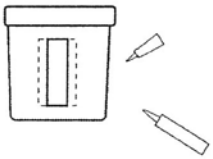
(using a 30-gallon garbage container)

1



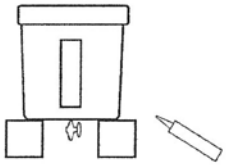
1. Cut a 2" x 30" vertical strip from a 30-gallon (or larger) garbage container, leaving the container intact for at least 3 inches of the bottom.

2



2. Glue a 4" x 30" piece of Plexiglas to the inside of the container and over the cutout. This will allow you to view the contents of the model landfill. This window will show the strata of waste and soil. (The window may be marked in increments of inches to help with layering of the soil and waste.)

3

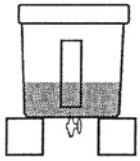


3. Before inserting a screw-in faucet on the side or at the bottom of the elevated model, cover the back of the faucet (the opening inside the tub) with the screened wire. This will help keep waste material from flowing out with the leachate. Seal around the faucet with caulking compound.

Preparation of Waste

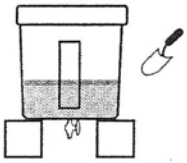
In a sanitary landfill, the accepted ratio of soil cover to waste is 1:12 (6" of soil : 72" of waste). In this model, 1" of soil cover will be used for 12" of waste. *(If you use a smaller trash can, try to stick as close to this ratio as you can.)*

4



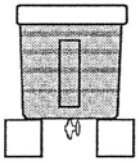
4. Place one layer of waste in the landfill model.

5

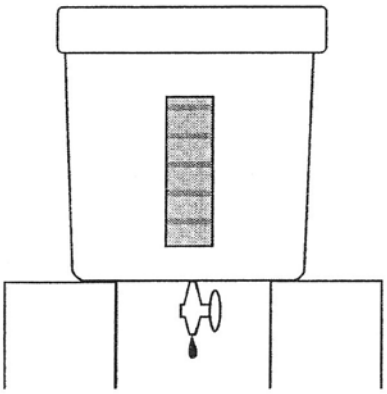


5. Cover the first layer of waste with 1" to 2" of damp soil. Tightly pack the soil cover by pounding it firmly to simulate a real landfill situation.

6



6. Continue the layering and compacting until the landfill model is full. The final layer should be 4" of soil.



Myths Of Soild Waste Crisis-
Facts Or Opinions

OBJECTIVES:

Students will be able to:

1. Explore the scientific ways to determine what people think about solid waste issues.
2. Conduct a survey of opinions on solid waste issues.

Grades:
9-12

Subjects:
Science, Health, Biology, Physics

Time Needed:
Two 50-minute class periods

Materials:
clipboards (optional)

BACKGROUND:

What people commonly call "garbage" is actually solid waste that must be disposed of properly to assure the safety of the environment. Recycling and/or burning garbage to produce energy are ways we can make use of garbage.

America's solid waste disposal problem continues to increase at an alarming rate. Approximately 222 million tons of municipal solid waste (MSW) was generated in the United States in 2000. This is more than 4.4 pounds per person each day or 1,300 pounds per person per year.

In the last 10 years, 12,000 landfills (or two-thirds) have been closed because they are full or environmentally unsafe. Most of these closed because they could not meet new regulatory standards designed to provide better environmental protection. Thirty landfills have closed in Alabama during this time. Only 1,000 new landfills have opened.

In the next six years, 40 percent of existing landfills will be filled. Eastern states with high density populations are suffering the most. While the average disposal fee in the United States is $27 per ton, for some large metropolitan areas it exceeds $100. Many of Canada's cities face similar problems.

MUNICIPAL SOLID WASTE COMPONENTS

Material	% By Weight
Paper and paperboard	37.4
Rubber, Leather and Textiles	6.7
Glass	12
Metals	11.2
Plastics	10.7
Wood	5.5
Food wastes	11.2
Yard wastes	12
Other	3.2

The attached pie charts clarify the rate of solid waste materials generated in the U.S. by volume, weight, and management done.

VOCABULARY:

pollution, solid wastes, disposal, landfills, recycle, sanitary landfills, open dumping, controlled incineration

PROCEDURE:

1. Ask students to survey adult students, and faculty using the "Solid Waste Fact or Opinion" survey.
2. Obtain responses from the survey questions and keep a record. Compare the responses with the answer key.

EVALUATION:

1. Have the students analyze the survey responses with the answer key and discuss whether the answers surprise them.
2. Contact local recycling services in the county and make a joint effort to have an advertisement on radio, TV, newspaper, or other media sources to educate people about " recycle, reduce, reuse, and rethink solid waste management."
3. Apply solid waste ideas locally and globally. Discuss.
4. Review "Solid Waste Fact or Opinion" responses with students. See Answer Key for answers and explanations.

ORIGINAL DEVELOPMENT RESOURCES:

Rathje, W. and Murphy, C. (1992, July). *Smithsonian Magazine*. "Five major myths about garbage, and why they're wrong."

www.epa.gov

SOLID WASTE
Fact Or Opinion

Read the following sentences. Place a check mark in the correct column indicating whether it is a fact or an opinion. Discuss the statements with your classmates; then check the answers.

Statements	Fact	Opinion
1. In one year, each person throws away 1900 pounds of trash.	☐	☐
2. All recycled paper towels are made from 100 percent recycled paper.	☐	☐
3. Leftover food (like green beans you didn't eat last night) makes up the bulk of most landfills.	☐	☐
4. All glass products can be recycled.	☐	☐
5. The comics you read last Sunday could have been last year's sport news.	☐	☐
6. Making a surfboard out of recycled peanut butter jars is a "nutty" idea.	☐	☐
7. Only a few brands of bathroom tissue are 100 percent recycled paper.	☐	☐
8. The aluminum soda can could have been a pie plate 20 years ago.	☐	☐
9. Plastic packaging makes up only a small portion of America's trash.	☐	☐
10. Some of the best recyclers are worms.	☐	☐
11. With the energy saved from recycling one soft drink can, you could power a TV for three hours.	☐	☐
12. No one knows how to recycle tires, colored paper, video cassettes cases, or corrugated cardboard.	☐	☐
13. Fast-food packaging, polystyrene foam, and disposable diapers are major constituents of American garbage.	☐	☐
14. America is running out of safe places to put landfills.	☐	☐

Fact Or Opinion (Answer Key)

1. *In one year, each person throws away 1,900 pounds of trash.*
   Fact: The average person living in an industrialized nation may produce as much as 1,900 pounds of domestic waste in one year.
2. *All recycled paper towels are made from 100 percent recycled paper.*
   Opinion: Brawny® paper towels was the first brand of 100 percent recycled paper towels. In addition, Georgia Pacific–the makers of Brawny® paper towels–produces more than 700,000 tons of paper with recycled content each year.
3. *Leftover food (like the green beans you didn't eat last night) makes up the bulk of most landfills.*
   Opinion: Paper makes up the bulk of most landfills at 35 to 45 percent by weight.
4. *All glass products can be recycled.*
   Opinion: Although bottles, jars, and many other forms of glass are recyclable, a few products, such as television screens, are not.
5. *The comics that you read last Sunday could have been last year's sport news.*
   Fact: Newspapers are recyclable. The U.S. paper industry is committed to recovering and recycling. Almost 69 percent of all old newspapers in the U.S. were recovered and recycled in 1998.
6. *Making a surfboard out of recycled peanut butter jars is a "nutty" idea.*
   Opinion: Plastic products are 100 percent recyclable if there is an infrastructure to collect, sort, and reuse the materials.
7. *Only a few brands of bathroom tissue, like Quilted Northern ®, are 100 percent recycled paper.*
   Fact: Georgia Pacific produces a number of products, such as bathroom tissue and paper towels, that are made with a range of 40 percent to 100 percent recycled paper.
8. *The aluminum soda can you drink out of today could have been a pie plate 20 years ago.*
   Fact: The number of times that aluminum can be melted down and reused is limitless.
9. *Plastic packaging makes up only a small portion of America's trash.*
   Opinion: About one-third of all plastics by weight in our landfills is from packaging. Students can help reduce this amount by buying foods and other products not packaged in plastic.
10. So*me of the best recyclers are worms.*
    Fact: Every year each of us tosses out about 1200 pounds of organic garbage. Worms placed in a compost heap can eat the organic matter and "recycle" it into fertile soil.
11. *With the energy saved from recycling one soft-drink can, you could power a TV for three hours.*
    Fact: Recycling aluminum is cheaper, and it consumes less energy than making products from new materials.
12. *No one knows how to recycle tires, colored paper, videocassette cases, or corrugated cardboard.*
    Opinion: All of these products can be recycled. Tires, for example, can be burned to make steam, electricity, or industrial process heat. They also can be ground up and used in asphalt for roads. Corrugated cardboard is recycled into more corrugated cardboard that is used in making big boxes, like the one your computer may have come in.
13. *Fast food packaging, polystyrene foam, and disposable diapers are major constituents of American garbage.*
    Opinion: Contrary to popular perceptions, fast-food packages make up far less that 1 percent of most landfills. The same is true for polystyrene foam and disposable diapers. When combined, they actually take up only about 3 percent of landfill space.
14. *America is running out of safe places to put landfills.*
    Fact: For the time being: yes. Scientists, however, are looking for better ways to reduce waste.

Figure 1. Materials Generated in MSW by Weight, 2000 (Total Weight - 232 Million Tons)

Source: EPA

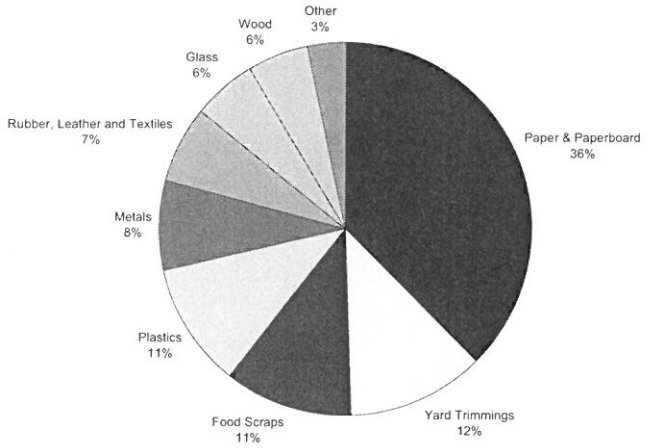
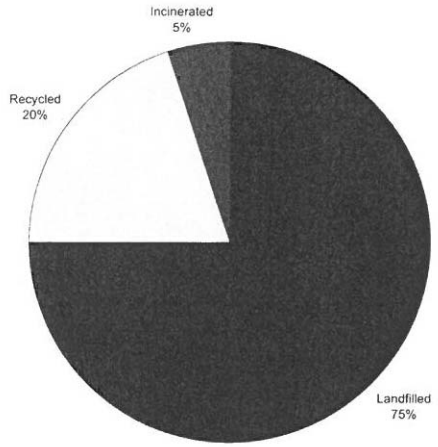


Figure 2. Management of MSW in Alabama, 1997

Source: EPA



Notes

Nuclear Energy

OBJECTIVES:

Students will be able to:
1. Discuss both beneficial and negative aspects of nuclear power.
2. Observe different aspects of nuclear energy.

Grades:
9-12

Subject:
Physics, Physical Science, Chemistry

Time Needed:
Three to five class periods

Materials:
some of the following materials:
- dominoes
- ping pong or Styrofoam balls
- mousetraps
- playing cards (need 2 decks with different designs on the backs)
- sugar cubes
- flashlight

BACKGROUND:

The energy that lies within the nucleus of the atom is tremendous (one pound of nuclear fuel can produce about three million times as much energy as can be obtained from one pound of coal). There are two nuclear power plants in Alabama: the Farley Nuclear Power Plant in Dothan near the Chattahoochee River and the Browns Ferry Nuclear Power Plant in Athens near the Tennessee River. These nuclear power plants are expensive and require highly skilled operators who conform to rigid safety procedures because of the toxic nature of the nuclear fuel and associated materials. Fossil fuel resources are finite, and both fossil fuel energy generation and nuclear energy generation impact the environment.

Nuclear energy has a number of benefits for the environment. The operation of a nuclear power plant does not produce the carbon dioxide emissions that are a growing concern due to changes in the climate. Nuclear plants also do not emit pollutants that contribute to acid rain. On the negative side, nuclear power plants use a tremendous amount of water for cooling, and they generate extremely dangerous wastes for which there is still no permanent management system. In addition, they raise the water temperature downstream. The extremely long half-lives of many of the radioactive substances generated by nuclear power reactors require containment of wastes for lengths of time approaching tens of thousands of years.

In order for fission to take place and to be sustained in a controlled chain reaction, a large number of nuclear collisions must take place in a small area. The concept of how energy, and thus the number of nuclear reactions, decreases with increasing distance from the source (the inverse square law) is illustrated using a flashlight beam at different distances. A chain reaction, or a reaction that, in turn, results in a series of even larger reactions, is illustrated using dominoes or playing cards. Finally, the concept of half-life, a very important aspect of nuclear waste management, is illustrated using playing cards.

VOCABULARY:

chain reaction, deuterium, fusion, fission, inverse square law, half-life, fossil fuels, nuclear energy

PROCEDURE:

1. Demonstrate the inverse square law by intercepting at right angles the ray from a flashlight at two or three points with a piece of cardboard. Calculate and compare the areas illuminated. Show that the brightness of the illumination on the cardboard gets dimmer the farther the cardboard is from the light source: the illuminated area gets larger as the distance increases, but the illumination (lumens per square foot) decreases.
2. Demonstrate the chain reaction by one of the following techniques: (a) set up dominoes so that one, when tipped over, knocks down two others and so on; (b) longitudinally bend an old deck of cards and stand

these individually so that one, when tipped over, knocks down two others and so on; (c) set up an array of triggered mouse traps that are "baited" with a Styrofoam or ping pong ball. Throw a single ball into the array, thus setting off a "chain reaction."

3. Demonstrate half-life by one of the following techniques: (a) Flip a deck of cards into the air and replace each one that falls face down with one card with a different decorated back. Keep a log showing "Trial #" and the number of cards replaced. Continue until all the cards with the original decorated back are replaced. Assume the half-life to correspond to the Trial # when half the cards were replaced. (b) Put a black dot on one face of 100 sugar cubes. Throw these as if they were dice and replace all the cubes falling dot-side up with unmarked cubes. Keep a log showing "Trial #" and number of cubes replaced. Continue until all the dotted cubes are replaced. Assume the half-life to correspond to the Trial # when half of the cubes were replaced. Graph this data.
4. Fusion is the fusing together of light nuclei to form a heavier nucleus. The mass of the resultant nucleus is less than the sum of the masses of the original nuclei because some mass is converted to energy in the reaction. It has been suggested that, from the amount of deuterium in a gallon of ordinary water, one might obtain the energy available in 300 gallons of gasoline! Have the students consider the energy resources represented by the deuterium in the oceans. (Optional: If time permits, discuss how deuterium comes from fusion. Explain to the students how the nuclear reactor replaces the boiler in conventional electricity generation.)
5. Ask students to identify peaceful uses of nuclear energy (power generation, quality control, medicine) and discuss them in class.
6. Have students compare fusion energy versus fission energy.
7. Write some of the entries from the following table on the board and discuss with the students.

Use of Energy Resources In Selected Countries

Country	Energy Sources as Percent of Total Use				
	Coal	Oil	Natural Gas	Nuclear	Hydro
Australia	43	40	12	0	6
Austria	19	42	13	0	27
Belgium	25	47	19	7	1
Canada	12	37	21	4	27
Denmark	31	66	0	0	0
Finland	25	45	2	14	13
France	17	50	11	13	9
Germany	33	44	16	5	2
Greece	25	69	0	0	6
Iceland	2	44	0	0	54
Ireland	23	60	13	0	3
Italy	10	65	16	2	7
Japan	19	63	6	6	6
Luxemburg	46	32	10	0	5
Netherlands	7	43	48	1	0
New Zealand	17	37	8	0	41
Norway	6	36	3	0	57
Portugal	4	82	0	0	12
Spain	27	60	3	3	7
Sweden	11	44	0	18	28
Switzerland	3	48	4	14	34
Turkey	46	45	0	0	9
United Kingdom	35	38	21	5	1
United States	23	41	27	4	4

EVALUATION:

1. Students' charts/graphs will be evaluated for accuracy, content, and creativity.

EXTENSIONS:

1. Have a student read an account of the first chain reaction, which occurred beneath the stands of the University of Chicago football field. (See books about the Manhattan Project or the atomic bomb.)
2. Gather information on different kinds of reactors.
3. Gather information about nuclear accidents that have occurred (Three Mile Island, Chernobyl) and identify any loss of life.
4. Obtain a free copy of *Nuclear Experiments You Can Do...from Edison* . (See Resources.) Also obtain the *Alabama Power Classroom Teachers' Service* publication (Catalog #AA45L). (See Resources.) Perform as many of these as you choose. A list of the eight experiments provided is as follows:
   - An Oil-Drop Model of a Splitting Atom
   - A Domino Model of a Chain Reaction
   - Observing Radioactivity with an Electroscope
   - Observing Radioactivity by Radiography
   - Observing Radioactivity with a Cloud Chamber
   - A Model Nuclear Power Plant Steam Turbine
   - Demonstrate How Radioactivity Can Be Shielded
   - Build a Geiger Counter–A Class Project

   Note: Information is given in this book about where you can obtain low level radiation sources for classroom experiments.
5. Have brief presentations in class (20 minutes each) by a local utility representative and someone from an anti-nuclear power group.

ORIGINAL DEVELOPMENT RESOURCES:

Faughn. J. S. and Kuhn, K. F. (1976). *Physics for people who think they don't like physics.* Philadelphia, PA: W. B. Saunders Co.

K.F. Kuhn. (1996) *Basic physics*. John Wiley & Sons. ISBN: 0471134473.

Cunningham, J. & Herr, N. (19940. *Hands-on physics activities with real-life applications: easy-to-use labs and demonstrations for grades 8-12*. Jossey-Bass: ISBN: 087628845X.

Power for life: educational resources for teachers. Alabama Power Company., Educational Services, P. O. Box 2641, Birmingham, AL 35282-9984. (available on-line: www.southernco.com/alpower)

Free and inexpensive science materials available from Tennessee Department of Economics and Community Development. www.state.tn.us/ecd/energy.

ADECA - Science Technology & Energy Division, 401 Adams Avenue, P.O. Box 5690, Montgomery, AL 36103-3690, 1-800-392-8098, www.adeca.state.al.us

Notes

Oil Spills

OBJECTIVE:

Students will be able to:

1. Investigate the effect and effectiveness of techniques (sinking, absorption, and disposal) used to get rid of oil floating on seawater.

BACKGROUND:

Every year millions of gallons of oil are released into the environment, either accidentally or intentionally. This oil comes from tanker accidents, blowouts or spills at offshore drilling rigs, and runoff and dumping of waste oil from cities and industries.

The type and amount of damage from an oil spill depends on a number of factors such as type of oil, weather conditions, kinds of organisms in the area, accessibility of the location to clean-up crews, and the season.

The effects of an oil spill are many and varied. The most obvious effect is the waste of an increasingly rare and valuable resource, the oil itself. Even though attempts are made to recover the spilled oil, much is lost; and much of what is recovered is not usable because of contamination from the clean-up process or the environment.

Crude (unrefined) oil is actually a mixture of hundreds of different substances. Some are very toxic; some are relatively innocuous. Some evaporate into the air, some dissolve in water, some float, and some sink. Some are very sticky and tend to coat whatever they contact.

Some of the components of crude oil, such as benzene and toluene, are extremely toxic (poisonous). Sticky oil coatings smother many organisms. Oil destroys the insulation and buoyancy of marine birds and animals, so that many drown or die of exposure to cold water and air. Fish gills are clogged. Animals that ingest the oil or eat other organisms contaminated by the oil may be poisoned or may have their digestive systems clogged.

Grades:

9-12

Subjects:

Physical Science, Biology

Time Needed:

45 minutes to conduct the initial experiment; 24 hours for experiment to be left; 10 minutes to observe the beakers after 24 hours

Materials:

tap water
table salt
scale
empty 1-liter bottle with cap
beaker containing heavy-grade motor oil (gear oil 80W)
four 250-mL beakers
two 10-mL measuring cylinders
teaspoons
small dish of sawdust
small dish of 10 g Styrofoam granules (made by breaking up a Styrofoam cup)
small dish of plaster of Paris
detergent (dishwashing liquid)
stopwatch
waterproof felt-tip marker

Oil companies, governmental agencies, and people who are concerned about the environment have tried a number of ways to clean up spilled oil. It is always a difficult, expensive effort. Even as recently as the 1989 Exxon *Valdez* spill, many of the methods used were still in the experimental stage; and some of the experiments didn't work well. Sometimes people's efforts to clean up after a spill may do more damage than good.

Two approaches remain paramount in any response to marine oil spills: the enhancement of natural dispersion of the oil by using dispersant chemicals and mechanical recovery using booms and skimmers. Attempts to deal with oil at sea are seldom very successful, and it is almost inevitable in a major spill that oil will threaten

sensitive coastal resources. Protective strategies seldom are employed to the fullest extent possible, and it usually necessary to mount a shoreline response operation. Priorities for protection and clean-up need to be agreed on and care must be taken to ensure that the techniques selected do not do more damage than the oil alone.

Despite continuing research, there has been little change in the fundamental technology for dealing with oil spills. New techniques are constantly being sought and old techniques are being reassessed. Two techniques currently receiving fresh attention are in-situ burning and the enhancement of the natural biodegradation of oil through the application of micro-organisms and/or nutrients.

VOCABULARY:

blowouts, runoff, supertanker, crude oil, benzene, toluene

PROCEDURE:

SAFETY PRECAUTIONS: Oil is flammable! BE CAREFUL! Be sure to extinguish all flames before carrying out this experiment.

1. Make artificial seawater by weighing out 5 g of table salt and adding it to the 1-liter bottle. Half fill the bottle with warm water from the faucet, put on the cap, and shake the bottle until the salt has dissolved. Fill the bottle to the top with water to produce "seawater" of the correct concentration.
2. Label four beakers "A," "B," "C," and "D." Half fill each of the beakers with the seawater.
3. Measure out 5 mL of oil in the measuring cylinder and pour into beaker A. Repeat this step with beakers B, C, and D.
4. Look at the four beakers and record in the Data Table what you see in each one.
5. Sprinkle one heaping teaspoonful of sawdust into beaker A.
6. Sprinkle one heaping teaspoonful of Styrofoam granules into beaker B.
7. Sprinkle one heaping teaspoonful of plaster of Paris into beaker C.
8. Measure out 10 mL of detergent in a measuring cylinder and pour into beaker D.
9. After 5 minutes, look at the four beakers and record in the Data Table what you see in each one.
10. Leave the beakers for 24 hours. After 24 hours, look at the four beakers and record in the Data Table what you see in each one.

DATA TABLE

Appearance of oily water

	Start/Before Additions	After 5 Minutes	After 24 Hours
A			
B			
C			
D			

EVALUATION:

1. Have students write a report comparing what happened to the oil in each beaker after 5 minutes and after 24 hours.
2. Have students answer the following questions:
   - Which treatment was most effective in making the oil sink?
   - Which treatment was most effective in soaking up the oil on the surface?
   - Did any treatments have no effect on the oil?
   - Which treatment do you think would be most effective at dispersing an oil slick at sea?
   - Would it be practical to use this method in the ocean? If not, why not?
3. Discuss the proper disposal of the oil after the experiment. How could the oil affect the environment if improperly disposed?

EXTENSION:

1. Experiment with other varieties of oil (cooking, crude, baby) and compare the effects. Add food coloring to clear oils to facilitate observation of effects.

ORIGINAL DEVELOPMENT RESOURCES:

Roe, M. L. (1993). *Environment science activities kit* . West Nijack, New York: The Center for Applied Research in Education.

http://www.itopf.com/clean-up.html

Beamish, T.D. (2002) *Silent spill: the organization of an industrial crisis*. MIT Press: ISBN: 0262025124.

Brabbia. C.A. (ed) (2001) *Oil spill modeling and process*. WIT Press: ISBN: 1853126721.

Keeble, J. & Fobes, N. (1999) Out of the channel: the exxon valdez oil spill in prince william sound. University of Washington Press: ISBN: 0910055534.

Notes

Packaging Alternatives (Waste Reduction)

OBJECTIVES:

Students will be able to:
1. Discuss product packaging and advertising.
2. Create a package design and advertising campaign.
3. Look at environmental choices in packaging.

BACKGROUND:

Each person in the United States generates about 660 pounds of packaging per year just through regular buying, and using, habits. In Alabama this packaging waste accounts for a significant portion of the waste going into Alabama's landfills and incinerators. The Alabama Solid Waste Management Act of 1989 set a goal that the volume of solid waste would be reduced by 25 percent by 1999. As an on-going process, Alabamians should take a look at the products they buy and the packaging wastes they throw away.

To reduce the negative environmental impacts associated with the disposal of packaging waste, consumers need to be aware of their packaging choices. For example, many consumers are not aware that **more than 70 percent of the packaging they discard is recyclable and could be used again to make new items.**

Recyclable packaging materials include most forms of paper, wood, steel, aluminum, glass, and some forms of plastic like PET (polyethylene tetraphthalate) soft drink bottles and HDPE (high-density polyethylene) milk, water, juice, and detergent containers. Other forms of packaging, like wax-coated paper containers, are often nonrecyclable and should be avoided if possible. In addition to purchasing recyclable packaging, consumers also can help to reduce the negative environmental impacts of packaging wastes by purchasing degradable packaging. Degradable packaging materials include paper and wood. (***Note:*** *The issue of degradability is controversial. Consider giving an assignment to review recent literature on the topic to share with the class.)*

In looking at packaging that is degradable, it is important to remember that these items do not degrade in a landfill and would need to be handled in a system such as a compost pile. In regarding a material as degradable, students must evaluate how, and where, this process will take place.

Buying items that can be degraded in a compost pile is only effective if there is a compost pile available and if the action is taken to get the item there. As it is with recycling, an item is only considered degradable if there is a system available to process it. A recyclable or degradable item that ends up in a landfill or incinerator has not achieved its purpose. Perhaps the most effective method of reducing the quantity of waste entering the waste stream is reusing. For example, a plastic margarine tub can be cleaned and reused many times to store leftovers. Reuse means rethinking shopping habits.

The most basic functions of packaging are to contain, carry, protect, and dispense materials. Containment is an essential element to packaging. Without the ability to contain products, especially liquids, distribution is

Grades:
9-12

Subjects:
Environmental Science, Economics, Art

Time Needed:
One class period to introduce assignment, then time to complete the project at home or school

Materials:
scissors
glue
tape
construction paper
markers
rulers
poster board
foil
plastic wrap
cardboard

difficult. Imagine how a grocery store would sell milk or juice without it. Packaging also can serve useful secondary functions: preserving freshness and safeguarding against contamination, tampering, and/or theft.

As competition for consumer attention in the retail market has grown, manufacturers have become increasingly dependent on packaging as a selling tool. The ability to display, motivate, promote, and communicate has been exploited to the point that these have become prime purposes of packaging. As a result, much of today's packaging is not fundamentally essential.

Packaging waste is placing a heavy burden on our nation's waste disposal systems. A large portion of used packaging also is discarded as litter on roadsides and beaches and in cities and parks. To minimize the environmental impacts associated with packaging, consumers need to make informed choices. For example, reducing the packaging used to "sell" products could greatly extend the capacity of waste disposal systems and could reduce the litter problem. At the same time, a reduction in the amount of unnecessary packaging used would conserve energy and resources. Through the purchasing of products with minimal packaging and products packaged in reusable, recyclable, and/or degradable/compostable materials, we all can help to reduce the impacts of packaging waste. Along with the strategy to recycle waste comes the responsibility to look for and buy products and packaging made from recycled materials.

VOCABULARY:

recyclable, nonrecyclable, reusable, degradable, compost

PROCEDURE:

Setting the Stage

1. Begin this activity by telling students to imagine that they have just gotten a job as an advertising agent for a company that sells _____ (*the product you select.)*
2. Explain that each group's assignment is to develop an advertisement campaign and packaging design to sell their product. These campaigns should consider effective packaging to sell the product balanced by environmental concerns.
3. Instruct students to keep a record of reasons they choose particular package designs and sales pitches. Explain that the ad campaign can consist of skits, poems, jingles, posters, or any other technique that could "sell" their product.
4. Briefly review the primary and secondary functions of packaging, and describe the negative environmental impacts associated with packaging waste. Discuss the potential conflicts associated with packaging designed to sell a product versus packaging designed to have a low environmental impact.

Activity

1. Divide the class into groups. Select a product for students to use in creating a package and sales campaign. The product should be the same for each team such as a baseball bat, personal care item, tennis ball, or other common item. If the package and advertising campaign work is to be done in class, collect the suitable materials for each team to use. If students are to complete projects at home, a list of possible materials will need to be provided.
2. In a class discussion, ask students to describe what advertisers do (create marketing plans and communications to help sell things*)* and ask them to identify the different means of communications advertisers use to sell products (television, radio, newspaper and magazine ads, billboards, contests, promotional flyers, packaging). Make sure students realize that an advertiser's main goal is to "sell" a product. Briefly discuss the different "pitches" advertisers use to sell a product (new and improved features, endorsements from famous people, status, convenience, "keeping up with the Joneses," sex-appeal, better for the environment, cheaper).
3. Have each group create a package and ad campaign for the product they have been assigned.
4. After groups have completed their projects, have each group present its ad campaign and package design to the rest of the class in a 10-minute presentation.

Follow-Up

1. Assign each product package a number, and display all package designs. Have students anonymously vote for the best package design and turn in their votes. Tally the scores and identify the first, second, and third place packages.
2. Conduct a whole class discussion addressing the following questions:
   - What made the winning package more appealing than the others?
   - How much packaging was involved in the package? Was the packaging necessary? Why or why not?
   - What influence does the packaging have on the quality of the product?
   - Why was the product packaged?
   - Who pays for the packaging?
   - Who should pay for the disposal of packaging that isn't recyclable or reusable?
   - Should the manufacturer of the product be concerned about disposal of the packaging?
   - What impacts will manufacturing and disposing of the packaging have on the environment?
   - If the manufacturer is primarily interested in selling the product, is it more important to package the item to sell than to package it to have low environmental impact?
3. Ask students to identify packaging choices they can make to reduce environmental impacts. Show the "Picking Packages" transparency and rate the different types of packaging according to the disposal and recycling options in your area.

EVALUATION:

1. The projects should be evaluated on creativity, content, and presentation.

EXTENSIONS:

1. Have students select several popular products and review the packaging. Can it be improved to create less waste? Do products contain any environmental claims that are not fully explained?
2. Have students write letters to companies inquiring about packaging and requesting improvements.
3. Invite a public relations firm representative into the classroom to discuss his/her company's mission and goals.

ORIGINAL DEVELOPMENT RESOURCES:

American Plastics Council: www.plasticsresource.com

Picking Packages

When you go shopping, pick a product wrapped in the least amount of packaging as possible. Use this sheet as a guide when making your packaging decisions. Place an "X" in the rating column for packaging that can be reused, recycled, or composted; a zero(0) for packaging that must be incinerated or landfilled; and a minus (-) for packaging that cannot be disposed of easily and should be avoided. Note: You must research, know, and understand what is, and what is not, recyclable in your area before you can accurately perform this exercise.

Kind of Package	**Grocery Store Item**	**Rating**
No packaging or natural package	Fruits, nuts, vegetables	☐
Glass bottles	Beverages, oils, sauces	☐
Reusable items	Cookie and cracker tins, heavy duty plastic plates from microwave dinners, sturdy glass jars, plastic tubs	☐
Uncoated paper	Bags of candy, cookies, chips	☐
Uncoated cardboard	Cereal boxes, detergent boxes	☐
All-steel cans	Canned fruits and vegetables	☐
All-aluminum cans	Beverage containers	☐
Steel cans with aluminum tops	Some pull-top cans	☐
Waxed paper	Liners in cake boxes and other food boxes	☐
Cellophane	Windows in paper boxes	☐
Coated paper	Paper milk and juice cartons	☐
PVC (polyvinylchloride)	Some plastic bottles and plastic wraps	☐
HDPE (high density polyethylene) and PET (polyethylene terephthalate)	Plastic milk jugs, juice and soda bottles, shampoo bottles	☐
Aerosol cans	Toiletries, deodorants, hairsprays, pesticides	☐

Rural Water

OBJECTIVES:

Students will be able to:
1. Differentiate between black water and gray water waste.
2 Explain how a septic tank drainage field system is constructed and functions.
3. List ways of abusing a septic tank system.
4. Describe symptoms of a failing septic system.

BACKGROUND:

Many rural areas are not served by centralized wastewater systems, and household wastewater must be disposed of on site. The septic tank, along with a soil absorption system, is the most common and effective method of wastewater treatment used in rural settings. Cesspools, which are no longer approved for new installations in most areas, and pit privies are the other most widely known methods.

Other alternatives include the following: aerobic (requiring oxygen) treatment tanks, off-lot systems where wastewater from several households is conveyed to a common disposal and treatment site (such as a soil absorption field), and evapotranspiration systems. Evapotranspiration is a process used for shallow soil depths. Grass or other plants are used to cover the field that receives the wastewater. The plants take up the water and selected minerals but leave the rest of the waste for organic decomposition. The water leaves the plants by normal transpiration processes.

Some of the more recent alternatives include biofilters, constructed wetlands, composting toilets, low-flush toilets, incinerating toilets, or recycling toilets and dual treatment systems that separate "black water" (human body wastes) from "gray water" (other domestic wastewater).

On-site disposal systems, such as septic tanks, discharge wastewater to the subsurface. A septic tank is simply a tank buried in the ground for the purpose of treating the sewage from an individual home or business. Wastewater flows into the tank where the design of the tank facilitates settling of the solids. Sewage bacteria then break down the organic matter, allowing partially treated water to flow out of the tank into the ground through a subsurface drainage system. The soils around the drainage field also are a part of the treatment system where additional bacterial action further breaks down the organic waste. Periodically, sludge or solid matter in the bottom of the tank must be removed and disposed of. Failing septic tanks and cesspools are frequent sources of groundwater contamination.

Grades:
9-12

Subjects:
Biology, Chemistry

Time Needed:
Two class periods

Materials:
2 sets of the following:
- funnel
- rubber tubing
- glass bend
- pneumatic trough
- 3 "T" connectors
- 250-mL side-arm flask
- 1-hole stopper
- wire gauze

coarse gravel
fine gravel
soil
water test kit (available through a biological supply catalog)
manure
detergent

VOCABULARY:

sewage, sludge, evapotranspiration, black water, gray water, effluent

PROCEDURE:

1. Discuss with the students the following concepts and terminology:

Sources of household wastewater:
- "black water" - water containing human body wastes
- "gray water" - water containing other domestic wastes

Disposing of wastewater:
- "black water" - septic tank
- "gray water" - deposit in stone-lined, deep well; used to irrigate lawns and gardens

Septic tank system:
- construction - see the student sheet "septic tank model"
- drainage field - subsurface area for dispersing water flowing out of septic tank
- maintenance - sludge removal

Practices that abuse septic tank systems:
- using excessive amounts of water
- allowing strong chemicals to enter tank
- driving vehicles over the tank and drainage field

Symptoms of a failing system:
- damp or wet ground in drainage field
- oily film in drainage field area
- noticeable sewer odor
- wastewater backing up into the house

2. Have students make working septic tank models. (See the student sheet "septic tank model" for suggestions.)
3. Run "wastewater" into the septic tank (flask) until it rises to the outlet. Do not allow wastewater to flow into the "drainage field" at this time. Allow at least 24 hours (or a weekend) at room temperature. One group runs "black water" through the system, and one runs "gray water" through the system.

Note: **Prepare** "black water" by adding to containers of tap water such materials as barnyard/ animal manure or animal manure purchased from a garden shop. Prepare "gray water" by adding to containers of tap water such materials as raw peanut hulls, ashes from burned peanuts, crushed peanuts, detergent, or grease.

4. Add an equal amount of the same type of "wastewater" to the septic tank (flask) and catch any effluent coming from the drain tubing. (A pinch clamp should be used on the tubing.)
5. Test final effluent for pH, odor, mineral content, hardness, color, and turbidity.
6. Have students compare effluents of the wastewater types.

EVALUATION:
1. Define "black water" and "gray water."
2. Explain how a septic tank is constructed.
3. Explain how to install a drainage field system.
4. List ways of abusing a septic tank system.
5. Describe several symptoms that indicate the septic tank system is failing.

EXTENSIONS:
1. Conduct research, and construct diagrams and specifications of systems for wastewater treatment making use of an aerobic treatment tank and evapotranspiration. After doing so, have students discuss such questions as the following:
   - What factors limit the volume of wastewater that can be processed?
   - Is each system equally effective in swampy and hilly terrain?
   - How does each system treat wastewater to avoid offensive odors?
   - Which system would work best in rural areas?
   - What type of system is used by the school?
   - Where are the system and drainage field for the school located if the school is on a septic tank system?

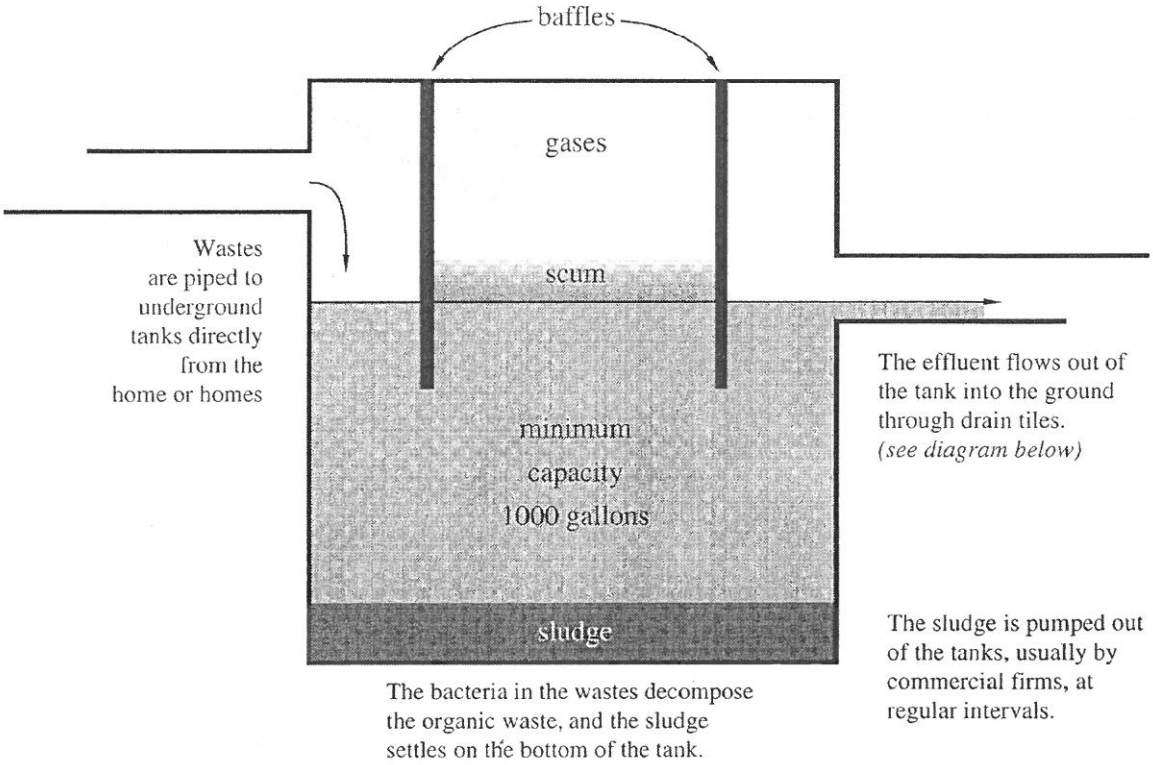
2. Have the students do a “perk” test on the soil in the area of a drainage field. (See your local health department for instructions to perform this activity.)
3. Have rural students check the site of effluent discharge from the systems at their homes in relation to the drinking water source. Is it adequate? What are the regulations for location of waste treatment systems?
4. Have students explore problems created by concentrated housing (mobile home/trailer parks) when only a septic tank system is used.

ORIGINAL DEVELOPMENT RESOURCES:

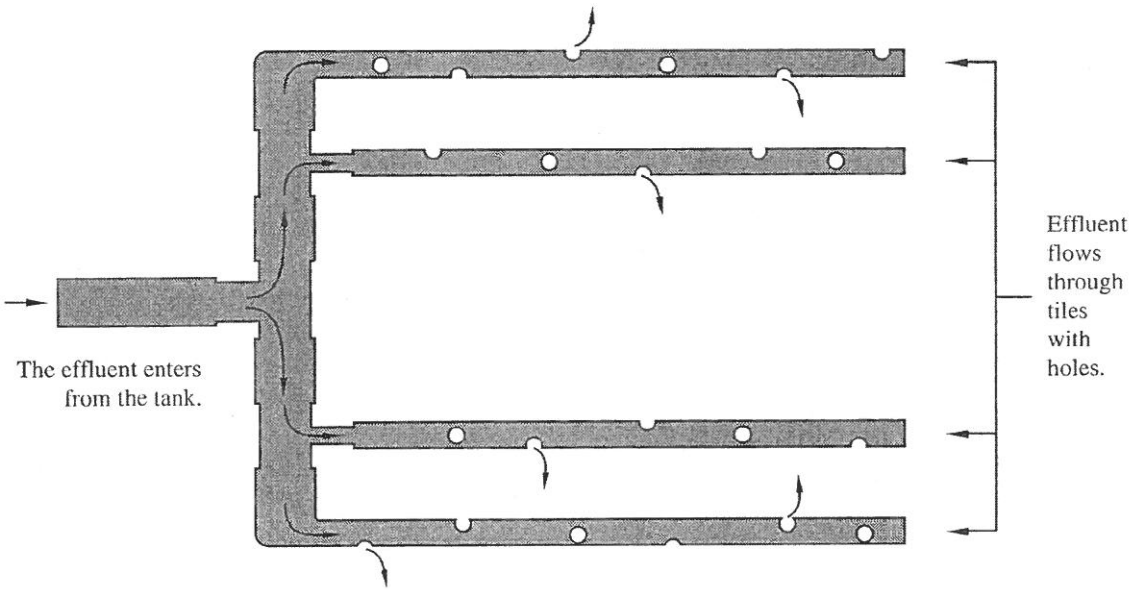
Alabama Department of Public Health: www.adph.org

Septic Tanks

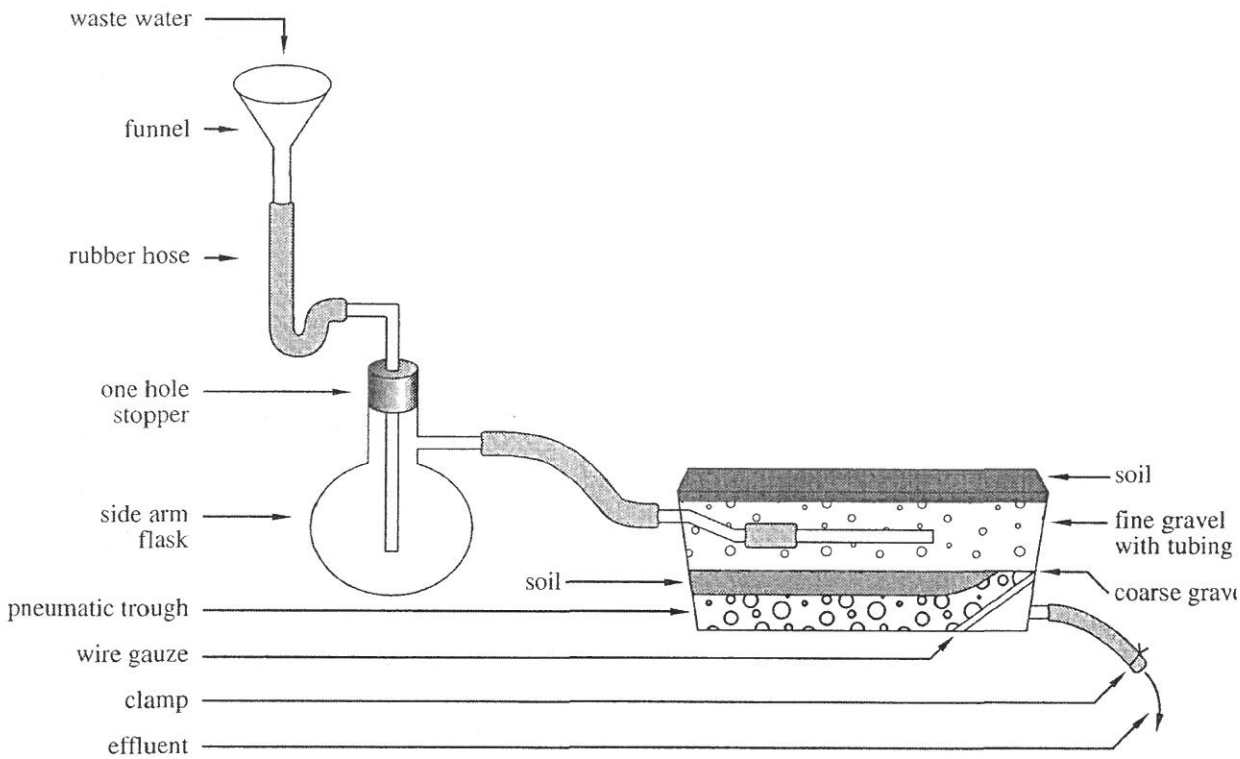
Septic tanks are used for domestic wastes when a sewer line is not available to carry them to a treatment plant.



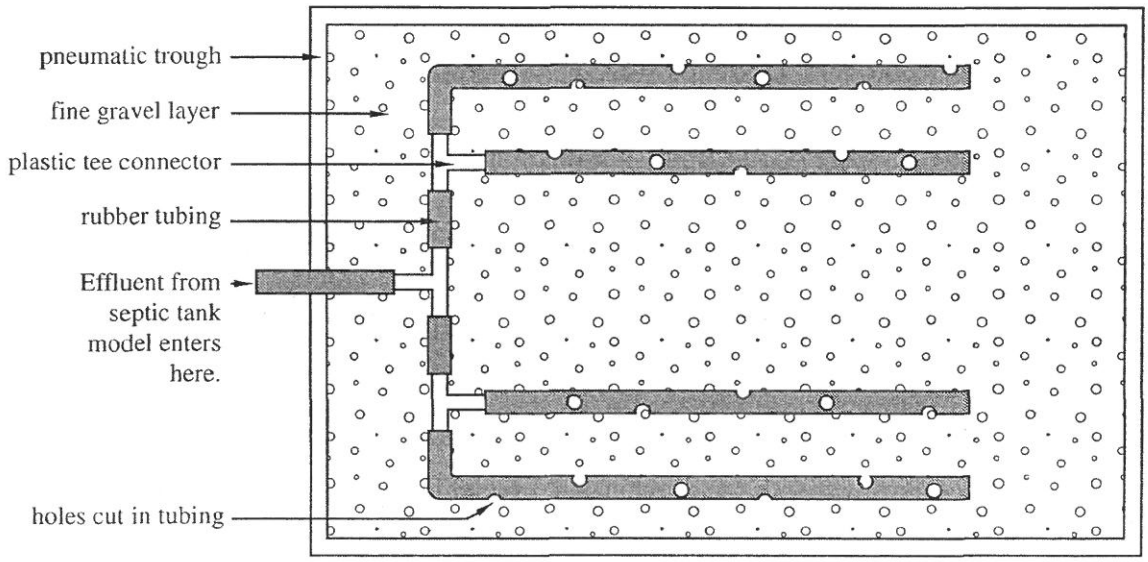
Aerial View of Drain Tiles



Septic Tank Model



Aerial View of Drain Tubing in Fine Gravel Layer



Notes

Spill It - NOT!

OBJECTIVES:

Students will be able to:

1. Notice hazardous materials that are being shipped through their community.
2. Investigate the consequences of a spill in their watershed.

Grades:
9-12

Subjects:
Ecology, Chemistry

Time Needed:
Several days or weeks for field observation
One class period for lab

Materials:
DOT Chart
Hazardous Materials Marking, Labeling and Placarding Guide

BACKGROUND:

Hazardous materials are regulated by the U. S. Department of Transportation (DOT) when they are shipped by truck, rail car, airplane, or ship. As you watch trucks on the highway, you can tell if they are carrying hazardous chemicals.

The diamond-shaped placard on the truck identifies the hazard class of the chemicals being transported. Most chemicals being shipped that are over 1000 pounds are regulated, and any quantity of the most dangerous chemicals must be identified.

If a truck has more than one placard, it is carrying multiple hazard classes of chemicals. The driver has the option of using the DANGEROUS placard for some multiple loads.

If the shipment is a bulk shipment, and is in a tank truck or tank rail car, the placard will have a four-digit number that identifies the chemical. The number is unique to one chemical or family of chemicals. Some numbers represent a small group of chemicals with similar chemical and physical properties. (See the Emergency Response Guidebook for a list of all numbers, the correspoinding chemicals, and the hazards.)

VOCABULARY:

placard

PROCEDURE:

1. Have students observe and record all the placard numbers they see from vehicles (or railcars) on the roads or railroads over a period of several days or weeks..
2. Give students the Emergency Response Guidebook to identify the contents of bulk carriers on the highways and/or railroads in their community.
3. In the classroom, students should look up the numbers in the guidebook and make a list.
4. Students should research the hazardous materials that are being transported and then predict the consequences of a spill.

EVALUATION:

1. Students should write a research report about the materials being shipped through their community. The teacher may wish to restrict the report to the most frequently observed or most dangerous chemicals.

EXTENSIONS:

1. Students could contact the local Emergency Management Agency (EMA) and report on the EMA's planned response to any hazardous chemical spills from trucks or trains in their watershed.
2. The students should investigate what would happen to the air and water supply in case of chemical spills.

3. Ask local industries, environmental engineers, or safety and health directors to come to class to explain how hazardous shipments are handled.

ORIGINAL DEVELOPMENT RESOURCES:

Department of Transportation Chart 11, Hazardous Materials Marking, Labeling and Placarding Guide. (Free). To obtain, call 1-800-HMR49-22 OR e-mail www.dot.gov. May be obtained by writing: U>S. Dot/RSPA/HMS/OHMIT/DHM-50, 400 7th Street, S.W., Washington, DC 20590-0001.

Emergency Response Guidebook. available at www.hazmat.dot.gov/ohmforms

Are You Down In The Dumps?

OBJECTIVES:

Students will be able to:

1. Construct a demonstration landfill.
2. Discuss different types of household trash.
3. Describe ways to cut down on trash.
4. Describe and discuss decomposition.

Grades:
9-12

Subjects:
Science, Ecology, Social Studies

Time Needed:
Four weeks or longer

Materials:
small plastic containers (about 16 oz.) with lids (need 2 for each student group)
trowel
spoons
soil
newspaper
trash materials (see activity)
water
spray bottle

BACKGROUND:

In its most basic sense, a landfill is a place where garbage is hauled, deposited, and then buried. But if you look at a modern landfill in closer detail it is really much more complicated than that. A typical, modern landfill is divided into a series of sections called cells. When the solid waste is hauled to a landfill, it isn't just strewn haphazardly. Rather it is placed on what is called a working face, which is a portion of a landfill cell that is currently exposed and available for trash disposal. Only limited sites in the landfill are exposed at any given time to minimize exposure of the landfill's contents to elements like wind and rain. In fact, because a landfill is filled so systematically, often modern landfill operators can pinpoint where a specific truck's load of garbage was deposited even days, weeks, or months afterward.

At the conclusion of each day's activity in a cell, a layer of earth or ash is spread across the compacted waste in the cell to minimize odor, prevent windblown litter, and prevent insect and vermin problems. The daily cover also may consist of a layer of foam materials or sheets of synthetic materials. The landfill operator moves from working face to working face, and from cell to cell as the landfill gradually fills over periods of many years, even decades.

But as noted, a modern landfill is more than just a hole in the ground where we dump trash and forget it. Today's landfills include multiple safeguards to contain wastes and isolate them from surrounding water and soil. In many cases, for example, such safeguards involve a protective liner to prevent filtration. Liners may be made of compacted clay or impermeable materials such as plastic. When clay is used, the layer may be as much as ten feet thick. All this site preparation is done so that any liquid entering the landfill can be controlled and treated externally or retained inside the landfill, rather than being allowed to pass through the site and come out the other side.

Decomposition is the process by which material breaks down. Air, water, sunlight, and other agents break down inorganic materials. Living organisms break down organic molecules such as food waste, wood, and dead animals. Warm, moist, and well-aerated conditions are necessary for most decomposers. Certain organisms can biodegrade organic materials in the absence of oxygen (anaerobic), but the process is slow.

Materials in a landfill go through the process of decomposition but it is very slow. The procedures of burying, compacting, and covering slow down decomposition of both inorganic and organic materials. There have been many instances in which newspapers have been uncovered in a landfill after being buried for over 20 years,

and they still can be read. Even some foods have not decomposed significantly in long periods of time. In this activity, students will set up a demonstration to see how long it takes different types of trash to decompose.

VOCABULARY:

biodegradable, compost, decomposition, landfill, decomposer

ADVANCE PREPARATION:

1. Introduce the terms biodegradable, compost, decomposition, landfill.
2. Have the students think about the trash their families throw out every day.
3. List the items students consider trash on the chalkboard or on an easel.
4. Divide the list of trash items into the following categories: paper products, food waste, glass, metal, plastic, yard waste, and others (items that do not fit any of the categories).
5. Have the students draw a trash can on poster board and fill up the trash can diagram with their families' "trash." Students may draw the trash or cut out pictures from magazines.
6. Display students' trash can drawings around the classroom.

PROCEDURE:

Setting the Stage

1. Read the background information about how trash is broken down. Also, explain how trash can lead to problems such as litter, overflowing landfills, toxic pollution, and wasted resources.
2. Discuss possible solutions to the problems caused by trash and have students come up with ways to make less trash.
3. Have students discuss the saying: Reduce, Reuse, Recycle.

Activity

1. Divide the classroom into small cooperative groups. Give each group two plastic containers with lids and have the students label both containers with their group number or name and label one container "A" and the other "B." The containers should also have a team name or number on them. Provide the students with, or have them bring in, enough of the following "trash" materials so that each group will have two samples each of: paper towel, aluminum foil, wax paper, plastic wrap, plastic package pieces, cracker, leaf, apple core, orange rind, banana peel.
2. Take the class outside to dig up soil for their containers. (Seek appropriate permission before digging.)
3. Choose a place that is likely to contain microorganisms such as under a tree or shrub. Make sure students take only what is necessary to fill their containers.
4. When students return to the classroom, have each team set up its containers as follows:
   • Fill each container about halfway with soil.
   • Place a piece of each "trash" item on top of the soil. Use items of the same type and size for each container.
   • Cover the items by filling up the containers with more soil.
   • Put a lid on container "A" and set the container aside. Spray the contents of container "B" with water until the soil is moist, not soggy. Leave container "B" open and place it next to container "A." At the end of each school day, spray the contents of container "B" with a little water and then put on the lid and shake the container to allow air and moisture to move among the soil particles. During the night, keep the lid on to reduce evaporation. During the day, leave the container open. Use the chart to describe what happens in each container. Then have each team make a prediction as to what will happen in each container.
5. At the end of the first week, have the teams empty the contents of each container onto a separate sheet of newspaper. Look for each of the trash items and separate them from the soil. Fill in a data chart for Week One by describing any decomposition that took place during the week in each of the items from each container. For those items that showed no signs of breaking down, write "no change" on the data sheet.

6. Put half of the soil from container “A” back into its container, put the container “A” items back inside, cover them with the remaining container “A” soil, and replace the lid. Repeat this process for container “B” but continue to keep the contents moist and to keep the lid removed during the day. At the end of a four-week period, have the teams analyze their data and discuss how accurate their predictions were. Have the teams compare data.
7. Have the students start a worm composting box outside.
8. Take the students outside and have them observe decomposition in a rotting log. Diagram and describe the decomposition.

Follow-Up

1. Have the students discuss landfills and the problems associated with them. If possible, take the students on a field trip to a landfill or bring in a guest speaker on the topic.
2. Tour the school cafeteria and analyze how much food is thrown away each day.

EXTENSIONS:

1. Have the students sponsor a community litter pick up.
2. Educate the community about the benefits of recycling.
3. Help set up a community composting program.
4. Start a campaign to have school officials and local businesses buy products made from recycled materials.
5. Investigate your community’s recycling program. What are the benefits/drawbacks?

ORIGINAL DEVELOPMENT RESOURCES:

Appelhof, M. (1982). *Worms eat my garbage*. Flower Press.

Javna, J. (1990). *50 simple things you can do to save the Earth*. Berkeley, CA: EarthWorks Press.

Keep American Beautiful http://www.kab.org

Worm composting system. Missouri Department of Natural Resources. www.dnr.state.mo.us

Goldstein. J. (1979) *Recycling*. New York: Schocken Books.

Notes

Plastic Numbers

Grades:
9-12

Subjects:
Biology, English, Chemistry
Environmental Ecology, Math

Time Needed:
60 minutes

Materials:
variety of plastic wastes

OBJECTIVES:

Students will be able to:
1. Explain the importance of plastics in our society.
2. Describe the plastics code system.
3. Demonstrate the ability to separate plastics for recycling.

BACKGROUND:

The word *plastic* is a collective term used to describe a wide assortment of products. Plastics are made from materials found in the natural environment— petroleum, natural gas, and coal. Organic compounds containing carbon, hydrogen, oxygen, and nitrogen are extracted from the materials and are combined to produce a wide variety of plastic products. Plastic is defined as an organic, synthetic, or processed polymer of high molecular weight that can be molded, cast, extruded, drawn, or laminated into objects, films, or filaments. Plastics can be found in all environments— home, work, play, health care, and industry. Plastics are used to protect, reduce weight, replace body parts, control temperature, and prevent corrosion. Because plastics are used in such a variety of places, they are a large percentage of our waste. There are at least 45 families of plastics. This could cause some confusion when trying to define the types of plastics which are recyclable. A Plastic Container Coding System has been established by the Plastics Council to aid in the recycling process.

VOCABULARY:

code, natural environment, organic, plastic, recycle, waste

ADVANCE PREPARATION:

1. Make a collection of a variety of plastic goods. Be sure all codes are covered. Students can help by bringing goods from home. Approximately 12 plastic pieces per group of 4 to 5 students are needed.
2. Have copies of the Plastic Container Code System and the Plastic Code Analysis.

PROCEDURE:

Setting the Stage
1. Introduce the topic of plastics by displaying a sample of plastics.
2. Ask for observations about types.
3. Compare and contrast plastic sample types.
4. Brainstorm uses of plastics in all settings.
5. Ask for student uses and users of recycled plastics, for example, socks and t-shirts made from plastic.

Activity
1. Group students and distribute copies of Plastic Numbers Activity including the Plastic Container Code System and the Plastic Code Analysis.
2. Discuss the objectives and background information.
3. Discuss the Plastic Container Code System; practice pronouncing plastic names.
4. Introduce the Plastic Code Analysis.
5. Students should begin identifying and recording on the analysis chart the different plastic types.
6. Using the Plastics Code Analysis workheet, students will complete a survey at the grocery store or their homes.

Follow-Up

1. After identifying the plastics, sort and group them. Observe and discuss characteristics of each group.
2. Students can write research reports about different types of polymers.

EXTENSION:

1. Students may complete the Plastics Code Analysis at home.

ORIGINAL DEVELOPMENT RESOURCES:

Waste: A hidden resource. (1988, December). TVA Environmental Educational Program.

American Plastics Council. www.plastics.org

California Department of Conservation: www.consrv.ca.gov (for plastic content code abbreviations).

Environmental Protection Agency. www.epa.gov

Plastic Code Analysis

Number Symbol	Letter Code	Product	Observable Package Properties
1 *2* *3* *4* *5* *6* *7*	*PETE* *HDPE* *V or PVC* *LDPE* *PP* *PS* *Other*	*In this colum, write the name of the product.*	*Flexible/Rigid* *Transparent/Opaque* *Translucent/Color* *White crease when crushed*

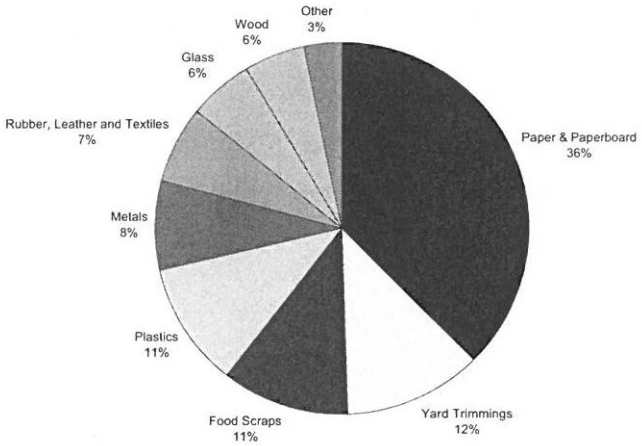
Plastic Container Code System

(found on the bottom of coded containers)

Code Abbreviation	PETE	HDPE	V	LDPE	PP	PS	Other
Full Name	Polyethylene Terephthalate	High Density Polyethylene	Vinyl	Low Density Polyethylene	Polypropylene	Polystyrene	Other resins or a mixture of resine types
Percentage of Total Bottles	48%	47%	1%	1%	1%	1%	1%
Can Be Transparent	Yes	No	Yes	No	Yes	Yes	Yes
Typical Containers	soft drink, instant coffee	milk, laundry degergent	liquid dish soap, peanut butter	grocery bags, coffee can lids	deli tubs, bottle caps, straws	foam cups, trays, egg cartons	catsup and syrup bottles

Materials Generated in MSW by Weight, 2000 (Total Weight - 232 Million Tons)

Source: EPA



Sewage Treatment Plant Model

OBJECTIVES:

Students will be able to:
1. Construct a model of a typical sewage treatment plant.
2. Explain the sewage treatment process.
3. Discuss the effects of sewage discharge on the aquatic environment.

BACKGROUND:

Waste from toilets, detergents from washing machines or dishwashers, food scraps from garbage disposals, and other organic substances are classified as sewage. Most areas have some form of sewage treatment; however, some areas use septic tanks or dump raw sewage directly into a local river or bay. This pollution often results in a foul smelling, unhealthy situation that kills aquatic life and makes the water unsuitable for recreation. Most environmental experts agree that all wastewater should undergo at least primary and secondary treatment before its release into a body of water. (See Figure 1.)

VOCABULARY:

disinfect, effluent, microorganism, primary treatment, raw sewage, scum, secondary treatment, sludge, tertiary treatment

ADVANCE PREPARATION:

1. Have students record the number of times that the toilets are flushed in their own homes , the garbage disposal is used, clothes are washed, and the dishwasher is run in a week's time.
2. Estimate the number of gallons discharged weekly.
3. Compile class results and discuss the impact on local waterways.
4. Arrange for a speaker from the local water treatment facility.

Grades:
9-12

Subjects:
Environmental Science, Biology, Geography, Math, Language Arts

Time Needed:
60 minutes for speaker, 2 weeks to complete project research and model, 2 hours for presentation and discussion

Materials:
plastic containers
aluminum cans
small boxes
straws
pipe cleaners
cardboard
plywood
sand
gravel
wire screens
PVC pipe

PROCEDURE:

Setting the Stage
1. Write the following categories on the chalkboard: the tap, a spring or well, a stream, a creek, a pond or lake, and a drainage ditch.
2. For each water source, record the number of students who respond "yes" to the question, "Would you consider drinking water from it?" If any student answers "no," ask for an explanation.

Activity
1. Divide the students into teams. Have them graph their advance prepared material.
2. Each team should research primary, secondary, and tertiary sewage treatment.
3. Each team should design and construct a functional sewage treatment plant model.
4. Each team should present its model and should defend the model to the class.

Follow-Up

1. Have the students list reasons that sewage treatment is important.
2. Have the students discuss how sewage can degrade a natural waterway, such as an estuary and bay area.

EXTENSIONS:

1. Tell students to imagine that raw sewage is being discharged from their school into a local waterway.
2. Using maps, have students trace the path that the sewage would take to the sea.
3. Have students estimate the time required for the sewage to reach the sea. (Add 25 percent for meanders and use an average flow speed of 3.2 km/hr or 2 mi/hr.)
4. Research alternative methods of sewage treatment such as using aquatic plants or constructed wetlands as is done in several Alabama towns including Fort Deposit, Luverne, enterprise, Satsuma, Robertsdale, Cintronelle, and Camp Hill. Arrange to wour one of those facilities if it is within a reasonable distance from the school.
5. Find out about septic tank regulations in the area. (See also the "rural Water" activity in this resource guide.)

ORIGINAL DEVELOPMENT RESOURCES:

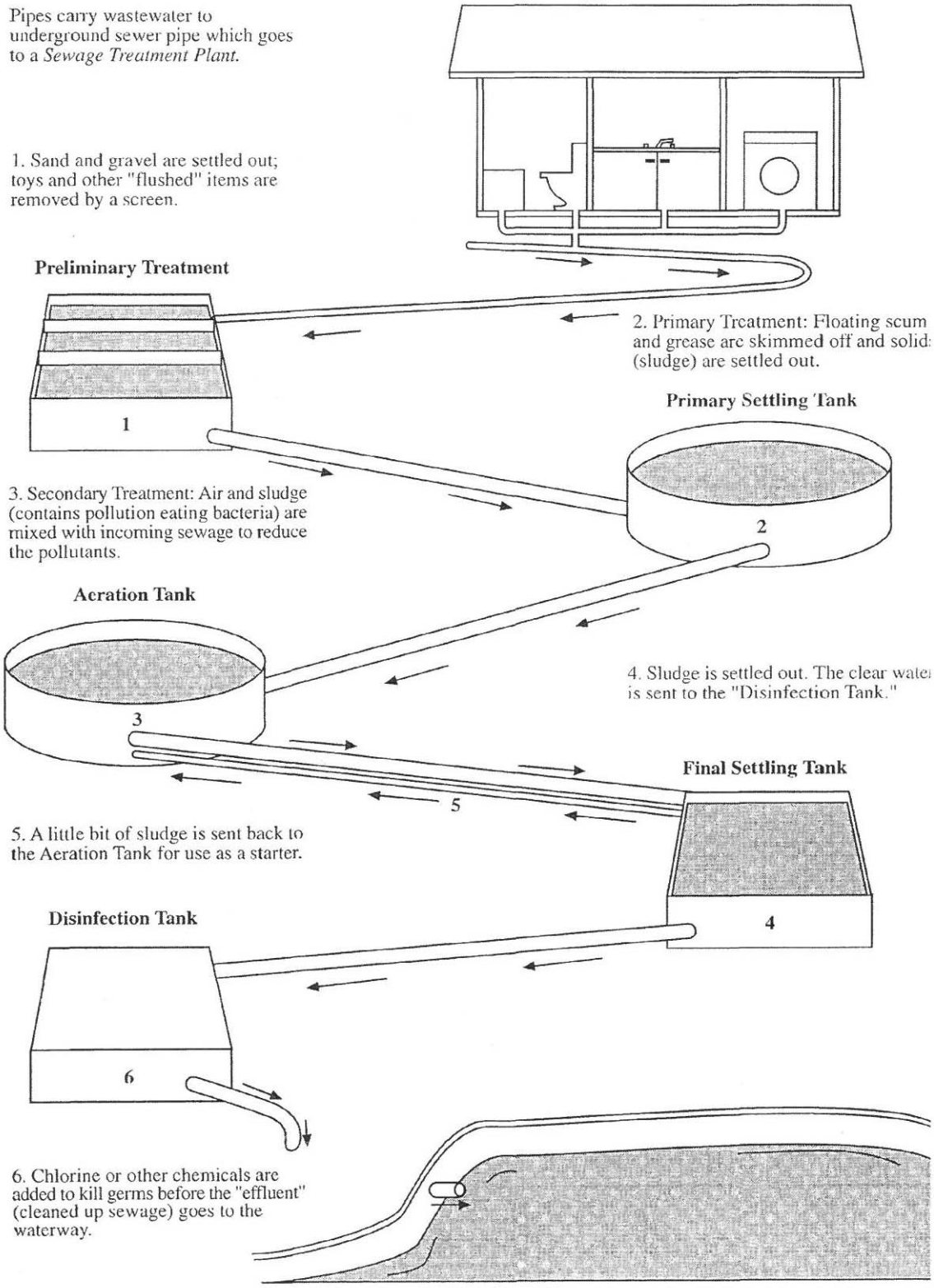
Arms, K. (1996). *Environmental science*. Austin, TX: Holt, Rinehart, and Winston.

Jacobson, C. (1983). *Water, water everywhere, but....* Loveland, CO: Hach Company.

University of South Alabama web site: www.southalabama.edu/usa/civileng/wetlands

Constructed wetlands for wastewater treatment and wildlife: www.epa.gov/owow/wetlands.

Figure 1 - Sewage Treatment



Notes

INTRODUCTION TO NATURAL RESOURCES

What Are Natural Resources?
A good working definition of Natural Resources requires defining the two words, natural and resources, separately and combining those definitions. “Natural” can be defined as something present or produced, in nature. “Resource” can be defined as that which is useful and for which there is an available supply. By combining these two definitions, “natural resources” can be defined as something present in, or produced by, nature with an available supply that can be drawn upon when needed. Natural resources also can be categorized as earth materials and as all life forms. Those natural resources include air, water, soils, natural vegetation, and all rocks and minerals.

Who Uses Natural Resources?
People use natural resources. Every aspect of life requires that we use natural resources. When one gets up in the morning and eats breakfast, one is using natural resources. The electricity that turned on the lights, the water in the shower, and the food that is on the table came from natural resources. All day long we use natural resources. Sometimes they are used in other ways, such as enjoying one’s surroundings by visiting a state or national park or forest.

Alabama’s Natural Resources
Alabama is fortunate in that it has an abundance of many natural resources. Farmers use the soil to produce many products, such as cotton, potatoes, tomatoes, and peanuts. On some areas of land, trees are grown to produce wood to build houses and to make paper for many purposes. In recent years, oil (a product that we use every day) has been found, and drilled, for in Mobile Bay. Across the state, people use water to produce electricity (hydroelectric dams) and to fish for food and sport. As one can see, Alabama has an abundance of natural resources, BUT we must manage them correctly so that they will last for generations to come.

Conserving Our Natural Resources for Future Generations
It is important for Alabamians to pay close attention to the ways they manage natural resources. There are many public and private organizations that work to assure that our natural resources are adequately maintained, but, in the end, it is up to the individual citizen to do his or her part. Whether it is by picking up trash, recycling, planting trees, or volunteering with an environmental organization, everyone makes a difference, and everyone must help to insure that generations to come have the necessary natural resources.

S*PARK*S

OBJECTIVES:

Students will be able to:

1. Describe the purposes for establishing national, state, county, and city parks.
2. List and locate on a map national parks of the U.S.
3. List and locate on a map parks in their state, county, and community.
4. Prepare a pictorial report.

Grades:
9-12

Subjects:
Biology, Ecology, Geography, Alabama History

Time Needed:
One class period

Materials:
copies of US national park map
404-562-3180
Alabama highway maps
cameras
poster board

BACKGROUND:

In 1872 Yellowstone In Wyoming was designated the world's first national park. By 1916 when the National Park System was established, there were an additional fourteen parks. Now the System manages about 83.6 million acres of land including 51 national parks, 102 national monuments and memorials, and 108 national historic sites and historical parks. Additionally, the U.S. Forestry Service manages many national recreation areas, states have established state parks on historic and recreational sites, and counties and cities have set aside land for their own parks.
The National Park Service mandate is to "conserve the scenery and natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."

Our parks have been visited, appreciated, used, and abused by so many visitors that many of them are now in danger of being "loved to death." Action is being taken to limit access to sensitive areas. In addition, many parks are underfunded, are not self-supporting, and are in dire need of repair work and refurbishing; there is a current push to sell some of these lands or to lease their management to for-profit organizations.

City parks are generally of the urban forest or playground variety. County parks tend to be recreational areas (boat launches, beaches, piers) or historic sites. Problems range from funding to vandalism.

Alabama has no national parks at present, but Little River Canyon near Fort Payne is slated to become Alabama's first. Currently, Little River Canyon is listed as a National Preserve. Twenty-four national forest recreation areas are managed for multiple use. Alabama has 24 state parks, plus abundant county and city parks. Alabama also has some national historic sites such as Sloss Furnaces in Birmingham.

VOCABULARY:

conservation, multiple use, preservation, stewardship, wilderness areas

ADVANCE PREPARATION

1. Make copies of the national park map and list for each student. Obtain an Alabama highway map for each student (free on request). The maps need to indicate the state parks and national forestry recreation areas. Obtain a list of county parks and maps, if available, from the county commission office.

PROCEDURE

Setting the Stage

1. Determine the extent of students' knowledge about public lands and their management.
2. Poll students to see who has visited a national or state park. Ask them to name the park and its location and to describe their experiences.
3. List on the board area county parks, first by students' suggestions and then by completing the list from your information. Again, see who has visited the parks and for what reasons.

Activity

1. After giving the students background on national parks and the National Park Service, pass out the maps and park lists. Ask them to list the national parks by region and discuss why some regions have more than others. List the first 10 parks to be established. Is there a connecting link between them? Which state has the most land set aside? What percentage of the total area is in the public trust? (Hint: 1 sq. mi.= 640 acres. Alaska's area is 591,004 sq. mi.)
2. Pass out the Alabama highway maps. The state parks and national forestry recreation areas are listed. Have them locate each on the map.
3. Assign each student or group of students a particular county or community park. Let them research the location, acreage, reason for being set aside, date of designation, and current usage. Create a large county map with each park location marked. Allow each group to present its findings.
4. Take the class on a field trip to a nearby park. Create a pictorial essay of that park. Assign different students to draw maps, measure, photograph, sketch, collect leaves (if permitted), and write descriptions of locations or activities.
5. If at all possible, let each group create a pictorial essay of "its" park. Include a map of the surrounding area; a map of the park area with usage marked; and a picture of the park sign, park scenery, roads, buildings, and activities.

Follow-Up

1. Play one of the land-use simulation games in which public land is in dispute.
2. Write newspaper articles, complete with pictures, detailing student findings and experiences with the city or county park system.

EXTENSIONS:

1. Choose an area that should be set aside and protected, and try to make it happen! Get the city or county to buy, develop, or clean up an area of beauty or interest. Write letters and visit the city council or county commission.
2. Invite a park ranger to visit the class as a resource speaker. Ask about the park service, the parks, describe a park ranger's job, explain training, and qualifications.
3. Assign research papers on each of the national parks. Write for information, do library and computer research, write a report, and make a poster or collage.
4. Show one or more of the national park videos produced by *National Geographic* and *Reader's Digest.* These may be available at a public library.

ORIGINAL DEVELOPMENT RESOURCES:

Arms, K. (1996). *Environmental science*. Austin, TX: Holt, Rinehart, and Winston.

Mitchell, J. (1994, October). *National geographic.* Our national parks: Legacy at risk. Plus Geoguide from the same issue.

Loving it too much. (1994). *Project learning tree.* (PreK-8).

The National Park Service. www.nps.gov

U.S. Major Public Lands

Major U.S. Public Lands	Approximate Size	Administered By	How the Land is Used
National Parks and Monuments	33.8 million hectacres (83.6 million acres)	National Parks Service (Department of Interior)	Hiking, camping , boating, fishing and other recreation; commemoration of historical sites. In some areas, hunting and mineral extraction are permitted.
National Wildlife Refuges	34 million hectacres (84 million acres)	U.S. Fish and Wildlife Service (Department of Interior)	Wildlife conservation, recreational activities, breeding areas for commercial fish, educationa dn scientific research. On some refuges, hunting, fishing mining for oil and gas, livestock grazing, and farming are permitted.
National Resources Lands	130 million hectacres (321 million acres)	Bureau of Land Management (Department of Interior)	Recreation, wildlife conservation, and industry such as livestock grazing or mining.
National Forests	76 million hectacres (188 million acres)	U.S. Forest Service (Department of Agriculture)	Recreational and commercial uses such as logging, grazing, and mining. Sometimes the land is leased for use as ski resorts or similar ventures.
Indian Reservations, Military Installations, etc.	29 million hectacres (72 million acres)	Bureau of Indian Affairs, Department of Defense, and others	Indian reservations: recreational and commerical uses such as farming, logging, grazing, and mining. Military installations: firing ranges, troop maneuvers, dumping ground from old military vehicles.

Notes

The Water Facts Of The Matter

Grades:
9-12

Subject:
Physical Science, Geography

Time Needed:
50 minute class period

Materials:
Wonder Water Fact Sheet to accompany Alabama Water Facts Activity Sheet

OBJECTIVES:

Students will be able to:
1. Read printed material from charts.
2. Demonstrate effective use of reference material and research skills.
3. Demonstrate an understanding of water facts for Alabama.

BACKGROUND:

Alabama is one of the leading states in water resources, which are used for work (navigation, power production), play (swimming, skiing, fishing, boating), drinking, food production (irrigation), tourism, and real estate development. Many Alabamians do not know a lot about, or value, their water resources. This activity presents water facts and improves understanding and appreciation of Alabama's bountiful water resources. The climate in Alabama is humid and subtropical with mild winters and hot summers. Average annual temperatures range from 58° in northwestern Alabama to about 68° in southwestern Alabama. Rainfall in Alabama usually is abundant and is distributed throughout all months of the year. Very little snow falls in Alabama in normal years.

VOCABULARY:

perennial, reservoir, wetlands, streamflow, navigable, barge, wastewater, intermittent streams, watercraft, runoff, groundwater, pumpout systems

PROCEDURE:

1. Have students complete the worksheet and then engage in a discussion of the facts. (See Alabama Water Facts.)

EVALUATION:

1. Research the impact of lack of rainfall in Alabama, particularly during the growing season.

EXTENSION:

1. Research how many marinas have pumpout stations for the boats in Alabama and determine what type of pumpout systems they are using. Have the students determine the amount of boating traffic at the marinas that require pumpout service.

Name: _____

Alabama Water Facts

1. _____number of boats in use in Alabama
2. _____total number of miles of rivers or streams
3. _____miles of ditches and canals
4. _____amount of drainage water flowing into Mobile Bay
5. _____approximate number of people in Alabama
6. _____miles of Gulf Coast shoreline and beaches
7. _____acres of wetlands
8. _____percentage of Alabama streams meeting requirements
9. _____number of state parks
10. _____minimum water depth for use by barges
11. _____number of hydroelectric power production plants
12. _____number of lakes, reservoirs, and ponds
13. _____amount of water used each time a lock is operated
14. _____square miles of estuaries
15. _____number of times a drop of water entering Alabama can be reused
16. _____range of average rainfall in Alabama
17. _____number of navigable river miles in Alabama

Alabama Water Facts (Answers)

Alabama has:

14 river basins
77,242 total miles of rivers and streams
47,072 miles of perennial rivers and streams (7th nationally)
30,170 miles of intermittent streams
32 miles of ditches and canals
43 lakes, reservoirs, and ponds (excluding farm ponds)
563,000 acres of ponds, lakes, and reservoirs (14th nationally)
3,627,600 acres of freshwater wetlands (24th nationally)
27,600 acres of coastal wetlands
610 square miles of estuaries
50 miles of Gulf Coast shoreline and beaches

1. The average annual rainfall in Alabama ranges from 48 to 68 inches with only approximately 22 inches draining from the land to form the state's rivers and streams.
2. The average streamflow of all streams entering this state is 60,341 cubic feet per second (38,980 million gallons per day) while the average streamflow of streams leaving the state is 134,793 cubic feet per second (87,076 million gallons per day).
3. Sixty-three percent of all streamflow (drainage) in Alabama flows into Mobile Bay.
4. Fifty-six percent of Alabama's 4.0 million people drink water obtained from lakes and streams. Forty-four percent drink water from wells.
5. Alabama has 21 hydroelectric power production dams.
6. Alabama has 17 state parks that provide recreational use of Alabama's waters.
7. A drop of water entering Alabama from other states can be reused up to 25 times before leaving the state.
8. Alabama has more miles of navigable streams (1,438 miles) than any other state. Seven of the 14 river basins have navigable rivers.
9. Alabama's navigable rivers must be nine feet deep and 100 to 300 feet wide before use by barges is possible.
10. Locks are structures at dams that allow raising or lowering of barges and other watercraft from one level to another. Each time a lock is operated, 15 to 45 million gallons are needed.
11. More than 250,000 boats use Alabama's water.
12. Fishing is important in Alabama and popular in the state's 38 major lakes and 23 fishing lakes.
13. There are 275 towns and cities that discharge 435 million gallons per day of treated wastewater to Alabama's rivers and streams.
14. There are 548 industries that discharge 8,168 million gallons per day of treated wastewater to the state's rivers and streams.
15. President George Bush established the Clean Vessel Act of 1992 to improve water quality.
16. The Clean Vessel Act provides funds for the construction, renovation, operation, and maintenance of pumpout stations and waste reception facilities, as well as education programs, to improve water quality. "Pumpout stations" are facilities at some marinas by which boaters can pump on-bouard sewage into proper receprtacles for disposal instead of emptying the sewage into a lake or river.

Notes

Alabama's Public Lands

Grades:
9-12

Subjects:
Social Studies, Environmental Science, Math

Time Needed:
45-60 minutes

Materials:
One Alabama road map per student
Alabama State Park booklets

OBJECTIVES:

Students will be able to:
1. Name five state parks.
2. Name one federal land.
3. Distinguish between public and private lands.
4. Locate places on a road map.
5. List examples of responsible citizenship.

BACKGROUND:

The purpose of this activity is to teach the differences between public and private lands and to familiarize students with the public lands in Alabama.

The main difference between private and public lands is ownership. Private lands, of course, are owned by private individuals, businesses, corporations. Public lands, on the other hand, are owned by the people through the government. It may surprise some students that they are owners of the property. These lands are paid for by taxes based on the level of government (local, state, federal) that is in charge of the property.

As property owners, it is important for citizens to take responsibility for their land. Thus "ownership" requires responsibility, and students should think about this responsibility.

VOCABULARY:

public land, private land, estuarine

PROCEDURE:

Setting the Stage
1. Write the words "public lands" and "private lands" side by side on the board. Define and write the definition under each.
2. Ask the students for examples of each and add them to the list on the board. Add additional examples if needed.
3. Ask the students to compare and contrast the two lists.

Activity
1. Give each student a road map of Alabama and allow time to look over the map. Use this time to assess their degree of map skills, and supplement those skills if needed.
2. Discuss the legend and key, and locate examples of each.
3. Point out the major roadways, cities, and rivers.
4. When all students have completed the exercise (provided), go over the answers, and have the students locate each place mentioned.
5. Locate as many examples of different types of public lands as possible. See if one example for each of those listed under "public lands" can be found.

Follow-Up

1. Lead the class in a discussion of responsibility of public property. Who makes the decisions? How are priorities determined? Does everything that should be done get done? Why or why not? What should and should not be included in a park? What laws govern public lands? Who works at public places?
2. Continue with discussion of the responsibilities of individual citizens. Make a list of these.
3. Let the students share experiences from having visited public lands.

EVALUATION:

1. Students will take a written test on the material covered.
2. They also will design a "perfect" public land. (This can be any type of public land—parks, forests, monuments.) To design the public land, they must submit the following:
   - A mission statement (What is the purpose? Why is it here?).
   - A list of goals.
   - A set of rules and regulations.
   - A map of the entire area.

EXTENSIONS:

1. Assign one or several students one of Alabama's public lands, and have them investigate and report to the class.
2. If possible, take the students on a field trip to a public land, and them complete a service project while there.
3. Let students interview employees of a public land, such as forest or park rangers, and report to the class on their job responsibilities, the problems they see facing public lands, what they wish the public knew about lands. (Or bring the official into class as a guest speaker.)
4. Let the students figure mileage and cost of gasoline to get from place to place.
5. Let the students plan a vacation to the public land of their choice. Include expenses and activities.
6. Have students research Forever Wild and other programs that allow the State of Alabama to buy land for the natural preservation of wetlands, bottom land hardwood forests, and other valued resources.

ORIGINAL DEVELOPMENT RESOURCES:

Alabama State Parks (1-800-ALA-PARK): www.dcnr.state.al.us.

U.S. Department of Interior: www.doi.gov

U.S. Department of Agriculture: www.usda.gov

Alabama's Public Lands
Crossword Puzzle

Word Bank:

Talladega	Golf	Russell	Estuarine
Bon Secour	Mound	Rickwood	Chattahoochee
Pier	Birmingham	Tennessee	Capitol
Sixty-five	Bankhead	Lakepoint	Wetlands
Florala	Guntersville	NASA	Chickasaw
Clio	Lurleen	Opp	Gulf
Wheeler	Desoto	Canyon	Cheaha
Martin	Chewacla	Pets	Farm

Alabama's Public Lands
Crossword Puzzle

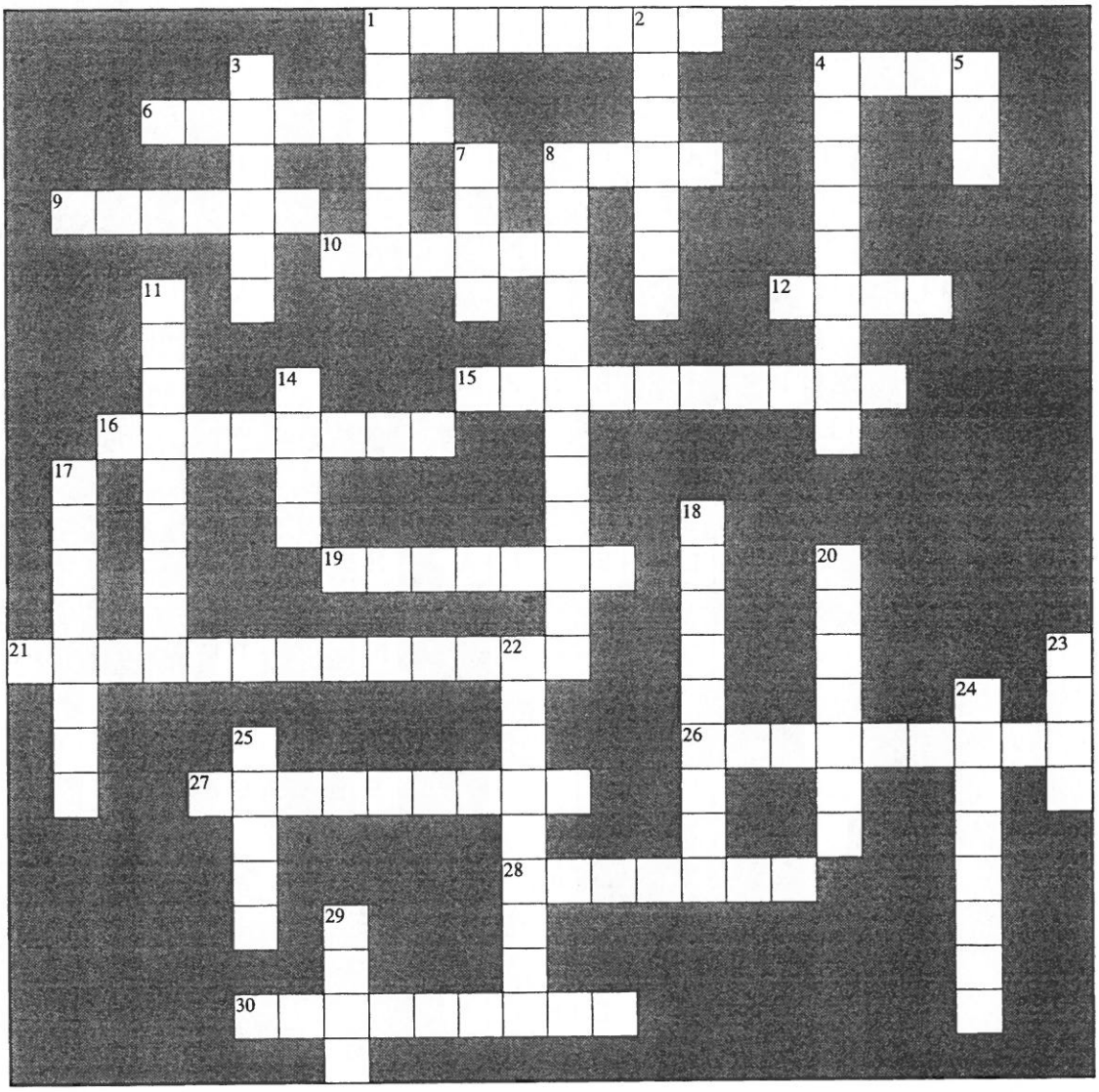
ACROSS

1. You might stay at this state park when you go to an Auburn football game.
4. Blue Springs State Park is located near the city of _____.
6. "Fighting Joe _____," a Confederate general, is for whom a large state park is named.
8. If you want to walk along a sandy beach, _____ State Park is the place.
9. The deepest _____ east of the Mississippi River can be seen when visiting DeSoto State Park.
10. Wind Creek State Park is located along the shores of Lake _____.
12. While staying at Monte Sano State Park, you also could visit this important space agency.
15. Oak Mountain State Park is located near Alabama's largest city, which is _____.
16. Meaher State Park is a good place to study the _____.
19. Which state park combines the names of two states?
21. This park is named for an important river, which is located nearby.
26. To get to Rickwood Caverns State Park, you would drive on Interstate _____.
27. _____ is a national wildlife refuge located in south Alabama.
30. Mt. Cheaha State Park is located in this national forest.

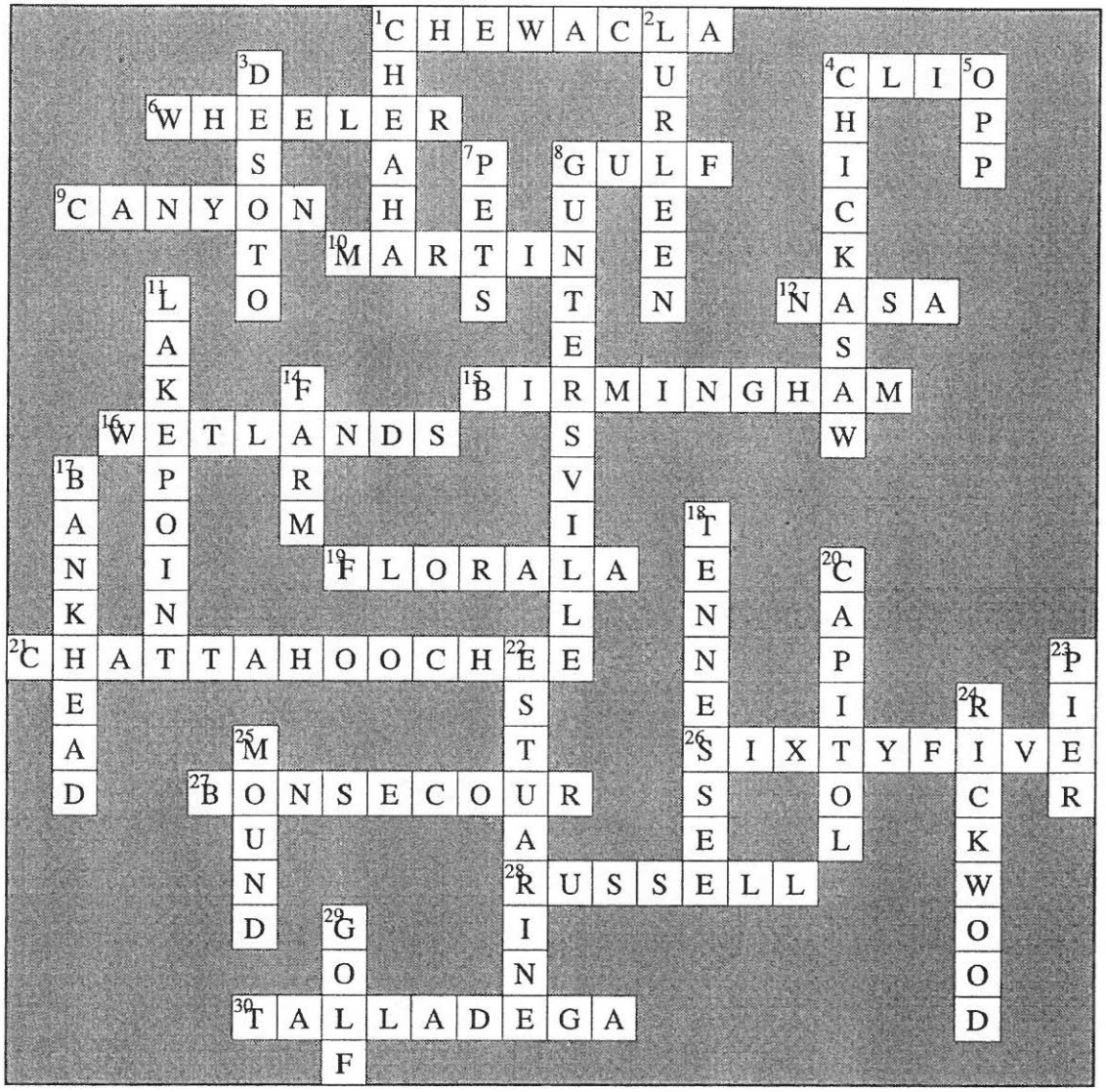
DOWN

1. This state park is located atop the state's highest mountain.
2. Lake _____ State Park was named for Alabama's only woman governor.
3. One state park is named for a famous Spanish explorer. Which one?
4. Which state park is named for one of the major Native American tribes in Alabama?
5. Frank Jackson State Park is located near the town of _____.
7. You should not see these in Alabama state parks.
8. This state park is one of the winter homes of our national symbol.
11. This state park is located on the "bass capital of the world."
14. You could enjoy this _____ at Oak Mountian State Park.
17. The Sipsey Wilderness is located in this national forest.
18. Lake Guntersville is located on this river.
20. The _____ of Alabama is Montgomery and the location of many important state buildings.
22. Weeks Bay is the state's only National _____ Reserve.
23. Gulf State Park has something that is 825 feet long. What is it?
24. Blind fish inhabit this state park.
25. _____ State Monument was set aside to protect important Native American relics.
28. This is one of the many recreational activities at Alabama state parks.

Alabama's Public Lands
Crossword Puzzle



Alabama's Public Lands
Crossword Puzzle (Answers)



Chain Gang

Grades:
9-12

Subjects:
Biology, Environmental Science

Time Needed:
One class period

Materials:
calculators
life science and biology texts and other reference materials

OBJECTIVES:

Students will be able to:
1. Construct a salt marsh food chain using organisms indigenous to Alabama.
2. Compute the amount of energy available to each order of consumers.

BACKGROUND:

When an organism eats, sleeps, walks, or performs any other daily activity, it is using energy. This energy must be replaced if the organism is to survive. In almost all ecosystems, the initial source of energy is supplied by the sun to the plants in the ecosystem. Light energy from the sun is transformed into usable energy (food) by the photosynthetic activity of autotrophs. As energy flows through the ecosystem, it can be separated into two channels: production and respiration. Through production, the energy is used in growth to create new tissues; while during respiration, the energy is lost permanently to the ecosystem. Since all living organisms respire, the loss of energy through respiration is very high.

The energy that is not lost through respiration is passed through the ecosystem. One can separate the organisms into different trophic levels: producers, herbivores, and carnivores. Herbivores feed almost exclusively on plants, while carnivores feed on other animals. With energy loss in every step between the trophic levels, many producers are needed to support fewer herbivores, which support even fewer carnivores.

The loss of energy from one level in a food chain to the next can be shown in a pyramid of energy (See included diagram.) The base of the pyramid consists of producers. Consumers make up each of the other levels. The size of each level represents the amount of energy available at each level.

VOCABULARY:

ecosystem, respire, herbivores, carnivores, trophic levels

PROCEDURE:

1. Using life science books, biology books, and/or encyclopedias, construct a salt marsh food chain indicating organisms that are producers, first-order consumers, second-order consumers, and third-order consumers.
2. Complete the food chain pyramid by labeling each level with appropriate organisms from your food chain.
3. As energy moves upward in the pyramid, only 9% of the energy is available to the next level in the pyramid. Assume that your chain has 10,000 kilocalories of energy available to plants (producers)..
4. Determine the amount of energy available to each order of consumers.

EVALUATION:

1. Diagrams and pyramids may be graded for content and creativity. Arithmetic calculations can be checked for accuracy.

EXTENSIONS:

1. How to feed the world's human population is becoming a major concern. Consider two types of human diets: one that consists almost completely of plants and one that consists mainly of meat. Which type of diet would better meet the food/energy needs of the world's population? Explain your answer.

ORIGINAL DEVELOPMENT RESOURCES:

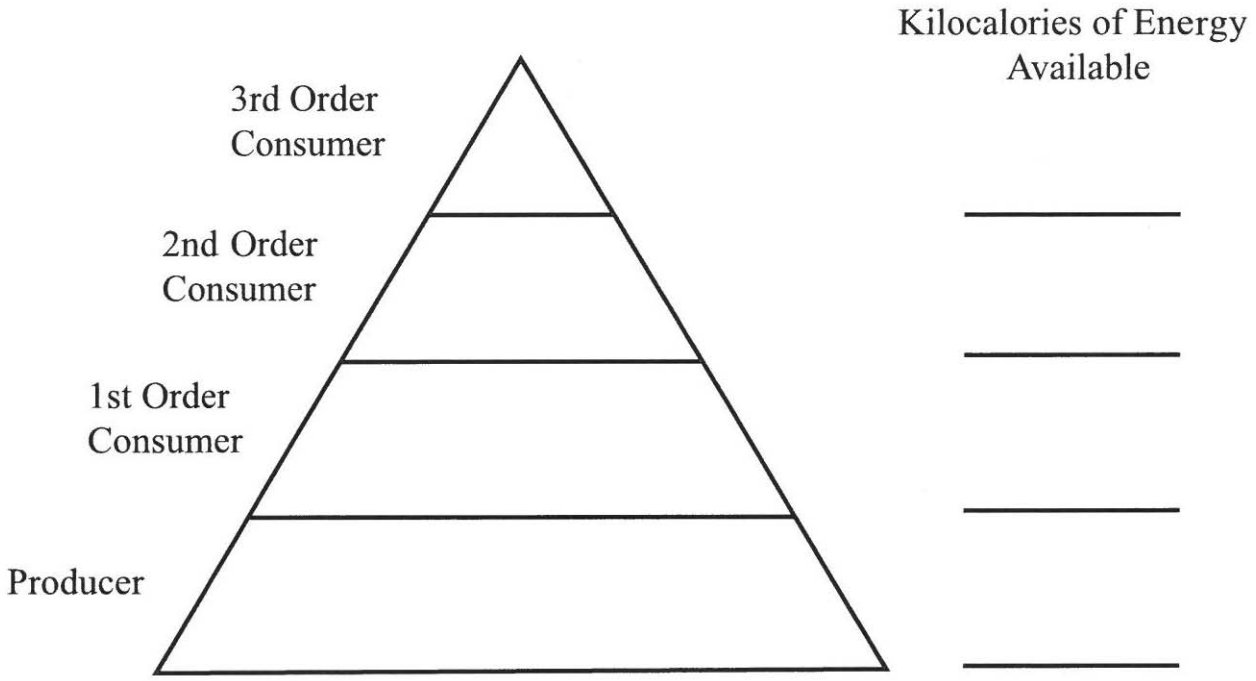
Discovering Alabama - Wildlife History. Videotape. www.discoveringalabama.com. May be obtained by writing Discovering Alabama, Box 870340, Tuscaloosa, AL 35487.

www.planetpals.com/foodchain

Animals for Food Chain Diagram

Alligator
Atlantic stingray
Bald eagle
Black skimmer
Blue crab
Brown pelican
Common egret
Cormorant
Cottonmouth moccasin
Diamondback terrapin
Fiddler crab
Field cricket
Flounder
Ghost crab
Great blue heron
Great horned owl
Green anole
Hermit crab
Horseshoe crab
Jellyfish
Kingfisher
Laughing gull
Marsh hawk
Marsh periwinkle
Mosquito
Osprey
Oyster
Possum
Raccoon
Red drum
Sandpiper
Shark
Sheepshead minnow
Shrimp
Snapping turtle
Snowy egret
Spotted sea trout
Striped mullet
Swamp rabbit
Toadfish
Wharf crab
Whelk

Food Chain Diagram
(Draw And Label Organisms)



Check It Out

OBJECTIVES:

Students will be able to:

1. Describe the groundwater contamination problem.
2. Research local underground storage tank facilities and discuss the differences in their operations.
3. Simulate, in class, an inspection of an underground storage tank facility.

Grades:
9-12

Subjects:
Biology, Physical Science, Environmental Science, Social Studies

Time Needed:
30 to 90 minute class period

Materials:
pen
paper

BACKGROUND:

Inspection of underground storage tanks (USTs) is one way of protecting our nation's groundwater. Groundwater is the most common source of clean drinking water known to humans. Groundwater contamination, in most cases, is very expensive to correct and, in many cases, is impossible to correct. Therefore, prevention is critical.

Federal, state, and local governements are able to oversee the operation of these facilities through regulatory inspections. Regulatory inspections cover a variety of operation procedures that owners and operators must follow: registering all active underground storage tank systems with the proper agency; recording and maintaining inventory records for petroleum input and output for each day of system operation; and meeting leak detection requirements for both tanks and piping by choosing an appropriate method, depending on the size and type of tank systems (See diagram). The last two requirements, which are corrosion protection and spill/overfill equipment, apply to underground storage tank systems that have been installed since December 1988 as well as any new or proposed installation to be installed in the future.

Most inspections indicate that owners and operators are aware of the rules, but the finer details of compliance are simply overlooked. That is where the inspector's job comes in. Advising, reviewing site-specific characteristics, and clarifying any rules and regulations are key roles in monitoring USTs. Being familiar with their local facilities might encourage people to have an active concern about their health and the protection of the environment for years to come.

VOCABULARY:

corrosion, groundwater, inspection, inventory, pressurized, record, suction, underground storage tank

PROCEDURE:

Setting the Stage

1. Read the background information aloud to the class.
2. Provide the students with access to a drawing or diagram showing pathways to groundwater pollution. (One such drawing is the Pathways to Groundwater Pollution Figure on Legacy's "Alabama's Water Resources Poster.")
3. Provide students with a copy of the background information and have them divide into groups of four for discussion.
4. Have the students participate in a question-and-answer session.
5. Have the students discuss the prevention of groundwater contamination versus cleanup. Which is more difficult? Which costs more? Is cleanup always possible?

Activity

1. Have the students create a checklist and include the following:
   - Number of tanks.
   - Inventory records (Y/N).
   - Method of leak detection (tank or piping).
   - Type of piping (pressurized or suction).
   - Corrosion protection (if applicable).
   - Spill/Overfill equipment (if applicable).
2. Determine if the checklist indicates compliance based on background information. (Compliance can be distinguished by whether or not each of the answers on the checklist is marked if applicable.)

EVALUATION:

1. Have the students research their neighborhood gas stations and ask some of the same questions from their checklist.
2. Once students have completed their neighborhood inspections, have them compare the differences between the types of gas stations in that area.

EXTENSION:

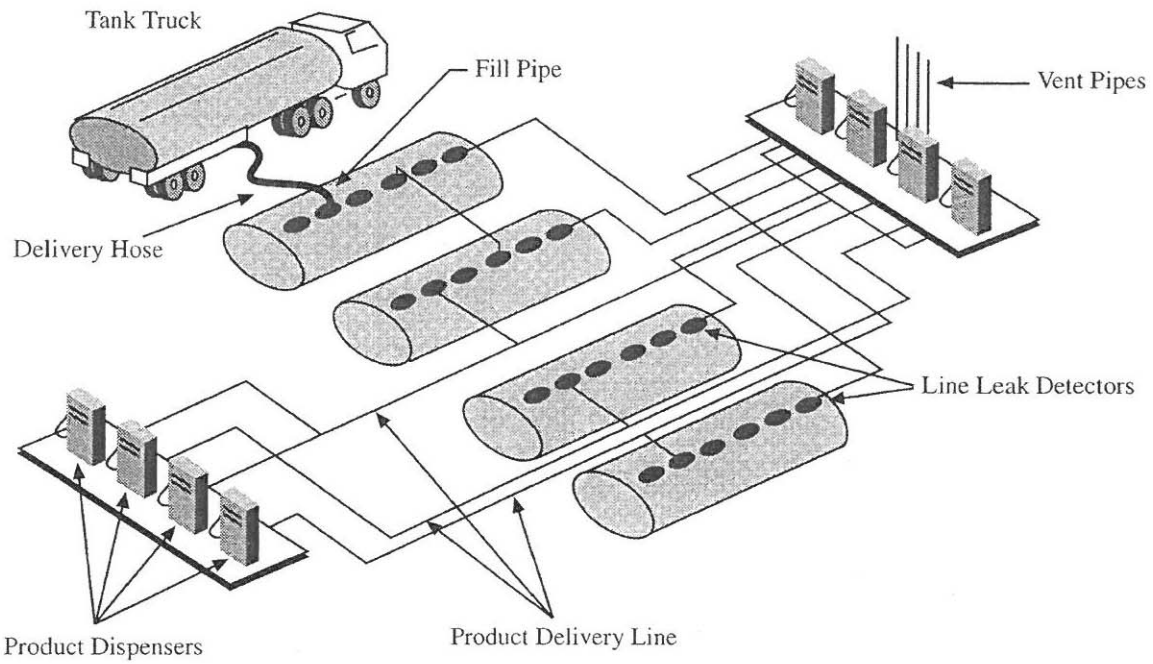
1. Additional research can be done to determine if old tanks have been removed from former service station sites.

ORIGINAL DEVELOPMENT RESOURCES:

Operating and maintaining underground storage tank systems, help and checklists. (2002) The Alabama Department of Environmental Management. 1400 Coliseum Blvd. Montgomery, AL 36110. www.adem.state.al.us.

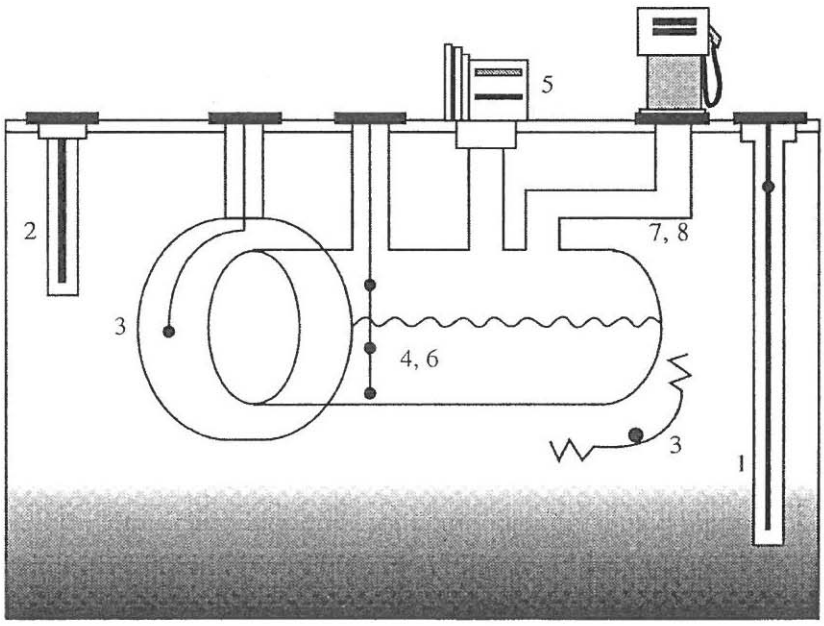
"Alabama Water Resources" poster, Legacy, Inc. P.O. Box 3813, Montgomery, AL 36109, www.legacyenved.org, 1-800-240-5115.

A Typical Tank Facility



Leak Detection Methods for Tanks and Piping

1 Ground-Water Monitoring
2 Vapor Monitoring
3 Secondary Containment with Interstitial Monitoring
4 Automatic Tank Gauging Systems
5 Tank Tightness Testing and Inventory Control
6 Manual Tank Gauging
7 Leak Detection for Underground Suction Piping
8 Leak Detection for Pressurized Underground Piping



Notes

Designer Streams

Grades:
9-12

Subjects:
Chemistry, Physics, Environmental Science, Biology, Art, Geography

Time Needed:
One 50-minute period

Materials:
pencils
colored pencils

OBJECTIVE:

Students will be able to:

1. Describe the importance of stream water quality and beautification in their area.

BACKGROUND:

Often, improvements can be made to streams to offset human impacts and to improve water quality.

Many towns and cities have made scenic improvements to high-exposure, urbanized streams; and streams often have been improved through various volunteer and cost-share programs. Techniques that have been used to improve streams include (1) adding rock weirs or lowhead dams for aeration, (2) constructing erosion barriers to stop siltation, (3) installing stream-side management zones by planting appropriate vegetation, and (4) planting trees for shading. Many other techniques, such as targeted upgradient improvements and stormwater controls, also are used.

All of the above actions have positive cost-benefits. Nonetheless, they are typically done only after stream assessment studies that include analyses of the cost-benefit ratios of various actions. Government funding for improvements generally is dependent on a favorable cost-benefit ratio. Many of the benefits are aesthetic and thus are very difficult to assign an economic value to. Benefits often extend beyond aesthetic and water quality into economic benefits, since businesses will go where people go; and people will move to clean, environmentally appealing areas.

VOCABULARY:

substrate, embeddedness, water quality, weir, debris

PROCEDURE:

1. Students should visit a stream in the area. Using the Student Information Sheet as a guide, students will complete the lab sheet and drawings. One drawing will consist of a present-day stream in the area. The second drawing will consist of improvements that would enhance its beauty and would improve water quality.

EVALUATION:

1. Have students complete the Student Lab Sheet.

EXTENSIONS:

1. Have a “Designer Stream” contest that allows students to construct models of their improved streams.
2. City officials could act as judges with the winning model then submitted to local government as a guide toward enhancing the stream.
3. Have the class join the Adopt-A-Stream Program sponsored by ADEM.

ORIGINAL DEVELOPMENT RESOURCES:

Information on water quality. The Alabama Department of Environmental Management (ADEM) 1400 Coliseum Blvd., Montgomery, AL 36110: www.adem.state.al.us.

Alabama Water Watch, 203 Swingle Hall, Department of Fisheries, Auburn Univeristy, Auburn, AL 36849, 1-800-844-4785.

Alabama Rivers Alliance: www.alabamarivers.org.

Arello, G. (ed.) *Alabama the river state*. (1998) Birmingham, AL: Natura Press.(available through the Office of Water Resources, Alabama Department of Economic and Community Affairs.

Student Information Sheet

Read the following stream characteristics. They will provide helpful information for completing the lab sheet.

HOW TO CHARACTERIZE THE SETTING: The setting is the land area immediately adjacent to or visible from the stream bank. Think in terms of perhaps 1/4 mile on either side of the stream channel. In other words, what kind of land does the stream flow through? If one (or more) of the land uses is dominant, place a "D" in the appropriate box(es). If a land use is present in small areas, place an "X." Use the blank spaces to fill in other land uses.

STREAMBANK CHARACTERISTICS
Left Bank (facing upstream) or Right Bank (facing upstream)

Sketch a segment of the river stream bank and corridor; indicate the location of the sample site. (NOTE: any unusual observations.) Sketch a bird's eye view of the stream segment containing your sample site. Circle the arrow that indicates the direction in which the current is flowing. Sketch as much of the segment as you can see from the bank, upstream and downstream of the site. Note any observations you think are important.

SUBSTRATE COMPOSITION: What is the stream bottom made of? Look at a 3-4 ft. band of streambed across the stream (transect). Check the percentage of the bottom that is composed of different materials.

EMBEDDEDNESS: Embeddedness is the percent surface area of larger particles (boulder, rubble, or gravel) surrounded or covered by fine sediment (sand or silt). This fine sediment can clog up spaces where aquatic organisms would otherwise live.

OVERHEAD CANOPY: What percentage of the stream width is covered or shaded by overhanging grasses, shrubs, and trees? This shading plays an important role in keeping the water cool in the heat of the summer.

NOTES: In your suggestions for changing the stream to enhance its natural beauty and improve water quality, include the stream location.

Name: _____

Student Lab Sheet

Creek or Stream: _____ Segment Studied: _____

1. How would you characterize the setting? Place a "D" for Dominate and "X: if Present (otherwise leave blank).

Roadless Wooded Area		Cropland		Dairy Farm		Scattered Residential	
Wooded Area with Roads		Grazing Pasture		Park Area		Village or Urban	
Woodlot Logging Area		Ungrazed Meadow		Golf Course		Commercial/ Insustrial	
Other (Specify)							

STREM BANK CHARACTERISTICS

2. What are the characteristics of the left bank (facing upstream)?
   a. Shrubs ___% Grass ___% Trees ___% Unvegetated ___%
   b. Is the left bank unstable or eroding into the stream?

3. What are the characteristics of the right bank (facing upstream)?
   a. Shrubs ___% Grass ___% Trees ___% Unvegetated ___%
   b. Is the right bank unstable or eroding into the stream?

4. Sketch a segment of the river stream bank before your improvements are made and after your stream improvements are implemented.

Before	After

SUBSTRATE COMPOSITION

5. What is the composition of the streambed in the are of your sample?
   Bedrock ___% Boulder ___% Rubble ___% Gravel ___% Sand ___% Silt ___%
   Organic Debris: >10" ___ 2-10" ___ .01-2" ___ <.01" ___

EMBEDDEDNESS

6. What is the percentage of surface area of larger particles (boulder, rubble, or gravel)?
   >5% ___ 5-25% ___ 25-50% ___ 50-75% ___ <75% ___

OVERHEAD CANOPY

7. What is the percenteage of stream width covered by overhanging grasses, shurbs, and trees?
   >5% ___ 5-25% ___ 25-50% ___ 50-75% ___ <75% ___

Journey To The Center Of A Tree

OBJECTIVES:

Students will be able to:

1. Measure the diameter and circumference of the cross section of a tree.
2. Identify and explain similarities and differences in tree rings.
3. Create a time-line on a tree cross section.

BACKGROUND:

People record events through oral stories, physical monuments, and written accounts. History helps us learn about the present—where we are today—by looking at what happened in the past. (Teachers should give an example of relevant historic/current perspectives relative to the age, location, and issues of students.)

In order to interpret the history of a particular tree, one must first look at the method a tree uses to record its history. A tree records "memories" within the structure of its trunks. Everything that impacts upon the tree throughout its life — from insects, cars, or disease to heat, nutrients, or flooding— will leave a mark. Trees can be used as bio-indicators. Environmental factors, such as drought, pollution, and fire, usually can be detected through analysis of sap, wood, and leaves. Impact may be positive, resulting in rapid growth or negative, resulting in slower growth.

A tree records its growth in its rings. Rings are a function of temperate zone seasonal changes—trees growing in the tropics do not have annual growth rings because their growth is fairly constant. A growth ring usually appears each year in dry weather with the outer growth rings being the most recent. When growth rings are very close together, the tree grows very slowly. When rings are widely spaced, the tree grows very quickly. This comparison should be used only when comparing the same species of trees.

Grades:

9-12

Subjects:

Botany, Biology, Environmental Science, Geometry, Social History, Natural History

Time Needed:

Two 40-minute class periods (minimum)

Materials:

A cross section of a tree or a core sample of a tree. A tree (or limb) cross-section usually can be obtained from a local tree-trimming service, forest industry, or utility company that is clearing or trimming trees from power or telephone lines. Other resources include your state or county Department of Natural Resources, Forestry, or Extension Service. Tree "cookies" can be obtained from a local paper company or forestry department. Sample pictures of tree cores can be included.

The trunk is the arterial system—like our arteries and veins—that transports material to the leaves in the outer layers of the tree trunk and inner layers of the bark. Just beneath the bark is the cambium, the "cell factory" of the tree. Cells that form outward from the cambium layer develop into the phloem (the layer of tissue that transports food up and down the trunk) and the bark. Cells that form inward from the cambium become xylem, or sapwood, which conducts water up and down the trunk.

As the tree grows outward, older xylem stops its transport function and becomes heartwood. In some cases, this heartwood actually may rot away completely, leaving a perfectly hollow tree with only the living outer rings performing all the necessary vital functions of the trunk. It is here in the outer layer of wood that, in a large tree, hundreds of gallons of water and nutrients are sucked up from the roots, and a great amount of sugar-laden sap is pushed down from the leaves in a pump-like action. This massive flow of fluids makes the tree the largest vascular creation on the planet.

A tree grows upward much like adding an ice cream cone to an extending stack of other cones. A branch that grows out of the trunk at a height of four feet from the ground certainly will grow in diameter, as will the trunk itself; but the branch will remain the same distance from the ground for the duration of the tree's life. The same goes for injuries, whether they are initials carved on a tree trunk or slashes from a mower. Trees overcome injuries and fight infections by sealing off the affected part. Whether wounded by a badly pruned branch or the attack of a bark beetle, a tree will carry its scars for the rest of its life.

VOCABULARY:

phloem, xylem, cambium, sapwood, board foot

PROCEDURE:

1. Obtain a cross section or core sample of a tree.
2. Measure the diameter and circumference of the cross section. Discuss how the circumference of the tree relates to its age and growing conditions. Calculate the surface area of the cross-section ($A=Cr^2$).
3. Identify similarities and differences in sizes of, and spaces between, tree rings. Discuss possibilities for these differences.
   - What do you think widely spaced growth rings mean for the tree?
   - What natural factors might have affected the tree's growth?
   - What man-made factors might have affected the tree's growth?
4. Have students create a time-line for the life of the tree. Start with an estimate of when the tree germinated (when it began to grow from a seed) and continue to the current date. Charting the time lines in five-year increments may be sufficient if the tree is relatively old.
5. Include memorable points along the time-line, relative to the student's point of view: birth dates, year began school, year the town or community was settled, year the state entered the union, year of the first presidential election they remember.

EVALUATION:

1. Present findings to the class. Have students quiz their classmates on the information presented.

EXTENSIONS:

1. Display the findings in a central location of the school.
2. Invite a person from a paper company or the logging industry to speak to the class.
3. Find out what wood or paper products are made at the paper plant in the area.
4. Make a list of the paper products you use each day.
5. Estimate what percentage of your home is made from wood.
6. List all the wooded furniture in your house/classroom.
7. Call a lumberyard or home improvement store. Find out the cost of different types of lumber per board foot.
8. Find the largest tree on the school campus and in the neighborhood. Measure its circumference.
9. Call the Alabama Forestry Commission and ask for a champion tree list for the state and counties.

ORIGINAL DEVELOPMENT RESOURCES:

Adapted from the *Growing Greener Cities* Education Guide, used with permission.

Alabama Forestry Commission, 513 Madison Avenue, P.O. Box 302550, Montgomery. AL 36130-2550. www.forestry.state.al.us.

Alabama Forestry Association, 555 Alabama Street, Montgomery, AL 36104, (334) 265-8733.

Alabama Trees. Discovering Alabama videotape. www.discoveringalabama.com

Lakes And Dams of Alabama

OBJECTIVES:

Students will be able to:

1. Demonstrate an understanding of the major and diverse efforts of people to control and use natural resources to their advantage.
2. Appreciate the system of man-made lakes in Alabama.

Grades:
9-12

Subject:
Biology, Environmental Science, History, Math

Time Needed:
One class period

Materials:
Alabama highway map (published and distributed by the Alabama Bureau of Tourism and Travel, 401 Adams Street, Montgomery, AL 36104-

BACKGROUND:

Although Alabama has no large natural lakes, the state is fortunate to have vast constructed lakes that provide recreational navigation and hydroelectric power. The three major builders of Alabama's lakes are the Alabama Power Company, a subsidiary of the Southern Company; the U.S. Army Corps of Engineers; and the Tennessee Valley Authority, the last two of which are under the jurisdiction of the federal government. The facilities of TVA are located on the Tennessee River and the Bear Creek rivers. Alabama Power Company has constructed dams on the Tallapoosa River, Coosa River, and the Black Warrior River. The Army Corps of Engineers has constructed dams on the Black Warrior, Tombigbee, Alabama, and Chattahoochee Rivers. Smaller electricity generating companies have built lakes on other rivers around the state. Many Alabamians enjoy the recreational opportunities offered by these lakes.

VOCABULARY:

reservoir, hydropower, navigation, locks, lakes

ADVANCE PREPARATION:

1. Make a transparency of "Alabama Rivers" map and copy the "Alabama's River-based Lakes" and "Alabama Rivers" for each group.
2. Obtain enough Alabama highway maps for groups of students.

PROCEDURE:

1. Show the transparency of "Alabama Rivers". Discuss the number of rivers and streams in the state. Relate how lakes are formed from rivers and stream. Locate the ones nearest the community.
2. Discuss how energy is obtained from rivers for electrical power and how locks and lakes are used for navigation in Alabama.
3. Give a highway map to each group of students. Ask them to locate the major rivers.
4. Using the highway map, ask students to label and highlight the major rivers on their copy.
5. Now ask students to locate the major lakes in Alabama on the highway map.
6. Using "Alabama's River-based Lakes," have students locate each lake and its associated river on the highway map. Calculate the length of each river using the scale of miles. Research who the developer of the lake was.
7, Discuss interstate water concerns between Alabama, Georgia and Florida. Contact the Alabma Rivers Alliance (www.alabamarivers.org) for current status and information.

EVALUATION:

1. Locate the lakes listed on “Alabama’s River-based Lakes” and their associated dams on the map.

EXTENSIONS:

1. Have a speaker from the Alabama Power Company, TVA, or Army Corps of Engineers speak to the class.
2. Find out the approximate amount of water in each lake.
3. Write and request brochures about lakes that are designated as recreational.
4. Find out the purpose(s) of the dams (irrigation, hydroelectric power, recreation).

ORIGINAL DEVELOPMENT RESOURCES:

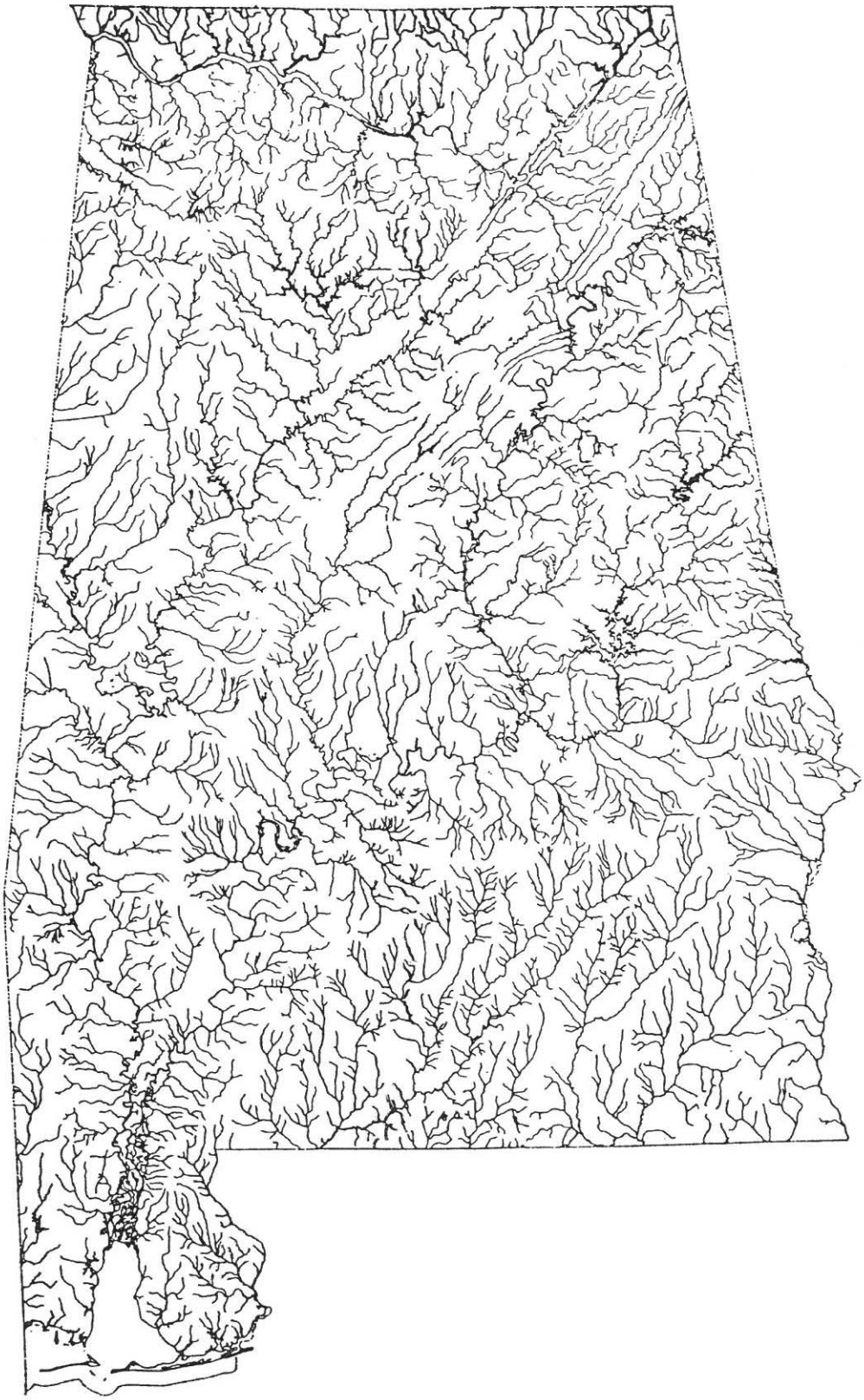
“Alabama Water Resources” poster, Legacy, Inc. P.O. Box 3813, Montgomery, AL 36109, www.legacyenved.org, 1-800-240-5115.

Alabama's River-based Lakes

Lake	River	Length	Developer
Wilson	_____	_____	_____
Smith	_____	_____	_____
Pickwick	_____	_____	_____
Wheeler	_____	_____	_____
Eufaula	_____	_____	_____
Weiss	_____	_____	_____
Martin	_____	_____	_____
Tuscaloosa	_____	_____	_____
Harris	_____	_____	_____
Jordan	_____	_____	_____
Bouldin	_____	_____	_____
Logan Martin	_____	_____	_____
Guntersville	_____	_____	_____
Lay	_____	_____	_____
Aliceville	_____	_____	_____
Demopolis	_____	_____	_____
Holt	_____	_____	_____
Mitchell	_____	_____	_____
Dannelly	_____	_____	_____
Robert Henry	_____	_____	_____
Bear Creek Reservoirs	_____	_____	_____
Bankhead	_____	_____	_____
Henry Neely	_____	_____	_____

Alabama's Rivers

Figure 1: Alabama Rivers



Name That Mineral

OBJECTIVES:

Students will be able to:
1. Examine techniques to identify minerals.
2. Differentiate basic minerals based on the techniques learned.

BACKGROUND:

Many things in our world involve minerals. A mineral is a naturally formed inorganic solid with a definite range of chemical compositions and usually a characteristic crystal form. In the United States, 35,000 to 40,000 tons of minerals are mined per year. Alabama contains many important economic minerals. For example, 350 million tons of the mineral hematite (iron ore) have been mined from the Red Ore District near Birmingham. Gold was also mined in Alabama between 1830 and 1946, producing 49,495 troy oz. (0.02 percent of the United States' production). Quartz, one of the most common minerals, is used for jewelry, glass, and common sand (play sand or construction sand). Mica and talc are mined in east central Alabama. There are several varieties of mica, which vary in metal-ion composition and color from white to black to green or purple. All varieties have the characteristic thin sheet structures.

Mica is used in oven windows in place of glass. Ancient Indian cultures in Alabama used it in pottery. Talc is used in the production of talcum powder. Large deposits of halite are found along the Gulf Coast. Halite is the mineral name for table salt. Pyrite is found in coal and marble deposits, although it is often considered an undesirable impurity in these deposits, its shiny cubic crystals are popular with rock collectors. Calcite is the mineral that makes up marble, chalk, and limestone, both of which are extremely common in Alabama.

Grades:
9-12

Subjects:
Physical Science, Geology, Chemistry

Time Needed:
Five class periods

Materials:
- pennies
- nails
- glass jar or microscope slide that can be scratched
- streak plate (small piece of unglazed porcelain)
- balance
- cups of water
- string
- pyrite
- hematite
- quartz
- mica
- calcite
- halite
- talc

In this activity, students will learn a good method for identifying unknown minerals using examples of minerals found in Alabama.

VOCABULARY:

pyrite, hematite, quartz, talc, streak, hardness, luster, mica, calcite, halite, mineral, specific gravity, fracture, cleavage

PROCEDURE:

1. Discuss with students the concept of hardness.
2. Have students rank fingernail, penny, nail, glass as to relative hardness.
3. Give hardness numbers from the attached list.
4. Students should determine hardness of samples of quartz, talc, and calcite.
5. Have students identify hardness using Moh's scale.
6. Discuss with students the concept of luster.
7. Have students look at quartz, calcite, talc, pyrite, and hematite; then describe luster.

8. Describe standard luster terms used and give examples.
9. Have students imagine that the samples of quartz, calcite, talc, pyrite, hematite are all the same size. Then they should rank them in order of increasing "heaviness."
10. Have students define specific gravity.
11. Weigh each mineral. (It may be useful to assign different minerals to different groups since this step will take a while.)
12. Weigh a plastic or paper cup containing enough water to cover the mineral easily. (Halite will dissolve in water, so you might want to skip it for this.)
13. Tie a string around the mineral and hang it from the balance into the water. It should be completely submersed but not touch the bottom. Reweigh water with mineral.
    Calculate: a) weight of cup of water with mineral minus weight of cup of water = weight of mineral in water
    b) $\frac{\text{weight of mineral in air}}{\text{weight of mineralin air minus weight of mineral in water}}$ = specific gravity
14. Identify minerals by comparing measured specific gravity to actual values.
15. Define fracture and cleavage and show examples.
16. Look at broken edges of quartz, calcite, talc, mica, and halite.
17. Have students identify the minerals based on fracture and hardness.
18. Have students define streak.
19. Have students test each mineral by scratching it on the streak plate. (They may notice that some may leave no streak.)
20. For each mineral sample, have students list its characteristics in each of the categories (hardness, luster, specific gravity, fracture or cleavage, streak) and try to identify it.

EVALUATION:

1. Give students unknown samples of the same minerals. Have them give the results of the test for each sample. Then have them identify it using the characteristics lists they developed during the activity.

EXTENSIONS:

1. Have students research the impact of mining on the land. Have them investigate land reclamation efforts currently taking place in Alabama. Refer to the Alabama Surface Mining Commisstion.
2. Find minerals and use these characteristics to identify them using a mineral guide such as the *Golden Guide to Rocks and Minerals*.
3. Visit a museum to observe a wider range of samples. The Alabama Museum of Natural History has many smaples.

ORIGINAL DEVELOPMENT RESOURCES:

Chesterman, C.W. *The Audubon Society Field Guide to North American Rocks and Minerals*. (1978). New York, NY: Alfred A. Knopf.

Dictionary of Geological Terms. American Geological Institute.

Klein, C. (1993). *Manual of Mineralogy*. New York, NY: Wiley & Sons.

Alabama Surface Mining Commission. www.surface-mining.state.al.us

Zim, H.S. & Schaffer, P. R. (1957). *Golden guide to rocks and minerals*. Western Publishing Co. ISBN: 0307244997.

Alabama Geological Survey www.gsa.state.al.us (contact to obtain rock and mineral samples)

Name that Mineral - Appendices

A. Definitions

Cleavage: the splitting or tendency to split along planes determined by crystal structure (example: cubic, planar, fibrous)

Fracture: manner of breaking and appearance when broken (example:conchoidal—curved, uneven)

Hardness: resistance to scratching or abrasion, measured relative to Moh's scale

Luster: the character of the light reflected by minerals (example: metallic, glassy, pearly)

Specific gravity: ratio of the mass of an object to the mass of the volume of water displaced by the object.

Streak: the color of the powder of a mineral as obtained by scratching the surface of the mineral

B. Moh's Hardness Scale (1 is the softest, 10 is the hardest)

1. Talc
2. Gypsum

<———— fingernail 2-2.5, penny 2.5-3

3. Calcite
4. Feldspar
5. Apatite

<————- nail 5-5.5, glass 5.5-6.5

6. Fluorite
7. Quartz
8. Topaz
9. Corundum
10. Diamond

C. Mineral Characteristics

	Calcite	Halite	Hematite	Mica	Pyrite	Quartz	Talc
Hardness	2.5-3.0	2.5	5.5-6.5	2.0-3.0	6.0-6.5	7.0	1.0
Luster	Grassy to Earthy	Transparent to Transluscent	Metallic or Dull, Earthy	Glassy to Pearly	Metallic	Glassy	Pearly to Glassy
Specific Gravity	2.7	2.16	5.26	2.75-3.20	5.02	2.65	2.70-2.80
Fracture/ Cleavage	Rhombo-hedral Cleavage	Cubic Cleavage	Fracture	Planar Cleavage	Fracture	Conchoidal Cleavage	Nonright Regtangular Prism Cleavage
Streak	White	White	Reddish Brown	Variable	Greenish Black	Too Hard To Scratch Plate	White

Notes

Threatened And Endangered Species of Alabama

OBJECTIVE:

Students will be able to:

1. Use materials and activities to understand the methodology of federal listing designations, descriptions of listed species, and means of preserving vanishing species.

BACKGROUND:

In comparison to other states, Alabama has a large number of threatened and endangered plants and animals. According to a 2002 report called States of the Union: Ranking America's Biodiversity, Alabama is fourth in the nation in the total number of species facing extinction. Alabama ranks second in the number of extinct species (first in the continental United States) and ranks fifth overall in biodiversity. The low rankings is due in part to the phenomenal number of different physiographic regions in the state, which contributes to the high level of biodiversity found here. Most species in trouble are being threatened by habitat conversion.

Endangered species are like fire alarms. They tell us about problems in our home we call Earth. If we listen to their alarm calls, they could help us improve our lives and the health of our planet. Threatened means the species is likely to become endangered if it is not protected. Endangered refers to being in danger of extinction throughout all or most of the species' range. Extinct means it is no longer in existence.

Grades:

9-12

Subjects:

Environmental Science, Biology, Art, Computer Science, History

Time Needed:

Approximately two weeks from assignment to completion; students can accomplish parts of the project as an outside assignment.

Materials:

drawing chalk
tempera paints
posterboard
surface for combined mural (classroom wall, school hallway)
lists of Alabama's threatened and endangered species
access to research materials (could be set up in a classroom learning area)

VOCABULARY:

Environmental Protection Agency, Fish and Wildlife Service, extirpated, endemic, endangered, extinct, threatened, genus, species

ADVANCE PREPARATION:

1. Obtain the *Discovering Alabama: Red-Cockaded Woodpecker* video and the Teacher's Guide from Discovering Alabama (see Resources).
2. Make copies of the attached list of Alabama Endangered Species for each group. of students.

PROCEDURE:

Setting the Stage

1. Have the class view the video. Introduce the issues of controversy and use the "Description of the Red-Cockaded Woodpecker" as a research assignment model.
2. Set up a learning center about threatened and endangerous species with resources available from the many agencies listed in the Resources section of this guide.
3. Discuss the difference between a threatened and an endangered species.
4. Discuss the following factors and the way they can threaten a species' survival:
   - The present or threatened destruction, modification, or curtailment of the species' habitat or range.
   - Over-utilization for commercial, recreational, scientific, or educational purposes.
   - Disease or predation.

- The inadequacy of existing regulatory mechanisms.
- Other natural or man-made factors affecting the species' continued existence.

5. Explain how a species is formally and legally listed by the U.S. Fish and Wildlife Service.
6. Compare the amount of listed species for each state on a map of the United States.

Activity

1. Assign threatened and endangered species to cooperative learning groups (composed of 3-4 students). Extensive information is available about some species, and very little is available about others. Groups should begin research on assigned species for presentations, an original art poster of the species, and a research paper with bibliography. Information gathered should include species' common and scientific names, limited classification information (kingdom, phylum/division, class, order if applicable, genus, and species), general characteristics, habitat, range, current and historical population, life habits (reproduction, feeding, and life spans), anatomy and physiology, student-determined "most interesting facts," folklore and mythology, reasons for listing (why a species is threatened or endangered), ways the species could be preserved (both technical and students' suggestions). Students should use professionally approved research paper formats.
2. Students should accomplish the necessary research with both class time and out-of-class time. The teacher should set definite deadlines for notecards, outlines, and first draft. Students should give 10-15 minute presentations on their group's assignments, using their original drawings of the species as a visual aid. The poster drawings should depict animals and plants in their natural habitats and should identify each species by common and Latin names. Teacher should emphasize participation, enjoyment, and learning experiences versus exact artistic rendition as students are completing their posters.
3. After the project is completed, the posters may be mounted for longer display on a classroom or hallway wall. Each member of the group should be required to complete part of the presentation. The presentation should be an abbreviated version of the research paper but should include taxonomic information, general description, range, population trends, most interesting facts, why listed, and ways to preserve the species. Students should submit the first draft of the research paper within two days after presentation, using experiences from the presentation to supplement/improve the research paper. Teachers should review drafts and should return the drafts to students in a timely manner for their revision.

Follow-Up

1. At project completion, students could compile the research paper final drafts into a student publication.
2. Students also may research the purpose and objectives of the National Endangered Species Act and write a paper on the conflicts, obstacles, and facilitating practices that relate to management in this area.

EVALUATION:

1. Evaluation will be based on completed research paper, presentation, and participation.

EXTENSIONS:

1. Use the project to present findings to parents, environmental groups, and/or elected officials.
2. Have the students research threatened species in their area and find ways they can help protect them.
3. Write the state fish and game/natural resources department to find out which species are rare in the area and what is being done to conserve them.
4. Visit a wildlife refuge in the area.

ORIGINAL DEVELOPMENT RESOURCES:

Alvin Diamond's Alabama slide show—especially slides of *Amphianthus pusillus, Sarracenia oreophila, Apios pricena,* and *Trillium relinquum.* Professor, Troy State University. Contact at adiamon@trojan.troyst.edu.

Discovering Alabama: Red-Cockaded Woodpecker Video and Teacher's Guide, Alabama Museum of Natural History. www.discoveringalabama.com

Endangered Species Issue Pacs, available from the U.S. Fish and Wildlife Service, P.O. Box 25485, Denver Federal Center, Denver CO 80225; or the National Institute for Urban Wildlife, 10921 Trotting Ridge Way, Columbia, MD 21044.

Endangered and Threatened Plants and Animals Under U.S. Fish and Wildlife Service Jurisdiction, U.S. Fish and Wildlife Service, Division of Endangered Species, February, 2000.

Additional information available from:

Alabama Environmental Council
EPIC, Jacksonville State University
Center for Environmental Research and Service, Troy State University
Alabama Department of Conservation and Natural Resources
Auburn School of Forestry and Wildlife Sciences
U. S. Forest Service/National Forests in Alabama
The Nature Conservancy www.nature.org

Alabama Threatened and Endangered Species List:
http://ecos.fws.gov/tess_public/pub/stateListingAndOccurrenceIndividual.jsp?state=AL

Notes

Treeless City

OBJECTIVES:

Students will be able to:
1. Describe and identify locations of treeless areas.
2. Compare contrasting habitats.

BACKGROUND:

It's easy to take trees for granted—they've always been there quietly providing many valuable services: slowing water, preventing flooding and soil erosion; stabilizing and adding nutrients to the soil; providing habitat, food, shade, shelter, recreation, and beauty. But what if there were no trees? What would our world be like? What would Alabama be like? Are there treeless cities in Alabama?

VOCABULARY:

habitats, erosion, degraded habitat, ecosystem

Grades:
9-12

Subjects:
Ecology, Social Studies, Geography, Biology, Environmental Science

Time Needed:
Two to three 40-minute class periods

Materials:
quiet area

PROCEDURE:

Setting the Stage

1. The teacher should lead the class through this journey.

   Sit back, close your eyes, and come with me on a journey to a strange and different world. Imagine taking a walk down a street on a warm summer day. Everything looks pretty and fresh. Overhead, leafy trees are giving you plenty of nice, cool shade. You hear birds chirping high in the branches. The air smells fresh and clean. Off in the distance, you see gently rolling green hills. A sparkling stream runs near you. You think you will go fishing later. People are setting up tables in a nearby park to enjoy a picnic.

   The neighborhood is quiet and peaceful today.

   But wait! Something strange is happening. You turn a corner, and a whole different scene appears. The air is hot, and you cannot find a spot of shade anywhere. Chirping birds and scurrying squirrels are fleeing because they have no place to live.

   The ground looks sun-baked and fried. The neighborhood doesn't look very pretty because everything is bare. Dust and soil fly through the air and make it hard to breathe. The wind blows all the time.

   You look at the hillsides in the distance. They are brown and bare and covered with gullies. When it rains, water rushes down those hillsides carrying lots of soil with it. The soil ends up everywhere, much of it collecting in streams and lakes. You wonder if the soil buildup is what has been killing fish and making the little stream in your neighborhood flood its banks.

   People in the parks are putting umbrellas over their tables to shade their picnics. You hear humming noises everywhere. Air conditioners are working overtime as people try to keep cool.

   What has made such a difference in your world? You have the feeling something important is issing—something that used to prevent and correct some of these problems. What is it?

   What is a world without trees?

   A world without trees would be a barren world. Giant dust storms would roll across the countryside blowing away precious topsoil and choking people, plants, and animals. Sunbaked fields could no longer grow enough food to feed the world's population. Hillsides would wash away, clogging rivers and streams with soil and silt.

   Without trees we would have little protection from summer heat and cold winter air. Air conditioners would burn precious energy 24 hours a day in the summer, and furnaces would work overtime in the winter. People would live most of their lives indoors because life outdoors would be too uncomfortable.

Activity

1. Have the students describe and identify locations for each of the following situations in the United States and throughout the world–past, present, and future. Look at urban, suburban, and rural settings for each scenario. Discuss why the area is treeless. Has it always been treeless, or was it caused by people or climatic factors?
   • **Blowing Soil**—Without trees or other vegetative cover, the wind easily picks up exposed topsoil. Dust clouds fill the air. What negative effects occur?
   • **Unprotected Farmland**—Without trees to serve as shade and windbreaks, crops, livestock, barns, farm homes, and other buildings catch the full strength of the wind and the full heat of the sun. What results?
   • **Dirty, Flood-Prone Rivers**—Without trees to stabilize the soil, erosion from hillsides can choke streams, killing fish and destroying wildlife habitats. The eroded soil raises the river beds. How would this make the river more likely to flood? What happens to surrounding lands?
   • **Overheated Cities**—Without trees our streets, buildings, and parking lots soak up the sun's heat and raise the overall temperature. No trees means nothing absorbs carbon dioxide, methane, or carbon monoxide. What does this do to air quality?
   • **Rapid Runoff**—Without trees and other vegetative cover, the soil on the hillsides is easily washed away. Rain flowing on the surface picks up speed and gathers more soil with each inch of slope, carrying topsoil, nutrients, pesticides, and herbicides. How does this affect the soil quality and water quality of the ecosystem? What does this mean in economic terms for the community relying on the ecosystem?
   • **Gullied Land**—Without tree roots to hold the soil in place, gullies eat their way into pastures and crop fields. In a suburban setting, gullies creep under fences, foundations of buildings, and roads. How does this affect land usage?
   • **Degraded Habitat**—Without trees, tree dwellers, such as birds, squirrels, and insects, would have nowhere to live, could not escape from enemies, and might have difficulty obtaining food. Without trees, especially in the tropics, other plants, fungi, and bacteria would not have nutrients, protection, or a place to grow. How does this impact upon the entire ecosystem?
2. Have students imagine a degraded habitat and a healthy or ideal habitat. Discuss these questions:
   • Do all healthy ecosystems look the same?
   • Is a desert a healthy ecosystem?
   • Could an area have many trees and still be a damaged ecosystem?
3. The students can illustrate two contrasting habitats in several ways. Have the students write paragraphs describing two habitats. They may write about areas they know, places they have read or heard about in the media, or fictional places.

EVALUATION:

1. Have the students create collages of unhealthy and healthy ecosystems. They may cut scenes from magazines or newspapers and add their own artwork.

EXTENSION:

1. Have the students draw or paint their interpretations of unhealthy, bad, and healthy ecosystems. Again, these pictures can be based on real or fantasized places.

ORIGINAL DEVELOPMENT RESOURCES:

Moll, G., et al. (1992). *Growing greener cities: environmental education guide*. American Forests, Washington. D. C. (activity adapted from guide - used with permission).

Alabama Urban Forestry Association. www.aufa.com

Develop A Stream Of Consciousness

OBJECTIVES:

Students will be able to:

1. Locate a stream or creek in the community
2. Adopt the stream or creek and monitor factors.
3. Create a plan to keep the stream clean.

BACKGROUND:

This year-long (or as long as it can be) project will serve as a focal point for water activities during the year. Students will be able to set up a plan, monitor factors, and make decisions about various environmental components of the environment as those components affect the stream or creek chosen. Many other activities in this guide can be used as part of this project. By using this project over the course of a year to integrate other activities, the teacher will be able to help students uderstand the relationship of a variety of interactions through seasonal changes in an area.

VOCABULARY:

erosion, habitat, pollution, watershed, weathering

Grades:

9-12

Subjects:

Physical Science, Environmental Science, Social Studies, Language Arts, Art, Geography

Time Needed:

Year-long project

Materials:

map of Alabama showing streams
vary depending upon group choice of activity

PROCEDURE:

1. Explain what a watershed is, and have students determine the boundaries of their watershed.
2. Have the class locate streams and creeks associated with the watershed in the community. Choose one as the study area.
3. Visit the site once as a group to brainstorm and to decide what to accomplish for the year.
4. In the classroom, divide into groups and have each group write one major goal and several objectives of how to accomplish the goal. Have each group share its goals and objectives then combine to make a final set everyone agrees upon. (Examples could include tree planting, habitat improvement, seasonal changes, fisheries rehabilitation, interpretive trails, water pollution sampling, litter patrol, funds collection to donate picnic tables, and so forth.)
5. Each group is to select a task and is responsible for creating a plan and timeline to accomplish the objective. Students should create a form with the following headings:

Task	Steps to Accomplish	Evidence of Accomplishment
1.	1.	1.
2.	2.	2.
3.	3.	3.

Entries under Evidence of Accomplishment will serve as a checklist for final evaluation to determine if the task was accomplished satisfactorily.

6. Set up a visiting schedule with activities to be completed within the time period.
7. Each group will develop a plan to keep the area clean. Consider the Adopt-a-Stream porgram for the segment or location being studied.

EVALUATION:

1. Groups will keep a journal of what they have done and the procedures they have followed.
2. Timelines will be checked for adherence to the proposed schedule.
3. Each task will be evaluated with a checklist created from the entries under Evidence of Accomplishment.

EXTENSIONS:

1. Build a model of the watershed which includes their stream.
2. Create a habitat diorama of the stream.
3. Collect rocks or soil from the area and display them.
4. Create a fish life cycle display.
5. List the trees along the stream, start a leaf collection.
6. Set up a weather station to record rainfall in relation to stream water depth changes.
7. Track the water level and rates of erosion throughout the year.

RESOURCE:

Adapted with permission from The Children's Groundwater Festival Outreach Packet, The Groundwater Foundation, Lincoln, NE.

Adopt-a-Stream program in Alabama. Contact Alabama Water Watch. www.alabamawaterwatch.org. or write to Alabama Water Watch Program, 203 Swingle Hall, Department of Fisheries, Auburn University 36849.

Water Woebegone

OBJECTIVE:

Students will be able to:

1. Discuss the impact of various water uses in a watershed on stream flow.

Grades:

9-12

Subjects:

Environmental Science, Earth Science, Mathematics, Economics

Time Needed:

One class period

Materials:

(per 2-3 students)
one 1-liter clear plastic beverage container
mL measuring cylinder
masking tape
marker
graduated cylinder or pre-calculated measuring cup

BACKGROUND:

A watershed is the geographical region composed of a drainage system. The water in this drainage system is allocated to many different users. If the total amount of water available in the watershed becomes allocated, then a drought situation occurs with conflict over who will get the resulting water. These conflicts may be settled by cooperation among water users; through emergency water allocation by state governments; or, in some cases, by the courts according to "water rights." Water rights are vastly different in different parts of the United States. In the western United States, water rights are based upon prior use. New water users must pay or otherwise compensate prior or existing users if they reduce the amount of water available. They must purchase water rights. In the eastern United States, water rights are less well defined and are based on what is known as riparian water rights. Landowners or others with access to streams can withdraw water without purchasing water rights. The only recourse when a water user harms another party (for instance, by excessive water withdrawal) is to seek legal relief. In such cases, the injured party must prove that the water user's activities were unusual or were not a normal practice. In any case, resource managers must be careful to maintain minimum stream flow so that populations of organisms in the watershed can be healthy.

VOCABULARY:

watershed, drought, water rights, resource manager, minimum stream flow, carrying capacity

PROCEDURE:

1. Mark a clear plastic 1-liter beverage container with forty 25 mL graduations by placing a strip of masking tape along its length and marking the units: pour in 25 mL of water, mark the waterline on the tape, and so on until the bottle is full. (Or use graduated cylinders).
2. Tell the students that the water in the bottle represents the amount of water available in their watershed.
3. They are responsible for allocating this water for their town, which has grown to 1000 households.
4. Give them the following chart and values to aid them in their task of water distribution:

minimum stream flow	322 mL
household use	42 mL/1000 households
industry use	42 mL/500 households
irrigation use	42 mL/500 households
hydroelectric use	42 mL/500 households

5. Calculate how much water would be used to support this town of 1000 by adding the amounts in mL needed per 1000 households for each of the uses from the list in procedure (4) above.. (294 mL)
6. Remove that amount of water from the bottle and record how much is left. Repeat these steps with a town of 2000 households, then 3000 and 4000.

TOWN SIZE	TOTAL WATER USED
1000	42+84+84+84 = 294 mL
2000	84+168+168+168 = 588mL
3000	126+252+252+252 = 882 mL
4000	168+336+336+336 = 1176 mL

7. Have the students note when there is no longer at least 322 mL of water left in the bottle such that the minimum stream flow is affected.

EVALUATION:

1. How large a town population can be sustained before the stream goes dry? Graph the town size (number of households) versus water use. Have the students use the graph to determine the population at which the entire stream flow would be used up.
2. Have the students discuss the compounding problem of low or no stream flow if the town's sewage discharge pipe is downstream of the town.
3. What have you learned about the carrying capacity of a habitat such as a watershed? (limited to how many people that it can support, not counting all of the other organisms present)

EXTENSIONS:

1. Research which watersheds in the world have problems with water overuse and why. Suggest ways to prevent the overuse of a water supply.
2. Invite a local water official to brief the class about the water user rate in your town.
3. Research the "Water Wars" between Alabama, Georgia, and Flordia. Contact the Alabama Office of Water Resouces for information and current status. 334-242-5499.

ORIGINAL DEVELOPMENT RESOURCES:

"Watershed Woes." (1992-1993). *National Science and Technology Week.*

Alabama Department of Economic and Community Affairs - Office of Water Resources, 401 Adams Avenue, Montgomery, AL 36104. www.adeca.state.al.us.

What A Watershed

OBJECTIVES:

Students will be able to:
1. Create a watershed diagram or model.
2. Illustrate the importance of the watershed in planning and locating a city or community.

BACKGROUND:

A watershed is a region or an area bounded peripherally by water parting and draining ultimately to a particular watercourse or body of water. Watershed, river basin, and drainage basin all refer to the same type of area. Watersheds are created by natural, rising elevations that act to divide the flow of water. The dividing line between two adjacent watersheds generally is along the highest points between the waterways in each watershed. The most well-known watershed separater is the Continental Divide in the western United States.

VOCABULARY:

watershed, agriculture, debris, erosion, terrestrial, topography, Continental Divide

Grades:
9-12

Subject:
History, Earth Science, Environmental Science, Biology

Time Needed:
Two 55-minute class periods

Materials:
regular-size poster board
markers
crayons
pencils

PROCEDURE:

1. Have students draw or create a model of a watershed that includes the following elements in the specific geographical location of a town:
   - Four mountains located northwest of the town
   - Rolling hills located to the southeast of the town
   - A major river flowing southeast from the mountains
   - Six tributaries entering the major river from the mountains and hills
   - A town that includes the following:
     a. School
     b. Post office
     c. Reservoir
     d. Shopping center
     e. Four churches
     f. Court house
     g. Water supply intake
     h. Municipal swimming pool
     i. Interstate highway going east and west
     j. A state highway that runs parallel to the river
     k. Two bridges over the river
     l. A recreational area west of town
     m. Neighborhood of at least 20 homes
     n. Municipal wastewater discharge
     o. Industrial wastewater discharge
     p. Municipal landfill site
     q. Recreational lake
   - An agricultural area south of the town with at least one barn

EVALUATION:

1. Complete the poster or model.
2. Explain poster or model and the implications of things located in the watershed.

EXTENSIONS:

1. Have a city planner speak to the class about how knowledge of watersheds affects planning.
2. Obtain a map of Alabama, or use the "Alabama Rivers" map in the Lakes and Dams of Alabama activity, and roughly outline each of them state's watershed areas.
3. Trace the drainage pattern in each watershed area to the Gulf of Mexico.

ORIGINAL DEVELOPMENT RESOURCES:

U.S. Environmental Protection Agency: watershed information network. www.epa.gov/win

Dobson, C. & Beck, G.G. (1999) *Watersheds: a practical handbook for healthy water.* Firefly Books. ISBN: 1-55209-330

"Alabama Water Resources" poster, Legacy, Inc. P.O. Box 3813, Montgomery, AL 36109, www.legacyenved.org, 1-800-240-5115.

GLOSSARY

abdomen: A part of the human body below the diaphragm, also the hind part of insects, crabs, or spiders.

abiotic: Relating to non-living components of the environment such as air, water, sunlight, and minerals.

abiotic factors: Non-living material and energy in an ecosystem.

abyssal: Of, or pertaining to, the biogeographic realm of the great depths of the ocean beyond the limits of the continental shelf, generally below 1,000 meters.

abyssopelagic: Pertaining to the open waters of the abyssal zone.

acidity: Extent to which something is acid: the concentration of an acid in a substance, often measured in terms of pH.

adapt: To make more suitable by altering.

agriculture: The production of plants and animals useful to people.

alkalinity: Measure of alkali: the concentration of alkali in a solution, measured in terms of pH.

anaerobic: Able to live and grow in the absence of free oxygen. Anaerobic decomposition of organic wastes results in the production and release of methane gas.

animalia: The animal kingdom.

aphotic zone: The deep part of the ocean where sunlight is absent.

arthropod: The largest phylum of the animal kingdom. Adults typically have segmented bodies, and many have jointed segmented legs.

atom: The smallest part of an element that has all the properties of that element; basic building block of matter.

autotroph: An organism capable of synthesizing organic nutrients directly from inorganic substances such as carbon dioxide and inorganic nitrogen.

barrier island: An island similar to an offshore bar but differing from it by having ridges, areas of vegetation, and swampy terraces extending toward a lagoon.

bathyal: Of, or pertaining to, the ecological zone along the continental slope in the deeper parts of an ocean, especially between 100 and 1000 fathoms.

bathypelagic: Of, or having to do, with the deeper part of the ocean.

benthonic realm: Area for bottom-dwelling forms of marine life.

benthos: Bottom-dwelling forms of marine life.

benzene: A colorless volatile toxic liquid with a distinctive odor, obtained from petroleum and used in the manufacture of dyes, polymers, and industrial chemicals such as phenol.

biomass indicator species: A species that indicates the health of a given area by its absence or presence.

biome: A major ecological community of organisms occupying a large area.

biotic: Relating to living factors (plants and animals) in the environment.

biotic factors: Factors of life or living species.

black needle rush: A marsh grass with stiff, pointed, needle-like leaves.

board foot: A unit of volume for measuring lumber, equal to the volume of a board that is one foot square and one inch thick.

browse: Twigs, shoots, and leaves eaten by livestock and other grazing animals.

camouflage: Any concealment by disguise.

chlorophyll: A green pigment in plant cells that allows plants to make food in the presence of sunlight.

clearcutting: The practice of clearing large areas of a forest of all trees.

climate: The average weather conditions over a period of time.

community: An interacting assemblage of plants and animals (biological community).

compost: A mixture of decayed plants and other organic matter used gardeners to enrich the soil.

coniferous forest: An area of wooded land predominantly of conifers.

conservation of mass: The principle that the total mass of an isolated system remains constant, no matter what physical or chemical changes take place.

consumer: A person who buys goods or services.

consumer food web: See *food web.*

Continental Divide: a massive area of high ground in the interior of a continent, from either side of which a continent's river systems flow in different directions.

continental shelf: Zone around a continent that extends from the shoreline and the continental slope.

cord grass: Any of a genus of marsh grasses.

cost benefit analysis: Analysis of factors contributing to the cost of operating a business and the cost that will result from alternative procedures and their effects on profits.

crustacean: A class of the arthropod animals characterized by jointed feet and mandibles, two pair of

antennae, and segmented bodies.

debris: Dead organic material such as leaves, twigs, and sediment.

deciduous forest: A large, geographical region with mature vegetation characterized by oak, elm, and maple trees that lose their leaves in winter.
decomposer: An organism, especially a bacterium or fungus, that causes organic matter to rot or decay.

degradable: Able to undergo chemical or biological decomposition - to rot away.

density: The mass of unit volume of a substance.

desert: A geographical area that has less than ten inches of rainfall each year, where there is not enough vegetation to support human life.

detritus: An accumulation of small fragments such as sand and silt worn away from rock.

detritus feeders: Any animal that feeds on the detritus that collects in the substratum at the bottom of water. Also known as deposit feeders.

disphotic: Of, or having to do, with reduced light.

diversity: Quality, state, fact, or instance of being diverse.

dominant vegetation: The prevailing vegetation of an area.

dorsal: Located near the back of an animal or one of its parts.

ecological succession: Gradual process incurred by the change in a number of individuals of each species of a community and by the establishment of a new species population that may gradually replace the original inhabitants.

ecosystem: A system dealing with the interrelationship of organisms living in one environment.

effluent: Liquid waste discharged from a sewage system, factory, nuclear power station, or other industrial plant. May also refer to a stream or river that flows out of a larger body of water such as a lake or a larger stream.

embeddedness: State or condition of being surrounded closely.

emission: Something that is produced or given out, as in, eenergy released from a source, usually in the form of electromagnetic radiation.

enzyme: Any of a group of catalytic proteins that is produced by living cells and that mediate and promote the chemical processes of life without themselves being altered or destroyed.

epipelagic: Of, or pertaining to, the oceanic zone into which enough light penetrates to allow photosynthesis.

erosion: The wearing away of the Earth's surface by running water, wind, ice, or other geological agents. A number of processes, including weathering, dissolution, abrasion, corrosion, and transportation by which material is removed from the Earth's surface.

estuary: The area where a river empties into an ocean, resulting in a mixture of salt water and fresh water.

eulittoral: A landward subdivision of the littoral zone of a body of water.

euphotic: Of, or constituting, the upper levels of the marine environment down to the limits of effective light penetration for photosynthesis.

exoskeleton: The external supportive covering of certain invertebrates.

food chain: A succession of organisms in a community that constitutes a feeding order in which food energy is transferred from one organism to another as each consumes a lower member and in turn is preyed upon by a higher member.

food web: Several food chains joined together to form a branching pattern reflecting the fact that more than one predator may prey upon a single species and that a single predator may feed upon several prey species. The flow of energy in the web branches and can even be reversed.

fossil fuel: Any carbon-containing fuel, for example, coal, peat, petroleum , and natural gas, derived from the decomposed remains of prehistoric plants and animals.

gleyed: Sticky, subsurface clay in some water-logged soils.

golden brown algae: A freshwater or marine alga that is yellow to golden-brown in color.

grassland: Land or region where grass predominates.

habitat: Native environment of an animal or plant.

hadal: Pertaining to the environment of the ocean trenches over 6.5 kilometers deep.

hardness: An indication of the amount of calcium carbonate dissolved in water.

hematite: An iron mineral (Fe_2O_3) crystallizing in the rhombohedral system. Hematite is the most important ore of iron.

heterotroph: An organism that obtains nourishment from ingestion and breakdown of organic matter.

highland: Land well above sea level.

hydric soil: Soil characterized by, or existing in abundance of, moisture.

hydrology: The scientific study of the distribution, circulation, and properties of the waters of the Earth.

hydrophytic: A plant growing in water or in soil too water-logged for non-aquatic or non-wetland plants to survive in.

infiltrate: To pass into or through as if by filtering.

intertidal sand community: Animals that live in the area between mean high tide and mean low tide.

intertidal zone: The area between mean high tide and mean low tide.

jointed appendage: Appendage having joints.

lava: A molten liquid extruded onto the surface of the Earth, or the solidified product subsequently formed.

leaching: The process in which water washes minerals from the topsoil to the subsoil.

light penetration: The depth to which light can go through water.

limiting factor: A factor whose absence exerts influence upon a population and may be responsible for no growth, limited growth (decline), or rapid growth.

littoral: See *intertidal zone and intertidal sand community.*

luster: The appearance of a surface dependent on reflected light.

maritime forest: A forest bordering the sea.

megalopae: Advance larval stage of true crabs, just preceding adult stage.

mesopelagic: Oceanic zone from 200 m to 1000 m in depth.

mica: Any of several shiny silica minerals that occur in igneous and metamorphic rocks. They split easily and are used as electrical insulators and in heating elements because of their resistance to electricity and heat.

mineral: Naturally occurring, inorganic solid that has a definite chemical composition and crystal shape.

mineral soil: Soil composed of mineral or rock derivatives with little organic matter.

mode of life: One of three categories of environments in which marine animals live: plankton, benthos, or nekton.

mollusk: An invertebrate with a soft unsegmented body, usually protected by a shell in one, two, or three pieces. Most mollusks are aquatic and include clams, snails, slugs, squid, and octopuses.

molt: To shed an outer covering as part of a periodic process of life.

monera: A kingdom that includes bacteria and blue-green algae.

mottled: Of a soil, irregularly marked with spots of different colors.

natural selection: Theory in which animals with favorable characteristics for a particular environment survive and produce offspring with the same suitable, favorable characteristics.

natural variation: The differences among individuals of a population.

nekton: Free-swimming aquatic animals, essentially independent of water movement.

nektonic realm: Area of water that is predominately occupied by nektonic or free-swimming animals.

neritic province: The ecological zone of the continental shelf extending from low tide to a depth of 100 fathoms.

nitrogen oxide: A compound containing oxygen and nitrogen.

nonillion: The number equal to 10 to the thirtieth power; written as 1 followed by 30 zeros.

nuclear energy: The energy released by nuclear fission or fusion.

oceanic province: An area of the ocean characterized by certain plants and animals.

organic soil: Any soil consisting chiefly of organic matter.

pH: A measure of the acidity or alkalinity of a solution, such as vinegar, or a damp substance, such as soil.

parasite: An organism that lives on or in another and gains nutrients and shelter from that organism.

pelagic division: The spread-out of the ocean waters. (The open sea.)

percolate: To drain or seep through a porous substance.

photic zone: The uppermost layer of water that receives enough sunlight to permit photosynthesis to occur.

phytoplankton: Plankton consisting of plant life.

pincer: A grasping claw, as on a crab.

plankton: Plant and animal organisms, generally microscopic, that float and drift in great numbers in fresh or salt water.

planktonic realm: Area of water that is occupied predominantly by planktonic or floating animals.

plantae: Any of a kingdom of living things typically lacking locomotive movement or obvious nervous or sensory organs and possessing a cellulose wall.

polar: Of, or relating to, a pole, as a geographic pole.

policy: A defined method or course of action.

polonium: a very rare naturally radioactive metallic element found in uranium ores, used to remove static electricity.

population: Any group of organisms of the same species that occupies a given space at a given time.

population density: Number of organisms in a particular population found in a specific area.

precipitation: Water droplets or ice particles condensed from atmospheric water vapor and sufficiently massive to fall to Earth's surface such as rain, hail, mist, sleet, or snow.

predation: The relationship between two gropus of animals in which one species hunts, kills, and eats the other.

primary: Of, or being, first.

primary consumer: An animal that subsists mainly on producers (green plants).

primary detritus feeders: Animals that feed primarily on detritus.

primary dune: Sand dunes nearest the water.

private land: Land owned by private citizens for their own personal use.

producer: An organism, such as a green plant, that produces its own food from elements in the environment.

protista: A proposed kingdom to include all unicellular organisms that lack a definite cellular arrangement.

public land: Land owned by a governmental entity..

purification: Process to rid a substance of impurities.

radioactive decay: The spontaneous disintegration of radioactive material along with the emission of one or more elementary particles or radiation.

runoff: Water (originating as precipitation) that flows across surfaces rather than soaking in, eventually entering a water body.

salinity: An indication of the amount of salt in water.

salt marsh: Flat land subject to intermittent overflowing by salt water.

secondary consumer: An animal that feeds on primary consumers, usually a carnivore.

secondary detritus feeders: Animals that eat animals that primarily feed on detritus.

secondary dune: The dunes behind primary dunes. Secondary dunes are farther from the water.

secondary succession: Revegetation of cleared land.

s**ediment:** Material that settles to the bottom of a waterbody.

snag: A dead tree that is still standing.

solid waste: The term referring to material, such as paper, wood, food and metals, that are sent to landfills, incinerators, or recycle centers.

spawn: The collection of eggs deposited by aquatic animals. The acti of depositing those eggs. The act of producing offspring.

strand line: A beach raised above the present sea level.

steppe: Region (usually vast, level, and treeless) receiving only slightly more precipitation than a desert.

sublittoral: Benthic zone from the low-tide line to the seaward edge of the continental shelf.

substrate: A substance reacted upon, or a base on which an organism lives.

subtidal zone: See *sublittoral.*

succession: The gradual predictable replacement of one community by another. The successional community itself creates the conditions that lead to its replacement by another community. Succession ends with the climax community.

sulfur oxide: A compound containing oxygen and sulfur.

supply and demand: Term used to refer to what is available and what consumers are willing and able to buy at various prices.

supratidal zone: Benthic zone above the high-tide level that is moistened by waves, spray, and extremely high tides.

suspended solids: Insoluble material suspended in water consisting mainly of particles derived from rocks, soil, and organic materials.

sustainability: Ability to stay in existence.

taiga: Zone of forest vegetation encircling the Northern Hemisphere between the Arctic, subarctic, and tundras in the North and the steeps, hardwood forest, and praries in the South.

temperate: Having a moderate climate.
terrestrial: Of, or having to do, with the Earth or its inhabitants.

tertiary consumers: Third-level consumers.

toluene: a colorless liquid aromatic hydrocarbon resembling benzene but less flammable, used in high-octane fuels and organic synthesis.

topography: The configuration of a surface including its relief and the position of its natural and manmade features.

trophic level: Any of the feeding levels through which the energy of an ecosystem proceeds.

tropical rain forest: A rain forest in a region near the equator, characterized by year-round warmth and very heavy rainfall. Tropical rain forests are green throughout the year. The largest tropical rain forest is that of the Amazon, covering a large portion of South America.

tropical savanna: Grassland containing scattered trees located in the area between the Tropics of Capricorn and Cancer.

tundra: A level or undulating treeless plain that is characteristic of arctic and subarctic regions. Consists of black mucky soil with a permanently frozen subsoil.

turbidity: The term describing water quality that is opaque and muddy as when particles and sediment are stirred up.

upland: High land, especially some distance from the sea.

water quality: The condition of a body of water.

watershed: Region or area drained by a particular body of water.

weir: A dam in a waterway over which water flows in order to regulate or measure it.

wetlands: Areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevelence of vegetation typically adapted for life in saturated soil conditions. (for example, swamps, bogs, ferns, marshes, estuaries).

zoea: The early larval form of many decapod crustaceans, especially crabs.

zooplankton: Planktonic animals that supply food for fish and marine mammals.

Notes

Internet Resources

What is the Internet?

The Internet is a network of networks. In many ways, it is no one thing and resides in no one place. Teachers can use the Internet to communicate and share information. Research suggests that use of electronic networking can help teachers (especially new teachers) reduce their sense of isolation, connect with peers, and increase their sense of professionalism and autonomy. This section explores the uses of the Internet for the purposes of Environmental Education.

E-mail

Electronic mail (E-mail) is the most frequently used of the Internet networks. Users are able to participate in discussion groups, contact particular people, and access information. The most helpful of sources of information are usually your own colleagues. E-mail provides another way to keep in touch with them within your school or around the world.

Internet discussion groups are an extension of electronic mail and provide an opportunity to be part of an electronic community made up of individuals with common interests. Mailing list capability may also provide online courses, which are often advertised on discussion lists.

General discussion groups for the grade level that you teach are very useful for a wide range of information. During some times of the year, such as the period near Earth Day, there will be some discussion on environmental topics and curriculum that you may find useful. You can also pose questions to these discussion groups; and your colleagues will answer, providing information about where to find resources and how other teachers at your level handle particular issues and opportunities. These general discussion groups are called ‘listservs”.

Listservs can be found on the world wide web at:
http://www.list.com
This list may provide you with a forum that most nearly meets your specific interests. You can enter keyword terms and get information about any list that would meet that interest. Information is provided on how to subscribe to the many diverse listservs that are available,

Once you have found am interesting listserv, send an E-mail message to subscribe. On the address line, type in listserv@listserv.net

On the message line, type in Subscribe, the name of the list, and your name. A sample message would read:
Subscribe ECEOL-L Jane Doe
(ECEOL-L is a listserv that serves members of the early childhood profession)

Once you have subscribed, it is appropriate to send a message to the list identifying yourself and your major interest.

EENETS is a moderated forum for people interested in the development and operation of electronic networks for environmental education. It does not post all messages sent to the group but only selected messages that will be of interest to all subscribers. The volume of mail you receive is, therefore, much lower and much more focused than on a general discussion group. The creation of this list was suggested at the Eco-Ed conference in Toronto in 1992. This list is an attempt to help coordinate information about projects and networks that are

of interest to educators. It is useful to subscribe to EENETS in order to obtain information about other discussion groups, on-line journals, and environmental meetings.

AskERIC is an internet answering service sponsored by ERIC (the database of the Educational Resources Information Center). AskERIC can provide information about specific resources for parents, teachers, and children. Requests for information should be sent by E-mail to:

askeric@ericir.syr.edu

The GreenDisk Paperless Environmental Journal is a comprehensive guide to the use of computers for environmental research. It contains over 1,000 listings of World Wide Web sites, listservs, on-line databases, bulletin board services, software, and educational programs. It is available on disk for IBM or Macintosh format and includes keyword searching as well as a six-month on-line subscription to updates for the guide. It can be ordered for $25.00 from :

The GreenDisk Paperless Environmental Journal
P.O. Box 32224
Washington, D.C. 20007

or by internet from greendisk@igc.apc.org

World Wide Web

There are many information collections on the World Wide Web (WWW) that contain full text of articles, lesson plans, and documents. There is often information on projects for children to participate in with their peers in other parts of the world, information from many government documents, and information from many cultures. Many sites have interesting graphics and interactive activities.

The following sites have specific information that is of interest to environmental educators. In each case, teachers should check out the site beforehand to decide which of the many resources available might fit into a lesson and ways to use them. Since the WWW is developing rapidly, these resources are only a suggested starting point and will contain links to many other interesting sites.

ALABAMA RESOURCES

AlaWeb - AlaWeb, the official state home page, has information on campgrounds, golf courses, tours, and other helpful information about the state. Available at:
http://alaweb.asc.edu/ or www.state.al.us

Alabama Information Resources - This is an electronic information guide to “The Heart of Dixie, Alabama.” Allows users from anywhere in the world to access information about the history, sites, and culture of Alabama. Available at:
http://www.secis.com/home/ala.html

Official Alabama Pages - These include pages for individual cities, Alabama conventions, visitor bureaus, travel and tourism offices. Available at:
http://www.scescape.com/cityweb/Alabama.html

Alabama Game and Fish Homepage - Conservation Education Programs; clickable map of public hunting areas; hunter education program. Available at:
http://www.mindspring.com/~spinson/ag&f.html

OTHER RESOURCES

Explorer, a searchable catalog of curricular resources for math and science education; TEXT files on energy, water, and waste management; Energy Education Resource Guide, School Nature Area Project Bibliographies with separate lists for primary and secondary school resources for investigating schoolyard ecology; Water Quality Curricula. Available at:

http://www.nceet.sure.umich.edu/classes.html

Many environmental resources can be found at:

http://www.webdirectory.com/Education/

EE-Link - Provides a keyword search, classroom resources, and regional information. Provides table of contents and monthly updates. Also the EnviroLink Education Network and the Environmental Education Network

Commonwealth of Learning - Includes Teacher In-service on Environmental Education; Video on sustainable development; Professional Development. Available at:

http://www.col.org/envir.html

Econet Environmental Education Directory - Provides a Global Action and Information (GAIN), which supports and encourages actions for a sustainable society. Available at:

http://www.igc.apc.org/igc/www/enved.html

Scroll down to find these sites:

Dodo Land in Cyberspace: an interactive, educational centre for kids: "Protect the Environment and Expand Your Imagination." There are lots of images here, soyou may want to use it with a fast connection.

The Environment and Natural Resources Policy and Training Project Resources for teachers. You can find the latest information about energy, industry, forestry, and watershed management.

Two interesting project sites for children at this address are :

The Global Thinking Project, which is a world-wide E-mail project for students and teachers to work with scientists to understand the global environment.

The International Education and Resource Network (I*EARN) is a site for teachers and youth (ages 6 to 19) to undertake projects via E-mail.

Ranger Rick of the National Wildlife Federation is also available from this site, or www.nwf.org

Environmental Organizations and Projects - There is a listing at http://www.ncet.snre.umich.edu/ that has electronic brochures for many organizations related to environmental education.

Institute for Global Environmental Strategies - EarthRISE is under development at this site:

http://www.strategies.org/

Internet Resources for Outdoor Recreation Research - This has many on-line resources and many links to others. It includes Tourism, Ecological Aspects of Outdoor Recreation, Recreational Issues on Public Lands.

Available at:
http://www.vt.edu:10021/Y/yfleung/recres.html

Learning Webs - This is a consulting service in the field of environmental education specializing in Arizona. Services available are fund raising (t-shirts, note cards, pens with environmental themes) educational resources, and an AzEENet Magazine, a look at environmental publishing on the web. Available at:
http://www.nwf.org/nwf/prog/things.html

Nationwide School Weather Network - Your children can keep track of the weather across the nation at this site. Available at:
emailatinfo@aws.com
or go to http://www.webdirectory.com/Education/and choose the Automated Weather Source

The Plastic Bag Information Clearinghouse - This has much information about recycling, teaching aids, an essay contest. Available at:
http://www.plasticbag.com/
or by email at pbainfo@aol.com

Regional Environmental Education Resources - This site has information about environmental programs and curricula listed by state. It includes a wealth of valuable information for teachers. Available at:
http://www.nceet.snre.umich.edu/regionalEE.html

State Education and Environment Roundtable - This is working to improve learning by incorporating environmental curricula into K-12 education. "A major part of our work relates to gathering and disseminating research about systemic approaches to incorporating environmental education into education reform." Available at:
http://millennianet.com/round

Stay up-to-date with what's new in environmental education on the World Wide Web at EE-Link. Available at:
http://www.nceet.snre.umich.edu/new.html

The Wild Ones Home Page - This will post your children's art work, writings and experiments related to the environment on the Internet web pages. Send work by fax to (212) 222-2191 or regular mail to:
The Wild Ones
c/o Wildlife Preservation Trust International
3400 West Girard Ave
Philadelphia, PA 19104

Windows on the Wild - or WOW, is an environmental education program of the World Wildlife Fund (WWF). The program educates the public about biodiversity issues and helps to stimulate critical thinking on behalf of the environment. It includes many activities for teachers to use in the classroom.
www.worldlife.org

Directories

ECOLOGY

Federal Government Organizations

Advisory Committee on Atmospheric Carbon Dioxide
U.S. Dept. of Energy
Washington, D.C. 20585

Bureau of Reclamation (U.S.)
Main Interior Building
18th and C St., NW
Washington, D.C. 20240
202-343-4662

Environmental Protection Agency (U.S.)
401 Mst., SW
Washington, D.C. 20460
202-382-2080

Environmental Protection Agency (U.S.)
Public Information Center, PM-211 B
401 Mst., SW
Washington, D.C. 20460

Federal Energy Regulatory Commission
Department of Energy
815 N Capitol Street
Washington, D.C. 20426
202-357-8118

Fish and Wildlife Service (U.S.)
Department of the Interior
Main Interior Building
Washington, D.C. 20240
202-343-5634

House Energy and Commerce Committee
U.S. House of Representatives
Washington, D.C. 20515
202-255-2927

House Agricultural Committee
U.S. House of Representatives
Washington, D.C. 20515
202-255-2171

National Marine Fisheries Service
Department of Commerce (U.S.)
1335 East-West Highway
Silver Springs, MD 20910
301-427-2370

National Park Service
Main Interior Building
Washington, D.C. 20240
202-343-4747

Office of Conservation and Renewable Energy
1000 Independence Ave., SW
Washington, D.C. 20585
202-586-9220

Save Our Streams Program
Izaak Walton League of America
707 Conservation Lane
Gaithersburg, MD 20878

Senate Environment and Public Works Committee
U.S. Senate
Washington, D.C. 20515
202-224-6176

Topographic Maps
U.S. Geological Survey
Box 25286
Denver Federal Center
Denver, CO 80225

Topographic Map Symbols
U.S. Geological Survey
National Center
Reston, VA 22202

EPA Regional Offices

U.S. EPA - Region 1
JFK Federal Building
Boston, MA 02203
617-565-3715

U.S. EPA - Region II
26 Federal Plaza
New York, NY 10278
212-264-2525

U.S. EPA - Region III
841 Chestnut St.
Philadelphia, PA 19107
215-597-9800

U.S. EPA - Region IV
345 Courtland St., NE
Atlanta, GA 30365
404-347-4727

U.S. EPA - Region V
230 South Dearborn St.
Chicago, IL 60604
312-353-2000

U.S. EPA - Region VI
First Interstate Bank Tower
1445 Ross Ave.
Dallas, TX 75270-2733
214-655-6444

U.S. EPA - Region VII
726 Minnesota Ave.
Kansas City, KS 66101
913-551-7050

U.S. EPA - Region VIII
One Denver Place
999 18th St.
Denver, CO 80202-2405
303-293-1603

U.S. EPA - Region IX
1235 Mission St.
San Francisco, CA 94103
415-744-1468

U.S. EPA - Region X
1200 Sixth Ave.
Seattle, WA 98101
206-442-5810

U.S. Fish and Wildlife Service
SE Regional Office
Richard B. Russell Fed. Building.
75 Spring St., SW, Room. 1200
Atlanta, GA 30303

Alabama State Agencies/Organizations

Alabama Audubon Council
2616 Mountain Brook Parkway
Birmingham, AL 35223
205-879-1935

Alabama Department. of Education
50 N. Ripley
Gordon Persons Building.
Montgomery, AL 36130
334-242-9700 or 334-242-8154

Alabama Energy Extension Service
Box 6282
University, AL 35486
1-800-452-5901

Alabama Power Company
Educational services
P.O. Box 2641
Birmingham, AL 35282-9984

Alabama Waterfowl Association
P.O. Box 67
Guntersville, AL 35768
205-259-2509

Alabama Wilderness Alliance
P.O. Box 223
Moulton, AL 35650
205-974-7678

Alabama Wildlife Federation
P.O. Box 2102
46 Commerce St.
Montgomery, AL 36102
334-832-9453 fax: 334-532-9454

Alabama Wildlife Society
118 Extension Hall
Auburn, AL 36849
205-844-5670

Alabama Zoological Society
2630 Cahaba Rd.
Birmingham, AL 35223

Audubon Society
749 Eastern Manor Lane
Birmingham, AL 35215
205-849-9202

Bankhead Watershed Project
P.O. Box 117
Moulton, AL 35650
205-974-7678

Center for Environmental Research and Service
Troy State University
Troy, AL 36081
334-566-4424 or 1-800 642-2377

Environmental Education Association of Alabama
Troy State University
Box 596
Troy, AL 36082

Department. of Conservation and Natural Resources
64 N Union St.
Montgomery, AL 36130
334-261-3486

Department. of Environmental Management.
1751 W.L. Dickinson Dr.
Montgomery, AL 36130
334-271-7700 fax: 334-271-7950

Geological Survey of Alabama
Sate Oil and Gas Board
420 N. Hackberry Lane
Tuscaloosa, AL 35486-9780
205-349-2852

Johnson Research Center - AL Solar Energy Center
University of Alabama in Huntsville
Research Institute/Annex D
Huntsville, AL 35899
1-800-228-5897

Marine Environmental Sciences Consortium
Dauphin Island Sea Lab
Attention: Dr. George Crozier, Director.
P.O. Box 369-370
Dauphin Island, AL 36528
334-861-2141

Perdido Bay Environmental Association
P.O. Box 573
Lillian, AL 36549
334-962-2879

Science, Tech. and Energy Division.
Dept. of Eco. and Community Affairs
P.O. Box 205347
Montgomery, AL 36125-0347
334-284-8952 or 1-800-392-8098

Shoals Audubon Society
1612 Sheffield Dr.
Sheffield, AL 35660
205-383-6338

U.S. Fish and Wildlife Service
P.O. Drawer 1197
Daphne, AL 36526
334-690-2181

Water Resource Res. Institute
Hargis Hall, Room 202
Auburn University, AL 36849
205-826-5075

Other Environmental Agencies/Organizations

Abundant Life Seed Foundation
P.O. Box 772
Port Townsend, WA 98368
206-385-5660

Acid Rain Foundation
1410 Varsity Dr.
Raleigh, NC 27606
919-828-9443 fax: 919-515-3593

Alliance for Environmental Education
P.O. Box 368
The Plains, VA 22171
703-253-5812 fax: 703-253-5811

Alliance to Save Energy
1725 K St. NW, Suite 509
Washington, D.C. 20006
202-857-0666 fax: 202-331-9588

American Fisheries Society
5410 Grosvenor Lane, Suite 110
Bethesda, MD 20814-2199
301-897-8616 fax: 301-897-8096

American Forests - Global Releaf Program
P.O. Box 2000
Washington, D.C. 20013
202-667-3300 fax: 202-667-7751

American Forests - Global Releaf
Coordinator
1516 P St., NW
Washington, D.C. 20005

American Forest Foundation
1250 Connecticut Ave., NW
Suite 320
Washington, D.C. 20036
202-463-2462 fax: 202-463-2461

American Geographical Society
156 Fifth Ave., Suite 600
New York, NY 10010-7002
212-242-0214 fax: 212-989-1583

American Meteorological Society
45 Beason Street
Boston, MA 02108
617-227-2425 fax: 617-742-8718

American Nuclear Society
555 N. Kensington Ave.
LaGrange Park, IL 60525
708-579-8265 fax: 708-352-0499

American Society for Environmental Education
P.O. Box 800
Hanover, NH 03755

Americans for Energy Independence
1629 K St., NW, Suite 602
Washington, D.C. 20006
202-466-2105 fax: 202-466-2108

Americans for the Environment
1400 16th St., NW, Box 24
Washington, D.C. 20036
202-797-6665 fax: 202-797-6646

American Nuclear Energy Council
410 First St., NE
Washington, D.C. 20003
202-484-2670

American Rivers
801 Pennsylvania Ave., SE, Suite 400
Washington, D.C. 20003
202-547-6900 fax: 202-543-6142

American Society for Environmental History
Center for Tech. Studies
New Jersey Institute of Technology
Newark, NJ 07012
201-596-3334

Americans for Nuclear Energy
2525 Wilson Blvd.
Arlington, VA 22201
703-528-4430

Animal Protection Institute of America
2831 Fruitridge Rd.
Sacramento, CA 95822
916-731-5521 fax: 916-731-4467

Animal Welfare Institute
P.O. Box 3650
Washington, D.C. 20007
202-337-2332 fax: 202-338-9478

Association for Environmental and Outdoor
Education
Attention: Roger D. Morrow
9616 Verhudson
Gig Harbor, WA 98335

Biomass Energy Res. Association
1825 K St., NW, Suite 503
Washington, D.C. 20006
1-800-247-1755

Center for Environmental Education, Inc.
1725 Desales St., SW, Suite 500
Washington, D.C. 20036

Environmental Action, Inc.
1525 New Hampshire Ave. NW
Washington, D.C. 20036

Environmental Education Coalition
R.D.2 Box 1010
Dingsman Ferry, PA 18328

Global Tomorrow Coalition
1325 G St., NW, Suite 915
Washington, D.C. 20005

Greenpeace USA, Inc.
1436 U St., NW
Washington, D.C. 20009

Institute for Earth Education, The
Box 288
Warrenville, IL 6055

International Ecology Society
1471 Barclay St.
St. Paul MN 55106-1405

Keep America Beautiful
9 West Broad St.
Stamford, VCT 06902

Living Lightly
Schilitz Audubon Center
1111 East Brown Deer Rd.
Milwaukee, WI 53217-1999
414-352-2880

National Association for Environmental Education
P.O. Box 569031
Miami, FL 33156

National Clearinghouse on Dev. and Envir. Edu.
American Forum on Global Education
45 John St., Suite 908
New York, NY 10038

National Consortium for Envir. Edu. and Training
School of Natural Resources and Environment
University of Michigan
430 East University Ave.
Ann Arbor, MI 48109

National Wildlife Federation
1400 16th St., NW
Washington, D.C. 20036-2266

National Geographic Society
17th and M St., NW
Washington, D.C. 20036

Nature Conservancy, The
1815 North Lynn St.
Arlington, VA 22209

North American Assoc. for Environmental Education
Box 400
Troy, OH 45373
(NAAEE Membership and Publications Office)

Oceanic Society, The
Executive Offices
1536 16th St., NW
Washington, D.C. 20036

Office of Environmental Education
U.S. EPA
401 M St., SW (A-107)
Washington, D.C. 20460

Population Institute, The
110 Maryland Ave., NE
Washington, D.C. 20002
Project WILD
Attention: Project WILD Director
Western Region. Environmental Education Council
4014 Chatham Lane
Houston, TX 77027

Public Citizen
2000 P St., NW
Washington, D.C. 20036
202-833-3000

Science, Mathematics, and Environmental Education
Analysis Center
Information Resource Center
1200 Chambers Rd., Room. 310
Columbus., OH 43212-1792

Wilderness Society, The
1400 I St., NW 10th Floor
Washington, D.C. 20005

Wildlife Conservation International
New York Zoological society
Bronx, NY 10460

Wildlife Society, The
5410 Grosvenor Lane
Bethesca, MD 20814

World Resources Institute
1709 New York Ave., NW
Washington, D.C. 20006

World-Wide Fund - Conservation Foundation
1250 24th St., NW
Washington, D.C. 20037

Worldwatch Institute
1776 Massachusetts Ave., NW
Washington, D.C. 20036

Zero Population Growth, Inc.
1601 Connecticut Ave., NW
Washington, D.C. 20009

Directory

POLLUTION PREVENTION

Federal Government Organizations

Environmental Protection Agency
401 M St., SW
Washington, D.C. 20460
202-260-2090

House Agriculture Committee
U.S. House of Representatives
Washington, D.C. 20515
202-255-2171

House Energy and Commerce Committee
U.S. House of Representatives
Washington, D.C. 20515
202-255-2927

Nuclear Regulatory Commission
Washington, D.C. 20555
301-415-7000

Senate Environment and Public Works Committee
U.S. Senate
Washington, D.C. 20515
202-224-6176

Tennessee Valley authority
400 W. Summit Hill Dr.
Knoxville, TN 37902
615-632-2101

United Coast Guard
Department of Transportation
2100 2nd St., SW
Washington, D.C. 20593
202-267-2229

United States Department of Energy
Office of Civilian Radioactive Waste Management
P.O. Box 44375
Washington, D.C. 20026
1-800-225-NWPA

United States Department of the Interior
Interior Building, 1849 C St., NW
Washington, D.C. 20240
202-208-1100

United States Geological Survey
12201 Sunrise Valley Dr
Reston, VA 22092 7
03-648-4000

EPA Regional Offices

See Ecology Directory

Alabama State Agencies/Organizations

Alabama Bottle and Can Coalition
307 Shooting Star Trail
Gurley, AL 35748
205-776-4015

Alabama Department of Education
50 N. Ripley
Gordon Persons Building
Montgomery, AL 36130
334-242-9700 or 334-242-8154

Alabama Lung Association
900 18th St., South
Birmingham, AL 35020
205-933-8821

Alabama PALS: People Against a Littered State
46 Commerce St.
Montgomery, AL 36104
334-263-7737

Alabamians for a Clean Environment
P.O. Box 1526
Livingston, AL 35470
205-652-9854

Center for Environmental Research and Service
Attention: Information and Public Relations Coordinator
Troy State University
Troy, AL 36082
334-566-4424 or 1-800-642-2377

Other Environmental Agencies/Organizations

Acid Rain Foundation, Inc.
1630 Blackhawk Hills
St. Paul, MN 55122

Air and Waste Management Association
P.O. Box 2861
Pittsburgh, PA 15230
412-232-3444 fax: 412-232-3450

Air Pollution Control Association
P.O. Box 2861
Pittsburgh, PA 15230

American Nuclear Energy Council
410 First St., SE
Washington, D.C. 20003
202-484-2670

American Petroleum Institute
1220 L St., NW
Washington, D.C. 20005
202-682-8000

American Rivers
801 Pennsylvania Ave., SE, Suite 400
Washington, D.C. 20003
202-547-6900 fax: 202-543-6142

Amoco Teaching Aids
P.O. Box 1400K
Dayton, OH 45414

Asbestos Information Association of North America
1745 Jefferson Davis Hwy., Suite 406
Arlington, VA 22202
703-412-1150 fax: 703-412-1152

Center for Environmental Information
46 Prince st.
Rochester, NY 14607-1016
716-271-3550 fax: 716-271-0606

Center for Marine Conservation
1725 DeSales St., NW, Suite 500
Washington, D.C. 20036
202-429-5609 fax: 202-872-0619

Chevron Chemical Company
Educational Materials
Public Affairs Department
P.O. Box 3744
San Francisco, CA 94119

Ciba-Geigy Corporation
Attention: Corporation Relations Department
Ardsley, NY 10502

Clean Air Working Group
818 Connecticut Ave., NW
Washington, D.C. 20006

Clean Water Action
1320 18th St., NW, Suite 300
Washington, D.C. 20036
202-457-1286 fax: 202-457-0287

Clean Sites
1199 N. Fairfax St.
Alexandria, VA 22314
703-683-8522

Dow Chemical U.S.A.
Ag Products
P.O. Box 1706
Midland, MI 48640

Environmental Action
6930 Carroll Ave., Suite 600
Takoma Park, MD 20912
301-891-1100 fax: 301-891-2218

Friends of the Sea Otter
140 Franklin St., Suite 309
Monterey, CA 93940
408-373-2747

Georgia-Pacific Corporation
Educational Services
133 Peachtree St., NW
Atlanta, GA 30303

Greenpeace, U.S.A.
1436 U St., NW
Washington, D.C. 20009
202-462-1177 fax: 202-462-4507

Hazardous Materials Control Research Institute
7237 Hanover parkway
Greenbelt, MD 20770
301-982-9500 fax: 301-220-3870

Household Hazardous Waste Project
1031 E. Battlefield, Suite 214
Springfield, MO 65807
417-889-5000

Inform
381 Park Ave. South
New York, NY 10016
212-689-4040 fax: 212-447-0689

ICI Americas, Inc.
Ag Chem Division
Attention: Lorraine Smith
Wilmington, Delaware 19897

Institute for Environmental Education
18554 Haskins Rd.
Chagrin Falls, OH 44023-1823
212-543-7303 fax: 216-543-7160

International Bird Rescue Research Center
699 Potter St.
Berkeley, CA 94710
510-841-9086

Keep America Beautiful, Inc.
99 Park Avenue
New York, NY 10016

LaMotte Company
P.O. Box 329
Chestertown, MD 21620
410-778-3100 fax: 410-778-6394

Manufacturers of Emission Controls Association
1707 L St., NW
Washington, D.C. 20036
202-296-4797 fax: 202-331-1388

National Agricultural Chemicals Association
1155 15th St., NW
Madison Building Suite 900
Washington, D.C. 22005
202-296-1585

National Association of Noise Control Officials
53 Cubberly Rd.
Trenton, NJ 08690
609-586-2684

National Coalition Against the Misuse of Pesticides
701 E St., SE, Suite 200
Washington, D.C. 20003
202-543-5450

National Geographic Society
17th and M St., NW
Washington, D.C. 20036

Nuclear Information and Resource Service
1424 16th St., NW, Suite 601
Washington, D.C. 20036
202-328-0002 fax: 202-462-2183

Smithsonian Institution
Office of Environmental Awareness
S. Dillon Ripley Center., Suite 3123
Washington, D.C. 20560
202-357-4797 fax 202-786-2557

Southwest Research and Igrass Roots Information Center.
P.O. Box 4524
Albuquerque, NM 87106
505-262-1862

Toxicant Program/HHWD Project
METRO M/S 81
821 2nd Ave.
Seattle, WA 98104

Water Environment Federation
601 Wythe St.
Alexandria, VA 22314-1994
1-800-666-0206 fax: 703-684-2492

Directory

WASTE MANAGEMENT

Federal Government Organizations

Federal Highway administration
400 7th St., SW
Washington, D.C. 20590
202-366-0600

House Energy and Commerce Committee
U.S. House of Representatives
Washington, D.C. 20515
202-255-2927

United States Department of Energy
Office of Civilian Radioactive Waste Management
P.O. Box 44375
Washington, D.C. 20026
1-800-225-NWPA

EPA Regional Offices

See Ecology Directory

Alabama State Agencies/Organizations

Alabama Bottle and Can Coalition
307 Shooting Star Trail
Gurley, AL 35748
205-776-4015

Alabama Department of Education
50 N. Ripley
Gordon Persons Building
Montgomery, AL 36130
334-242-9700 or 334-242-8154

Alabama PALS: People Against a Littered State
46 Commerce St.
Montgomery, AL 36104
334-263-7737

Environmental Education Association of Alabama
Troy State University
Box 596
Troy, AL 36082

Other Environmental Agencies/Organizations

Aluminum Association, Inc., The
Attention: Manager of Educational Services
818 Connecticut Ave., NW
Washington, D.C. 20006

American Nuclear Energy Council
410 First St., NE
Washington, D.C. 20003
202-484-2670

American Nuclear Society
555 N. Kensington Ave.
LaGrange Park, IL 60525
708-579-8265 fax: 708-352-0499

American Plastics Council
1730 D St., NW
Washington, D.C. 20006
202-737-8300

Americans for Nuclear Energy
2525 Wilson Blvd.
Arlington, VA 22201
703-528-4430

Association of Foam Packaging Recyclers
1025 Connecticut Ave., NW, Suite 515
Washington, D.C. 20036
202-822-6424 fax: 202-331-0538

A-Way With Waste
Washington State Department of Ecology
4350 150th Ave., NE
Redmond, WA 98052

Center for Environmental Information
46 Prince St.
Rochester, NY 14607-1016
716-271-3550 fax: 716-271-0606

Center for Renewable Resources
Publications Department
641 S. Pickett St.
Alexandria, VA 22304

Department of Environmental Management
Hazardous Waste Branch, Land Division
1751 Cong. W.L. Dickinson Dr.
Montgomery, Alabama 36130
334-271-7700

Dow Chemical U.S.A.
Ag Products
P.O. Box 1706
Midland, MI 48640

Hazardous Materials Control Research Institute
7237 Hanover parkway
Greenbelt, MD 20770
301-982-9500 fax: 301-220-3870

Hazardous Waste Management and Resource Recovery Program
University of Alabama
HAMMARR
P.O. Box 1968
University, AL 35486

Household Hazardous Waste Project
1031 E. Battlefield, Suite 214
Springfield, MO 65807
417-889-5000

Inform
381 Park Ave. South
New York, NY 10016
212-689-4040 fax: 212-447-0689

National Clearinghouse on Dev. and Envir. Edu.
American Forum on Global Education
45 John St., Suite 908
New York, NY 10038

National Geographic Society
17th and M St., NW
Washington, D.C. 20036

National Solid Wastes Management Association
1730 Rhode Island Ave., NW, Suite 1000
Washington, D.C. 20036
202-659-0708 fax: 202-775-5917

Nuclear Information and Resource Service
1424 16th St., NW, Suite 601
Washington, D.C. 20036
202-328-0002 fax: 202-462-2183

Polystyrene Packaging Council, Inc.
1025 Connecticut Ave., NW, Suite 515
Washington, D.C. 20036
202-822-6424 fax: 202-331-0538

Reynolds Aluminum Recycling Company
Attention: Public Relations Manager
P.O. Box 27003
Richmond, VA 23261

Smithsonian Institution
Office of Environmental Awareness
S. Dillon Ripley Center., Suite 3123
Washington, D.C. 20560
202-357-4797 fax 202-786-2557

Southwest Research and Igrass Roots Information Center.
P.O. Box 4524
Albuquerque, NM 87106
505-262-1862

Steel Recycling Institute
680 Andersen Dr.
Pittsburgh, PA 15220
1-800-876-SCRI or 412-922-2772 fax: 412-922-3213

Toxicants in Consumer Products
METRO Exchange Building
821 2nd Ave.
Seattle, WA 98104
206-447-5875

Washington Citizens for Recycling
157 Yesler Way
Seattle, WA 98104
206-343-5171 fax: 206-624-2110

Directory

NATURAL RESOURCES

Federal Government Organizations

Army Corps of Engineers
Department of Defense
20 Massachusetts Ave., NW
Washington, D.C.
202-272-0010

Bureau of Land Management (U.S.)
Main Interior Building
18th and C St., NW
Washington, D.C. 20240
202-343-5717

Bureau of Land Management
Department of the Interior (U.S.)
Anasazi Heritage Center
27501 Hwy. 184, P.O. Box 758
Dolores, CO 81323
303-882-4811 fax: 303-882-7595

Bureau of Mines (U.S.)
Motion Pictures
Cockrans Mill Road
P.O. Box 18070
Pittsburgh, PA 15236
412-675-4338

Bureau of Reclamation (U.S.)
Main Interior Building
18th and C St., NW
Washington, D.C. 20240
202-343-4662

Coast Guard (U.S.)
Department of Transport
2100 2nd St., SW
Washington, D.C. 20593
202-267-2229

Department of Agriculture
12th and 14th St., NW
Washington, D.C. 20250
202-477-8732

Department of Defense
The Pentagon
Office of the Secretary
Washington, D.C. 20301-8000

Department of Justice
Environment and Natural Resources Division
10th St. and Constitution Ave., Room 2143
Washington, D.C. 20530
202-514-2701

Department of the Air Force
Washington, D.C. 20330

Department of the Interior
Interior Building
1849 C St., NW
Washington, D.C. 20240
202-208-1100

EPA Regional Offices

See Ecology Directory

Federal Hwy. Administration
400 7th St., NW
Washington, D.C. 20590
202-366-0600

Fish and Wildlife Service (U.S.)
Department of the Interior
Main Interior Building
Washington, D.C. 20240
202-343-5634

Forest Service (U.S.)
P.O. Box 96090
Washington, D.C. 20090
202-447-3957

Geological Survey (U.S.)
12201 Sunrise Valley Dr.
Reston, VA 22092
703-648-4000

House Committee on Interior and Insular Affairs
U.S. House of Representatives
Washington, D.C. 20515
202-255-2761

House Energy and Commerce Committee
U.S. House of Representatives
Washington, D.C. 20515
202-255-2927

House Merchant Marine and Fisheries Committee
U.S. House of Representatives
Washington, D.C. 20515
202-255-4047

Minerals Information Office Bureau of Mines (U.S.)
Department of Interior Building
19th and C St., NW MS 2647-MIB
Washington, D.C. 20240

National Marine Fisheries Service
Department of Commerce (U.S.)
1335 East-West Hwy.
Silver Springs, MD 20910
301-427-2370

National Oceanic and Atmospheric Administration
14th St. and Constitution Ave., NW
Washington, D.C. 20230
202-343-4747

National Park Service
Main Interior Building
Washington, D.C. 20240
202-343-4747

Office of Conservation and Renewable Energy
1000 Independence Ave., SW
Washington, D.C. 20585
202-586-9220

Office of Surface Mining
1951 Constitution Ave., NW
Washington, D.C. 20240
202-343-4953

Senate Agriculture, Nutrition and Forestry Committee
U.S. Senate
Washington, D.C. 20515
202-224-2035

Senate Commerce, Science and Transportation Committee
U.S. Senate
Washington, D.C. 20515
202-224-5115

Senate Energy and Natural Resources Committee
U.S. Senate
Washington, D.C. 20515
202-224-4917

Soil Conservation Service
Department of Agriculture (U.S.)
14th St. and Independence Ave., SW
P.O. Box 2890
Washington, D.C. 20013
202-447-4543

U.S. Army Construction Engineering Research Lab
P.O. Box 9005
Champaign, IL 61826-9005
217-352-6511

Alabama State Agencies/Organizations

Agriculture and Industries
Attention: Information Director
P.O. Box 3336
Montgomery, AL 36109
334-242-5872

Alabama Audubon Council
2616 Mountain Brook Parkway
Birmingham, AL 35223
205-879-1935

Alabama BASS Chapter Federation
3717 Sola Cr.
Fort Payne, AL 35967
205-845-1441

Alabama Conservancy, The
2717 7th Ave., S. Suite 207
Birmingham, AL 35233

Alabama Cooperative Extension Service
109 Duncan Hall, Auburn Hall
Auburn University, AL 36849-5612
205-844-4444 fax: 205-844-5544
E-mail: athompso@acenet.auburn.edu
Alabama Cooperative Fish and Wildlife Research

Unit
331 Funchess Hall,
Auburn University
Auburn, AL 36849
205-844-4796

Alabama Department of Education
50 N. Ripley
Gordon Persons Building
Montgomery, AL 36130
334-242-9700 or 334-242-8154

Alabama Energy Extension Services
Box 6282
University, AL 35486
1-800-452-5901

Alabama Forest Owner's Association
P.O. Box 104
Helena, AL 35080
205-987-8811

Alabama Forestry Association
555 Alabama St.
Montgomery, AL 36104
334-265-8733

Alabama Forestry Commission
513 Madison Ave.
Montgomery, AL 36130
334-240-9300

Alabama Natural Heritage Section
State Lands Division
Department of Conservation and Natural Resources
64 Union St.
Montgomery, AL 36130
334-242-3484

Alabama Surface Mining Commission
P.O. Box 2390
Jasper, AL 35502
205-221-4130

Alabama Waterfowl Association
Rt. 2, Box 179
Scottsboro, AL 35768
205-259-2509

Alabama Wilderness Alliance
P.O. Box 223
Moulton, AL 35650
205-974-7678

Alabama Wildflower Society
3914 S. River Circle
Birmingham, AL 35243
205-967-0304

Alabama Wildlife Federation
46 Commerce St.
Montgomery, AL 36104
334-832-9453

Alabama Wildlife Society
Auburn University, Department of Zoology
331 Funchess Hall
Auburn, AL 36849-5414
205-844-4850 or 205-844-9247

Alabama Zoological Society
2630 Cahaba Road
Birmingham, AL 35223

Audubon Society
Birmingham Chapter
749 eastern Manor Lane
Birmingham, AL 35215
205-849-9202

Bankhead Watershed Project, The
P.O. Box 117
Moulton, AL 35650
205-974-7678

Bass Anglers Sportsman Society
5845 Carmichael Rd.
Montgomery, AL 36117
334-272-9530

Cahaba River Society
2717 7th Ave., S., Suite 207
Birmingham, AL 35223

Department of Agriculture and Industries
P.O. Box 3336
Montgomery, AL 36193
334-261-2650

Department of Conservation and Natural Resources
64 Union St.
Montgomery, AL 36130
334-242-3486

Department of Environmental Management
P.O. Box 301463
Montgomery, AL 36130-1463

Ducks Unlimited
7706 Shadow Bend Dr., SE
Huntsville, AL 35802
205-881-6895

Ducks Unlimited
3413 Old Woods Lane
Birmingham, AL 35243
205-322-8636

Ducks Unlimited
305 4th St., #408
Decatur, AL 35601
205-350-5557

Environmental Education Association of Alabama
Troy State University
Box 596
Troy, AL 36082

Forestry Commission
513 Madison Ave.
Montgomery, AL 36130
334-240-9304

Geological Survey of Alabama
State Oil and Gas Board
P.O. Box 0
Tuscaloosa, AL 35486-9780
205-349-2852

Gulf Coast Conservation Association
P.O. Box 16897
Mobile, AL 36606
334-478-3474

Johnson Research Center/Alabama Solar Energy Center
University of Alabama In Huntsville
Research Institute, Annex D
Huntsville, AL 35899
1-800-228-5897

Marine Environmental Sciences Consortium
P.O. Box 369-370
Dauphin Island, AL 36528
334-861-2141

Montgomery Zoo
P.O. Box ZEBRA
Montgomery, AL 36109-0313
334-240-4900

National Forests in Alabama
USDA Forest Service
2946 Chestnut St.
Montgomery, AL 36107
334-832-4470

Nature Conservancy of Alabama, The
2821 C 2nd Ave., S.
Birmingham, AL 35233
205-251-1155 fax: 205-252-4444

Sea Grant program
Gulf Coast Research Laboratory
P.O. Box 7000
Ocean Springs, MS 39566-7000
601-875-9341 fax: 601-875-0528

Shoals Audubon Society
1612 Sheffield Dr.
Sheffield, AL 35660
205-383-6338

Soil Conservation Service
P.O. Box 311
Auburn, AL 36830
205-887-4523

The Bankhead Monitor
(A publication about the Bankhead National Forest)
P.O. Box 117
Moulton, AL 35650

The Talladega Monitor
(A publication about the Talladega National Forest)
P.O. Box 117
Moulton, AL 35650

U.S. Forest Service
1765 Highland Ave.
Montgomery, AL 36107
334-832-7630

U.S. Fish and Wildlife Service
P.O. Drawer 1197
Daphne, AL 36526
334-690-2181

Water Resource Research Institute
Hargis Hall, Room 202
Auburn University, AL 36849
205-826-5075

Wheeler National Wildlife Refuge
T. 4, Box 250
Decatur, AL 35603
205-353-7243

Wildlife Action of Alabama
P.O. Box 949
Point Clear, AL 36564-0949
334-479-1098

Wildlife Rescue Service
2107 Marlboro Ave.
Birmingham, AL 35226
205-663-7930
Hotline: 205-320-6189

Wildlife Sanctuary
9344 County Road 59
Troy, AL 36081
334-735-2950

Wildlife Society, Alabama Chapter
Route 7, Box 131
Andalusia, Alabama 36420
334-222-7779

Other Agencies/Organizations

Alliance to Save Energy
1725 K St., NW, Suite 509
Washington, D.C. 20006
202-857-0666 fax: 202-331-9588

Alternative Energy Resource Organization
25 S. Ewing, Room 214
Helena, MT 59601
406-443-7272 fax: 416-442-9120

American Association of Zoological Parks and Aquariums
Oglebay Park
Wheeling, WV 26003
304-242-2160

American Cave Conservation Association
American cave and Karst Center
P.O. Box 409
Horse Cave, KY 42749
502-786-1466 fax: 502-786-1466

American Cetacean Society
P.O. Box 2639
San Pedro, CA 90731
310-548-6279 fax: 310-548-6950

American Coal Foundation
918 16th St., NW, Suite 404
Washington, D.C. 20006-2902

American Council for an Energy Efficient Economy
1001 Connecticut Ave., NW, Suite 801
Washington, D.C. 20036
202-429-8873 fax: 202-429-2248

American Fisheries Society
5410 Grosvenor Lane, Suite 110
Bethesda, MD 20814-2199
301-897-8616 fax: 301-897-8096

American Forest Foundation
1250 Connecticut Ave., NW, Suite 320
Washington, D.C. 20036
202-463-2462 fax: 202-463-2461

American Forests - Global Releaf program
P.O. Box 2000
Washington, D.C. 20013
202-667-3300 fax: 202-667-7751

American Gas Association
1515 Wilson Boulevard
Arlington, VA 22209

American Geographical Society
156 5th Ave., Suite 600
New York, NY 10010-7002
212-242-0214 fax: 212-989-1583

American Geological Institute
5220 King St.
Alexandria, VA 22303
703-379-2480 fax: 703-379-7563

American Humane Association
63 Inverness Dr., E.
Englewood. CO 80112
303-792-9900 fax: 303-792-5333

American Institute of Professional Geologists
7828 Vance Dr., Suite 103
Arvada, CO 80003
303-431-0831

American Iron and Steel Institute
attention: Education Cooperation Services
1000 16th St., NW
Washington, D.C. 20036

American Mining Congress
1920 N St., NW, Suite 300
Washington, D.C. 20036-1662
202-861-2800 fax: 202-861-2846

American Nature Study Society
5881 Cold Brook Rd.
Homer, NY 13077
604-749-3655

American Petroleum Institute
1220 L St., NW
Washington, D.C. 20005
202-682-8000

American Rivers
801 Pennsylvania Ave., SE, Suite 400
Washington, D.C. 20003
202-547-6900 fax: 202-543-6142

American Society for Environmental History
Center for Technology Studies
New Jersey Institute of Technology
Newark, NJ 07012
201-596-3334

American Society of Agricultural Engineers
2950 Miles Rd.
St. Joseph, MI 49085
616-429-0300 fax: 616-429-3852

American Society of Agronomy
Crop Science Society of America
Soil Science Society of America
677 South Segoe Rd.
Madison, WI 53711
608-273-8080 fax: 608-273-2021

American Society of Mammalogists
Bell Museum of Natural History
University of Minnesota
Minneapolis, MN 55455

Americans for Energy Independence
1629 K St., NW, Suite 602
Washington, D.C. 20006
202-466-2105 fax: 202-466-2108

Amoco Teaching Aids
P.O. Box 1400K
Dayton, OH 45414

Animal Protection Institute of America
2831 Fruitridge Rd.
Sacramento, CA 95822
916-731-5521 fax: 916-731-4467

Animal Welfare Institute
P.O. Box 3650
Washington, D.C. 20007

Appalachian Mountain Club
5 Joy St.
Boston, MA 02108
617-523-0636

Biomass Energy Research Association
1825 K St., NW, Suite 503
Washington, D.C. 20006
1-800-247-1755

Caretta Research Project
Savannah Science Museum
4405 Paulsen St.
Savannah, GA 31405
912-355-6705 fax: 912-355-0182

Center for Environmental Information
46 Prince St.
Rochester, NY 14607-1016
716-271-2550 fax: 716-271-0606

Center for Holistic Resource Management
5820 Fourth St., NW
Albuquerque, NM 87107
505-344-3445 fax: 505-344-9079

Center for Marine Conservation
1725 Desales St., NW, Suite 500
washington, D.C. 20036

Children's Rainforest, The
P.O. Box 936
Lewsiton, ME 04240

Climate Protection Institute
5833 Balmoral Cr.
Oakland, CA 94619
510-531-0100

Conservation International
1015 18th St., NW, Suite 1000
Washington D.C. 20036
202-429-5660 fax: 202-887-5188

Defenders of Wildlife
1244 19th St., NW
Washington, D.C. 20036
202-659-9510 fax: 202-833-3349

Delta Waterfowl Foundation
102 Wilmot Rd., Suite 410
Deerfield, IL 60015
708-940-7776

Earthtrust
25 Kaneohe Bay Dr., Suite 205
Kailua, HI 96734
808-254-2866 fax: 808-254-6409

EARTH WATCH
Office of Public Affairs
P.O. Box 403N
Watertown, MA 02272
617-926-8200 fax: 617-926-8532

Energy Research Institute
6850 Rattlesnake Hammock Rd.
Naples, FL 33962
813-793-1922 fax: 813-793-1260

Environmental Action
6930 Carroll Ave., Suite 600
Takoma Park, MD 20912
301-891-1100 fax: 301-891-2218

Environmental Education project
19600 S. Molalla Ave.
Oregon City, OR 97045

Environmental Media Corporation
P.O. Box 1016
Chapel Hill, NC 27514
919-933-3003 fax: 919-942-8785

Florida Solar Energy Center
300 State Road 401
Cape Canaveral, FL 32920

Friends of the Sea otter
140 Franklin st., Suite 309
Monterey, CA 93940
408-373-2747

Fund for Animals, The
200 W. 57th St.
New York, NY 10019
212-246-2096 fax: 212-246-2633

Georgia-Pacific Corporation
Educational Services
133 Peachtree St., NW
Atlanta, GA 30303

Hawk-Watch International, Inc.
P.O. Box 35706
Albuquerque, NM 87176-5706
505-255-7622 fax: 505-255-1755

Inform
381 Park Ave., South
New York, NY 10016
212-689-4040 fax: 212-447-0689

Institute for Environmental Education
18554 Haskins Rd.
Chagrin Falls, OH 44023-1823
212-543-7303 fax: 246-543-7160

Marine Technology Society
2000 Florida Ave., NW, Suite 500
Washington, D.C. 20009

Mississippi-Alabama Sea Grant Consortium
Caylor Building
Gulf Coast Research laboratory
Ocean Springs, MS 39564

Missouri Botanical Garden
P.O. Box 299
St. Louis, MO 63166

National Audubon Society
801 Pennsylvania Ave., SE
Washington, D.C. 20003

National Clearinghouse on Dev. and Env. Education
American Forum on Global Education
45 John St., Suite 908
New York, NY 10038

National Council for Geographic Education
16A Leonard Hall
Indiana University of Pennsylvania
Indiana, PA 15705

National Consortium for Environmental Education and Training
School of Natural resources and Environment
University of Michigan
430 East University Ave.
Ann Arbor, MI 48109

National Energy Foundation
5160 Wiley Post Way, Suite 200
Salt Lake City, UT 84116
801-539-1406

National Food and Energy Council
409 Van Diver W., Suite 202
Columbia, MO 65202
314-875-7155

National Geographic Society
17th and M St., NW
Washington, D.C. 20036

National Parks and Conservation Association
1015 31st St., NW
Washington, D.C. 20007
202-223-6722

National Wildflower Research Center
2600 FM 973
North Austin, TX 78725

National Wildlife Federation
1400 16th St., NW
Washington, D.C. 20036-2266

National Wildlife Refuge Association
10824 Fox Hunt Lane
Potomac, MD 20854
301-983-1238

National Zoological Park
Smithsonian Institute
Washington, D.C. 20008

Natural Resources Defense Council, Inc.
40 West 20th St.
New York, NY 10011

North American Bluebird Society
P.O. Box 6295
Silver Spring, MD 20906

Oceanic Society, The
Executive Offices
1536 16th St., NW
Washington, D.C. 20036

Rainforest Action Network
450 Sansome, Suite 700
San Francisco, CA 94111

Resources for the Future
1616 P St., NW
Washington, D.C. 20036

Smithsonian Institution
Office of Environmental awareness
S. Dillon Ripley Center, Suite 3123
Washington, D.C. 20560
202-357-4797 fax: 202-786-2557

Soil Conservation Society of America
7515 N.E. Ankeny Rd.
Ankeny, Iowa 50021-9764

Southwest Research and Igrass Roots Information
Center
P.O. Box 4524
Albuquerque, NM 87106
505-262-1862

Student Conservation Association
P.O. Box 550
Charlestown, NH 03603
603-543-1700 fax: 603-543-1828

Tennessee Valley Authority
Division of Land and Economic Resources
1A16 Old City Hall Complex
Knoxville, TN 37902
615-632-6449

Trout Unlimited
501 Church St., NE
Vienna, VA 22180
703-281-1100

Union of Concerned Students
26 Church st.
Cambridge, MA 02238
617-547-5552 fax: 617-864-9405

Wildlife Conservation International
New York Zoological Society
185th St. and Southern Blvd.
Bronx, NY 10460-1099
718-220-5141

World Resources Institute
1709 New York Ave, NW
Washington, D.C. 20006
410-516-6963

World Society for the Protection of Animals
P.O. Box 190
Boston, MA 02130
617-522-7000 fax: 617-522-7077

World Wildlife Fund/Conservation Foundation
1250 24th St., NW
Washington, D.C. 20037

Directory

OTHER ENVIRONMENTAL SOURCES

Federal Government Agencies/Organizations

Army Corps of Engineers
Department of Defense
20 Massachussets Ave., NW
Washington, D.C. 20314
202-272-0010

EPA Regional Offices

See Ecology Directory

House Appropriations Committee
U.S. House of Representatives
Washington, D.C. 20515
202-255-2771

House Interior Committee
U.S. House of Representatives
Washington, D.C. 20515
202-255-2761

House Merchant Marine and Fisheries Committee
U.S. House of Representatives
Washington, D.C. 20515
202-255-4047

House Public Works and Transportation Committee
U.S. House of Representatives.
Washington, D.C. 20515
202-255-4472

National Institute for Occupational Safety and Health
U.S. Department of Labor
200 Constitution Ave., NW
Washington, D.C. 20240
202-343-4953

Senate Commerce, Science and Transportation Committee
U.S. Senate
Washington. D.C. 20515
202-224-5115

State Agencies Organizations

Alabama Cooperative Extension Service
State Headquarters
Auburn University, AL 36849
205-826-4444

Alabama Farmers Federation P.O. Box 11000
Montgomery, AL 36191-0001
334-288-3900

Alabama Handicapped Sportsmen
44 Huntington Place
Northport, AL 35476
205-339-2800

Alabama Hiking Association
P.O. Box 4311
Birmingham, AL 35206

Alabama Solar Association
Route 3, Box 160
Decatur, AL 35603

Alabama State Museum of Natural History
University of AL, Department of Archeology
13075 Moundville Archaeological Park
Moundville, AL 35474
205-371-2266

Bureau of Tourism and Travel
401 Adams Ave., Suite 126
Montgomery, AL 36104

Dothan Landmarks Foundation, Inc.
P.O. Box 6362
Dothan, AL 36302
334-794-3452

Exploreum Museum of Discovery
1906 Springhill
Mobile, AL 36607
334-476-6873

Friends of Little River
P.O. Box 111
Mentone, AL 35984
205-634-4510 or 205-634-4066

Ruffner Mountain Nature Center
1214 South 81st St.
Birmingham, AL 35206
205-833-8264

Sierra Club, Alabama Chapter
22 Hilltop Estates
Northport, AL 35476
205-339-4692 or 205-348-6695

Sierra Club, Alabama Chapter
Montgomery Group
P.O. Box 70031
Montgomery, AL 36107

Vulcan Trail Association
Attention: Office Central
P.O. Box 19116
Birmingham, AL 35219-9116
205-933-4170

Other Environmental Agencies/Organizations

American Association for the Advancement of Science
133 H St., NW
Washington, D.C. 20005
202-326-6640 fax 202-371-9526

American Camping Society
Bradford Woods
5000 State Road 67, North
Martinsville, IN 46151-7902

American Chemical Society
1155 16th St., NW
Washington, D.C. 20036
202-872-4600 fax: 202-833-7732

American Litteral Society
Highlands, NJ 07732
908-291-0055 fax: 908-872-8041

American Nature Study Society
5881 Cold Brook Road
Homer, NY 13077
607-749-3655

American Red Cross
1730 D St., NW
Washington, D.C. 20006
202-737-8300

American Society of Agricultural Engineers
2950 Niles Road
St. Joseph, MI 49085
616-429-0300 fax: 616-429-3852

American Society of Civil Engineers
345 East 47th St.
New York, NY 10017
1-800-548-2723 fax: 212-705-7300

Anheuser-Busch Companies, Inc.
Department of Consumer Awareness and Education
One Busch Place
St. Louis, MO 63118
Call your local distributor

Asbestos Information Association/North America
1745 Jefferson Davis Hwy., Suite 406
Arlington, VA 22202
703-412-1150 fax: 703-412-1152

Association for Experimental Education
P.O. Box 4625
Denver, CO 80204

Association of Interpretive Naturalists, Inc.
Central Business Office
6700 Needwood Rd.
Derwood, MD 20855

Bureau of Outdoor Recreation
DEpartment of Interior
18th an C St., NW
Washington, D.C. 20240

Center for Emergency response Planning
Workplace Health Fund
815 16th St., NW, Suite 301
Washington, D.C. 20006
202-842-7833 fax 202-393-0623

Center for Safety in the Arts
5 Beekman St.
New York, NY 10038
212-227-6220

Citizens for a United Earth
1880 Route 64
Ionia, NY 14475
716-624-3673

Coalition for Education in the Outdoors
Box 2000, SUNY College at Cortland
Cortland, NY 13045
607-753-4971

Council on Economic Priorities
30 Irving Place
New York, NY 10003-2386
212-420-1133 fax: 212-420-0988

Council on Outdoor Education
1900 Association Dr.
Reston, VA 22091

Cousteau Society, Inc., The
870 Greebrier Cr., Suite 402
Chesapeake, VA 23320-2641
804-523-9335 fax: 804-523-2747

Development Education Program
Office of the Publisher
The World Bank
1818 H St., NW, #T8082
Washington, D.C. 20433

Earth Island Institute
300 Broadway, Suite 28
San Francisco, CA 94133
415-788-3666 fax: 415-788-7324

Edison Electric Institute
Education Service Department
701 Pennsylvania Ave., NW
Washington, D.C. 20004

Epcot Teachers Center
Walt Disney World
P.O. Box 10000
Lake Buena Vista, FL 32830

Friends of the Earth Foundation, Inc.
1045 Sansome St.
San Francisco, CA 94111

Humane Society of the United States
2100 L St., NW
Washington, D.C. 20037
202-452-1100 fax: 202-778-6132

International Council for Outdoor Education
P.O. Box 17255
Pittsburgh, PA 15235

Izaak Walton League of America, Inc., The
P.O. Box 824
Iowa City, IA 52244

League of Conservation Voters
1707 L St., NW, Suite 550
Washington, D.C. 20036
202-785-8683 fax: 202-835-0491

Monitor
1506 19th St., NW
Washington, D.C. 20036

National Association of Biology Teachers
11250 Roger Bacon Dr., #19
Reston, VA 22090

National Council for Social Studies
3501 Newark St, NW
Washington. D.C. 20016

National Education Association
1201 16th St, NW
Washington, D.C. 20036

National Science for Youth Foundation
130 Azalea Dr.
Roswell, GA 30075

National Science Teachers Association
1742 Connecticut Ave., NW
Washington, D.C. 20009

Outdoor Biology Instructional Strategies
Lawrence Hall of Science
University of California
Berkeley, CA 93305

Planetary Society, The
65 North Catalina Ave.
Pasadena, CA 91106
818-793-5100

Project ROSE
University of Alabama
Box G
Tuscaloosa, AL 35487
1-800-452-5501 or 205-349-4878

Rails-to-Trails Conservancy
1400 16th St., NW, Suite 300
Washington, D.C. 20036
202-797-5400 fax: 202-797-5411

Safari Club International
4800 West Gates Pass Rd.
Tucson, AZ 85745

Seventh Generation
Catalog Requests Department
Colchester, VT 05446-1672
1-800-456-1177

Thames Science Center
Gallows Lane
New London, CT 06320
401-849-5952

Union of Concerned Students
26 Church St.
Cambridge, MA 02238

World Food Day
1001 22nd St., NW, Suite 300
Washington, D.C. 20437

World Game Institute
University City Science Center
3508 Market St.
Philadelphia, PA 19104
215-387-0220

Worldwise Schools
United States Peace Corps
1990 K St., NW
Washington, D.C. 20526

Discovering Alabama Program Guide

Discovering Alabama, a public television series, highlights the natural features and environmental issues of the state. Host Dr. Doug Phillips explores natural features on location by means of backcountry hiking and canoeing. Produced for general audiences, *Discovering Alabama* is also designed as an interdisciplinary teaching. Teachers' Guides have been published for several of the videos, and others are being developed. The series is a production of the Alabama Museum of Natural History in cooperation with Alabama Public Television.

Mobile-Tensaw Delta

Just south of Mobile Bay lies Alabama's Mobile-Tensaw Delta, named for the juncture of the Mobile and Tensaw Rivers. Among U.S. river deltas, the Mobile-Tensaw is second in size to the Mississippi River Delta. It, like other major river deltas of the world, has served as a natural attraction to early adventurers and as a globally significant wetland. Host Dr. Doug Phillips canoes the delta to examine its historical role in the exploration and settlement of the New World and its present status as a remarkable natural resource increasingly subject to competing human uses.

Cheaha Mountain/Talladega National Forest

The Talladega Division of the Talladega National Forest contains the southernmost reaches of the Appalachian mountain chain, which extends approximately eighty miles into northeast Alabama and includes the state's highest peak, Cheaha Mountain, elevation 2,420 feet. Host Dr. Doug Phillips hikes several miles along the Chinnabee Silent Trail, a footpath constructed in the Talladega National Forest by scout troops from the Talladega School for the Deaf. Along the way, Phillips describes local history and explores many of the natural features of the area. He is joined by a group of elementary school students who climb Cheaha Mountain with him and discover the value of learning in the wondrous classroom of the outdoors.

Cahaba River

Host Dr. Doug Phillips canoes a segment of the Cahaba River in northern Bibb County where the Cahaba lily grows, describing many natural features of the river and stopping for a close-up look at the rare lily. Joined by a fisheries biologist from the Alabama Department of Conservation and Natural Resources, Dr. Phillips discusses a number of concerns about environmental changes along the river. This program is the first of two ***Discovering Alabama*** programs featuring the Cahaba River. A second program, entitled the **Cahaba River Watershed**, explores the full length of the Cahaba and examines changes affecting the entire watershed.

Southeast Alabama/Wiregrass Region

Because southeast Alabama lacks prominent features like the mountains of north Alabama or the beaches of coastal Alabama, it is a region that is sometimes overlooked by those seeking such natural attractions. However, in this program, Dr. Doug Phillips reveals that the southeast part of the state is quite rich in natural qualities with their own special wonder. Phillips travels across several southeast Alabama counties exploring a variety of unique features from the historically and biologically significant wiregrass region to the caves and sinkholes of adjoining limestone areas and visits the Conecuh National Forest.

Oakmulgee Division/Talladega National Forest

Host Dr. Doug Phillips sets out from his own tract of Tuscaloosa County farm and forestland into the adjoining Oakmulgee Division of the Talladega National Forest. With camera crew in tow, Phillips invites viewers on a casual interpretive walk across the Oakmulgee to the National Forest Recreation Area, Payne Lake. Along the way, he examines a variety of plants and animals that live in the Oakmulgee and discusses the importance of maintaining such forestlands.

Lake Guntersville State Park

Few places can match Alabama's Lake Guntersville State Park for its combination of mountainous natural setting and full scale accommodations for recreation. Dr. Doug Phillips explores both of these and other facets of the park's popular appeal, giving particular emphasis to the potential of the area's natural surroundings for helping to recover the endangered bald eagle, America's national symbol. Included is a visit with the park naturalist, who leads a group of children on an interpretive nature walk and discusses the importance of environmental education for America's youth.

Coastal Alabama-Natural Diversity

Alabama's coastal area, though relatively small in size, is diverse in natural qualities. Series host Dr. Doug Phillips journeys across most of Alabama's coastal region exploring the area's rivers, bays, swamps, marshes, and beaches, together with numerous resident plant and animal species. He is joined at various points by local naturalists and wildlife officials to discuss environmental change in the region.

Coastal Alabama-Environmental Issues

Host Dr. Doug Phillips highlights a range of primary environmental issues when he revisits coastal Alabama and examines several of the leading causes of environmental change in the region. Included are interviews with local experts who add their perspectives to the discussion of activities such as farming, forestry, commercial fishing, and overall growth and development on the coast of Alabama.

Tannehill State Park

Tannehill Ironworks Historical Sate Park has one of Alabama's best displays of buildings, tools, and other lifeway artifacts dating from the period of early European settlement to the time of the first iron making in the state. Host Dr. Doug Phillips presents many of these important cultural features in the context of the park's natural features. Phillips explores Alabama history through visits with teachers at the park's "living history" classroom, discussions with craftsmen who have reconstructed historical log buildings, and visits to the park's unique Iron and Steel Museum of Alabama.

Little River Canyon

Host Dr. Doug Phillips hikes the seventy-mile length of the Little River from its northeast origins near the Alabama-Georgia state line into the final fifteen-mile segment of Little River Canyon. Along the way Dr. Phillips describes the river and the canyon, discusses various features of the area, and recounts several points of local history. The show's opening segment recreates the mid-19th century experience of Union troops who encountered the impassably deep Little River Canyon by surprise as they hurried through Alabama with Confederate troops in pursuit.

Caves of Alabama

With almost 3,000 caves, Alabama ranks among only a few states that have such an abundance of subterranean wonder. Host Dr. Doug Phillips takes viewers on an actual exploration of an unmapped cave in north Alabama. During the journey, Phillips and an accompanying caving expert encounter many common features of caves and discuss how caves are formed, the diversity of geological and biological features that occur in caves, and the history and location of caves in Alabama.

Oak Mountain State Park

More than 10,000 acres in size, Oak Mountain State Park is Alabama's largest state park. The park also happens to be located only minutes from Alabama's largest city, Birmingham. Host Dr. Doug Phillips leads viewers on a hurried escape from the crowded urban scene of downtown Birmingham to the serene setting of Oak Mountain with its forested ridges, valleys, streams, and abundant wildlife. Phillips discusses the geological origin of Oak Mountain, its early history, and the natural attractions of the area as he hikes through the remote reaches of the the park. Later, he is joined by a Birmingham area teacher and her students who regularly visit the park for nature study.

Locust Fork River

Dr. Doug Phillips takes a personal journey when he canoes part of the Locust Fork River in a nostalgic return to the site of his childhood home. But as Southern writer Thomas Wolfe observed in his novel, *You Can't Go Home Again*, things change - for better or worse. On this journey, viewers will learn of the river's past and explore crucial questions about its future. For much of this century, the Locust Fork was familiar only to the residents of its immediate watershed. In recent times, the river has gained attention as more Alabamians recognize its uncommon appeal and as more citizens have grown concerned about changing land practices that pose environmental threats to the river.

Moundville

This video features Moundville Archaeological Park and the mound-building Indian culture of the prehistoric Mississippian Period that lasted from around A.D. 1000 to 1550. The program examines the symbols, beliefs, and the lifeways of this once dominant southeastern culture and traces two centuries of archaeological study attempting to understand these early Native Americans and the significance of their earthen mounds. This video links the science of archaeology with the timeless human quest to understand the meaning of life. The story of Moundville offers a unique opportunity for interdisciplinary instruction in history, social studies, science, geography, and environmental education.

Alabama's Natural Diversity

Alabama often has been viewed as a backwoods region without sophistication. Yet many high-growth urban areas in our country have become synonymous with a stressful lifestyle often associated with noise, traffic, pollution, and crime. In comparison, Alabama's backwoods are no longer equated with being backward. This video presents an overview of Alabama's natural qualities from the state's Appalachian highlands to its coastal wetlands. Alabama's great variety of terrain, of wild habitats, and of native plants and animals ranks the state among the most naturally diverse in the nation. As other parts of our country lose their native natural qualities, Alabama's wildlands help to make our state exceptional.

Geological History of Alabama

This video presents a brief overview of the geological history of Alabama and describes natural resources in the state. As far back as the 18th century, geologists from other countries were attracted to Alabama by reports of the region's diverse geology. Since then, researchers have pieced together the history of how the landscape and life forms found in Alabama have changed over time. This video follows those changes, from the Earth's formation through the major geological eras (Paleozoic, Mesozoic, and Cenozoic) of the fossil record, and concludes with the recent scientific question of whether industrial societies cause environmental changes that may accelerate geological change.

A Walk in the Woods

The fields, streams, and woods that once surrounded our schools are being replaced rapidly by shopping areas and adjoining parking lots, while bulletin boards, overhead projectors, and computers are now the primary sources of information. In this video, viewers take a walk in the backwoods and encounter nature on a basic level, a theme which runs throughout the video using quotations from famous Native Americans. Even with the many material advances of our industrial society, we remain dependent upon fundamental processes in nature. The program does not seek to deny the value of technology; rather, the video's essential purpose is to underscore the importance of remembering that our natural environment is the basis of life.

Alabama Forests

Alabama is one of the most forested regions in the world. The state contains scores of forest communities that provide an abundance of natural habitats, home to a great variety of native plants and animals. A healthy forest is more than merely a collection of trees. It is a setting in which the whole is greater than the sum of its parts because its parts - soil, water, wildlife, various plants and trees - work together to form a self-perpetuating natural community, or ecosystem. This video describes the importance of forests in Alabama while also exploring forest history and key concerns for the future of Alabama's forests.

Dauphin Island

Dauphin Island is unique among barrier islands because of its special natural qualities and its important role in the history of American settlement. The island has a diversity of natural habitats including marshlands, forests, and lakes. The island also attracted a variety of early explorers including the Spanish, the French, and the English. This video presents both the natural and the human history of Dauphin Island and describes the forces of geological change to barrier islands. The video concludes by looking at environmental changes occurring to the island from modern growth and development and examines the question of how to manage such activities for the island's future.

Black Warrior River

The Black Warrior River has been prominent in the history and development of Southeastern societies since the emergence of prehistoric cultures many thousands of years ago. In fact, the river's name was taken from the famous Native American Chief Taskalusa (derived from the words *tasska* and *luska* meaning **black warrior**) who encountered the De Soto expedition in 1540. This video recalls the history of the Black Warrior River from the time of early human settlement to the present. We examine the river both in terms of its environmental role and its economic importance, with special focus given to the river's changing status since the construction of a series of dams and locks completed earlier this century.

The Sipsey Wilderness

This video explores Alabama's Sipsey Wilderness Area and tells about the environmental controversy associated with a citizen campaign to preserve the Sipsey in the 1970s. Efforts to gain federal protection for the Sipsey Wilderness sparked an angry national debate revealing society's conflicting desires both to subdue nature and to preserve nature. The video traces this duality from early civilizations to the present, giving particular focus to the rapid settlement of the American frontier. Dr. Phillips recalls the influence of 19th-century romanticism and the emergence of a national movement for the preservation of American wilderness regions.

Village Creek

One of the South's earliest industrial cities is Birmingham, Alabama, a place known for its history of iron and steel production. Often forgotten, however, is the history of Birmingham's natural features that were essential to the establishment of this city. One of those features is Village Creek which flows through the heart of the Birmingham area. Village Creek was originally a pure stream extending across a fertile valley that attracted settlers to the region for the purpose of farming in the early 19th century. As the Industrial Age advanced, Village Creek changed dramatically and has now become a prime example of how uncontrolled urban growth can change the native landscape. This video traces the history of Village Creek and examines the value of urban planning as a means of maintaining a high quality of life in urban areas and preventing environmental degradation.

Wildlife History

Our nation is rooted in a rich, natural heritage that helped define our national identity. Central to this heritage is the history of our society's changing relationship with wildlife. This video gives an overview of Alabama's role as a national leader in wildlife conservation and restoration.

Red Hills Salamander

This video follows a team of research scientists as they go on an actual search for the Red Hills salamander and examine the ecological significance of this threatened species. Private landowners, along with wildlife officials, develop strategies to conserve the salamanders' habitat.

Horse Pens 40

Located atop Chandler Mountain in St. Clair County, this site is a unique ring of large rocks forming a natural corral, used by Indians and settlers for gathering horses, and today operated as a commercial attraction. This video shows the cultural values and natural beauty of historical Horse Pens 40.

Alabama Adventure

Using beautiful nature footage from throughout Alabama, this special presentation is a visual feast accompanied accompanied by a continuous musical background for viewers who delight in Alabama's forests, beaches, fields, mountains, rivers, flora and fauna.

Long Leaf Ecosystem

Experts now believe that the Long Leaf ecosystem was at one time the single largest forest ecosystem in the south. This video highlights on-going efforts to better understand and perpetuate the Long Leaf Ecosystem.

Wetumpka Impact Center

In an 1891 report, state geologist, Professor Eugene Allen Smith, noted that the area around Wetumpka was "structurally disturbed". In this video, Dr. Phillips, along with expert geologists, examine evidence that suggests the altered landscape around Wetumpka is the result of an ancient asteroid collision.

Alabama Trees

In this program, host Dr. Doug Phillips takes an autumn stroll through Alabama woods to introduce viewers to individual members of the forest community and answer the commonly asked question, "shat kind of tree is this?"

Native American Festival

This show reflects on Alabama's native heritage as we learn the importance of the Native American Festival held each year at Moundville Archeological Park. The show features Native Americans as they demonstrate arts and crafts unique to the Indian culture, play games from long ago and listen to stories about primary tribes, tribal territories, and basic lifeways.

Arboretums

Highlighted in this video are four of Alabama's arboretums and their significant contribution to the preservation of our native plants and trees.

Mobile River Basin

Few places boast such an abundance of freshwater as our state of Alabama. Join host Dr. Phillips for a journey across 44,000 square miles of the Mobile River Basin, a freshwater drainage encompassing most of Alabama.

Fort Morgan

Visit historic Fort Morgan and witness an active archaeological dig, take a trek through an ancient maritime forest and witness the capture, banding, and release of migratory birds. Fr. Phillips talks to local residents in presenting the past and considering the future of Fort Morgan Peninsula, one of Alabama's best coastal wonders.

Fort Toulouse/Jackson

Take a journey back in time for a visit to Fort Toulouse/Jackson State Park and the park's annual Frontier Days Festival. Meet Alibamous Indians, French soldiers, Davey Crocket, Andrew Jackson's regiment, and converse with 18th century botanist William Bartram while also learning about the natural appeal of the location.

Sipsey River Swamp

Launch a canoe with Dr. Doug and discover the wild allure of the Sipsey River Swamp. The 100-mile long Sipsey River is one of Alabama's few remaining unimpounded rivers, much of it surrounded by river-bottom swamp.

Forever Wild

Alabama's "Forever Wild" land conservation program is recognized nationally for its effectiveness in protecting significant wildlands. This video reflects on the history of how the "Forever Wild" program was established and tells how Alabamians can participate in promoting such land conservation.

Dugger Mountain Wilderness

The Dugger Mountain Wilderness contains Alabama's second highest peak, Dugger Mountain, and is one of several federally designated "wilderness areas" in the state. In this program, Dr. Phillips hikes through the wilderness as he follows the Pinhoti Hiking Trail. Along the way, he encounters many natural wonders while considering the citizens, scientists, and government officials interested in protecting the area.

Earth Day

This video visits Selma, Alabama to join the local school system's annual celebration of Earth Day. Interviews with teachers, students, parents and various officials highlight the significance of this national day of environmental appreciation and give special emphasis tot the importance of environmental education throughout the school year.

Tuscaloosa County

The era of "new south" progress has brought important improvements to the southern region. However, parts of the South are also experiencing rapid growth and development that could threaten such traditional southern qualities as abundant natural surroundings and a comfortable pace of life. This video examines Tuscaloosa County, Alabama as an example of a southern community affected by accelerating new-south growth and faced with the challenge of managing this change so as to protect local rural and environmental values.

Alabama Soils

Host Dr. Doug and faithful companion Turkey journey across Alabama to examine the seven major soil areas of the state and learn about the more than 300 soil types associated with these areas. Guest experts discuss the vital ecological function of healthy soil and highlight the importance of Alabama soils to the state's economic and environmental health.