"Cultivating Agriculture Knowledge"

"Plant A Seed In Tennessee"
“Cultivating Agriculture Knowledge”

6th - 8th Grade Curriculum

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Acknowledgments

The following lesson plans and activities are adapted from various resources that are included in the Teacher Resource Library provided by the Tennessee Foundation For Agriculture In The Classroom. The purpose of this curriculum is to make available lessons that are correlated to the TerraNova instrument (which is used in Tennessee). It is not our intention to replace textbooks or conventional educational materials, rather to enhance these materials with hands-on activities. The lessons, for the most part focus on agriculture’s role in natural resource management, especially water quality. Educators who receive this curriculum at one of the University Workshops conducted by the Tennessee Foundation For Agriculture In The Classroom also receive many other lesson materials that focus on agriculture while teaching problem solving skills, science, math, nutrition and language arts objectives as recommended by the Tennessee Department of Education. This curriculum contains adaptations of lessons from the following sources, as well as others.

  
  Project Food, Land & People, Resources for Learning  
  American Farm Bureau Federation  
  Tennessee Beef Industry Council  
  The University of Tennessee Institute of Agriculture  
  Natural Resources Conservation Service  
  United States Department of Agriculture  
  National Cattlemen’s Beef Association  
  National Association of Conservation Districts

Many of the activities have been used in a variety of lesson plans over the years, and we do not claim to have created “all new” lessons... we merely adapted and compiled a group of lessons to introduce you to “Agriculture literacy”. Agriculture literacy is knowledge about agriculture, the source of our food and fiber.
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Point source pollution of ground water can originate from a variety of situations. These include leaking pipes, faulty landfills, and underground tanks. However, many storage tanks were placed underground for various reasons; gasoline, fuel, and chemical waste products were used and continue to be used, to store petroleum contamination, chemical waste, and industrial waste.

Ground water testing to discover the source of contamination has been a practice for many years. Many years ago it became a practice to bury storage tanks underground. These tanks were used and continue to be used, to store petroleum products (gas and oil), chemicals, and industrial waste.

The student will describe how point source pollutants move through ground water. They will analyze data from test wells and identify point source contamination. 

The student will translate their data to create a poster. 

The student will identify the sources of pollution and the locations where their data will be used.
Contamination: A True Story

When contaminants dissolve in or are carried by ground water, they move the direction of ground water flow. If water is being pumped from a well near the pathway of the flowing contaminants, the pollutants are likely to be drawn up into the well along with the water. Contaminants seeping underground from concentrated masses are called plumes. These plumes resemble the smoke from a chimney, only underground. The concentration of the pollutant is high near the source of contamination, and dilutes as it spreads further from its origin. The shape and size of these plumes are influenced by several variables, including the physical and chemical properties of the contaminant, the rate at which materials are added to the contaminating source, the action of wells pumping or withdrawing ground water, and the rate water moves through the substrate.

When it was discovered that pollutants from leaking underground storage tanks had been affecting ground water supplies, new legislation was established to regulate existing tanks and strengthen environmental protection criteria for new tanks. For example, the use of underground tanks requires extensive leak-monitoring equipment and less corrosive tank materials. In many instances, old tanks are removed and replaced with updated tanks (sometimes above ground), and monitoring equipment is installed along with the tank. This is done for liability purposes; it cost far less to replace tanks than to clean up after one has leaked. Millions of dollars are currently being spent to clean many sites with leaking underground tanks.

However, leaking underground storage tanks are not the only threat to ground water quality. Septic tank systems, hazardous waste sites, sanitary landfills, and wastewater disposal ponds also pose threats.

Not all contaminants have an odor. They can go undetected in a drinking water supply if it is not regularly tested. City water is frequently tested for contaminants. People who use private wells must have their water supply tested regularly.

GETTING STARTED

Prepare a cup by poking several holes in the bottom of it. Then fill this cup with a mixture of sand and grape-flavored drink mix. Also fill a baking dish with sand to a depth of 1.2 inches (3 cm) and elevate one end of the pan for the demonstration.

PROCEDURE

1. Introduction

   A. Show students a cup of sand mixed with grape-flavored drink mix and ask if it appears to be clean. Pour water onto the cup and allow water to filter through; it should pick up the drink mix and turn purple. Have students ever heard of a situation where water in the ground got contaminated? How was the source of the contamination detected? Tell students that sometimes clues help to locate the origin of underground pollutants.

   B. Fill the clear baking pan with sand to a depth of 1.2 inches (3 cm) and elevate one end of the pan 2.4 inches (6 cm). Make a small hole in the sand at the elevated end of the pan and bury a small pile of grape-flavored powder in the hole. Tell students the powder represents a substance that has been stored underground. Ask students to predict what will happen when you spray water on the pan. List reasons for their predictions on the board.

   Represent years of rainfall by gently spraying the pan with water for 5 to 10 minutes (or until the sand is saturated). Lift the pan and show the bottom. A streak of purple should originate from the source and follow the flow of water as it filters downhill. Discuss student observations. Explain that the streak of "contaminant" is
called a plume. Tell students that since the source of the contamination can be identified, the pile of powder is known as point source pollution. What if a community well field or homes with private wells were pumping water from the formation through which the plume was traveling? Discuss how drinking water could be affected by the underground contaminant.

2. Ask students to form small groups. Each group is a well drilling company (team) that tests ground water quality. Give each team an aluminum cake pan filled with 2.4 inches (6 cm) of sand. Have each group mark the outside of one end of the tray with an "X."

3. Tell students to bury a small pile of lemonade-flavored powdered drink mix somewhere in the sand. Have them sketch a map showing where they have hidden the contaminant, then switch pans with another team.

4. Distribute the Project Bitter Water Blues Background, Procedures, and Data Sheet. Have students complete the investigation and record their results. Each team should compare their results to the maps made by the teams that hid the contaminant.

Ask students to share what they observed. How did they use the results of the pH tests to locate the contaminant? Ask students if they had enough pH test papers to pinpoint the source of the contaminants. If they were given an unlimited supply, could they guarantee that the source could be accurately located? In a real situation, would testers have unlimited time and resources?

Explain that in reality underground storage tanks can contain fuel oil or radioactive materials. Discuss what problems could arise if these materials leaked into water supplies. What challenges do students think there could be to cleaning ground water?

Students may be interested in researching what steps their community is taking to avoid ground water contamination from storage tanks, septic tank systems, sanitary landfills, chemical landfills, or wastewater disposal ponds.

**EVALUATION OPTIONS**

Have students:

1. -simulate ground water testing methods (step 3).

2. -identify a source of contamination using simulated ground water testing methods (step 3).

3. -cite challenges to locating and cleaning underground contamination.

**EXTENSIONS AND VARIATIONS**

Students can also compare the length and size of plume formations in different soils.

Prepare five clear baking pans as follows:

- **Pan #1**: 1-inch (2.5 cm) depth of sand (this pan remains level)
- **Pan #2**: 1-inch depth of sand, (elevate one end about 1 inch)
- **Pan #3**: 1-inch depth of sand (elevate one end about 2 inches (5 cm))
- **Pan #4**: 1-inch depth of gravel (elevate one end about 1 inch)
- **Pan #5**: 1-inch depth of a mixture of equal amounts of sand and gravel, (elevate one end about 1 inch)
- **Pan #6**: 1-inch depth of soil (elevate one end about 1 inch)

Make a small hole in the sand at the elevat-
ed end of each pan, and bury a small pile of grape-flavored powder in the hole. Ask students to predict what will happen when you spray water on each pan. List reasons for their predictions on the board. Spray each pan with water and discuss student observations. Ask them to summarize how the size and shape of sand particles and slope influence the shape and size of the plume.

Have students investigate the real costs of drilling test wells. Why would these costs vary among regions (depth of water table, hardness of substrate, access to site, etc.)?

Have students collect newspaper articles that convey information about ground water contamination within their own community, region, or state.

RESOURCES


EDUCATOR'S NOTES
Ground Water Contamination - A True Story

People in a community noticed the smell of petroleum in their basements and in their well water. The fire department was notified because residents feared an explosion would occur in their homes. (A few days earlier, a manhole cover was blown off by ignited gas vapors.) Because this was an obvious public health threat, an intense effort was made to locate the source of the petroleum. Was it a leaking pipeline? Old diesel fuel tanks in the basement of a neighbor’s abandoned house? The gas station at the end of the block? These were among the many possible sources of gas leaks. The health department limited the possible sources by mapping places that had identified petroleum odors and by determining the intensity of the fumes. They knew that as the concentration of petroleum smells increased, they were likely getting closer to the source. They narrowed the search further by drilling test wells to measure the petroleum content in ground water. After a few weeks of testing and systematic elimination of potential sources, officials located the origin: an abandoned underground gas tank. Apparently, the tank had been leaking for more than a decade before the plume reached the sewer systems and basements. The plume, flowing in the direction of ground water, was approximately one mile long, several feet wide, and several feet deep. An engineering company was contracted to clean the ground water. The process was time consuming and costly.
Project Bitter Water Blues:

Your Task: Conduct water quality tests and locate the leaking underground storage tank in your community.

Background:
In the fall of 1995, the ACME Lemonade Corporation closed its manufacturing facilities. This action took place amid allegations that the company had secretly been producing a highly bitter unsweetened brand of lemonade. Since the plant closed, the buildings and all above-ground evidence of the site have been removed. Recently, a few people living in the area have developed strange symptoms---puckered lips leading to sour dispositions.

The Challenge:
The ACME Lemonade Corporation is suspected of abandoning a large storage tank filled with a vile, unsweetened lemonade product that has leaked into the local drinking water supply. With limited resources, you must track down and describe the extent of the spreading chemicals before the pucker effect strikes full force.

The Tools:
An environmental TESTING DRILL RIG (a straw)

The Hygiene-O-Matic SANITATION STATION (a beaker of water)

A multi-million dollar, TESTING LABORATORY (pH test paper)

Hints: The chemical leaked by ACME produces a telltale acidity when combined with water. Acidity can easily be measured by using a system of pH values. Ordinary tap water will leave test paper blue, while the contaminants turn it green.

WARNING: Resources are limited. Find the leaking underground storage tank with your allotted number of test papers or risk the pucker effect for every citizen.

Procedures

1. Write the name of your team and student's names on the data sheet.

2. Elevate the end of the pan that is marked with an "X" 1 inch (2.5 cm).

3. Sketch a picture of the pan on the data sheet, top view.

4. Fill a misting bottle with water, test the pH of the water, and record the reading on the data sheet. After the test paper has dried, affix it to the data sheet. This is the normal color of the water without contamination.

5. Simulate a gentle rain by misting the site with water for 5-10 minutes. MIST SLOWLY; no surface runoff should occur.
6. Fill SANITATION STATION with water. Rinse DRILL RIG with water.

7. Begin collecting and testing as follows:
   a. Place the DRILL RIG over the most likely location of the contaminant plume.
   b. Press the DRILL RIG down into the soil.
   c. Plug the top of the DRILL RIG with your finger. (Avoid losing any of the sample!)
   d. Lift the DRILL RIG from the soil.
   e. Place a small quantity of the collected sample onto the edge of the pH test paper (TESTING LABORATORY).
   f. Observe and record the test results.
   g. Rinse (sterilize) the DRILL RIG to eliminate contaminating the next sample.
   h. Repeat steps a through g until you have used all of your pH test papers or until you think you have found the contamination site.

8. Record the location of each test site on the data sheet by affixing the dried test paper to the location.

9. When the contamination site is found, mark the location on the data sheet with a large "X."

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Project Bitter Water Blues:

Data Sheet

Team Name _____________________________________
Teacher:______________________________________
Team Members___________________________________________________________
Date:_________________________________________

Misting Water pH Value:__________________________ Affix Paper Here  X

SITE MAP

MARKED WITH AN “X”

RAISED END OF TRAY

LOW END OF TRAY
BRIEF DESCRIPTION
Our water can become polluted very easily. Everyday activities can contribute to water pollution if their consequences are not weighed in advance.

SUPPORTING INFORMATION
The soil and water that we depend on for our food and oxygen are in danger! We hear about tankers that spill oil in the oceans, and how toxic waste can pollute our soil around factories. The “superfund” has been set up to pay for cleaning up these “large” problems. But a larger scale problem exists when individuals forget that every day activities can result in pollution if we are not careful.

Chemicals that are used on farms in very small amounts are sometimes sprayed on lawns to kill pests without regard to the label directions. Farmers have to be certified pesticide applicators. They keep accurate records on the location and amount of chemical applied to food crops. Our law requires that they keep up with federal regulations and protect both their crops and the environment. Home owners, on the other hand apply chemicals at higher rates and without recording vital information. Some products that we use everyday can cause damage to our environment when they are not disposed of properly. Used motor oil, salt (used to melt snow and ice), leftover paint and old batteries are just a few items that cause problems. When was the last time that you heard a news story about any of these items? The liquids that drip out of a vehicle can cause a small spot on the parking space. Multiply that spot by a few hundred sitting at a shopping center and the spot would be bigger. Now

LEVEL: 6th grade
SUBJECT: Health
SKILLS: describing, understanding cause and effect
OBJECTIVES
The student will
- learn the many causes of water pollution from human waste to industrial dumping.
- make their own sample of water pollution.
- examine causes and effects of pollution and come up with solutions to this problem.
- understand that their actions can make a difference in the quality of water.

ESTIMATED TEACHING TIME
1 class period

MATERIALS
Materials needed for 10 groups of 2
- 10 plastic jugs with the top cut off
- water to fill the container approximately 1/4 full
- 1/4 cup of oil for each group (cooking oil)
- lawn fertilizer (flour and green jello, enough to make the water green)
- candy wrappers or pieces of paper
- 10 plastic 6 pack rings
- popcorn or other snack
- detergent (powder)
- 10 instruments for stirring (suggest using straws or sticks)

VOCABULARY
pollution, fertilizer, compost, detergent
think what happens when a rain washes the spots off of the parking lot. Where does the dirty water go? Does it magically become clean? The water does get “cleaned” in a sense. The pollutants usually end up in the soil that the water runs through. But what happens to this soil over time?

Farmers use filter strips near streams to “catch” the chemicals that could run off of their fields and end up in a creek. Filter strips are areas adjacent to streams that are not tilled or disturbed. This allows the water that runs off to be “filtered”. The chemicals (fertilizers and pesticides) are used by the plants in the filter strips and produce food and shelter for wildlife. The water that reaches the stream is clean, especially when compared to the water that runs off of our streets and parking lots.

Another part of the problem involves the amounts of chemicals applied. Farmers have soil samples analyzed to determine the amount of fertilizer to apply for a particular crop. Since fertilizer cost money, farmers use only as much as is needed by the crop. Any more would be a waste of money. Some home owners take soil samples, but the majority just apply as much as they think the lawn or garden needs. “If a little will do good, a lot will do better” is often the idea behind chemical application at home. With just a small yard or garden, doubling the amount of chemical does not cost very much… so put all you want. This is a large source of the pollution attributed to farms. Most people live in a home that has a yard, but less than two percent of our population produce the food that we all enjoy. The next time you hear about agriculture polluting the environment, think about the real source.

**GETTING STARTED**
Gather materials

**PROCEDURE**

1. Read the story of Pam and Phil. Stop after each section to discuss with the students problems and alternatives.

2. When the story and discussion are completed, begin making your own polluted water. Refer to the board before adding each item to the water.

3. Put the oil in the water, just like Dad did.

4. After the oil is added to the water, ask students if they would like to drink this water. Ask why not.

5. Put the fertilizer in the water, just like Mom did.

6. After the lawn fertilizer is added, ask students if they would like to swim in this water. Ask why not.

7. Put the candy wrappers and plastic rings in the water, just like their friends threw on the ground.

8. After the candy wrappers and plastic ring are added, ask the students if they would like to fish in this water. Ask why not. Remind the students how plastic rings are dangerous to animals.

9. Put the popcorn, detergent and salt in the water.

10. After the popcorn, detergent and salt are added, ask the students if fish, ducks, and insects can live in this water. Ask why not.

11. Stir the water around to illustrate rain.

12. Discuss what can be done differently to keep the water clean. Put the answers on the board.
13. Have the students re-write the story of Pam and Phil noting alternatives to using products and correct disposal of trash.

HELPFUL HINTS:
- Cat or dog food and cat litter in plastic jugs will work best. Clear plastic shoe boxes or storage boxes will also work. It is not recommended that milk or water jugs be used because they are not sturdy enough.
- The purpose of the green jello is to illustrate fertilizer and to color the water a bit. The only other powder found that will change colors is pistachio pudding mix however, the water does not change that much.
- Any tool will work to stir the water. If you use straws, make sure the students do not blow in them - they might inhale by mistake.
- Make sure the plastic rings are cut up before disposing of them.
- For older students use real fertilizer and do pH testing before and after the pollution is made.
- Add leaves and grass to the mixture because they get washed away during rain.
- Add other ingredients as necessary to recreate the story being used.
- Change the story to meet individual class needs.

EVALUATION OPTIONS
1. Have the students write an essay describing how water becomes polluted and what they can do to prevent it.

2. Have the students create artwork.
   "Polluting Our Waters."

RESOURCES
Water Use in the United States, July 16, 1998
http://www.water.usgs.gov/watuse (as of July 23, 1999)
PAM AND PHIL

It was a bright sunny Saturday morning. Phil stopped by Pam's house to pick her up. They were going to the mall, to meet their friends. Just as they were about to leave, Pam's dad stopped them.

"Hey, you two," said Dad. "How about helping me change the oil in my car. I'll show you how to do it!"

"But we are going to the mall!" Pam said.

"You have all day to do that, I want you to help me." Dad said.

Soon all three were on their hands and knees, watching the thick dirty oil pour into the pan. Once the oil had drained, Phil poured the new, clean oil into the engine through the funnel. Then Dad carried the pan of dirty oil to the curb and poured the oil down the sewer drain. When Dad returned to the car, Pam closed the hood.

(Discuss what Dad did wrong and alternatives to dumping the oil - write alternatives on the board - recycling the oil)

Pam and Phil said good-bye to Dad and set out to take a short cut through the back yard. "Hey, you two," Pam's mom said. "I really could use your help here in the garden."

"But we have to get to the mall," Pam said. "We just helped Dad, can't we go?"

"There is plenty of time to go to the mall. Weeds are everywhere and if you want to eat these vegetables, you need to help me." said Mom. "Come on, I'll show you how we can make that broccoli you love so much grow really big!" In a short time Mom had sprinkled a lot of green powdery fertilizer around the garden.

(Discuss what Mom did by using chemical fertilizers without a soil test - write alternatives on the board - soil test, using compost)

"Now, why don't you water the garden," Mom said. "I don't think it's really going to rain today like the weatherman said."

Phil found the garden hose in the driveway. He turned the water on full blast and watered the garden for a long while. With all that water, some ran off the sloping garden and into the street and down the sewer drain.

"Thanks for your help," said Mom. "Now you can go to the mall. Don't be too late." Pam and Phil
continued on their way. They passed the Andrews’ house. Mr. Andrews had trash piled up at the end of his yard including a big bag of rock salt from last winter and a very soggy box of laundry detergent. Pam and Phil had to walk over it. "I wish Mr. Andrews would either put that stuff up or throw it away," said Pam. "I'm tired of walking around it, and it looks disgusting!"

(Discuss what Mr. Andrews is doing wrong and correct disposal of trash - write alternatives on the board)

Finally Pam and Phil got to the mall and went to their favorite spot. Sure enough, Joe and Carla were already there drinking cokes and munching on candy bars and popcorn.

"Want a soda or something?" asked Joe.

"Sure," said Pam and Phil. They pulled the last two cokes out of the six pack ring and threw it on the ground along with the candy wrappers that Joe and Carla had thrown there.

(Discuss what Pam, Phil and their friends are doing wrong - write alternatives on the board)

Suddenly, Pam asked, "Do you feel rain?"

"Oh, yeah," said Carla. "Maybe we should go inside the mall."

In just a moment, a black cloud swooped over them and rain came pouring down. All four of them ran into the mall. The candy wrappers, popcorn and six pack holder got washed away.

Later that day the sun came out again. The corner outside of the mall looked as good as new. Mr. Andrews' bag of rock salt and box of laundry detergent were even more soggy than before. In the muddy garden, flowers on the vegetables were beginning to bloom. The driveway was spotlessly clean.
PUDDLE SECRETS

BRIEF DESCRIPTION
Many farmers create ponds or “permanent puddles” on their farms to be used by their livestock as well as wildlife. Great Blue Herons and Canada Geese are frequent visitors. This lesson allows students to explore puddles, understand mapping techniques and observe those served by the puddle.

LEVEL: 6th grade
SUBJECT: Health, Math
SKILLS: analysis, classification, comparing similarities and differences, computation, description, discussion, drawing, estimation, measuring, mapping, observation, inferring

OBJECTIVES
- The student will predict where puddles will form and how they will change,
- observe and describe organisms that live in or near puddles,
- measure and record the amount of water in puddles,
- make inferences about what types of organisms occupy puddles.

ESTIMATED TEACHING TIME
2-3 class periods

MATERIALS
pencil, data sheets, measuring instruments (rulers, yardsticks, tape measures), string (for use in making measurements)

VOCABULARY
puddle, wildlife, area, depth, volume, area, pi, accumulation, grid

SUPPORTING INFORMATION
Water flows downhill and for a variety of reasons it sometimes stops flowing. When this happens a puddle, pond, lake, or inland sea is formed. Puddles form in low spots or depressions in the land’s surface. Water gathers in depressions until the holding basin is filled to capacity. Then the water flows out on the downhill side. Depending on the size of the puddle, water may be trapped for some time. If the puddle lasts for several days, there is a strong possibility it will be visited by wildlife.

As an example, one of the most amazing life histories is that of the spadefoot toad. Spadefoots spend most of their adult life underground. They emerge at night to feed on insects and other invertebrates during warm weather. In extreme cold or hot weather these toads stay hidden.

Immediately after the first heavy rains of summer, spadefoots emerge to mate. The female lays between 300 and 500 eggs in temporary puddles and ponds. The male goes into the puddle or pond and externally fertilizes the eggs. The eggs hatch and the tadpoles complete their development in 10 to 12 days hopefully completing their growth before the water dries up!

Many other toads and salamanders also use temporary puddles and ponds for their reproduction. What advantage could a temporary pond have over a permanent pond? One favored theory is that temporary ponds have no fish to prey on the eggs or tadpoles. Freshwater shrimp such as fairy shrimp and tadpole shrimp also utilize temporary puddles and ponds to reproduce. One-celled
animals, aquatic insects and other invertebrates also use puddles for reproduction. Many species of flying insects such as butterflies, wasps and flies visit puddles and appear to "suck" from the mud at the puddle's edge. They are getting vital salts and other minerals from the mud.

Some animals, swallows and mud-dauber wasps, may visit puddles for mud building materials for nests.

Other animals may visit the puddle to bathe or drink. Many animals take advantage of temporary puddles and ponds to reproduce, thus completing the animals' life cycle.

Studying ponds and lakes and the life forms found in and around them is a primary concern to many aquatic biologists. Some of the techniques these biologists use can also be duplicated by students examining schoolyard puddles. Size, depth, circumference, cause of accumulation and the identity of transient animal life can be determined by simple observations and measurements.

The major purpose of this activity is to increase the students' appreciation of the value of something as apparently humble as a schoolyard puddle!

GETTING STARTED
Prepare a set of materials for each group of students.

PROCEDURE
1. Begin with a discussion about rainfall and runoff. Where does the water come from? Where does the water go? When water ceases to run off a surface, a puddle forms. Tell the students that the class will make a study of the smallest body formed as water flows across the land—the puddle! If necessary in drier climates, a few puddles could be created by using buckets or a hose.

2. Divide the students into teams of three to five members. Send the teams outside on the schoolgrounds to make observations and predictions about where puddles will form in a rain storm. Have each team of students prepare a map of the school, showing the location of the predicted puddles. Also have the students make a comprehensive list of all the forms of wildlife that can be seen on the school site. Look for birds, insects, rodents, worms, mammals, and reptiles, etc. Ask the students to look beyond direct observation and also find indirect evidence of wildlife, like tracks, droppings (scat), slug trails, feathers, ant hills, etc. Keep these maps and wildlife lists for later use following the storm.

3. After a storm, when there are puddles on the schoolgrounds, send the teams outside again.

They should again map the schoolgrounds, this time locating the actual position and gross dimensions of the puddles on their maps. They should find the area of one or more puddles.

Round Puddles
Area = \( \pi r^2 \) (\( \pi = 3.14 \): it is a mathematical constant) \( A = 3.14 \times r \times r \) =
Area = Length (average) \times Width (average)
Average Length (La) = \( L1 + L2 + L3 / 3 \)
(3 is the number of measurements)
Average Width (Wa) = W1 + W2 + W3/3

\[ A = La \times Wa \]

The team should also determine the volume of water in one or more puddles. Before that number can be calculated, the average depth of the puddle must be measured. There are many ways to determine the average depth. Either of two methods shown below can be used:

METHOD 1
1) Establish a grid on the surface of the puddle, (Lengths of string tied to rocks or nails pushed into the soil anchor the strings.)
2) Measure the depth at every place the strings cross. (See the small arrows on the drawing.)

METHOD 2
1) Imagine a grid on the surface of the puddle.
2) Measure the depth every place the imaginary lines come together

Use the following formula for average depth (Da). There are ten measurements of depth shown in the example on the previous page.

\[ Da(average) = \frac{D_1 + D_2 + D_3 + D_4 + D_5 + D_6 + D_7 + D_8 + D_9 + D_{10}}{10} \]

Now the volume can be calculated:

\[ Volume = La \times Wa \times Da \]

4. Once all the measurements have been taken for each puddle--or during the same period of time while at a puddle--the team should also make observations about wildlife. Each team should list any species of animal for which they have direct or indirect evidence of using the puddle in some way. Ask them to organize their observations in a written form.

For example, they could list: species; evidence; apparent uses of puddle by species; estimated number of animals of this kind using the puddle

5. Back in the classroom ask each team to report. Discuss their findings. Compare similarities and differences in the teams' findings. Ask the teams to compare their early predictions about the puddles and wildlife with their actual findings. After all the reports are finished, ask each team to make a summary statement of one minute or less reflecting the inherently fascinating nature of the under-appreciated puddle!

**EVALUATION OPTIONS**
1. How would you determine the amount of water in a puddle? Explain your method.
2. Describe common characteristics of animals that use puddles. Explain the value of puddles to these animals.

**EXTENSIONS AND VARIATIONS**

1. Keep a record of these areas of accumula-
tion over the seasons. What similarities occur? What differences? Ask the students to calculate how much water is "caught" each year by the puddle they studied.

2. Find relatively permanent puddles (small ponds) and carry out the same observations as those done with the playground puddles.

3. Biologists sometimes need to know what the underwater surface of a pond is like. They want to find out where the pond is shallow and where it is deep. They use the same gridwork approach used in the procedures above. The difference is that they keep a record of the change in depth along a straight line. See the drawing below:

When you do this on all the lines, you can get a good approximation of the shape of the puddle bottom.

4. Repeat this "Puddle Secrets" activity using metric measurements.

RESOURCES

CREDIT

EDUCATOR’S NOTES
Traditionally, water diverted to storm water drainage systems. Before storm drainage systems were common, cities experienced localized flooding because of poor or nonexistent drainage patterns and flooded sewer systems that overflowed with storm water. Both circumstances caused significant health and safety concerns that warranted solutions. Today, most city governments require housing developers to install city-approved storm water drainage systems.

Removing water quickly and efficiently from city streets, parking lots, and schoolyards following precipitation is an important task for municipal governments. Water flowing through city drainage pipes is often referred to as an urban watershed. Before storm drainage systems were common, cities experienced localized flooding because of poor or nonexistent drainage patterns and flooded sewer systems that overflowed with storm water. Both circumstances caused significant health and safety concerns that warranted solutions. Today, most city governments require housing developers to install city-approved storm water drainage systems.

Traditionally, water diverted to storm water systems received little or no treatment before flowing into a stream or body of water. Environmental agencies found that water draining off lawns, sidewalks, driveways, parking lots, and streets carried significant amounts of pollutants. These pollutants included fertilizers, motor oil, litter, pesticides, animal waste, and other contaminants. Receiving waters were degraded and aquatic plants and animals were affected. Some communities resolved the problem by channeling storm runoff into a wastewater treatment plant. But this is an expensive procedure, and some plants are unequipped to process the inorganic materials found in urban runoff. A more cost-effective system was needed to treat storm water discharge. The scenario below describes such water treatment system.

Imagine the parking lot of a large shopping center. Each year thousands of cars park in the lot, each depositing a small amount of pollutant in the storm water system.
engine oil and grit (loosened road materials). A gentle rain begins to wash the lot. At the lot's lowest point, oil and gas-tainted runoff water begins to flow into the street's gutter. A few blocks away, an urban river flows, filled with floating debris, sediment, and multi-colored water from another street, then another, and another. The flow now nearly fills a ditch constructed to channel urban runoff. From a distance the storm water in the drainage system appears dark-colored. Perhaps the road salt used to melt ice on roads and sidewalks has mixed in. How about the paint a neighbor pours into the gutter? The pet waste near the sidewalk? Whoosh, more water moves by! What next? What about the nearby stream and the people using water downstream for their drinking supply?

You follow the water to a large pond that the city constructed to catch storm water. The water in the pond is now moving slowly through cattails and other emergent wetland vegetation, and its color has started to change. (Some plants such as cattails are capable of breaking down toxic substances and are being used in this manner to clean up waste sites, urban runoff, leachate from old landfills, etc.) Where is the debris and the sediment? (The debris and settlement are trapped here.) And what about other waste materials? (Other waste materials may be trapped or broken down by bacteria and other decomposers.) A woman from the city health department tests the water as it enters a small stream; she concludes that the water is cleaner than the river it is about to enter.

Solutions to urban storm water pollution problems require participation by everyone. Homeowners can help by carefully following directions when applying pesticides and fertilizers, using biodegradable products whenever possible, cleaning up pet wastes, not disposing of household wastes in the street, and fixing oil leaks in vehicles. City sanitation departments can supply information on proper disposal procedures for paint cleaners, used oil, or leftover paint. In addition to developing wetland systems to help treat urban runoff, many city governments periodically sweep roadways to remove wastes. They plant greenways and preserve green space to help filter runoff from streets and parking lots.

**GETTING STARTED**
Prepare a can or bottle labeled “chemicals” or “oil”.

**PROCEDURE**
Show students a can or bottle labeled "chemicals" or "oil". Tell students you need to dispose of the chemicals and plan to dump them in the street in front of the school. Ask students if they think this is a good idea. Have students describe what they think will happen to the waste material. Read the first paragraph of the scenario in the SUPPORTING INFORMATION. Ask students what they think might happen to the runoff.

Following are two options for simulating urban runoff being collected within a storm drain system.

**Option I**
1. Discuss how water is used to clean things, such as the surface of a table after a spill. Relate how rainwater washes the outdoors. Explain that as it flows over plants, soil, and sidewalks, it picks up and carries away soil and other materials. Inform students that cities use water to clean the waste from city streets and sidewalks. Often the water goes down storm drains, collects in pipes, and flows to a river or treatment plant. (If a media center or water table is available, younger students can use pieces of tubing and plastic pipe to construct a mini-water transport system. They can explore how pipes help water travel over distances by pouring water into one end of a tube.
2. Draw a simple but large maze on the school blacktop or arrange the chairs in the classroom to form the maze. The maze represents underground pipes that collect and transport surface water that has flowed down storm drains. Have students run the maze. Inform them they are water flowing through the drainage pipes to the river or treatment plant.

3. Discuss sources of water that run into the storm sewer system (streets, lawns, parking lots, etc.). What might this water carry? (Oil from cars, fertilizers, litter.)

4. To simulate surface water transporting pollutants into drainage pipes, have several students position themselves along edges of the maze. They represent storm drains and the contaminated water flowing through them. They should hold pieces of self-sticking paper or bowls of flour to symbolize the pollutants. When other students run through the maze, the students representing storm drains stick pieces of paper or sprinkle flour onto the clothing of the maze runners (if appropriate clothing is available!) to represent contaminated water mixing with water (that may or may not be clean) flowing through the system. Allow students to take turns playing different roles.

5. After several trips through the maze, discuss what happens to this dirty water. What if it flows into the river? Can treatment plants process all the waste? Have students summarize why they should not litter.

6. To represent a treatment system, have two students stand at the maze exit. Similar to the game London Bridge, the two treatment students "trap" each passing water student and remove as many pollutants as possible before he or she goes into the river. What are students attitudes about the quality of this water passing into the river?

**Option 2**

Prepare or have students make mazes representing storm pipes carrying away street runoff. Build each maze on a piece of cardboard covered with wax paper. The walls of the maze are made from clay or modeling dough. Coat the walls and floors of the maze with wood glue and allow to dry. (Allow one day for clay to dry, and one day for glue to dry.)

The maze should have one starting point and two exits. One exit leads to a sewage treatment plant, and the other flows into a stream. Use a wax pencil to label the exits.

3. Have students list materials people purposefully or inadvertently add to gutters and storm drains. Have students draw a picture of a city street depicting these activities. They can switch drawings with a partner to see if their classmates can identify the polluting activities.

4. Place drops of food coloring, salt water, and sugar water mixed with pepper on different places in the maze. Allow one day for the water to evaporate. Drops of oil can also be placed at certain locations. These all represent contaminants added to urban waste systems.

5. Tell students to place a large drop of water at the starting point and to tilt the maze so that the drop flows slowly toward one of the exits. Toward which one should they aim?

6. As the drop flows through the paths, it should pick up dye from the food coloring, particles from the salt and pepper, and possibly oil droplets. This represents water moving through a municipal storm water system.

7. When the drop reaches the exit, have students describe what the drop looks and feels like. If it ended in the treatment plant, the drop...
gets replaced with a clean drop of water. If it ended in the overflow ("untreated" water—exit), the drop is added to a cup labeled "stream."

**Summary and Discussion**

1. Discuss the problems associated with untreated urban runoff entering rivers or other bodies of water. Have students identify or research ways contaminated water affects aquatic life and drinking water supplies.

2. Introduce students to the many actions people can take to limit contaminants entering urban runoff. These include properly disposing of pet waste and litter, and discarding chemicals and oils according to manufacturer's directions. Inform students that many cities have developed systems to treat runoff. Refer to the scenario in the SUPPORTING INFORMATION and read the second paragraph.

3. Have students contact their local wastewater treatment plant or public works department to determine whether their street runoff enters the treatment plant or if it flows directly into the river or filters into ground water systems.

4. Students may want to begin a storm drain monitoring program. This involves sending messages to the community illustrating how and why it should monitor what flows down streets into storm drains. Students can design a brochure describing ways individuals can reduce their contribution to surface and ground water pollution via urban runoff. Students can contact recycling centers, wastewater facilities, or their state department of natural resources to research ways individuals can reduce the amount of fertilizers and pesticides they use, choose alternatives to home and garden chemicals, and safely dispose of household wastes. If the city or county recycling office has a hazardous waste collection program, this could be included in the brochure as well.

5. In addition to the brochure, students can start a stenciling program. Students can make or purchase a stencil (see Resources) with a message about monitoring what flows down storm drains (e.g., "DUMP NO WASTE-DRAINS TO STREAM"). The stencils are used to spray-paint the message on neighborhood storm drains. Students can include information about the stenciling and its intent in their brochure, which they deliver to community members who live near the drains. Make sure students obtain permission from city or county public works departments before beginning the project.

**EVALUATION OPTIONS**

Have students:

1. Identify urban sources of pollution.

2. Design mazes to simulate storm water drainage systems.

3. Explain why certain materials should not be dumped into the street or used carelessly.

4. Design a brochure describing steps individuals and communities can take to prevent surface water contamination.
EXTENSIONS AND VARIATIONS
Students can research alternatives to house and lawn chemicals and cleaning agents. Contact the local recycling center, the waste treatment facility, or a local environmental group for details. Invite a representative from the local water treatment plant to enrich the activity. Visit a local gas station and have the manager explain what happens to oil after cars are serviced.

RESOURCES


The Water Education Foundation, 717 K Street, Suite 517, Sacramento, CA 95814. (916) 448-7699.

For information on storm drain monitoring and stenciling programs, contact:

Step Coordinator, Oregon Department of Fish and Wildlife, P.O. Box 59, 2501 S.W. First Avenue, Portland, OR 97207.

Earthwater Stencils, 4425 140th SW, Rochester, WA 98579.

Center for Marine Conservation, 306A Buckroe Avenue, Hampton, VA 2366.
BRIEF DESCRIPTION
In this lesson students learn to separate perceived risk from actual risk. By calculating actual risk factors and writing persuasively students learn how perceptions can be influenced.

SUPPORTING INFORMATION
A is for ... alar? A few years ago alar was used on apples as a growth retardant and was used to hold apples on the tree so they would become more red from exposure to the sunlight. Alar also slowed down the deterioration of apples in storage. It was also used on golf courses to reduce the amount of mowing and in greenhouse plants to keep plants compact as bedding plants and gift plants such as poinsettias that are grown during short day length periods which cause plants to elongate. It's use, however, touched off a well publicized controversy about food safety and chemical residues. "I think the controversy overshot the mark in terms of creating anxiety about the food supply and apples in particular. But it brought to public attention that we ought to change our laws."
-Linda Fisher, Environmental Protection Agency

As our nation becomes better fed and conquers immediate survival threats, do we obsess about dangers that are based solely upon our perceptions? Arguably, many threats today are perceived -- they may or may not be backed up by hard data. Can your group name any problems in the U.S. today that are perceived as critical, yet may not be the real situation. Can they name some perceived threats that are very real, in terms of data and research?

GETTING STARTED
Prepare materials.
PROCEDURE

1. Ask the students the following questions:
   - Do you know a myth when it's heard? Ask the person relaying the myth to cite their source, and then analyze the information. Does it contain facts, or only opinions, beliefs, and value judgements?
   - Watch cartoons on TV that talk about the environment.
   - Do they contain facts?
   - Do they appeal to emotion or are they logical?

We can measure substances in very minute quantities -- one part per million, billion, or even trillion. Does that mean that the substance may have an effect at this quantity? You make the call!

Say "Today we are going to determine if a risk is perceived or real, and how to tell the difference."

2. Activity I

Separate participants into groups of three or four. Hand out The Poisoned Peanut Butter sheet to each group. Give the groups a few minutes to complete the sheet (they may need calculators).

Discuss the importance of this calculation. Would it be common for someone to eat a toxic amount of pesticides from food? Do they think people worry about this happening?

3. Activity II

Hand out two copies of STUDENT SHEET 2 to each participant. Explain that they will write two separate news stories about a fictitious study report that concludes that drinking apple juice causes illness in children.

For the first news release, they should write the story so that it shows the most amount of risk. They should use the information in the text box from STUDENT SHEET 2 to make the story emphasize risk. They can use the space at the bottom of STUDENT SHEET 2 to write the report. Remind them that a good news release gives the "who, what, where, when, why,and how"of the story.

For the second news release, participants should write a story that minimizes the risk felt by the reader. Again, they can use the information from STUDENT SHEET 2. After they finish, let each person read their releases. The group can try to guess which story emphasizes risk and which one minimizes risk.

Ask participants if they think that the media (newspapers, television, radio, etc.) accurately portray risks. See if your group can cite recent examples to support their opinions (or they can bring in some articles to share). What types of stories dominate the media? Are the risks they portray perceived to be important or likely by, your group?

Summary and Discussion

Does everything have a risk, or potential effect? For example, we need oxygen to breathe, but living in a room of pure oxygen would kill us. What are some things that make risk seem worse than it really is? Does the media influence risk perception?

EVALUATION OPTIONS

1. Use the calculations on the student worksheet to assess comprehension. (The correct answer to the calculation is 803,571 sandwiches per day to get the equivalent dose of pesticide.)

2. Have the students write an essay about “The Methods Used by the Press,” “Perceived vs. Actual Risk,” “Living in a World of Risk,” “Life is a Series of Trade-offs,” or “How We Are Influenced.”

3. Have student research and write about
recent scares and what the final outcome was. Ask them to address what the science actually found about major news story scares of the past decade (most have proven to be untrue.)

EXTENSIONS AND VARIATIONS
1. Invite a journalist or others to join your group and critique your press releases, sharing their opinion about the media and risk communication.
2. Interview someone who has had a news article or story written or reported about them. Ask whether or not the journalist made correct quotes, backed up the facts, had corroborating evidence or hearsay, etc..

EDUCATOR’S NOTES
A is for ... alar? A few years ago alar was used on apples to help regulate their growth. It's use, however, touched off a well publicized controversy about food safety and chemical residues. "I think the controversy overshot the mark in terms of creating anxiety about the food supply and apples in particular. But it brought to public attention that we ought to change our laws.
-Linda Fisher, Environmental Protection Agency

The Poisoned Peanut Butter.
Joe wanted to eat a peanut butter sandwich. He went to the kitchen and began spreading the crunchy spread onto some raisin bread. His friend Max grabbed the sandwich before he could take a bite.

"What are you doing, trying to kill yourself?" said Max. "I heard that peanut butter has pesticides in it!"

"What?" exclaimed Joe. "I'm hungry give me my sandwich."

"Nah" said Max, "I'm going to save you from yourself. Don't you know that lab rats keel over big time when they eat this stuff!"

"Yeah, right" hissed Joe. "Like I wouldn't already be dead. This is my third sandwich today. I ate two yesterday. Four on Saturday. Gee, I must be a walking zombie and not even know it."

What do you think? Is Max right? The pesticides found in the peanut butter DO harm some laboratory rats. But at what dosage or amount? Let's do some simple calculations. All numbers are approximate.

Highest residue concentration of Pesticide Y ever detected in peanut butter tests: .01 milligram of pesticide per kilogram of peanut butter (or .01 part per billion).

Amount of peanut butter to make a sandwich: .5 ounce or .014 kilogram

Weight of Joe: 100 pounds or 45 kilograms

Concentration that harmed a laboratory rat: 2.5 milligrams of pesticide per kilogram of the rats body weight each day.

How many sandwiches would Joe have to eat everyday of his life to get the same dose that the laboratory rat did? Assume highest dose in each sandwich:

1. A sandwich would then contain .01 milligram x .014 kilogram (weight of peanut butter in sandwich)
   = ______________ total milligrams in sandwich

2. Amount of pesticide Joe would need each day to get toxic dose: 2.5 milligrams x 45 kilograms
   = __________ total milligrams

3. Amount of sandwiches Joe would have to eat each day to get a toxic dose:
   answer #2 / answer #1 total milligrams of pesticide in each sandwich = _____# of sandwiches

What do you think? Could Joe eat this many sandwiches every day of his life?
What do people fear?

Generally, they will worry more if:

- there are many fatalities per event (airplane crash) versus fewer (deaths from falls);
- there is a high probability it will happen (lung cancer among smokers) versus low probability (rare diseases);
- the fatalities are grouped in space and time (large industrial explosions) versus dispersed (automobile accident deaths);
- there are irreversible consequences (AIDS) versus reversible ones (chicken pox);
- victims are identifiable (person lost in mountains) versus unidentifiable (highway fatality estimates);
- there are unfamiliar risks (chemical residues) versus familiar risks (household accidents);
- the exposures are involuntary (air pollution) versus voluntary (sunbathing);
- there is little personal control over the outcome (airplane travel) versus some control (driving an automobile);
- there is much media coverage (airline crashes, drive-by shootings) versus little media attention (on-the-job injuries).
WHICH GROUP ARE YOU IN?

LEVEL: 7th grade
SUBJECT: Health
SKILLS: researching, comparing and contrasting, analyzing, problem solving

OBJECTIVES
The student will
- compare two citizen groups, special-interest groups, or government agencies involved in the same issues.
- create visual representations of the two groups.
- explain ways students can become involved in the civic action process through participation in such groups.

ESTIMATED TEACHING TIME
2 class periods over the course of several weeks

MATERIALS
scratch paper, copies of telephone directories, list of organizations and agencies, two copies of Student sheet per team, large sheets of colored or white paper, drawing materials, scissors (optional)

BRIEF DESCRIPTION
Democratic systems depend on the involvement of citizens in policy and decision making. This activity will help students learn about the roles and responsibilities of citizen groups in environmental policies and decision making, and how young people can become involved in the process.

SUPPORTING INFORMATION
Democratic countries are founded on the principle that all citizens have the right to participate in policy-setting and decision-making processes. Civic participation is especially evident in environmental issues and policies. In the United States, there are currently over 10,000 environmental organizations; and new ones are being formed each year. Young people are not usually involved in setting policies, yet they are greatly affected by the decisions made by governing bodies. For example, each time the local school board meets, it makes decisions that both affect students and determines what school is like for them. Board members might decide whether to adopt a schedule of year round classes, which textbooks to use, what the requirements will be for graduation, whether to change the length of the school day, or when vacations will be scheduled. Similarly, local, state, and federal governments constantly decide on issues that touch students in many aspects of their lives. Those issues might include health standards, traffic regulations, rules for recycling, or laws about other environmental choices. Young people can take part in social decisions and policy making in many ways. They can join a group that represents their interests. They can write letters to lawmakers or other influential parties. They might even ask to sit on local boards or councils as student advisors. Your local telephone directory is a good resource for locating gov-
ernment agencies, associations, and other
groups working on a particular topic. The blue
pages usually list government agencies or
departments; the yellow pages list businesses,
associations, groups, and clubs; and the white
pages list both individuals and many organiza-
tions also found in the yellow pages. Your
local library will have other, specific directories
that list organizations nationally and interna-
tionally. The internet is an excellent source of
information

GETTING STARTED

Draw a large coat-of-arms on the chalkboard
or on a large sheet of paper for the students to
see.

PROCEDURE

1. Ask students to jot down a list of five or six
things that interest or concern them. Their list
might include hobbies they have, animals they
care for, sports they like to play or watch, or
crime or health issues they care about. Invite
volunteers to share their ideas.

2. Explain to students that they will have an
opportunity to learn about groups that have
interests or concerns similar to theirs. They
will try to find out what issues those groups
deal with and how the groups try to influence
decision-making processes. Have students
look over their lists and circle three items they
would like to learn more about.

3. Divide the class into teams of two to four
students who have similar interests. To do this,
ask a student to share his or her first choice;
then ask students with a similar interest to join
that student’s team. (If no one else is interest-
ed in the topic, try the student’s second or third
choice. If the team becomes larger that four
students, divide it into smaller teams.)
Continue this process until all students are on
a team.

4. Ask each team to find two interest groups,
organizations, or agencies that are involved in
making decisions about the team’s topic.
Explain that after teams have located two
groups, students are to contact each group’s
offices to get written information and to ask
questions. (Give each team two copies of the
questions on the Student Sheet. If a team
finds a local citizens’ group, they can contact
one of its members to answer the questions.
(When writing to any group, try to include a
self-addressed, stamped envelope, which will
greatly increase the chance of a reply.

5. Give students time to brainstorm ideas
before starting their search. Have telephone
directories available to help students gather
ideas and contact sources. If a team can’t get
started, offer suggestions. For example, if the
team is interested in animals, you might sug-
gest that they try the local humane society or
the Agricultural Extension Service. If they are
interested in health issues, you might suggest
they contact the local Red Cross chapter or
state health agencies. Students might also call
the local chamber of commerce or city offices
(like the city council or the mayor’s office) to
ask if there are any committees that address
their issues.

6. Allow time for students to contact and ques-
tion members of their two groups, and to
receive necessary printed materials.

7. When all teams have completed the student
page, give each team two large sheets of
paper. Have them draw the outline of a coat-
of-arms on each, similar to the one you drew
earlier. Ask students what a coat-of-arms is.
(It is an emblem that represents the identity of
a group.) Assign teams the task of designing
two coats-of-arms, one for each group they
researched. The coat-of-arms should have six
sections, each with a drawing or symbol that
represents the group’s answers to the ques-
tions on the Activity Sheet.

8. Have teams share the designs and describe
what they represent. Lead a discussion on the
value of civic action, using the coats-of-arms
as a basis for your discussion:

* What similarities did you find in the two
groups you researched? What differences?
* How are both groups you researched the same? In what ways do they differ?
* Why are groups like these important?
* What might happen if either of the groups you researched did not exist?
* In what ways can people take part in policies and decisions in our community? In the state? In the nation?

**EVALUATION OPTIONS**
Assess student’s comprehension by examining coats-of-arms and student worksheets. For example, how successful were they at getting answers to their questions? How well do the coats-of-arms communicate the identity of the researched organizations? How well does the design identify issues the organization deals with? Does it reflect their views on issues?

**EXTENSIONS AND VARIATIONS**
1. Instead of having teams conduct their own research, invite a local representative from each of several organizations with different perspectives on an environmental issue to speak with your class. The guests might be from groups such as the Audubon Society, Nature Conservancy Bureau of Land Management, National Association of State Foresters, state forestry associations, and outdoor sports group, or a citizens’ group.
   A. Have the class interview the guests by asking questions from the Activity Sheet, plus any other questions students think of. (Guest can come on different days or give a panel presentation.)
   B. Afterward, as they answer the questions on the Activity Sheet, students should use information and impressions gained from the guests.
2. Help class members choose an environmental issue or topic about which they would like to learn more. For example, they could choose forests, water, recycling, landfills, endangered species, or a current local topic.
   A. Invite representatives of groups with different views to speak to the class about their group’s positions on a topic and to answer student questions.
   B. Have students prepare questions for each interviewee in advance.
   C. After the interviews use a class discussion to compare the groups’ positions on the issue or topic.

**RESOURCES**

**EDUCATOR’S NOTES**
GROUP PROFILE

Team’s Topic

Group’s Name

Contact Person

Name

Phone Number

1. What are the overall goals of the group?

2. What does the group do to influence decision making about the topic? (Examples might include lobbying, making recommendations to lawmakers, or encouraging members to write letters to lawmakers.)

3. What important issue is the group working on right now?

4. What is the group’s position on that issue?

5. How is this group different from _________? (your other group)

6. How can someone become a member of the group?
SUPPORTING INFORMATION

Natural and Synthetic Pesticides

We naturally assume that the foods we buy - whether fresh, frozen, or canned - are safe to eat. Yet, recent news stories have presented information about pesticide residues in fruits and vegetables and the possible risk of cancer they pose to our health. Should we be concerned? The consensus among medical experts is that there is a greater risk of getting cancer and other diseases by not eating fresh fruits and vegetables than that from consuming minute amounts of pesticides.

When thinking about pesticides and food safety, it is important to consider several factors:

* The sophistication of modern detection methods
* The new generation of synthetic pesticides
* Naturally occurring plant pesticides
* Consequences of not using pesticides
* Safety testing in place to assure both public health
* Safety for the environment
* Safety and effectiveness of the chemicals in use

Today, we are able to detect levels of contaminants in parts per billion (ppb) that were undetectable just a few years ago. As technology continues to improve, we may routinely detect amounts
as small as one part per trillion, or one part per quadrillion. So how do pesticides at these levels affect us? Essentially, we are unable to eat or drink enough of a product to be affected by pesticides present at parts per billion and lower levels.

The nature of manufactured pesticides has changed dramatically over the last 30 years. The new pesticides break down faster in the environment, are effective in smaller doses (often at ounces per acre rather than pounds per acre), and are targeted to be harmful only to specific organisms. For example, a compound called glyphosate (found in Roundup® herbicide) works by interfering with plant photosynthesis. Because insects, birds, and people do not carry on photosynthesis, it has no serious effect upon them. And glyphosate is degraded by microorganisms found in the soil in days, so it does not accumulate in the environment.

Most plants naturally produce chemicals that act like pesticides. By weight, we ingest at least 10,000 times more of these natural pesticides than residues of manufactured pesticide. And chemicals are chemicals, whether they are naturally-occurring or manufactured.

Finally, we need to consider the possible consequences of not using pesticides. To protect our food crops, farmers and ranchers around the world must compete with approximately one million insect species, a thousand species of harmful nematodes, hundreds of weed species, and enough varieties of fungi to cause 1,500 plant diseases. Without pesticides to control molds, much of our food supply would rot and consumer health would be at risk, since molds in high enough concentrations can be lethal. For example, without the use of pesticides to control fungi, celery would produce its own natural pesticides, called psoralens, which can cause a severe skin reaction in humans. The use of a fungicide prevents this from happening.

**Regulating Food Product Safety**

Pesticides are regulated by federal and state government agencies. Often states have regulations more strict than the federal requirements. At the federal level, pesticides are regulated by the Environmental Protection Agency (EPA) under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Federal Food, Drug and Cosmetic Act. No pesticide can be legally sold or used in the United States unless its label bears an EPA registration number and establishment number. The EPA approves a pesticide only for specific uses. The label tells where and how the pesticide may be used. A number of pesticides are labeled as "restricted use" pesticides, and only certified applicators may use these products.

Before being registered, pesticides are subject to extensive testing to insure that, when used properly, they will not present unreasonable risks to human health or to the environment. The EPA calculates safe, lifetime human exposure levels called the Acceptable Daily Intake, or ADL.

These safe levels are determined by using the most sensitive laboratory animal species - usually rats - to find the No Observable Adverse Effect Level, or NOAEL, and dividing it by 100 or 1,000 in order to provide a margin of safety for children, the elderly, or especially sensitive individuals.

Using worst-case levels seemed to be the sensible approach to product safety when the government first began testing pesticides. Given how much our level of scientific knowledge has changed, these methods still being used by the EPA are believed by many scientists to be inaccurate indicators of product safety.
Food Safety and the Delaney Clause

In 1958, the Delaney Clause was signed into law to protect public health by safeguarding our food supply. The Delaney Clause prohibited additives in processed foods that were shown to induce cancer in experimental animals. It allowed for zero tolerance. Any product that had a detectable amount of an ingredient known to cause cancer was banned, regardless of its potential benefits. However, at that time, scientists were able to detect substances only in parts per hundred.

Since then, the nature of pesticides and the means of detecting them have changed. We now routinely detect substances in parts per billion, and even in parts per trillion. This means that the same foods tested in 1958 and declared to be safe would today be considered contaminated merely because technology allows us to detect the presence of a mere handful of molecules.

In 1996, after years of urging and recommendations by leading scientific groups, the U.S. Congress repealed the zero-tolerance Delaney Clause and passed the Food Quality Protection Act (FQPA) to keep up with new technology. The law establishes additional safety standards for agricultural chemicals used on food crops, and requires major supermarkets to provide consumer information on the risks and benefits of agricultural chemicals and how to reduce exposure. Implementation of the FQPA provisions will take place over the next few years.

Irradiation and Food Safety

Some people get nervous at the thought of irradiated food, which they believe is radioactive and dangerous to human health. However, irradiation technology has been around for 40 years and is being used to sterilize medical supplies, surgical instruments, makeup, personal hygiene products, as well as the food eaten by astronauts and patients with compromised immune systems.

Much like pasteurization, food is irradiated to rid it of insects, parasites, and microorganisms that produce spoilage or disease. Irradiation destroys insects, fungi, parasites and bacteria such as Salmonella, E. coli, Listetia and Trichinella that cause human disease and food spoilage. Food can be kept longer, and in better condition.

Food passes through a radiation field at a set speed to control the amount of energy that passes through the food. Both the speed and the amount of radiation are computer controlled. The irradiated food no more radioactive than your luggage is after passing through airport security, or your teeth are after an X-ray at the dentist. Irradiated food is as nutritious as food preserved by any other method, and poses absolutely no health risk. In fact, there is currently no way to detect whether or not a food was irradiated, because there are no residues to use as indicators.

Animal Product Safety

The Food and Drug Administration (FDA) is responsible for monitoring and regulating the use of animal health products. Very strict regulations exist for drugs used to treat animals and how long after treatment the farmer or rancher must wait before butchering animals, or selling their milk. These drugs also are tested to make sure they are safe for humans.

Milk production is one of the most regulated food production processes. Recently, concerns have been raised about the use of bovine somatotropin, or bST, to increase milk production. Cows naturally produce bST, which shows up in their milk. The genetically engineered
bST simply enables more efficient milk production. Tests have shown that supplemental bST does not change the amount normally found in milk, which is completely safe, natural and harmless. bST is an inactive hormone in humans.

The USDA makes sure that all meat processing follows strict guidelines and handling procedures to insure that the meat is not contaminated. Department of Agriculture inspectors test meat animals for more than 400 drugs, pesticides, industrial chemicals and heavy metals. Still, bacteria are present in raw meats and most of the food poisoning cases in the United States occur because of mishandled food at home, not in institutions and restaurants. Ultimately, proper hygiene and safe food handling and preparation methods (such as thorough cooking) are our best protection from accidental food poisoning.

Food Safety and Acceptable Risk

Risk is a part of our daily routine. We get in our cars knowing there is a risk that we might be involved in an accident. We watch toddlers take their first steps knowing there is a risk of them falling and getting hurt. We allow our children to eat grapes and peanuts even though there is a possibility they could choke to death on them.

There are certain things we can do to minimize risks. We can wear seat belts and drive defensively. We can move toddlers away from furniture with sharp edges, and keep unsafe items like electrical cords out of their way. We can encourage our children to chew their food before swallowing it, and to not talk when their mouth is full. But, even with these measures, we realize there is still a certain degree of risk. Nothing is 100% safe.

We come to believe that certain benefits far outweigh the amount of risk involved. The risks involved in food safety should be no different. Yet, sometimes, information gets distorted and it is difficult to determine exactly what the risks are. Misinformation occasionally causes products to be taken off the market when there is no reason to do so. For example:

1. Cyclamates and saccharine, both artificial sweeteners, were banned even though in the case of saccharine, a person would have to drink over 800 cans of soft drinks a day for years to reach the point where they might risk getting cancer. The public uproar over saccharine has kept it on the market despite the fact that the FDA has ordered it to be re-tested and has restricted its use to that of a controlled, over-the-counter table-top sweetener. Cyclamates on the other hand still have not regained approval.

2. Alar, a growth regulator used on apples to keep them from dropping off the tree too early, was removed from the market because of a media scare that linked it to cancer in children. However, a child would have to eat 28,000 pounds of alar treated apples daily for 70 years in order to cause any tumors at all to occur.

3. Atrazine, a popular herbicide, is frequently detected in ground water supplies, particularly in the Midwest during the approximately three month growing season, when farmers apply a one-time application to their fields. But the levels detected, even during times of peak usage, are so low that a person would have to drink 154,000 gallons of water a day just to reach the EPA's No Effect level of 20 parts per billion. Yet, there is a move to ban atrazine.

We have the right to expect that the food we buy is safe to eat, and our water safe to drink. But we also need to realize that nothing is ever going to be guaranteed 100% risk-free. We
need to weigh the benefits against the risks and decide if the risk is acceptable. If we do this we will find that our food supply is one of the safest in the world. And while there are certainly risks involved, they do not come from the pesticides, chemicals, or technologies used to produce them.

Before the EPA approves a substance it is tested extensively on rats. These rats are either force-fed or injected with the substance at a level thousands of times higher than a human could possibly consume. This means that, at a high enough dose, even the safest substances will cause death or cancer in rats. These test results are then applied to humans and many otherwise safe products are removed from the market, or never approved in the first place. Saccharine and cyclamates are examples. Alar was not banned by the EPA as is supposed by most people. It failed to be proven harmful. Meryl Streep got involved and created the uproar. Emotional displays won out over overwhelming science.

GETTING STARTED

Make copies of “Food Safety Facts” and Food Safety Quotations” pages for each student

PROCEDURE
Activity I
1. Divide the plants into three groups and label each group.

2. Each plant in Group A is to be “watered” with 50 mL of pure vinegar daily.

3. Each plant in Group B is to be “watered” daily with 50 mL of tap water to which one drop (or .05 mL) of vinegar has been added.

4. Group C is the control group. Each plant will receive 50 mL of tap water daily with NO vinegar added.

5. Make sure conditions for all three groups of plants are the same with the exception of what they are watered with. Keep the watering containers used for each group separate and marked so as to not accidentally use a contaminated watering container on a different group of plants.

6. Record the changes in the plants on a daily basis. Alternate ways that this can be done is by taking pictures, or using a video camera to record changes. Continue for two weeks.

Activity II
1. Break the class into student groups of 5-6 students. Ask each group to create a listing of the questions they may have concerning food safety.

2. Share the supporting information as appropriate during the activity.

3. Distribute copies of the “Food Safety Facts.”

4. Have the students use their questions and the Food Safety Facts to create questions for a “Jeopardy” type game. Have them assign points as a difficulty level for their questions from 10-100. Have them write the question on a 3"X5" card with the point value on the back. As they do this create categories for the game to be played on the board.

5. Combine the groups’ questions and play the game with the class.

Activity III
1. Hand out copies of the “Food Safety Quotations” to each student.

2. Ask the students to write a news article concerning the safety of the food system based upon what they have learned from this lesson
and select one or more of these quotes to support their story.

**EVALUATION OPTIONS**

1. After the first day have the students hypothesize what the result will be of each watering solution upon the plants. When the activity is completed have the student assess the impact on their plants using the following questions.

   A. The plants “watered” with vinegar (died), (showed no effect) (grew rapidly).

   B. The plants “watered” with the water/vinegar mixture grew at rates similar to the plants “watered” with (vinegar), (tap water).

   C. Was the small amount of vinegar harmful to the plants? (yes) (no)

   D. Is watering the plants with pure vinegar a good way to estimate the type of damage that a plant would receive from a tiny amount of vinegar? Explain.

   E. How would you design a better test to determine the effect vinegar in the environment might have upon plants?

2. Can you drink vinegar? Will it hurt you? Do we eat food containing vinegar? (pickles, salad dressing, sweet and sour Chinese food, etc.) Does it hurt us? What do you think the effects would be if you drank the same amount of vinegar as the plants were watered with on a daily basis for two weeks?

3. Can the results of something that is toxic to one organism be applied to whether or not it will hurt another organism? What can you say about the reliability of the rat tests used by the EPA?

   "To sell nothing except foods untreated by pesticides would not only leave storekeepers with rotting food, but would also fail to protect the consumer against molds that in high enough concentration can be lethal. People who are so worried about pesticides fail to realize that the cancer rates have dropped over the, past 40 years."

   C. Everett Koop, MD
   Former US Surgeon General

   "Manufactured chemicals, such as dioxin, are believed to cause less than 1% a all cancers. When people are exposed to the small amounts of such chemicals usually found in the air, water, soil and food, they have very little added risk getting cancer."

   American Institute For Cancer Research (AIRC)
1. The quality and abundance of our food supply is due to modern agricultural practices which include the use of pesticides, animal medications and sanitizers.

2. A pesticide is a generic term used to refer to substances used to kill or control pests.

3. Most plants are capable of producing their own natural pesticides. We ingest at least 10,000 times more of these natural pesticides, by weight, than we do of synthetic pesticide.

4. Chemicals are chemicals, whether they are naturally-occurring or manufactured.

5. Detection alone does not mean contamination. We are now able to routinely detect amounts in parts per billion (ppb). This means we can now detect things we previously could not.

6. One part per billion is the same as 1 second in 32 years, or 1 cent in $10 million.

7. One part per trillion is the same as 1 second in 32,000 years, or 1 cent in $10 billion.

8. Manufactured pesticides have changed over the last 30 years. They are increasingly less toxic, break down faster in the environment, are effective in much smaller amounts, and are more likely to be harmful only to specific organisms.

9. At the federal level, pesticides are regulated by the Environmental Protection Agency under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Federal Food, Drug and Cosmetic Act. No pesticide can be legally sold or used in the United States unless its label bears an EPA registration number and establishment number.

10. Pesticides are subject to extensive testing before being registered to insure that when used properly they will not present unreasonable risks to human health or the environment.

11. The EPA calculates safe, life-long human exposure limits using the most sensitive laboratory animal species through a process resulting in the No Observable Adverse Effect Level, or NOAEL.

12. The EPA calculates a safe, daily exposure level for humans called the Acceptable Daily Intake, or ADL. This is done by taking the NOAEL amount and converting it to humans, providing an additional margin of safety for children, the elderly, and especially sensitive individuals.

13. Carcinogens or other natural toxins are present in foods such as beans, lettuce, apples, celery, strawberries, beets, spinach, cabbage, carrots, radishes, onions, oranges, bananas, as well as many others.

14. The Delaney Clause, enacted in 1958, prohibited any additive in processed foods that had been shown to cause cancer in laboratory animals. The law did not distinguish between natural and synthetic substances.

15. Because the Delaney Clause was never updated to take into account improved detection methods, the same foods previously considered safe in 1958, today could legally be declared contaminated.

16. Over 99.99% of the carcinogenic sub-
stances we consume in our diet are naturally occurring defense mechanisms produced by the plants themselves.

17. Much like pasteurization, food is irradiated to make it safer and more resistant to spoilage. Irradiation destroys insects, fungi, parasites and bacteria such as Salmonella, E. coli, Listeria and Trichinella that cause human disease, or cause food to spoil.

18. Irradiation does not make food radioactive and leaves no residues, so it is currently impossible to detect whether or not a food has been irradiated.

19. Irradiation does not decrease the nutritional value of food any more than other food preservation methods.

20. Irradiation does not harm the environment, uses relatively low amounts of energy, produces little heat, and no radioactive byproducts that could accidentally be released into the environment.

21. Cows naturally produce bovine somatotropin, or bST, which shows up in their milk. Genetically engineered bST simply enables more efficient milk production. This supplemental bST does not change the amount naturally found in milk.

22. There is no such thing as zero-risk. Although there are things we can do to minimize risk, risk is a part of our daily routine, and nothing is ever going to be 100% risk-free.

23. Acceptable risk is where the benefits far outweigh the risk involved.

24. Saccharine, an artificial sweetener, was banned even though a person would have to drink more than 800 cans of soda every day for years to develop a risk of cancer. It has been approved only as a regulated, over-the-counter table-top sweetener.

25. A media scare caused alar, a growth regulator for apples, to be voluntarily removed from the market despite evidence that it did not cause cancer in children even in doses equal to 28,000 pounds of apples per day.

26. Atrazine is a herbicide found in some drinking water supplies it such minute concentrations that a person would have to drink 154,000 gallons of water every day in order to reach even the No Effect Level of 20 ppb.

27. Proper hygiene and safe food handling methods are our best protection from accidental food poisoning.

28. The food supply in the United States is generally recognized as the safest in the world.

29. Experts agree that a diet rich in fruits and vegetables is still our best defense against cancer.
"The cancer risk for children from eating fruits and vegetables as it relates to pesticides is very, very small. The benefits that you get from eating fruits and vegetables far outweigh any risk from pesticide residue in vegetables and fruits.

Dan Nixon, MD, PhD
American Cancer Society

"Epidemialogic reports of the past decade reinforce the conclusion that fruit and vegetable consumption is linked to reduced cancer risk. The levels of synthetic pesticide residues in food seem so low as to be of no consequence whatever."

American Medical Association

"To sell nothing except foods untreated by pesticides would not only leave storekeepers with rotting food, but would also fail to protect the consumer against molds that in high enough concentration can be lethal. People who are so worried about pesticides fail to realize that the cancer rates have dropped over the, past 40 years."

C. Everett Koop, MD
Former US Surgeon General

" Manufactured chemicals, such as dioxin, are believed to cause less than 1% of all cancers. When people are exposed to the small amounts of such chemicals usually found in the air, water, soil and food, they have very little added risk of getting cancer."

American Institute For Cancer Research (AIRC)

"I think the controversy overshot the mark in terms of creating anxiety about the food supply and apples in particular. But it brought to public attention that we ought to change our laws.

Linda Fisher, Environmental Protection Agency
BRIEF DESCRIPTION

Few things are more enjoyable than catching fish from a clear mountain stream, splashing around at the edge of a lake, or floating lazily down a river on a hot summer day. All of these activities depend on access to quality water supplies. In this activity students identify categories of water pollution and then attempt to clean water using various materials.

SUPPORTING INFORMATION

Since the Clean Water Act was passed in 1972 as the nation's primary water pollution prevention legislation, we have made great strides in cleaning up our water supplies. Yet, much of the attention has been given to easily recognized "Point" sources of pollution, such as factories and sewage treatment plants. Today, attention is shifting to "non-point" sources of water pollution.

Water Pollution Categories

Sources of water pollution can be grouped into two major categories:

1. Point-source pollution. This type of pollution can be pinpointed directly to its source, such as a pipe discharging raw sewage or wastewater directly into a river. Regulations detailing what may be discharged, and under what conditions, have essentially taken care of flammable liquids and much of the ammonia and phosphorous water pollutants. It is important to note that, prior to the Clean Water Act and the Clean Rivers Act, these types of activities were perfectly legal.

2. Non-point-source pollution. We do not know the exact location and source of this pollution. Non-point-source pollution accounts for most of the water pollution in our country's rivers, lakes, streams, bays, and estuaries. Contributors to this type of pollution can be grouped into four general categories:
   * urban and industrial
   * agricultural

LEVEL: 8th Grade
SUBJECT: Health
SKILLS: identification, problem solving, presenting,

OBJECTIVES
The student will explain
- reasons for water quality degradation.
- challenges in determining water quality standards.
- how best management practices that use natural filtering properties of plants, soil, clay, and rock can protect water quality

ESTIMATED TEACHING TIME
2-3 class periods

MATERIALS
3 clear disposable, kitty litter, plastic cups (per group) food coloring, sterile sand, aquarium charcoal, almond extract, cleaned gravel, coffee filter, water copies of the student pages

VOCABULARY
point-source, non-point-source, contaminant, fecal contamination, coliform, alkalinity, MCLs
Point-Source Pollution
Point-source pollution has been the primary focus for control efforts since the Clean Water Act was passed. This type of pollution generally comes from the millions of gallons of wastewater discharged by municipal sewage treatment plants and industrial sources. Since 1977, all industrial and municipal dischargers have been required to have both federal and state permits. Wastewater is considered a potential source of pollution because it can contain organic and inorganic materials that can be hazardous to humans and wildlife. Although some wastewater may actually be cleaner than the stream or river into which it is being discharged, it may still have adverse effects. For example, wastewater may reduce dissolved oxygen in water by introducing different organic materials that require different amounts of oxygen to be broken down and stabilized in the environment. The process that breaks down waste materials is known as Biochemical Oxygen Demand, or BOD. The greater the BOD, the greater the oxygen depletion of the water.

Urban and Industrial Non-Point-Source Pollution
Rainwater runoff typically carries contaminants such as motor oil and grease, herbicides and pesticides, household, chemicals and medical wastes. Rainwater is routed through drainage systems that usually are separate from wastewater treatment systems. And most municipal wastewater treatment facilities are not equipped to treat pesticides, herbicides, toxic household chemicals and chemotherapy wastes. Consequently, these chemicals pass unchanged through the water treatment process to be discharged in wastewater.

Any construction, particularly highway construction, can be a major source of pollution as ground cover is disturbed and the underlying soil is exposed to wind and rainfall, both of which can carry dust and dirt particles. These particles can then be either deposited by wind, or mixed with rain and deposited.

Acid rain is another source of non-point-source pollution. Acid rain forms when airborne chemical compounds such as hydrogen sulfide (produced by burning high sulfur coal) combine with water droplets to form mild acids (in this case sulfuric acid), for example. Power plants, industry, and exhaust from cars can contribute to acid rain. While some lakes and rivers are naturally acidic due to the underlying geology, acid rain can increase the acidity of those that are not, disrupting the aquatic ecosystems living in them.

Agricultural Non-Point-Source Pollution
Traditional agricultural practices such as irrigation, fertilizer and pesticide use, and animal manure are potential sources of pollution. With the adoption of newer conservation practices, however, these pollution problems are less likely to occur.

Confined feeding operations such as dairies or feedlots are special categories of non-point-source pollution. These types of operations are prohibited from allowing wastewater or animal waste to leave the property. All runoff must be controlled, except when excessive rainfall occurs. In these cases, it is not always possible to prevent runoff from fields, or overflow from other types of holding structures.

Few studies exist to measure the exact amounts of nutrient loading contributed by individual sources of agricultural non-point source pollution. One such study by the U.S. Geological Survey on a ranch in south Texas
indicated 204,000 pounds of fertilizers and nutrients, and 10,000 pounds of pesticides had been applied to the fields. From June 23 to June 30, 1996, 6.12 inches of rain amounting to 61,546,290 cubic feet of water fell on the ranch. Runoff amounted to 2,661,952 cubic feet. The nutrient load in this runoff was measured at 3,843 pounds. Of this, 2,284 pounds were attributable to the rain. Yet, in all this runoff, only 0.92 lb. of pesticides left the property.

Pesticides in Water

Until the late 1970s, ground water was thought to be protected from pesticide contamination by overlying layers of topsoil, subsoil, rock, and clay. By using increasingly sophisticated detection methods, we have found this belief is false. But, while pesticides may be present in our drinking water, they are not present at harmful levels. According to the 1991 National Pesticide Survey, less than 1 percent of either rural domestic wells or community water systems contain any pesticides, even seasonally, above the life-time health advisories.

The greatest health hazard from pesticide exposure occurs in the mixing and transfer of chemical concentrates, not so much in the spraying, and certainly not in the levels that are being detected in ground water.

Natural Non-Point-Source Pollution

One of the problems with controlling non-point-source pollution is the lack of information about the amounts of pollution contributed by natural sources. Nitrogen is considered to be an agricultural pollutant. Yet every thunderstorm creates several thousand pounds of nitrogen. Wildlife also adds to the nutrient loading of streams and rivers.

In addition, the underlying geology of a region can add salts, heavy metals and other toxins to water. Streams and rivers erode rocks, adding these eroded elements to the water. A National Academy of Science study indicated between 25 and 60 percent of sediment in streams is from streambank and streambed erosion. Unfortunately, these sources can be difficult to measure and few baseline studies are being done to determine exactly what effects these factors have on water quality. Better information is needed for informed decision making.

Best Management Practices Protect Water Quality

Farmers and ranchers are the original conservationists. They realize that good management of natural resources increases the value and productivity of their land. Over the years, agricultural production practices have improved in ways that benefit both the farmer and the environment by reducing pollution and, at the same time, reducing production costs. These best management practices include:

- Efforts to minimize the loss of nutrients applied to fields into surface and ground water while still maintaining the soil fertility and nutrients at levels necessary for the best crop growth.

-Integrated Pest Management (IPM), a comprehensive approach to controlling pests through cultural, biological, and chemical control systems. Pesticides are applied only when needed, which means fewer chemicals that could be lost to surface and groundwater, and substantial monetary savings for farmers.

-Manure management systems that temporarily store animal nutrients - manure, milkroom wash water, and feedlot runoff for future application to croplands.

-Vegetative and tilling practices such as
conservation tillage, contour farming, contour strip cropping, and field borders are other types of best management practices that are reducing the movement of pollutants and lessening soil erosion by wind, rain, and runoff.

All these practices are not only good for the environment, because they reduce or eliminate pollution, they also conserve energy and save money.

**Chemical Water Quality Indicators**

Depending upon the circumstances, tests of water quality should attempt to determine the presence of heavy metals, pesticides, industrial chemicals, and various types of toxins. Water quality is affected by factors such as: temperature, pH, salinity, nitrate-nitrite, phosphorus, alkalinity, dissolved oxygen, and fecal coliform bacteria.

The amount of dissolved oxygen present is related to water temperature. Warm water holds less dissolved oxygen than cold water. Different species of fish require different dissolved oxygen levels in order to thrive. Consequently, raising the water temperature could be considered a form of pollution because it lowers the amount of dissolved oxygen in the water, which in turn can adversely affect the aquatic ecosystems of that particular body of water.

The pH level of water is determined by a number of things. Distilled water has a pH of 7, which is neutral. Normal rainfall is naturally a bit on the acidic side, with a pH of about 5.5. Depending upon the geology of the region, the water's pH may be higher or lower. Water running through rocks and soils that are of granite origin, for example, would be expected to have a pH of around 4 to 4.5. Water running through rocks and soils that are primarily of a limestone origin could be expected to have a pH of about 8 to 8.5. Over time, acid rain can change the pH of the water and have a negative affect upon the aquatic communities that are adapted to a particular range of pH.

Alkalinity is a measure of water's ability to neutralize acids. It is a fairly reliable measure of the productivity of a lake or stream. Too low an alkalinity level will not support much life, even though the water may appear nice and clear. Geology and acid rain can contribute to low alkalinity. High alkalinity levels can result from respiration in water, the underlying geology (usually limestone or dolomite), or sewage pollution.

Water needs a certain level of nutrients to be productive. Overloading it with nutrients, however, can cause problems such as algae blooms. These blooms clog the water and block sunlight from reaching the lower levels of the water column. When the algae dies, the process of decay uses up the oxygen in the water. Severe cases of oxygen depletion can result in fish-kills.

Runoff from nitrogen and phosphorus fertilizer applications and animal manure is the most frequently cited source of nutrient loading in streams, rivers, lakes, and bays. Much of this runoff comes from urban sources. The average homeowner uses eight times the amounts of fertilizers and other chemicals per acre as the average farmer. Septic tanks, wastewater discharges, and improperly functioning wastewater systems are other sources for high nutrient levels. It is also important to remember that nitrogen is also added through rainfall as part
of the natural nitrogen cycle.

Phosphorus is another nutrient necessary for water productivity. Unlike nitrogen, very little available phosphorus enters water bodies through runoff. This is because soil particles, particularly clay, can hold on to phosphate ions. Phosphorus is also believed to be a limiting factor in the production of algal blooms regardless of the level of nitrogen and other nutrients present in water. As a result, many sewage treatment plants have special units designed to remove up to 95% of the phosphorus from wastewater.

Most of the fecal coliform bacteria found in the digestive tract of all warmblooded animals is relatively harmless in and of itself. However, because its presence is an indicator of other pathogens that cause infectious diseases like hepatitis and cholera, it is regulated at levels designed to prevent human illness.

Water Quality Standards

More than one set of water quality standards exists, depending on intended use. Maximum Contaminant Levels (MCLs) are the legally enforceable drinking water standards. Stricter quality standards are applied to water used for contact recreation, such as swimming, than water intended for noncontact recreation such as boating. When a water body has more than one usage, the standards applied are generally the more stringent water quality criteria.

One of the greatest problems affecting the issue of water quality is the lack of adequate data. Because water testing is time-consuming and expensive, the majority of our rivers and streams have never been adequately monitored. Much of the testing is done downstream of urban areas where a problem is more likely to exist. Consistent, long-term monitoring is required if we are going to develop an accurate, scientifically sound picture of the overall health of our nation’s water.

GETTING STARTED

Gather materials. Make copies of the student pages, one for each student. Copy the Basic Understandings page. Cut the statements apart for each student to have one statement.

PROCEDURE
Session 1
1. Lead a discussion about drinking water. To generate interest, show the students a glass of water with a few drops of a pollutant, like white vinegar or rubbing alcohol mixed in. Ask the students if they would drink from the glass. (Do not tell them about the “pollutant”.) Ask a volunteer to inspect the glass using all of their senses. Ask them if they would recommend drinking the water. Would they drink from the glass themselves? Drinking water becomes polluted or degraded by many sources. Today we will identify some of these sources and how to clean our water.

2. Present the information from the Supporting Information section in the form of a lecture, or distribute copies as handouts to assist in discussion. Allow students to suggest ways that water can become polluted. Ask the students to describe “clean” water. After listing these qualities, ask a student if water is ever truly pure.

3. Divide the students into groups and give each group a copy of the Student Sheet Clean It Up!.

Direct the groups to complete the activity using proper techniques and to report their findings to the class.

Session 2
1. Break the class into groups of 5-6 students.
Provide each student with one of the Basic Understandings or if you have more than 28 students provide each group with a set of five questions.

2. Have students create “Believe It or Not” statements based upon the 28 understandings. Instruct them to create half of the statements as true and half as false statements that are believable.

3. Once all groups are finished, play “Believe It or Not” with the class or invite another class in and play it with them.

4. After each of the “Believe It or Not” statements are used, the students should read the Basic Understanding statement from the lesson and the concept discussed. Use the additional background information provided in the lesson.

EVALUATION OPTIONS

Distribute the Summary Questions Sheet. Have the students complete this sheet individually. Check for understanding.

EXTENSIONS AND VARIATIONS

1. Using the Basic Understandings list have the students compare their feelings about water pollution before this lesson with their feelings after completing the activity.

2. Create a “Protect our Waters” campaign which the whole school can participate in. Have the class design the campaign, recruit other students and propose what recommendations they should have.
Basic Understandings

1. Point-source pollution can be attributed directly to its source, such as a pipe discharging raw or partially treated sewage or wastewater into a river.

2. Non-point-source pollution means we do not know the exact location and source of the pollution.

3. Wastewater is the most common type of point-source pollution.

4. The EPA estimates that each American household generates 20 pounds of chemical waste each year, much of which is improperly disposed of and ends up in rivers, lakes, and aquifers.

5. Sources of non-point-source pollution are classified as either urban/industrial, agricultural, atmospheric deposition, or natural background.

6. Urban and industrial sources of non-point-source pollution include runoff from streets and lawns, construction sites, and acid rain.

7. Agriculture has traditionally borne most of the blame for nonpoint-source pollution. Potential sources of agricultural non-point-source pollution include the irrigation of crops, applications of fertilizers and pesticides, and animal manure.

8. According the 1991 National Pesticide Survey, less than 1 percent of either rural domestic wells or community water system wells contain any pesticides, even seasonally, above the lifetime health advisories.

9. Until the late 1970s it was generally believed that ground water was protected from pesticide contamination by the overlying layers of topsoil, subsoil, rock, and clay. With increasingly sophisticated methods of detection, we now know that this is not true.

10. The greatest health hazard from pesticide exposure occurs in the mixing and transfer of chemical concentrates, not so much in the spraying, and certainly not in the levels that are being detected in ground water.

11. Natural sources of non-point-source pollution can add nutrients, heavy metals, and other toxic chemicals. Very few baseline studies exist to determine the amounts of these natural pollutants or their effects on water quality.

12. Thunderstorms add thousands of pounds of nitrogen to rainwater.

13. Wildlife also add to the nutrient and coliform loading of streams and rivers. For example, one wild goose produces as much fecal coliform as 10 cows.

14. Streams and rivers naturally erode the rocks they flow through, adding salts, toxins and heavy metals to the water.
15. Farmers and ranchers are the original conservationists. They realize that good management of natural resources increases the value and productivity of their land.

16. Best management practices on agricultural lands are good for the environment because they reduce or eliminate pollution, while helping the producer conserve energy and save money.

17. Water quality is determined by a number of factors such as temperature, pH, salinity, alkalinity, nitrate-nitrite, phosphorus, dissolved oxygen, and fecal coliform bacteria.

18. The amount of dissolved oxygen present is related to water temperature. Because warm water does not hold as much dissolved oxygen as cold water, raising the water temperature could be considered a form of pollution.

19. The pH level of water is determined by a number of things. Distilled water has a pH of 7, which is neutral. Normal rainfall is naturally a bit acidic, with a pH of about 5.5.

20. Water needs a certain level of nutrients to be productive, but overloading it with nutrients can cause algae blooms that clog the water and block sunlight from reaching the lower levels of the water column.

21. When the algae dies, the process of decay uses up the oxygen in the water; severe cases of oxygen depletion can result in massive fish-kills.

22. Runoff from nitrogen-phosphorus fertilizer applications and animal manure are the sources most frequently cited as the cause of nutrient loading in streams and rivers.

23. Alkalinity is the ability of water to neutralize acids.

24. The average homeowner uses eight times the amounts of fertilizers and other chemicals per acre as the average farmer.

25. Usually fecal coliform bacteria, by itself, is a relatively harmless bacterium found in the digestive tract of all warm-blooded animals. As an indicator of other pathogens that cause infectious diseases like hepatitis and cholera, it is regulated at levels designed to prevent human illness.

26. There is more than one set of water quality standards. Maximum Contaminant Levels (MCLs) are the legally enforceable drinking water standards. Other standards of water quality are determined based upon the intended use of the water.

27. One of the greatest problems affecting the issue of water quality is the lack of adequate data. The majority of our rivers and streams have never been adequately monitored.

28. Because of a lack of nationally consistent, long-term monitoring programs to determine water conditions, we do not have an accurate, scientifically sound picture of the overall health of our water.
Until the early 1970s people believed that ground water was pretty well protected from surface contamination by the layers of soil, clay, and rock overlying it. For the most part this is true. When combined with a system of agricultural best management practices such as conservation tillage, nutrient management and filter strips at the margins of production fields to prevent runoff, the ground and overlying vegetation does indeed act as a very efficient water filtering system.

With improved measuring techniques, however, we have discovered that it doesn't filter out all contaminants. We can now detect extremely minute amounts of substances that we were previously unable to. This does not necessarily have any effect on the safety of our surface and ground water, just our ability to detect impurities in it. It is the dose that makes the poison, not merely the presence of a substance. According to the EPA's 1991 study on pesticides in ground water, less than 1% of the water wells in this country had any levels of pesticides, even seasonally, that were above recommended levels.

In general, agriculture receives most of the blame for water quality problems associated with run-off. While few studies exist to measure the exact amounts of nutrient loading contributed by various individual sources of non-point-source pollution, those that do exist show resounding evidence that agricultural sources actually contribute insignificant amounts.

**PROCEDURE**

You are in charge of water quality for your community's water system. Residents have complained that the water looks and smells "funny". Using the materials provided, determine how you will provide them with high quality drinking water and also convince them it is safe to drink.

1. Fill one of the plastic cups half full of water. Add food coloring and almond extract.

2. Poke 5-8 small holes in the bottom of the second cup. Arrange any or all of the filtering materials (sand, litter, charcoal, gravel) in this cup in whichever order you think will best clean up the water sample.

3. Leave the third cup as is and use it to catch the cleaned water supply.
Summary Questions

1. What materials did you use to clean up your water sample?

2. Did the order that you used them make a difference to the end result?

3. Were you successful in cleaning up your water sample?

4. How did you decide that the water was or was not clean?

5. What criteria did you use to determine that the water was safe to drink?

6. Given what you know about what it takes to clean up water, suggest some best management practices that might prevent, or at least reduce to negligible levels, any water pollution.

7. How would you encourage the implementation of these practices without resorting to only punitive measures?
SUPPORTING INFORMATION

From dandelions in our lawn, or a wasp nest on the front porch, to caterpillars chewing up our tomato plants, a mouse invading our pantry, or a line of ants marching toward the open jelly jar we forgot to put away - each of us has confronted pest problems. Often, the first response is to apply a pesticide. Sometimes we apply pesticides to prevent invasions by pests. Most of us do not think twice about using these products.

While the overuse of pesticides can lead to environmental damage and health hazards, the availability of pesticides has improved our lives. Because of pesticides, food production per acre has gone up, the variety of foods has increased, certain diseases have been controlled, and our quality of life has continued to improve. Without pesticides, we would pay higher prices for food that would invariably show signs of damage by insects or other pests. In addition, we would be forced to divert land into food production that is being set aside as forests, wetlands, and wildlife habitat. The land itself would suffer as we began to cultivate soils of marginal fertility.

What is a Pesticide?

The word pesticide is a generic term that refers to products meant to kill or control the entire spectrum of organisms that people consider to be pests. The specific categories of pesticides are:

1. Insecticides for insects
2. Herbicides for plants

LEVEL: 8th Grade
SUBJECT: Health
SKILLS: identifying benefits, problem solving, lab skills
OBJECTIVES
The student will
- explain why detection of a substance does not necessarily mean it is harmful.
- explain why pesticides can be used in such small amounts.
- explain why pesticides benefit people and the environment.
- explore issues of pesticide use and management.

ESTIMATED TEACHING TIME
1 class period
MATERIALS
vinegar, pH paper, 25 mL distilled water, spray bottle, eye dropper, safety goggles, table top, paper towels or newspapers to cover surface of tab table, graph paper, copies one per student of the Basic Understandings page, Student sheet and Student chart, Categorizing 20 Basic Understanding Statements

VOCABULARY
IPM, pesticide, fungicide, rodenticide, herbicide, nematocides, arachnicides, insecticide
3. Rodenticides for rodents
4. Nematocides for nematodes
5. Fungicides for fungi
6. Arachnicides for spiders, mites, ticks

Some pesticides are formulated to be effective on specific pests while others are useful for a broad spectrum of pests and therefore are multi-purpose.

Access to Pesticides

Farmers, ranchers, landscaping services, pest control services, and others engaged in commercial use of pesticides must be trained and licensed, or certified, to apply pesticides. Annual continuing education courses are required in order for pesticide applicators to maintain their certification. Stringent regulations exist to control how pesticides must be mixed, stored and disposed of.

Relatively few pesticides are licensed for "restricted use only" by certified applicators. The vast majority of pesticides are available to everyone. The primary difference in the pesticides homeowners use and those that commercial applicators use is the size of the container. The concentrations available remain the same. Unfortunately, a lot of homeowners mistakenly believe that if a little is good, then twice as much is twice as good. Consequently, the average homeowner uses eight times the amount of pesticide per acre as the average farmer.

The average homeowner is also less likely to know how to properly dispose of excess product. Too often, remaining pesticides and containers are put out for regular trash pick-up, or residues are poured down a drain into the sewage system. Municipal sewage treatment systems are generally not designed to remove pesticides, so these untreated contaminants become part of non-point-source pollution.

Farming Practices Reduce Pesticide Use

When incorporated into certain farming practices, pesticides can actually benefit the environment. For example, soil erosion has been drastically reduced with the introduction of conservation tillage. Conservation tillage, or no-till, means that farmers do not have to mechanically till their fields to get rid of weeds. Instead, they leave crop stubble and dead grass in between the crop rows and apply herbicide to kill the weeds that would otherwise rob a crop of moisture and nutrients. This practice allows farmers to reduce soil erosion, as well as reducing fuel consumption and associated costs.

Although herbicide use has gone up with expanded use of no-till, overall pesticide use in the United States continues to go down each year. In part, this is because of safer, more effective pesticides that can be used in smaller amounts. In addition, the development of pest resistant plant varieties has enabled farmers to control certain pests with less pesticide. Pesticides represent a sizeable investment; farmers do not want to use more than is absolutely necessary. The ability to use fewer applications and smaller amounts of pesticides means increased profit for farmers.

Global positioning system (GPS) units make use of computer technology linked to satellites to determine precise field locations where control is needed, and to regulate the amounts of pesticides delivered in a more efficient manner than was previously possible.

Integrated Pest Management Offers Multiple Strategies

Another reason for reduced pesticide use in
agriculture is the increased adoption of integrated pest management, or IPM. IPM is a systems approach to pest management that integrates the use of chemicals with cultural, mechanical, and biological control methods to minimize pest damage. The goal of IPM is not to completely eradicate pests, but rather to control pest populations in order to prevent both the pests and the pest management activities from having an adverse affect upon both crops and the environment. The methods of doing this vary among crops and among regions of the country.

IPM is not an anti-pesticide program. But pesticide application is only one technique, and one that is used only when pest numbers exceed a tolerable limit. IPM involves selective use of pesticides designed specifically for an intended pest, and only in amounts necessary, since overuse can cause insects to build up resistance to pesticides.

Healthy plants can withstand a surprisingly large number of insect pests. In an IPM program, both the pest populations and the beneficial populations are monitored. Naturally occurring organisms such as ladybugs, preying mantises, and lacewing larvae frequently prevent pest populations from reaching damaging levels. Birds are also an effective biological control.

A successful IPM program also uses cultural controls such as uniform planting and plow-up dates to prevent pests from moving from field to field. Planting crops before insects become active and using seeds that are pest-resistant and faster maturing enable farmers to harvest before pests become too abundant. The use of intermixed plantings can help control pests by attracting beneficial insects or by attracting pests away from one crop into other plantings.

Pheromone traps can be used to trap insects, or keep them from mating. Pheromones are chemicals naturally emitted from mature insects that attract the opposite sex. These traps are also useful in determining the kinds and numbers of insects in a field. Commercially available insect pathogens can also be employed to kill certain pests but spare beneficial species. Nets, reflective mulches, and planting distance from roads are other means of mechanically controlling the movement of pests into a field. Together, these integrated pest management practices attempt to create favorable growing conditions for plants and unfavorable conditions for pests.

New Generation of Pesticides

The pesticides used today are more effective in smaller amounts, and they break down faster in the environment than those used 30 years ago. One of the best examples is glyphosate (Roundup®), a broad-spectrum herbicide used to kill a wide variety of unwanted plants with no effect on birds, animals, or other wildlife. Because glyphosate is a compound that breaks down in the soil in days and does not accumulate in the environment or the food chain, it is highly attractive to farmers. It allows them to more easily rotate their crops. But because glyphosate does not distinguish between weeds and crop plants, researchers have developed several crop varieties that are resistant to glyphosate. This allows farmers to use one of the safest herbicides available to kill weeds in their fields without any danger to their crops.

Pesticides and Groundwater

Atrazine is one of the most common herbicides used to control weeds and, at the same time, prevent soil erosion. It is used only during three months of the year and is applied to a field once during the growing season. Not surprisingly, atrazine is one of the herbicides that
frequently shows up in ground water supplies. But is it dangerous? It has been safely used for over 30 years without being linked to any form of cancer. Atrazine breaks down quickly in the environment, leaving no by-products to build up from year to year. Recent testing has shown that it is 10 times safer than previously thought. The EPA has raised the No Effect level for atrazine from 3 ppb, to 20 ppb. Using those levels, a person would have to drink 22,000 gallons of water per day to reach the No Effect level of 3 ppb, and 154,000 gallons of water a day to reach the new 20 ppb No Effect level. According the 1991 National Pesticide Survey, less than 1 percent of either rural domestic wells or community water system wells contain any pesticides, even seasonally, above the life-time health advisories. So, although there is a chance that pesticides are present in our drinking water, they certainly are not present at levels that pose any real risks to our health and to the environment.

GETTING STARTED

Gather materials. Make copies of student pages, one for each student.

PROCEDURE

Session 1
1. Explain that there are many materials that are sprayed: paint, hairspray, starch, fire retardants, pesticides, etc. Ask each student whether they think it is easy to evenly spray paint, spray a lawn, garden, field with pesticides, or spray fire retardant to put out a fire? Ask what experiences they have had with spraying of any type.

2. Provide each student with the Student Sheet and materials. Follow the directions as written.

3. Once the activity is completed, ask these questions:
   “What areas are over sprayed?”
   “What areas are under sprayed?”
   “If you were spraying a crop, or a lawn, or painting a car what impact would either over spraying or under spraying have?”
   “Did any of your spray drift off of the intended target?”
   “Did you spray anything other than the intended target?”
   “What impact would drift or spraying something other than the intended target have?”

Session 2
1. Provide each student with a copy of the 20 Basic Understandings and graph paper. Have the students cut up the 20 Basic Understandings.

2. Have the student divide these into two piles: one pile for “I knew that!” and the other for “I didn’t know that!” Assure them before they begin that you don’t expect them to have a lot of knowledge about this topic and it is not a bad reflection on them if they don’t. In fact, it is expected that their “I didn’t know that!” pile will be much greater.

3. Ask the students to count up each category and calculate the percentage (out of 20) for both piles.

4. Have the students create either a bar graph or pie graph of the comparison.
Session 3
1. Provide copies of the Student Chart, 20 Basic Understandings, and graph paper one per student.

2. Have the students divide the 20 Basic Understandings statements into one of three categories.
   - Positive Fact About Current Use of Pesticides
   - Negative Fact About Current Use of Pesticides
   - Neutral Statement or Uncertain

3. Again, have the students calculate the percentage of each category total out of 20.

4. Have the students make either a pie graph or bar graph of their percentages.

5. Review the categories to discuss any differences in opinion.

6. Once the graphs are complete have each student write their own positive and negative statement concerning the use of pesticides from what they have learned.

EVALUATION OPTIONS

1. Make up a series of statements from the 20 Basic Understandings and provide those as a quiz. If you produce 20 True/False questions these may then be graphed as to those that the student now understands versus those they still do not understand and graphed. The graph from session one may be compared to this graph and the students can visibly see how much they have learned in this lesson.

2. Have the students write a positive, negative and neutral factual statement about pesticide use from what they have learned.

3. Have the students write a one page paper about pesticides from the 20 Basic Understandings and discussions that have resulted from this lesson.

EXTENSIONS AND VARIATIONS

1. Conduct session three in two groups instead of groups of five or six students.

2. Using the 20 Basic Understandings rewrite enough statements so that there are an equal amount in each category.

3. Create either a Jeopardy-type game or Believe It or Not-type game as in the previous two lessons.
20 Basic Understandings

1. Pesticide is a generic term referring to anything used to kill or control pests. Specific forms of pesticides are herbicides, insecticides, fungicides, rodenticides, nematicides, arachnicides.

2. Anyone who applies a pesticide commercially must be trained and certified to apply pesticides. Annual re-training to maintain certification is required.

3. Except for a very few "restricted use" pesticides, anyone can buy and use pesticides.

4. The main difference between pesticides used by the general public and those used by commercial applicators is the size of the container, not the concentrations available.

5. The average homeowner uses 8 X more pesticides per acre than the average farmer.

6. The use of pesticides enables us to grow more food, at a higher quality and at a reasonable cost, on less land.

7. Without pesticides it would be necessary to use more land for agriculture, thereby reducing the land available for wildlife habitat.

8. IPM does not attempt to completely eradicate pests, but to keep them at acceptable levels. Healthy plants can withstand large numbers of pests without adverse effects.

9. Monitoring the proportion of beneficial insects compared to harmful insects is a vital part of IPM. Ladybugs, praying mantises, and other insects help to control pests.

10. Pesticides are carefully chosen to target only specific pests and used only in amounts sufficient to eradicate the infestation, in order to prevent environmental damage as well as increased insect tolerance.

11. Cultural, biological, and chemical controls are all important components of IPM.

12. Soil erosion in the United States has been drastically reduced by using herbicides to control weeds in no-till and conservation tillage farming.

13. Newer, safer pesticides that break down quickly in the environment and are effective in much smaller doses are constantly replacing older, less effective and less safe ones.
14. Plant varieties that are resistant to certain pests enable farmers to use less pesticide.

15. Glyphosate (Roundup) is one of the safest, broad-spectrum herbicides available. It does not harm birds, animals, or other wildlife. It also breaks down very quickly in the environment and poses no risk to humans.

16. Plant varieties that are resistant to glyphosate enable farmers to control weeds with one of the most environmentally safe herbicides without damaging their crops.

17. Atrazine, one of the major pesticides being detected in drinking water, has been used safely for over 30 years and is not linked to any risk of cancer.

18. Atrazine breaks down quickly in the environment and leaves no residual by-products to build up from year to year. Atrazine is applied to a field only once during the approximately three-month growing season.

19. The EPA has raised the No Effects level for atrazine from 3 ppb (parts per billion) to 20 ppb. In order to get 20 ppb, it would be necessary to drink 154,000 gallons of water a day.

20. According to the 1991 National Pesticide Survey, less than 1 percent of either rural domestic wells or community water system wells contain any pesticides, even seasonally, above the life-time health advisories.

**Student Chart**

**Categorizing 20 Basic Understandings Statements**

Write the number of the Statement in the box under the category. Uncertain? List as Neutral.

<table>
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<th>Positive Statement</th>
<th>Negative Statement</th>
<th>Neutral Statement</th>
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Pesticides today are nothing like they were 30 years ago. They are increasingly effective in much smaller amounts, are not nearly the health hazard that they once were, and are much more friendly to the environment. They are also increasingly expensive. All of this means that a farmer is not going to use any more than is absolutely necessary to control a pest. As a general rule, the amount of pesticide farmers use is equal to spreading a pint of water evenly over a football field. In this activity, the learner will attempt to spread a small amount of vinegar evenly over a surface area in much the same way a farmer would spread a pesticide over a field.

Materials

Vinegar, pH paper, 25 mL distilled water, spray bottle, eye dropper, safety goggles, table top, paper towels or newspapers to cover surface of lab table. (Note: a syringe used for allergy shots or insulin injections can also be used to accurately measure out the vinegar)

Procedure
1. Wearing safety goggles, test the pH of the vinegar and record it in the table below.

2. Test the pH of the distilled water and record it in the table below.

3. Pour 25 mL of distilled water into the spray bottle. Measure out 0.05 mL of vinegar and add it to the distilled water. Cap and shake to mix.

4. Test the pH of the mixture and record it in the table below.

5. Cover your lab table with the paper towels or newspapers. Spray the vinegar/water solution evenly over the surface of the lab table. Hold the spay bottle one foot above the table.

<table>
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<td>vinegar</td>
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<td>distilled water</td>
<td>______</td>
</tr>
<tr>
<td>vinegar/distilled water</td>
<td>______</td>
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</table>

6. Using the pH paper check the pH of the field (table top) to see if all of the field has the same coverage as measured by pH.

7. Draw a picture of field and mark any variations that you notice (pH).
1. The pH of the vinegar/water solution was most like the pH of 
   (the vinegar), (the distilled water), (somewhere in between).

2. How is trying to spread the 0.05 mL of vinegar evenly across the table similar to how a farmer 
   spreads pesticide on a field?

   How is it different?

3. Most accidents with pesticides happen during the mixing and transfer stage. Why do you 
   think this happens?

   What could be done to help prevent it from happening?

4. Explain the role technology plays in reducing pesticide use.

5. Why does the detection of a pesticide in drinking water not automatically mean the water is 
   unsafe to drink?
Student Chart  
Categorizing 20 Basic Understandings Statements  
(Here is our opinion.)

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<tr>
<th>Positive Statement</th>
<th>Negative Statement</th>
<th>Neutral Statement</th>
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Positive 9 out of 20 = 9/20 = 45%

Negative 2 out of 20 = 2/20 = 10%

Neutral or Uncertain 9 out of 20 = 9/20 = 45%
We don’t actually mean a six legged member of the animal kingdom. It is just a figure of speech. When plant crops get “sick”, sometimes it is caused by a real bug! People can do several things to avoid getting a cold, like proper diet, dressing appropriately, avoiding sick people, etc. Farmers avoid plant sickness by planting crops that are resistant to certain diseases, by using traps or biological controls and applying chemicals. Since chemicals are expensive they are used sparingly and only when necessary. Medicines and pesticides are both very important tools used correctly, but dangerous if used improperly.

LEVEL: 8th grade
SUBJECT: Health
SKILLS: Learning through experience, identifying problems
OBJECTIVES
The student will - gain awareness of the potential effects of direct pesticide exposure.

ESTIMATED TEACHING TIME
1 class period

MATERIALS
copies of the Student Sheet, optional containers of insect repellent, garden herbicides, and insecticides (make sure these containers are child-proofed, so that no one is inadvertently exposed to the material)

VOCABULARY
pesticide, exposure
GETTING STARTED

Make copies of the quiz to distribute to students or prepare an overhead of the quiz for all to see as you read the questions.

PROCEDURE

1. Start this activity by asking participants if they know how to identify a pesticide. If you have brought in samples of pesticides, ask the group if they have any of the items in their homes, or if they have seen them before in a store. Ask them if they can define pesticide. What do pesticides do? Why do we use them in our homes?

2. Let your group know that pesticides, like other substances used in the home, can be dangerous to people if not used correctly. Pass out copies of the Student Sheet. Explain that pesticides can make people sick in three ways if used incorrectly. Pesticides can enter the body through the mouth. They may accidentally be spilled on the skin, allowing some of the chemical to go into the body through the skin. Or people may accidentally breath them into their lungs.

3. Ask the children to complete the quiz. If you have young children in your group (K-2), you might want to read the questions aloud and ask the group to answer them. You also can ask for each scenario whether they would take in the substance through their mouth, skin, or lungs, if at all.

4. Review and discuss the correct answers with the group. Correct answers are below.

Correct answers to pesticide quiz:

1. Yes, you might possibly get a rash or worse. Always pay attention to warning signs and labels. You can get sick through skin contact.

2. Yes. You could potentially get sick from inhaling the product.

3. No. You’re safe. Pesticide residues are rarely found on produce. When they are found, they are at levels below those that could harm humans.

4. Yes. Have your mom read the label first! You could be over-applying the fungicide. You could get sick by breathing, through skin contact, or through your mouth by eating. It’s best to let adults apply pesticides. Tell your mom that children shouldn’t handle pesticides.

5. No. Try this and check the next day to see if the bugs are back.

6. No, because the cleaner was diluted and washed away by the flush. If he forgot to flush and left the cleaner in the bowl, it could be a problem. Before he cleaned the toilet, there were germs in the bowl. You might have gotten sick from those!

7. No. But it’s still a good idea to wash all fruits and vegetables to remove soil, droppings, and insect remains.

8. Yes. The bleach is very, very good at killing germs. But you need to wash right away if you spill bleach on your hands. It can hurt your hands or get into your mouth or eyes.

9. Yes, bad idea! We don’t use herbicides on humans! You can really hurt him, especially if the spray gets in his eyes or mouth.
EVALUATION OPTIONS
What are the three ways in which pesticides can enter your body? Do you think that toddlers or adults are more likely to get sick from pesticides? What would happen if your parent put pesticides in a milk carton for storage? Could someone accidentally drink the chemical?

EDUCATOR’S NOTES
PESTICIDE QUIZ

Can people get sick from pesticides by doing the following things? Write yes or no.

1. You run barefoot on a lawn that has just been sprayed with pesticides. There are warning signs posted telling you to keep off for at least forty-eight hours.__________

2. You are curious and open a household germ product and inhale.__________

3. You eat fruit from the grocery store. You have washed the fruit at home.__________

4. You help your mom put fungicide powder on her roses to control mold. You sprinkle the leaves until they are white as snow.__________

5. You wash bugs off plants with a hose.__________

6. Your dad just cleaned the toilet with a germicide, and flushed. Can you get sick from sticking your fingers in the water?__________

7. You eat a tomato right from the garden without washing it first. You know that no pesticides were used.__________

8. You help your mom clean the kitchen. You spill some bleach on your hands.__________

9. You want to help your dad, so you grab the dandelion spray from the shed. You run around and shoot the dandelions. You think you are a space alien with a zap gun. You see your brother, and you spray him too.__________
BRIEF DESCRIPTION
While learning about the conditions that produce condensation, students create poems that express thoughts and feelings about rain, snow, and other forms of precipitation.

SUPPORTING INFORMATION
Precipitation affects our lives in a variety of ways. Plans for daily outings are adjusted or canceled as weather changes. People’s moods may fluctuate in response to changes in cloud shapes or colors. Variations in the amount of rainfall cause crop yields and grocery store prices to increase and decrease.

Culture reflects how weather affects human lives. Language, artwork, and poetry often contain weather terms. For example, one might be said to have a stormy personality. Songs include lyrics about rain, such as “Raindrops keep falling on my head”, “I love the rainy nights”, Singing in the rain” and others. Words may describe the physical environment or be used symbolically to relay emotions or perceptions. For example, an author might set the mood for her story by stating that it was a dark, stormy night; and beautiful snow-covered land might be described as a “winter wonderland.”

An indication of the importance of precipitation to lifestyles is the popularity of weather reports on daily news broadcasts. Watching cloud shapes and measuring temperature and the amount of moisture in the air helps people predict when and what type of precipitation is likely to occur.

Clouds form when water vapor in the atmosphere condenses into tiny ice crystals or water droplets. When droplets or crystals merge, the result is a raindrop.

LEVEL: 6th Grade
SUBJECT: Language Arts
Skills: analyzing, interpreting (inferring), presenting (writing)
OBJECTIVES:
The student will:
- describe how clouds are formed.
- recognize that thoughts and feelings are influenced by weather conditions.

ESTIMATED TEACHING TIME:
Preparation time: Part I: 30 minutes Part II: 10 minutes
Activity time:
Part I: 50 minutes
Part II: 50 minutes
Part III: 50 minutes

MATERIALS:
balloons (about half as many as there are students in the class), garbage bags (1 for every 5 students in the class), samples of poems and songs about precipitation (optional)

VOCABULARY:
humidity, precipitation, condensation, evaporation, vapor
they become larger and heavier, and gravity pulls them to the ground. They fall as rain or snow, depending on the temperature of the air. Because the upper atmosphere is so cold precipitation usually starts out as snow and melts to rain as it falls nearer Earth's warm surface.

Cloud formation depends on the amount of moisture in the air, temperature, and presence of condensation nuclei (dust particles onto which water vapor condenses). Water vapor condenses when the temperature decreases. (Refer to illustration.)

Temperature decreases when molecules lose heat energy or when pressure is reduced. When molecules lose heat energy, they slow down. At higher elevations, there is less pressure, allowing air and water molecules to spread out. When air and water molecules are further apart, they bump into each other less often and lose energy. (The motion of molecules-kinetic energy--is maintained when molecules collide with each other.) Slower moving water molecules do not have enough energy to remain a vapor and will settle on condensation nuclei floating in air. The temperature at which water molecules condense is called the dew point.

GETTING STARTED
Obtain the materials, balloons, garbage bags, samples of poems and songs.

Introduction
Ask students to describe current weather conditions. What kinds of weather do they like and dislike? Discuss why people are interested in reading or listening to weather reports. How do different weather conditions influence moods or feelings? Share a poem, song, or saying that includes weather terms and ask students to interpret its meaning or message. Ask about the mythology of rain and clouds. (Rip Van Winkle bowling, Greek myths about weather, etc.)

Ask students how they know when it will rain. Some students may listen to weather reports; others may look for environmental clues. Ask students to describe how rain is formed.

If necessary, review the processes of evaporation and condensation. Show water condensed on the outside of a glass of ice. Describe how water vapor in the air is a source of that water.

PROCEDURE
Part I
1. Have students identify times when they have seen condensation. Ask students what they think water condensed in the upper atmosphere would look like. If there are clouds outside, point them out as collections of floating water droplets. What does a cloud feel like? Ask students if they have walked through fog. Explain that fog is a cloud formed at ground level.

2. Tell students they are going to demonstrate how water droplets form in the upper atmosphere. Explain that the molecules in air (oxygen, nitrogen, water vapor, and other gases) move about freely, bumping into each other, maintaining their speed of motion. When they do not collide into each other or gain heat energy, the molecules slow down.

3. Have the students count off by fives. Give the "ones" large plastic bags (see Materials) and tell them they are "condensation nuclei." The rest of the students are "air molecules."

4. Tell the air molecules to stand at arms length from each other. They must keep one foot in place at all times, but can pivot about that foot. Explain that in reality, air molecules move about freely, bumping into each other. However, for this exercise their movements will be limited.

5. Tell the students that when you clap your hands, they increase the space between them-
selves by taking two steps away from each other. Explain that the clapping represents air rising further into the atmosphere. At higher altitudes there is less pressure, and molecules move further apart. Therefore, the molecules are not pressed together, making it harder for them to transfer heat energy to each other.

**NOTE:** If space is limited, have certain students leave the playing area when you clap your hands.

6. Tell students that the balloons represent water molecules. Explain that when the demonstration begins, you will toss balloons in the air; air molecules should volley the balloons to keep them aloft. Every time a student taps a balloon, he or she should call out "energy." This represents energy of motion (kinetic energy) being transferred between air and water molecules, keeping heat levels constant.

7. Explain that when a balloon falls to the ground, it means that heat energy has been lost from the water molecule. The condensation nuclei should gather the fallen balloons in their plastic bags. When two or more balloons have been collected, the condensation nuclei becomes a "water droplet."

8. Begin the activity. Clap your hands about every minute. As the distance increases between students, more balloons should fall to the ground. When most of the balloons are collected, stop the activity. Ask students what all these water droplets represent. (A collection of water droplets makes a cloud.)

9. Explain that the water droplets are too heavy to float in air. Designate one side of the room as Earth's surface; have water droplets represent precipitation falling to the ground by moving to that wall. Air molecules can flash the classroom lights and make the sound of thunder by stomping their feet.

10. Based on this demonstration, have the students diagram the formation of a cloud (water droplets). They may wish to use other science books to enhance their diagram.

**Part II**

1. Have students list different types of precipitation they know or have experienced. Ask them to describe what each looks and feels like. What moods, feelings, or thoughts are associated with each precipitation type?

2. Tell students to create a poem about a type of precipitation. They can use their descriptions, thoughts, and feelings for topic material. Share poetry from Robert Frost, Walt Whitman, Emily Dickinson, e. e. Cummings, Shel Silverstein, or your personal favorites.

**EVALUATION OPTIONS**

Have students:
- diagram how a cloud forms (Part I step 10).
- write poems that include weather terms and thoughts and feelings about weather (Part II, step 2).
- analyze poems about weather (VARIATIONS). 

**EXTENSIONS AND VARIATIONS**

1. Have students share and analyze each others' poems. They should determine if the poems were written to educate about weather types, set a mood, and/or express emotion. What is unique or interesting about the work? Students can produce a book of their weather poems. The poems should be grouped according to seasons or particular weather patterns. Copies of the book could be given to friends and family. Local weather stations may be
interested in presenting the poems on their programs.

2. Students may be interested in setting up a simple weather monitoring station. Some simple instruments include a rain gauge (a jar with a plastic ruler taped inside), a thermometer, and a wind vane (a piece of ribbon stapled to a stick). They could conduct a weekly cloud watch and learn the names of different cloud types. They may want to contact another school in a different town or state to compare weather reports. The National Geographic Society has a Weather in Action Kit with which students set up a weather monitoring station and share findings with other student observation stations around the country through telecommunication software systems. Write to: National Geographic Society, Educational Services, 1145 17th Street NW, Washington, DC 20036-4688 or call 1-800-368-2728 for information.

3. Before meteorologists were able to use advanced technology to track and interpret weather, people used look at other environmental clues to predict the weather. Following is a list of some old sayings. Students may want to test them out to see if they make accurate forecasting tools.

*If a dog eats grass, it is a sign it will rain.

*Robins in the bush are a sign of an oncoming storm.

*Fall is coming when the blackbirds start to bunch up in big flocks.

*When people have aching joints, they say the weather is changing for the worse.

*When dew is on the grass, rain will never come to pass.

Cold is the night when the stars shine bright.

*If the ants build up their hills, rain from the clouds will be spilled.

*A ring around the moon means cold weather.

*Red sky at night-sailors' delight. Red sky in morning-sailors take warning.

*An early, heavy coat on farm animals (or city park squirrels) means a long, cold winter is ahead.

*When leaves stay on the trees in the fall, it is a sign of a cold winter.

*Rain will occur on the 3rd, 30th, and 60th day after a fog.

*It won't snow very long if large snowflakes are falling.

*It's a sign of rain when cattle bunch together.

*If it rains when the sun is shining, it is going to rain tomorrow.

*Students acting up in school indicate that a change in the weather is coming.

*When corn husks are thick, it is going to be a long, hard winter.

Have students generate a hypothetical weather report using some of these old sayings. Have them pretend they are weather personalities and present their weather report to classmates.

EDUCATOR’S NOTES
These and their terrestrial kin from actively on the trail of day myth lure of the monster, Champy in Lake Ness gave birth to mermaids, sea sailors and early explorers. The Loch Ness monster, Champy in Lake Champlain, and the strange happenings of the Bermuda Triangle are a few contemporary examples of the lure of the sea’s mysteries. Modern day myth chasers are actively on the trail of these and their terrestrial kin from the high Himalayas to the equatorial forests, from coastal swamps to chasmic depths. But were there ever such real creatures? Early sailors claimed to have seen beautiful mermaidens with fish-finned tails. Later accounts shifted the mythic images to the wondrous and real manatee. This aquatic mammal, sometimes called the "sea cow," inhabits rivers, estuaries and the open sea. Manatees bear no typical resemblance to the legendary mermaid. An active imagination plus, perhaps, a long isolated sea voyage seem necessary to convert the manatee into the more conventionally captivating image of the mermaid.

Bizarre perceptions are possible if one chooses to describe ordinary organisms with detailed imagination, such as aquatic insects or other organisms found in pond water. Investigating such life forms in this way can provide an increased awareness of the characteristics of local habitats and aquatic wildlife.

LEVEL: 6th Grade
SUBJECT: Language Arts
SKILLS: writing, presentation, describing
OBJECTIVES
Students will:
- describe how imaginary creatures may be inspired by actual animals.
- distinguish between mythical and actual aquatic wildlife.
- give examples of how wildlife can inspire myth and art.

ESTIMATED TEACHING TIME
12 class periods

MATERIALS
library resources; art materials; a variety of photographs of real aquatic animals (insects, amphibians, fish, mammals, etc.)

VOCABULARY
manatee, chasmic
species. The major purpose of this activity is for students to increase their appreciation for the qualities of differences between real and mythical aquatic animals. Additional purposes are to explore some of the folklore and myths related to aquatic creatures and to learn more about the fascinating animals they are in reality.

GETTING STARTED

gather materials (library & art) a variety of photographs of real aquatic animals as described in the Materials section.

PROCEDURE

1. Ask the students to sit quietly with their eyes closed and try to picture a mythical creature that lives in a water environment. A mythical creature means an animal that you create in your mind and one that probably never lived outside your mind. Ask each student to picture a creature and prepare to describe it to the class.

2. Ask a few of the students to volunteer to describe the creature that they pictured. Many of their images will likely be the result of film or television experiences.

3. Offer the students an opportunity for discussion about classic marine myths regarding mermaids, sea serpents and lake monsters. Explore their beliefs about whether they think these creatures were and are real or imaginary.

4. Tell the students that they are going to go off on a mythic voyage where they will meet a wondrous aquatic creature. Their responsibility will be to have each crew of three to five sailors write as accurate a description of the creature as they can. The crew is to work together to produce a single written description.

5. Divide the students into an even number of crews with three to five students in each crew. Provide each crew with an image of an actual aquatic animal. Use the photographs you have collected. Be sure to select aquatic insects as well as larger animals. Tell each crew to keep their animal a secret and insure their privacy so that the students on other crews do not see the creature.

6. Have the different crews find out as much as they can about their animal's actual appearance, behavior and habitat. Allow them to use any references or resources that are available.

7. Once the research is finished, ask each crew to begin to develop the written descriptions they are going to present to the other crews. Each student should contribute at least two or three lines to the group description. Each student could describe a different characteristic. For example: "This creature eats fish and other things in the ocean. It has a parrot-like beak in the middle of long tubes. It swims by forcing water out of its body. It has gigantic, glistening eyes." (octopus) "This is a hump-backed creature with stout, powerful wings. Its offspring live in capsules under water where they hang onto stationary objects in flowing streams. When they grow up, the females often feed from the blood of humans. The humans that are attacked by these creatures develop huge sucker-like welts which ooze fluid from their centers. Discomfort to the humans lasts for days." (blackfly)

8. Once the descriptions are complete, each crew should prepare to read their group's description to another crew. It is useful to have the descriptions copied so they can be exchanged in writing, as well as prepared to be read aloud.

9. Have each crew choose one other crew to work with. With the crews paired up, ask one crew to read aloud their description to the other crew. Provide the written descriptions at this point. The crew who receives the description
then must create an image of the creature that was described. Reverse and repeat the process so that both of the paired crews have written descriptions to work with. Now each crew must draw or paint images of what they understood the other crew to have described. Individual drawings or paintings can be done by each student or a composite can be created by the entire crew. Limit the number of questions the crews can ask of each other.

10. Once both crews have completed their images, they should compare the written or oral descriptions with the resulting art work. They should also now reveal their original source photos or specimens, looking for similarities and differences.

EVALUATION OPTIONS
1. Assess the written descriptions or have the other groups of students evaluate the descriptions based upon an agreed to criteria. A significant factor in the assessment should be whether the group is able to identify the organism.

2. Show a photo or illustration of each organism or a series of organisms and have students write a key adjective for the organism.

EXTENSIONS AND VARIATIONS
After the students have described the organisms have each individual illustrate their perception of what the organism looks like.

RESOURCES
A good resource for the teacher is the internet. Searches can be done using a search engine, (Yahoo, Webcrawler, etc.) Avoid having students do this kind of search for pictures...ALL kinds of pictures are returned even though you limit the request.
http://aquariacentral.com/pictures/
http://www1.yahooligans.com/downloader/pic-
tures/animals___nature/marine_life
The Tennessee Aquarium at- http://www.ten-
nis.org/

EDUCATOR’S NOTES
BRIEF DESCRIPTION
Water is one of the most abundant compounds and covers 75% of the earth. However, the clean water that living creatures need to survive is not always abundant and must therefore be understood and conserved. Students will complete a webbing exercise to determine pollution sources.

SUPPORTING INFORMATION
Over 65% of our body is water and every living creature uses the water that has been on the earth for thousands of years.

All of the earth relies heavily on farms for food, but sometimes people do not understand farming and place considerable blame on farmers for water pollution. They see cows drinking from a stream and think that the animals are polluting the water. The truth is, animals are living creatures and need water too. Farmers use many practices such as recycling of manure, soil runoff prevention techniques, etc. to protect the water. Remember, we all drink water.

Water is “recycled” through the water cycle. Pollution has always been a threat to the water humans use and often, blame for water pollution has been unfairly placed on a small percent of the population. In this lesson, you will learn how water reservoirs, such as groundwater, are affected in rural as well as urban areas.

GOT WATER?

Farmers are just one sector of our population who work daily to preserve our water sources through management and conservation. Let’s spend some time today learning how pollution is generated and how it affects water sources in the rural as well as urban areas of our nation.

GETTING STARTED
1. Before class, get a flip chart,
large pieces of paper or perhaps a poster board and some markers. These will be utilized in the webbing exercise.

2. Make Water cycle overhead or handouts.

PROCEDURE

1. Inform students that the lesson today will focus on water and water pollution and how important it is that we humans protect water sources because all living things require water to survive.

2. Discuss key terms—possibly use key terms for a pre-test. Use water cycle sheet on overhead projector (or handout) to illustrate the key terms.

3. Utilize a webbing exercise to discuss sources of pollution. Most students will have different opinions about which sector of the population is the largest contributor to non-point source pollution.

   A. Begin the activity by asking students about their knowledge of where their drinking and household water originates, (this will lead to a discussion of groundwater).

   B. Ask students to complete three webs (rural, urban, suburban) listing the sources of water pollution in all three areas. Give students 5-8 minutes per unit to brainstorm about pollutants. If you haven’t used webbing in your classroom before, give students a brief description and perhaps an example, (see Word Webbing).

   C. Tape all webs for each area on the board and ask each group to present their findings.

4. End your discussion by explaining the following, and expand with your own ideas of how we can each solve the pollution problem.

   “Though some of you might have assumed that farms are large polluters of water, farmers actually use many practices to reduce water pollution. Some farmers plant cover crops to protect soil from running into streams during bad weather, and some spread excess animal manure on their crops. This also prevents runoff into streams and water sources. (Many students may gasp in horror, but you can let them know that farmers have been using organic nitrogen sources on their crops for years. The first Americans, (the Native Americans) used to bury fish in their crops for nitrogen. When the fish would decay, the nutrients from the decaying fish would provide nutrition for their corn and other crops.)

5. Have the students write about their attitude before and after this discussion. What changed their opinion if anything?

EXTENSIONS AND VARIATIONS

1. Have students write a 100 word essay about a practice that livestock farmers use to protect water from pollution. Have them research the library and Internet for sources. Many Universities are conducting research on the topic and their web pages can be easily accessed on the Internet.

2. Have the students visit a farm or an Agricultural Experiment Station that uses methods of control to prevent runoff into streams or water sources. Dairy and swine farms usually have manure handling facilities and the farmers may let the students visit their operation.

EVALUATION OPTIONS

Give each student a handout of the water cycle “test” and let them answer the questions. Compare pre-test scores for glossary terms to the handout for evaluation purposes. Reteach or start another lesson as needed.

EDUCATOR’S NOTES
The Water Cycle

1. Precipitation: Rain, sleet, hail, snow
2. Evaporation: Water from the surface of lakes, rivers, oceans
3. Condensation: Water vapor in the air
4. Advancing Air Mass
5. Sun's Rays (Energy)
6. Cloud Formation (Condensation)
7. Water Vapor

Steps:
- Surface Runoff to Streams
- To Lakes
- To Rivers
- To Ocean
- Ground Surface
- Infiltration
- Water Table
- Impervious Material
- Parent Material
- Bedrock
- Zone of Saturation (Ground Water)
- Deep Percolation

Natural Processes:
- Precipitation
- Jet Planes, Tractors, Autos, Furnaces, Fires (Combustion)
- Ponds, Lakes, Swamps, Marshes
- Animals (Respiration)
- Soil
- Plants (Transpiration)
- Ocean
1. Fill in the numbered blanks above with the correct words. (1-7)

2. What are the three areas that runoff water can originate?

3. How does water from one area differ from the others? How are they similar?
Alternate Water Cycle Sheet

THE WATER CYCLE

WORD BANK

EVAPORATION
When water changes from liquid to gas.

CONDENSATION
When gas changes back to liquid.

PRECIPITATION
When water returns to the earth as rain, snow or sleet.

GROUND WATER
Water beneath the surface of the earth.

DIRECTIONS:

1. Label the arrows in the picture using the correct words from the WORD BANK.

2. What is the heat source in this picture?

3. Draw a circle around the part of the picture where water returns to the surface from under the ground.

4. Where does condensation take place in this picture?

5. On the back of this page, write your personal observation of the water cycle. It might be about a rainstorm, a snowfall, or even a foggy day.
This is an example of a word web that describes who or what might use the water in a farm pond. Have the students select one of the words: Urban, Rural, Suburban. They should place the word they choose in the center of their paper. Branching out from this word have them list sources of pollution that affect the water in each area. Some “links” may not have as many branches as others. Next have them list “how” each source affects the water. They should do the same for the other two words. Have them pay attention to similarities.
BRIEF DESCRIPTION
One of Tennessee’s natural resources is our abundance of wildlife. Our use of the land and environment is sometimes perceived as detrimental to wildlife, but there are benefits. Students create posters and write essays on misconceptions about forestry and wildlife management in this lesson.

SUPPORTING INFORMATION
There are many widely held misconceptions about forest and wildlife management. These misconceptions are leading to unwise decision making and incorrect public policy. If the general public were more well informed with accurate information about forests and wildlife, both would benefit from wise decision making. In Summary, the forest is capable of producing a wide variety of valuable foods needed by wildlife, but no single food source is sufficient for year-round use. Well planned forest management practices can provide the conditions necessary to produce adequate supplies of food for both game and non-game species during every season of the year indefinitely. For detailed information see the information on the "Misconception Cards".

GETTING STARTED
Make copies of the "Misconception Cards" and “Layers” sheet. Have materials available.

PROCEDURE
1. Divide the class into 10 Cooperative Learning groups of 2 or 3 students.

2. Assign one "Misconception Card" to each group. Give each group a "Layers" sheet.

3. Invite a professional forester or wildlife biologist to speak to the class. Have students create a list of interview questions prior to his/her visit, based on their assigned reading. (Pay particular attention to unfamiliar vocabulary.)

4. After researching the subject, each group is to design an informative poster to illustrate the information about their assigned misconception.

5. Display completed posters in a hallway.

6. Have the students write an essay about the misconception that their group studied or one that they are interested in knowing more about.

EVALUATION OPTIONS

LEVEL: 8th grade
SUBJECT: Language Arts
SKILLS: Presenting, writing
OBJECTIVES
The student will:
-identify misconceptions about forestry & wildlife management.
-create a poster about the misconceptions.
-write an essay about the misconceptions.
-practice interview skills.

ESTIMATED TEACHING TIME
2 class periods

MATERIALS
drawing materials
posterboard, copies of the information cards (1 for each group of 3 students), copies of Layers of Habitat in Tennessee’s Forest workshees

VOCABULARY
browse, clearcutting, crowns, even-aged stand, forage, hardwoods, high-grading, mast, prescribed burning, softwoods, stand, thinning
Have the students read and critique another students essay. They can judge the essays based on facts and writing skills.

EXTENSIONS AND VARIATIONS
Visit a site at which forest management practices may be observed. Have students note the forest layers, plant diversity, etc.

EDUCATOR’S NOTES
VOCABULARY

browse (n.) - tender vegetation eaten by "browsers" such as deer

clearcutting - removal of all marketable trees

crowns - the top portions of trees

even-aged stand - group of trees of about the same age

forage - leaves and stems eaten by wildlife

hardwoods - slow-growing trees such as oaks

high-grading - cutting only the larger, most marketable, trees

mast-berries ("soft mast"), or nuts/seeds ("hard mast")

prescribed burning - deliberate use of controlled fires

softwoods - fast-growing trees such as pines

stand - a group of trees in a forest

thinning - removal of some trees to prevent over-crowding
**10 Most common Forestry/Wildlife Myths & Misconceptions In Tennessee**

**MISCONCEPTION #1:**

CUTTING ONLY BIG TREES LEAVES THE YOUNGER TREES ROOM TO GROW AND BECOME MORE VALUABLE.

You have probably heard it said that the best way to harvest (or sell) timber is to cut the big trees and let the little trees grow. This reflects the common misconception that large trees are old trees and small trees, primarily in the middle layer of the forest, are young. It is assumed that small trees will grow into large trees to produce logs for lumber and food for wildlife.

In many cases large trees are not older than the small trees. In fact, the bigger trees are usually about the same age as the smaller ones. The larger trees are larger because they grew faster. The rate at which trees grow depends mainly on the species, site fertility and moisture, and competition with neighboring trees. This principle can be observed in any tree plantation, where the diameters of trees often vary from small to large, even though all were planted at the same time. The same is true in natural stands of mixed species that regenerate following a natural disaster or harvest cutting.

Therefore, there is no wisdom in cutting only the larger trees, a type of timber harvesting often called "high grading" since, in effect, all the larger, higher grade trees are removed, leaving mainly lower quality trees to restock the stand. More properly, timber should be evaluated by a forester before any harvesting occurs to determine whether enough trees with the potential for continued production of wood products and wildlife benefits would remain should a portion of the timber be cut and sold. If so, the stand may be thinned and still support a productive stand. If not, both timber and wildlife habitat would be better served by harvesting and regenerating the entire stand.
MISCONCEPTION #2:

PINE FORESTS ARE BIOLOGICAL DESERTS AND OFFER NOTHING FOR WILDLIFE. Tennessee's forests are composed primarily of hardwoods; however, many forest sites are incapable of producing high grade hardwood timber for which the State is famous. Such sites are often more productive for timber if converted to pine. Although there may be limited diversity within a single pine stand, pine can add diversity to a hardwood dominated forest landscape.

Because some forests and fields are being converted to pine plantations, many hunters are afraid that wildlife habitat is being destroyed. Through proper forest management pine plantations can provide good wildlife habitat, and food or cover for deer, turkey, and quail.

Pine plantations go through many stages, just as a person goes through many changes from birth to adulthood. Throughout the life span of a pine plantation, which may vary from 30-60 years, wildlife habitat is constantly changing. For the first 5 -6 years after seedlings are planted, a wide assortment of plants in the understory provides an abundance of food for wildlife. During this period, young pine plantations can be very productive for quail, rabbits, deer, turkey, and many non-game birds, especially if they are interspersed with other habitat types such as older pine stands, hardwood stands, and pine/hardwood stands.

After this first period of growth, the pine tree crowns soon grow close together, and less and less sunlight reaches the forest floor. Ultimately, understory plants which need sunlight to grow begin to disappear. If left unmanaged, the "biological desert" appearance of pine stands will result. This is where management can play an important role. Pine stands can produce and provide good wildlife habitat, but to do so they must be managed, primarily through use of prescribed burning and timely thinnings.
MISCONCEPTION #3:

FIRE IS BAD FOR WILDLIFE.

Wildfires can be devastating for wildlife and timber, but prescribed burning in pine stands can improve wildlife habitat. Prescribed fire is not recommended in hardwoods.

Prescribed burning is the deliberate use of fire under controlled conditions to accomplish certain forest management objectives. It is one of the best and least costly wildlife habitat improvement techniques available to forest managers.

Browse plants (hardwood sprouts) will soon grow beyond the reach of deer in managed pine stands. Prescribed burning at 2-3 year intervals will keep browse within reach of deer and will stimulate the growth of nutritious forage plants. Quail and turkey also benefit because heavy brush is removed and seed-producing plants are encouraged to grow.

Prescribed burning used in conjunction with pine thinnings can dramatically improve wildlife habitat, Research has shown that burning can result in more than a five-fold increase in available wildlife food.

One good example is the changes following the devastating fire several years ago in Yellowstone National Park. For years, it was believed that the Roosevelt Elk needed a habitat that included climax forest. After the fire there was a great deal of concern that this rare elk would be in serious jeopardy perhaps brought to the edge of extinction. Today the Roosevelt Elk numbers are climbing dramatically. The fire has benefited their numbers not devastated them.
MISCONCEPTION #4:

ALL HARDWOODS ARE EQUALLY VALUABLE TO WILDLIFE.

Early in the century, chestnuts provided a substantial portion of the mast (nuts, berries and seeds) utilized by wildlife, but during the past 50-60 years, oaks have been the most valuable hardwoods in terms of providing food for wildlife in Tennessee forests. Oaks are valuable to deer, turkey, squirrels, and waterfowl because they produce acorns, one of the most accessible and nutritious wildlife foods.

Acorn production depends on two important factors. The first is the age of the tree. Most species of oak in Tennessee begin producing acorns after about 25 years. The second factor is species group. Two broad oak groups occur in Tennessee: red and white. One important difference in them is acorn production. Red oaks are generally more reliable acorn producers, but acorns take two years to mature. White oaks produce acorns in only one season; and although some may be produced every year, production may vary widely.

Some oak species important to wildlife in Tennessee include the Red oak group (black oak, cherry bark oak, northern red oak, Nuttall oak, scarlet oak, Shumard oak, southern red oak, pin oak, water oak, willow oak) and the White oak group (chestnut oak, overcup oak, swamp chestnut oak, white oak).

Red oaks often grow faster, are somewhat more sensitive to drought stress, and reach physical maturity at an earlier age than the white oaks. Therefore intensive management by thinning and other stand improvement measures are important. Several other hardwoods that produce "hard mast" valuable to wildlife include hickory, beech, pecan, and walnut. Some Tennessee hardwoods valuable for "soft mast" production are blackgum, dogwood, persimmon, maple, ash, and cherry. Both are important food sources for wildlife at different times of the year. Hardwood species of relatively less value as food producers for wildlife include sycamore, cottonwood, and elm.
MISCONCEPTION #5: CLEARCUTTING TIMBER IS ALWAYS BAD FOR WILDLIFE.

Contrary to popular sentiment, the practice of clearcutting is often an efficient and effective management tool for production of both timber and many species of wildlife. Clearcutting involves the removal of all the trees from a given forested area. The practice is normally applied in mature stands of timber for the specific purpose of regenerating fully stocked stands of valuable native species such as oak, ash, yellow poplar, and walnut, which is not easily achieved through a partial or selective cutting system. It is well known that some species will not regenerate and grow in the shade of other trees. Foresters call them "intolerant" species because of their inability to develop in the reduced light of the forest floor. Only when sunlight is allowed to reach the forest floor does nature permit seeds of some species to germinate and seedlings of intolerant species to grow and develop.

"Selective cutting" of timber will allow some seedlings to become established where individual trees are harvested, but adjacent uncut trees soon expand their crowns into spaces created by harvesting, and further development of the new seedlings is suppressed by the progressively lower level of light. The introduction of sunlight created by clearcutting stimulates germination of seeds and provides room for growth and development of seedlings and fast growing sprouts, which usually form the fastest and highest quality trees in the new stand.

Because clearcutting begins a whole new cycle of plant growth in which a whole new community of shrubs, grasses, fungi and wildflowers are produced in addition to an abundance of tree seedlings, a series of new habitats are created over time that provide browse and forage for deer and nesting areas and food for turkeys, rabbit, and quail which was previously unavailable. As such, clearcutting provides diversity of habitat within a larger landscape.

Most public resistance to clearcutting is related to its visual impact rather than to its effectiveness in achieving regeneration of timber or improving wildlife habitat. Most of the clearcutting familiar to the public has been carried out on forest industry lands where efficient timber production accomplished through large cutting units is the primary goal.

Clearcuts need not be large to achieve timber regeneration and wildlife habitat goals on nonindustrial private and government-owned lands. Although larger areas are easier to manage, research has shown that the minimum size area needed for regenerating timber is a space about twice the mature height of the adjacent timber stand in width, about an acre. Visual impact can be reduced and usefulness to wildlife enhanced by varying the size and shape of clearcuts and distributing them at random across the forest property, which also creates habitat diversity.

Cuttings can be scheduled every 5-15 years to achieve a balanced distribution of timber age-classes and productive wildlife habitat. A well regulated, forest composed of many even-age stands of timber randomly dispersed across the forest will provide all the habitat components necessary for many game species of Tennessee wildlife and will almost guarantee "good hunting" indefinitely. Most foresters and wildlife biologists recognize clearcutting as beneficial for both timber and many species of wildlife. It is unfortunate that such a beneficial forestry practice has received so much negative criticism, because Tennessee's hardwood forests have an amazing ability to regenerate naturally under such a system. Better understanding of the need for clearcutting by forest and wildlife managers can result in better timber and more wildlife for everyone.
MISCONCEPTION #6:

TIMBER HARVESTING ALWAYS CAUSES SOIL EROSION AND POLLUTION OF STREAMS AND LAKES.

Many people believe that clearcutting and other harvesting practices cause soil erosion and contribute to water pollution, but research has shown that cutting trees does not in itself cause soil erosion, regardless of the cutting practice employed. Erosion occurs in areas where leaves and other organic debris, which cover the forest floor, have been pushed back or incorporated into the soil and where the soil itself has been disturbed or loosened. Areas where the organic litter remains undisturbed are protected from raindrop erosion. The energy of falling rain is absorbed by the litter layer, preventing detachment of soil particles. Precipitation then soaks harmlessly into the forest soil to feed vegetation and recharge underground water supplies.

Soil erosion and water pollution may be prevented or minimized through the use of best management practices (BMPs) developed for use by loggers and other forest operators. Proper location and construction of logging roads, log decks, and skid trails to minimize soil movement and use of streamside management zones to protect stream channels and banks can prevent most soil erosion and ensure that streams and lakes remain free of sediment.

The potential for generating erosion is probably greater when conducting, so-called selective cutting, in which individual trees are removed, than when clearcutting, where all trees are removed, since more roads, landings, and skid trails must be constructed over a larger area in order to cut and remove a given volume of timber. In addition, with selective cutting; the cutting cycle is shorter, which requires more frequent reentry and disturbance of skid trails, landings, and roads.
MISCONCEPTION #7

HERBICIDES ARE ALWAYS HARMFUL TO THE FOREST ENVIRONMENT.

Herbicides are chemical substances used to control unwanted vegetation such as grasses, brush, and undesirable trees. These chemicals have proved to be effective and economical tools for controlling vegetation which would overtop and kill newly planted seedlings or otherwise interfere with the growth of desirable trees.

Application of herbicides, especially over relatively large areas, has raised questions about the effect such chemicals have on fish and wildlife, water quality, non-target plants, and human health. However, while any substance administered in sufficient quantities can act as a poison and kill. The toxicity (the degree to which substances are poisonous to humans or other animals) of most of today's forestry herbicides is low and poses little or no threat to man or animals in formulations and volumes commonly applied. Most forestry herbicides in common use today actually have a lower oral toxicity than similar amounts of table salt or aspirin and the active ingredients are applied at very low doses. Also, the interval between applications is extremely long (30-60 years) compared to agricultural chemicals, which are applied annually.

Many herbicides bind themselves to soil particles and tend not to move through the soil. Sunlight, soil microbes, and other natural processes chemically break down herbicides into other harmless substances relatively quickly after application. Most persist for only a few weeks or months. Thus, rapid decomposition of herbicides helps to reduce the hazards associated with their use. If carelessly or improperly applied, herbicides, may cause harm in the environment as may any substance. Especially if applied directly to water or, non-target crops or in other than recommended amounts. Conversely, when properly used, herbicides cause few, if any, detrimental effects and are valuable tools for achieving timber and wildlife management objectives in a safe and cost effective manner.
MISCONCEPTION #8:
FORESTERS ARE CONVERTING ALL OUR HARDWOOD AREAS TO PINE.

According to a 1989 forest survey conducted by the U.S. Forest Service, 11.9 million acres or 89% of Tennessee’s forests were classified as hardwood or hardwood-pine types. A 1952 forest survey of the State shows that the proportion of hardwood and hardwood-pine types was only 75% of the forest resource. Thus the amount of pine types has steadily declined and the amount of hardwood has increased. From 1952 until 1989, the amount of Southern pine type dropped from 2.0 million acres to 1.3 million acres. A drop of 34%.

Most of the "new" pine has been established by the wood-using industries on company land, which supported mostly low-grade hardwood stands, and by private landowners who planted pines under one or more of the federal cost share programs such as the Soil Bank Program, Agricultural Conservation Program, Forestry Incentives Program, and Conservation Reserve Program. The distinctive pattern of planted pines on the landscape, which make them more noticeable to the average citizen, provides a false impression that much of our hardwood forest lands are being converted to pine. Tennessee is still a "hardwood state"!

There has been relatively little change in the total amount of forestland in Tennessee during the past 37 years (7% increase), but substantial changes have been made in specific areas of the State that affect timber and wildlife production. In West Tennessee, for example, hundreds of thousands of acres of bottomland timber have been cleared during the past 20 years, for crop production. Since bottomlands are the most productive sites in the State, conversion to another land use exerts a devastating impact on timber and wildlife in that region. Concurrently, forestland acreage in other areas of the State has increased as old fields have been allowed to revert to forestland, providing additional habitat for wildlife. However, urban expansion, road and utility right-of-ways, and other land uses are expected to continue gobbling up forestland in the Volunteer State and, as such, pose a grave threat to timber production and wildlife habitat in the future.
MISCONCEPTION #9:

IT IS GOOD HARDWOOD LAND IF HARDWOODS ARE GROWING ON IT.

Hardwoods are the climax timber type in most areas of Tennessee. The oak-hickory type alone occupies 72 percent of the State's forestlands. Hardwood species composition may vary from the highly desirable oaks and hickories to species less beneficial to wildlife such as maple, ash, and yellow poplar. Therefore, the occurrence of hardwoods doesn't necessarily indicate a good site for either timber growth or wildlife food production. Poor quality forest sites, even though they may support several oak and other hardwood species, provide relatively less potential for wildlife food. Conversely, good sites have the potential for producing good crops of food for wildlife, especially hardwood mast (acorns and other nuts), as well as high-grade timber.

Good hardwood sites are not difficult to recognize. The trees growing on them are tall, long-bodied, and relatively free of limbs. Such trees are usually found on river bottoms, stream terraces, and north and east facing slopes where the soil is deep and moist and plenty of organic litter is present. Also, production of acorns, wild grapes, and other foods valuable to wildlife are heavier and more consistent. Poor sites are characterized by short-bodied, flat-topped, mostly limby timber. Ridge tops, upper slopes, and South and West facing slopes support low grade hardwood stands in many areas of the Volunteer State. These locations are characterized by shallow, dry soils with little moisture-holding capacity. Production of wildlife food on such sites is much lighter and more sporadic than on the better ones. Some landowners have been criticized for converting low grade hardwoods to pine because it "destroys" wildlife habitat. In most instances such sites aren't nearly as productive for wildlife as one might think. If interspersed with native hardwoods in relatively small blocks, pines can provide valuable habitat diversity by breaking up the continuous forest. Wherever possible, of course, hardwoods should be retained on good sites and managed intensively if production of high-grade, high-value timber products and wildlife habitat are important landowner objectives.
MISCONCEPTION #10:
IF PLENTY OF ACORN-PRODUCING OAKS ARE PRESENT, THERE IS NO NEED TO WORRY ABOUT PROVIDING OTHER FOOD FOR WILDLIFE.

Wildlife food is produced in the forest environment by the trees in the overstory and by plants on the forest floor. Hardwood trees produce nuts, berries, and other fruits. Other plants on the forest floor such as shrubs, vines, forbs, fungi, and grasses produce browse, forage, fruits, seeds, and similar nutritious foods needed and used by a variety of game and nongame species. Mast is a collective term for the fruit of forest plants used for food by wildlife. "Hard mast" consists of nuts such as acorns, walnuts, pecans, beechnuts, and hickory nuts. So-called "soft mast" includes dogwood berries, wild cherries, persimmons, maple seed and the soft fruits of many other species. Mast is high energy food that provides many mammal and bird species the nutrition they need to maintain health for winter survival and reproduction. The size and health of wildlife populations are often directly related to variations in mast supply.

Because hard mast is so valuable, other foods needed by wildlife during each season of the year are sometimes dismissed as unimportant. Although most species of wildlife feed on acorns and other mast, production of such food is seasonal and sporadic from year to year; so wildlife must seek a variety of foods in order to survive. Deer, for example, depend heavily on year-round forage and browse plants for food in addition to mast. Other species also need browse, forage, seeds, insects, and other foods during the year when mast is not available.

Often, the best way to ensure reliable year-round supplies of food for wildlife is by managing our forests. Every management activity affects wildlife and the food supply. Clearcut areas where timber is regenerated, temporarily provide excellent year-round deer browse and forage. They also furnish fruit, seed, and insects needed by turkeys, quail, and many other game and non-game birds.

When such areas are interspersed among forested areas of varying age and size, they provide access to food and cover needed by practically all species of native wildlife. Areas in which adequate food, cover, and water are provided on a continuous basis will attract and retain wildlife indefinitely.

Additional forest management practices which enhance wildlife habitat include periodic thinnings and prescribed burning, both of which give rise to nutritious browse growth, shrubs, grasses, and seed-producing plants. Since all forest environments exist in a constant state of growth and change, harvest cuttings, thinnings, and prescribed burnings must be conducted every few years to maintain habitat of optimum quality for all wildlife species. Therefore, a decision to "do nothing" is in fact, "doing something," since change is natural and inevitable.
Layers of Habitat In Tennessee's Forest

**Overstory** (Canopy)

The canopy is made up of the leaves, branches and upper trunks of the largest trees. The canopy is the nut or "hard mast" producing layer. Many animals depend on this layer to produce nuts in the fall so they can fatten up for the winter. The following species of wildlife may be found at this layer:

- Great Horned Owl
- Oak Tree Hopper (insect)
- American Crow
- Tent Caterpillars
- Gray Squirrel
- Cooper's Hawk

**Midstory** (Understory)

The middle layer of the forest usually runs from the leaf litter to about 25 feet above the ground. This layer produces high amounts of small seeds and green food (leaves and stems) called forage for many species of wildlife. The following species of wildlife may be found at this layer:

- Jumping Spider
- Dark-eyed Junco (bird)
- Southern Flying Squirrel
- Raccoon
- Whiteface Hornet
- Black Bear

**Forest Floor** (Litter Layer)

Most forest mammals will spend all or some portion of their life on the forest floor. This layer is made up of materials like fallen leaves, twigs, logs, and grasses. The following species of wildlife may be found at this layer:

- Chipmunks
- Lone Star Tick
- Carolina Wren
- White-tailed Deer
- Timber-Rattlesnake
- Eastern Wild Turkey

**Soil** (Underground Layer)

The soil layer could be considered the most important layer. This layer supports the forest by providing nutrients and by physically holding the tree’s roots. Protection of the soil is very important because this is where the forest begins. The following species of wildlife may be found at this layer:

- Eastern Starnose Mole
- Yellow Jackets
- Longtail Shrew
- Ground Hog
- Red Worms
- Voles
BRIEF DESCRIPTION
Students find out that water is a shared resource that is reused over and over again. Tennessee averages fifty-two inches of precipitation each year. The water that falls has been through the water cycle many times.

SUPPORTING INFORMATION
Many of us have experienced standing up in a large crowd to watch a performer or speaker on stage. Often, to get a better view, someone will sit on the shoulders of a friend. How does this make people standing behind the couple feel? Sometimes what works for the individual may not work for the group.

Water is used by all members of a community. Because water is important to all water users, as demands for this finite resource grow, the need to conserve and manage supplies also grows.

Fortunately, water is a reusable resource; given time, biological (e.g., filtering through soil and vegetation) and physical (e.g., rain, settling out of sediments) processes in healthy ecosystems replenish water quality and quantity. Wastewater treatment plants facilitate these processes as well.

Since the recent enactment of water quality control laws, many rivers and lakes are cleaner than they were in the 1960s. There is good news regarding water quantity as well. Farmers throughout the country have reduced ground water consumption through efficient water use practices (planting crops that require less water, adopting irrigation methods that use less water, capturing and reusing runoff, etc.).

Conservation and practical use of water can be employed by water users (homeowners, businesses, industry, etc.) to prevent water shortages and ensure long-term supplies. If sharers of a water resource; given time, biological (e.g., filtering through soil and vegetation) and physical (e.g., rain, settling out of sediments) processes in healthy ecosystems replenish water quality and quantity. Wastewater treatment plants facilitate these processes as well.

Since the recent enactment of water quality control laws, many rivers and lakes are cleaner than they were in the 1960s. There is good news regarding water quantity as well. Farmers throughout the country have reduced ground water consumption through efficient water use practices (planting crops that require less water, adopting irrigation methods that use less water, capturing and reusing runoff, etc.).

Conservation and practical use of water can be employed by water users (homeowners, businesses, industry, etc.) to prevent water shortages and ensure long-term supplies. If sharers of a water
source consider the needs of all users, and plan for and manage those needs, then water of sufficient quality and quantity should be available. We can all make a difference!

GETTING STARTED
Prepare materials listed in the Materials List.

PROCEDURE
Session 1
1. Have students list major water user groups in their community and how they use water. The Yellow Pages can be a source of ideas. Ask students to arrange the water users, from those who they think use the most water to those who use the least.

NOTE: This activity may involve spilled water and should be conducted outdoors or in an area that can get wet.

2. Fill a large bucket to the brim with water. Tell students that the bucket represents water stored in a reservoir, pond, or lake. Some communities depend on ground water. If this is the case, the bucket resents water underground (and the sponges symbolize wells).

3. Tell students they are going to simulate changes in a watershed over several time periods. Each 30 second round represents a time period (see Round Scenarios). In each round, students represent different water users; they may want to make nametags to identify their roles.

4. For each round, students should position themselves an equal distance from the water source. When the round starts, students fill sponges with water from the reservoir (bucket). To represent water consumption, have them squeeze water out of the sponges into individual containers. Students can refill their sponges as often as they like during the round.

5. At the end of each round, note how much water remains in the bucket. Tell students to empty half of the water from their containers back into the bucket. This represents used water that makes it back to the reservoir (i.e., when it percolates through soil, when it is discharged from a factory, after it runs off the surface). Students will notice that the water is colored. Inform them this represents sewage and runoff from urban and rural areas.

6. Record students’ comments about the amount of water used and the amount of waste materials generated, compare after each round. To represent the water source eventually cleaning and replenishing itself over time, fill the bucket to the brim with clean water before each round.

Round Scenarios
Following are four suggested rounds to symbolize use of a common source of water over time. The relationship of the rounds and the allotment of sponges is shown in the chart Suggested Distribution of Sponges for the Rounds. Depending on time considerations or extent of investigation, rounds can be added or deleted. (For the first two rounds use sponges laced with a few drops of yellow food coloring. Use darker colors for later rounds to add dramatic effect.)

Round 1.
It is 200 years ago. The watershed is inhabited by a few homesteaders operating small farms. Have three students represent the homesteaders. Give each of them one-fourth of a sponge...
and a container.

Round 2.

One hundred years have passed. A large farm and a small town are now located in the watershed. Distribute sponges, cut in fourths, to six students (town dwellers) and a half sponge to a student representing the farm. Provide each student with a container. Complete another round.

Round 3.

It is now just after World War II. The size of the town has increased. Many of the town residents are employed in an industry that makes typewriters. The factory is represented by half a sponge. Two farming areas supply milk and some food (meat, grains, vegetables) for the town; they get one sponge each. Give one sponge to a student who represents a power company. Several community services, such as hospitals, schools, and stores, are now part of the town; each student representing such a service agency gets half a sponge. Provide each family (about 10 students) with a third of a sponge. Provide each student with a container. Complete a round.

Round 4.

It is the present. The town has continued to grow. A new industry that makes household cleaning products has moved in (another sponge). Represent residential expansion by giving sponge pieces and a container to any remaining students. Complete a round.

Have students discuss the quantity and quality of water in the round. Discuss proportions of sponge pieces distributed to different community members. Are water users in their own community represented by the characters in the simulation? Do students think the sponge sizes were appropriate? Were there any groups who used too much water or did not get enough? Schools were a service agency in the demonstration. Have students identify the different ways their school uses water. Do students think the school uses water wisely?

How could the activity be adjusted to ensure enough clean water for all users? Students may suggest making fewer trips to soak their sponges or reducing the size of their sponges. They may suggest adding another bucket of water to increase supply. Where would this water come from? Would another community experience water shortage as a result of these diversion projects? Methods to reduce waste discharge can also be discussed (e.g., applying organic fertilizers (manure) to crop land based on soil test results, reducing litter, upgrading sewage treatment plants). Have students interview local water managers to identify water distribution policies and conservation programs. Students may want to run another round to test their adjustments.

Discuss the statement: "Water for all water users." Do students think this is possible? What can communities do to ensure everyone gets enough clean water? Students can create a display or mural, titled Water for all Water Users, depicting ways a community shares its water supply. If water quality or quantity is an issue in the community, students can research what the community is doing or should do to maintain clean water supplies. These actions should be included in the display as well.

OR

Have students list groups of water users in the com-
munity. Explain that a water shortage exists. Working in groups, tell students they must determine who has rights to use water first and how much water each group can use. Are students able to determine which group most deserves water? Remind students that communities, like ecosystems, are interconnected and interdependent. For example, if students believe an industry uses too much water and should limit consumption, determine if production may need to be reduced. This would entail laying off workers, which will affect families. Some farms use large quantities of water, yet they supply people with large quantities of inexpensive food. Solutions to limited water supplies will require input from all sectors of society.

Session 2
1. Divide the class into small groups of 4-5 students.
2. Have each group devise a graph to depict the water users in each of the four rounds played in Session 1. Each group must decide the type of graph to use for their depiction. Use graphs from USA Today to provide insight on a variety of ways information can be depicted and made easy to understand.
3. Have each group present their graph and identify why they felt this type of graph was the best choice to display their information.

EVALUATION OPTIONS
Have students:
1. demonstrate scenarios in which water quality and quantity are threatened when water users use the resource without considering the needs of others (steps 3-5).
2. propose and illustrate ways a community could supply its members with clean and ample water supplies.
3. assess the accuracy of each group’s graphs. Ask the students to provide peer review input concerning the choice of graph, and how the information is displayed, and whether this was an effective method to make the information easy to understand.

EXTENSIONS AND VARIATIONS
1. Involve individual and group cooperative efforts, with everyone conserving water and using water efficiently.
2. Create a different scenario based on the occurrence of a drought. Have a full bucket represent a normal year and a half filled bucket represent a drought year.

RESOURCES

EDUCATOR’S NOTES
BRIEF DESCRIPTION

Students will learn the various measures Tennessee farmers use to control pests on their farms by determining percentage of crop damage required to be of economic importance. Students will also obtain a greater sensitivity to home and business chemical use, storage, and disposal.

SUPPORTING INFORMATION

We all have experienced a pest "problem". When we leave a window open on a warm summer night, flying insects sometimes take up residence in our lampshades. Ants, mosquitoes, and gnats crash picnics and swimming parties. Gardens and flowerbeds are havens for all types of weeds and "creepie-crawlies". What other ways have bugs, weeds, or rodents presented problems to people or to the environment?

Humans try to control and sometimes eradicate pests by using traps or pesticides. Pesticide is a generic term that refers to a chemical designed to kill or control pests. Many "control measures" are ecologically sound, that is they are not harmful to the environment or to people, but, sometimes pesticides are used inappropriately and can result in harm to humans and/or to the environment.

For example, except for a very few restricted pesticides, any homeowner can buy and use pesticides. Because homeowners do not have to receive any special training or permission to use most pesticides, often the homeowner doesn’t know how to use them properly and safely. The average homeowner uses eight times the amount of pesticides per acre as the average farmer. Also, the average homeowner is less likely to know how to dispose of excess product properly and safely. They throw away containers for regular trash pick-up. Sometimes they pour excess products down the drain. Municipal sewage treatment systems generally are not designed to remove pesticides, so small amounts of pesticides can end up in our drinking water.

Farmers must deal with pests on their farms. Pests such as bugs and fungi can destroy their crops. While farmers want to protect their crops, they also try to protect the environment by using chemicals appropriately and only when necessary.

One method farmers use to protect their crops from insects, weeds, and plant diseases is integrated pest management (IPM). IPM is an approach to pest management that prevents pest popu-
lations from reaching damaging levels by using one or a combination of biological, cultural, chemical, genetic, or mechanical control measures to manage pests. Biological controls include the use of helpful diseases or beneficial insects, such as ladybugs, preying mantises, and lacewing larvae to prevent pest populations from getting out of control. Cultural controls include planting grass or other plants to compete with weeds for moisture, nutrients and sunlight. Chemical controls include the use of herbicides for killing or inhibiting plant growth or reproduction. Genetic controls include the use of genetic engineering to enhance a plant’s ability to fight pests on its own. Mechanical control methods include mowing, cultivation, digging, or chopping plants to control pests.

IPM takes into account interactions among pests, the environment, and the crop. Crop specialists go into a field and scout the field to look for pests and other problems with the crops. The crop specialists also monitor populations of beneficial insects.

To keep plants healthy, farmers can choose from the various control practices to change what is grown in the field, choose crops that fight off pests, change planting and harvest dates, use different machines, and/or control pests with pesticides. The goal of IPM is not to get rid of pests altogether, but to keep pests from damaging too much of the crop. Pest controls are applied only when the value of the crop that is saved is greater than the cost of controlling the pests. Only when all else fails are the minimum amounts of pesticides applied to a farmer’s fields to control pests. This allows farmers to use less pesticide. Some pesticides target a specific plant or insect, others are broad-spectrum and treat a variety of pests. Because pesticides are costly, farmers must watch how much they spend on them to control their costs of production.

Farmers have to be trained and certified to use pesticides. In addition, they must take annual continuing education courses in order to maintain their certification. Stringent regulations exist to control how pesticides are used, what safety precautions are taken, as well as how and where they are mixed, stored, cleaned-up, and disposed.

The use of pesticides and other IPM control measures on farms has resulted in an increase in food production per acre, increase in the variety in our diet, greater control of diseases, and improvement in our quality of life.

GETTING STARTED

Make copies of the IPM Simulation Worksheets.

PROCEDURE

Give the students the information about IPM as a study sheet or in the form of a lecture. Have the students complete the worksheet.

EVALUATION OPTIONS

1. Evaluate the student worksheets for accuracy using the answer key.
2. Have the students compare and contrast the decisions they made in selecting the IPM options they would use. Ask them to defend their position.
3. Have each student make a chart of the IPM options available and the time at which they would decide to use the various options and the consequences.

EXTENSIONS AND VARIATIONS

1. Schedule a farm visit where students can observe an integrated pest management technique in practice.
2. Take a nature walk individually or as a class to collect insects. Group like insects together. Divide the class into groups. Assign one or several insects, depending upon the variety found, to each group. Have the group note
characteristics about color, size, shape, etc. of the insects. Have them use books to identify the insects by name, environment they prefer, what they eat, and other notable information. Each group will make a short presentation on their insects.

EDUCATOR S NOTES

The students should have strong skills in multiplication and division and a familiarity with percents and ratios.
Suppose you are a corn farmer and have found a pest infestation in your field that may reduce your corn yield by eight percent. Your expected yield (with no insect damage) is 135 bushels/acre and the expected price of corn at harvest is $2.90/bushel. The cost of reducing the pest population such that no damage occurs is $15.65/acre. Solve the following problems:

1. Should you treat your corn crop to reduce the pest population?
   This is a two-part problem:
   a. First, find out how much money per acre would be lost if you did not treat your fields.
   b. Second, compare your answer from (a) to how much money per acre you would spend to treat the pests. **HINT:** If the cost of treating the pest is lower than the money you would lose if you didn’t treat for pests, then you should not treat the field. Write yes or no in response to question #1 and circle your answer.

2. What is the maximum amount of money per acre you would pay to treat the pests for the same eight percent estimated level of damage? Circle your answer. **HINT:** You should pay no more than the estimated amount per acre that you would lose at harvest for a pest damaged crop.

3. What is the maximum percentage of crop damage you would allow before spending $15.65/acre to treat the pests? This is a two-part problem:
   a. Find the maximum bushels per acre you would be willing to lose to pest damage. Circle your answer.
   b. Find the maximum percentage of crop damage you would allow before spending $15.65/acre to treat the pests. Circle your answer.
Answer Key for IPM Simulation Worksheet

1.  
   a. The estimated value of the yield reduction, if the pest is untreated, is (.08)(135 Bu/acre)($2.90/bu.) = $31.32/acre

   b. The reduced value of $31.32/acre is greater than the treatment cost of $15.65/acre. This suggests that with the data given, the treatment should be applied. The correct answer to question #1 is "yes".

2. The most that could be paid to control the pest problem that causes eight percent damage is $31.32/acre. If the cost increases beyond this point, then the treatment cost exceeds the value of the benefits.

3.  
   a. Treatment is not economical if the benefit of controlling the pest isn’t at least $15.65/acre. At $2.90 per bushel, this means the maximum bushels you are willing to lose to pest damage would be

\[
\frac{($15.65/acre)}{($2.90/bu.)} = 5.4 \text{ Bu/acre}
\]

   b. This represents a damage level of (5.4 Bu/acre) / 135 Bu. = .04 = 4% Thus, treatment is economically justified at damage levels of 4% or greater
1. You are a farmer that raises sweet corn. Your customers do not like to purchase ears of corn that have worms in them. It is better to find a whole worm than a half worm, but the presence of a worm causes customers to go somewhere else for their produce. You have several options to prevent worms from ruining your business.

For our example let us assume the cost of planting and harvesting (not including pest control) one acre of sweet corn is $450. You expect to produce 1000 dozen ears of corn at a selling price of $1 per dozen.

1. Mechanical Control such as Cultivation
The cost of fuel and time to cultivate should be considered. (4 gal. fuel @ $1.20/gal. and 4 hours labor @ $5/hour) per application. Expected level of control: 10% reduction of worm population per application. (Worms usually inhabit the soil deep enough to avoid disturbance by cultivation.

2. Scouting the Crop
A scout will scout (inventory pests) so many times a season for a set fee per acre with a minimum fee or could be paid on a per visit basis for so much per acre with a minimum cost to visit. The scout is paid regardless of recommendation for pest control. Controls are applied when necessary (Economic Threshold)
Assume $10/visit with a minimum of three visits to limit damage to 8% accompanied by a single application of chemical control. Three more visits would limit damage to 6% with two more applications of chemical control. Chemical cost $20/acre/application.

3. The Threshold Concept
You can afford 6% damaged crop and still make a profit. How many ears of damaged corn would that equal? _______. What is the value of the affected corn if they are all bundled together? (Assume $1/dozen)._______ But if the affected ears are in different dozens it could be disastrous. How many dozens would you want to buy if each one had one wormy ear? Not many. You would probably go somewhere else for your next dozen. It will take time and effort to find the wormy ears, and this is an expense that cannot be overlooked. At what level (percentage) damage would you be willing to pay for control of the worms if it cost $50? Circle your choice.
   a. 1% damage costs = .01 x 1000 dozen @ $1 per dozen= ______
   b. 3% damage costs = .03 x 1000 dozen @ $1 per dozen= ______
   c. 5% damage costs = .05 x 1000 dozen @ $1 per dozen= ______
   d. 7% damage costs = .07 x 1000 dozen @ $1 per dozen= ______

4. If you knew that you were going to have some pest damage, could you afford not to inspect the ears before they were sold? Circle your choice Yes or No This could mean the difference in selling $940 worth of corn and selling none.
BRIEF DESCRIPTION
Agriculturists breed plants or animals with desirable traits together to pass those traits on to new generations. Some of these include plants that are resistant to disease and drought, as well as animals that grow faster on less feed. These superior offspring place less stress on our natural resources while being more cost efficient.

SUPPORTING INFORMATION
All improvement in the genetic quality of livestock or plants is a result of variations in the genetic makeup of the parents. If the parents combination of genes are identical (with the exception of male/female), the offspring's combination will be identical also.
Fortunately, gene combinations vary from animal to animal. (With the exception of identical twins, and being identical (both male or female) they can not reproduce sexually.)
The students in your class are a result of the mixing of genes from their parents. Their looks are dependent in part to the combination of genes received. This activity helps them identify the traits that they have and see that they came from their biological parent. (NOTE: Be sensitive to the issue of adopted children and others with various family situations)

GETTING STARTED
Make copies of the STUDENT SHEET.

PROCEDURE
1. Discuss some traits that are noticeable to the students, and the fact that these traits can be passed on to their offspring.
2. Have the students get into groups of twos. Distribute the STUDENT SHEET, and have them list the traits that they have. Then have them list the traits of their partner under the heading of Other. This is a good activity to create excitement in scientific research.
   After the students have completed the column for themselves and their partner, list the different traits on the board.
   Have the students raise their hand if they have the trait in question.
3. A pie chart can be constructed showing the prevalence of one trait over another.
   Using the information gathered from the pie chart, have the students calculate the percentage of students that express each trait.
4. Have the students take the sheet home to identify traits expressed by their parents. (see NOTE!)
5. Conclude this activity by tallying the traits of parents just as you did for the students. Which traits are least prevalent? Most

LEVEL: 6th Grade

SUBJECT: Math

SKILLS: observation, analyzing, inferring, calculating percentages, graphing

OBJECTIVES
The student will
- identify traits that are inherited from parents.
- calculate the percentages of each.
- identify traits that people would seek and select for when raising animals and plants.

ESTIMATED TEACHING TIME
12 class periods plus home work

MATERIALS
Student sheet

VOCABULARY
inherited, traits
prevalent? Is there a pattern among families, (cousins, grandparents, etc.)?
6. Ask the students to identify genetic traits that humans would look for in plants and animals and actually select for when breeding. Make listings under different categories on the board and have them be specific. Use headings such as Horses, Roses, Sweet Corn, Dairy Cattle, Beef Cattle, Peaches, Apples and Tomatoes. Some traits that are selected for are:

- **Horses** - Speed, Strength, Color, Size, Jumping Ability, Conformation
- **Roses** - Color, Size of Bloom, Lasting Flowers, Fragrance, Stem Length
- **Sweet Corn** - Amount of Sugar, Disease Resistance, Ear Length
- **Dairy Cattle** - Quantity of Milk Production, Good Feet and Legs, Conformation, Color, Breed Characteristics
- **Beef Cattle** - Quality of Meat, Rapid Growth, Good Mothering Ability, Conformation, Color, Breed Characteristics, Size, Good Feet and Legs
- **Peaches** - Flavor, Ability to Hold Their Shape When Canned, Color
- **Apples** - Red Color, Flavor, Storage Traits, Will They Brown When Sliced, Color When Cooked
- **Tomatoes** - Flavor, Ability to be Shipped, Density of Flesh, Amount of Water

**EVALUATION OPTIONS**
1. Determine if the students can identify the traits listed by having them check out a person at school, (maybe the Principal!).
2. To check for understanding of percentages, have the students include their families, and friends into their calculations and check for accuracy.
3. Have the students survey 5 classmates as to the genetic traits that each would seek in their favorite foods. Provide a few suggestions such as tomatoes which taste good in the winter, sweeter grapefruit for juice, hamburger with less fat, etc.

**EXTENSIONS AND VARIATIONS**
Have the students come up with a list of other traits that are inherited. Ask them if all traits can be identified with Yes or No questions. Why not? Not all traits are represented by simple dominance. Some are expressed as a combination of traits. See if the students can identify traits that seem to go together, ie. fair complexion and blue eyes.
**Ear Lobes**
Ear lobes can be attached at a point above the bottom of the ear lobe or attached at a point below the bottom of the ear lobe. Write "above" or "below" in the space provided.

**Tongue Rolling**
By rolling the sides of the tongue up and in, some people can roll the tongue into a cylinder. Others can't do this. Write "yes" for a tongue roller; "no" if unable to roll tongue.

**Right- or left-thumbed**
When interlocking the fingers of both hands some will place the left thumb over the right thumb; others will have the right over the left. Fold your hands with the opposite thumb on top. How does it feel? Write "left" if the left thumb is on top; "right" if the right thumb is on top.

**Folding arms**
Some people will fold the right arm over the left and some will fold left over right. Fold your arms in the opposite way. Is this difficult to do? Write "left," if the left arm is on top; right if the "right" arm is on top.

**Spreading Fingers**
Some people will be able to spread fingers of either hand in a "V" shape - two fingers on one side and two on the other side. Write "yes" if fingers are spread: "no" if this can't be done.

**Dominant eye**
Place hands at arm's length and form a triangle. Focus on an object across the room. Bring your hands back to your eye, keeping the object in the triangle. Which is the dominant eye? How can you tell? Write "left" if the left eye is dominant or right if not.

**Widow's peak**
The shape of the hairline across the forehead varies from person to person; some have a dip or point in the hairline in the middle of the forehead called a Widow's peak. Write "yes" if there is a Widow's peak. Write "no" if there is none.

**Finger length**
Place the first three fingers of your hand on a table. Note the length of the index finger and the ring finger. Index fingers vary in length some are shorter than the ring finger and others are longer than the ring finger. Write "longer" if the index finger is longer: "shorter" if it is shorter.
BRIEF DESCRIPTION
Humans have always had a strong need to record the events of their lives. From cave painting to writing paper, humans have preserved their history in many ways. In this activity, students will discover how the development of paper revolutionized the way people communicate and record information.

SUPPORTING INFORMATION
Communicating and recording information has always been a basic part of human society. In earliest times, humans used stone paintings and, carvings to record their ideas. Humans have used stone and clay tablets, leaves and bark, animal skins, bronze, and cloth to find the ideal surface to record and transport the written word.

In China in A.D. 105, a Chinese court official invented paper as we know it today. This first paper was made from fibers of hemp, cloth, and mulberry bark that were mixed with water and mashed, then pressed into a sheet and allowed to dry in the sun. Early papermaking technology traveled from China, across the Near East to North Africa and Europe. But it was not until a French scientist in 1719 observed wasps building their nests from bits of wood that wood fiber entered papermaking.

Since that time, the basic principle of papermaking has remained the same, but the process has become much more efficient. Wood fiber is still the principal ingredient, but recovered waste paper is playing an increasingly large role.

GETTING STARTED
Make sure you have examples of different types of paper by asking students to bring samples from home. Make copies of the activity sheet.

PROCEDURE
1. Divide students into ten teams. Assign each team a numbered period in the history of papermaking (see "History of Papermaking").

2. After group members have read and reviewed the history of papermaking, and discussed their time period, have groups create a mural that depicts their time period's paper making technology. They can use actual paper samples to make their murals (e.g., coarse, brown paper towels for early paper; homemade paper for the Chinese era, computer paper for the recent era).

3. Have each group describe its mural to the other groups. Teams should mount their murals on the wall in chronological order. Groups also should create a paper chain out of their symbolic paper stock to link each era to the next.

**EVALUATION OPTIONS**

Using the "around the room" mural they created, students should each sketch an informational timeline of papermaking. The timeline should include at least six major periods in papermaking technology.

**EXTENSIONS AND VARIATIONS**

1. Using different kinds of paper (paper towels, typing paper, cloth paper, homemade paper, colored paper, newspaper, etc.), representing different historical periods, have students in their groups create a collage or mosaic of paper representing those different periods in papermaking history.

2. Students can investigate current trends in the way humans record information (e.g., using magnetic tape, microfilm, silicon chips, and compact disks in place of paper). By interviewing parents and other adult users of computers and other electronic equipment, students will discover what kinds of information are stored in new electronic ways and what kinds still must be stored on paper. Do these systems really cut down on our paper use? What are the pros and cons for the storage of information on paper versus electronic storage?

**RESOURCES**


**EDUCATOR’S NOTES**
1. Humans have always had the need to communicate their experiences and ideas. In ancient times, people worked hard carving pictures and symbols into the walls of caves, and on rock and bone. As human civilizations developed, surfaces were found that were easier to write on, such as beeswaxed boards, palm leaves, bronze, silk, parchment made from animal skins, and clay tablets.

2. Long before humans thought of making paper, insects were doing it. Bald-face Hornets build their nests by chewing tiny slivers of wood to make a paste that dries as paper.

3. About 4,000 years ago, the Egyptians discovered how to make a writing surface out of papyrus, a type of reed that grows along waterways in southern Europe and North Africa. The reed was cross-woven into a mat and then pounded into a hard thin sheet. The word "papyrus" is the origin of the word "paper."

4. The Chinese invented paper-making in A.D. 105 (about 2,000 years ago). A court official named Ts'ai Lun under the Chinese Emperor Ho Ti made paper from hemp, old cloth, and mulberry bark mixed with water. This mixture was formed into a sheet, the water was squeezed out, and the sheet was allowed to dry in the sun. Paper remained a secret of the Chinese until A.D. 751, when Muslim invaders captured a Chinese paper mill and took the secret across the Near East and North Africa to Europe. In 1151, the first paper mill was built in Spain.

5. Paper was still very scarce and expensive because it was made by hand from rags of cloth—which were limited in supply. Somehow as the craft of papermaking spread across Eurasia, the technique of using wood as the source was lost. Worn-out clothing, which was mostly linen (made from flax), and cotton fiber provided the raw material for paper. Each sheet was made by dipping a screen into a mixture of 99 percent water and 1 percent pulp fibers, and then filtering the water away from the fibers. Only about 750 sheets could be made in a day. But after Johnann Gutenberg invented the movable-type printing press (in about 1450), the demand for paper grew. Mechanical pulpers, and beaters were invented, and rags as raw materials became scarce.

6. In 1690, a group of Americans from Philadelphia formed a partnership to build America's first paper mill. William Penn and Benjamin Franklin were among early Americans to support the development of papermaking in America, and the industry thrived as the 18th century progressed. During the Revolutionary War, the demand for paper was so great that soldiers had to tear up old books to make wadding for their muzzle-loading guns. Messages to General George Washington were sent on scraps of paper sometimes using "invisible ink". The technique was to write the message with a sugar and water solution that would dry clear. When the message reached its destination the reader would hold it up to the heat of a lamp but not burn the paper. The heat would make the sugar caramelize (turn brown) and the message would appear. Students can try this today. By the end of the Revolutionary War, the new nation had nearly 100 paper mills and by 1810, nearly 200. In this period people used the ancient process of spreading and drying pulp in a sheet on a screen with a wooden frame called a "paper mould." The mould was dipped into a vat, and the water drained away. The wet sheets of paper were turned off the mould and layered with blankets of.
felt. Then they were pressed and separated to dry.

7. About the middle of the 1700’s a French scientist, Rene de Reaurnur, observed wasps using tiny fibers of wood to make their nests. Some years later, a German named Friedrich Gottob Keller invented a machine designed to turn wood into pulp by grinding away its structure with a revolving grindstone. Englishman Hugh Burgess improved this process with chemical pulping --- digesting wood with solutions of various chemicals. Wood chips were boiled in a caustic chemical soda (sodium hydroxide); this was called the "soda process." Later sodium sulfate was used, and this was called the "sulfate process."

8. In 1798, paper went from being handmade to machine-made. Nicholas Louis Robert, a clerk at a papermaking mill in France, invented a large handcranked machine with an endless wire screen that filtered the pulp-die mixture of fibers were ground up and suspended in water. Robert sold his design to the Fourdrinier brothers, two English paper-makers, who improved his design and produced the machines for sale. Paper could now be made by rollers that squeezed out the excess water from the pulp on the screens, and the damp paper was rolled up at one end of the machine. However, the raw material for pulp, cloth rags, was still in short supply.

9. America’s early papermaking mills were located mostly in New York and the New England states. The spruce trees in those areas made excellent ground wood and sulfate pulp. The industry expanded to Wisconsin, Michigan, and Minnesota where there were spruce and balsam trees; to Washington, Oregon, and California where there were hemlock, fir, and pine; and to the southeast, which had mostly pine. By the turn of the 20th century, the age of mass-produced paper had been launched in the United States. Newspapers and magazines appeared on stands. School slates disappeared in favor of notebooks and lined paper. Five-and-ten-cent novels rolled off the presses. Plentiful, low-cost paper and paperboard were important to the Industrial Revolution and the development of the United States and the world.

10. Today, raw logs, industrial wood and paper waste, and recovered paper are the primary sources of paper pulp. However, fibers from cotton, flax, sugar cane, and other fibrous plants are used for special papers. The pulp can be produced by either mechanical or chemical processes. In the mechanical processes, wood logs or chips are reduced to fiber by holding them against huge grindstones. In chemical processes, wood chips are cooked in a giant pressure cooker or digester where the wood is dissolved into fibers. The chemical pulps are often bleached to produce bright paper required for books, writing, and business. Unbleached pulps are used in the manufacture of cardboard, grocery bags, and other products. Today, recycled waste paper is also being used—it is repulped and used in the production of many paper and paperboard products. Tomorrow paper may be produced form agricultural fiber crops other than trees. One such crop is already being introduced. It is Kenaf, and industrial fiber crop. Paper made from Kenaf can be found in some stores today.
BRIEF DESCRIPTION
Since becoming a state in 1796, Tennessee has seen many changes. In this activity students will study changes in the local environment over short and long periods and will identify change.

SUPPORTING INFORMATION
It has been said that change is really the only constant in the universe. Change is all around us—sometimes we notice it, and sometimes we do not. One pattern of change is the 24-hour day. The Earth rotates on its axis, causing the cycle we know as day and night. Small changes in the rotation and the tilt of the Earth cause changes in the length of day and night throughout the seasons, but these, too, are predictable.

Some changes happen fast, such as a tree falling in a storm. Others happen so slowly, like the slow washing of mountains into the sea, that we are hardly aware of them. Some changes are noticeable through patient observation, like the movement of the tide. Some systems are so complex, like a forest, that we hardly notice when changes take place.

History is a record of changes, be it the history of a tree, forest, society; or nation. Humans have been recording the history of people, places, and things for thousands of years; much of this information can be found in libraries and museums. Historians, people who study and record history, can be a great help in tracing the changes over time.

MATERIALS
roll of paper for timeline, colored markers, copies of "Timeline Plan".

LEVEL: 6th grade
SUBJECT: Social Studies
SKILLS: researching, comparing and contrasting, identifying relationships and patterns, concluding

OBJECTIVES
The student will
-identify changes in their local environment over the course of time.
-create a timeline to illustrate patterns of change over time.

ESTIMATED TEACHING TIME
Preparation time: 30 minutes
Activity time: 1-5 50 minute periods
One example of change in your community could be transportation systems. Today you move around in cars, trains, buses, on bicycles, and on foot. Just 50 or 60 years ago, you probably would have observed a lot more people riding bikes and walking, and not as many cars. A hundred years ago, people probably walked, rode on horses, or drove in horse-drawn carriages—things we seldom see today!

The challenge is to be aware and notice changes as they happen, and then to look back to identify patterns.

**GETTING STARTED**

Contact your local library or historical society for historic photos, books, and information about your community. Cut butcher paper into five 4-6-foot (1.2-1.8-m) sections, or prepare similar-sized pieces of paper.

(Optional) Schedule a visit to the local museum. Invite a local historian or elderly person to talk about changes that have taken place in the local community.

**PROCEDURE**

**PART A**

**CHANGES IN YOU**

1. Ask students what major changes happened in their lives between their birth and age four. Encourage them to brainstorm ideas, and record their answers on the chalkboard under the heading "Changes From Birth to Four." (grew taller, learned to eat real food, toilet trained, learned to walk, learned to talk) Then ask them how they know these things—can they remember? Did someone tell them? Did they see pictures?

2. Now ask students to brainstorm about how they have changed since they started school. Record answers under the heading "Changes Since Starting School." (go to school every day, play with friends, learned to read, etc.)

3. Now ask students to think about how they have changed just since they woke up this morning. Record answers under the heading "Changes Since This Morning." (hair changed from messy to neat after brushing, stomach changed from hungry to full after eating breakfast, etc.)

4. Discuss how some of these changes are obvious (such as learning to walk). Other changes are harder to see—such as gaining knowledge. Point out how changes can sometimes be linked to a time or date. Demonstrate how students can make a timeline of their life changes from birth to the present.

**PART B**

**MAKING A TIMELINE**

1. Ask students to gather information about the history of their community by visiting a museum, listening to a historian invited to talk to the group, or visiting a library. Share with students any information you've already gathered.

2. Tell students that they are going to create a timeline of the history of the local community. Divide the class into five groups, and make each responsible for chronicling a particular time period, either one decade of the past 50 years or one of the periods listed below.

   * Ancient Times (native peoples)
   * Early Years (early settlers or community development)
   * Olden Days (grandparents' lifetimes and earlier)
   * Recent History (parents' lifetimes)
   * Modern Times (today)
Students should compile information about their time period from interviews, museums, and libraries.

3. Give each group ample time to collect information. Before beginning their timeline, each group should complete a "Timeline Plan", describing at least five events students plan to include. Tell them to consider changes in landscape, wildlife, and human lifestyle over their time period. Ask what might have been the causes of some of these changes, and then have them incorporate changes into their timeline period.

4. They should then draw or paint the events of their decade or time period on the timeline mural. Students can use poster paints or markers on butcher paper to make their section of the mural. Five separate mural pieces—one for each team—are easiest to manage; these can later be joined by masking tape when all are finished and dry.

5. In summary, ask each team to explain the history of the changes they recorded in their section of the mural. After reviewing the entire mural, discuss the following:
   * What are changes in the environment, wildlife, and human lifestyle?
   * What caused some of these changes?
   * Do you think these changes have made your community a better or worse place to live, or have they made no difference?
   * Did any changes that were considered good at some time turn out to be bad?
   * Can you identify any trends and what implications they might have for the future?

**EVALUATION OPTIONS**

1. Have the students write essays about how the local environment has changed through each period the class researched.

**EXTENSIONS AND VARIATIONS**

1. If you’re working with older students, you might consider getting permission to paint your timeline mural on a blank outdoor or indoor wall-making a permanent artistic expression of the local history.

2. Have students become cultural archaeologists and go searching with a parent through the attic, basement, closets, shelves, and drawers for "really old stuff." Have students ask the parent if he or she knows the history of the items found. Who was the original owner? Where did it come from? What was it used for? Have students write a real or imaginary story about one of the items that interests them.

3. Display the student-made murals in the hallway of the school or cafeteria.
TIMELINE PLAN FOR YOUR LOCAL AREA

Team members:

________________________________________

________________________________________

________________________________________

________________________________________

Option 1
A decade of the past 50 years

____1950s  ____1960s  ____1970s  ____1980s  ____1990s

Option 2
A time period:

____Ancient Times (native peoples)

____Early Years (pioneers and settlers)

____Olden Days (grandparents' or greatgrand parents' lifetimes)

____Recent Times (parents' lifetimes)

____Modern Times (today)

Describe at least five events from your time period and the dates when they happened. Include this information in your part of the timeline:

In your community, what changes have taken place in:

* vegetation:

* wildlife:

* human environment and lifestyle:
  (homes, transportation, work, schools)

What are some of the causes of these changes?

Explain whether you think these changes have made your community a better or worse place in which to live, or have made no difference. Use the back of this sheet if necessary.
BRIEF DESCRIPTION

What could cause a people to leave their homeland of a thousand years? By conducting simulations, building models, and solving a mini-mystery, students compare the economic and ecological costs of different irrigation systems. Tennessee receives on average 52 inches of precipitation each year, which allows our farmers to produce most crops without irrigating.

VOCABULARY
irrigation, irrigation system, flood irrigation, sprinkler irrigation, drip irrigation, salinization

SUPPORTING INFORMATION

The fruits and vegetables you consume likely were grown on irrigated cropland. Without irrigated agriculture, crops such as lettuce, pineapples, oranges, soybeans, and others grown in arid parts of the world would be available in lesser quantities and at higher prices. Students may live in areas that have irrigated agriculture or may have seen it on television. Learning about different irrigation systems helps students consider the demands growing food places on water resources. People have been growing crops for a long time. In fact, some 10,000 to 12,000 years ago a cultural shift known as the agricultural revolution began in several regions of the world. This food-producing revolution involved a gradual move from a lifestyle based on nomadic hunting and gathering to one of settled agricultural communities; people learned how to domesticate wild animals and cultivate wild plants. Early growers practiced subsistence farming; that is, they grew only enough for themselves. About 7,000 years ago the invention of the plow allowed farmers to cultivate larger areas. In some and regions, early farmers increased crop output by diverting water from nearby streams in ditches and canals, dug by hand, to irrigate crops. This gradual shift from hunting and gathering to farming had several significant effects.

Population increased as a result of greater food supplies, better living standards, and longer life spans. And people built increasingly larger irrigation systems, cleared larger fields, and organized villages. Today, irrigated agriculture plays

LEVEL: 6th grade

SUBJECT: Social Studies

SKILLS: designing, evaluating, observing, organizing, interpreting, analyzing

OBJECTIVES

The student will
- identify reasons people irrigate.
- construct a classroom irrigation system and monitor crop growth.
- describe different irrigation methods and evaluate the costs and benefits
- propose explanations for an ancient culture abandoning its homeland.

ESTIMATED TEACHING TIME

Part I: 50 minutes
Part II: Extended
Part. III: 30 minutes

MATERIALS
Raincoats and shoes that can get wet, paper towels, Hose attached to running water or buckets of water, Used plastic trays from fast-food restaurants with small holes punched in the bottom for drainage Plastic straws, some with flexible sections, Clay or wood glue, Sand, Potting soil, Grass or bean seeds Plant food, Sprinkling can, Small funnels, Paper cups, Poster board, World map
a critical role in providing large quantities of low-cost food for the United States and other parts of the world. Worldwide, almost 20 percent of the land farmed for crops is irrigated and produces about one-third of the world's food. For certain crops, the statistics for the United States' production are much higher than these.

Irrigation gives farmers and ranchers the ability to manage their lands (to add water at the appropriate time) and to increase productivity. To raise crops people irrigate certain areas, because precipitation cannot meet plant water needs. This is especially true in the Western United States. From about the 98th meridian of longitude west to the Pacific Coast, average annual rainfall dips significantly below the 20 inches (50 cm) that normally support nonirrigated crops in the East.

Important factors when considering irrigation include:
$ climate suitable for growing crop (varies from crop to crop)
$ soils capable of being irrigated (irrigable soils)
$ proximity to an economical source of ground or surface water (irrigation becomes less cost effective the greater the distance and height that water needs to travel to crops; governments have gone to extraordinary lengths to develop public works designed to deliver water from water-rich sources to areas of need)
$ quality and quantity of water that will not adversely affect crops
$ topography suitable for applying irrigated water (level, slightly sloped, or gently rolling)
$ money to purchase, operate, and maintain operation systems (Pipes, pumps, ditches, etc.)
$ time, energy, and skills needed to set up, operate, and maintain an irrigation system
$ a market for irrigated crops

"Irrigation system" is the generic term used to describe a system used to supply water to crops. A system has the following general components:
- a source of water
- a means of retrieving water from the source (Ground water sources require a well and pump, while surface water sources need an intake pipe and pump.)
- a method of moving water from the source to the field (In some areas water is pumped directly onto the field; in other locations water is pumped long distances through pipes or canals to the site where it is applied.)
- a method of applying water onto the field such as:
  - flood irrigation (field is flooded with water)
  - ditch irrigation (pumps and pipes or siphons put water into ditches along row crops and gravity moves water throughout the field)
  - sprinkler (water is pumped into pipes that have nozzles and sprinkler heads of varying design, and water is sprinkled or sprayed on crops)
  - drip irrigation (a system of water lines is set up near the base of crops, and water is applied in exact amounts to the root systems of plants)

Irrigated land can produce crop yields two to three times those of non-irrigated land. In fact, in many dry areas if you do not irrigate, you
cannot grow crops. Irrigation, however, can have its downside. Irrigation water may contain salts. In dry climates, much of the water from this saline solution evaporates, leaving behind the salts (such as sodium chloride) in the top soil. The accumulation of these salts, called salinization, stunts crop growth, lowers yields, eventually kills crop plants, and can ruin the land.

Another management problem for irrigators is waterlogging. Farmers often apply heavy amounts of irrigation water to leach salts deeper into the soil. Without adequate drainage, water accumulates underground, gradually raising the water table. Saline water eventually envelopes the roots of plants and kills them.

A look at the past reveals evidence of cultures devastated by the salinization of their soil. The Hohokam people lived in the Gila and Salt River valleys (in the American Southwest) in A.D. 1300. The Salt River was named Rio Salado by the early Spanish and Jesuit explorers because of its high salt content, caused by the heavy salt formation through which the river passes about 100 miles (160 km) north of Phoenix.

The Hohokam people lived in this location for more than 1,000 years. They built complex cities and had an advanced irrigation system, consisting of ditches running from their water source, the Salt River, to their crops.

The Hohokams suddenly disappeared from the area around A.D. 1400. Some scientists think a widespread epidemic might have occurred. The people could have become frightened and fled, but no evidence supports this hypothesis. Other scientists think the area was hit by a severe drought.. Perhaps the mountains received little or no rain for many years and the rivers dried up, eliminating the Hohokams' water source. Evidence exists of a drought from A.D. 1277 to 1299. Tree ring studies from both river valleys indicate little growth during these years. This may be an indication of limited rainfall. However, scientists have found that only people from the villages near the small canals moved at that time; the people living on the river, streams, and large canals remained.

Scientists believe Hohokam irrigation practices may have severely damaged the land. After years of irrigation, the soil became less absorbent and the water did not run off as quickly. The soil became waterlogged at the surface. The high salt content of the Gila and Salt Rivers caused the roots of plants to die. Finally, the salt content was so high plants could not grow.

Irrigated lands in some areas around the world are prone to having problems with salinization today. In areas where these problems exist, landowners can reduce salinization by flushing fields or leaving fields fallow for a few years.

**GETTING STARTED**

The day before the lesson ask students to come to class tomorrow prepared to get wet, wear rain coats etc.. Gather the materials listed in the Materials Section. Copy the Student Sheet.

**PROCEDURE**

Ask students to list the essential elements that plants require for growth. One of these is water. Discuss rainfall patterns of the United States; show a map depicting Average Annual Rainfall. Have students identify the drier regions of the country. How do they think crops there get water? Have students describe agricultural lands they have seen. What irrigation methods have they seen or do they know?

**Part I**

1. Take the class outside and tell students they
are going to demonstrate some basic irrigation practices. Warn them that they will be getting wet.

2. Have students stand in rows to represent planted crops. Give each student a paper towel or absorbent cloth. Tell them it represents soil around their roots. They should lay the paper towel by their feet. Roots need to be surrounded by wet soil to absorb nutrients; this is represented when the cloth or towel becomes saturated.

3. One or two students will simulate the irrigation practices. Explain that one method of irrigation is ditch irrigation, involving gravity flow systems. Have the irrigating students allow the hose to run (or have them pour bucketfuls of water) in front of each row of students. Students representing crops should find their paper towels are soaked.

Move the students to a new location where the ground is dry. Have them lay a new set of cloths or towels at their feet.

The second irrigation method represents a center-pivot sprinkler system. Have the irrigating students partially block the flow of water from the hose, so that it sprays out. They should point the hose upward so that water sprinkles over the crop students, continuing until the paper towels are saturated.

Have the crop students move again to a dry location and lay down new towels. This time the irrigating students take the hose and water each towel. They should block the flow between waterings, so that no water is lost. This represents a drip irrigation system.

Part II
1. Students can build separate models to demonstrate each irrigation system. For the ditch irrigation method, instruct them to plant rows of grass seed or beans in a long planter and create a furrow beside each planted row. To irrigate the plants, water is poured into the ditches (furrows) in the long planter. To simulate the center-pivot irrigation system, students should use a sprinkling water can. For the drip irrigation system, distribute plastic trays, straws, clay, sand, potting soil, Plant food, a small funnel, and grass seed to small groups of students. Have the students design and build a grass farm irrigation system in a plastic dish (see Design a Drip Irrigation System).

2. Discuss the three irrigation systems. Which used the most and least water? How might evaporation affect each system? Which do students think would be the most expensive to build and maintain? Discuss the cost of water loss compared to the cost of construction.

Part III
1. Read or have students read the mini-mystery, Lost Homeland. They are allowed 20 questions to find the answer. They may only ask questions that can be answered with a "yes," "no," or "not relevant."

2. If students are not close to the answer after 15 questions, provide additional information about the location and the water source of these people (the Salt River).

3. After students have guessed or been told the solution, ask if they think modern cultures could have these problems. Discuss the benefits of and problems facing current irrigation practices.

4. To demonstrate how salt collects in soil,
have students do the following: Saturate some water with salt, carefully measuring the amount of salt added to the water. Poke a number of small holes in the bottom of a paper cup and fill the cup two thirds full of soil. Pour the salt solution through the soil. Collect the water that runs through the soil; then allow it to evaporate. Compare the salt left after evaporation to the measured amount added to the water. Dry the soil and look for evidence of salt in the soil particles.

**EVALUATION OPTIONS**
1. Have students:
   - demonstrate and identify irrigation systems.
   - construct classroom irrigation models, demonstrating and comparing different irrigation systems.
   - develop a questioning strategy to determine why a culture would abandon its homeland.
   - create a chart summarizing irrigation techniques and assessing ecological and economic benefits and costs.
2. Upon completing the activity, for further evaluation have students:
   - research and identify on a world map locations with salinization problems.
   - investigate and report what is being done to overcome salinization problems.

**EXTENSIONS AND VARIATIONS**
1. Discuss modern irrigation strategies with students. What types of irrigation can they identify? What technologies are used today?
2. Have the class make a chart summarizing agricultural techniques and assessing ecological and economic benefits and costs. The chart could be posted in the hallway.
3. Have students modify their irrigation models to demonstrate the problems of waterlogging in irrigation practices.

**EDUCATOR’S NOTES**
Lost Homeland

A certain culture lived in the Southwest in A.D. 1300. The culture had been living there for more than 1,000 years.

The people had developed a huge irrigation system. They used sharp sticks to dig long, deep canals. These canals carried water across the desert. Some of the canals ran up to 12 miles (19 km) from the river; one of them was 30 feet (9 m) deep. By A.D. 1300, the canals covered approximately 150 miles (240 km).

They also built dams across the river, which were made of brush cut in the nearby mountains. These dams backed up the water and made it easier to send it into the canals. The dams also held back water to be stored for times of the year when no rain fell in the mountains.

The people grew cotton, corn, beans, squash, and pumpkins on their irrigated land. They hunted deer in the mountains. They trapped rabbits and other small game in the desert.

This was an advanced and creative culture. They made beautiful objects, like pottery. They built sturdy houses; walls and roofs were made of poles, brush, and mud plaster. At first the houses had only one story. By A.D. 1300, however, these people were building houses of several floors. They even had four-story buildings!

Sometime around A.D. 1400 these people seem to have disappeared from the area. What was the cause for their sudden departure?
SUPPORTING INFORMATION

Every human activity has an impact on the environment. This includes the wildlife, plants, air, and water. Some activities have a positive impact while others have a negative result. Also an impact that is positive for one species, will harm other species in the environment. We must consider the benefit to the most species as the goal, while limiting the negative impacts for the environment as a whole. Are we willing to endure inconveniences in order to preserve the habitat for a particular species? And at what costs? These are some questions that predict how we view our environment.

GETTING STARTED

If possible, obtain pictures or drawings of your community, township, or city from various stages in its past. (Municipalities or counties often have publicity pieces that feature these pictures.) If you're unable to bring in pictures, arrange to have your group visit a facility with such pictures, perhaps a local museum, heritage landmark, historical societies, or library. For the variation, you will need to know of several historical changes in your community, but you will need no special materials.

PROCEDURE

PART I

THE WAY IT WAS

1. Ask students if they've noticed any changes in their community recently. For example, have any new malls been built? Are there housing developments or schools? Has any land been put aside as a park or wildlife sanctuary?

2. Ask students how those changes make them feel. Discuss the pros and cons of how those changes have occurred in their community over the course of time.

3-4. Discuss ways to remedy negative changes.

LEVEL: 6th grade

SUBJECT: Social Studies

SKILLS: Researching, Formulating questions, Comparing and Contrasting, Generalizing, Solving Problems

OBJECTIVES

The student will -describe the environmental changes that have occurred in their community over the course of time.

- discuss whether those changes have been positive or negative for the community.

- discuss ways to remedy negative changes.

ESTIMATED TEACHING TIME: One class period

MATERIALS

Paper and pencils, historical pictures of your community
developments affect people and communities. Talk about how such changes might affect wild animals and plants in the area.

3. Show students the old pictures of your community. If possible, identify each photo's location and have students describe what the site looks like now.

EXTENSIONS AND VARIATIONS

Instead of using pictures or visiting a museum, take your students back in time through an imaginary time machine. Have them close their eyes, imagine stepping into the time machine, and pretend they're going back 25, 50, 100, or 200 years. At each stop of the time machine, have the students step out and visit familiar places around town. Describe to the students what they might see. After returning from this imaginary journey, do Step 2 of Part A with your students.

NOTE-Your imaginary descriptions should be based on your actual knowledge or research about your community's past.

1. Brainstorm with the group to first areas in the community that have more or less been left in their natural states, for example, parks, wildlife sanctuaries, or private holdings. Then assign the students into small groups and have each group choose one area from the list. Have the groups research the area to find out the following information:

   What is the history of the area?

   Why has the area not been developed?

   Who lives in or uses the area (including wildlife)?

   Are there plans to change the area in any way?

   Have members of each group prepare and present a report about their natural area.

2. Tell students to imagine they have traveled into the future. Have them write stories about how their community might be different 25, 50, or 100 years from now.

EVALUATION OPTIONS

1. Tell students that they'll interview an older person who has lived in the community for many years. This person could be a parent, grandparent, neighbor, or anyone who has lived in the area long enough to see many changes.

2. Have each person develop a list of Interview questions. Here are a few suggestions for questions students might ask:

   How long have you lived in the community?

   How has the landscape within the community changed during that time?

   Have the changes helped you in any way?

   Have the changes hurt you in any way?

   How have the changes helped or hurt the community?

3. Give students time to conduct their interviews. Tell them not to feel bound by their list of questions. Encourage them to ask other questions that they may think of during the interview. Students will need to take notes during the interview or to tape record it and make notes later.

EDUCATOR’S NOTES
BRIEF DESCRIPTION
Throughout history, people have depended on natural resources for survival. The availability of food, water, and resources to build shelters has generally determined where humans have settled and how cultures evolved over time. In this activity, students will explore how ancient civilizations developed systems for using their natural resources.

SUPPORTING INFORMATION
One definition of ecology is "the science of interrelationships between living organisms and their environment." The term "human ecology" generally refers to the relationship between humans and their environment the way humans use the environment within the context of their society and culture.

Many civilizations throughout history have lived in balance with their resources for hundreds, even thousands of years. These societies may have been the ones whose use of resources was balanced with the Earth's ability to renew itself and who had the ability to adapt to changing environmental conditions.

Other civilizations may have over-exploited their resources. This could have been the result of new technologies or population growth that put more stress on natural resources. Changing climate conditions or other environmental factors (such as prolonged drought) also may have affected resource availability and caused societies to disperse and eventually disappear. For example, the disappearance of the Anasazi Indians in the United States may be linked to changing environmental conditions. Needless to say, factors such as politics, war, and disease also have enormous influence on the history of civilizations.

LEVEL: 6th Grade
SUBJECT: Social Studies
SKILLS: researching, analyzing, concluding

OBJECTIVES
- The student will investigate how ancient civilizations used natural resources and affected the environment.
- Apply environmental lessons learned in the past toward solving current environmental problems.

ESTIMATED TEACHING TIME
1 class period

MATERIALS
Student Sheets

VOCABULARY
ecology, human ecology, civilization, prosperous, erosion, silt
GETTING STARTED
Make copies of student pages.

PROCEDURE
1. Divide your group into two, teams, and prepare for a debate on the land-use practices of the ancient Babylonian culture. Choose a particular debate statement, for example, "the downfall of the Babylonian society was primarily caused by its use and abuse of natural resources, particularly the soil."

2. Have students read the article "By the Rivers of Babylon," and fill in the "Role of Land Use" section for the Babylonian Culture. This exercise will help your students determine the costs and benefits of each land use practice.

3. In the debate, one team is to argue that land use or abuse had a major influence on the downfall of Babylonian society while the other should take the position that land use or abuse played a minor role in its collapse. In preparing their arguments, both teams should consider the costs and benefits of the land use practices they identified on the student pages. Students may use additional resources to support their arguments.

EXTENSIONS AND VARIATIONS
BEFORE & AFTER
Instead of a debate, you can try the following activity:

1. Have students read "By the Rivers of Babylon."

2. Divide your group into teams of three to five students. Have each team draw two murals (using both sides of the same paper). One side should depict a scene of Babylon before its decline; the other should depict a scene after its decline.

3. Each team should present its view of Babylonia's decline by first showing the "before" and then the "after" pictures. They should explain what caused each change.

OR
1. Have students research and discuss present-day problems related to land use, such as soil conservation, deforestation, over-grazing, famine, and so on. Students can use periodicals to research modern environmental catastrophes, such as the 1983-85 famine in Ethiopia in which an estimated one million people died of starvation.

They should consider the political, economic, social, and security factors involved in each situation. You might also have them write an "update" on the land areas involved in the ancient cultures that they studied. For example, the land once called "Babylonia" is now Iraq.

EVALUATION OPTIONS
Examine the students' work on the student page to see whether they identified both sides of an issue, not just the side they were assigned to debate. Look for evidence that they understand that there are different approaches to analyzing and interpreting historical events.

RESOURCES
Natural Resource Conservation Service

EDUCATOR’S NOTES
BY THE RIVERS OF BABYLON

In the fertile valley where the Tigris and Euphrates rivers meet (in present-day Iraq), great ancient civilizations once flourished. One of the first peoples to settle in the valley were the Sumerians in about 4500 B.C. The Sumerians cleared the land for growing food and irrigated it by digging canals and draining swamps along the rivers. Because of irrigation and the fertility of the soil, the Sumerians had time to develop other aspects of their civilization.

During the time of Babylonian culture, which followed the Sumerian in about 1800 B.C., people kept digging canals. The water of the rivers became muddy, not just during the spring floods as in the past, but all the time. Deposits of silt settled in the canals and over time clogged them up. To keep the canals open to water the fields, people carried the silt out of the canals in baskets. Settlements grew around each system of canals, and each town had to be responsible for its own land and water, because to neglect either would mean starvation. Land and water were so important that the first Babylonian king, Hammurabi, decreed death to any person who wasted water or spoiled the land.

However, as the people of Babylon became prosperous and accustomed to luxury, they did not take as good care of the land. King Nebuchadnezzar, ruling more than a thousand years after Hammurabi, was recorded as saying: "That which no king before me had done, I did.... Great canals I dug and lined them with burnt brick laid in bitumen and brought abundant waters to all the people.... I paved the streets of Babylon with stone from the mountain.... Magnificent palaces and temples I have built... Huge cedars from Mount Lebanon I cut down."

Because of erosion from canal digging, logging, and grazing, more and more silt kept washing down the rivers from the hills to the north. As the soil washed off the unprotected hills and settled in the irrigation canals of Babylonia, more and more people had to spend all their time maintaining the canals. War captives and slaves were even brought in to do the work.

Invasions by Alexander the Great and others in the fourth century B.C. meant that the soil and canals were neglected. As time went on and silt filled the valley, the land could support fewer and fewer people. About 700 years ago, the Babylonian canals were finally destroyed by the invasion of the Mongols who destroyed the irrigation system and allowed the land to return to desert.
Role of Land Use in the _____________ Culture

Position in Debate:

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GREAT WATER JOURNEYS

BRIEF DESCRIPTION
As water travels through a small watershed and out to a larger one, some objects travel along. What do Lewis and Clark, gray whales, and coconuts have in common? Using a global map and a set of clue cards, students locate some significant water journeys.

SUPPORTING INFORMATION
Water is a restless compound, driven by solar energy, wind, gravity, and pressure (for glaciers and some ground water). It can be an obstacle to travel, as in the case of river crossings, and a dangerous medium (ocean storms or fast rivers), but it can also be the very highway that makes travel possible. People, other animals, and plants move (and migrate) in response to a variety of environmental and social conditions. Sometimes water journeys are a matter of accidents or coincidence. A tree falls into a flooding river, travels halfway across a continent, and ends up snagged in the trestles of a railroad bridge. In other cases, plants and animals have evolved to take advantage of water travel as part of their survival strategy. Some water plants have buoyant seeds that will float until they reach a favorable habitat in which to take root. Many aquatic species rely on water transportation in the course of their seasonal migrations, traveling to and from food sources, spawning grounds, and suitable climates.

Human water journeys throughout history have been motivated by various factors. Social oppression can cause whole sectors of a population to move away, sometimes by boat or across frozen expanses of water. Starvation, changing climate, and natural disasters are all capable of precipitating mass human movements. Curiosity or a desire for riches has sparked other water explorations. In island and coastal cultures, people constantly move across the water out of contamination.

LEVEL 7th grade
SUBJECTS:
Social Studies
SKILLS
gathering information; organizing; applying; presenting
OBJECTIVES
The student will - locate a few of the diverse pathways water travels around the globe. - describe how water provides an important mode of transportation for plants and animals.

ESTIMATED TEACHING TIME
1 class period

MATERIALS
Pencils; copies of Water Journey Trivia Clues and Summaries; encyclopedia; copies of global map; world atlas; wall map

VOCABULARY
migration, browsing, Gulf Stream, Equatorial Counter Current, Polynesians, expedition, contaminating
necessity or to benefit from their aquatic surroundings. Gravity pulls water downhill, eventually into the ocean. Winds and the rotation of the earth combine to power ocean currents, like rivers within the ocean. On many of these journeys, water carries myriad passengers along with it, destined for new homes, new discoveries, and unexpected adventures.

GETTING STARTED
Copy the Summary Cards and gather the materials listed.

PROCEDURE
1. Ask students to think back to the last journey they took that involved water travel (even a short trip or water crossing). If they have never traveled by water, ask if they would like to take a water journey. Ask them to think about places where water provides the most efficient, or perhaps the only, transportation (oceans, swamps, cliffy coastlines, tropical forests). Briefly discuss how plants and animals have been transported around the world by water. Have students think of three famous water journeys taken by humans. (People of local fame or from folklore and fiction, like Huck Finn, are acceptable.) See if students can think of examples of any plant, animal, or water molecule journeys.

2. Divide the class into small groups. Tell students that they will be playing a geographic water journey trivia game. They should pool their knowledge to identify specific water journeys.

3. Read the clues out loud for each card and allow time for the groups to discuss their guesses. Make sure each group gets at least one summary card. (Some groups may receive a point but no card for a correctly guessed journey; the card is given to another group.)

4. After all the summary cards have been distributed, tell groups to read their cards and, if possible, supplement the information with readings from science texts and history books.

5. Hand out copies of the Global Map to each group. Based on their summary cards and any other information, each group should sketch the path they think the subject of their summary card(s) traveled. The starting and ending points are indicated on their summary cards, but remind students that the shortest distance between A and B is not always the BEST path. Mountain ranges or deserts, contrary winds or stormy seas may create obstacles. Students may consult a world atlas, if necessary.

6. When students think they have the correct pathway, have them check the master map and compare their routes against actual ones. Discuss any major discrepancies. What explanations for the differences can they provide? (Consult the atlas or world map as necessary.) Ask students to erase and redraw any of the routes that were inaccurate on their first attempt.

8. Wrap up the activity by having each group give a class presentation about the water journey they studied. Encourage them to be accurate, but creative. On a class map, they should show the pathway of the journey and tell the other groups to copy the route onto their own maps. Have the class make one master map of great water journeys, to be posted in the school library.

9. Have each small group brainstorm a few other great water journeys. After selecting one, they should come up with several appropriate clues and try to draw a route on their map as
accurately as possible. (Some research time may be necessary.) Groups can take turns presenting clues and trying to stump other teams with their water journey trivia.

**EVALUATION OPTIONS**
Have students:
1. Plot water pathways based on geographic clues.
2. Compare and evaluate projected water journeys versus actual travel routes.
3. Develop a presentation about a great water journey.
4. Research and create their own water journey trivia clues and summary cards.

**EXTENSIONS AND VARIATIONS**
Orient students to watercourses by having them trace the routes of the major North American rivers (e.g., Colorado, Columbia, Mississippi, Missouri, Rio Grande), as the water moves from each river’s headwaters (starting point) to its confluence (end point or where it enters another river). Have students estimate the distances water travels using the map scale.

**EDUCATOR’S NOTES**
Journey "A"
Clues:
* The president of the United States requested this journey in the first years of the 1800's. If it hadn't been for the Louisiana Purchase, the trip might never have been taken.

* Many new species of plants and animals were discovered and named, including the grizzly bear.

* They were just a couple of ramblin' guys, but sometimes they had help from an extraordinary Native American woman, Sacajawea.

Summary:
Meriwether Lewis and William Clark, along with their company (consisting of more than 30 people), spent more than two years (1804-1806) exploring the wild frontiers of what is now the western United States. Their journey took them up the Missouri River to its headwaters, across the Continental Divide and the Rocky Mountains, and down the watershed of the Columbia River to reach the Pacific Ocean. After spending a miserable winter there, they retraced their route to St. Louis, exploring the Yellowstone River along the way. They were sent on their mission by President Thomas Jefferson, largely to secure America's claim to the recent Louisiana Purchase. Accompanying the party were William Clark's slave, York, and the wife of an interpreter, Sacajawea, who brought her young son. Remarkably- in a journey of that duration and covering thousands of uncharted miles-only one man in the expeditionary party perished. Charles Floyd died of appendicitis on August 20, 1804.

Water Path:
Start: St. Louis, Missouri  End: St. Louis, Missouri

Journey "B"
Clues:
* My three ships were the Pinta, the Nina, and the Santa Maria.

* When I touched land at the end of my voyage, I thought I had reached the Orient.

* My claim to be the first European in the New World is now in doubt.

Summary:
Christopher Columbus, born in 1451 in Genoa, Italy, went to sea at the young age of 14. After a decade or more of sailing adventures, Columbus harbored a growing ambition to achieve great glory, and great wealth, by sailing westward over the Atlantic. As years passed he became obsessed with his goal.

It wasn't until 1492 that Columbus secured the support of Ferdinand and Isabella, sovereigns of Spain, that would allow him to set out. He left from the port of Palos on August 3, 1492. His voyage to a landfall on the Caribbean island of San Salvador covered 3,066 miles (4,913 km) and took 33 days. On October 12, 1492, Columbus set foot on land he thought was part of the Orient. It was a misconception he carried to his deathbed in 1506.

His voyage has been credited with the "discovery" of America, a land long inhabited by native peoples. But more recent information indicates that the first European visitor here may well have been Saint Brendan of Ireland or Norse explorer Leif Ericson.

Water Path:
Start- Palos, Spain  End: San Salvador
**Journey "C"**

**Clues:**

* I was tagged on a beach in Costa Rica, late one moonlit night, and was found one year and 800 miles later on the coast of Cuba.

* My children were hidden under layers of warm sand.

* Chances for my survival have improved since humans started putting escape devices on fishing nets,

**Summary:**

Green sea turtles are a threatened and endangered species. They live in both the Atlantic and Pacific Oceans and migrate across long stretches of open water. Browsing in beds of turtle grass, they prefer shallow water vegetation for their food. Their habit of basking in the sun out of water is unique for marine turtles. Adults can attain shell lengths of 3-6 feet (1-2 m) and weigh up to 300 pounds (150 kg).

Along with other species of marine turtles, green sea turtles lay their eggs in sand pits at specific beach locations scattered around the world. Green sea turtles are known to live as long as 20 years, and will, in that life span, travel many thousands of kilometers. (This specific journey was verified by tagging studies.)

As with many marine turtles, the green sea turtle's future is uncertain. Destruction of nesting beaches and the practice of raiding nests for eggs threaten the species' continuation.

**Water path:**

**Start:** Tortuguero, Costa Rica **End:** Cortes, Cuba

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**Journey "D"**

**Clues:**

* I "talk" in songs.

* Each year I migrate between two watery homes—one in the Arctic and one off the west coast of Mexico.

* My babies are called calves, and at birth are 15 feet (5 m) long.

**Summary:**

Summering each year in the north and wintering, in the Gulf of California, where they give birth to their young, California gray whales spend their fives in the Pacific Ocean. From late May through October, they reside in the north, where they seem to be limited by pack ice in the Arctic Ocean. They concentrate along the coasts of Alaska and Siberia, feeding on a rich ocean harvest in shallow waters.

From the end of October through January, the gray whales move south, staying within a few miles of shore most of the time and traveling at an average rate of 115 miles (185 km) per day.

By February the gray whales have reached the warm tropical waters near the Gulf of California. Calves are born, usually in shallow lagoons. Although just 15 feet (5 m) long at birth, gray whales reach lengths of up to 42 feet (14 m) and weigh as much as 36,000 pounds (16,500 kg) as adults.

**Water path:**

**Start:** Gulf of California **End:** Off coast of Siberia or Alaska
**Journey "E"
Clues:**
* I am a river of water 1,000 times bigger than the Mississippi River, and I have no banks.
* England is warmer than Newfoundland because of me.
* Ships use me to increase their speed.

**Summary.**
Gulf Stream originates in the Gulf of Mexico, passes through the Straits of Florida, then flows northward across the Atlantic toward Europe. Powered by ocean currents, the Gulf Stream moves as fast as 70 miles (112 km) per day and has a rate of flow 1,000 times that of the Mississippi River. Ships ride the Gulf Stream to shorten their sailing times, and animal and plant species also hitch rides on the current. The Gulf Stream parallels the eastern coast of North America and is separated from the shore by a zone of chilly water, known to sailors as the "cold wall." By the time the Gulf Stream reaches Newfoundland, it has slowed to approximately 10 miles per day. It continues east toward Europe, becoming the North Atlantic Current. Much of Europe has a warmer climate than corresponding latitudes in North America. These gentler climates can be traced, at least in part, to the moderating effect of the warm Gulf Stream.

**Water path:**
**Start:** Gulf of Mexico **End:** The North Atlantic off European Coast

**Journey "F"
Clues:**
* I travel by water, but don't need a boat.
* I will grow into a tropical tree, associated with beaches and islands.
* My milk is used in Asian curry dishes.

**Summary:**
Coconuts are less dense than water, so they can float. The outer husk encloses the critical nut, which is capable of riding ocean currents for up to four months without dying. With luck, and favorable currents, the coconut will wash up on a beach, where it can sprout and send down roots.

Once established, coconut trees grow with a pronounced lean toward the sea, so that when their seeds drop, they will land in sand below the hightide mark and be carried away on their journey.

This specific coconut voyage began on the island of Madagascar, off the east coast of Africa, and ended on a small volcanic island called Aldabra, 250 miles (400 km) away in the Indian Ocean. It rode the Equatorial Counter Current.

**Water path:**
**Start:** Madagascar **End:** Aldabra
**Journey "G"**

**Clues:**
* We are the original colonists of Americas 50th state.
* Our boats were held together by coconut fiber.
* We were also the first people known to colonize New Zealand and Easter Island.

**Summary:**
Polynesians in the South Pacific were accomplished sailors thousands of years before Columbus was born. Because they live in a section of the world full of small islands, Polynesians have counted boats and ocean travel as a part of their culture for millennia. Evidence indicates that Polynesians purposefully explored and colonized much of the Pacific, including the Hawaiian Islands.

Polynesians traveled in double canoes capable of carrying hundreds of passengers. These boats were lashed tightly together with twine made from coconuts, and their sails were woven from other plant fibers. Their astonishing skill as navigators took them as far afield as Easter Island, New Zealand, and Hawaii. Traveling from Samoa to Hawaii required an ocean voyage of 5,000 miles (8,000 km).

**Water path:**
**Start:** Samoa  **End:** Hawaii

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**Journey "H"**

**Clues:**
* Sir John Franklin, along with 128 others, died trying to navigate me.
* I am icebound much of each year, and sometimes for years at a time.
* Darkness reigns over me for half of each year.

**Summary:**
In the late 1800’s and early 1900’s the quest for a Northwest Passage to the Orient fueled a feverish competition between European expeditions. Dozens of men, scores of ships, and more than a few fortunes were lost in the process. Expeditions often spent years frozen in the ice pack, suffered the effects of scurvy and other diseases, and endured the rigor of Arctic storms and six months of night, all to pioneer a route that would never result in any prize other than geographic conquest.

The islands north of the Canadian mainland bear the names of these explorers, their sponsors, and the homes they must have longed for through the long winter nights.

It was Roald Amundsen, the Norwegian who would also be the first to reach the South Pole, who finally navigated the tortuous, ice-locked Northwest Passage, during the years 1903-1906.

**Water path:**
**Start:** London, England  **End:** North coast of Alaska
**Journey "I"**

**Clues:**

* I was unintentionally introduced into the United States in the late 1980's; I was carried in freshwater ballasts (loads that provide stability) of ships traveling from Europe.

* I am only about 2 inches (5 cm) long, and have a hard, striped shell; like my American cousin, I secrete tough fibers which I then use to attach myself to rocks, boats, pipes, and many other things.

* Much to the dismay of the fishing industry and water treatment plants, my population is quickly growing and expanding into each of the Great Lakes as well as to connecting rivers ... If my population continues to grow, I may appear in a river near you!

**Summary:**

Zebra mussels are freshwater mollusks. It is believed they originated in the Black and Caspian Seas and were carried by ship through fresh waters in Europe. They were accidentally introduced to the United States in the mid-1980's. The mussels spread quickly down the St. Lawrence River and through the Great Lakes. They were first discovered in Lake St. Clair in 1988. They are expected to spread to a majority of United States waterways within a decade. The spread of zebra mussels throughout freshwater systems is attributed to their ability to cling like barnacles to almost any surface, some of which (boats, drifting materials, and fishing equipment) unintentionally transport the mussels to new locations. They have a high reproduction rate and lack natural predators in this new habitat.

The growing population of zebra mussels causes many problems. They colonize on pipes, clogging and contaminating water treatment systems; they remove large quantities of nutrients and out-compete native organisms; they foul beaches and jam boat engines. Communities, industries, and businesses are currently spending hundreds of thousands of dollars to eliminate zebra mussels.

**Start:** Black Sea  **End:** Mississippi River
THE FARM GAME

BRIEF DESCRIPTION
Students play a game that involves decision making and planning to try to “make it” farming.

SUPPORTING INFORMATION
Issues to Discuss
How much do farmers affect the environment? Can farmers grow crops and make a living while protecting the environment? Which is more important—feeding people or protecting the environment? No special preparation is required. This activity is background for some of the economic and environmental issues related to farming. For more activities on this subject refer to the resource section.

GETTING STARTED
Make copies of the student sheet The Farm Game, one per student and the 3 scoring sheets, one per group.

PROCEDURE
1. You may wish to start out with a general discussion of where we get our food. Then play the Farm Game with participants.

2. Divide participants into teams of three or four. Each team represents a family that has inherited a farm. Give everyone a copy of STUDENT SHEET 1. Each team is in charge of allocating resources and planning a season of planting and harvest on the farm. The goals are:

--to make enough money to continue farming,

--to provide food to feed consumers;

--to protect the environment.

LEVEL: 7th grade
SUBJECT: Social Studies
SKILLS: Analyzing, collaborating, communicating, comparing similarities and differences, developing vocabulary, discussing

OBJECTIVES
The student will allocate resources and plan practices wisely to harvest and sell a hypothetical crop.

ESTIMATED TEACHING TIME
1 class period

MATERIALS
Student sheet one per student, copies of scoring pages one per group

VOCABULARY
economic, environmental
3. Give teams time to decide how to manage their farms, using the options on STUDENT SHEET 1.

4. After they have finished, bring teams back together. Ask them to discuss their responses. (You can trigger the discussion by asking questions such as: How many people picked the land near the river for the farm? Why or why not?) Review their answers and rationale.

5. Next, hand out a copy of STUDENT SHEET 2 to each team. They should use the sheet to score their responses. (Note: These scores are just a general guide. In real life, it's not such an exact science!)

6. Now ask teams: How many survived economically? How many protected the environment? How many teams met the original goals? Is it easy to allocate resources and run a farming business?

EVALUATION OPTIONS
1. Have the students summarize their experiences by writing what types of resources must be managed on a farm? (People, raw materials such as seeds and chemicals, machinery, land.) What are some goals of most farmers? (Produce food, make a living, protect the environment, work outdoors, work independently.)

2. Have each team self-evaluate using a set of criteria you establish.

EXTENSIONS AND VARIATIONS
1. Visit a farm. If you aren't acquainted with a farm owner, call your Cooperative Extension office or state department of agriculture and ask if it has any farm-visit programs. Ag in the Classroom, an educational program found in most states, also can help match your group with a farmer.

2. Careers to Consider.
Farmers—grow crops such as corn, cotton, soybeans, and wheat or raise animals for meat or milk production. Farmers run their own businesses, owning or renting land. To harvest and
plant crops, farmers use specialized machinery. They must be proficient at accounting, engineering, maintenance, environmental science, and other specialties to be successful (or they must employ people with such specializations). No university work is required to become a farmer, although it is helpful. Many farmers have relatives in the business who helped them get started.

Crop scientists-- help farmers increase the amount of food they grow on their land. They may specialize in the type of machinery needed to get better harvests, or they may focus their expertise on a crop such as corn. Some crop scientists become farmers; others become inspectors who check crops; others work for food manufacturing companies. Some become researchers at universities or companies. Plan to attend College for at least four years if you would like to become a crop scientist. If you would like to teach or do research, you'll probably have to complete a master's or doctoral program as well.

RESOURCES

THE Farm Game

You have recently inherited your aunt's 120-acre farm. It has grown many types of crops over the years. You must be able to grow crops each year and make enough money to keep the farm solvent. You also are trying to protect the environment. You want to support the local community as much as possible, too.

Select one of the options in each section, and circle your selection.

A. Pick a LOCATION for your field

1) in a low spot near a river with excellent soils
2) in an area that was once a field and can be converted back by plowing some shrubs and grasses

B. Pick a CROP to grow in your field

1) corn
2) potatoes
3) soybeans
4) other ________________

C. Will you use FERTILIZER on your crop?

1) no
2) yes, bought from the co-op in town
3) yes, manure from the neighbor's cows.

D. What type of SEEDS will you use?

1) collected from last year's crops (a neighbor gave them to you)
2) hybrid, certified disease-free, which are more expensive

E. How will you PLANT the seeds?

1) by hand
2) use a tractor

F. How many PEOPLE will you employ?

1) just you, your two sons, and your spouse
2) your family and four local hired hands
3) a full staff of seasonal workers

G. How will you keep the WEEDS, INSECTS, and DISEASES away?

1) use pesticides
2) use people to hoe weeds, hand-kill insects, and watch for viruses

H. How will you SELL your crop?

1) sell by -the road to passersby
2) sell to the local co-op, which sells it to bigger wholesalers
3) open a store in town
A. Pick a **LOCATION** for your field

1) Oops! In wet years, the likelihood of flooding or puddling is very high. Most crops don't like this much water, but rice will do okay. Also, think about what happens to any pesticides you may add. It's a quick trip to the river, where they can sometimes cause small animals and plants to die.

2) This is probably a better choice, but be aware you are disturbing habitat by plowing the field again. Still, how else will you grow food?

Economic Score 1) 3  2) 5     Environmental Score 1) 3  2) 5

B. Pick a **CROP** to grow in your field

As long as people want to buy the crop, you can plant just about anything that suits your soil. Corn, potatoes, rice, and other crops will work.

Economic Score  5 for any crop     Environmental Score 5 for any crop

C. Will you use **FERTILIZER** on your crop?

1) The first year might not make too much difference, but soils need to have nutrients put back after growing crops. You can decrease the amount of fertilizer you use by rotating crops and planting cover crops that restore nutrients.

2) Commercial fertilizer can wash off fields into ponds and rivers, sometimes causing algae to grow and fish to die. Make sure you apply it correctly.

3) Many farmers spread manure on their fields. Watch out for extra weeds from the seeds in the manure.

Economic Score 1) 3  2) 5  3) 5     Environmental Score 1) 5  2) 3  3) 3

D. What type of **SEEDS** will you use?

1) Well, you should definitely have some interesting crops, since these seeds have "mystery parents." You might have multicolored corn or other oddities. And your yield will probably be lower.

2) By buying disease-free seeds (especially for potatoes), you'll probably increase your harvest, since more seedlings will grow.

Economic Score 1) 1  2) 5     Environmental Score 1) 5  2) 5

E. How will you **PLANT** the seeds?

1) Really! Plant 120 acres by hand? You might not get all the seeds planted before it's time to harvest, but a huge crew could help.
2) Most farmers use tractors and other machinery, which also means they use diesel fuel and oil, both of which can pollute the air and soil if not handled properly.

Economic Score 1) 2 2) 4

Environmental Score 1) 5 2) 3

F. How many **PEOPLE** will you employ? 

1) A real family farm. Your wages paid out are probably low, but are there enough people to do the work?

2) Four full-time people on the payroll can get expensive!

3) If you hire people only when they're needed, you will probably make the most money.

Economic Score 1) 4 2) 3 3) 4

Environmental Score 1) 5 2) 5 3) 5

G. How will you keep the **WEEDS, INSECTS**, and **DISEASES** away?

1) Many farmers use pesticides. But they can hurt animals and plants in the air and water. Use the pesticides only according to the label.

2) You would need many, many people to take care of an insect infestation or disease. Still, many farmers grow their crops organically, without the use of pesticides. If you're growing organic crops, make sure you're only using manure to fertilize.

Economic Score 1) 4 2) 2

Environmental Score 1) 2 2) 5

H. How will you **SELL** your crop?

1) It would be hard to sell 120 acres worth of crop from a roadside stand.

2) Many farmers sell to a middle person who buys their crops in bulk.

3) If you have grown organic products, opening your own store might be a good idea, if the town has enough demand for the product.

Economic Score 1) 2 2) 5 3) 3

Environmental Score 1) 5 2) 5 3) 5
What your score means

Add up your economic and environmental scores. Find out where you fit below.

**Economic**

Under 25: Your farm business may not survive to see another year.

25-29: It's a coin toss whether you'll be able to meet the mortgage next month, but you're hanging in there.

30-34: Economically, things, are going pretty well on the farm. Looks Like you'll be back for another season.

Over 34: You've managed your farm well, moneywise. You've got enough profits to buy a red four-wheel-drive truck. But how did you do on the environmental score?

**Environmental**

Under 33: You're showing a real disregard for the environment. You're probably causing damage to the soil and water of your own farm and the surrounding areas.

33-35: You need to take more steps to protect your farm habitat.

36-38: You're doing a pretty good job of protecting the environment in the area.

Over 39: You could be part of an environmental tour, you're doing such a good job of protecting the environment! Now... how's your economic score? Will you be back next year?
BRIEF DESCRIPTION
By conducting a small group sorting activity, students can learn the importance of reducing, reusing, and recycling solid waste. Students then develop plans to alter personal behaviors.

MATERIALS
Writing materials; masking tape; collection of clean “trash” (see Getting Started); eight containers labeled biodegradable, reusable, recyclable, landfill; three to four biodegradable organic materials (grass, fruit, vegetable peelings) in small plastic bags; large plastic trash bags; transparencies of the attached Materials Discarded and Is It Really Trash? sheets and photocopies of the attached What’s in the Barrel? sheet.

SUPPORTING INFORMATION
Over the past 50 years Americans have become a “throw-away” society. Each year we generate millions of tons of trash. We have created far too many disposable items. Until the late 1980s, few people recycled because it was not cost effective or convenient.

In the 1960s and early 1970s it was not uncommon to see people burning their trash in a container in their backyards. Open dumps were used to dispose of trash and became a threat to the environment. Rain water leached through the garbage, some times polluting rivers and groundwater supplies. In some cases, dumps smelled, attracted rodents, and artificially sustained wildlife populations, such as bears and raccoons, that came to feed on the garbage. As a result, these kinds of dumps are illegal today.

Modern sanitary landfills are a big improvement over open dumps. Geologists survey the land to select the best possible sites. Construction workers dig a large hole in the ground and line it with plastic or a layer of impermeable trash.

LEVEL: 7th grade
SUBJECT: Social Studies
SKILLS: Analyzing, collaborating, communicating, comparing similarities and differences, developing vocabulary, discussing, identifying, listing, sorting, valuing, writing

OBJECTIVES
The student will - identify and sort trash that is biodegradable, reusable, and recyclable. - analyze personal behavior, explaining six actions to take to reduce solid waste. - develop a plan to change personal behavior in order to reduce solid waste.

ESTIMATED TEACHING TIME
12 class periods

VOCABULARY
biodegradable, compost, percentage, recycle, reduce, reuse, sanitary landfill, solid waste, trash
clay or bentonite. This prevents potentially harmful liquids from leaking into the water supply. The workers cover the trash daily with a layer of soil. When the landfill is full, they cap or seal the hole. Governmental agencies monitor the sites for several years. Many times the sites are eventually reclaimed for parks or open space areas.

Sanitary landfills work well, but they create many problems. First, they require a lot of space. Second, it is becoming more and more difficult to find environmentally safe places to them. Third, no one wants one in their backyard. Fourth, the landfills fill up quickly. Another problem is that biodegradable materials (those capable of decomposing through a natural biological process) are unable to decompose in landfills. Biodegradable materials need moisture and oxygen to decompose. Because the soil is so compact, the amount and condition of waste remain the same. People have recovered paper and other items from landfills essentially unchanged after 15 years and, in some cases, after 25 years.

The United States Environmental Protection Agency (EPA) uses the term municipal solid waste to describe what most people call trash. Municipal solid waste is waste generated from residential, commercial, institutional, and industrial sources. It includes such things as large and small appliances, carpeting, furniture, tires, disposable diapers, paper and paper products, containers and packaging, food waste, yard trimmings, miscellaneous inorganic wastes, and more. In 1960 about 88 million tons of municipal solid waste were generated. In 1995, it was 208 million tons. And by the year 2000 it is projected to reach 222 million tons.

Citizens can encourage local government to address trash issues. Many states have developed innovative programs for reducing waste, with many cities offering curbside recyclable pickups. The federal government develops and provides information, looks for incentives to create less waste, and helps communities plan and carry out source reduction measures.

Four of the many solution to the trash problem are:

1. **Reducing trash** - In simple terms this means reducing the amount of trash sent to landfills or waste combustion facilities. It is often called waste prevention and involves everyone from the designer and manufacturer to the purchaser and consumer. Reducing trash includes such things as designing products to minimize the amount of packaging; buying frequently used items in large quantities; buying products in refillable bottles (e.g., liquid laundry detergent); extending the useful life of a product through maintenance and repair; minimizing the use of products that contain hazardous compounds; borrowing, renting or sharing items that are used infrequently; and backyard or on-site composting. These kinds of actions can conserve natural resources, reduce pollution, and avoid the cost of recycling.

When people take extra steps to prevent trash from going to a landfill, they continue to reduce trash. For example, many items, such as yard and non-animal food waste, are biodegradable. If put in a compost pile, they break down into simpler elements rich in nutrients. In this state, people can use them to fertilize a garden or house plants. To avoid problems, people should locate compost piles in a corner of the yard and away from homes or schools. They must also avoid putting in too many grass clippings to prevent odor.

2. **Reusing** - Anytime we reuse things, we are being friendly to the environment. We can reuse many items or pass them on to another
person to be used again. For example, secondhand stores or resale stores always need our old items. The reuse of items has big benefits such as:

- less trash ending up in landfills
- less energy needed to make new items
- more income for people selling the items

**Reusable items include:**
- clothing
- furniture
- toys and games
- cars
- books
- tools
- appliances
- computers
- CDs or records
- sports and camping equipment
- plastic milk and water bottles
- nondisposable dishes, silverware, and other household furnishings

3. **Recycling** - The third step is equally important: recycling and buying recycled products. Recovery of materials for recycling grew at a slow pace during the 1960s, 1970s, and early 1980s. Renewed interest in recycling came about in the late 1980s. The recovery rate of recyclables was estimated to be 17.2 percent in 1990, increasing to 27 percent in 1995. Some products made from recycled materials are now competitive with products made from nonrecycled materials. Many are similar in price and quality. Many businesses will stock products made from recycled materials if customers ask for them. More offices, schools, and businesses today are choosing to use recycled paper products. Many other items can be reused several times before recycled:

**Recyclable items include:**
- clean clothing
- glass bottles and jars
- newspaper
- tin and aluminum cans
- phone books
- paper and plastic
- school paper
- grocery bags
- office and computer paper
- corrugated cardboard
- cracker and cereal boxes
- small batteries
- magazines
- polystyrene
- various small-neck plastic bottles numbered 1 and 2 on the bottom (in selected locations, some plastic bottles and containers numbered 3-7 on the bottom)
- some used automobile items in exchange for new items; a slight fee may be asked for tires, motor oil, batteries, antifreeze, transmission fluid

Most plastic containers are labeled with a number and in some cases with letters, to identify the type of resin from which they are made. This helps the recycler accurately sort materials but it does not necessarily mean that an item is recyclable. Following is a listing of numbers, resin, and examples of each.

1. PETE (polyethylene terephthalate): soft drink bottles, some peanut butter and other jars
2. HDPE (high-density polyethylene): milk and water bottles; many laundry detergent,
bleach, shampoo, and cleanser bottles
3. PVC (polyvinyl chloride): some water, cleanser, shampoo, and other household bottles
4. LDPE (low-density polyethylene): plastic bags, butter and some yogurt containers
5. PP (polypropylene): some household bottles, caps on bottles, medicine bottles
6. PS (polystyrene): meat and deli trays, egg cartons, clean coffee cups, packaging peanuts
7. OTHER: bottles or containers made from other plastics or a combination of more than one plastic

All of the items listed may not be recyclable in your area. To learn more about what is being recycled call a waste management company, city or county government offices, or look in the Yellow Pages of your telephone directory under recycling.

Products made from recycled materials include
- facial and toilet tissue
- paper towels and plates
- greeting cards
- clothing
- plastic trash bags
- paper and plastic grocery bags
- carpeting
- office and school paper
- cereal and cracker boxes
- aluminum cans
- plastic lumber
- plastic containers
- shoes, sandals, boots
- bicycles
- packaging supplies

4. Research and development - Another solution to the trash problem lies in the research and the development of more environmentally-friendly products. Research in this area has resulted in the use of agricultural crops such as corn and soybeans to develop biodegradable alternatives for plastics bags and printing products (e.g., paper, ink).

Research and development of more environmentally-friendly products
- cornstarch peanuts
- cornstarch flatware
- kenaff (fiber-rich plant used to make paper)
- soy-based ink

No matter how much we are able to reduce, reuse, recycle, and develop new products, some things will end up in sanitary landfills as solid waste. Solid waste, also referred to as trash, is worthless, unnecessary, unsafe, or offensive material that must be thrown away. Tomorrow’s technology may find ways to manufacture products differently or to recycle some of these things, but today’s’ examples of solid waste items are numerous.

Solid waste items include
- disposable diapers
- sterilized hospital waste
- aerosol cans
- used facial and toilet tissue
- some paper and plastic packaging
- unfixable toys, appliances, furniture
- disposable pens and razors
  - toothpaste tubes, toothbrushes

Millions of people in the United States are reusing, reducing, recycling, composting, and buying products made from recycled materials. That includes the agricultural community, from the farmers and ranchers to the processors and chemical companies. Examples include recycling waste oil and plastic pesticide containers, reduced packaging, reusable containers for some pesticides, and composting materials such as wood waste, animal manure, plant
materials, straw, produce waste, and grass and yard clippings. Even the animals participate in reducing waste. Sheep have been used to clean up carrot and sugar beet fields. Rather than sending the carrot and sugar beet tops to a landfill after harvest, the sheep eat the cast-offs. Livestock consume about 18 billion pounds or 25 percent of the by-products generated by food processors, materials that would otherwise end up in landfills. Pulp left over from brewing veer, for example, is sold to farmers and used as cattle feed.

Farmers are becoming processors of urban waste especially in locations where landfill costs are high. There are farms that compost wood waste, animal manures (e.g., stock shows, zoos), and grass and yard clippings from nearby urban areas. And in some locations, cattle eat foods such as cookies and candy bars that have exceeded their expiration dates. These foods were once sent to landfills by grocery stores.

There are many factors that must be considered in addressing the trash issue. It is not a decision that can be made blindly the tradeoffs must be weighed as people consider the environment (use of renewable vs nonrenewable natural resources), economics (jobs, cost of landfills, cost to use water and electricity in recycling), availability of recycling opportunities, and health issues. The solution will likely require a combination of actions.

Wise consumer can make a difference. When they buy long-lasting products, recyclable products, or products made from recycled materials, they help reduce landfill trash. Wise consumers avoid buying products with excessive packaging. In addition, consumers who buy items with recyclable packaging send a strong message to manufacturers.

**GETTING STARTED**

Label the two sets of four containers: biodegradable, reusable, recyclable, and landfill or label and tape off spaces on the floor. make a transparency of **Materials Discarded** and **Is It Really Trash?** sheets. Photocopy **What's in the Barrel?** sheet, one copy for every four to five students (optional for older students).

For homework, have students bring in a non-food, dry, clean item, such as polystyrene trays, used paper, aluminum cans, foil, packaging. Partially fill three or four plastic bags with different biodegradable organic items on hand, such as fruit or vegetable skins or peelings, lettuce, grass clippings, and leaves. Place all of these items in large plastic trash bags for use in Session Two.

**SESSION ONE**

1. Ask students to define trash, garbage, or solid waste. Agree as a class on a definition. It may change through the lesson as students receive new information. (Trash or solid waste is material usually thrown away because it is considered unsafe, offensive, worthless, or unnecessary. Many items presently thrown away as trash or solid waste may have the potential to be recycled or reused or may be biodegradable.)

2. Review and discuss the **Materials Discarded** transparency. The percentages given represent municipal solid waste that is presumably combusted or landfilled. It does not include materials that have been recycled or composted. Students have seen and heard many of these figures. help them to create personal meaning. Ask:

    - What are the ways we get rid of our trash and things we no longer use? (Put in garbage, take to landfill, recycle, give away, sell at garage sales.)
- Which methods do you think are best? Why?

- What do you think it means when we say something is biodegradable? (Able to decompose in soil through a natural biological process, as in composting.)

- What are some examples of biodegradable materials? (Yard and nonanimal food wastes.)

- Why can biodegradable items be used in composting? (Biodegradable items break down and decompose in soil, adding rich nutrients that are good for the soil.)

- What do you think it means when we say something is reusable? Give examples. Recyclable? (Able to be processed into something else.) Give examples.

- What does reduce mean? (To lessen the amount of trash we generate for landfills by reusing, recycling, and buying recycled products and products without excessive packaging.)

- Where does much of the trash end up that we put in the garbage? (Most ends up in the sanitary landfills. See Supporting Information about landfills.)

- What do you think are some problems of sending too much trash to landfills? (They fill up quickly. They are expensive. In some parts of the country, it is very difficult to find appropriate places for landfills. Reusable and recyclable resources, such as aluminum, glass, and paper, are buried instead of recycled. We also lose the benefit of biodegradable items. For example, many kitchen scraps make good compost.)

SESSION TWO
Note: Steps 1 and 2 are optional for older students.

1. Have students list possible trash items (see Supporting Information). Ask:

- Which of these items could be reused, recycled, or used in compost because they are biodegradable?

- What are some ideas to get people to stop putting reusable, recyclable, and biodegradable items into the landfill?

- Think about the way you do things. What are some actions you can take to reduce the amount of trash you generate? Are you willing to take these actions? Why or why not?

2. Divide the class into groups of four or five. Distribute one copy of What's in the Barrel? to each group. Using the list of possible trash items the students generated, have them analyze, discuss, and sort each item into one barrel. Have them write the item names on the lines in the barrels. Ask:

- What items were in each of your barrels?

- Did all the members of your group agree on how you sorted your trash? Why or why not?

3. Have a trash relay race with students. The challenge is to sort trash into the appropriate container. For each team, set up four containers labeled biodegradable, reusable, recyclable, and landfill. (You can use tape to label spaces on the floor instead of using containers.)

Divide the class into two teams. Put the collection of trash items and/or names of the items in a pile between the teams. The first member of
each team takes one item of trash, places it in the team’s appropriate container, then returns to tag the second player. This player repeats the process, and so the game continues.

Once both teams are finished sorting, have them trade containers to analyze and discuss each other’s sorting choices. If questions arise, accept the sorting choice if the team can logically defend the choice. The winning team is the one with the most correct sorting choices. Ask:

- How are reducing, reusing, and recycling similar? Different?

- Why do you think it is important to reduce, reuse, and recycle?

- How can what you learned in this sorting activity help you decide what to do with your own trash?

- How can you make a difference in the way your family or school gets rid of its trash? The amount?

Show the transparency Materials Discarded. Ask:

- Which of the materials are recyclable? (Glass, plastics, paper and paperboard, and metals.)

- Which of the items are biodegradable and could be used in composting? (Yard wastes and nonanimal food wastes.)

- Why aren’t all these items presently being recycled or used in composting? (No place to recycle them, too much work, no incentives, don’t know how to compost.)

- What difference would it make if less waste were going to the landfill?

- What are you willing to do to help make a difference in the amount of solid waste?

- What is at least one thing you learned that you will share with others?

4. Throughout this lesson we have used the word trash. Trash usually implies the materials are worthless or have no value. But is it really trash? Show and discuss the transparency Is It Really Trash?

5. Have students write individual plans that list six actions they could take to reduce the amount of trash they generate. Explain why the plan is important.

**EVALUATION OPTIONS**

1. Students define the words biodegradable, reusable, and recyclable. Give six examples of each.

2. Conduct the sorting activity again. Note if students choices are different based on what they’ve learned.

3. Tell students you found the following things in the school trash. Some of these could still have use. Write items under the most likely heading (Biodegradable, Reusable, Recyclable, Landfill) so they could avoid being sent to a landfill.

   books, potato peelings, newspapers, toys, plastic pop bottles, school paper, rotten apple, brown paper bags, grass clippings, clothing aluminum cans, phone book

4. Have students complete one or both of the following phrases.

   - I use recyclable and reusable things when possible because...

   - It’s important to me to recycle because...

**EXTENSIONS AND VARIATIONS**
1. Collect all the trash your class generates in a day, including lunchtime. Weigh it and sort it according to what is biodegradable, recyclable, reusable, and goes to the landfill. Using calculators, find the percentages of total weight for these categories. Project total weights for a week of trash. Discuss the implications of reducing, reusing, and recycling for the class. Have students generate specific goals, such as reducing trash by 10 percent. Challenge other classes to reduce their trash. Designate waste watchers to measure the level of waste reduction, especially in the cafeteria, since it is one of the most challenging sites. Perhaps waste watchers could measure the level of waste reduction.

2. Students tie a small plastic bag to their belts or wrists and collect and carry their trash for one day. Have them weigh, sort, and analyze the contents.

3. Investigate composting and vermiculture (composting with earthworms). Students could compost at school using biodegradable items from the cafeteria and student lunches.

4. Polyester is a chemically-formed synthetic fiber. One of the most important and widely produced polyesters is polyethylene terephthalate (PET). PET is probably best known for its use in plastics but it can also be found in clothing. Have students identify other unexpected uses for recycled materials.

5. Instead of bringing a trash item from home for Session Two, have students collect litter from the playground to use. Another option is to use trash in trash cans from various sites on your school campus. Make sure students wear gloves.

6. Invite someone from the recycling industry to talk about the many careers in recycling. Many jobs are available in areas such as public relations, education, office management, word processing, receptionist, sales, mechanics, forklift and truck drivers, baling machine operators, and material sorters.

7. Sing the following song with students to reinforce the lesson concepts.

**REDUCE, REDUCE, RECYCLE**
Song Tune: “Twinkle Twinkle Little Star”
Lyrics used with permission from Beverly Bruns, Victoria, Texas

Air, and Water and the Soil
Trees and Wildlife, we can’t spoil!
Con-serve Na-tural Re-sour-ces
Re-use, re-duce, re-cycle
We need them in many ways.
And the fu-ture end-less days.

**RESOURCES**


*Bottle Biology*, Department of Plant Pathology, University of Wisconsin - Madison; 1630 Linden Drive, Madison, WI 53706; (608) 263-5645


*Recycling Study Guide*, Wisconsin Department of Natural Resources, 1989. Bureau of Solid Waste Management, Wisconsin DNR, P.O. Box 7921, Madison, WI 53707; (608) 267-7565

Environmental Action, 6930 Carroll Ave., Suite 680, Takoma Park, MD 20912; (301) 891-1100. Information on plastics, tires, and toxins, free listing of recycling contacts and publications.

National Recycling Coalition, 1101 30th St. NW, Suite 305, Washington, DC 20007; (202) 625-6406.

All the following EPA publications can be ordered by calling the Resource Conservation and Recovery Act (RCRA) Hotline at 1-800-424-9346.

CREDIT

EDUCATOR’S NOTES
MATERIALS DISCARDED
(in percent by weight)

Yard Wastes — 13.7%

Food Wastes — 8.9%

Other — 20.6%

Plastics — 11.5%

Paper and Paperboard — 32.2%

Glass — 6.4%

Metals — 6.4%

*Other includes 3.6% rubber and leather and 8.8% wood products.

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IS IT REALLY TRASH?

Recycling steel and tin cans saves 74 percent of the energy used to produce them from raw materials.

Recycling aluminum saves 95 percent of the energy used to make the material from scratch. That means 20 cans can be made out of recycled material with the same energy it takes to make one can out of new material.

Recycled HDPE can be turned into items like flower pots, trash cans, traffic barrier cones, and curbside recycling bins.

We save over a ton of resources for every ton of glass recycled. Specifically we save 1,330 pounds of sand, 433 pounds of soda ash, 433 pounds of limestone, and 151 pounds of feldspar.

Recycling one glass bottle or jar will save enough energy to light a 100 watt light bulb for 4 hours.

If everyone in the United States recycled just 1/10 of their newspapers, about 25 million trees could be saved every year.

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What's in the Barrel?
BRIEF DESCRIPTION
As Tennessee’s population grows, our natural resources are affected. Students play a board game to simulate changes in land use and discover the effects of change on the carrying capacity in the world.

SUPPORTING INFORMATION
Population growth is one of the greatest challenges our world faces today. Few of us are really aware of the consequences of continued growth, be it of rabbits, deer, or people. Carrying capacity is an issue people need to understand. Carrying capacity is the number of individuals the land can support indefinitely. A given piece of land, whether it be an acre or a continent, can support only a limited number of organisms. For example, when mountain lions were hunted to extinction on a plateau in Arizona, deer, the lions’ prey, grew in numbers. Within a few years, many deer began to starve. The deer population had exceeded the ability of the plateau’s food supply to support it. Some people may not understand these relations. We tend to think that the carrying capacity of land is limitless. Until recently, we have converted grasslands and forests to crop-land to increase land’s ability to feed us. As a result, each U.S. farmer produces food and fiber for 129 people. It cannot be assumed, though, that our ability to increase the carrying capacity is unlimited. Also, it cannot be assumed that conversion of land can be done everywhere in the world.

LEVEL: 8th Grade
SUBJECT: Social Studies
SKILLS: collaborating, communicating, concluding, understanding cause and effect.
OBJECTIVES
The student will
- model the concept of carrying capacity by playing a board game.
- observe the relationship between population growth and environmental effects.
- invent guidelines for the game that will conserve or renew resources.
- discuss how we can increase capacity.

MATERIALS
One of the following for each group of five students: blank transparency; transparency pen; small envelope; piece of brown paper 9" x 12"; small cup; 64 beans; photocopies of the attached Game Piece, Master, Data Sheet, Game Instructions, New Guidelines Data Sheet, and Summary Questions sheets.

VOCABULARY
- carrying capacity, sustain
Earth has been able to carry relatively small human populations practicing subsistence agriculture (producing enough food to feed a family, with little left over to sell or reserve for bad times) with ease. For instance, farmers in the Amazon Basin practice a form of shifting agriculture called "slash and burn" in which forest material is cut down, dried, and burned. Crops are planted immediately and thrive for several years because of the nutrients from the ashes. The soil is depleted in just a few years, however, and the land must be abandoned for a new part of the forest, where the process is repeated. When the farmers were few in number, the rain forest suffered no long-term permanent effects, as the land was able to recover.

In more recent times, the burgeoning human population has created greater demands on the land. This has resulted in environmental changes few could foresee a generation ago. Some examples include nitrate pollution of groundwater, the accumulation of DDT in the food chain, and the selenium pollution of bird habitats in semiarid regions.

Earth's population is now nearing six billion people, with projections as high as 11 billion people by 2100. Many doubt that Earth can support such a number. To do so, environmental systems would be altered, threatening the long-term survival of the human race. What is Earth's maximum carrying capacity? No one knows for sure.

If people consciously alter the environment to support more of our numbers, then we must understand the effects of those alterations. We also need to understand that people can make conscious decisions about development of the land and the use of natural resources such as trees and water. Connecticut, for example, was 70 percent forested at settlement; over time it dropped to as little as 30 percent. Through conscious decisions to alter the course of deforestation, the state is once again 70 percent covered with trees.

The population of a given area will likely fluctuate over time for any number of reasons. People may migrate in and out of an area in response to factors such as economics, lack of natural resources, drought, and so on. Populations also change as a result of wars, natural disasters, diseases, famines, and natural deaths. This lesson offers students the opportunity to simulate and examine a variety of issues as they explore the question, "What will the land support?"

**GETTING STARTED**

1. Calculate the number of board game kits needed for your class. You will need one kit for each group of five students. Each kit requires:
   * One brown piece of paper (two can be cut from one brown paper sack) or a 9" x 18" piece of brown construction paper divided into 16 "plots" (representing bare ground)
   * Envelope or plastic bag for photocopied game pieces from the Game Piece Master sheets
   * 64 blue water drops
   * 64 green trees
   * 16 houses
   * 50 people
   * 64 beans (representing food and/or cultivated crops)
   * 1 cup labeled Allocated Water

The following chart will help you determine how many photocopies to make of each Game Piece Master sheet.

<table>
<thead>
<tr>
<th>Game Piece Master</th>
<th>Each Master Contains</th>
<th>Each Kit Needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water drops</td>
<td>96</td>
<td>64</td>
</tr>
<tr>
<td>Trees</td>
<td>64</td>
<td>64</td>
</tr>
<tr>
<td>Houses</td>
<td>48</td>
<td>16</td>
</tr>
<tr>
<td>People</td>
<td>160</td>
<td>50</td>
</tr>
</tbody>
</table>

2. Photocopy the Game Piece Master sheets on paper of different colors. Be sure to make extra game pieces for Session Two when students are able to change the guidelines.

3. Decide if the group's kits will be completed in advance or as a part of Step 3 in Session.
One.

4. Cut the **Game Piece Master** sheets apart using a paper cutter. Make kits by placing each kit’s game pieces in an envelope or plastic bag. (If possible, laminate game pieces before cutting. Note: You can use other readily available items for game pieces, such as colored plastic tokens.)

5. Make game boards on construction paper or by cutting the bottom out of a brown paper sack. Cut the bag in half. Have students divide each sheet into 16 rectangles, or plots, each of which will represent a plot of land during the game.

6. Photocopy Data Sheet, Game Instructions, New Guidelines Data Sheet, and Summary Questions, one copy per group. Each group will need a blank transparency and transparency pen in Session Three.

**PROCEDURE**

**SESSION ONE**

1. Ask students to think about how we use land. Have them share some examples. If possible, have students look out the window and imagine what this piece of land looked like 25 years ago, 50 years ago, 100 years ago, and even 200 years ago. (Answers will vary, but should indicate a realization that the site has changed dramatically over time, due primarily to human decisions regarding land use.)

2. Ask students what they think early settlers found when they came to the area that is now their school, city, region, and state.

-What do people need from their environment? (Food, clothing, shelter, water, air, recreation.)

-How did people get their food 50 years ago? 100 years ago?

-How have people been able to meet the food needs of an increasing population? (Conversion of land, irrigation: increased use of science and technology to increase agricultural production.)

3. Divide the class into groups of five students. Explain that each group is going to participate in a simulation game, beginning with the simulation of the effect of early settlers moving into an unsettled area. Each student represents one family of four people. Distribute the board game kits or have students in each group assemble their kit.

4. Ask each group to identify a Recorder. The Recorder is responsible for recording data on the Data Sheet. (Be sure to give each recorder a copy of the sheet. A Data Sheet Answer Key is provided for your reference after Resources.)

5. Distribute one Game Instructions sheet to each group. Ask each group to identify one
person to read the instructions to their group. Have those students read Setting the Stage from the instructions so the game board can be set up. The board should look like that shown below.

6. Once students have their game boards set up, remind them that they will be simulating the effects of early settlers moving into an unsettled area. Explain that the Basic Game Guidelines for Session One on the Game Instructions sheet establish specific land development and uses of natural resources (e.g., building a house uses two trees) by these earlier settlers.

7. Decide if you want to play the first round with the class as a whole or have groups work independently. Have the designated student in each group read the Basic Game Guidelines for Session One on the Game Instructions sheet.

8. Play the game. Assist groups that request your help. After round 1 the following is an example of what the board may look like.

9. Continue the game until game pieces or resources run out. Have students draw conclusions. Ask students why they think the game came to an end.

SESSION TWO

1. Begin this session by asking

- What were some of the guidelines used in the early settlers' simulation game?

- What are some things we can do to change how we interact with the land?

-if you could change one guideline, what would it be? Why?

2. Explain to students that by changing guidelines we can affect the relation between land development and the use of natural resources and, therefore, the carrying capacity of the land. Tell students that in this session, each group is to develop new guidelines or change the guidelines from Session One in order to conserve and renew resources. (For example, students might require all settlers to use less wood when building homes or to replant trees.)
Encourage students to consider issues such as water conservation, soil erosion, death, imports, or limits on growth. (For instance, they might add the following as a new guideline. After 10 trees are removed from the board, move one water symbol from the board area to a Polluted Water area. Remove one bean because of soil erosion and loss of soil fertility. As a result, the field becomes barren. Students will need to convert more virgin forest into farmland by removing a tree and replacing it with a bean or peanut. Repeat after the next 10 trees are removed.)

3. Distribute the New Guidelines Data Sheet to the Recorder in each group. Give students time to generate ideas and have the Recorders list the new guidelines on the New Guidelines Data Sheet. The Recorder guides the playing of the game again. Students continue the game until game pieces or resources run out. Tell students that in Session Three they will discuss the game as played with the new guidelines and compare it to the game played in Session One.

SESSION THREE

1. Distribute the Summary Questions sheet, blank transparency, and transparency pen to each group. Have the Recorder in each group use the blank transparency to write their new guidelines at the top and responses to five or more of the Summary Questions on the remainder of the transparency. Ask each group to identify one person to lead a discussion using the Summary Questions. Encourage students to use their data sheets.

2. After groups discuss the questions, have each group use their transparency to present their new guidelines and responses to their questions to the other groups. (Note: At the end of the lesson is one page of Summary Questions and Possible Answers. These answers are to serve as a guide for you only.)

3. In closing, ask
   - How can what you have learned about carrying capacity and environmental effects help you in the future?
   - What will you share with others about carrying capacity and the environmental effects?

EVALUATION OPTIONS

1. Evaluate students’ active participation, understanding, and creativity while playing the game and when designing new guidelines for the game.

2. Ask groups to write responses to the Summary Questions. Or ask individual students to choose a question to respond to in writing.

3. Evaluate groups’ answers on the Data Sheet and ideas that emerged during class discussion.

4. Have students consider the concept of carrying capacity in discussion or writing. Have them describe things that can happen as more and more people try to live on the same amount of land. What are ways in which people can increase carrying capacity? Describe choices people must make when a certain piece of land cannot support all the people who live on it.

EXTENSIONS AND VARIATIONS

1. Play the game early in the school year and then again later. Check for changes in students’ understanding, perceptions, atti-
tudes, and problem-solving abilities.

2. Play the game again, but start with less water and a prairie instead of a forest to represent the situation that settlers found in the Midwest. Or start with a dry prairie and groundwater representing the situation in the Western United States; the water must be allocated for irrigation of cropland.

3. Play the game simulating urban sprawl. The population is growing and needs to expand into an undeveloped area (represented by the game board). Have students assume the following roles:

- Commissioner - responsible for reading the Game Instructions to the group and managing the game. (Be sure to give each commissioner the Game Instructions.)

- Resource Manager - responsible for making and/or gathering the supplies for the kit and for keeping track of the game pieces.

- Planner - sets up the game according to the description on the Game Instructions sheet, adds people and crops, and moves water pieces.

- Builder - decides on the placement of houses and adds and removes tree and house game pieces during each round.

- Recorder - responsible for recording data on the Data Sheet and New Guidelines Data Sheet and leading the group discussion of the Summary Questions. (Be sure to give each recorder a Data Sheet, New Guidelines Data Sheet, and Summary Questions.)

4. Have students make a home survey of what their households are doing to extend Earth’s carrying capacity (conserving natural resources, preventing pollution, and more).
The land was the surface of the earth and all its natural resources: the plants, the animals, minerals, and, more importantly, the soils. The United States is a nation blessed with 25% of the world’s Class I soils - the best soils possible. Also important was the fact that abundant clean water supplies were present in most of the early areas settled. It was called a land of abundance by early explorers and settlers. They came from Europe in the 1600’s and 1700’s. When they arrived they found large forest for timber. They found many animals for their fur pelts. The soils were the source of this great abundance.

The land and the soil were also very important from 1820 to 1900. At that time the U.S. was rapidly growing westward. Most Americans felt that they had the right to move westward into the Louisiana Purchase, California, and the Oregon Territory. The western soils were fertile. The land was free or inexpensive. As pioneers moved west, the nation became larger.

**GETTING STARTED**

Copy the student page, one per group. Several days before the activity, contact your school librarian to obtain reference material on the topics. This will help your students get started. (A list of references appears in the resource guide.) Since your students will be working in small groups on a report, a key to this activity is organization. You may want to present this action plan to your students to help them organize.

1. Select one of the questions for research.
2. Conduct preliminary research on the topic.
3. Create an outline.
4. Determine what information you need to complete the outline.
5. Conduct the research.
6. Decide how to present the information.
7. Select visual aids that can be used to help your presentation.

**PROCEDURE**

1. Divide the class into small groups and discuss the interrelationships that exist among land,
soils, water, plants, animals, and minerals.
2. Then ask your students to read the activity
master.
3. Assign a topic to each group or let them
select their own. As the students get started,
let them know if the end result should be an
oral or written report.

EVALUATION OPTIONS
Have a panel assess the presentations in a
self assessment activity using established crite-
ria developed by the class.

EXTENSIONS AND
VARIATIONS
Instead of a written or oral report, have the stu-
dents create a newscast or newspaper to pre-
sent their findings.

RESOURCES
Educational Resources Information Center
(ERIC)
ERIC Science, Mathematics, and
Environmental Education
The Ohio State University
1200 Chambers Rd., Room 310
Columbus, Ohio 43212

Media & Educational Services Branch
USDA Natural Resources Conservation
Service
P.O. Box 2890
Washington, D.C. 20013

Soil and Water Conservation Society (SWCS)
7515 Northeast Ankeny Road
Ankeny, Iowa 50021-9764

EDUCATOR’S NOTES
U.S. History Was Affected by Soils

The land is the surface of the earth and all its natural resources: the plants, the animals, minerals, and, more importantly, the soils. The United States is a nation blessed with 25% of the world’s Class I soil - the best soil possible. Much of the earliest land settled also had abundant clean water supplies. It was called a land of abundance by early explorers and settlers. They came from Europe in the 1600's and 1700's. When they arrived they found large forest for timber. They found many animals for their fur pelts. The soils were the source of this great abundance.

The land and the soil were also very important from 1820 to 1900. At that time the U.S. was rapidly growing westward. Most Americans felt that they had the right to move westward into the Louisiana Purchase, California, and the Oregon Territory. The western soils were fertile. The land was free or inexpensive. As pioneers moved west, the nation became larger.

Below are a list of questions about these two periods of U.S. history. Get together in small groups with your classmates. Research the topics. Later, share the information that you find with your class in an oral or written report, in a play or other creative expression.

1. Why did Europeans move to the New World during the 1600's and 1700's?

2. Describe the life of a typical family during the 1600's or 1700's.

3. What were land rushes? How did they originate?

4. What was the Homestead Act of 1862? Why was it important?

5. Why did pioneers move into the Great Plains?

6. Describe the life of a pioneer family during the 1850's.

7. What is the history of inventions such as the steel plow, barbed wire and windmills?

8. What difficulties did railroads have in the westward expansion?

9. What advantages did railroads bring to the western pioneers?

10. Describe farming practices during the 1700's and 1850's, and compare them with modern practices.

11. How did this westward movement affect the Native Americans, their agricultural practices, and their use of the land?

12. How did minority groups influence the settlement of the United States? What has been their impact on American agriculture?
VOCABULARY
conserve, conservation, consumption, demands, environment, increase, natural resources, non-renewable, population, recycle, reduce, renewable, reuse.

SUPPORTING INFORMATION
This lesson is not meant to foster anxiety or a doomsday foreboding in students. It is an introduction to the effect that increasing populations have on the environment. One intent of the lesson is to have students realize some steps that individuals and communities can take to reduce the strain on natural resources.

This lesson is effective as an introductory or culminating activity for the study of any natural resource, including water, air, plants, animals, and soil. To provide examples for this lesson, it is best if students have researched the natural resource and know how it is being used and how it can be conserved and/or replenished.

Earth's human population is likely to reach six billion persons by the end of the 20th century. The strain placed on natural resources (both renewable and non-renewable)
will be greater than ever before and may become increasingly severe if the population continues to grow. Renewable resources are those dependent on sun, air, water, and soil to regenerate. Non-renewable resources are those which are available only in finite amounts, such as oil, gas, and metals.

The more individuals of one species living in a given area, the greater the impact on natural resources within that area. Conservation is an important tool in reducing this impact and protecting the natural resources and local ecosystem. An effective conservation practice is reducing the amount of natural resources consumed. Consumers can choose not to buy an item that they don't need. Recycling and reusing are two other ways to reduce the consumption.

In addition, consumers can refuse to buy products that are not recyclable or biodegradable. They can also refuse to buy over-packaged products. By being aware of the supply of natural resources consumers can substitute items made from plentiful raw materials for ones made from more scarce ones. Consumers also can find alternate energy sources that are renewable.

Consider water. People use water daily in many ways, often in unrealized amounts. A single family home that has no water conservation fixtures may use as much as 64.6 gallons per person per day (gpd) or 244.5 liters per day. Some of the major water uses include 18.3 gpd (69.3 liters per day) for toilet flushing, 14.0 gpd (56.4 liters per day) for clothes washers, 12.2 gpd (46.2 liters per day) for showers, and 10.3 gpd (39 liters per day) for faucet uses such as hand washing, drinking and cooking water, and washing dishes. We also use water in many indirect ways, such as in the production of manufactured items and food, irrigation of lawns and food crops, preparation of food, cooling, and heating.

Even though there is an abundance of water on Earth, much of it is unusable for consumption by people or animals in its present form. More than 97 percent of Earth’s water is salt water. Salt water is not easily treated for our consumption, nor is it economically feasible to convert it to fresh water. Of the freshwater supply (less than 3 percent of the total amount of water on Earth), most is in-consumable. Glaciers and icecaps hold more than 2 percent of Earth’s water. Less than 0.5 percent of Earth’s water is fresh water available in lakes, groundwater, and streams. People face serious challenges when a limited resource such as fresh water has many demands for its use.

There is a limited amount of water actually available for use. It is unevenly distributed and everyday more and more people need that water for a variety of uses. Most of us are so accustomed to having an unlimited supply of water any time we need it that we rarely think about running out of water. Like any natural resource, our water resources need to be protected to have good-quality water for present and future generations.

Water is naturally recycled through the hydrologic (water) cycle. The water we use in our homes, schools, businesses, and industries is cleaned and treated (recycled) so it can be
returned to the environment and reused. Agriculture, businesses, and industries reuse water. Some agricultural fields and golf courses have systems for collecting and reusing runoff from precipitation, sprinklers, and irrigation. Most steel companies use water over and over in a circulating cooling system.

Reducing our demands on it can conserve water. Some communities and homeowners conserve water through xeriscaping (landscape for water conservation). Farmers may use drip irrigation to conserve water.

For most of us, water conservation means being aware of some of our habits in how we use water. When you brush your teeth, do you leave the water running? Do you take a long shower? Is the dishwasher fully loaded when it is used? Do you fix leaky faucets? (Leaky faucets can waste 6.6 gallons [25 liters] a day.) When you wash your car do you use a hose or a bucket of water? When you water outdoor plants, do you water the entire garden or do you water the area immediately around each plant?

Whether we live in an urban, suburban, or rural area, we can all be more aware of how we use water within our homes, schools, and community. No one needs to stop taking showers or watering their lawns but we can all help stretch our water resources by conserving water and using it more wisely.

GETTING STARTED

Obtain a world map or globe, measuring cup, large, clear glass container with lid, sponges (one piece per student), mixing bowl, towels, marker or masking tape, paper towels, tint (food coloring), and drawing paper. Cut sponges ahead of time. Add the tint to the water. Photocopy the Pie Chart for students. (Note: Water is used as the example of a natural resource. The water, however, could represent other natural resources such as soil, Air, trees, and more.)

PROCEDURE
SESSION ONE
1. Show students a map of the world and discuss the amount of water covering Earth. Ask: - How much of Earth's surface is covered by water? (About 3/4.) - Is all of this water usable for consumption by people or animals in its present form? (No. See Supporting information.)

2. Have students make several pie charts or bar graphs that show how the world's water is distributed as salt, fresh, and available water by using the following table of information.

Earth's Total Water Supply

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>97.2%</td>
<td>Salt Water (oceans, seas, and salt lakes)</td>
</tr>
<tr>
<td>2.8%</td>
<td>Fresh water</td>
</tr>
<tr>
<td>100.0%</td>
<td>Total water on Earth</td>
</tr>
</tbody>
</table>

Earth's Total Freshwater Supply

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.38%</td>
<td>Icecaps, glaciers</td>
</tr>
<tr>
<td>0.397%</td>
<td>Groundwater - available</td>
</tr>
<tr>
<td>0.022%</td>
<td>Surface water - available</td>
</tr>
<tr>
<td>0.001%</td>
<td>Air and soil</td>
</tr>
</tbody>
</table>

2.8% = Total fresh water on Earth
SESSION TWO

1. Measure about eight cups of the tinted water into the container. Ask students to pretend that the container represents Earth and the water represents all the available fresh water.

2. Have students brainstorm ways in which we use water (drinking, irrigation, recreation, cleaning, processing, cooking, bathing, transportation, and more). Write the responses in a visible place.

3. With a marker or masking tape, mark the water level on the outside of the container. Drop a piece of sponge into the container as you state one demand you made on water today. Remove (don't squeeze) the wet sponge from the container.

4. Have students examine the water level. (it probably shows very little change.)

5. Ask students, one at a time, to state a demand they made on water today. Have them drop their sponge into the container. Leave the sponges in the container. The students may begin to notice a change in the water level. After the students have dropped all the sponges in the container, remove them. Don't squeeze them out! Set them aside in the bowl. Draw attention to the dramatic change in the water level. Mark this water level on the outside of the container. Help students understand that the demands on natural resources of a large population have more effect than the demands of a small one. (Use the Supporting Information to expand on these ideas.) Ask
   - What happens to the water level as we remove all the sponges?

   - What will happen if we keep using water at this rate?

   - What can we do about this situation?

   - How can we conserve or give water back to the environment?

Put the lid on the glass container and cover the bowl to avoid evaporation.

SESSION THREE

1. Review the previous session's discussion and note the water level. Remind the students of reducing the amount of water they use.

2. Take one wet sponge, name a way you can reduce the amount of water you use, and squeeze the water out of the sponge back into the container. Notice the slight change in the water level. Explain that one person reducing the amount of water he or she uses does make a difference. The effect, however, will be greater when many individuals reduce. Ask "In what ways can you be more careful about the demands (reduce) you make on Water (or reduce, reuse, and/or recycle other natural resources)?"

3. When students have an idea about how they can make more careful demands on water, have them squeeze the water out of a wet sponge into the container. Have them tell the class their idea. The water level will go up. It won't go back to the original mark, however. Summarize by asking
   - Why doesn't the water level return to the original mark even after all the sponges are squeezed out? (Some water remains in the sponge.)

   - What happens to the water left in the sponge? (It evaporates to return later in condensation. Water is endlessly recycled.)
-Why is it important to make only careful demands (reduce) on water (or other natural resources)? Justify your reasons.

-How can the water in this activity represent other resources people use?

-What are some resources that cannot be recycled?

-How can they be conserved?

-What are some resources that are renewable? (Water, trees, fertile soil.)

Describe one thing you have learned from this demonstration. (Answers will vary, but should reflect an appreciation for the finiteness of all natural resources, the renewability of some, and the desirability of using natural resources wisely.)

EVALUATION OPTIONS

1. Students draw two pictures. In the first picture, have them show themselves making one or more demands on a natural resource. In the second picture, show how the demand(s) can be made more carefully. (Look for recycling, reusing, and reducing the use of resources.)

2. Students write a statement or paragraph about one or more ways in which they personally can recycle, reuse, and/or reduce the use of any natural resource.

3. Students complete the following statements.

* -I believe that using less water is important because...

* -I believe that reusing water is important because...

* -One morning I turned on the shower and there was no water. There was no water anywhere in the house. I am going to...

EXTENSIONS AND VARIATIONS

1. Use different colored sponges, with each color representing a different natural resource (blue = water, green = plants, yellow = minerals, and so on). Have students identify ways in which they use water, plants, minerals, and other resources each time they drop a piece of colored sponge into the container of water.

2. By tipping the container "accidentally" and spilling some of the water out of the container, demonstrate how accidents and natural disasters can limit the availability of natural resources. Discuss accidents and natural disasters (floods, oil spills, groundwater contamination, and others) and their effect on natural resources.

3. Start a class recycling and reusing project. Recycle paper, cans, and bottles from the classroom, the cafeteria, or home. Have students setup a book, toy, clothing, game, or computer software exchange. Students might also collect materials for Salvation Army, American Cancer Society, or Goodwill. Challenge another class to match or beat your efforts.

4. Have students role play a demand they make on a natural resource. Let the student who correctly guesses what is being acted out drop the next sponge in the water. That student acts out another demand on natural resources.

5. Students can take a different slant on the activity by examining how resources are unequally distributed and consumed around the world. From an atlas, students can use...
selected thematic maps, such as petroleum production and consumption, observing and analyzing relations about the differences among the patterns shown on the maps.

6. Have students draw "Waste/No Waste" pictures showing people "wasting" and "not-wasting". Have students fold pieces of white paper in half. On one side have them draw pictures showing how they might use a resource. On the other half, they can draw a picture of how they can conserve that resource.

7. Find out what is being done within your community to conserve water resources. (See Supporting Information for possibilities.)

CREDIT

Adapted from PROJECT FOOD, LAND & PEOPLE "DON'T USE IT ALL UP!"
HUMAN TRAITS THAT ARE INHERITED

BRIEF DESCRIPTION
Agriculturists breed plants or animals with desirable traits together to pass those traits on to new generations. Some of these include plants that are resistant to disease and drought, as well as animals that grow faster on less feed. These superior offspring place less stress on our natural resources while being more cost efficient. This lesson introduces students to the wide array of traits that can be passed from one generation to the next through genetics.

SUPPORTING INFORMATION
All improvement in the genetic quality of livestock or plants is a result of variations in the genetic makeup of the parents. The characteristics of each parent is determined by both their genetic make-up and the environmental factors that influenced how those genes are expressed. Gene combinations vary from animal to animal and plant to plant. If both parents were to have exactly identical genes then their offspring would be identical to the parents. But this is not the case. So, each offspring has a unique mixing of both parent’s genes. Each offspring will have a different mixing of those genes unless they are identical twins, triplets, etc., which were produced from a single fertilized ovum. Whatever genetic makeup one possesses comes from one’s biological parents. Also remember that not all genes are expressed physically. Parents may have recessive or modifier genes, which cannot be seen.

GETTING STARTED
Make copies of the STUDENT SHEET.

PROCEDURE
(NOTE: Be sensitive to the issue of adopted children and others with various family situations)
1. Discuss some traits that are noticeable to the students, and the fact that these traits can be passed on to their offspring.
2. Have the students get into groups of twos. Distribute the STUDENT SHEET, and have them list the traits that they have. Then have them list the traits of their partner under the heading of Other. This is a good activity to create excitement in scientific research. After the students have completed the column for themselves and their partner, list the different traits on the board. Have the students raise their hand if they have the trait in question.
3. A pie chart can be constructed showing the prevalence of one trait over another. Using the information gathered from the pie chart, have the students calculate the percentage of students that express each trait.
4. Have the students take the

LEVEL: 6th Grade
SUBJECT: Science
SKILLS: observation, analyzing, inferring, calculating percentages, graphing

OBJECTIVES
The student will - identify traits that are inherited from parents. - identify traits that people would seek and select for when raising animals and plants.

ESTIMATED TEACHING TIME
2 class periods plus homework

MATERIALS
Student sheet

VOCABULARY
inherited, traits
sheet home to identify traits expressed by their parents. (see NOTE!)
5. Conclude this activity by tallying the traits of parents just as you did for the students. Which traits are least prevalent? Most prevalent? Is there a pattern among families, (cousins, grandparents, etc.)?
6. Ask the students to identify genetic traits that humans would look for in plants and animals and actually select for when breeding. Make listings under different categories on the board and have them be specific. Use headings such as Horses, Roses, Sweet Corn, Dairy Cattle, Beef Cattle, Peaches, Apples and Tomatoes. Some traits that are selected for are:

   Horses - Speed, Strength, Color, Size, Jumping Ability, Conformation
   Roses - Color, Size of Bloom, Lasting Flowers, Fragrance, Stem Length
   Sweet Corn - Amount of Sugar, Disease Resistance, Ear Length
   Dairy Cattle - Quantity of Milk, Production, Good Feet and Legs, Conformation, Color, Breed Characteristics
   Beef Cattle - Quality of Meat, Rapid Growth, Good Mothering Ability, Conformation, Breed Characteristics, Size, Good Feet and Legs
   Peaches - Flavor, Ability to Hold Their Shape When Canned, Color
   Apples - Red Color, Flavor, Storage Traits, Will They Brown When Sliced, Color When Cooked
   Tomatoes - Flavor, Ability to be Shipped, Density of Flesh, Amount of Water

EVALUATION OPTIONS
1. Determine if the students can identify the traits listed by having them check out a person at school, (maybe the Principal!).
2. To check for understanding of percentages, have the students include their families, and friends into their calculations and check for accuracy.
3. Have the students survey 5 classmates as to the genetic traits that each would seek in their favorite foods. Provide a few suggestions such as tomatoes which taste good in the winter, sweeter grapefruit for juice, hamburger with less fat, etc..

EXTENSIONS AND VARIATIONS
Have the students come up with a list of other traits that are inherited. Ask them if all traits can be identified with “Yes” or “No” questions. Why not?
Not all traits are represented by simple dominance. Some are expressed as a combination of traits. See if the students can identify traits that seem to go together, ie. fair complexion and blue eyes.
**Ear Lobes**
Ear lobes can be attached at a point above the bottom of the ear lobe or attached at a point below the bottom of the ear lobe. Write "above" or "below" in the space provided.

**Tongue Rolling**
By rolling the sides of the tongue up and in, some people can roll the tongue into a cylinder. Others can't do this. Write "yes" for a tongue roller; "no" if unable to roll tongue.

**Right- or left-thumbed**
When interlocking the fingers of both hands some will place the left thumb over the right thumb; others will have the right over the left. Fold your hands with the opposite thumb on top. How does it feel? Write "left" if the left thumb is on top; "right" if the right thumb is on top.

**Folding arms**
Some people will fold the right arm over the left and some will fold left over right. Fold your arms in the opposite way. Is this difficult to do? Write "left," if the left arm is on top; right if the "right" arm is on top.

**Spreading Fingers**
Some people will be able to spread fingers of either hand in a "V" shape - two fingers on one side and two on the other side. Write "yes" if fingers are spread: "no" if this can't be done.

**Dominant eye**
Roll up a sheet of paper to make a tube 2" in diameter. Look through it, focusing on an object across the room. Close first one eye, then the other. Which is the dominant eye? How can you tell? Write "left" if the left eye is dominant; "right" if the right eye is dominant.

**Widow's peak**
The shape of the hairline across the forehead varies from person to person; some have a dip or point in the hairline in the middle of the forehead called a Widow's peak. Write "yes" if there is a Widow's peak. Write "no" if there is none.

**Finger length**
Place the first three fingers of your hand on a table. Note the length of the index finger and the ring finger. Index fingers vary in length—some are shorter than the ring finger and others are longer than the ring finger. Write "longer" if the index finger is longer: "shorter" if it is shorter.
BRIEF DESCRIPTION
Farmers manipulate the environment to improve the land’s carrying capacity for selected crops, plant or animal. Doing so allows more land to be used for other human activities. Students become herds of animals seeking food in a physically-involving activity.

SUPPORTING INFORMATION
Carrying capacity affects all living things, including humans. Carrying capacity may be seen as a type of dynamic equilibrium. It is typically expressed as the number of animals of a given type which can be supported in a given area. Carrying capacity is also interpreted more broadly as the number of living things (plants as well as animals) any area of land or water can support at any one time. Different life forms will have a different carrying capacity within the same area. Carrying capacity is usually limited by some aspect of a species’ habitat requirements. These requirements include the quantity and quality of available food, water, shelter, space and the suitability of their arrangement. Different factors will be important in each case. Carrying capacity is influenced by natural factors both human and non-human. Effects may be short or long term. Carrying capacity for many species is in a constant state of change, both seasonally and from year to year. For example, it is typically most limited for terrestrial animals in the winter season when food supplies are reduced. Year to year variations may result from factors such as natural disasters, changes in rainfall and temperature patterns, or human interventions. Factors affecting plant growth will affect animals since they are either directly (as herbivores or omnivores) or indirectly (as carnivores) dependent on plants. Populations of living things tend to fluctuate naturally around some level. Carrying capacity is that

LEVEL: 6th grade
SUBJECT:
Life Science,

SKILLS: analysis, comparing similarities and differences, description, evaluation, generalization, hypothesis formation

OBJECTIVES
The student will - formulate hypotheses related to wildlife populations and carrying capacity.
- describe the significance of carrying capacity.

ESTIMATED TEACHING TIME
12 class periods

MATERIALS
- one bag of dried beans; kitchen timer, Deer Feeding Chart

VOCABULARY:
carrying capacity, population, management, habitat
A population may be below carrying capacity such as in the spring following a hard winter, or temporarily above it. The latter situation inevitably results in a decline of the population due to a variety of natural limiting factors, e.g., mortality, disease, migration and lowered reproduction rate, and usually lasts for a short period. The carrying capacity of any area can be affected and adjusted by such natural factors including human intervention.

A population will therefore tend to naturally fluctuate with carrying capacity, with or without human intervention. Human intervention occurs to increase the carrying capacity for humans. It affects wild populations by altering their habitat. It may include cutting down trees, clearing hedgerows, removing dead or dying trees, clearing fields, growing and harvesting crops, eliminating predators, hunting, paving acres of fields, building schools, etc.. Humans also take steps to mitigate (lessen) their impact as well as the impact of natural events. Examples of intentional human intervention are, reintroducing predators, winter feeding, constructing nesting boxes, planting additional vegetation suitable for food, relocating animals and hunting. Human intervention can reduce a population or prevent its expansion to meet an expected natural reduction in carrying capacity. Such an intervention may result in a higher survival rate.

Alteration of habitat quality or quantity may increase or decrease carrying capacity. Environmental degradation may reduce it for affected species. Activities such as development or pollution tend not to be aimed at intentionally reducing carrying capacity, but often have this impact.

Intentional intervention may be based on a particular management philosophy or practice. Management of an area of land or water in relation to its carrying capacity for certain species can be subject to questions and controversy. Whether and/or how it is appropriate for humans to intervene in natural systems is sometimes a part of such questions and controversy. Management may be defined as intentional changes based on human goals and objectives. Such goals and objectives are always open to questions by other groups and individuals.

The major purpose of this activity is to provide students with a general introduction to the topic of carrying capacity.

**GETTING STARTED**
Gather materials, make copies of Deer Feeding Charts, one per group.

**PROCEDURE**
Session 1
1. Count out enough beans so that there are five per student. Spread the beans out on a table in a cleared area of the classroom. This arrangement of the beans is to represent a food supply which has been fixed by the end of a growing season.
2. Divide the class into "herds" of five students each, and have them all gather on the periphery of the cleared area.
3. Act as a timekeeper and set the timer to ring at intervals of one minute or less.
4. Each "herd" is to come up to the table at each interval. Each student in each herd is to attempt to take one piece of food per turn, simulating the animal's need to eat reasonably regularly. Have the students in each group number off 1-5. Tell the students that #1 is the strongest and healthiest deer, at the peak of his/her life. Number twos are the next strongest and so on until #5 are the oldest, weakest deer that may be ill or poorly nourished.
5. Provide each group with a deer feeding chart that they will use in the activity. Indicate to the students that as they each take a piece
of food they should put a 1 in the box under their number for that round. Note how long it takes to complete the first round. When you start, all first people from each herd will move at once to get food. Then they tag the next person in their herd who moves to get food, who then tags the next person and so on. After round #1 the chart should look like this.

<table>
<thead>
<tr>
<th>Deer Number</th>
<th>Round #1</th>
<th>Round #2</th>
<th>Round #3</th>
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<tbody>
<tr>
<td>One</td>
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<td>Five</td>
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</table>

6. After round one is complete, all the students have marked their charts, and you have noted how long it took to complete the round, repeat the process with slightly less time on the timer for the next round and successively less for each round thereafter. Continue for at least 5 more rounds until some students do not feed for three rounds. Any member of a herd going for three rounds without getting a bit of food dies. (The time interval you use per round depends on the size of the physical area you use for the activity as well as the size of your class of students. For the purposes of this activity, all students should not get enough food to survive.)

7. The food will run out before the next growing season and a significant percentage of the animals will die depending upon the size of the "herd." Discuss with the students what could be done or might happen to allow more of the population to live through the "winter" on the food available. Options may include reducing the population in various ways to match the carrying capacity—for example, by redistributing some of the population to another area, reintroducing or increasing natural predator populations, or opening the area to hunting before the winter begins. One option should be that the weather is very bad for one winter with a lot of snow or extensive fires have made food unavailable and there is little food on the table. Options to increase the carrying capacity could include bringing in or planting more "food" for the "herds". Another option is no action in the form of human intervention. Each of these options involves drawbacks as well as benefits, and each may be controversial.

8. Introduce the concept of Carrying Capacity. Share with the students that carrying capacity is more than just the availability of food. Indicate that it also involves shelter, predators, freedom from disease, each animal needs its own space so lack of overcrowding is needed, the right balance of male and female animals, lack of competition from others that use the same habitat, etc..

Session 2
1. Have the students develop their own hypothesis about how to increase the carrying capacity of this environment for the deer.
2. Repeat the activity two more times, incorporating two different options the students have discussed.
3. Ask the students what happens to the number of survivors that live to reproduce the next year?

Session 3
1. Repeat the activity one more time, incorporating one of the options used above, and also include five or six young animals born the previous spring. This can be done by designating one student in each "herd" to take food for themselves and an offspring.
2. Ask the students—
How does this annual increase affect the population?
What must now happen to re-establish the herd size within carrying capacity?
3. Record the number of "survivors" that result from the various manipulations of carrying capacity on the chalkboard. Ask the students
“What can be learned from this numerical representation?”
Which manipulation was the most successful? Using what criteria for success? What are examples of both cultural and natural influences on carrying capacity?

4. Ask for a summary of some of the most important things the students feel they have learned about the concept of carrying capacity.

EVALUATION OPTIONS

1. It is the early 1900s, and you are a scientist. You have just learned of the following situation: All the natural predators of deer in Cade’s Cove were removed from the area. Within a few years, the deer population had increased tremendously and within another few years, the population had collapsed to a very small number. Formulate a hypothesis that might explain the increase and decrease of the deer population related to carrying capacity. Explain how you would test this hypothesis.

2. Have the students draw the deer herd and its environment. Ask them to include and label all of the things that influence the carrying capacity of the environment for the deer herd. Assess the completeness of their drawing and labels.

EXTENSIONS AND VARIATIONS

1. Introduce predators to the game! Select students to act as predators that prey on the students as they try to get their share of the food. Have the fallen prey become predators in the following round.

2. A. Have the students act as plants that are trying to get enough supplies (water, air, space, etc.) by standing in an area set up as follows. B. Using colored paper or poker chips scatter pieces on the ground. Make sure the various elements are well distributed. C. With the students standing in the area, tell them which colors represent which resource. D. Start this activity by using just one resource. (Water is a major concern in agriculture)

E. Have the students bend down and pick up one resource, without moving from their spot, (remember plants can not relocate!)
F. If any student did not get a particular resource inform them that they are “limited” by that fact. They will be sick if they do not get that resource the next round.

G. Scatter the pieces again and repeat.

H. According to the kind of year, ie. dry, wet etc. adjust the number of pieces.

I. As plants die due to lack of resources more resources are available for the survivors. This is an example of why farmers use pesticides such as herbicides. By limiting the “weed population” more resources are available for the “crop population”.

EDUCATOR’S NOTES
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<tr>
<th>Deer Number</th>
<th>Round #1</th>
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BRIEF DESCRIPTION
In this lesson the students will conduct an experiment to become familiar with the scientific method. Agricultural researchers use the scientific method to "discover" better products to use in the production and processing of our food and fiber.

SUPPORTING INFORMATION
A hypothesis is one part of the process by which we discover and learn new things. It is an educated guess. The first step in scientific discovery is to ask questions. If you are interested in clean streams, you might be curious about what makes streams unclean. You might ask, "What pollutes streams?"

NEXT
Develop a hypothesis. Based on what you already know about streams - they carry water from the land to the oceans - you might guess that some of the pollution is soil from the land. This would be a hypothesis—"Streams are only polluted by soil."

NOW
Gather evidence. Obtain as much factual information or data about the subject as you can. You might talk with experts, watch a film, read a reference book or magazine or if you live near a stream, you might actually look in the stream. There are many ways of gathering scientific evidence.

THEN
Confirm or disprove the hypothesis. From the evidence you have gathered, you will either confirm your hypothesis, "Streams are polluted by only soil," or disprove it. "Soils are polluted with many things, including soil."

This working hypothesis, "Streams are polluted by only soil," was used to guide you in your study of stream pollution.

You made an educated guess or assumption based on what you already knew about streams and then you used different resources to get more information about the subject. You use hypotheses often, but probably call it making an educated guess. You have a question about something, then make a guess as to the answer and try to confirm or disprove that what you
Some hypotheses can be tested experimentally in a science lab. An environmental scientist would be able to test this hypothesis by observing the pollution problems in streams using testing equipment. Try to think of a question and a hypothesis that you could confirm or disprove by gathering evidence and then doing an experiment in your science class.

**Remember:** Personal experience can be used to help develop a hypothesis. However, it should not be the only thing you look at when developing a hypothesis or gathering evidence.

**GETTING STARTED**
Make copies of the worksheet. Have bread with and without preservatives available.

**PROCEDURE**
1. Distribute the worksheet describing the use of the scientific method to prove a hypothesis.
2. Lead a discussion about hypotheses and the scientific method.
3. Have the students complete the experiment using the materials available.
4. Each day have them write descriptions of the different samples.
5. After the ten days are completed have the students record their conclusion and explanation.

**EVALUATION OPTIONS**
Have the students list the steps of the scientific method and describe its use in their experiment.

**EXTENSIONS AND VARIATIONS**
Other foods can be used as long as only one variable is tested at a time.

**RESOURCES**
Digging for Data, Published by the Education Department NATIONAL CATTLEMEN’S BEEF ASSOCIATION, 444 North Michigan Ave.
PROBLEM:
I do not want to have moldy bread. Should I buy bread with or without preservatives?

HYPOTHESIS:
I believe with/without preservatives will mold the fastest. (Circle with or without.)

EXPERIMENT:
Materials - two types of bread (with and without preservatives) in plastic bags, data table

Procedure - place both slices of bread in the same type of wrapping material and in the same dark location.

Variable - one bread has preservatives; one bread does not

<table>
<thead>
<tr>
<th>Days</th>
<th>Description of Bread With Preservatives</th>
<th>Description of Bread Without Preservatives</th>
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CONCLUSION: Did your experiment confirm or disprove your hypothesis? Why?
**SECRETS OF PLANT GROWTH**

**BRIEF DESCRIPTION**
Farmers produce plant crops that are suited to the climate and soils of their area. This is to insure maximum yields of the food and fiber products, while conserving natural resources and helping to protect the environment. Well suited plants need less added chemicals and do a better job of holding soil in place, preventing erosion.

**SUPPORTING INFORMATION**
A plant is a biological system with these basic requirements for functioning and growing: sunlight, water, air, soil, and space. This activity allows students to explore what happens when a plant’s basic needs are not met. A plant is a living system. To function and survive, it needs sunlight, air, water, soil, and space in the amount suitable to that plant.

Green plants get their energy from the sun. In a process called photosynthesis, sunlight activates the chlorophyll in leaves to convert raw materials from soil and air into carbohydrates (starches and sugars), which are the plant’s food. Plant leaves draw carbon dioxide from air and combine it with water to make carbohydrates.

Water is essential to plants for several reasons. Besides being a main ingredient for photosynthesis, water is a primary component of protoplasm, the basic material that constitutes the plant’s structure. Water also helps transport nutrients from the soil to the plant’s roots.

Plants depend on soil to sustain and support them. Soil provides water and nutrients. How well soil sustains a plant depends on its texture (compact or porous), its water-holding capacity, its acidity, and its population of beneficial soil organisms. Different plants depend on different soil types for their particular needs.

Plants also need space to grow. If they do not have enough space and if they must compete with neighboring plants for nutrients, light, and...
water, plants may find it difficult to grow or survive.

It is important to learn everything we can about plants because they provide us with food and drink (fruits, vegetables, grains); shelter (wood or grass houses); clothing (cotton, flax); products (paper, cellulose, wood furniture); and medicine (cough syrup, aspirin).

GETTING STARTED
Approximately three weeks before beginning the activity, place about 50 bean, pea, or alfalfa seeds in a clear jar on a layer of damp paper towels and put the jar near a window. Monitor the seeds daily, and keep the paper towels moist.

PROCEDURE
1. Discuss with students what seeds need to sprout and develop. Seedlings will be ready for experimentation when they have developed leaves and roots. (Time varies by seed type.)

2. Introduce or review the concept of the scientific method.

3. Divide the students into five research teams. Ask what factors they think are necessary for plants to grow. Have the group develop a hypothesis to test. Invite the teams to devise experiments to test whether or not plants really need those elements to grow. Help teams to think through each step of their experiment and to predict what might happen; then, help them conduct their experiment. Here are two sample experiments.
   A. **Hypothesis**: Plants need direct sunlight to grow healthy.

   **Control** - as written
   Plant four seedlings in four separate containers of potting soil. Label these containers "Control." Place them near a window or other light source. Water as needed.

   **Test for Light**
   Plant four seedlings in four separate containers of potting soil. Label the containers "No Light," "Low Light," "Bright Light," Place them in a dark cupboard or closet as appropriate. Water as needed.

   B. **Hypothesis**: Plants need adequate water to grow healthy.

   **Control** - as written
   Plant four seedlings in four separate containers of potting soil. Label these containers "Control." Place them near a window or other light source. Water as needed.

   **Test for Water**
   Plant four seedlings in four separate containers of potting soil.
   Do not water. Label the containers "No Water," "Adequate Water," "Low Water," water half as much. Place them near a window or other light source.

4. Have the groups set up their experiments as designed and test their hypothesis. Direct them to select seedlings that are all nearly the same size before planting their control and test subjects. This will insure that the results are not skewed by starting with seedlings of different sizes.

5. As the plants begin to grow, graph their heights. Students can measure the plants' heights with rulers and transfer the measurement to graph paper. Graph the plants daily or weekly.

6. Discuss these questions:

   Which plants grew the most? Which grew the least?
What other differences did you observe among the plants?

What does a plant need to grow? How do plants get those needs?

What happens if a plant doesn't get enough sunlight? Water? Soil?

Which parts of the plants seemed most affected by lack of sunlight? Water? Soil?

If you were going to plant a tree on the school grounds, where might you plant it? Why? (Look for a place with the right conditions: sunlight, air, water, soil, room to grow.)

If you were to plant a tree on the school grounds, how might you benefit from it? (It looks nice, attracts animals, provides fruit, blocks wind, and provides oxygen.)

EVALUATION OPTIONS
1. Have students draw a series of pictures showing the development of a seedling under different environmental conditions. Below each picture, have students use symbols to show what the plant has or lacks in each situation.

2. Have the students write up a report on their experiment. Include the hypothesis the group was testing, the design of their experiment, the observations they made, the results of the test and the conclusion about whether or not their hypothesis was correct.

EXTENSIONS AND VARIATIONS
1. Ask students what plants require for growth. Let them choose one requirement to test: light, water, soil, or space (see above).

2. Using two plants or seedlings of the same size and species, allow one to have a single requirement, while denying that requirement to the other (as described in Step 1 of the main Activity).

3. At set intervals, let students measure the seedlings. After a period of time, have students measure and compare the plants. Ask students whether the plants look different, and if they do, what causes the difference?

4. Follow the same procedure to test another requirement suggested by the students.

OR

1. Help students compare their own growth to that of the experimental plants. Measure student heights at the beginning and end of the experiment.

2. Arrange to visit a nursery or orchard to see trees in various stages of growth and to find out about the needs of different trees.

3. Have students try propagating seeds from a local tree. If possible, collect a number of seeds. Experiment with planting and caring for the seeds under various conditions. For example, try different soils, some from near the parent plant and some from other areas; or try different amounts of water. After a seedling is well established, plant it in an area suited to the tree's needs.

4. Have students make a small "flip-it" book that shows plant growth in animation. Give each student four 3" x 5" (7.6 cm. x 12.7 cm) index cards. Have students cut each card into quarters so that they have 16 small rectangular cards. On the far right edge of each card, have students draw a small picture of the plant as it grows from a seed to a mature plant. For example, card #1 can show a seed, cards #2-15 can show the seed sprouting and gradually...
growing until it's full grown in card #16. Tell students to stack the cards in numerical order and hold them on the left side with their thumb and forefinger. By flipping through the cards on the right side, students will see the seed sprout and continue to grow. (Create and illustrate a sample booklet to show students before they begin their flip-it books.)

RESOURCES

EDUCATOR’S NOTES
SUPPORTING INFORMATION
Living organisms are made of systems that enable them to grow and reproduce. All living things have some system for reproducing members of their species.

Many plants reproduce using a system that includes flowers and seeds. In general, seeds develop within the ovary of the plant's flower after either being fertilized by pollen from another plant of the same species or being self-fertilized.

For a seed to germinate and grow into a mature plant, environmental conditions must be just right. Each plant needs a certain amount of sunlight, air, water, and nutrients from the soil. If a seed simply drops from the parent plant, it might compete with the parent for those essentials and have difficulty growing. Therefore, most seed-bearing plants have developed a way to disperse seeds away from the parent, giving the new plant a better chance to find what it needs to grow.

Some plants produce very light seeds with sail-like or hairy outgrowths that enable them to be carried by the wind. For example, a maple seed has a papery wing that flutters like a helicopter, while a dandelion seed has a fuzzy parachute that carries it on air currents. Some plants, like beech trees and Queen Anne's lace, produce seeds with spines, hooks, or gooey coatings that catch on an animal's fur or people's clothing and are carried to distant places. Some plants, like black cherry trees and raspberries, develop seeds within an attractive, tasty fruit. Those seeds are eaten by animals, carried in the animals' digestive systems, and deposited in a different location when the animal defecates. Still other plants, like locust trees, violets, and witch hazel, have seeds that...
are ejected away from their parent plant. For example, witch hazel seeds develop within a pod that squeezes the seeds as the pod dries. When the seeds finally shoot out, they can travel up to 40 feet (12.2 m)!

**GETTING STARTED**
If students are to collect seeds from a vacant lot or natural area, be sure to obtain any necessary permission if it is other than school property. Also, keep in mind that late summer and autumn are the best times for collecting seeds.

**PROCEDURE**
1. Ask students what seeds are and what they do. Ask for examples. (Don't worry about misconceptions at this point. Step 5 should clarify those ideas.) Tell students they are going to learn more about seeds by gathering and sorting them.

2. Ask your class to gather a collection of seeds. Students might bring in birdseed or seeds saved from fruits' collected from food in kitchen cabinets, or gathered from trees or other plants in their garden. You might also take students to a nearby field or vacant lot full of seed-bearing plants. They can collect seeds in one or more of the following ways:
   - Have students walk around the area, pick up any seeds they find on the ground, and collect the seeds in a cup or other container.
   - Help students drag an old blanket or other piece of fuzzy cloth through the area. Or have them wear large, old, wool socks over their shoes and walk around the area.
   - Have younger students wear bracelets of masking tape with the sticky side out so they can stick small seeds or seed parts directly on their seed bracelets.

   Encourage students to invent other simple seed-gathering techniques that do not harm the environment.

3. Put all seeds into a class collection. Divide students into groups of two to five, and give each group an assortment of seeds from the collection. Ask groups to examine their seeds and invent a system for sorting or classifying. Invite students to share their methods for sorting.

4. Lead a discussion about the structure and function of seeds. Ask these questions:
   - What are seeds? (A seed is a "plant egg." It contains an immature plant and a supply of plant food wrapped in a protective covering.)
   - Where do seeds come from? (The plant's ovary, or female part, is located in its flowers or cones.)
   - Is there a reason for so many different kinds of seeds? (Every type of plant has a special type of seed designed for the plant's particular habitat and method of distribution—see supporting information.)

5. Ask students why it might be important for seeds to be dispersed away from parent plants. Invite students to share different ways they have noticed that plants disperse their seeds. Write those ideas on the board. If students have trouble thinking of various ways, you might mention particular seeds to stimulate more ideas. Ask students whether any of the ways they have
observed seem similar. For example, they might have said that dandelions blow in the wind and that milkweed floats in the air. If appropriate, help students compile groups of similar dispersal systems so the class ends up with a set of about five to eight categories. Remember there is no one right way to group the seed dispersal systems. Use students’ examples to help them create their own categories (see examples of categories).

**CATEGORIES OF SEED DISPERSAL**

**Floats on air**
- milkweed, dandelion, cottonwood

**Flies through air**
- maple, ash, tulip poplar

**Floats on water**
- mangrove, coconut, cranberry

**Bounces or rolls**
- acorn, pecan, black walnut

**Eaten by animals**
- cherry, apple, pyracantha

**Stored by animals**
- acorns, hickory, beech

**Thrown**
- locust, violet, witch hazel, lupine, jewelweed

**Sticks to animals**
- beard grass, burdock, cocklebur, foxtail, goldenrod, wild barley

6. Ask students to group their seeds according to the dispersal categories they identified.

7. Discuss these questions:

**How do a seed's shape and size affect its dispersal?**

**Why is it important for seeds to be dispersed in different ways?** (Plants have different requirements that are served best by different seed-dispersal systems.)

**How far can a seed be dispersed?** (Seeds can glide on the wind for several miles, float on the water for hundreds of miles, or travel on, or in a bird for thousands of miles.)

Can some seeds go farther than others? (yes)

**How is distance important?** (It reduces competition for a plant's needs in a particular area. Widespread plants increase the species' chances of survival.)

What value might seed dispersal have for plants, wildlife, and humans? (food, medicine)

**How does fleshy fruit help a seed be dispersed?** (An animal eats the fruit and seed and the seed is left behind in a different area in its waste.)

8. Challenge students to design their own seeds with specialized dispersal mechanisms. Students can use a dried lima bean as the base of their design, along with "junk" materials (such as popsicle sticks, toothpicks, cardboard, egg cartons, cotton balls, string, and rubber bands), to design a seed that:

* Floats in water for at least five minutes.
* Attracts an animal to carry it away.
* Floats in air for at least 5 feet (1.5 m).
* Sticks to an animal and can be carried at least 10 feet (3 m).
* Is thrown at least 2 feet (.6 m) away from the parent plant.

**EXTENSIONS AND VARIATIONS**

1. Suggest that students plant some of the seeds they collected so they can observe plant germination in action.

2. Drop seeds in front of a fan to demonstrate what effect moving air has on various seed designs. Note differences in movement, direction, speed, and rotation. Graph the distance...
each seed flies.

3. Many animals, including many of our favorite backyard birds, depend on seeds as their food source. By setting up a bird feeder, students can learn which birds like which seeds best. Students can either build or buy a bird feeder. They can make feeders from milk containers, aluminum pie tins, or other used materials. Set a feeder on a window sill or attach it to a tree or post where students can closely observe the birds. Bring to class a bag of mixed birdseed (usually sunflower seeds and millet). Give pairs of students a small handful of birdseed to study. Have them describe the different kinds of seeds. Ask what types of birds might like to eat the different seeds. Then, have students fill the feeder with birdseed and spend a little time each day observing it (try to have a pair of binoculars on hand). They should try to find out 1) which birds prefer which seeds, 2) what method each bird uses to eat seeds, and 3) the reason the bird uses that method. For instance, a chickadee will usually take one sunflower seed, fly to a nearby branch, and hammer the seed with its beak until the seed opens. Students can periodically check to see which seeds are eaten most often.

EDUCATOR’S NOTES
BRIEF DESCRIPTION
Water flowing downhill or down a slope can move/remove a great deal of soil from fields. Therefore, agriculturist use conservation practices such as no-till and contour farming to reduce soil losses due to running water.

SUPPORTING INFORMATION
Many students have witnessed the energy in water when they looked at a waterfall, river, or dam. However, they may not relate the movement of water to turning lights on and off or moving heavy objects. Designing simple machines that use water to move things helps students appreciate the energy in water and how water can work for us.

For thousands of years, inventive people have tapped the natural energy in water to do useful work. Water has been used to help play a musical instrument (the water organ invented by Ctesibius, a Greek engineer); grind grain into flour, (water-driven grist mills); spin silk; pump bellows; operate sawmills; tell time (the clepsydra or water clock); operate flush toilets, dishwashers, water meters, and centrifugal pumps in automobile cooling systems; lift heavy ships over land separating bodies of water (through locks in the Panama Canal, C & O Canal, etc.); operate automobiles, locomotives, and ships (steam engines); generate electricity; vary the buoyancy of submarines; and do a host of other jobs.

Following this activity is a time line (Water Through Time) showing a sampling of the historic human adaptations of water power.

Moving water can be used to do work because its potential energy changes to kinetic energy. When water is elevated (such as on the brink of a waterfall or in a reservoir behind a dam) it has gravitational potential energy. This potential energy changes to kinetic energy when the water falls or is allowed to flow. For example, when holes in the bottom of a container allow water to escape, the water’s potential energy becomes kinetic energy.

The energy generated by moving water can be transferred to other

LEVEL: 6th grade
SUBJECT: Science
SKILLS: Observing, designing, problem solving, evaluating
OBJECTIVES
The student will - identify the forms of energy in water.
- demonstrate how water can be used to do work.

ESTIMATED TEACHING TIME
5 class periods and student design time on their own

MATERIALS
Two 1-pound (450-g) coffee cans with plastic lids, Student Invention Kits, hammer, nails, thread, masking tape

VOCABULARY
work, energy, kinetic energy, potential energy
objects, causing them to move and thus accomplishing work. Work involves applying force (a push or a pull) to an object to create movement. Sometimes humans use water alone to help execute work (e.g., carrying logs or moving boats downstream). Water has also been used to complement the actions of many simple machines that lift, push, turn, and pull objects. These include levers, pulleys, wheels and axles, and screws. Using the energy in water involves locating or creating places where potential energy is changed into kinetic energy (such as a waterfall or dam). Water can also be channeled and diverted to where it is used to produce work (such as over a turbine or into a lock).

GETTING STARTED
Using hammer and nails, pound several equally spaced holes around the bottom of one can. Do the same with the second; however, when you drive the nails into the second can, force the nail sharply to the left. Cover the holes on the bottom of both cans with masking tape. Poke a pair of holes near the top of each can through which to thread a string, making a handle.

PROCEDURE
1. Show students the coffee can (with the straight-punched holes) and fill it with water. Ask students if they think there is any energy in the can. Discuss what forces might be present that could produce energy. Indicate gravitational pull and explain that it causes the water to have potential energy. Have students define potential energy and relate it to the water in the can.

Hold the can by its handle above a sink or tray. (This could be messy, so it may be done outdoors. Remove the tape from the can with the straight holes so students can observe what happens. Water will drain from the can in straight streams, but the can should remain motionless.

Ask students what happened to the potential energy of the water. Explain that it was converted to kinetic energy when water was allowed to flow. Define work (application of force to create movement) and ask if students think any work was accomplished. The force of gravity caused the water to move, but did the can do any work? Since it did not move, no work was done.

Repeat the procedure with the other can. The streams of water draining the can will be directed sideways by the bent holes, and the can will spin in the opposite direction. Explain how you can make the flowing water do work by altering or directing its flow as it drains from the can (a simple classroom example of engineering).

2. Share the Water Through Time time line with students. Discuss how water has been used throughout history to do work.

3. Tell students they are going to create their own designs to use water to do work. Their task is to build a machine, develop a technique, or demonstrate an action that illustrates how the energy generated by water (changing from potential to kinetic) lifts, moves, pulls, twists, smashes, or in some way changes the present placement or condition of an object.

The following are suggested challenges. Use water to:

- *lift a pencil 3” (7.5 cm) off a flat surface.
- *move a pencil 10” (25 cm) across a surface.
- *wind a piece of thread around a pencil.
- *drop a pencil from a height of 5” (12.5 cm).
*throw a soft object 2’ (60 cm).
*grind a cracker into small pieces.
*break open a hollow object.
*rotate a series of gears.

4. Divide the class into small groups or "engineering teams." Give each team a Student Invention Kit containing common materials from the classroom and describe the challenges. They may use the materials in their trays (or others that they may find in the classroom) and the knowledge they have acquired observing the introductory demonstration.

5. Allow groups several hours to design projects; more challenging endeavors may take a few weeks. Encourage students to visit with engineers and architects to help with their design.

EVALUATION OPTIONS
1. Have "engineering teams" tell the class how they approached the challenge or task, and explain and/or demonstrate the team's solution. (They should identify what form of energy was used and what work was accomplished. Encourage them to relate the action to work done in real life in the past or the present). Other teams can evaluate the design and provide suggestions for improvement. Designs can be presented in a school display case.

2. Have students:
   * invent or build a simple device that demonstrates the ability of water to do work and evaluate the success of the inventions.
   * identify forms of energy present in water
   * relate inventions to examples of how water has actually been used to conduct work
   * evaluate water inventions and provide suggestions for improvement

EXTENSIONS AND VARIATIONS
Further alterations can be made to the cans used in the first activity. Explain that energy is transferred to the suspended can, causing it to spin in the opposite direction of the force applied by the jets of water, and that the can spins at a rate equal to the force of the water leaving the can.

Discuss how the flow of water draining from the cans can be increased or decreased by changing the rate of flow (e.g., by having fewer or smaller holes, by changing the angle at which water drains from the can, or by creating a vacuum or partial vacuum by covering the open end of the can with a plastic lid). Note that as the water level drops and the weight of the column of water decreases, the pressure of water escaping from the can decreases and so does the rate of spinning. Thus, a constant flow of water into the can would be required to keep the can spinning at a constant rate.

Have students collect images (photographs, paintings, drawings) depicting the movement of water in nature (raindrops striking the ground, a river valley, a glacier or ice...
field, etc.) Students can use the pictures they have gathered to make a hallway exhibit or a portfolio for the classroom.

Using the time line presented at the end of this activity (supplemented with other events if desired), instruct students to make a montage of pictures showing the natural power of water intermixed with images of ways people have tapped the power of water through the ages.

Visit a local power plant and have a representative explain the role of water in the generation of electricity. Advanced students can try to build a mini-turbine able to generate an electrical current.

**RESOURCES**


**NOTE:** Student Invention Kits, are trays containing the following items: blocks of wood, coarse sandpaper, glue, masking tape, paper cups of different sizes, pieces of styrofoam, pipe cleaners, plastic spoons, plastic straws (flexible and non-flexible), scissors, several corks of varying size, several dowels of varying length, several pieces of cardboard, string or monofilament line, tongue depressors.

**NOTE:** Because of the experimental nature of the student activity this listing includes suggested materials. Items that are readily available in classroom can be included at the teacher's discretion.
Water Through History

3000 B.C. - 2500 B.C. Egyptians use water power to carry stones from distant quarries to build pyramids at Giza

A.D. 100 Greeks invent first waterwheel

A.D. 100 Greek scientist Hero invents simple steam engine called the aeolipile. Its potential is not tapped for over a thousand years

159 First water dock, or clepsydra, invented in Rome

1019 First water-driven mechanical clock built in Peking (Beijing), China

1328 Sawmill is invented. Early versions are powered by water

1510 Leonard da Vinci designs a horizontal water wheel, the precursor of the water-driven turbine

1543 Blasco da Garay designs first steam-driven ship

1582 First waterworks founded in London. Waterwheels are installed on London Bridge

1589 First flush toilet, or water closet, designed by Sir John Harrington

1700 Mills driven by water power in common use throughout Europe

1705 Thomas Newcomen invents first practical steam engine. Water turbine invented by Pierre-Simon Girard

1764 James Watt invents condenser, first step leading to development of efficient steam engine

1769 First steam-operated "road carriage" invented by N. J. Cugnot

1775 James Watt perfects development of steam engine

1782 James Watt invents rotary steam engine

1783 Jouffroy d'Abbas sails paddlewheel steamboat on the Saete River

1785 James Watt and Mathew Bolton install steam engine in cotton spinning factory

1803 Robert Fulton invents steam-powered boat

1814 First practical steam locomotive invented by George Stephenson. London Times printed by steam-operated press

1815 First steam-driven warship (the Fulton) built

1818 First steamship (the Savannah) crosses the Atlantic

1830 Steam-driven cars common on the streets of London

1850 The Francis turbine, now in use in many powerplants, invented by James Francis

1859 Steamroller invented

1884 Sir Charles Parson develops first practical steam turbine engine

Present Water used as coolant in nuclear power plants
BRIEF DESCRIPTION
By becoming soil particles and water droplets, students simulate soil particle sizes and their pore space.

SUPPORTING INFORMATION

Soil is important in supporting life. We need it for building homes, planting vegetation, raising animals, and growing our food and fiber. Soil is made up of mineral particles, organic matter (once living plant and animal matter), and pore spaces (potential living spaces filled with air, water, or living organisms). Mineral particles, classified according to size, include:

- Sand: soil particle between .05 and 2.0mm in diameter
- Silt: soil particle between .002 and .05 mm in diameter
- Clay: soil particle less than .002 mm in diameter

Sand is the largest mineral particle and it has more pore space between its particles than silt or clay. Silt particles are smaller than sand, but larger than clay particles. Likewise, there is less pore space between silt particles than between sand particles, but more than between clay particles.

Clay, the smallest particle, has the least amount of pore space.

Since these particle sizes are difficult to visualize, an analogy helps clarify. If a sand particle is the size of a basketball, a silt particle would be the size of a golf ball, and a clay particle the size of a dot made by chalk. Rarely made up of only one type of particle, soils consist of varying combinations of the three. The percentage of sand, silt, and clay in a particular soil determines its texture.

THE RELATIVE SIZE OF SAND, SILT, AND CLAY

LEVEL: 7th Grade
SUBJECT: Science
SKILLS: Analyzing, comparing similarities & differences, demonstrating, role playing
OBJECTIVES
The student will:
- Describe the three main types of soil particles: sand, silt & clay.
- Simulate and compare the sizes of the three soil particles.
- Recognize that soil is generally made up of a combination of all three types of soil particles.

ESTIMATED TEACHING TIME
2 class periods

MATERIALS
Magnifying glasses or hand lenses; one (or more) empty, clear, plastic 1-liter soda bottle and lid; several different soil samples; water; 60 feet of string; photocopies of the attached Soil Settling and The Feel of Soil sheets.

VOCABULARY
Absorption, clay, groundwater, particle, percolation, pore space, porosity, sand, saturated, silt.
All clusters of soil particles have the ability to attract and hold water. Water moves quickly through a sandy soil because of the large pore, or empty spaces, between the particles. A clay-type soil, however, will actually attract water and absorb it like a sponge. Clay particles, as a clump, swell as they get wet and shrink as they dry. These particles have the ability to pull and hold onto water with 2,500 pounds of force!

Water passes down, or percolates, through the soil at various rates. Over the years, some of this water may end up in the groundwater supply. The rate of water percolation, however, is reduced when all the pores are full of water, causing the soil to be saturated. Unfortunately, this can cause water to collect on top of the soil, increasing the possibility of soil erosion and flooding.

The porosity of the soil - the available pore space of a soil type - determines how quickly water will move through the soil. Some of the water is held by the soil particles. Gravity pulls the rest of the water, called free water, downward. The water held by soil particles actually helps plants grow.

Along with farmers, city and town planners are concerned with soil texture and porosity. A heavy clay soil can crack a building foundation because it shrinks and swells. Soil type is an important consideration in the location and size of septic systems and landfills.

Percolation and other soil tests help city and town planners and builders understand the soil types. From these tests, they can learn if there is too much clay in the soil, for example. If negative soil conditions exist, the builders will have to adjust their plans.

GETTING STARTED

Have students bring in soil samples from home or a nearby area; gather one (or more) empty, clear, plastic 1-liter soda bottle with lid, water, string, and magnifying glasses or hand lenses. Make photocopies of Soil Settling sheet for individual or pairs of students and The Feel of Soil sheet for pairs or small groups of students.

PROCEDURE

SESSION ONE

1. Ask the students what they know about soil and why it is important. List their comments in a visible place. Explain that they are going to learn about the different sizes of particles in soil.

2. Explain that students are going to become soil particles. They will simulate different soil particle sizes and pore spaces between the particles. Designate three or four students as "water droplets." The rest of the students will all simulate the "particles": sand, silt, and clay. Explain that they will use arm actions to represent each soil particle. Draw these three stick people figures in a visible place.

3. Have all the "particle" students represent "sand" particle size by getting in a round group with their arms outstretched. They should stand in a random arrangement and be able to rotate 360 degrees without hitting another student. (You may need to arrange some of the students.) Tell students their outstretched arms represent the largeness of a sand particle. The
empty space between sand particles represents pore space. These "living" spaces in nature are filled with air, water, or living organisms. Place the string in a circle on the floor around all the sand particles. Explain that this circle is a flower pot filled with soil. (Leave the string in the same position on the floor during the whole simulation.)

4. Add the "water droplet" students. Have them pass through the "sand" particles in the flower pot and out of the pot (circle). Throughout the simulations, the "water droplets" aren't allowed to go around the "particles" but must pass through them in the easiest way possible by walking upright. (Students representing "sand" particles must allow "water droplets" to push their arms slightly to pass through the "sand" particles.)

5. Discuss briefly the relative ease with which the "water droplets" passed through the large pore spaces between the "sand" particles.

6. Next have all the "particle" students represent "silt" particles by placing hands on their hips with arms bent at the elbow. Have the students move next to each other with elbows just touching each other. They must stay within the string circle. Add the "water droplet" students. Again, "water droplets" must pass through the particles in the easiest fashion and out of the pot. They may swing the arms of the particles.

7. Discuss the differences in water movement through the silt and the sand. Ask "Did the sand or the silt particles take up the most space in the flower pot?"

8. Finally, have all the "particle" students represent "clay" particles by standing with their arms at their sides and touching the shoulder of another "clay" particle. The particles will be bunched in together. Add the "water droplet" students. The droplets pass through the particles by moving two particles "slightly apart" and moving through them. Have the "slightly apart" particles stay apart to represent the swelling action of clay. In some cases, the droplet may be absorbed by the "clay" particles briefly and stay in place until gravity pulls the droplet down into the soil.

9. Explain to students that when water percolates through a soil in nature each dry soil particle actually holds some water. Only the extra or "free" water that the soil particles can't hold can be pulled further down by gravity. This water held by the soil particles is the water plants "drink" (suck up) with their roots.

10. Ask students to discuss the differences in - particle size - pore space - total space occupied in the flower pot by the same number of different particles - ease of "water droplets" passing through the "sand" and "silt," versus the "clay" particles

Make sure students understand that the same number of soil particles were in the flower pot each time. Ask

- Why do the same number of "clay" particles take up less room in the flower pot than the "silt" particles? (The "clay" particle size and...
pore space between particles are smaller.

- Why do the same number of "silt" particles take less room in the flower pot than the "sand" particles? (The "Silt" particle size and pore space between particles are smaller.)

11. Have the "particle" students, still in the flower pot, demonstrate "clay," "silt," and then "sand" particles by adjusting their arm actions and the space between particles. Have the particles go from "sand" to "clay" to demonstrate the differences.

Have individual students be the particle of their choice so that the flower pot contains a combination of particles. (Be sure that the different particles are scattered in the pot.) Let students decide, based on the arm positions of the particles, if the flower pot's soil has a sandy, silty, or clayey texture. Is there an equal combination of particles, or is there more of one than the others? Have students repeat this process several times to help them draw the conclusion that the size of the pore space is directly related to the proportion of particle sizes in the soil. (More clay particles mean smaller total pore space while more sand means larger total pore space. You can add the "water droplet" students to the mixtures to aid in the understanding of pore space.) Ask

- Was it easier or harder for the "water droplets" to pass through the pore spaces in the pure samples of sand, silt, and clay or in the mixtures you created?

- Which soil type does water move through the fastest? (Sand) The slowest? (Clay) Why?

- What are the three soil particles called? (Sand, silt, and clay.)

- Soils in nature are usually a mixture of the three soil particles. What might be the advantage of having a very sandy soil? A heavy clay soil? The disadvantages to one or the other? (Sandy soil holds less water for plants and dries out more rapidly. Water moves through clay soils very slowly and may cause plants to suffocate by drowning the roots. Play areas in sandy soils would drain quickly and not be muddy. Play areas of clay soils would be wet a long time after a rain and be muddy. Clay soils shrink and swell and may break up things built on them.)

- What kind of soil texture do you have at home or at school? How would you manage it to grow healthy plants? Why?

SESSION TWO

1. Distribute the Soil Settling sheet for individual or pairs of students to complete during the demonstration.

2. Add several handfuls of one soil sample to the 1-liter soda bottle and fill it with water. (Break up any clumps of soil before adding the water. It sometimes helps to add a few drops of detergent to break up the clay aggregates so that they perform like individual clay particles.) Cap and shake the bottle well. Set it on a table where students can observe the soil particles settling. Ask

- What do you think will happen? What is happening?

- Why are some of the soil particles settling and some floating?

- Which soil particles weigh more? The ones settling or floating?

- How long will it take for all the soil particles to settle?
The sand will settle in less than 1 minute. The silt will settle on top of the sand, followed by the clay. This process can take all day or even as long as a week. Have students observe the differences in the soil particles' sizes, colors, and amounts. Have students record and draw their findings on the sheet.

3. Discuss with students the fact that a typical soil sample contains all three soil particles in varying amounts. Water allowed us to separate the particles. Use the diagram showing the relative size of the particles (see Supporting Information).

4. Optional: Repeat Step 2 using soils from different locations. Compare the differences. Ask:

- Is the amount of sand, silt, and clay the same in each sample?

- How would you describe the colors of sand, silt, and clay in each sample? Are they the same color in each sample?

- Is there anything still floating after the bottles have been sitting for 24 hours? What is it? (Organic matter [e.g., plant and animal material] will generally float.)

5. Students can identify a soil's texture by experiencing the "feel" of different soil samples. Distribute The Feel of Soil sheet. Have several students place a small amount of soil from different soil samples in their hand, add water droplets slowly, and knead the soil to break up any clumps. Tell students the proper consistency for identification exists when the soil stays together.

   Have students identify its general texture using the information on The Feel of Soil sheet. Pass the soil samples around so all the students can feel the differences and similarities among the various samples. (The samples will dry quickly after several students have handled them. Add a little water to the samples after they have been handled by a few (4-6) students.) Ask if students agree with the assigned texture of each sample. Encourage the use of magnifying glasses or hand lenses to observe soil particle sizes.

There are several commercially available types of claylike substances used in schools, such as "Plastcine and Permoplast Modeling Clay", that are more like plastic than soil. If your school has any available, have students investigate its texture and its particle size with a hand lens. Have them add water to it. Ask "What are some similarities and differences between these samples and real clay?"

6. To increase students' understanding of soil particle sizes, have them repeat the soil particle simulation from Session One.

EVALUATION OPTIONS

1. Evaluate students' Soil Settling and The Feel of Soil sheets for understanding and completeness.

2. Have students fold a piece of paper into thirds and draw lines between the sections. In the first section, have students draw "sand" particles, in the middle section, "silt" particles, and in the last section, "clay" particles. In all three sections, have students label the particle types and indicate the amount of pore space between the particles.

3. Give students a handful of soil. Have them identify the sample's general texture of sand, silt, or clay, using the technique and characteristics described in the procedure on The Feel of Soil sheet.
4. Have students imagine they had three flower pots, one full of sand, one full of silt, and one full of clay. Which pot has the smallest pore space, the largest? Which soil type will hold more water?

EXTENSIONS AND VARIATIONS

1. Have students demonstrate porosity. Porosity, the available pore space in a soil, and water-holding capacity vary from one soil type to another. Porosity determines how fast water will move through the soil. It's important for water to move through soil, but not so quickly that plants don't get enough for their needs.

Have students -

A. Assemble four clear plastic cups. Punch several drainage holes in the bottom of two cups. Line the bottom of the cup with a piece of thin cloth or paper towel so the soil is not washed out of the cup.

B. Put an equal amount of two different types of soil in the two cups with the holes in them. (Preferably a 'heavy' soil with clay content in one cup and a sandy soil in the other.) Which cup will have more soil particles in it?

C. Pour equal amounts of water onto the soil in each cup. Hold or place the cups over the other two cups, without holes, to catch the water draining out.

Ask:

- Which soil type drains more quickly?
- Did equal amounts of water drain out of both soil types?
- Which soil type is holding more water for plants to use? Why?

2. Have a student contact the office of the county commissioner and inquire about soil "perc tests" required before any new construction can be initiated.

3. Invite a soil scientist from your local conservation district or the U.S. Department of Agriculture's Natural Resources Conservation Service to discuss local soil types with the class or obtain a soil survey report for your area. Discuss or investigate the implications local soil types have for agriculture, construction, home owners, and others. Ask the soil scientist to bring soil profiles or pictures of them, if possible. Upon what type of soil is your school built?

4. Place different-size metal balls (or plastic beads) in glass jars filled with an equal amount of water. Explain that the various balls (or beads) are similar to the different types of soil. The space between the balls is similar to pore space. Have students compare the water height. What does this show about the different types of soil?

5. See the FLP lesson "Till We or Won't We?" to learn about soil formation, soil erosion, and soil conservation. See the FLP lesson "Root Root for Life" to learn about the importance of roots to soil. See the FLP lesson "From Apple Cores to Healthy Soil" to learn about soil nutrients and composting.

RESOURCES See Soil in the Resources located in the Appendixes of the FLP Notebook

CREDIT

PROJECT FOOD, LAND & PEOPLE

Relative size of particles drawing from U.S. Department of Agriculture, Natural Resources Conservation Service.

EDUCATOR'S NOTES
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<table>
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<tr>
<td><strong>1.</strong> Your teacher will mix soil and water in a clean plastic soda bottle by shaking the bottle and will then set it down for you to observe. What do you think will happen?</td>
<td><strong>4.</strong> Why do you think what happened did?</td>
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<tr>
<td><strong>2.</strong> What is happening in the bottle immediately after shaking? Record your observations here.</td>
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<tr>
<td><strong>3.</strong> What is happening in the bottle 30 minutes after shaking? Is anything heating? Record your observations here.</td>
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<td><strong>4.</strong> Observe the plastic bottle the next day. What did happen? Record your observations here.</td>
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<tr>
<td>With your teacher's help, label the three types of soil particles in your diagram above.</td>
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<tr>
<td><strong>Draw a picture here:</strong></td>
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THE FEEL OF SOIL

You and your partner(s) are going to discover the general texture of a soil sample.

1. Place a small amount of soil from your soil sample in your hand, add drops of water slowly, and knead the soil to break up any clumps. When the soil is moist, not wet, it is ready to identify.

   2. The soil texture is mostly
      Sand if it
      - feels gritty
      - has grains (or particles) that can be seen
      - will not remain in a ball when squeezed
      Silt if it
      - feels smooth like flour
      - is not really sticky
      - forms a short snake and then breaks apart when rolled between hands
      Clay if it
      - feels really sticky
      - forms a long snake when rolled between hands

3. Our soil sample is mostly________ We know this because

1. __________________________________________

2. __________________________________________

3. __________________________________________

4. Using a hand lens or magnifying glass, describe your sample (draw a picture too).

5. With another group, compare your samples. How are they the same? Different?
BRIEF DESCRIPTION
All good things come to an end. Everyone has heard this saying at some point in their lives but have you ever stopped to think that the conservation of our natural resources is a necessity if we don't want to see them vanish forever. One of these resources, clean groundwater, can be polluted by numerous sources or used up entirely. In this activity, students will learn about recycling and wise use to conserve Tennessee’s natural resources.

SUPPORTING INFORMATION
Natural resources are the raw materials we use for housing, clothing, transporting, heating, cooking, and so on. They include the air we breathe, the water we drink, the land we farm, and the space we use for living and recreation. In short, they are all the things we use in our physical environment to meet our needs and wants. We can put them into three categories: renewable, non-renewable, and perpetual resources.

In a human time frame, perpetual resources such as solar energy, wind, and tides last forever. Non-renewable resources, however, exist in fixed amounts and once they’re used up, they’re gone forever. For example, fossil fuels are formed through natural processes that take millions of years. If we use all the available fossil fuels, no additional amounts of them will ever be available to us—at least not for millions of years. Other non-renewable resources such as copper and other metals were created billions of years ago during the explosion of giant stars. These non-renewable resources are not created through natural processes here on Earth. The only way we could get more of them is to mine them on other planets.
Renewable resources are materials that can be replenished through natural and/or human processes. For example, even though trees die naturally or are harvested, new trees are naturally reseeded or can be replanted by humans. And even though people consume livestock, new animals are constantly being raised. It is important to realize that renewable resources need to be carefully managed. People can use a renewable resource in a way that it cannot recover itself. For example, in the early 1900's the passenger pigeon was hunted so heavily and irresponsibly that its numbers dwindled and it became extinct. Grasslands can become overgrazed to the point where the soil loses its ability to support plant life and the area becomes much like a desert. Groundwater supplies may be pumped out of the ground faster than precipitation can trickle down to replenish them.

The maximum rate at which people can use a renewable resource without reducing the ability of the resource to renew itself is called sustainable yield. For example, a sustainable yield of timber would mean harvesting only the amount of trees that the forest could grow. This term also applies to water and wildlife. The sustainable yield of any resource varies from region to region, and it can be altered through various management practices.

When people recycle or re-use natural resources, they decrease the demand on the resource and save energy. (Of course, the recycling process itself also consumes energy.) For example, when people recycle aluminum cans, less bauxite needs to be mined to create “new” aluminum. Recycling aluminum saves lots of energy as well. With paper products, the equation is more complicated since paper fibers cannot be recycled indefinitely and new fiber from trees must be added to the papermaking cycle. However, recycling keeps paper out of landfills and incinerators. Many resources, including renewable and non-renewable ones, can be recycled and reused.

GETTING STARTED
Make a copy of the student page for each team of four students.

PROCEDURE
Activity I: SORTING WHAT’S WHAT
1. Write the terms “renewable resource,” “non-renewable resource,” and “perpetual resource” on the chalkboard. Ask students to write a definition or give a few examples for each. Tell them not to worry if they’re not sure what the terms mean. By the end of the activity they will have a better understanding.

2. Divide the group into teams of four. Explain that teams will be working together to come up with a one-or two-sentence definition for each of the three terms.

3. Give each team a copy of the student page. Have them cut out the clues and give one to each team member.

4. Each student should read their clue card and share the information with the rest of their team. Then, each team should use these bits of information to synthesize a definition for “renewable,” “non-renewable,” and “perpetual” resources. Everyone on the team should understand each of the clues and agree with their team’s definitions.
5. Teams should then discuss the questions on the student page, with one member designated to record their responses and one designated to report them.

6. Review each of the questions with the entire group, with each team reporting its answers.

Activity II: GREED OR NEED
1. Divide the group into teams of four. Give each team 16 pieces of popcorn (nuts or candies can also be used). Explain that students will play a game in which the popcorn represents the team’s supply of a renewable resource that is replenished after each round of play. Each student can take freely from the team supply; however, the team should keep in mind the following rules: (a) At the end of the game, each team member will get to eat all the popcorn or candy that he or she amassed. (b) Each team member needs to take at least one piece per round to be sustained. (c) At the end of each round, the resource will be replenished by one-half of its existing amount.

2. Allow students to take freely from their team’s popcorn pile. Students should record how many pieces they have taken and how many are left in the team pile.

3. Find out how many pieces each group has in its central pile, and give the group half that amount in new pieces.

4. Play three or four more rounds, stopping after each to find out if any of the students didn’t survive. Then provide each group with the prescribed amount of new popcorn.

5. After four or five rounds, have the students share what happened in their teams. In which teams did all the students survive? Which students had the most popcorn in their personal supplies? Which team had the most popcorn in its collective pile? Which teams think they would be able to keep eating popcorn forever as long as the resource kept renewing itself? On these teams, how many pieces were these students taking each round?

6. Discuss these questions with the entire group:
(a) What are the advantages and disadvantages of using a resource in a sustainable way? (Advantage: It can last forever. Disadvantage: You need to control your use of it.)
(b) What advantages and disadvantages are there to using a resource in a non-sustainable way? (Advantages: People will have a large amount of the resource available when they want it; they can make a lot of money in the short term. Disadvantage: They can destroy the resource base for themselves and future generations).
(c) In this activity, the population of each group stayed same. In reality however, the human population is increasing rapidly. What would have happened if one or two or three additional people would have been added to your group?

NOTE—Some of the groups may run out of resources right away or after only two rounds. But one or more of the groups should figure out a way to collect at least one piece of popcorn each round and still have leftovers in their collective pile to be “renewed” each round. During the discussion, be sure to introduce the concept of “sustainable yield.” (See Supporting Information.)

Activity III: POPCORN GENERATION
1. Fill a large jar or other container with popcorn. Mark 14 slips of paper as follows: Two “1st Generation,” four “2nd Generation,” and eight “3rd Generation.” Put the slips into a
NOTE-You should have extra popcorn available after the demonstration is over for the students that don’t participate directly in the demonstration.

2. Have 14 students each draw a slip of paper from the sack. They should not tell anyone what the paper says. Give these students a lunch bag and explain that they will be part of a demonstration.

3. Ask the two 1st Generation students to come up to the big jar of popcorn. Explain that the food in the jar represents the world’s supply of a non-renewable resource. Tell them they can take as much of it as they want. Let them fill their bags while the rest of the group watches.

4. When the 1st Generation students have gotten their fill, invite the four 2nd Generation students to go up and take as much of the remaining popcorn as they want. After they’ve finished, have the 3rd Generation students come up and take what’s left.

5. Discuss with the students what is happening to the world’s popcorn supply. What happened to the total amount of the resource? How much was left for each successive generation? Was anything left for a 4th generation? Did any of the students who were part of the demonstration think about those who might be eating after them, or were they only trying to get as much popcorn as they could?

6. What parallels do the students see between what happened in the demonstration and what happens in the real world?

NOTE-Students may eat as much of the popcorn as they can without any thought as to who will come after them. By the time the 3rd Generation students are finished, there should be little or no popcorn left for the 4th. Even if the students don’t eat as much as they can, they will eat some and the 4th generation will have very little. The students should realize that as new generations come along, there will be less and less of the resource available to them, and eventually there will be nothing.

Activity IV: GLOBAL COOKIE JAR
1. Before your group arrives, label different parts of the room with signs saying Africa, South America, North America, Europe and the Middle East, Russia, and Asia. Prepare slips of paper, one for each student. For a group of thirty students, label eighteen “Asia,” four “Europe and the Middle East,” three “Africa,” two “South America,” two “Russia”, and one “North America.” (For different size groups, adjust these numbers, keeping approximately the same ratio.) Put these slips in a bag. You will also need to bring a jar or box of 88 cookies or crackers (“Global Cookie Jar.”) You can also use individually wrapped candies.

2. When the students arrive, have each pick a slip and go the the section of the room assigned to that region. Display a large map of the world so students can see the regions they belong to. Tell them that they represent the relative population of the regions. Each group should appoint an “ambassador” to represent their region.
3. Tell the regions that they will receive a certain number of cookies, which represent their Gross National Product (the total value of goods and service that their region produces in a year). Give Africa two cookies, Russia three cookies, Asia nine cookies, Europe and the Middle East twelve cookies, South America twenty cookies, and North America thirty cookies. (Ask students why they think the wealthy countries are wealthy. Possible reasons: agricultural system, stable government, educated population, climate, etc.).

4. Explain that each person must have at least one cookie to survive. Students can exchange cookies freely between regions but only the appointed ambassador can leave the group’s designated area.

5. Allow the game to go on for 15 minutes. Let the students work out the inequalities of “wealth” any way they think. Take notes on what you hear and see happening.

6. Announce the end of the activity. Discuss students’ experiences by using the following questions:
   (a) What was your overall experience?
   (b) What was your initial reaction?
   (c) How did you feel when you looked around the room and saw who had what?
   (d) Did you think you would survive?
   (e) Did you ask others for food? How?
   (f) What did you do with your food? Share it, hide it? eat it?
   (g) What choices are available to nations that do not have enough money to buy food from other countries?
   (h) What are some important ideas involved in this game?
   (i) What is missing from the game that would make it more realistic?

ANSWERS TO THE QUESTIONS ON THE STUDENT PAGE
1. Renewable: corn, trees, tuna, salmon
   Non-renewable: oil, coal, gold, sand
   Perpetual: sunshine, tides, hot springs, breeze, river

2. Answers will vary depending on what’s in your classroom.

3. Answers will vary. For example, students may suggest that wood may be used as a substitute for plastic or metal in chairs and other equipment.

4. Answers will vary. Students may suggest that some materials are cheaper than others, that products made from renewable resources are better since the materials to make them can always be available, or that some materials from non-renewable resources are superior to others because they’re lighter in weight or have other properties.

5. If the students don’t come up with answers to this question, don’t worry. And don’t give them an answer! The activities should teach students conditions under which this could occur.

6. Solar energy, winds, tides, etc.

EVALUATION OPTIONS
Have each student write in his or her own words what renewable and non-renewable resources are. Then have the students answer these questions:
1. If a resource is renewable, does that mean it will continue to exist no matter what people do? Explain your answer.

2. What two factors would you say are most important in determining how fast natural resources are used? (This question may be difficult for some students. By recalling the activities, though, they should be able to deduce that the number of people using a resource and the amount each person uses are very important in determining how fast resources get used.)

EDUCATOR’S NOTES
CLUES & QUESTIONS

CLUES

1. On Earth, there are only limited amounts of fossil fuels such as oil, coal, and natural gas. There are also only limited amounts of minerals such as iron, copper, and phosphates. These resources either cannot be replaced by natural processes or require millions of years to replenish.

2. Some non-renewable and renewable natural resources can be recycled or reused. This process decreases the rate at which the supplies of these resources are depleted. For example, aluminum cans can be recycled and turned into new cans or other aluminum products many times over. Recycling reduces the need to mine bauxite, the mineral used to make aluminum.

3. Renewable natural resources include plants, animals, and water, when they are properly cared for. Minerals and fossil fuels such as coal and oil, are examples of non-renewable natural resources.

4. Trees, wildlife, water, and many other natural resources are replaced by natural processes. Plants and animals can also be replenished by human activities. Water is continuously cycled and reused. Sunlight, wind, geothermal heat, tides, and flowing water are perpetual resources.

QUESTIONS

1. Categorize the following as renewable, non-renewable, or perpetual resources:
   (a) a field of corn     (b) oil in the Arctic tundra     (c) coal in the Appalachian Mountains
   (d) sunshine          (e) tides in the Bay of Fundy       (f) trees in a forest
   (g) tuna in the ocean (h) gold mines in western U.S.    (i) hot springs in Alaska
   (j) sand on a beach   (k) breeze over the plains       (l) salmon in streams    (m) water in a river

2. Look around the classroom and list as many items as you can that are made from renewable natural resources. Make a separate list of all the items made from non-renewable natural resources.

3. What renewable natural resources could be used to replace the non-renewable ones used in the items you listed in Question 2? What non-renewable resources could be used in place of the renewable ones?

4. What advantages and disadvantages might there be for using renewable natural resources in place of non-renewable ones?

5. Under what circumstances, if any, would a renewable natural resource not be renewable?

6. Which resources, if any would continue to be available no matter how much people used them?
SOIL CONSERVATION

LEVEL: 8th grade
SUBJECT: Science
OBJECTIVES
The student will-
- tell why soils can be called one of our most valuable resources, and categorize reasons for conserving soils as humanitarian, economic, stewardship, environmental, or aesthetic.
- investigate the history of the Natural Resource Conservation Service (NRCS) and soil conservation districts.
- students will locate their local NRCS and soil conservation district offices and describe the services offered
- define a watershed, and sketch the watershed of a stream.
- describe the hydrologic cycle.
- summarize the importance of properly managing soils and surface water runoff to minimize erosion and water pollution.

ESTIMATED TEACHING TIME
3-4 class periods

MATERIALS
Student pages, telephone book

VOCABULARY
Conservation, erosion, famine, natural resources, watershed

BRIEF DESCRIPTION
This lesson first examines the philosophic and economic reasons for conserving soil and minimizing its degradation. Next students learn how soil and water resources can be properly managed to prevent erosion.

SUPPORTING INFORMATION
There are many reasons why we should conserve soils, so many in fact that it is helpful to describe only categories of reasons.

Humanitarian Reasons
These reasons concern human welfare and social reform, in particular providing an adequate supply of nutritious food for the hungry. The U.S. has traditionally been the largest contributor of food aid to developing nations. Food constitutes about 30 percent of all our foreign aid. Providing enough for exports, food aid, and domestic use requires high soil productivity.

Economic Reasons
Economic reasons concern expenses incurred on the farm to produce food, the costs of goods of the consumer, and exports.

Soils which wash away or are blown away are not available for crops and cause economic as well as other problems elsewhere which may have economic consequences. The downfall of many previous civilizations had its beginnings in the loss of soil fertility as their unprotected soils washed away. Recent dust storms caused by wind erosion of soils cause two major problems with economic impacts. A severe dust storm closed the new Denver International Airport for close to 8 hours, snarling air-traffic and causing losses to travelers and the airlines alike. A dust storm in the northwest caused a huge multi-car pile-up on an interstate highway with a loss of life and much economic damage.

The U.S. is the world's leading exporter of agricultural products. Maintaining high levels of exports will help match trade deficits to foreign countries and help strengthen our economy. (Trade
deficits occur when the value of our imports exceeds the value of our exports.) Our recent high volume of imported oil has helped create a trade deficit.

**Stewardship Reasons**

Stewardship refers to our responsibility to manage natural resources to assure an adequate supply for future generations. Stewardship connotes the practices of wise use, conservation, and preservation.

**Environmental Reasons**

Soils should also be conserved for environmental reasons. It is a societal benefit to have a clean environment with adequate supplies of pure drinking water, clean air, productive soils, and recreational areas.

**Aesthetic Reasons**

This final category concerns maintaining the environment as a beautiful site to experience. Most people would like to avoid unsightly scars and bare, eroded soils on the landscape.

Agencies of government at the local, state and federal levels cooperate to help landowners and operators manage soil resources. All were formed as a direct result of the 1930's Dust Bowl era. They work together to help identify and solve local soil conservation problems. At the federal level, there are two agencies of the U.S. Department of Agriculture (USDA). One is the Natural Resource Conservation Service (NRCS), which conducts soil surveys and provides technical assistance by its employees who are located in almost every county of the nation. NRCS also publishes information materials on soils and soil conserving methods. The other USDA agency is the Farm Service Agency (FSA) which provides cost sharing to land users for conservation work.

In each state there is a state soil conservation agency which has the responsibility of dealing with soil conservation policies and programs on a statewide basis as well as coordinating and assisting the local conservation efforts. The soil conservation district concept began with the idea that the local people who owned the farms and ranches best understood local soil needs and problems. Therefore, local people should be in charge of local soil conservation planning. In February 1937, President Franklin Roosevelt urged all governors to pass laws permitting soil conservation districts. Arkansas was the first to do so; today all states, Guam / Northern Mariana Islands, and the District of Columbia have conservation districts.

The soil conservation district is a state governmental subdivision with boundaries usually the same as the county. The district is governed by locally appointed or elected men and women who are responsible for planning, approving, and implementing conservation projects.

**Managing Water Resources**

A watershed is all of the land area that drains into a particular stream or stream system. It is outlined by the highest ridges around the stream. The water flows through the watershed in the hydrologic or water cycle.

The hydrologic cycle begins as evaporation. First, water evaporates from surface and underground water storage. It is also lost as vapor from leaves of plants through transpiration. When the water vapor rises, it cools and eventually condenses into clouds. When enough water vapor condenses, it finally falls back to earth as precipitation. The water may run off into waterways or lakes as surface stor-
age. Or, it can percolate (seep) through the soil into ground water storage. Then the water is lost by evaporation and transpiration-completing the hydrologic cycle.

Soils are the major reservoir of usable water for plants. If a soil is rich in organic matter and has a cover crop or mulch, most of the precipitation will percolate into the soil for plant use. But if the soil surface is bare, hard, and crusty with little organic matter, most of the precipitation will run off into streams, carrying sediment, and there is less water available for plants. Periods of heavy rains increase erosion, silt buildup in larger waterways, and the possibility of flooding.

Managing the soils within a watershed not only controls erosion, but also helps keep silt out of the waterways. Poor soil management upstream generally results in water quality degradation downstream.

The goal of proper water management within a watershed is to decrease the rate and volume of runoff so that water can percolate into the soil as fast as possible. And one of the best ways to do this is to maintain soils rich in organic matter and soil organisms, and to practice soil conservation methods.

GETTING STARTED

Copy the student pages, one per student. Invite speakers to the class from the County Soil and Water Conservation District or NRCS office. (See activity 2 for details.)

PROCEDURE

Activity 1

1. List the five categories of soil conservation reasons on the board and explain their meaning to your students. Then have your students categorize each of the 15 statements on the activity sheet. Students can place the following abbreviations on the space before each statement: HUM for humanitarian reasons; ECON for economic; STEW for stewardship; ENV for environmental and AES for aesthetic. It is possible that one reason may fit into more than one category.
2. Ask your students to brainstorm other examples for each of the categories.
3. Conclude the activity by asking the question, "Why can soils be called one of our most valuable natural resources?" Clearly all of the reasons listed on the activity sheet and those brainstormed by your students answer the question.

Activity 2

1. Begin this activity by asking your students to read the top of the activity sheet. You may decide to add any additional information from the guide or other resources as a supplement. Students could also further research the topic of soil conservation in a library. They could focus on former national figures such as Hugh Hammond Bennett, the first chief of SCS, or Louis Bromfield, a prominent writer, conservationist, and farmer. They could look under these subject headings for appropriate topics: Conservation, Natural Resources, Soil Conservation, or Soil Erosion.

2. If a local individual or group (such as youth groups, the Farm Bureau, or the Audubon Society) has a significant role in conservation, students could report on their activities. Local libraries and historical societies are good sources of this information.
3. Otherwise the offices may be overrun with calls. It may be helpful to ask a conservationist from these offices to speak to your classes. Students should write a list of questions to ask the speakers. Such a resource person would be an asset for this and the remaining activities of this lesson.
Activity 3
1. Students will need to know the definition of a watershed and the basic principles of the hydrologic cycle for this activity. Begin by providing this information to your class.
2. Describe how to outline a watershed on a map. This can be done by drawing a line around a waterway along the crests of the highest ridgetops. On a 7 1/2-minute-scale U.S. Geologic Survey topographic map, this can be done using the elevation contour lines. On a road map or on the activity master, draw a line roughly equidistant between adjacent waterways.
3. Have your students do this for a local stream, using tracing paper and maps. Help students draw the watershed for the Little Green River on the activity master. Then answer the questions as a class exercise.
4. Have students read each question, then ask for volunteers to answer them.

The following are possible answers:
1. All the land area that drains into a particular stream or stream system.
2. See dashed line on map.
4. None. They are in different watersheds.
5. Natural Resource Conservation Service and the local soil conservation district.
6. Upstream along the Little Green River, and within its watershed.
7. It could cause more silt to enter the Little Green River. It could also cause more frequent flooding since water could run off the fields faster.
8. Dark, rich and full of organic matter and living organisms.
9. Soil and water management practices affect the movement of water within the watershed, not between watersheds.

EVALUATION OPTIONS
Check accuracy of student sheets.

EXTENSIONS AND VARIATIONS
1. Demonstrate how rapidly water percolates into the soil on the schoolyard. Remove the ends of a large juice can, place a board on top of the can, and tap the can down into the soil to a depth of about two inches. Do not disturb the soil or plant material. Add one quart of water, and immediately measure the depth in the can. Then measure the depth of the water in the can every minute for the first ten minutes and at ten-minute intervals until the water has drained. Students should plot a graph of depth of water vs. time. Conduct similar experiments in several different soil conditions: on a compacted path, in a grassy area, etc. Discuss the role of soil compaction and organic matter content on percolation.
2. Using the appropriate maps, find out the watershed in which your school is located. Have students use tracing paper to sketch this area. Then take a walking tour of part or the entire watershed. Students should make a list of all the factors that affect the movement of water in that area. Examples could be drainage ditches to control runoff, woodlots that allow more water to percolate into the soil, and street drains to remove precipitation.

RESOURCES
Natural Resource Conservation Service,
Farm Service Agency

CREDIT
Adapted from CONSERVING SOIL, An information packet of the National Association of Conservation Districts.

EDUCATOR’S NOTES
WHY CONSERVE SOILS?

There are 15 words hidden in this puzzle. These words are listed below. Try to find as many as you can. You can circle them across, down, and diagonally. The letters of each word are always in order. Then use the letter of the correct word to fill in the blanks in these statements.

______ 1. Soils are one of our most valuable ________.
______ 2. Severe soil erosion can lead to water ________.
______ 3. Soil ________ must be kept high to produce all of the food we need.
______ 4. People in many developing nations would be ________ without food aid from the U.S..
______ 5. Prosperous, productive farms provide us with beautiful ________ as we travel along our nation’s highways.
______ 6. Windbreaks and other soil conservation practices create homes for birds, rabbits, foxes, and other kinds of ________.
______ 7. The ________ depends upon productive soils.
______ 8. U.S. food aid helps meet the ________ needs of many in developing nations.
______ 9. More than 40 years after the Dust Bowl era, ________ is still a national challenge.
______ 10. Soil erosion can increase the price of the ________ we eat.
______ 11. Mudslides, gullies, and muddy water are ________ to look at.
______ 12. Soil ________ is an important part of prosperous farming.
______ 13. ________ occurs when there is severe food shortages in an area.
______ 14. Every day, more and more ________ is lost to non-agricultural use.
______ 15. Food is a major ________ that we sell to nations around the world.

WHY CONSERVE SOILS?

STUDENT SHEET ACTIVITY 1

Here are 15 words hidden in this puzzle. These words are listed below. Try to find as many as you can. You can circle them across, down, and diagonally. The letters of each word are always in order. Then use the letter of the correct word to fill in the blanks in these statements.

N O N B F A R M L A N D Q F A P
E A U Z U A R P O I M F E K I B
X H T G T D P O L L U T I O N E
C L R U J S C E N E R Y C N X
O M I N R O O E U T D J F I P P
N K T Z E A I V G A H R M Q C O
S B I G D W L I X Q G A I R I R
E X O L H Y E R P R F O O D I T
R E N D U M R K E Y U S Y T S W
V P A O N H O Z F S R K P B A N
A Y L T G O S U Q Z O B G M E S
T X G T R X I X L A C U G L Y H
I O U A Y L O Q N B V Z R E W C
O V P E Q F N V N F B O M C I N
N W F W I L D L I F E J S K E L
P P R O D U C T I V I T Y C M S

a. conservation  j. pollution
b. export  k. productivity
c. famine  l. scenery
d. farmland  m. soil erosion
e. food  n. ugly
f. future  o. wildlife
g. hungry  h. natural resources
i. nutritional

SCI-43
There are 15 words hidden in this puzzle. These words are listed below. Try to find as many as you can. You can circle them across, down, and diagonally. The letters of each word are always in order. Then use the letter of the correct word to fill in the blanks in these statements.

1. Soils are one of our most valuable ___.
2. Severe soil erosion can lead to water ___.
3. Soil ___ must be kept high to produce all of the food we need.
4. People in many developing nations would be __ without food aid from the U.S..
5. Prosperous, productive farms provide us with beautiful ___ as we travel along our nation’s highways.

6. Windbreaks and other soil conservation practices create homes for birds, rabbits, foxes, and other kinds of ___.
7. The ___ depends upon productive soils.
8. U.S. food aid helps meet the ___ needs of many in developing nations.
9. More than 40 years after the Dust Bowl era, ___ is still a national challenge.
10. Soil erosion can increase the price of the ___ we eat.
11. Mudslides, gullies, and muddy water are ___ to look at.
12. Soil ___ is an important part of prosperous farming.
13. ___ occurs when there is a severe food shortage in an area.
14. Every day, more and more ___ is lost to non-agricultural use.
15. Food is a major ___ that we sell to nations around the world.

a. conservation
b. export
c. famine
d. farmland
e. food
f. future
g. hungry
h. natural resources
i. nutritional
j. pollution
k. productivity
l. scenery
m. soil erosion
n. ugly
o. wildlife
During the Dust Bowl era, many people became very worried about soil erosion. As a result, three cooperating agencies were created. They help Americans conserve soils. All three are still working together to help us use soil resources wisely.

The Soil Conservation Service (SCS) was formed in 1935. It is part of the U.S. Department of Agriculture (USDA). This agency has offices in almost every county in the U.S. Its headquarters are in Washington, D.C. The SCS conducts soil surveys. It also researches conservation methods and shows citizens how to use soil properly. An important job is to give land owners information to help them conserve soil and water.

Another USDA agency, the Agricultural Stabilization and Conservation Service (ASCS) - now part of the Farm Service Agency (FSA), provides cost-sharing to land users for conservation work.

A third unit is the soil conservation district. Conservation districts are located in almost every county. They are a branch of the local government. In 1937 President Franklin Roosevelt asked the states to pass laws permitting conservation districts to organize. A group of people who are either elected or appointed are in charge of the district. They set local conservation priorities.

With the help of your teacher, answer the following questions about these two agencies.

**MANAGING SOIL RESOURCES**

**STUDENT SHEET ACTIVITY 2**

Another USDA agency, the Agricultural Stabilization and Conservation Service (ASCS) - now part of the Farm Service Agency (FSA), provides cost-sharing to land users for conservation work.

A third unit is the soil conservation district. Conservation districts are located in almost every county. They are a branch of the local government. In 1937 President Franklin Roosevelt asked the states to pass laws permitting conservation districts to organize. A group of people who are either elected or appointed are in charge of the district. They set local conservation priorities.

With the help of your teacher, answer the following questions about these two agencies.

**Natural Resource Conservation Service (NRCS)**

Under what listing in the telephone book would you find this agency?

____________________________________________________________________________

What is the telephone number and address of your local NRCS office? ___________________

What recent projects has your local NRCS office worked on? ___________________________

How can your local NRCS office help the landowner? _________________________________

**Farm Service Agency**

Under what listing in the telephone book would you find this agency?

____________________________________________________________________________

What is the telephone number and address of your local office? _________________________

What recent projects has your local office worked on? ________________________________

How can your local office help the landowner? ______________________________________
1. Define the term "watershed."

2. Outline the Little Green River watershed.

3. The person that owns Pleasant View Farm practices poor soil conservation. Describe the water that flows through Riverdale after a heavy rain.

4. What effect would poor soil conservation practices on Pleasant View Farm have on Wood Creek?

5. The citizens of Riverdale are angry because the Little Green River floods every spring. It is also brown with silt after every rain. What local government agencies can help them?

6. Suppose you are a soil conservationist. Where would you look for the source of Riverdale’s water problems?

7. Suppose the person that owned Pleasant View Farm allows cattle to overgraze the fields. The pastures are almost bare. What effect(s) would this have on the Little Green River?

8. Describe the ideal type of soil to prevent runoff and soil erosion for the owner of Pleasant View Farm.

9. Why is the watershed an important unit of land to study in soil and water conservation?
1. Define the term “watershed.”
   All the land area that drains into a particular stream or stream system.
2. Outline the Little Green River watershed. (Shown as dashed line.)
3. The person that owns Pleasant View Farm practices poor soil conservation. Describe the water that flows through Riverdale after a heavy rain.
   Brown and full of silt.
4. What effect would poor soil conservation practices on Pleasant View Farm have on Wood Creek?
   None. They are in different watersheds.
5. The citizens of Riverdale are angry because the Little Green River floods every spring. It is also brown with silt after every rain. What local government agencies can help them?
   NRCS and local soil conservation district.
6. Suppose you are a soil conservationist. Where would you look for the source of Riverdale’s water problems?
   Upstream along the Little Green River, and within its watershed.
7. Suppose the person that owned Pleasant View Farm allows cattle to overgraze the fields. The pastures are almost bare. What effect(s) would this have on the Little Green River?
   It could cause more silt to enter the river. It could also cause more frequent flooding since water could runoff the fields faster.
8. Describe the ideal type of soil to prevent runoff and soil erosion for the owner of Pleasant View Farm. Dark, rich, and full of organic matter and living organisms.
9. Why is the watershed an important unit of land to study in soil and water conservation? Soil and water management practices affect the movement of water within the watershed, not between watersheds.
SUPPORTING INFORMATION

Each person cannot produce all of the food, or all of the products used in our modern society. A system of producing goods has evolved to supply these basic requirements. Often this system involves many steps between extracting the resource from the land and using the manufactured product at home. Many soils throughout the world are affected.

Producing the goods we use can be categorized into two procedures: obtaining, then processing resources. First the resources are obtained from the land and its soils. For example, vegetables are grown in soil. Animals are raised on grasses, grains, and soybeans that are grown in soil. Mineral resources—coal, iron ore, petroleum, and many others—are mined from beneath the soil and the bedrock below.

Processing, the second procedure, usually occurs in industrialized locations that may be far removed from the resource. The end result of the various steps in processing is a consumer good and usually waste by-products that need to be recycled or discarded.

Consider, for example, the production of an aluminum beverage can. The can started as a mineral resource, bauxite ore. Since we must import most of this ore, the can probably began in a foreign nation such as Suriname in South America. After it arrived in the U.S. the ore was smelted into aluminum metal. Then the metal was formed into cans and filled with beverages.

Nine thousand miles from Suriname, with one kilowatt-hour of electricity invested in its processing, the aluminum can is ready to be purchased. Most of the products we buy are obtained through such a system of production. And every product is obtained either directly or indirectly from the land and its soils. In our complex society, not only local soils, but soils across the world are affected by the items we purchase.

In this activity, students investi-
igate the steps required to produce several goods and they identify the land as one natural resource common to all consumer products.

GETTING STARTED

A few days before this activity, contact your school librarian for some reference materials that your students will need to complete this activity. Most of the information will be available from almanacs, encyclopedias, maps, product labels, and personal knowledge.

PROCEDURE

1. Have the students complete the first section of the activity master and then ask for volunteers to read their answers to the class.

2. Divide your students into small groups to research one of the pizza ingredients. Also ask the group to add at least one of their favorite ingredients to the list. Each group should present their findings to the class so that others can fill in the chart at the bottom of the activity sheet.

3. Conclude the activity by pointing out that every product that we buy, the energy we use, and the foods we eat are directly or indirectly a product of soils. More complicated items, such as an automobile, require more resources. Thus, more soils in different locations are involved.

EVALUATION OPTIONS

Check accuracy of answers.

EXTENSIONS AND VARIATIONS

Your class could investigate the resources required and the steps involved in manufacturing an automobile. As students found in their study of the pizza, resources needed to manu-

RESOURCES

Everyday uses of minerals.
Mineral Information Institute
475 17th Street, Suite 510
Denver, Colorado, 80202

CREDIT

Adapted from CONSERVING SOIL, An information packet of the National Association of Conservation Districts.
National Association of Conservation Districts
PO Box 855, League City, TX 77574-0855

EDUCATOR’S NOTES

Answers to first part of Student Sheet.

Lightbulb- tungsten, iron, copper, glass
Telephone- copper, iron, oil, rubber
Soft drink can- aluminum, iron
Electric power- coal, oil
Compact Disc- oil & soybean oil
Jeans- cotton, iron, oil
Automobile- iron, aluminum, copper, chromium, rubber
Winter jacket- wool, cotton, oil, iron
We Depend Upon Soils

Where do our consumer products come from?
This is a list of items that we often use. Using encyclopedias and other references, try to match the resources with each item. Most items need more than one resource. And each resource may be used more than once.

**ITEMS**

| Lightbulb- | Oil | Aluminum |
| Telephone- | Copper | Wool |
| Soft drink can | Coal | Rubber |
| Electric power | Tungsten | Chromium |
| Compact Disc | Iron | Cotton |
| Jeans |  |  |
| Automobile |  |  |
| Winter jacket |  |  |

Either the land, soil, or water could have been listed as a resource for each item. Why?

Where did our pizza come from?
Listed below are some of the ingredients of a pizza. You may want to add some of your favorites that are not on the list. Look up:

1. the resource material of the ingredient.
2. a possible geographic location of the resource material.
3. what processing step(s) are needed to make the ingredient.
4. a possible geographic location of the processing.

---

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Resource Material</th>
<th>Location</th>
<th>Processing</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flour</td>
<td>Wheat</td>
<td>Kansas</td>
<td>cleaning, milling</td>
<td>Indianapolis, Indiana</td>
</tr>
<tr>
<td>Salt</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spices</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tomato Sauce</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sausage</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pepperoni</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Your favorites</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The ingredients came from many different locations and were processed in many others. What basic natural resources are common to the pizza ingredients? ___________________________
BRIEF DESCRIPTION
In this activity, students will discover that plants have a lifecycle that is similar to that of other living things. They will investigate a plant’s role in the ecosystem at each stage of its life. Tennessee’s various regions have a multitude of plants at all stages of their lifecycle most of the time.

SUPPORTING INFORMATION
One of the best ways to learn about plants is to look at their life history. Plants, like all living things, have a lifecycle that includes birth, growth, injury, and disease, aging, and death. As plants go from birth to death, their physical form changes, as well as their role in the ecosystem. You can learn about past changes in environmental conditions by looking at the growth rings in a cross section of a tree. Even more can be learned about the lifecycles of plants by observing a tree from birth as it grows and develops throughout its life. (This takes a very long time for most trees. Using radishes or other annual plants will take less time.) Most trees begin as seeds. Generally, trees are put into flowering and non-flowering categories. The angiosperms are flowering plants, including wildflowers, shrubs, and many trees. Insects, bats, birds, and the wind pollinate angiosperms. Plants that have flowers also protect their seeds inside a fruit. Apple, peach, oak, and all other broad-leaved trees are angiosperms. Gymnosperms (from Latin "gynno-", meaning "naked") have seeds that are not enclosed in fruit or flowers. Rather, most gymnosperms produce their seeds in cones and are pollinated by the wind. If a seed lands in an area with favorable soil, climate, and nutrient conditions, it will germinate (some remain dormant for long periods before germinating). Usually, many more seeds will be produced than can possibly survive. Most seeds will be destroyed by fungi or other decomposers, or eaten by birds or mammals, leaving only a few sprouts to survive and become mature members of the community.

As part of the plant community,
young seedlings must compete with other plants for sunlight, nutrients, water, and space. In dense forests, many young trees must wait for years for older trees to fall and leave openings in the canopy for them to grow into. The length of time it takes a tree to reach maturity depends on the species of tree. Other plants only live for one growing season. These are called “annual” plants and complete their lifecycle in one year.

Plants have many different roles in the ecosystem depending on their stage of development and size. Their leaves, bark, seeds, flowers, fruit, and roots provide food for many kinds of animals. Plants such as trees also provide roosts, shade, and shelter to many living things. For example, holes in older trees and around their roots provide shelters for nests and dens.

Like all living things, plants are subject to disease and injury. Physical damage may not kill a tree, but may provide holes and openings in which animals and insects can live and feed. Eventually, trees weakened by injury and disease will die, fall down, and be decomposed. When they die, plants return their nutrients and other elements back into the soil to be recycled through the ecosystem.

GETTING STARTED
Select a few books on plants from the school library including field guides and stories. Start a "Plant-Resource" center, so the students have easy access to materials for researching plants. Make a copy of the Activity sheet for each student.

PROCEDURE
1. Discuss the idea of lifecycles by asking students to describe the lifecycle, or history of a person. Make sure students include birth, childhood, teenage years, young adulthood, and so forth, in the discussion. Write these stages on the chalkboard. Ask students to identify the different jobs, roles, or things that a person might do in each stage of the lifecycle. Next, ask them to describe the lifecycle of a plant in similar terms (see diagram)

2. Distribute art materials and ask students to create the lifecycle of a plant, from germination through death and decomposition. Students should include at least three stages or events in their lifecycles (eg., a hail storm or insect invasion). Encourage them to research a particular species of plant for accuracy in life characteristics, climate, and environment. Remind students that one event that affects the tree (eg., insect damage) is likely to clear the way for another event (eg., a hole for larvae). The lifecycle could be represented by a circle on the page, with illustrations and a label for each stage or event, or could be shown in a line or a long, narrow piece of paper taped together at the ends.

3. Students should fill in the details for at least three stages or events on the "Plant Lifecycle" student Sheet. Some items may stay the same throughout the plant’s life.

4. Give students the opportunity to share their lifecycles in small groups or with the entire group. Create a "History of the Community" exhibit by mounting all the lifecycles around the classroom.

EVALUATION OPTIONS
Have the students write an imaginative story about the lifecycle of the particular plant they created. The story can be written as a fable in which the plants, and animals can talk. In the story, students should include at least three stages or events of the plant’s life, such
as sprouting from a seed, or dying and decomposing into the soil. Ideally, the life events should show a cause-effect connection (e.g., a drought one year might lead to a fire that enables the seeds of a particular tree to sprout).

EXTENSIONS AND VARIATIONS
Using fast growing plants such as Wisconsin Fast Plants study the stages of a plant's lifecycle.

EDUCATOR'S NOTES
Fill in the information for various stages or events your plant’s lifecycle. Describe at least three stages or events.

**TYPE OF PLANT** ____________________ **SCIENTIFIC NAME** ____________________

**DESCRIPTION OF PLANT:**

<table>
<thead>
<tr>
<th>Lifecycle Stage or Event</th>
<th>Lifecycle Stage or Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Age</td>
<td>Plant Age</td>
</tr>
<tr>
<td>Role in ecosystem</td>
<td>Role in ecosystem</td>
</tr>
<tr>
<td>List of things plant depends on to survive</td>
<td>List of things plant depends on to survive</td>
</tr>
<tr>
<td>Things that depend on the plant to survive</td>
<td>Things that depend on the plant to survive</td>
</tr>
<tr>
<td>Processes that might move plant into the next stage</td>
<td>Processes that might move plant into the next stage</td>
</tr>
</tbody>
</table>

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**LIFECYCLE STAGE OR EVENT** ____________________ **LIFECYCLE STAGE OR EVENT** ____________________

**PLANT AGE** ____________________ **PLANT AGE** ____________________

**ROLE IN ECOSYSTEM** ____________________ **ROLE IN ECOSYSTEM** ____________________

**LIST OF THINGS PLANT DEPENDS ON TO SURVIVE** ____________________ **LIST OF THINGS PLANT DEPENDS ON TO SURVIVE** ____________________

**THINGS THAT DEPEND ON THE PLANT TO SURVIVE** ____________________ **THINGS THAT DEPEND ON THE PLANT TO SURVIVE** ____________________

**PROCESSES THAT MIGHT MOVE PLANT INTO THE NEXT STAGE** ____________________ **PROCESSES THAT MIGHT MOVE PLANT INTO THE NEXT STAGE** ____________________

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**LIFECYCLE STAGE OR EVENT** ____________________ **LIFECYCLE STAGE OR EVENT** ____________________

**PLANT AGE** ____________________ **PLANT AGE** ____________________

**ROLE IN ECOSYSTEM** ____________________ **ROLE IN ECOSYSTEM** ____________________

**LIST OF THINGS PLANT DEPENDS ON TO SURVIVE** ____________________ **LIST OF THINGS PLANT DEPENDS ON TO SURVIVE** ____________________

**THINGS THAT DEPEND ON THE PLANT TO SURVIVE** ____________________ **THINGS THAT DEPEND ON THE PLANT TO SURVIVE** ____________________

**PROCESSES THAT MIGHT MOVE PLANT INTO THE NEXT STAGE** ____________________ **PROCESSES THAT MIGHT MOVE PLANT INTO THE NEXT STAGE** ____________________