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Ecosystems

STUDENT ACTIVITY BOOK

FIELD TEST EDITION

SCIENCE AND TECHNOLOGY FOR CHILDREN

NATIONAL SCIENCE RESOURCES CENTER
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LESSON 1

Getting Started: Thinking about Ecosystems

Think and Wonder

Many complex relationships exist in nature. For example, some living things depend on others for food. They may also depend on non-living things in their environment for shelter. Today you will start to create some environments with living and non-living things. These environments are called ecosystems.

Materials

For you

1 science notebook

For you and your partner

3 clear plastic soda bottles with bases and caps, preferably the same brand
1 funnel

For the class

Hot water
Buckets or pans
3 thermometers
Cleanup supplies
OR
3-5 electric hair dryers
1 wall chart entitled "The Woodland Ecosystem"

Find Out for Yourself

1. You will need to set up a notebook for this unit. You will use it to record your ideas and observations in writing and sketches, and to hold any Activity Sheets your teacher gives you.
2. What do you already know about how living things depend on one another? What would you like to find out? Join your class in a brainstorming session on these two questions.

3. Your teacher will record your ideas about ecosystems on two different charts. After you have finished the unit you will look at these lists again to see how much you have learned.
4. Spend a few minutes observing the picture of the woodland ecosystem. What different kinds of relationships can you find? Be ready to discuss these questions with your class:
   - Identify the living things in this ecosystem. Are they plants or animals? Do the plants depend on the animals? Do the animals depend on the plants? How?
   - Do any of these living things need each other in order to survive?
   - Identify the non-living things in this ecosystem. What part do they play in the lives of the plants and animals?
5. Now make the first entry in your science notebook. Write today's date. Then record your thoughts on these two topics:
   - Describe a situation in nature where one living thing depends on another living thing.
   - Look at the woodland ecosystem again. Imagine that a pioneer family has decided to make its home here. What will change? List all the changes you can think of.

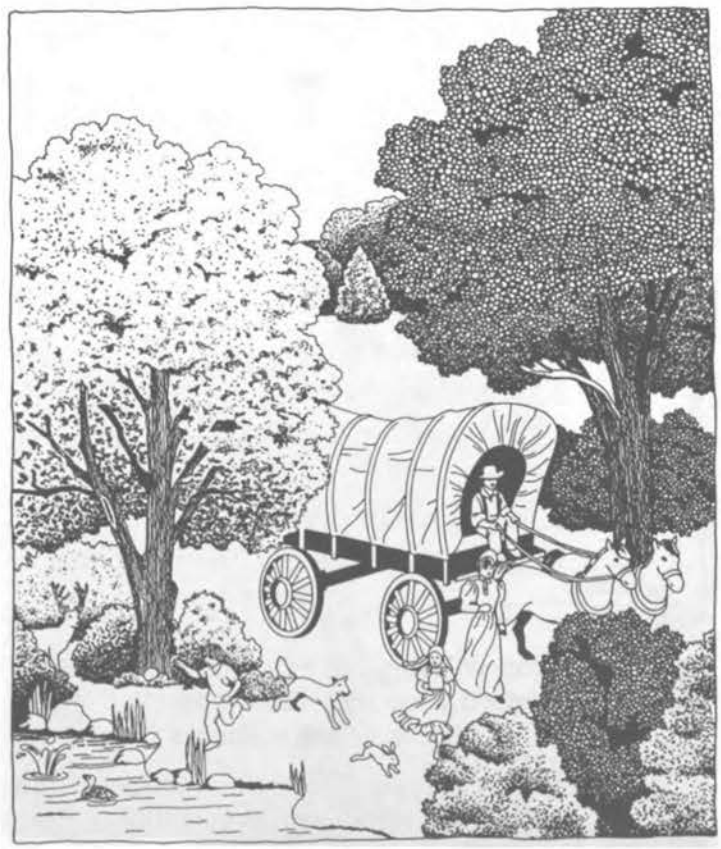


Figure 1-1

Imagine that a pioneer family has decided to make its home here.

6. Now follow along as your teacher goes over the instructions on pg. 4 on how to prepare the bottles. Ask questions if there is anything you don't understand. Then work with your partner to complete the activity.
7. Cleanup is a regular part of science activities. If everyone does a fair share, it will go a lot faster. Here is what you need to do today:
   - discard the water
   - mop up spills

   OR

   - put label scraps in the trash
   - unplug the hair dryers and put them away
   - put the bottles in the designated storage area
8. Did you ever think of the schoolyard as an ecosystem? It is. Take a look.
   - What plants live in the ecosystem?
   - Is there evidence of any animal inhabitants? (Don't forget that people are animals.)
   - Do the animals depend on the plants for any of their needs?
   - Do the plants depend on the animals?
   - What non-living things do the plants and animals depend on? Discuss this with your class.

Ideas to Explore

1. The place where you are living has probably changed a lot over time. You might find a local historian to tell you about the development of your area. What did the area look like before people lived there? What changes occurred one hundred years ago, fifty years ago, ten years ago? What caused the changes? These would also make interesting topics for you to research in the library.
2. What was here before they built your school? Draw a picture of the place where your school stands as you imagine it might have looked three hundred years ago. What plants and animals were part of that ecosystem?

Student Instructions for Preparing the Bottles: Removing Labels and Bases

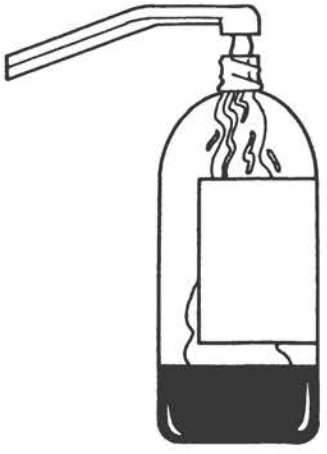
In this unit you will connect three 2-liter, clear plastic soda bottles to build a column of three sections. One section will be an aquarium, one a terrarium, and one a connecting piece. When it's all put together, we will call it an **ecocolumn**. Today you will begin to prepare the bottles for your ecocolumn.

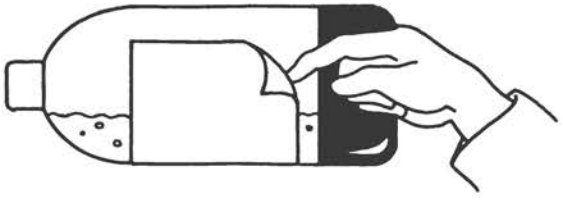
Tips:

- You and your partner should try to bring in the same brand of soda bottles (with bases). They will fit together much more easily if they are the same brand.
- Use bottles that never have been creased. Creases are weak spots.
- Rinse out your bottles well with clean water. Do not use soap, because it may harm the living creatures you put in later.
- The labels and bases are held on by glue which heat will melt easily. But it is important not to use water that is too hot (over 65° C or 170° F). If you do, the plastic bottles may become too soft and change shape permanently. Before you pour water into the bottles, use a thermometer to check its temperature.

The Hot Water Way

1. Fill the bottle about 1/4 full with very hot water (55° to 60° C or 120° to 160° F). Put the cap back on; otherwise the bottle may collapse when you hold it tightly.
2. First, work on removing the labels. Find the place on the bottle where the label is glued. (Each brand is a little different, so examine your own bottles closely.) Then lay the bottle on its side so the water inside warms the area where the label is glued to the bottle.
3. Wait a few minutes for the glue to soften. Then, with your fingernail, lift a corner of the label and gently peel it off of the bottle. If the label doesn't peel easily, wait a little longer or try hotter water.

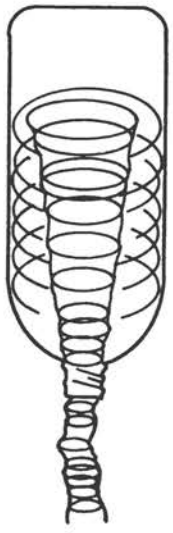




4. Now work on removing the bases from two of the bottles. (Leave the base on the third.) Stand the bottle upright. The hot water should soften the glue holding the base to the bottom of the bottle.

5. Wait a few minutes for the glue to soften. Then hold the bottle tightly and slowly twist off the base.

6. Remove the cap and pour out the water. Try this: swirl the bottle around as it starts to empty. The water will form a funnel shape, like a mini-tornado in a bottle.



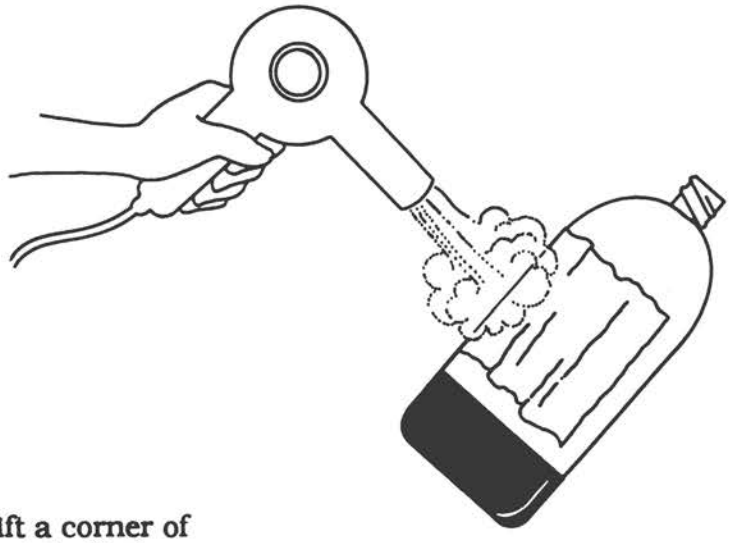
This way the water empties slowly, and the bottle's sides won't collapse.

7. Put all of the bottle parts in a safe storage place until the next lesson, when you will mark and cut them.

The Hair Dryer Way

1. First, work on removing the labels. Find the place on the bottle where the label is glued. (Each brand is a little different, so examine your own bottles closely.)

2. Then focus the nozzle of the hair dryer on the strip of glue for about 5 to 10 seconds. It's important to use low heat and to keep the hair dryer moving during this time so the plastic does not get too hot and deform.



3. With your fingernail, lift a corner of the label and gently peel it off of the bottle.

4. Now work on removing the bases from two of the bottles. Focus the nozzle of the hair dryer on the bottom of the bottle where the base is attached for about 15 seconds. Be sure to keep the cap on while you are doing this.

5. Hold the bottle tightly, and slowly twist off the base.

6. Put all of the bottle parts in a safe storage place until the next lesson when you will mark and cut them.

LESSON 2

Marking and Cutting the Bottles

Think and Wonder

Today you and your partner will prepare the three bottles that will make up the three parts of your ecocolumn: the aquarium, the terrarium, and the piece that connects the two. In the next lesson, you will set up the aquarium. What do you think will go in it?

Materials

For you

- 1 pair of scissors
- 1 science notebook

For you and your partner

- 3 clear plastic soda bottles from the last lesson
- 1 marking box
- 1 permanent marking pen

Find Out for Yourself

1. Let's review:
   - Why are we preparing these bottles?
   - What do you think will go in them?
   - What is an aquarium? What is a terrarium?
   - Do you have an aquarium or terrarium? What do you keep in it?
2. Follow along as your teacher goes over the **Instruction Sheet** on pg. 10 on marking and cutting the bottles. Ask questions if you do not understand exactly what to do.
3. Pick up your materials.
4. Now follow the step-by-step directions to mark and cut the bottles. To do a good job, you need to work cooperatively with your partner.

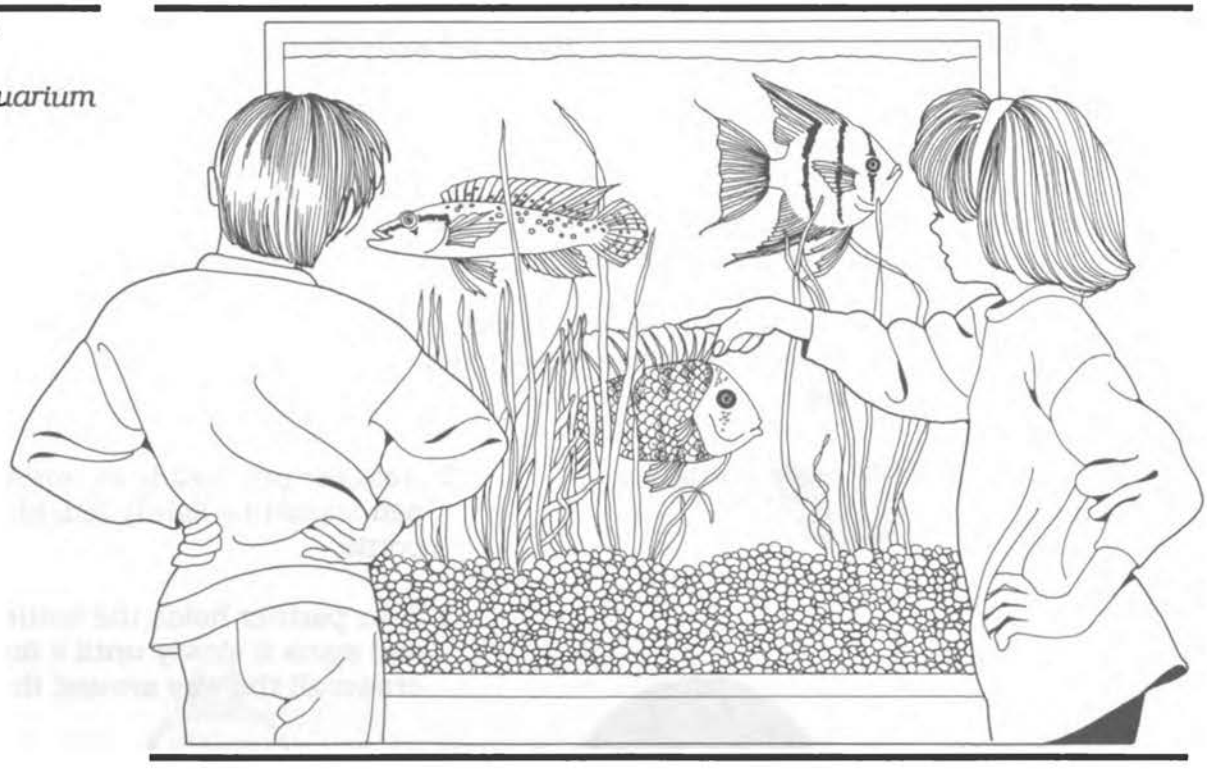
5. When you have finished cutting the three bottles, double-check to make sure your names are on all three pieces and that each piece is labeled either A, C, or T. Then store them away until the next class. Do your share to help clean up.
6. Join your classmates in a discussion about what you think will go into your aquarium, section A. (Remember, it only holds about one liter or one quart of water.) What creatures do you think will stay healthy in such a small space? Here are some questions to talk about during the discussion:
   - What kinds of living things might you find in a real pond? Think about both plants and animals.
   - What kinds of non-living materials would you find?
7. Now record your ideas on these two questions in your science notebook:
   - What are some things that water plants need to grow well?
   - How do plants help the animals in a pond?

ideas to Explore

1. Many fascinating creatures inhabit the ponds, lakes, streams, and oceans of our world. Use the library to find out more about them.
2. Visit a watery environment. Perhaps you can take a trip to an aquarium, a natural body of water, or a pet shop. You might talk to a naturalist, a pet shop owner, or a fish hobbyist to find out more about the underwater world.

Figure 2-1

Visit an aquarium



3. Make a list of all the water words you can think of that contain the Latin root *aqua*.

Student Instructions for Marking and Cutting the Bottles

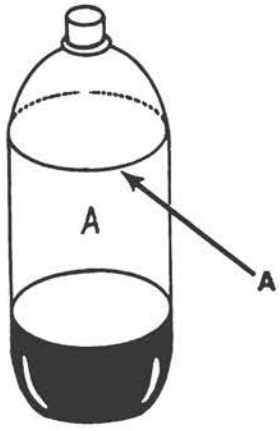
Marking the Bottles

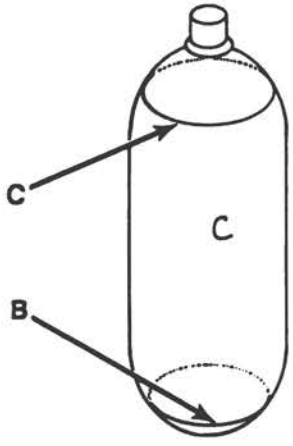
You and your partner will work together. Take turns holding the bottle and drawing the lines.

Bottle 1 (the one with the base still attached) will become the aquarium. Mark it "A." Then draw line A on this bottle. Here is how:

1. Take off the cap and place Bottle 1 in the marking box.
2. Hold the pen steady in slot A. The pen should be lightly touching the bottle.
3. Your partner holds the bottle in place and spins it slowly until a line is drawn all the way around the bottle.

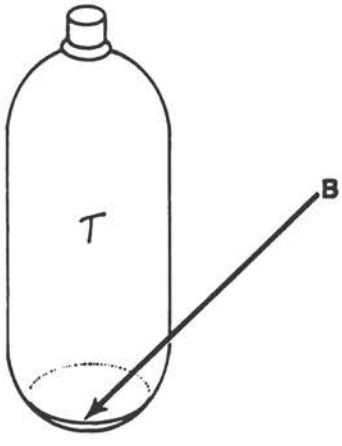
4. Take the bottle out of the marking box and put the cap back on. While you are working on the next bottle, your teacher will come around with a knife to make the first puncture on the line for you. This will make it easier for you to get your scissors started.





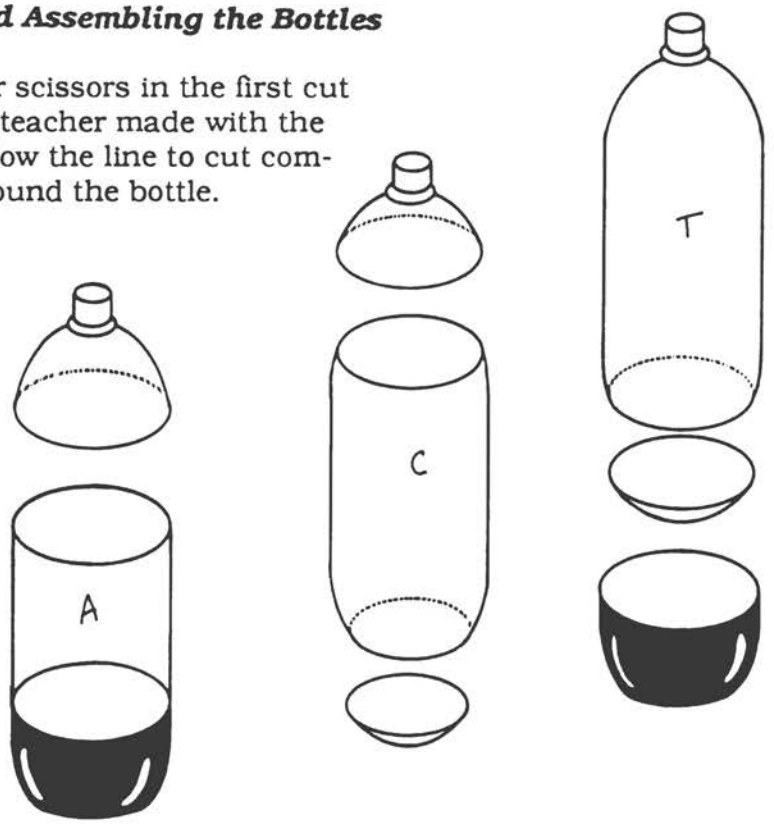
Bottle 2 (the one with the base removed) becomes the connector. Mark it "C." Draw lines C and B on this bottle. Use the same method as you did for Bottle 1, but this time draw two lines.

Bottle 3 (also with the base removed) becomes the terrarium. Mark it "T." Save this base to form the terrarium lid. Draw line B on this bottle using the same method as before.



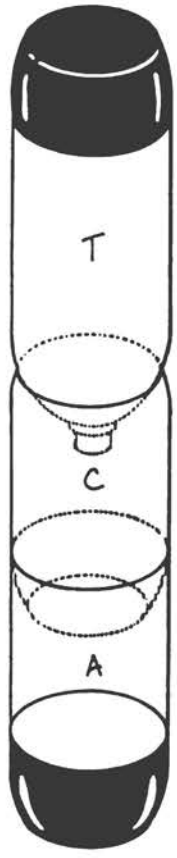
Cutting and Assembling the Bottles

1. Place your scissors in the first cut that your teacher made with the knife. Follow the line to cut completely around the bottle.



2. When you are finished, you should have a column that looks like this:

If your bottles don't fit well, try to figure out how to adjust them so that they will.



LESSON 3

Setting Up the Aquarium with Plants

Think and Wonder

Today you will set up your aquarium and examine the living plants that will go in it. Each plant is unique. Each has special needs to live and grow. Take the time to observe each plant very carefully today. Then, some readings will help you think about how each one will fit into the life of your aquarium.

Materials

For you

- 1 science notebook
- 1 **Activity Sheet 1, Setting up the Aquarium with Plants**

For you and your partner

- 1 section A of bottles prepared in the previous lesson
- 1 liter (or quart) of water
- 1 cup of gravel
- 1 or 2 sprigs of *Elodea*
- 10 to 15 duckweed plants
- 4 droppersful of algae
- 1 dropper
- 1 hand lens
- 2 clear plastic cups
- 2 spoons
- 1 metric ruler

Find Out for Yourself

1. Join your classmates in an important discussion about what living creatures need. You may want to look back at your notes from the last lesson. Share your ideas on these questions:
   - What do plants need to live?
   - What do animals need to live?

- Pick one creature and describe how it gets what it needs to live in nature.
- How will we provide for these needs in the environment that we are creating?

2. Look at the instructions on pg. 21 for the first stage of setting up your aquarium. Read through them now with your teacher. Ask questions if there is anything you do not understand.
3. Listen while your teacher tells you how to record your observations, either on an Activity Sheet or in your science notebook. It is important to start keeping records today so that you can keep track of changes in your aquarium.
4. Watch while your teacher explains how to pick up your materials. Remember: these are live plants. Handle with care. Be very gentle. Do not keep them out of water for more than a few minutes.
5. Once you understand all the directions, work with your partner to set up your aquarium. Take the time to observe your plants really closely. Use the hand lens for a better look. Remember to record your observations.

Figure 3-1

Using your hand lens

6. Time to clean up. You need to
   - Place your aquarium in a safe location. It should get plenty of light (but not direct sun), and be easy for you to observe often.
   - Return materials to the distribution center.
   - Throw away your own trash.
   - Wipe off any wet surfaces.
7. To find out more about the plants in your aquarium, read the **Reading Selection** starting on pg. 16. Look for reasons why plants are important in an aquarium.

Ideas to Explore

1. If you're interested in aquatic environments, you might enjoy researching one of these topics:
   - Your aquarium will be like a pond. What other kinds of wet environments can you think of? Make a list.
   - Pond water is slow-moving. If you studied a fast-moving water environment (like a river or a waterfall) how might the plants living there be different? How might they be the same?
2. Hundreds of fascinating plants live in and around ponds: water lilies, cattails, irises, horsetails, arrowheads, and algae, to name just a few. Pick out one pond plant, draw it, and do some library research about how it lives. Then you can share what you have learned with the class.
3. If your teacher approves, add a few more non-living things to your aquarium to make it more interesting. But do not add any more living things. That could cause problems.

Reading Selection

Water Plants: Not Just Beautiful to Look At

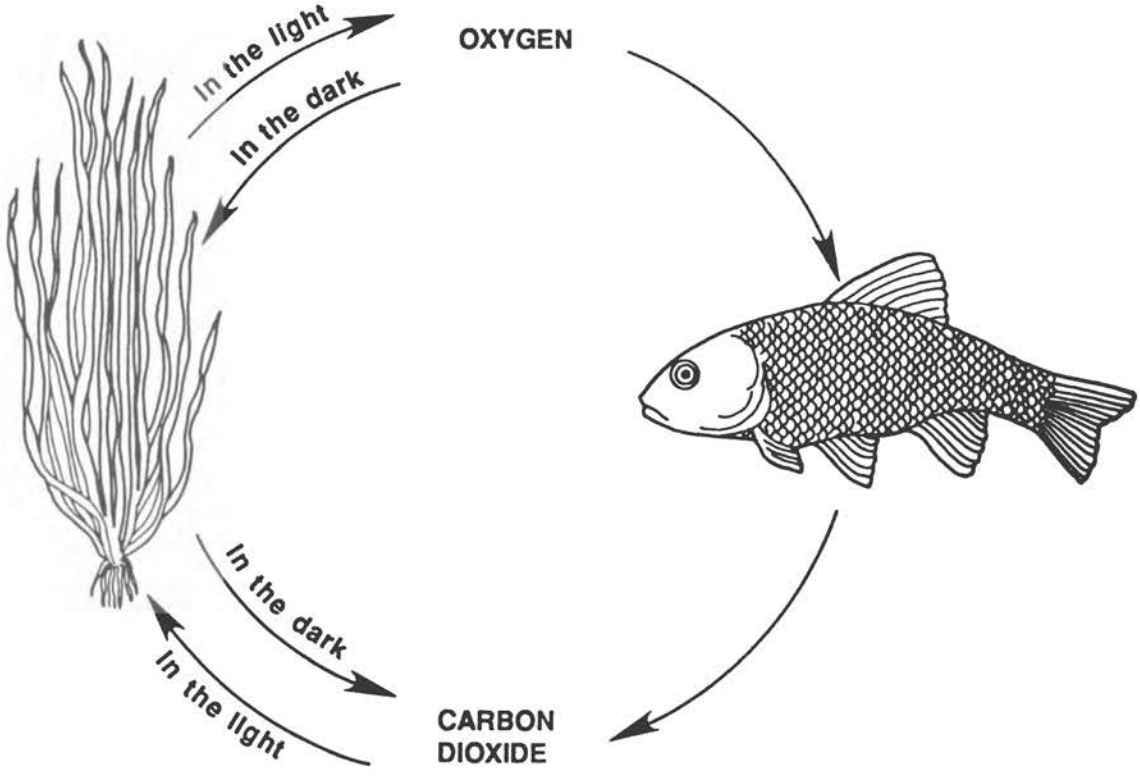
Why should you add plants to your aquarium? There are many reasons. Water plants play an especially important role in a pond or slow-moving stream. They help to keep a healthy exchange of gasses in the water by taking in one gas (carbon dioxide) and giving off another (oxygen). This is part of their complex food-producing process, called **photosynthesis**.

During daylight hours, plants make their own food using the sun's energy, water, and carbon dioxide. At the same time, they give off oxygen as a waste product into the water. But when it is dark, plants take in oxygen and give off carbon dioxide.

Oxygen is used by animals who breathe underwater, such as fish, snails, and tadpoles. Then, as a waste product, the animals give off carbon dioxide into the water. Look at the illustration below to understand this cycle better.

Figure 3-2

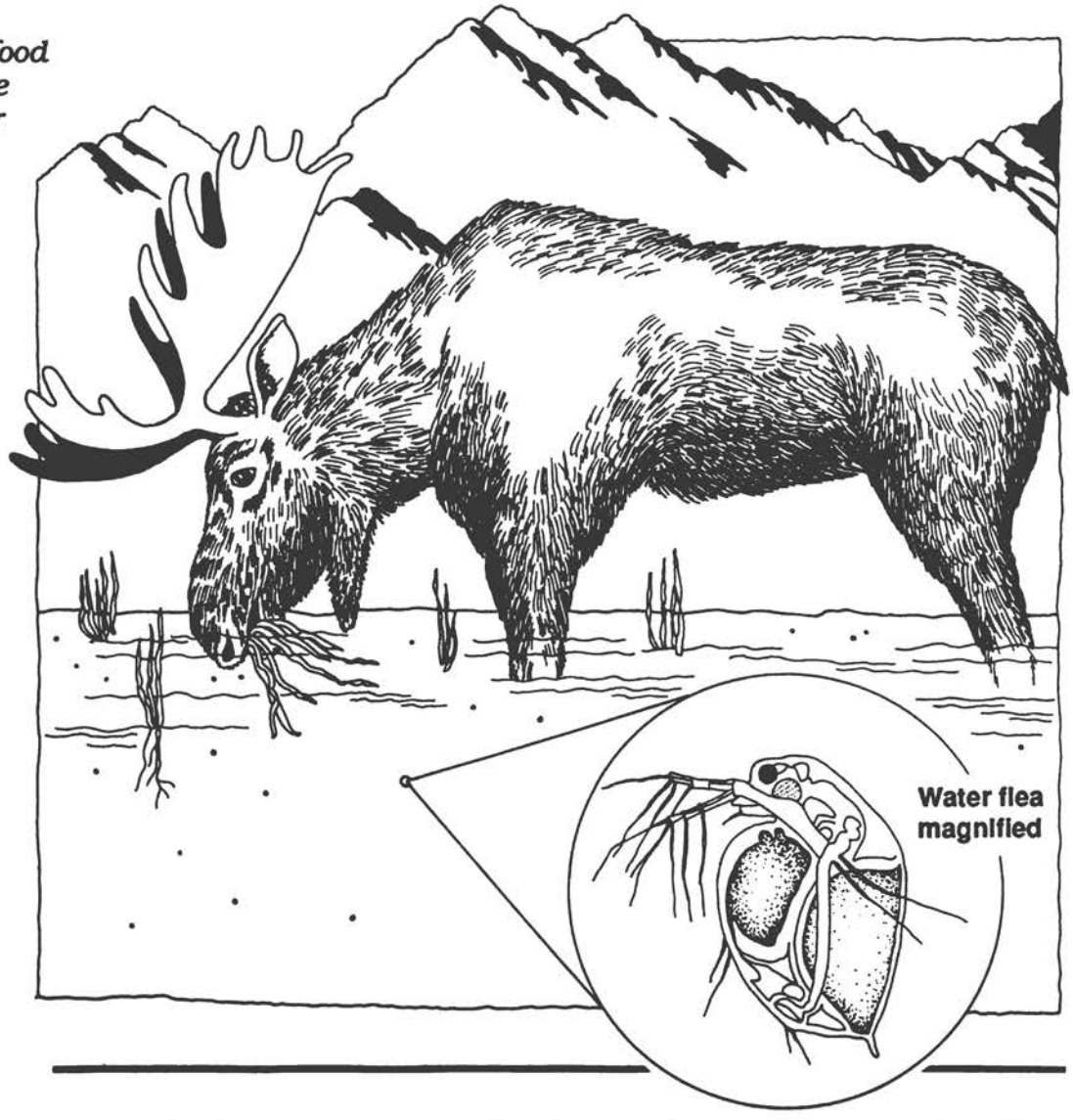
Oxygen-carbon dioxide cycle



From moose to flea

Figure 3-3

Water plants are food for the huge moose and the tiny water flea.



Water plants are an important food source for many animals, from the huge moose to the tiny water flea. In all the world, green plants are the only living things that can carry on photosynthesis (using energy from the sun to make their own food from water and carbon dioxide). For this reason they are called **producers.** Only green plants can produce the food animals depend on to live. Since animals cannot produce their own food and must eat plants for the energy they need, they are known as **consumers.**

Some aquatic plants also provide homes, protection, and hiding places for small creatures and newborns of many kinds. Nestled in the leafy fronds of underwater plants, these tiny water animals can live safely.

Water plants add a special kind of beauty to our world. Observe their bright colors and unusual shapes, and their gentle motion as they sway with the slow currents.

Where there's water, there are algae

Thousands of kinds of algae live in every imaginable wet environment in the world. They come in all sizes from microscopic (like the kind you will be growing) to gigantic (like the 46 ml [150 ft.] long brown kelp). They also come in assorted colors: blue-green, green, golden, brown, and red.

Microscopic algae are too small to see with just your eyes. But if you've ever seen a pond with what looks like green water you've seen algae by the millions. It's actually the algae that turn the water green, but you can see them only when they grow in great numbers.

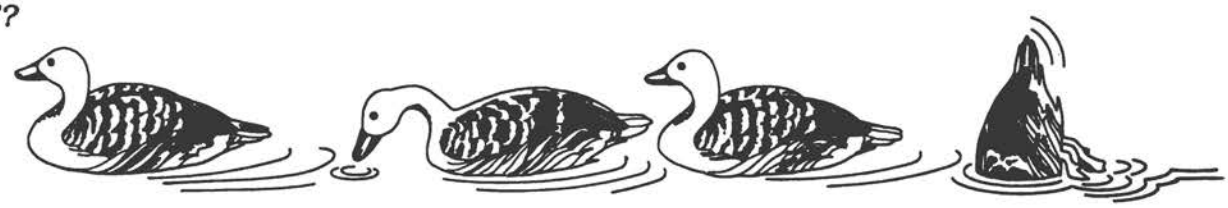
Algae are called "primitive" plants. Although they carry on many of the same activities as the "higher" plants, they do not have true roots, stems, and leaves.

Duckweed: food for fowl

Duckweed is a tiny floating plant which usually grows on the surfaces of ponds, lakes, and slow-moving streams. Duckweed is a favorite food of many waterfowl—ducks, for instance—which is how it got its name. Fish and snails will eat duckweed too.

Figure 3-4

Why do you think they call it "duckweed"?

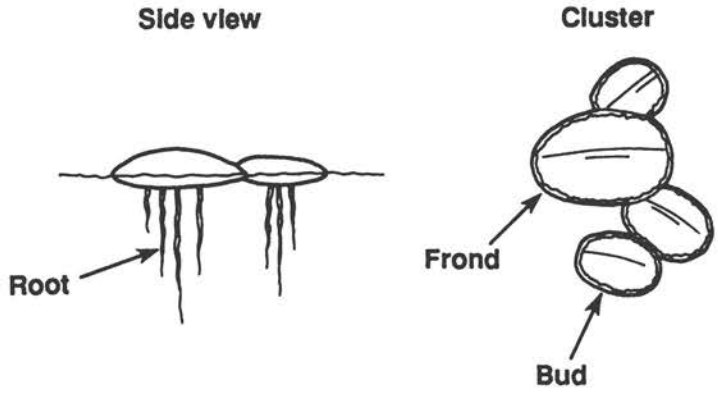


When growing conditions are good, duckweed plants will multiply very rapidly and form a lush carpet on the water's surface. This thick covering is lovely to look at. But it can cut off so much light from other underwater plants that it can kill them. The dead plants then decay, robbing life-giving oxygen from the water.

Healthy duckweed is a bright yellow-green. It is an unusual plant because it has no leaves or stems. Instead, it consists of one to three leaf-like fronds attached at the center, each with a single root hanging from it. Use your hand lens to observe a single plant up close.

Figure 3-5

Duckweed



Make new fronds

Duckweed flowers rarely, and almost never in captivity. So how does it make new plants? It reproduces by budding to form new fronds. Each frond grows its own root and then becomes an independent plant. In nature we can't usually observe a single frond of duckweed; the fronds tend to stay in groups until four or more plants are produced.

Elodea: a well-adapted plant

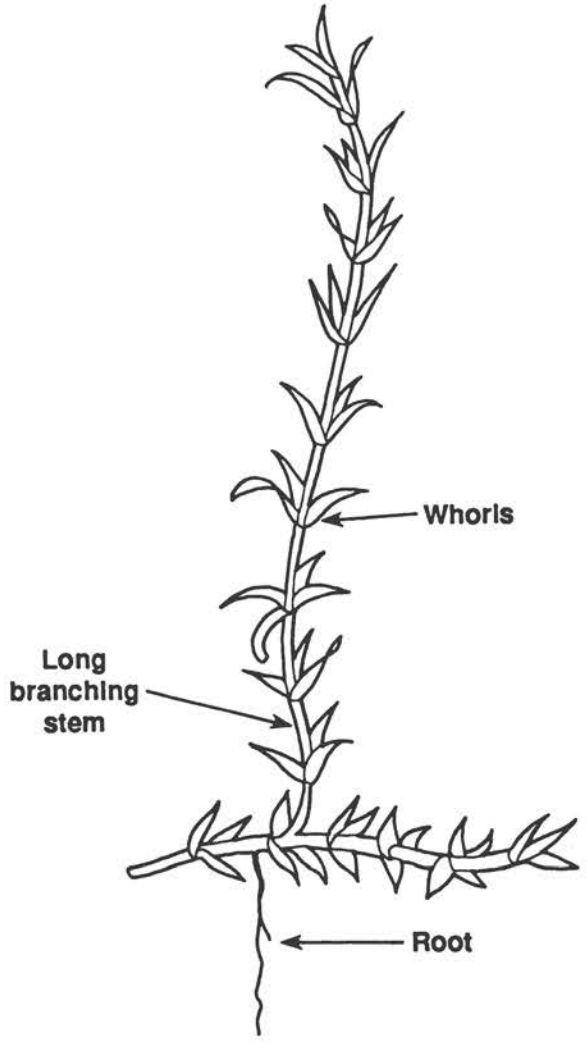
Elodea is a dark bottle-green plant commonly found in ponds and slow-moving streams. Its pointed leaves are arranged around the stem in tight whoirs (or circles) of three or more. The stem itself is rather brittle and may grow up to two feet long. Often the plant produces branches along its main stem.

You will find *Elodea* interesting to observe for many reasons. First, it can grow either attached or unattached. That is, it can float freely near the surface of the water or take root at the bottom. You may notice free-floating plants sending down long pale roots.

Also, when broken apart into smaller segments, each piece of *Elodea* can grow into a new plant. And like its parent, each new plant can either float or become rooted.

Figure 3-6

Elodea



Easy to grow

Elodea is very hearty and easy to grow. It thrives in strong light. But it can survive for a fairly long time in low light, too. Under poor lighting conditions, the plant will become thin and may lose some of its bright color. But if you put it back in bright light it will grow strong again.

All of these features are called "adaptive." They help the plant to survive under poor conditions. But they can also make the plant a problem for people, animals, and other plants. Can you imagine why? Well, first because *Elodea* grows so rapidly it can clog waterways. It can also crowd out other plant life both on the top and at the bottom of the water.

Student Instructions for Setting Up the Aquarium with Plants

1. Use part A for your aquarium. This is the one with the base still attached.

2. Put one plastic cup of gravel in the bottom of the aquarium.

3. Add water until the container is nearly full. Record how much. Use your ruler to measure how many centimeters (or inches) the water is from the top of the container.

4. Add the three kinds of plant life:

   - **1 or 2 sprigs of Elodea**
     Measure the plant and record its size.
     Place the plant in the aquarium.
     You can let it float freely, or you can plant it in the gravel.

   - **10 to 15 duckweed plants**
     Use your spoon to scoop up the tiny plants.
     Count the plants and record the number.
     Put the plants in the aquarium.

   - **4 droppersful of algae**
     Can you see the algae in your aquarium?
     Could you see it in the holding tank? Record what you see in your notebook.

5. Draw and label a picture of how your aquarium looks today. Use your hand lens to observe closely. Record what you see as accurately and as completely as possible.

LESSON 4

Adding Animals to the Aquarium

Think and Wonder

Take another close look at your plants. Think about them as food factories, or producers. Then meet the animals who will live with the plants in the aquarium. Like the plants, each animal is unique and has special needs. How will each animal get what it needs in your aquarium?

Materials

For you

- 1 science notebook
- 1 **Activity Sheet 2**

For you and your partner

- 1 aquarium set up in the previous lesson
- 2 medium-sized pond snails
- 2 guppies
- 1 hand lens
- 1 small dip net
- 2 spoons
- 1 clear plastic cup
- 1 dropper
- 1 metric ruler

Find Out for Yourself

1. With your partner, pick up your aquarium and a hand lens. Put them down in front of you so you can observe them during the class discussion.
2. You now know a lot about aquatic plants. Share what you have learned from your reading and from your own observations. Here are some questions to guide your thinking. Don't forget to look at your plants as you think about your answers.
   - Describe the three kinds of plants you placed in your aquarium. How are they alike? How are they different?

- What does it mean when we say that plants are producers? What do they produce?
- What are plants good for in an aquarium?
- What problems can these plants cause?

3. Pay attention as your teacher goes over the instructions on pg. 30 for adding animals to your aquarium. Ask questions if the instructions are not clear to you.
4. Listen while your teacher tells you how to record today's observations. You will use either an Activity Sheet or your science notebook.
5. Watch while your teacher demonstrates how to pick up your live animals from the holding tanks. Remember to handle them with great care, and try not to touch them with your fingers.
6. Now follow the directions, and work with your partner to add the animals to your aquarium. Don't forget to use your hand lens to observe closely. Each animal has a unique color, size, shape, and way of moving. Talk to your partner about what is special about your own animals. Then record your observations.
7. Time to clean up. Mop up your spills, return your supplies to the distribution center, and put your aquarium in a good location. It should get plenty of light but not direct sun. Try to avoid places like radiators or cooling vents where the temperature jumps up and down a lot.
8. Share your first impressions of your animals with the class. Everyone's animals will not be exactly like yours, but they might be similar in some ways. Talk about their similarities and differences.
9. Be a detective. Start looking for evidence that one living thing in your aquarium depends on another for some of its needs. What clues might you find? Record your ideas in your science notebook.
10. As you've discovered, you can learn a lot about your animals simply by observing them. Now read the selections starting on pg. 26 to learn more. Be ready to discuss what you read by the next lesson.

Ideas to Explore

1. Jump in. Imagine you are one of the fish or snails in your aquarium. What would it be like to live in water? Write all about it.
2. Many different kinds of fascinating animals live in small ponds, including frogs, newts, mosquito larvae, caddisfly larvae, planarian worms, tubifex worms, turtles, mussels, diving beetles, water striders, and water boatmen. Go to the library and research the life of one of them. Or make a scientific drawing of one of them. Then share what you find out with the class.

3. Just how slow is a snail's pace? Figure out a way to measure how far your snails can travel in ten minutes. At that pace, how long would it take a snail to travel one mile?

Reading Selection

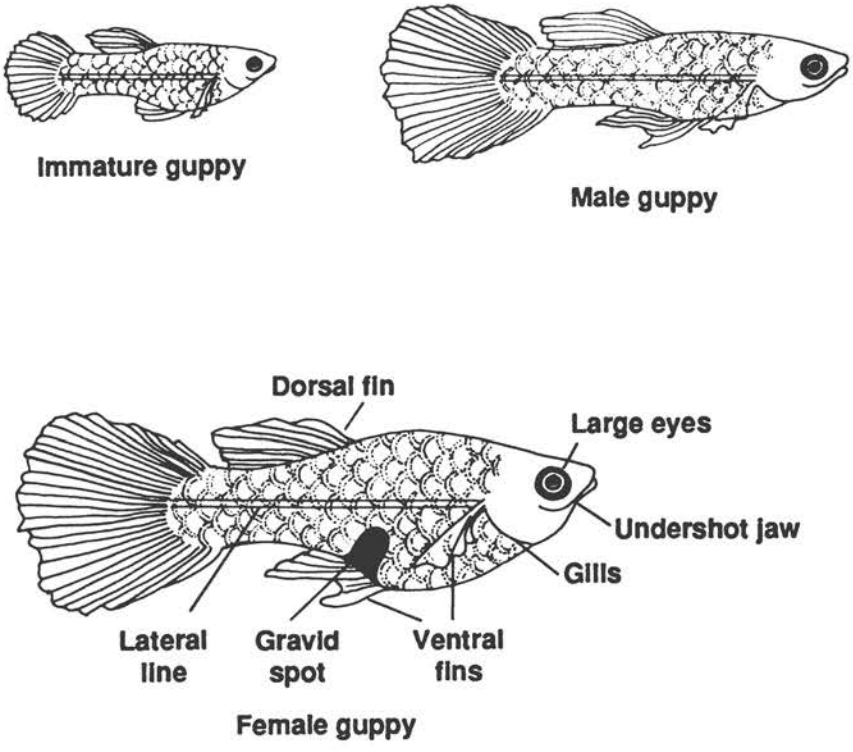
Guppies: Lively Little Fishes

You may have seen guppies in aquariums before. But did you know these strong, lively little fish are actually native to the tropical waters of northern South America and Trinidad?

The guppies in your aquarium will be either adult males, adult females, or immature (young) guppies. As you observe them, try to figure out which kinds you have.

Figure 4-2

Guppies



Notice too, the characteristics all guppies share:

- Their bodies are covered with protective scales which overlap like roof tiles. Use your hand lens to see them better.
- They have large round eyes, and see very well.
- They have a dark line (called the lateral line) running the length of their bodies. The lateral line is made up of sensitive nerve endings which detect pressure in the water.

- Like all fish, they breathe by pumping water through their mouth and over their gills. How many times a minute does your fish breathe?

Like a Peacock
The adult male guppy grows to a length of 3 cm (1 1/4"). He is very colorful, with shiny orange, pink, black, blue, or white markings. His body is slim, and his fins are pointy. He has a large handsome tail, and often fans it open for display—like a peacock—especially during the courting dance he does to attract the female.

What a Mom!
The female looks so different from the male, that you might almost think they were two different species of fish. The female is much larger than the male, and can grow up to 6 cm (2 1/2") long. She is a drab greyish-green and may have a black spot on the tail. Her fins and tail are rounded, and so is her body.

When pregnant, the female's abdomen becomes very swollen, and a black spot, called the gravid spot, appears on each side of her body just above the rear fin. She may have only one or two young, or she may have up to fifty at one time!

Babies Head for Cover
Baby guppies are born alive and fully formed. In order to survive, they swim immediately for the protective cover of plants. They are less than 1 cm (1/4") at birth, and become adults in about eight months. They resemble females in that they are rounded and dull colored, but are more transparent. Can you think of a reason why dull coloring is an advantage for a baby fish?

Reading Selection

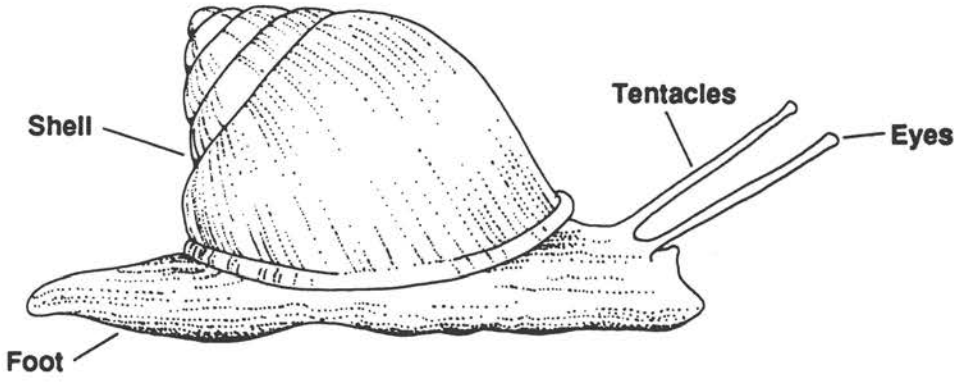
Snails: A Head at the End of a Foot

Snails are found all over the globe. There are over 1500 kinds that live on land, 35,000 kinds in the sea, and 80,000 kinds in fresh water. Snails belong to a large class of animals called gastropods. This odd sounding name has an equally odd meaning, which is "stomach foot." Can you guess why?

Gastropods have certain features in common. For instance, most have soft bodies enclosed by a protective shell. Part of the soft body sticks out from the shell. This is called the "foot" and consists mainly of muscles for movement. The snail's foot also secretes a thin film of protective mucus over which the tender body glides.

Figure 4-3

Pond snail



Like an antenna

The head (at the end of the foot!) has a set of tentacles with eyes. Snails can pull in these tentacles; you may be able to observe your snail moving them up and down, like a car radio antenna. The snail sees poorly. It can probably only tell the difference between light and dark. Snails are silent, and cannot hear.

The snail's mouth is on the underside of the head. Look for it when your snail is gliding along the side of the aquarium. The mouth is a small opening which opens and closes rhythmically. Inside is a tongue called a **radula**. The radula has tiny teeth which the snail uses to file down its food into tiny particles.

Looking for baby snails

Most snails reproduce by laying eggs. You may be lucky enough to find some in your own aquarium. Examine the plants and the sides of the aquarium for a small jelly-like mass in which you can see tiny,

developing snails. Look especially carefully close to the water line. Use a hand lens to watch them grow inside the capsule for a week or two. Then they will simply walk out, miniature copies of their parents.

As the baby snail's soft body grows, so must its protective shell. The snail makes its own shell, much the same way you make your own fingernails. Inside the snail's body, an organ called the **mantle** secretes the shell. Some snails are also protected by the **operculum**, a shell-like plate on the end of the foot. The snail can retreat into its shell and pull the operculum shut behind it like a door.

Pond snails are scavengers, and are a valuable part of the cleanup crew in their environment. They eat the soft tissues of dead plants and animals, but will also eat algae and other living plants. In turn, snails are food for fish, turtles, ducks, large insects, and mammals.

Student Instructions for Adding Animals to the Aquarium

1. From the holding tank, dip an inch or two of water into your clear plastic cup.

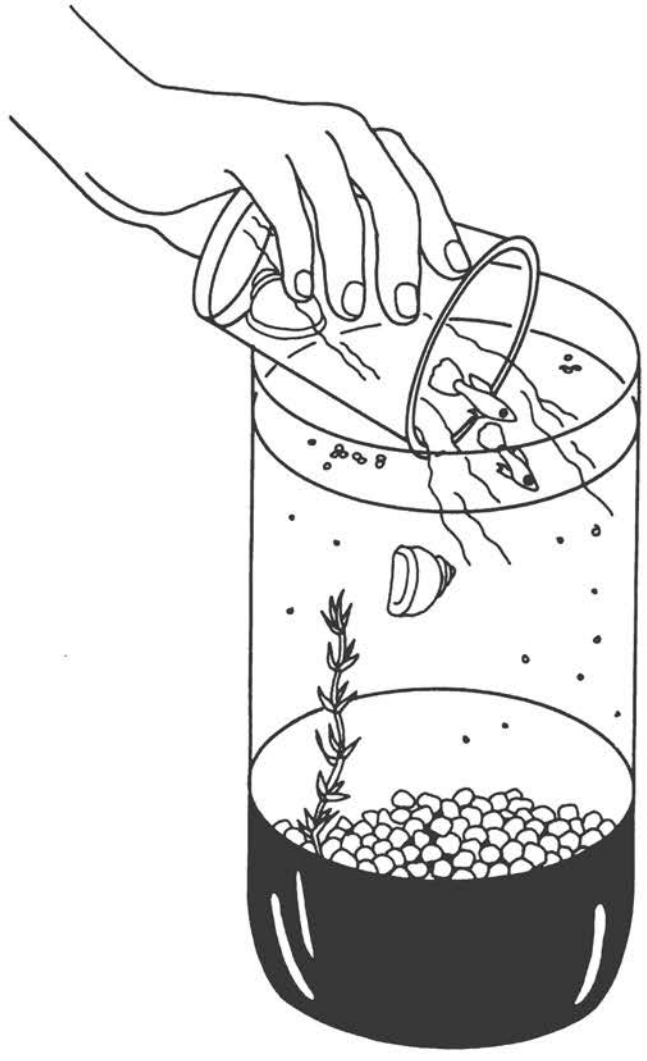
2. Use a spoon to scoop two snails out of the holding tank into your cup.

3. Catch two guppies in the net. Turn the net inside out, and touch it to the water to release the fish into your cup.

4. Use your hand lens to observe the animals in the cup. Notice their size, shape, and color. Watch how they move.

5. With your dropper, transfer some of the water from your own aquarium to the cup. Work slowly and carefully, adding the water gradually until the cup is about half full. This will help your creatures get used to the water in your aquarium before you put them into it.

6. Now pour the animals gently into your aquarium.



7. Use your hand lens again to observe your plants and animals. Record your observations. Make a new drawing of your aquarium to show how it looks today. Label everything in the drawing.

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LESSON 5

Observing the Completed Aquarium

Think and Wonder

Your aquarium is completely set up now. All the living and non-living elements are in place. What have you learned about this ecosystem so far? What evidence can you observe that certain elements depend on each other for some of their needs?

Materials

For you

1 science notebook

For you and your partner

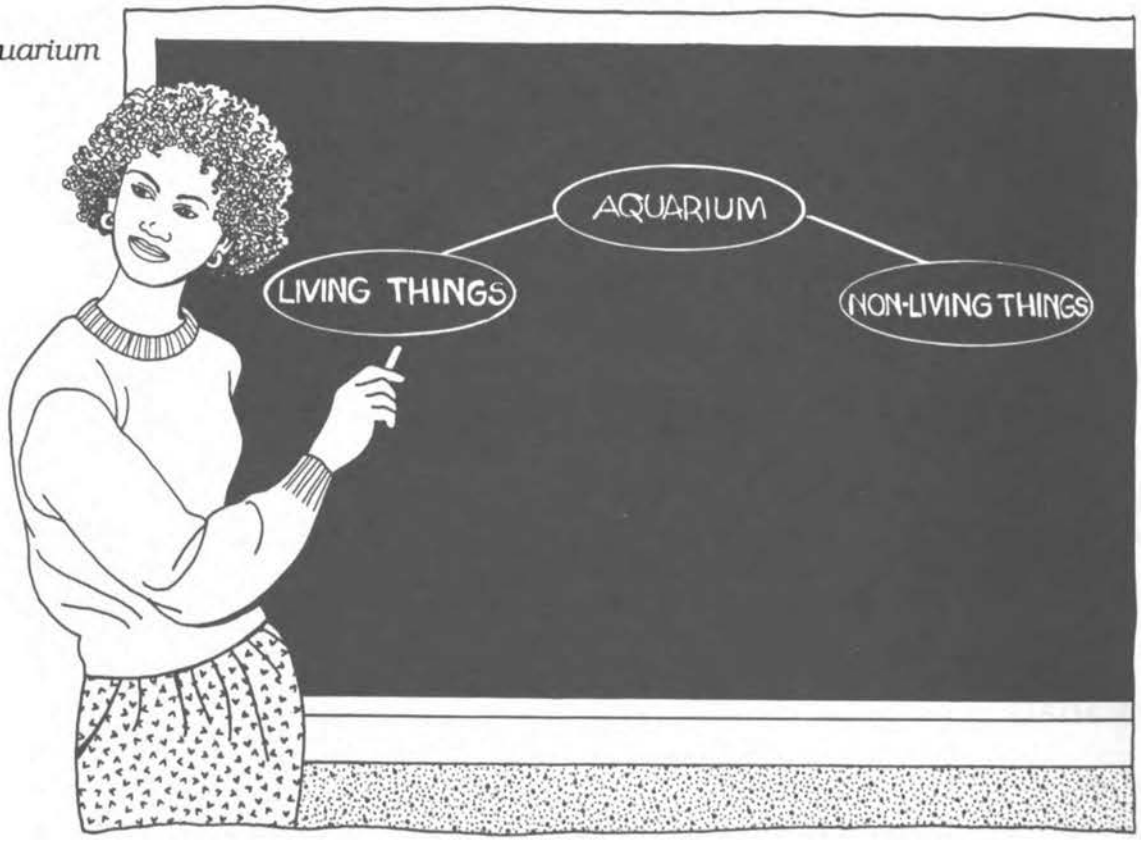
1 aquarium
1 hand lens

Find Out for Yourself

1. With your partner, pick up your aquarium and a hand lens. Place them in front of you so you can refer to them in the discussion that follows. Check your own ecosystem to see if you agree or disagree with other classmates' observations.
2. Take a few minutes to observe your own ecosystem first. Then share what you have learned from your observations and from your readings.
3. To help you see the different relationships in your aquarium, your teacher will record your observations in a special way known as webbing.
   - To begin the web, your teacher will write the main topic, "Aquarium," in the center of the sheet.
   - Then the teacher will add the words "living" and "non-living" to the web, like the one on the next page:

Figure 5-1

Starting the aquarium web



- How can you divide the "living" category into two smaller parts? Help your classmates add to the list of all the living and non-living elements in your aquariums.
- Now let's work on the idea of dependence in the aquarium. For example, which of the living things in the aquarium depend on water to live? Your teacher will draw an arrow from water to each of the creatures who need it to survive.
- Some things share an interdependent relationship. That is, each one gives something to the other, and each one gets something from the other. Describe one of these interdependent relationships. Your teacher will record the relationship with an arrow going in both directions.

4. It is important for you to continue to make and record observations of your ecosystem. Things will change, and you especially will want to record major events. (Don't forget to date each recording.) What are some changes to watch for in the coming weeks? Share your ideas with the class.
5. Write a paragraph or two in your science notebook on this topic: What would happen to your ecosystem if all the plants in it died? Draw some pictures to illustrate what you write.

Ideas to Explore

Aquatic ecosystems come in all sizes and shapes, from the little puddle to the mighty ocean. List as many aquatic ecosystems as you can think of. Then web the interdependent relationships that exist in them. Read more about some of these other aquatic environments. Then use what you have learned to create a mural of your favorite aquatic ecosystem.

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LESSON 6

Setting Up the Terrarium with Plants

Think and Wonder

Now we'll think about terrestrial ecosystems, ones that exist on land. What kinds can you think of? What kinds of plants and animals live there? How do they interact? Let's build our own terrestrial ecosystems. They are called terrariums.

Materials

For you

- 1 science notebook
- 1 **Activity Sheet 3**

For you and your partner

- 1 bottle part T with cap
- 1 bottle part C
- 1 bottle base
- 1 piece of nylon stocking
- 1 rubber band
- 2 plastic cupfuls of soil
- 1 spoon
- 1 cup of water
- 1 water dropper
- 20-30 each of grass, alfalfa, and mustard seeds
- Leaf litter, small stone, twig
- 2 toothpicks
- 1 hand lens

Find Out for Yourself

1. Join your classmates in a brief discussion of terrestrial ecosystems. Talk about some producer-consumer relationships you observed on your own playground or in the chart called "The Woodland Ecosystem."

2. Pay attention as your teacher goes over the instructions on how to set up a terrarium on pg. 41. Ask questions if the directions are not clear to you.
3. Listen while your teacher explains how to record information today, either on **Activity Sheet 3** or in your science notebook.
4. Watch while your teacher demonstrates how to pick up your materials today.
5. Time to get to work. After you collect your materials, follow the instructions to set up your terrarium. Don't forget to
   - Keep count of everything you put in.
   - Record everything you put in.
   - Stop from time to time to observe each item with your hand lens.
6. All finished setting up? Please return materials and clean up your own space. Then put your terrarium in a place where it will get plenty of light and is fairly warm.
7. What do you think you might observe in the terrarium during the next week? Share your predictions:
   - Which seeds do you think will germinate (sprout) first?
   - What will the sprouts look like?
   - Do you think every seed will germinate?
   - Will the dead plant material change? Will the rock change?
8. Read more about seed germination on pg. 39.
9. You now have two ecosystems to keep track of. Remember to observe and record your observations on each every day.

Ideas to Explore

1. In about a week to ten days, the germination process should be over. Then you can make some calculations. What percentage of seeds germinated? Compare germination rates of the different seeds. Did one kind of seed have a higher germination rate than the other two? What is the class average germination rate?
2. If you are interested in germination, you might enjoy doing a few experiments. Use seeds from your lunch (like apple, orange, peach cherry) or from the playground (acorn, dandelion, grass, maple). You could decide on a question to investigate, such as "Will seeds germinate faster in the light or in the dark?" Or you could simply lay the seeds on wet paper towels or sponges to see what sprouts.
3. In Latin the word for land is *terra*. How many English words can you list that relate to land and have "terr" in them?

Reading Selection

Growing Plants: How Seeds Spring to Life

If you think about it, it's kind of amazing. Given just water and the right temperature, a seed springs into new life.

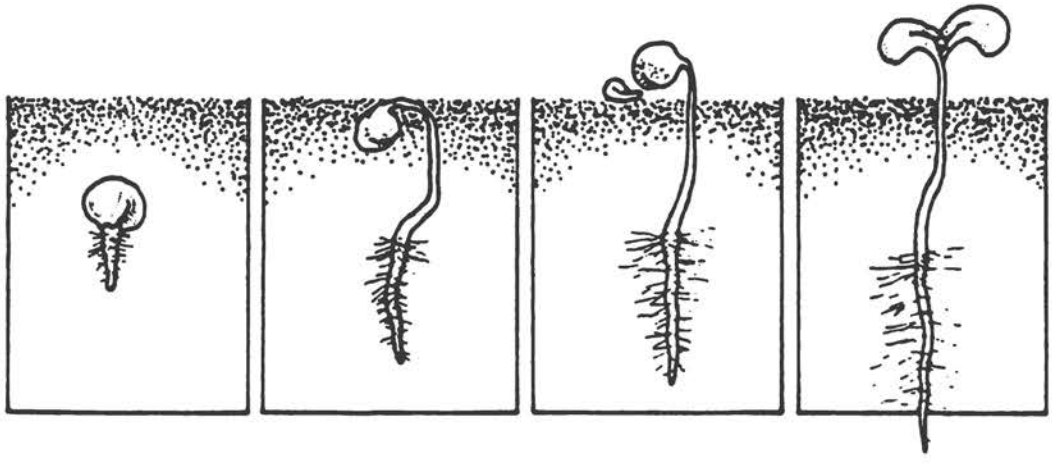
Moisture is very important to germination. Never allow seeds to dry out once you have planted them. Be sure to check your terrarium daily, and sprinkle it gently when the soil's surface appears dry.

Temperature is important too. Most seeds will germinate at 24° to 26° C (72° to 78° F). This is a good temperature for most people, too. So if **you** are comfortable, then probably all is well with your seeds.

It's interesting that most kinds of seeds do not need light to germinate. (That makes sense since they are underground.) But once a plant has emerged from the seed, it needs lots of light to produce its own food.

Figure 6-2

Seed germination

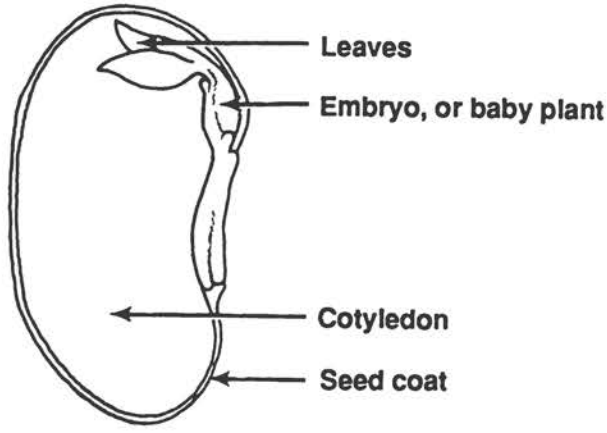


Tiny Food Warehouses

So what does the plant use for energy before it gets into the light where it can start making food? Each seed carries along its own built-in warehouse of food to provide it with enough energy to start growing. Look at this picture of the inside of a bean seed. Only a small portion is the embryonic (baby) plant. The rest is all stored food.

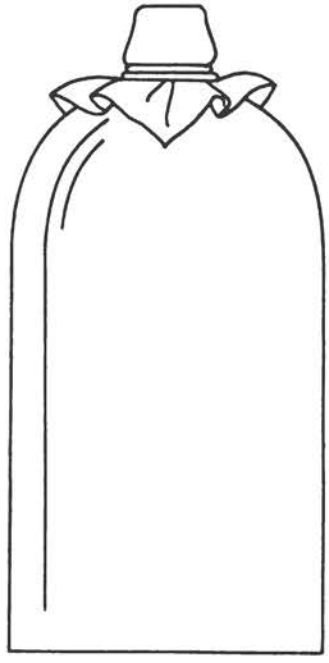
Figure 6-3

Inside of bean seed



In nature, not every seed germinates. Can you think of some reasons why? Well, some are eaten, some rot, and some fall into places where they can't grow (like parking lots or sewers, for instance). That is why most plants produce so many seeds—to make sure that life continues, no matter what.

Student Instructions for Setting Up the Terrarium



1. Use part T for the terrarium. Part C, slipped inside a base, will serve as a stand for part T.

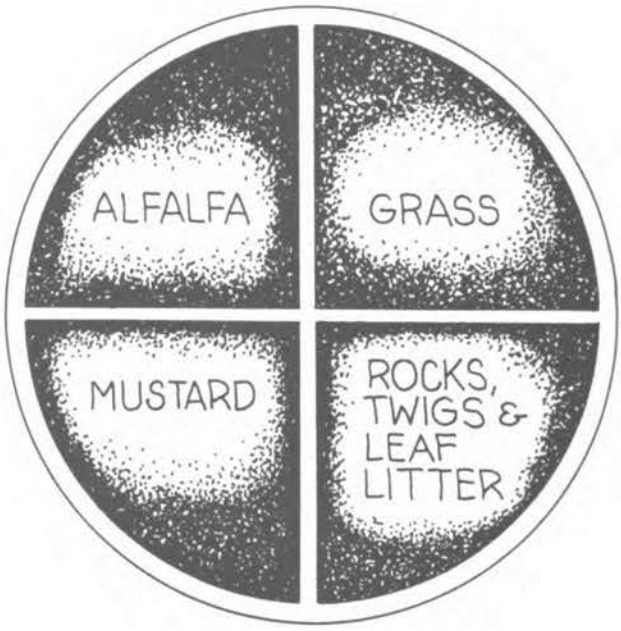
2. Remove the cap from part T. Place a square of nylon stocking over the mouth of the bottle. Wrap a rubber band around the neck of the bottle, above the screw-on part, to hold the piece of stocking in place.

3. Stand part T, neck down, on part C and a base. One partner will need to hold the terrarium steady while the other puts things in. Be sure to take turns doing this.

4. Add two plastic cups of soil. Try not to muddy the sides of the terrarium as you work.

5. Divide the surface of the terrarium into four equal parts. (You can use your toothpick to draw the dividing lines in the soil.) Each part will hold something different.

6. In three of the parts you will plant seeds. Plant all three kinds the same way:



- First, count your alfalfa seeds, and record the number. Sprinkle the seeds evenly on the soil's surface in their proper section. Use your toothpick to spread them out if necessary. Press them down gently with your fingers.

- When you have planted all the alfalfa seeds in their proper section, plant the grass and the mustard seeds the same way in their own sections.

- Use the water dropper to wet the soil thoroughly. Add water until it drips out of the bottom. Then replace the bottle cap to prevent leaks. Keep count of how many droppersful of water you add. It is important to know how much liquid the soil in your terrarium will hold before it begins to leak out.

7. In the fourth section add some dead plant material, like leaf litter, and a trig or two. A small rock would fit nicely, too.

8. Draw and label a picture of what you put in your terrarium. Include information on how many seeds you planted, what the dead plant material is, and what the rock looks like.

LESSON 7

Adding Animals to the Terrarium

Think and Wonder

Now that your seeds have germinated, how do they look? After you observe them, it's time to add some animals to your terrarium. And, you'll learn about crickets and isopods, first by observing and then by reading some more.

Materials

For you

- 1 science notebook
- 1 **Activity Sheet 4**

For you and your partner

- 1 terrarium planted in the previous lesson
- 1 bottle base for lid
- 1 hand lens
- 2 crickets
- 2 isopods
- 2 clear plastic cups
- 2 index cards for covering cups
- 2 spoons

Find Out for Yourself

1. With your partner, pick up your terrarium and a hand lens, and place them where you can observe the terrarium during the discussion. As other classmates share their observations, check your own terrarium to see if you agree or disagree.
2. First, take a few minutes to observe your own terrarium. Review any notes you have made in your science notebook.
3. Share with the class what you have observed in your terrarium and what you have learned by reading about seed germination. Here are some questions to guide you:
   - How long did it take for your seeds to germinate?

- How many of your seeds germinated?
- Can you observe any roots?
- Do you remember why we call plants producers? Why did we wait until now to add the animals?
- How are these plants like the ones we put in the aquariums? How are they different?

4. Go over the instructions on pg. 50 on how to add isopods and crickets to your terrarium. If there is anything that you don't understand, ask questions.
5. Listen while your teacher explains how to record today's observations. You will either use an Activity Sheet or your science notebook.
6. Watch while your teacher shows you how to pick up your animals from the distribution center. Remember: these are living animals. Be gentle.
7. Follow the directions to pick up your isopods and crickets and add them to the terrarium. Don't forget to stop, observe, and record.
8. Put your terrarium back in the location reserved for it. Return your supplies to the distribution center.
9. Share what you observed about your crickets and isopods with the class.
   - How are your two crickets alike?
   - How are they different?
   - How are the crickets and isopods alike? How are they different?
   - What body parts did you notice?
   - What are some things that the animals did?
10. Now read the **Reading Selections** starting on pg. 47 to learn lots more about your new animals.

Here is an important reminder. You and your partner are responsible for observing your two ecosystems every day. Be sure to record your observations in your science notebook. As you observe, keep looking for interdependent relationships.

Ideas to Explore

1. Can you observe some ways that crickets behave that remind you of ways humans behave?

2. Find out if crickets can really tell temperature. See if you and your partner can figure out the temperature in Celsius and Fahrenheit by using these math challenges:

   - To find the temperature using the Celsius scale, count the number of cricket chirps for one minute, divide that number by seven and then add four. The total should be the same as the room temperature.

   Our cricket (_____ **÷ 7) + 4 = degrees C.**
   number of chirps in one minute

   - To find the temperature using the Fahrenheit scale, count the number of cricket chirps for fifteen seconds, then add forty to that number. The total should be the same as the room temperature.

   Our cricket _____ **+ 40 = degrees F.**
   number of chirps in fifteen seconds

3. Would you like to try trapping some "wild" isopods outside? Here's how:

   - Slice a large potato in half and hollow out each half. (Get an adult to help you with that part.)
   - Put the two halves back together and secure them with string, rubber bands, or toothpicks.

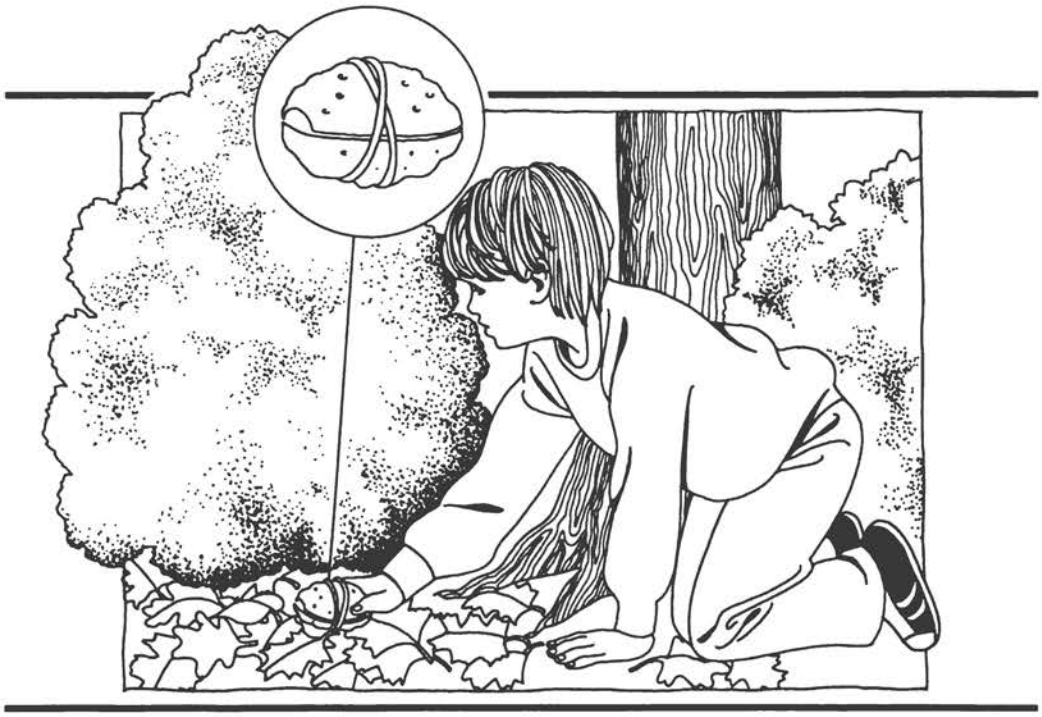


Figure 7-1

Trapping "wild" isopods

- Cut a bit off one end to make an opening for the isopods to enter the trap.
- Place the trap in a spot where it is cool and damp, and there is some leaf litter.
- Cover it with a little soil and some dead leaves.
- Check the trap every few days to see if any isopods have entered to feed on the inside of the potato.

Reading Selection

Isopods: More Like a Lobster!

Scientists call them isopods, which means "equal legs." But you probably know them by some other name, like wood louse, pill bug, sow bug, or roly poly. Isopods are not insects, but are close relatives of lobsters, crabs, and shrimp. In fact, most isopods live in water. There are a few terrestrial kinds of isopods, though, and yours belong to this group.

Examine your isopod with a hand lens. You will see a flattened oval body covered by smooth, hard plates, almost like a suit of armor. At the head end is a pair of antennae and two tiny eyes.

Now, count the pairs of legs. If your isopod has six pairs of legs, it is very young and has not experienced its first molt yet. After the molt it has seven.

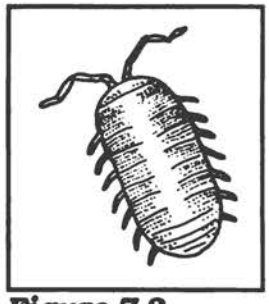


Figure 7-2
Isopod

What is a molt? That stiff suit of armor is actually a skeleton worn on the outside, called an **exoskeleton.** And while it is very good protection, it cannot grow. So in order to grow, the isopod must shed its old exoskeleton, or "molt."

Half a Molt Is Better Than None

It's odd: the isopod only sheds half of its exoskeleton at a time, usually the front half first. Check your isopod's color. If it is all dark gray or black, then it has been wearing this exoskeleton for some time. If it is light gray (or maybe even half light and half dark) it has just experienced a molt or is mid-way through one.

Like its aquatic relatives, the isopod needs moisture at all times because it breathes through specialized organs similar to fish gills. Keep this in mind whenever you schedule a rainshower for your terrarium. Make sure the isopods' corner gets wet too.

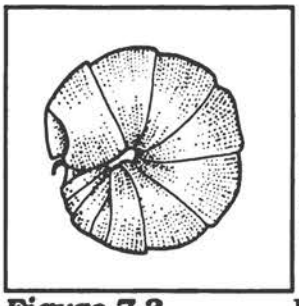


Figure 7-3
Pill bugs curl up into a ball for protection

The isopod has many predators, mostly birds, lizards, and spiders. (That is why some of them, the pill bugs, curl up into a ball to protect themselves.) Besides being a food source, isopods perform another valuable service. They are scavengers, part of the cleanup crew that eats dead and decaying plant matter.

Be on the lookout for baby isopods. If you are lucky enough to have a pregnant female, her brood pouch may be bulging with up to 200 eggs! How many legs will each baby have? How do you think they will look?

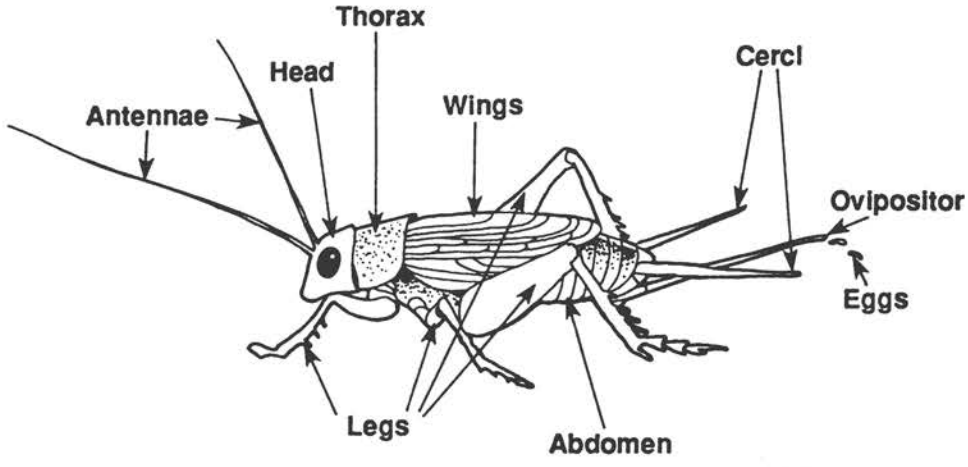
Reading Selection

Crickets: A Closer Look

You probably recognize the cheerful chirping of crickets at night. But have you ever looked at one up close? Crickets are insects, and like all insects their body is divided into three main parts: the head, the thorax (or mid-section), and the abdomen. Look at your own crickets to identify these parts.

Figure 7-4

Female cricket



On the head are the eyes, the chewing mouth parts, and the antennae. (Use your hand lens to get a closeup look.) The antennae are almost as long as the cricket's whole body. They tell the insect about the feel, taste, smell, humidity, and temperature of the world outside. You may observe your crickets pulling their antennae through their mouths. Why do you think they do that?

On the thorax (or mid-section) you will find four wings which give you clues about your cricket's age. A very young cricket, or nymph, has no wings at all. A larger "teenage" or adolescent cricket has very short wings. And the largest crickets, the adults, have full-grown wings.

Although this kind of cricket's wings are weak, they do have a purpose: chirping. But only the adult males can chirp, by scraping one wing against another. Why do you think male crickets chirp?

Mighty Jumpers

Also attached to the thorax are the cricket's mighty legs. Count them. Notice that each pair is different. Which are the most powerful? Crickets can jump about 60 cm (2 feet), which is about equal to a 180-cm (6-foot) tall person jumping 4,320 cm (144 feet)!

On the abdomen, or back section, look for more clues to your cricket's identity. Both males and females have two short spines called **cerci** projecting out of the rear of the abdomen. These are used to detect vibrations in the air and ground. But only the adult female has a third projection: a long, dark, needle-like **ovipositor** which she uses to place her eggs in the ground.

The eggs are very small, banana-shaped, and yellowish-white. They usually hatch out in two to three weeks. But the newly hatched babies (or nymphs) are so tiny that it is difficult to see them without a hand lens. In four to eight weeks, after a series of molts, they are mature adults.

Crickets are food for such animals as birds, snakes, lizards, frogs, and toads, and are a valuable part of the food chain. But they can also do a lot of damage to plants, and, in some places, farmers consider them pests.

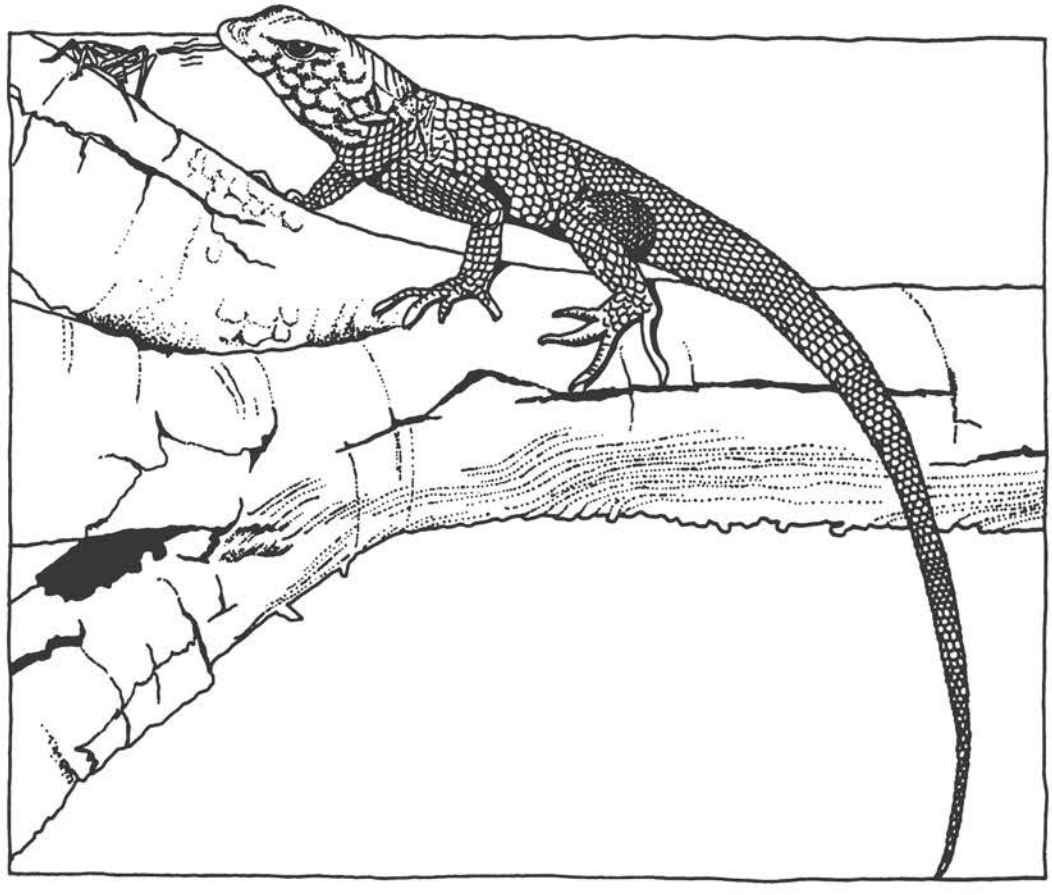


Figure 7-5

Crickets are a valuable part of the food chain

Your own observations will tell you a lot about how the cricket moves, eats, explores, defends its territory, mates, lays eggs, and hides. But to learn how it hears with its legs or how it breathes through holes in its body, do some research in the library.

Student Instructions for Adding Isopods to the Terrarium

1. Use a spoon to scoop two isopods into your clear plastic cup.

2. Return to your seat and observe your isopods closely with the hand lens. Record your observations. Include information on size, color, movement, and body parts. Illustrate your observations.

3. Place your isopods gently in the terrarium and watch what they do for two or three minutes. Record your observations.

Student Instructions for Adding Crickets to the Terrarium

1. Capture two crickets. There are lots of different ways to do it. Be sure you are very gentle.

- If they are cold and slow-moving, you may be able to scoop them up easily with your cup and spoon.

- Or you may be able to shake one or two off of the egg carton, twig, or paper towel in the holding container into your cup.

- Or, clamp your upside-down cup over the cricket, slip an index card underneath the cup, and turn the cup over with the cricket inside.

2. Cover the cup with the index card and return to your seat to observe the cricket with the hand lens. Record your observations. Include information on size, color, movement, and body parts. Illustrate and label your observations.

3. Gently place your crickets in the terrarium and watch what they do for two or three minutes. Record your observations.

4. Cover the terrarium with one of the bottle bases to keep the crickets from hopping out.

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LESSON 8

Joining the Terrarium and Aquarium

Think and Wonder

Today you will compare the plants and animals in your terrarium to the ones in your aquarium. Then you will put together all three bottle parts to make an "ecocolumn." In the world around you, water and land ecosystems are linked to each other. Now your aquarium and terrarium will be linked, too.

Materials

For you

- 1 science notebook

For you and your partner

- 1 terrarium
- 1 aquarium
- 1 connector, bottle part C
- 4 strips of tape
- 1 hand lens

Find Out for Yourself

1. Pick up all three bottle parts: the aquarium, the terrarium, and the connector. The connector is the part you have been using as a stand for your terrarium.
2. Take a few minutes to observe your two ecosystems and to review the notes in your science notebook. Then share what you have observed and what you have learned about the terrarium through readings.
   - What dependent relationships have you noticed in the terrarium?
   - What interdependent relationships have you noticed?
3. Look at the web of aquatic relationships from Lesson 5. How did the class develop it? Summarize in your own words.

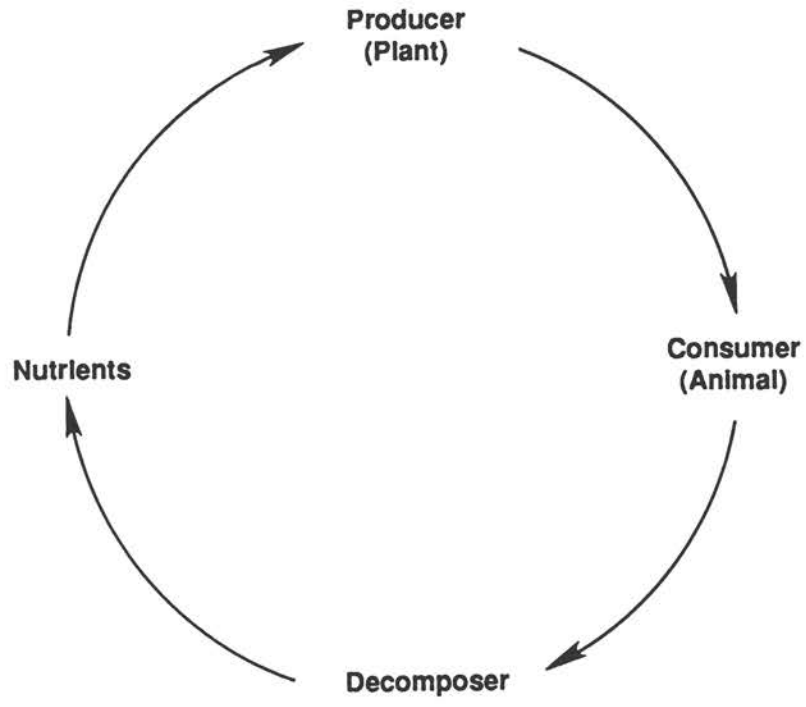
4. The same kind of web will help to organize your thoughts about the relationships in the terrarium. Take an active part in building the new web.
   - First, discuss the terrarium web with your partner for three or four minutes.
   - Draw a quick sketch of your web in your science notebook.
   - Join your class to discuss your ideas. Then help to construct the new web. Work through each element (both living and non-living) until the web includes everything in the terrarium.
5. Now look at both webs and get ready to compare a pair of living things. Here are some questions to get you started:

   Compare two plants, one from each ecosystem.
   - How are the plants in the two systems alike?
   - What do they need to live?
   - What do they give to their ecosystem?

   Compare two animals, one from each ecosystem.
   - What does each animal need to live?
   - How do they move?
   - How do they protect themselves?
   - What do they give to their ecosystems?
6. In the real world, no ecosystems exist alone. They all touch each other in some way. Your ecosystems will touch each other, too. Today you will put them together into a three-part stack called an ecocolumn. With your teacher, go over the instructions on pg. 57.
7. Put your ecocolumn away in the right place. Hold it from the bottom and walk slowly. Return all other supplies to the distribution center.

Figure 8-1

The Nutrient Cycle



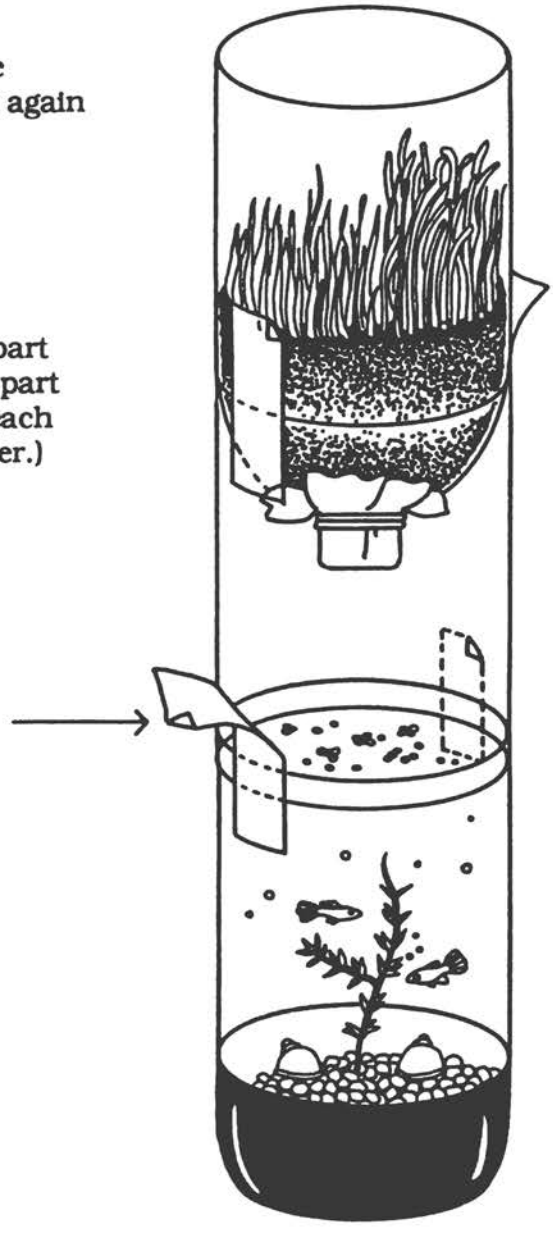
8. Look at the two charts one more time, but this time think really big. How could one entire ecosystem be related to another? In other words, how could something that happens in your terrarium affect your aquarium?
9. Can you think of a real-world example of a terrestrial system and an aquatic system that affect each other? Share your ideas.
10. In your science notebook, write a paragraph or two to describe a change that might occur in your terrarium. Then predict how a change in the terrarium might cause a change in the aquarium.
11. It is more important than ever for you to make daily observations and to record them in your notebook. There is a lot going on in your ecocolumn, and you will need to remember all of it.

Ideas to Explore

1. In your science notebook, write down the name of a natural disaster (like a forest fire, tornado, hurricane, or drought) and make a list of all the different ways it would affect the ecosystem in one special place. Pick a place you know well, like your yard, park, or schoolyard.
2. Look through newspapers or magazines for examples of both natural and human-made ecological disasters. Bring them in to share with the class.

Student Instructions for Putting the Ecocolumn Together

1. Remove the bottle cap from the base of the terrarium. Keep it. You may want to use it again later.
2. Pick up four strips of tape.
3. Stack your bottles as pictured below.
4. Use two pieces of tape to attach part A to part C. Use two pieces of tape to hold part T to part C. (Helpful hint: Turn back one corner of each piece of tape to make it easier to get off later.)



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LESSON 9

Upsetting the Balance

Think and Wonder

Every ecosystem in the class has changed in some way since you set them up. But some may have changed more than others. What caused these changes?

The changes in your ecosystems happened naturally, without your interference. What might happen if you did interfere with the natural balance and polluted your ecosystem?

Materials

For you

1 science notebook

For you and your partner

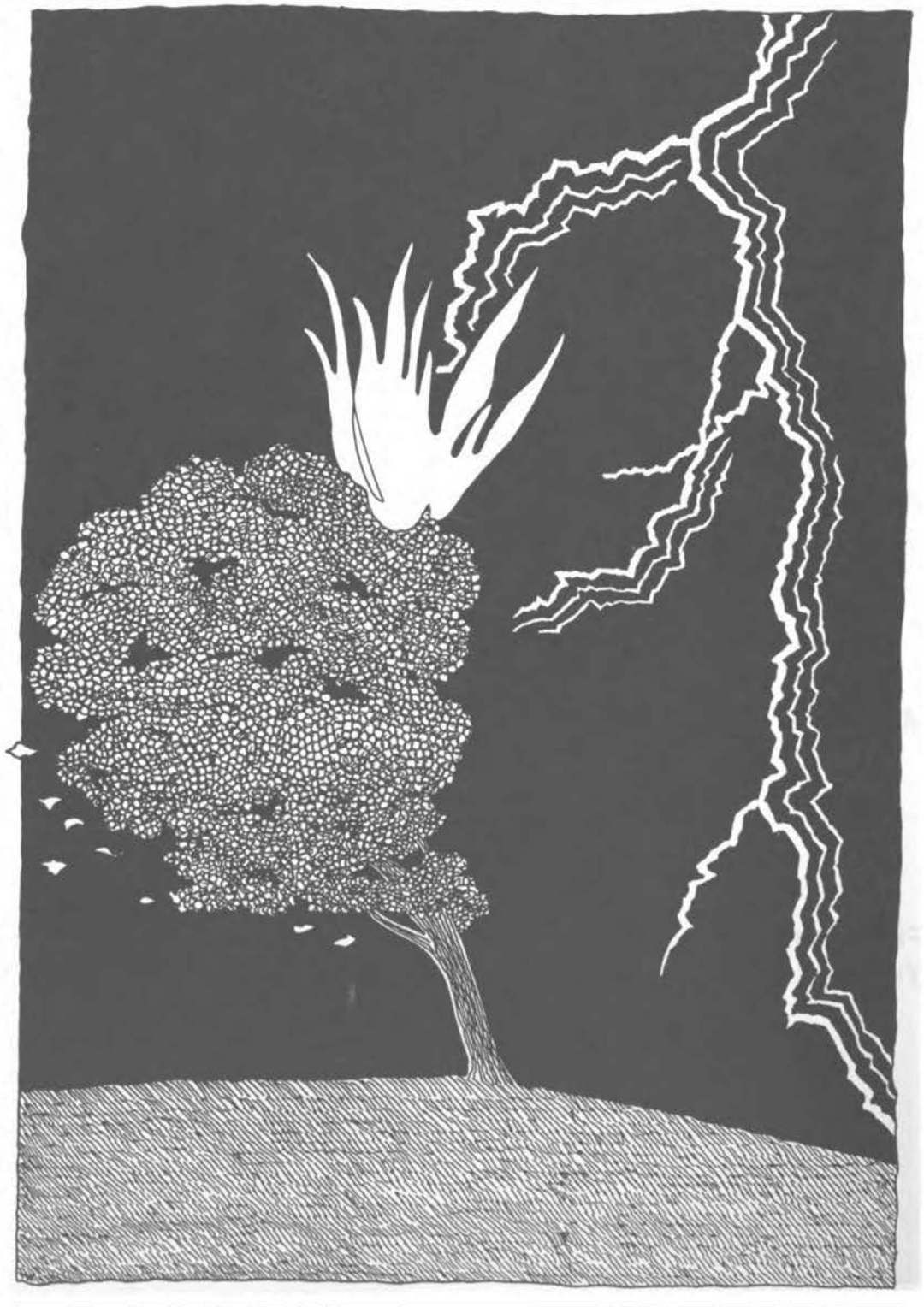
1 ecocolumn

Find Out for Yourself

1. If something has happened to unbalance your ecosystem, show it to the class. Explain what happened, and what the consequences are.
2. Nature unleashes some powerful unbalancing forces, like tornadoes and hurricanes. Describe to the class how these forces can unbalance an ecosystem.

Figure 9-1

A natural disaster



3. Natural disasters are only a part of the reason why ecosystems become unblalanced. Humans are another part, because we pollute. In your notebook, jot a quick list of all the ways you can think of that humans pollute.

4. Share your list with the class. Your teacher will record your ideas.
5. Now look at the class list of ideas. If you wanted to set up an experiment, which of the pollutants your class listed could you add to your own ecosystem to study? Keep these limits in mind:
   - The pollutant has to be fairly common and easy to get.
   - It cannot be toxic (poisonous) to people in small doses.
6. In the next class you will plan pollution experiments using three common substances: vinegar (to imitate acid rain), salt (to imitate salt used to de-ice roads), and fertilizer (to imitate agricultural run-off). To plan a good experiment, you need to know more about these three pollutants. Read the selections starting on pg. 62 for background information.
7. Remember to continue your daily observations and recordkeeping.

Ideas to Explore

Keep your eyes open for news about pollution in newspapers and magazines. Bring in your articles and share them with the class.

Reading Selection

The Story behind Acid Rain

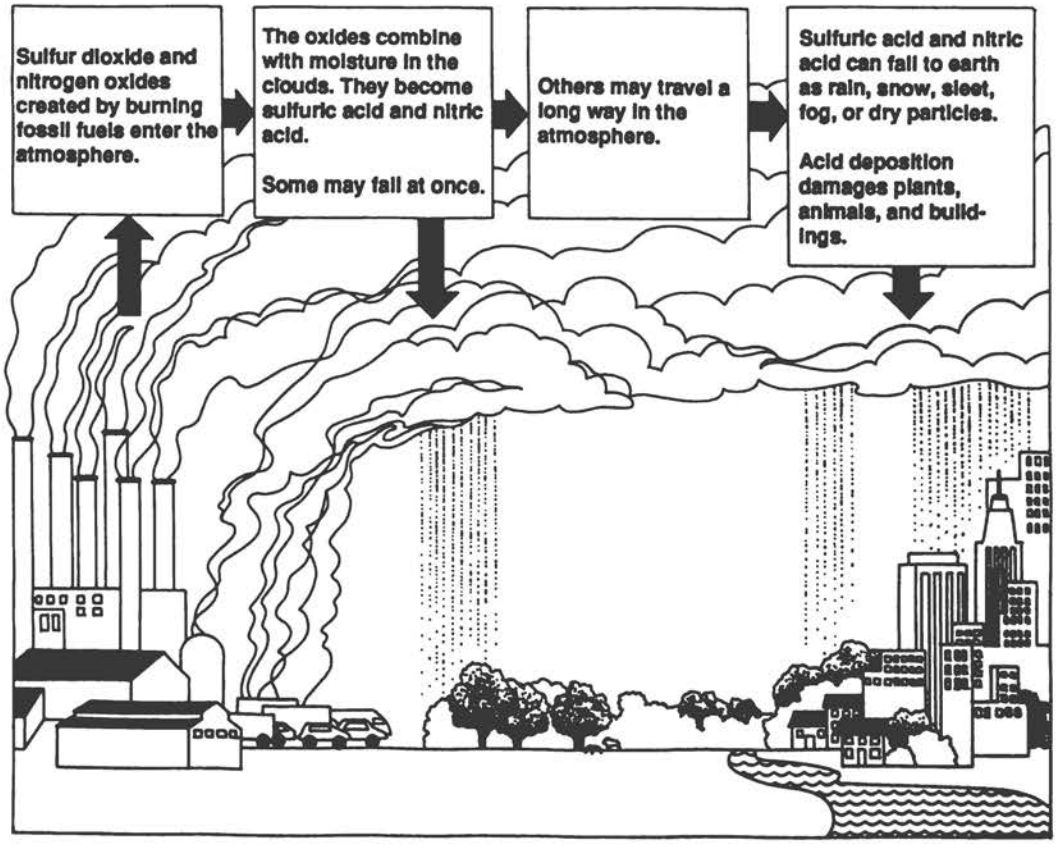
There is a lot of talk these days about acid rain. Do you know what it is? Or the part humans play in causing it?

The problem begins when we burn fossil fuels, which are coal, oil, and gas. When we burn these fuels in our cars, homes, or factories, they release sulfur and nitrogen, which then combine with oxygen in the air. (In this new form they are known as sulfur dioxide and nitrogen oxides.) Then, both pollutants escape through smokestacks, chimneys, and tailpipes, and climb skyward.

Eventually the oxides become trapped by moisture in the clouds and form new chemicals called acids. These acids (sulfuric acid and nitric acid) fall to earth in rain, snow, sleet, hail, or fog. This is acid rain, or more correctly, "acid deposition."

Figure 9-2

How acid rain is formed



How do we measure acidity?

All chemicals can be divided into three categories: acid, base, or neutral. You already know some acids, such as vinegar and lemon juice. They have a sour, biting taste.

The chemical opposite of an acid is called a base. Some base chemicals you might know are baking soda, liquid bleach, and milk of magnesia (for acid indigestion!)

Do you know what happens when you mix an acid with a base in the right proportions? You make a neutral substance (one that is neither acid nor base.) In other words, you have neutralized the acid with a base.

Just as there are degrees of temperature, there are degrees of acid and base. We use a special scale called the pH scale to measure acid and base.

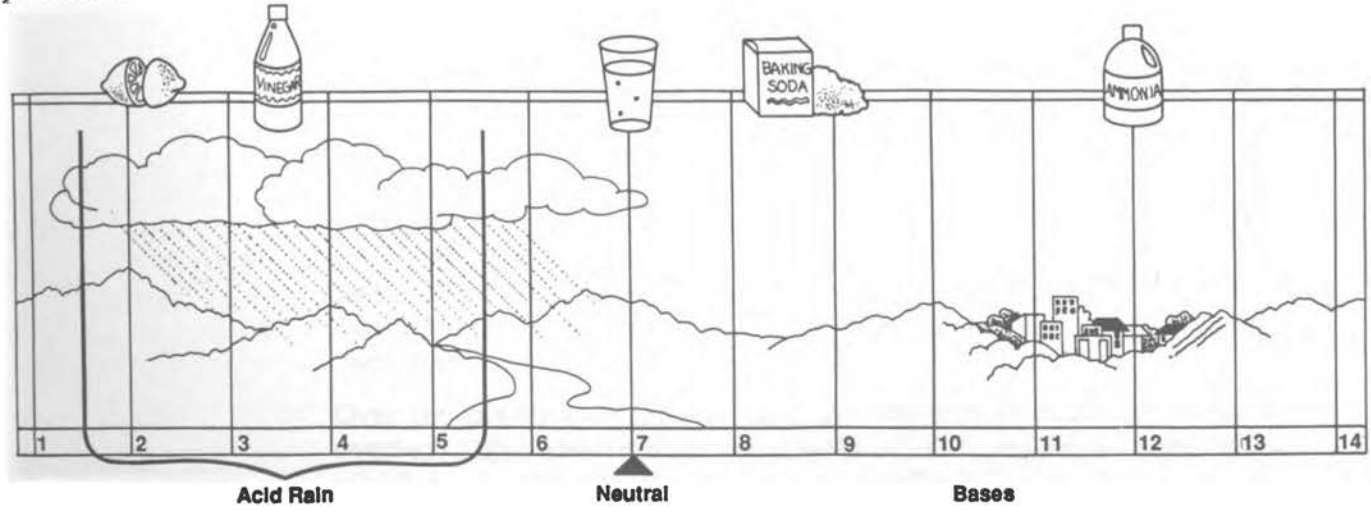
The pH scale has a range from 0 (extremely acid) to 14 (extremely base). In between is 7, or neutral. Remember: the lower the number, the more acidic something is.

Use the pH chart to answer these questions:

- Look at the pH chart and find pure distilled water. What is its pH ? Is it acid, base, or neutral?
- Now find normal rain on the scale. You will see that normal, uncontaminated rain is slightly acidic. What is its pH?
- Locate the section labeled acid rain. What is the range of pH for acid rain? What are some other things that fall into the same range?

Figure 9-3

pH scale



Why are we worried about acid rain?

Although a little acid in rain is normal, a lot becomes an unbalancing force in many ecosystems, especially aquatic ones. For example, different kinds of animals have different levels of sensitivity to acid. So, while an adult wood frog can tolerate a pH level of 4, certain fish (like the rainbow trout and the smallmouth bass) cannot survive below pH 5.

Clams, crayfish, snails, and mayflies are in trouble at pH 6. The eggs and larvae of aquatic creatures seem even more sensitive to low pH. Fewer eggs hatch, and fewer creatures grow to adults.

Experts have a harder time measuring acid rain's effects on terrestrial ecosystems. But it seems that too much acid in the soil may harm plants' root systems, and that acid rain is damaging the leaves of sensitive trees.

What can we do to help?

Remember, when we burn fossil fuels, we generate the pollutants that form acid rain. The energy in fossil fuels heats, cools, and lights our homes, powers our vehicles, cooks our food, and runs our machinery. We aren't going to stop doing these things altogether, but we can each try to cut down. Every time we walk or bike instead of driving, or turn down the heat, or shut off extra lights, we help to prevent pollution.

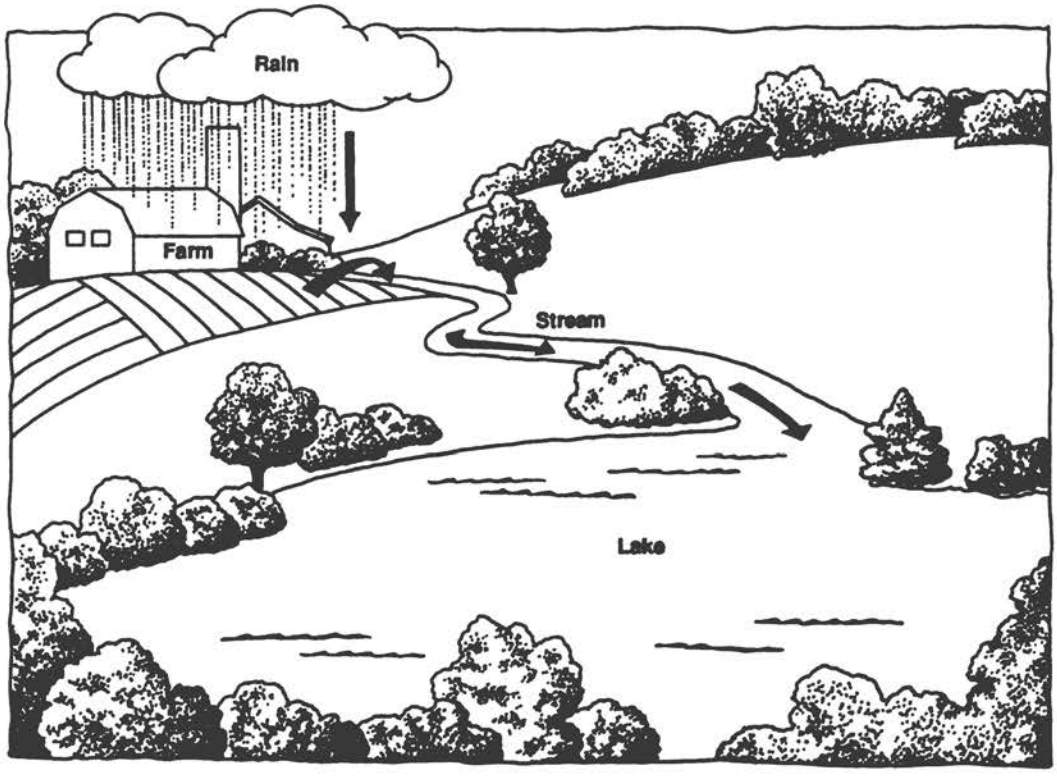
Reading Selection

Crops and Cows—What's the Problem?

Agriculture, or farming, grows the fruits, vegetables, and grains we need to survive. But the fertilizer used to grow these crops also pollutes our water systems. How? Chemical fertilizers run off from fields, and animal manure runs off from barnyards and feed lots. Both are washed into ponds, streams, rivers, oceans, and even underground water supplies.

Figure 9-4

Agricultural run-off



How can a fertilizer pollute?

These fertilizers are rich in nutrients, especially nitrogen, phosphorous, and potassium. That's how they help crops to grow. But if you think of a pollutant as too much of any one thing, then fertilizers can be pollutants, too. They provide too many nutrients in a water system. So the body of water and the plants in it become too "well fed."

Over-fed plants can grow so quickly that they choke waterways. When overfed, algae also reproduce rapidly. (This is called an algae bloom, which turns the water a bright green.) When the plants use up the nutrients in the water, they die and rot. Then bacteria feed on the dead material, using up valuable oxygen in the process.

Manure is rich in nutrients too, and also carries bacteria with it. In the water, these bacteria have a population explosion which robs the water of oxygen. In serious cases, the bacteria may use up so much oxygen that the plants and animals in the water suffocate.

What can we do?

Certainly we want to continue to harvest good crops and to keep cattle. So we will need to find solutions for the run-off problem. Many experts are working to find ways to keep pollutants out of the water. They're doing research to determine exactly how much fertilizer to spread on the soil for each type of crop. That way we won't use any more than we need, and the extra fertilizer won't wash into the water. Other scientists are experimenting with ways to recycle manure cheaply. What are your ideas?

Reading Selection

When Salt Isn't Safe

If you have ever ridden in a car in a snowstorm, you know that the roads can get awfully slippery. So, in parts of the country where winters are fierce, the highway departments spread a mixture of sand and salt on the roads to make them safer for traffic. The sand helps tires get a grip, and the salt melts ice.

Figure 9-5

Salt helps melt the ice, but it can be harmful, too.

Although we want people traveling on these wintery roads to be safe, we are concerned about the damage salt does. When spring comes and the snow and ice melt, salt dissolves in the water and gets washed or sprayed by passing cars out to the roadside. There it coats the bark of trees and soaks down into their roots. It "burns" the tops of tender

shoots just coming out of the soil. It covers plants that roadside animals like rabbits and woodchucks depend on for food and shelter. It travels down through the soil to the water system below ground, and eventually into other bodies of water.

When salt enters a body of water (like a stream or a lake) it can have harmful effects there too. Both plants and animals are sensitive to salt in different degrees. Some, like the egg and larval stages of many aquatic animals, cannot survive even the slightest increase in salt.

Is there a solution? Other chemicals can melt ice just as well as salt does, but they are more expensive. And while officials want the roads to be safe, they also want to treat as many roads as possible within their budgets.

Once again, it's a trade-off. Some areas have started using other less harmful, but more expensive chemicals. But many other areas are still dumping tons of salt on the roads every winter. If you were an official, what would you do?

LESSON 10

Planning the Pollution Experiments

Think and Wonder

Now you know how three pollutants affect ecosystems in the world around you. How will they affect the systems in your ecocolumns? You and your new teammates will conduct an experiment to find out. But first, you need to work together to develop a good experimental plan.

Materials

For you

1 Fact Sheet

For you and your teammates

2 ecocolumns

1 **Activity Sheet 5, The Planning Worksheet**

Find Out for Yourself

1. With your classmates, discuss the three pollutants you will use in your experiments.
   - What causes the pollution?
   - What are the effects of these pollutants?
   - What are the trade-offs? Why do we continue to use fossil fuels, road salt, and fertilizer?
2. In order to do a good experiment, you must set it up as a fair test. What does that mean? Well, a race should be fair, too. Talk about this with the class:
   - When you run a race, what question are you trying to answer?
   - How do you set up the race to make it a fair test? What things must be kept the same for all runners?

Figure 10-1

A "fair test" is like a fair race.

3. Let's use those same ideas to plan your experiment on pollution.
   - What question will your team be trying to answer?
   - What things will we have to keep the same for all the ecocolumns in the class?
   - What one thing will your team change in the experimental ecocolumn?
4. Listen while your teacher explains how to use the Activity Sheet to plan your team experiment.
5. Read over your Fact Sheet carefully. It will give you important information about how much of your pollutant to add. Then ask questions if there is anything you do not understand.
6. Meet with your teammates to discuss the sheets and plan your team experiment. After you agree on a plan, fill out the Activity Sheet and give it to your teacher to look over.

7. On each team there will be one ecocolumn that is not polluted. This ecocolumn will be called the "control." Think of as many reasons as you can why the control ecocolumns will be an important part of the experiment.
8. Use the last few minutes to decide which ecocolumn will be polluted and which will be the control. Remember, this should be a team decision.

Ideas to Explore

Set up a race during outdoor recess. Make the rules. Afterwards, talk about whether or not it was a fair test.

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LESSON 11

Setting up the Three Pollution Experiments

Think and Wonder

Today you will follow your team's plan to set up your pollution experiment. You will mix the chemicals and apply them to the terrarium for the first time. What do you think the effects of your pollutant will be? How long do you think it will take to notice changes?

Materials

For you

- 1 **Activity Sheet 6, Keeping a Record of Our Experiment**
- 1 science notebook

For you and your teammates

- 1 soda bottle with cap (to contain the pollution solution)
- 1 permanent marking pen
- 1 funnel
- 2 liters of water
- 1 set of measuring spoons
- 1 cup
- 1 dropper

For the class

- 1 pint vinegar
- 1 lb. salt
- 1 container plant food
- 1 roll pH test paper
- Cleanup supplies
- Newspapers

Find Out for Yourself

1. Join your class in a brief discussion about one team's experimental plan. What will the team members do? How often? What changes will they look for? Why is the control ecocolumn important?
2. If you have any questions about your own team's plan, ask them now.
3. Pick up all the supplies you will need for your team's experiment.
4. Work with your teammates to set up your pollution experiment. Remember to follow your plan, measure accurately, and record what you do either in your notebook or on the Activity Sheet. Use the permanent marking pen to label your team's bottle of pollution with your names and the name of the pollutant.
5. Clean up your workspace. Return supplies to the distribution center, but keep your ecocolumns in front of you for the next part of the lesson.
6. On pg. 63 you read about acid and how to measure it on a pH scale. Now you will try the test for yourself. Your teacher will give you a piece of pH test paper. Notice the color.
7. Use your pH paper to test for acid. Here's how to do it:
   - Dip the paper or touch it to what you want to test for two seconds.
   - Compare the color of the paper to the special color chart.

   The color chart shows you how acidic a substance is: yellow is the most acidic, and green is the least acidic.

Figure 11-1

pH testing

8. Each paper is good for only one test, so you need to talk to your teammates about who will test what. Here are the four substances your team should test:

   - The water in the control ecocolumn.

   Two teammates should work together to separate the column, dip the paper, and put the ecocolumn back together.

   - The water in the experimental ecocolumn.

   Again, two teammates need to work together to take apart the ecocolumn, dip the paper, and put the ecocolumn back together.

   - The soil in the control ecocolumn.

   Press the paper against the soil so it absorbs some of the moisture.

   - The soil in the experimental column.

   Press the paper against the soil.

9. Share your team's results with the class. Did you discover acid in any of the four locations?
10. Put your ecocolumns back in their assigned places.
11. Remember to continue to follow your experimental plan, and to water and pollute on schedule. You may begin to notice changes in the experimental terrariums very soon. Be sure to record your observations every day.

Ideas to Explore

Is acid rain falling in your area? Bring in some water samples to test with pH paper. You might collect rain water or snow, pond water, puddle water, or even tap water.

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LESSON 12

Observing Early Effects of the Pollution Experiments

Think and Wonder

In some of the polluted terrariums, big changes have occurred. Which pollutants have caused damage? How long did it take? Have the control ecocolumns changed?

Materials

For you

1 science notebook

For your team

2 ecocolumns
1 spoon
1 cup
2 hand lenses

Find Out for Yourself

1. Pick up your ecocolumns and hand lenses. Sit with the group experimenting with the same pollutant your team is using.
2. Examine your two ecocolumns and review your notes. Examine the other ecocolumns in the group too, and compare the polluted ecocolumns with the control ones.

Figure 12-1

Observing the pollutants' effects

3. Join in a discussion about the effects of each pollutant. Talk about these questions:

   - Describe how your terrarium looks today. How soon after you added the pollutant did you begin to notice changes?
   - How does your terrarium compare with the others which were polluted in the same way?
   - Describe how the control terrarium looks today. Why is the control terrarium important to your experiment?
   - Have any of the aquariums changed? If so, how have they changed?

   If you are experimenting with acid rain, answer this question too:

   - How could you find out if any acid rain has entered the aquarium yet?

   If you are experimenting with over-fertilization, answer this question too:

   - Why is it important to record "no change?"

4. Make some predictions about what you think will happen as you continue to add pollutants for the next few weeks. Share them with the class. Then record your predictions in your notebook.

5. You may be concerned about the crickets and isopods living in the salt-polluted and vinegar-polluted terrariums. How could you protect them?
6. Your teacher will give you a choice of where to transfer the crickets and isopods from the polluted terrariums. You may need to add more seeds to their new environment, too.
7. Return your ecocolumns to their assigned place.
8. Did you decide to move your animals out of your terrarium or not? Discuss the reasons for your decision.
9. Don't forget to continue to observe, record, and pollute on schedule.

Ideas to Explore

Sometimes animals have to be rescued from human-made pollution. For instance, birds drown if their feathers get covered with oil, and a seal can starve if a plastic ring from a six-pack gets caught around its neck. Look for stories in the news about animals rescued from human-made pollution. Share them with your class.

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LESSON 13

Where Do the Pollutants Go?

Think and Wonder

By now you can observe some big changes in the polluted eocsystems. Think about how the pollutants are affecting the aquariums. What will happen if the animals stay there?

Take some time to review your experiences as part of an experimental team. Go back and think about how you worked and what your team discovered. How do your findings compare with those of other teams that experimented with your pollutant?

Materials

For you

- 1 science notebook
- 1 completed **Activity Sheet 6, Keeping a Record of Our Experiment**
- 1 completed **Activity Sheet 5, The Planning Worksheet**
- 1 **Activity Sheet 7, Analyzing the Results of the Pollution Experiment**

For your team

- 2 ecocolumns
- 1 dipnet
- 1 cup
- 2 hand lenses

Find Out for Yourself

1. Pick up your ecocolumns and your supplies, and sit with the other group of students experimenting with your pollutant.
2. Observe the ecocolumns in your group, and review your records.
3. Join the class discussion about changes in the ecocolumns. Talk about these questions:
   - What further changes do you observe in the polluted terrariums?

- Compare the terrariums polluted in the same way. What similarities do you see?
- Compare the control aquariums to the experimental ones. What is the evidence that the pollutants have reached the aquariums?
- What might happen to the animals living in the aquariums?

4. If you have decided to take out the guppies and snails today, your teacher will tell you where to put them.
5. Return all supplies, and put the ecocolumns back in their assigned places.
6. Look at **Activity Sheet 7**, and listen while your teacher goes over it with you. As you work on the Activity Sheet, keep these points in mind:
   - The information you need to fill out this Activity Sheet is in your own records. Review your own experimental plan (**Activity Sheet 5**), and reread your own records of daily observations (**Activity Sheet 6** or your science notebook). Real scientists use this very same process to make sense of their data.
   - It's a good idea to discuss the questions with your teammates, but then be sure to complete your own Activity Sheet.

Figure 13-1

Analyzing the experiment results

7. Pass your Activity Sheet to your teacher when you complete it.
8. In the next class, each team will give a brief report on the results of their experiment. Then the class will try to reach some conclusions about each pollutant's effects on an ecosystem.

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LESSON 14

What Happened to Our Ecosystems? Coming to Conclusions

Think and Wonder

Today you will finish your pollution experiments. You have a lot of data to examine, not just your own, but your classmates' too. Based on all this data, can you and your classmates agree on some conclusions? Then you will read about a real ecosystem, the Chesapeake Bay.

Materials

For you

- 1 science notebook
- 1 completed **Activity Sheet 7, Analyzing the Results of the Pollution Experiment**

Find Out for Yourself

1. Your teacher has prepared three charts. The class will use them to organize and analyze the conclusions you have reached about the effects of the three pollutants. Everyone will have a chance to agree, disagree, or add new information to the charts.
2. First, listen while one team reports its findings. The teacher will record these on the chart.
3. If your team has experimented with the same pollutant, you can react to the findings in three different ways:
   - If you agree, you can simply go to the chart and add the word "agree" next to the finding.
   - If you disagree with a finding, write the word "disagree" next to it, and then write your own finding next to it in parentheses.
   - If your team has findings no one else has recorded, add them to the chart. Invite other teams to agree or disagree.
4. The class will repeat this procedure for all three pollutants.
5. Now try to draw some conclusions.

- Reread the three sheets, and look for statements that everyone agrees on. Your teacher will circle these. The circled statements are your firm conclusions, backed up by data collected by more than one team.
- Look for statements that students disagreed on. How could you clear up the dispute?
- Why do you think results differed?

6. Now turn to pg. 87 to read about a real-life ecosystem, the Chesapeake Bay.

   Think about these questions as you read:

   - What are the main problems in the Chesapeake Bay?
   - How are the Chesapeake's problems similar to the problems you experienced with your ecocolumn?
   - Describe a situation where too much of something is going into the Bay.
   - Describe a situation where too much of something is being taken out of the Bay.

Ideas to Explore

1. There was probably some disagreement on the conclusions your class reached today. Design an experiment to resolve the disagreement. If possible, carry it out, too.
2. You have probably heard the expression "jumping to conclusions". Write a story in which one of the characters jumps to a conclusion which is not necessarily the right one.
3. Go to the library to find out more about the Chesapeake Bay.

Reading Selection

The Chesapeake Bay: An Ecosystem in Danger

*Exploring [the Bay] in 1608, Captain John Smith found a bounteous bay full of fish such as "brettes, mullets, white Salmonds, Trowts, Soles, Plaice, Herrings, Rockfish, Eeles, Shades, Crabs, Shrimps, Oysters, Cocles and Muscles . . . . In somer," he wrote, "no place affordeth more plentie of Sturgeon, nor in winter more abundance of fowle . . . . In the small rivers all the years there is good plentie of small fish, so that with hookes those that would take paines had sufficient."**

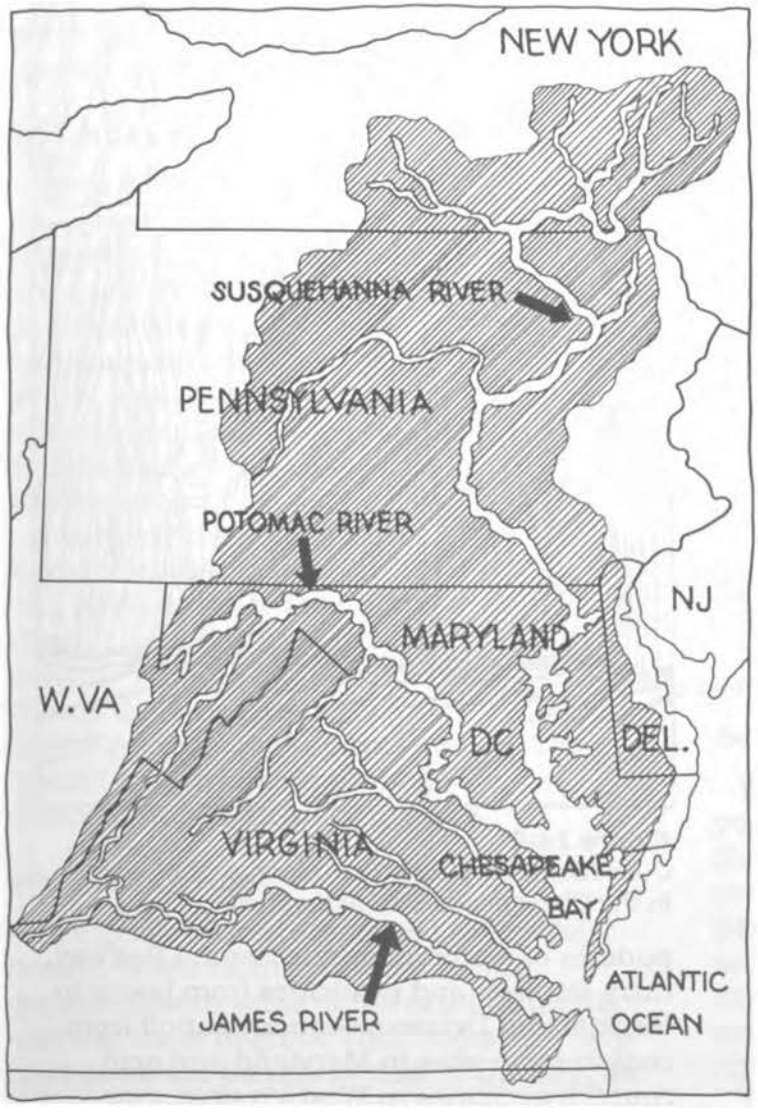

Figure 14-1
Chesapeake Bay watershed area

The Chesapeake Bay is an ecosystem

The Chesapeake Bay area is a vast and complicated ecosystem. Covering a surface area of over 2,200 square miles, its waters are a mixture of fresh water from about 150 rivers and streams, and salt water from the Atlantic Ocean. The Bay holds 18 trillion gallons of water.

The Bay is teeming with life. Its plant inhabitants include everything from water grasses anchored to the bottom, to spiky saltmeadow hay, to algae so tiny you can't see one with your eyes. And its animals range from crabs, fish, muskrats, and seahorses to swans, diamondback terrapins, and billions of baby eels.

The land around the Chesapeake is a jumble of different environments: marshes, wetlands, meadows, forests, mountains, and beaches. Each environment is home to many different kinds of plants and animals. In fact, over 2,500 different kinds of plants and animals live in the Bay area.

In the Bay's ecosystem (as in all ecosystems) every single element—water, land, air, light, plants, and animals—is connected in a

* Eugene L. Meyer, *Maryland Lost and Found: Peoples and Places from Chesapeake to Appalachia.* Baltimore, MD: The Johns Hopkins University Press, 1986.

complex web of relationships. For the Bay area, the web is very complex indeed.

But remember: through your work on the ecocolumns, you have already learned a lot about ecosystems. This will help you to understand the tangle of relationships that make up the ecosystem of the Chesapeake Bay.

How is the Bay like your ecosystem?

You have seen that what happens on land (like in your terrarium) can greatly affect what happens in water (like in your aquarium). Now apply this idea to the Chesapeake's land, an area covered with farms and factories, cities and highways, schools and apartment buildings, landfills and campgrounds, restaurants and marinas. Over 13 million people live, work, and play there. One way or another, pollutants from all of these people wind up in the Bay's waters.

So if a homeowner in the Chesapeake area over-fertilizes his lawn, that extra fertilizer eventually washes into the Bay. The same goes for the road salt applied after a snow storm. And what about the acid rain caused by industry, homes, and cars. Where do you think it goes?

What is a watershed?

A watershed is an area of land whose waters all drain into the same place. You could think of your terrarium as the watershed for your aquarium. The Chesapeake Bay's watershed is huge. It drains water from six states (Maryland, Delaware, Pennsylvania, Virginia, West Virginia, New York) and the District of Columbia, and covers 64,000 square miles between Vermont and North Carolina.

It's all downhill

Think about this: the land in this watershed slopes towards the Bay, the way a bathtub slopes toward its drain. So much of the liquid that runs off this land flows down the slope, towards the Bay. Industrial waste pouring out of Baltimore's factories,

Figure 14-2
Over 13 million people live, work, and play in the Chesapeake Bay watershed.

puddles of motor oil on the Capitol Beltway, extra fertilizer and pesticides from lawns in Virginia and Delaware, muddy runoff from construction sites in Maryland and acid runoff from mines in West Virginia, cow manure from Pennsylvania dairy farms, and sewage from 13 million people's toilets eventually flow toward the Bay.

With all this human-made pollution, no wonder the Bay is in trouble.

Problems: too much goes into the Bay, too much comes out

The problems in the Chesapeake stem from two main causes:

- people are putting too many pollutants into the Bay
- people are "overharvesting" or taking too much seafood out of the Bay.

Let's take a closer look at each cause. How does each affect the Bay, and all the plants and animals in it?

Too many nutrients

From your ecocolumns, you know that pollutants in an ecosystem can set off a chain of events. For example, when pollution kills plants, the animals who depend on those plants must either move out to find other food or starve. This has happened to the Chesapeake.

Too many nutrients from human sewage, cow manure, and fertilizer are overloading the Bay, causing algae blooms. Too much algae clouds the water and keeps light from reaching the grass below. The result? Underwater grass beds are disappearing at an alarming rate.

More than grass

The grass beds are essential to the Bay's health. When nutrients wash in, the grasses absorb some of the extra nutrients and use them to grow. Their roots also help hold down the muddy bottom of the Bay, so it doesn't get stirred up, cloud the water, and block the sunlight.

Grass beds near the shoreline help to absorb the waves' pounding and can prevent the soil there from wearing away. When the grass beds do their job, the water stays clearer, sunlight pours in, and plants thrive.

Animals need underwater grasses too. Ducks, geese, swans, snails, isopods, worms, muskrats, beavers, and sea slugs and other animals of the Bay depend on the grasses for food. The Bay's grass beds are prime breeding grounds and safe nurseries for baby fish, shrimp, crabs, seahorses, and even turtles. What will happen to these animals if the grass beds disappear?

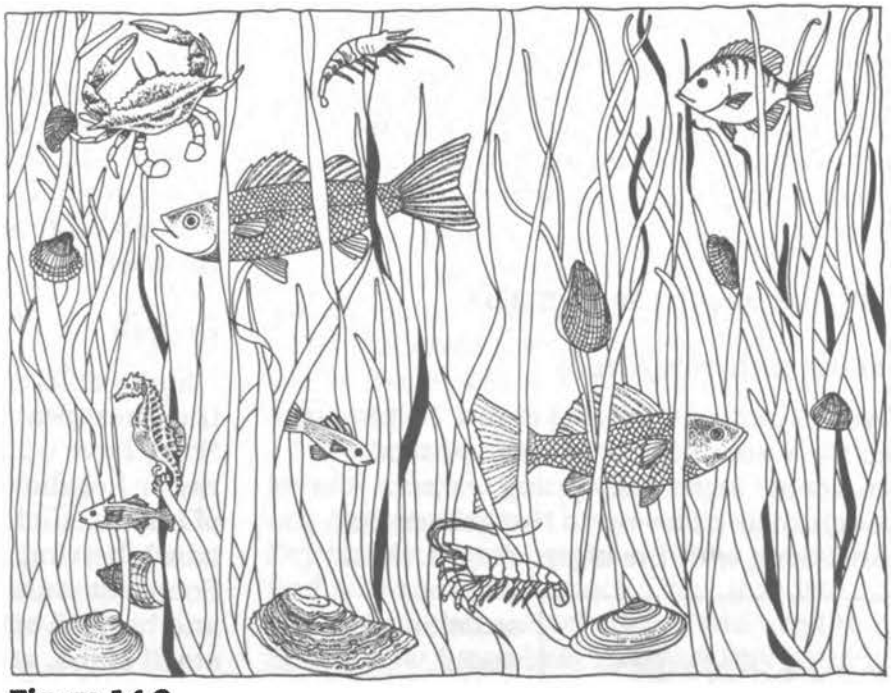

Figure 14-3
Underwater grass beds are home to many living things

Sediment kills

Did you notice that when you watered your terrarium enough to cause a runoff, the runoff was cloudy? That's because it contained not only water but also tiny particles of soil, called **sediment**. Some sedimentation occurs naturally, but humans cause most of it, especially when we cut down trees and other plants, and remove grass.

Trees help keep sediment out of the Chesapeake. Their roots help to hold the soil in place. Their leaves and branches cushion rainfall so it hits the ground more gently. (Then the soil and roots have time to

absorb the water.) Leaf litter on the forest floor acts like a sponge to soak up the water and slow its flow.

But we've cut down about forty percent of the forests in the Chesapeake watershed to build highways, houses, shopping centers, and offices. Unlike trees, the hard surfaces we build (such as pavement and rooftops) prevent water from seeping slowly into the soil. Whenever it rains, more sediment (and whatever it holds, such as fertilizer and pesticides) races off these surfaces and gushes toward the Bay.

Like algae, sediment clouds the water and prevents light from reaching the underwater plants. It can also clog fish gills and smother fish eggs. Bottom dwellers such as clams, oysters, worms, sponges, and coral, can smother under a layer of sediment.

What happens to the animals?

Oysters: nature's filters

Oysters serve as natural filters, helping to keep the water clear. To trap their food, microscopic algae, they pump water through their gills—up to two gallons per hour! Along with the algae, they suck in and trap sediment that would otherwise cloud the water. Oysters pump the clear water back out, digest the algae, and then drop harmless pellets of waste (which include sediment) to the Bay's bottom.

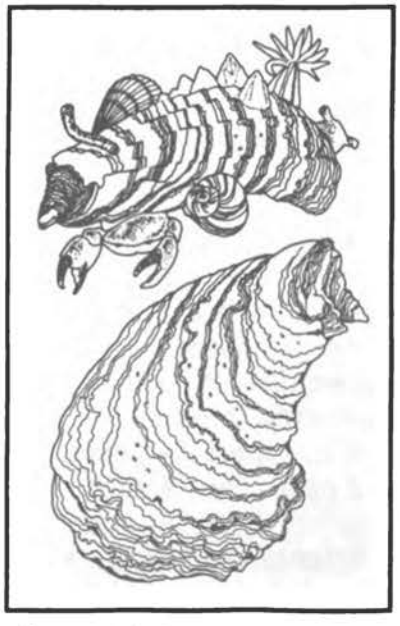

Figure 14-4
Oysters: nature's filters

In Colonial times, the Chesapeake was so piled with oyster beds that ships had to be careful to steer around them. But today, only one percent of the oysters are left. And they can no longer play a big part in keeping the water clear.

This is also bad news for the snails, crabs, and small fish that live in the millions of nooks and crannies in a healthy oyster bed. Many of these creatures have lost their homes.

What happened to all the Chesapeake's oysters? Well, a virus infected some, pollution killed others, and oyster drill snails ate still more. But the main reason so few oysters remain is that people have eaten them.

Lots of people find oysters so tasty that they will pay a high price for them. So it is no surprise that watermen are taking so many out of the Bay. As a result, not enough oysters are left to replace themselves.

Go fish

Many different kinds of fish live in or visit the Chesapeake Bay for part of the year. Some have unusual names, like cownose ray or hogchoker. But you may have heard of others, such as shad, rockfish (striped bass), herring, perch, eel, and bluefish. Some eat plants. Some are bottom feeders and hunt in oyster or grass beds for snails, small crabs, and worms. Some eat smaller fish.

Fish that visit the Bay for only part of the year seem to be doing fine. But other fish who live there year-round may be in trouble. In fact, the rockfish population is so low that some states, like Maryland, have either banned or severely restricted fishing for rockfish.

Why have fish catches declined? There are many reasons. People built dams across the rivers in the Bay's watershed area, and these prevent fish from swimming upstream to lay eggs. Cars and power plants which use fossil fuels have created acid rain which damages both eggs and young fish.

Harmful chemicals from factories and mines can kill fish outright or give them

cancer. Plus, there is the sediment that can kill fish eggs and clog fish gills.

And remember, one of the Bay's big problems is that we take too much out of it. For most kinds of fish, there are no limits on how many can be caught. This means that commercial fishermen (who catch fish for a living) as well as sports fishermen, continue to over-fish the Bay.

Blue crabs: the last great catch

The Chesapeake Bay still produces about half of the nation's blue crab harvest. They are the last great catch in the Bay. As fish and oysters become scarcer, the demand for crabs grows. Watermen can sell just about as many as they can pull out of the water.

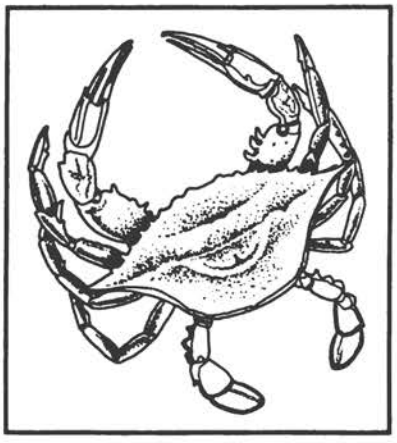

Figure 14-5
Blue crabs are the last great catch in the Bay

Blue crabs are real survivors. They are scavengers who eat almost anything they can find. They also seem able to tolerate pollution, survive temperature changes, and adjust to different amounts of salt in the water.

But even the blue crab is showing signs of trouble. As the grass beds disappear, crabs are losing their safest hiding place. (To avoid being eaten during molting, for example, crabs need to hide in the grass while their shells harden.) And as the oyster beds disappear, young crabs are losing their favorite place to live in winter.

Searching for solutions

When your animals were threatened by pollution in your ecocolumns, the solution was simple: move them to a safe place. In the real world of the Chesapeake Bay, the problems are much more complicated. And the solutions are, too.

Everyone agrees that the Chesapeake Bay has many problems, most of them human-made. But depending on where they live and what they do, people who live, work, and play in the Chesapeake Bay watershed area see these problems from widely different points of view. And what seems like a solution to one group may seem like a problem to another group.

Let's examine the Bay's problems from several different points of view and see if we can come up with some solutions. Depending on your point of view, you will find some solutions more difficult to live with than others. Each group will need to decide how it can best help the Bay without giving up too much.

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LESSON 15

Examining a Real Environmental Problem

Think and Wonder

You have read about the Chesapeake Bay ecosystem, and how complex it is. You have also read that the Bay is in trouble. Today you will try to look at the Bay's problems through someone else's eyes. Every group involved has its own ideas of how best to clean up the Bay. But not every solution is acceptable to people of different points of view.

Materials

For your team

1 **Activity Sheet 8, Problem-Solving Sheet**
1 sheet of newsprint (or space on the chalkboard)

For you

1 **Point of View Sheet**

Find Out for Yourself

1. Let's review some of the things we know about the Chesapeake Bay. Join in a discussion:
   - What are some of the problems in the Chesapeake's ecosystem?
   - What is one situation where something added to the Bay has upset the balance in its ecosystem?
   - What is one situation where something taken from the Bay has upset the balance in its ecosystem?
2. With your group, read the **Point of View Sheet** your teacher assigns to you.
3. Discuss the Bay's environmental problems with your small group. Cover these topics in your discussion:
   - From your group's point of view, what are the main environmental problems? How does your group contribute to these problems?

Figure 15-1

From your group's point of view, what are the main problems?

- What could your group do to help solve the environmental problems in the Bay? Think of as many solutions as you can.
- Some of the solutions might require your group to give up something. But other groups and the Bay might benefit. This is called a "trade-off," where you give up one thing in return for another. Discuss the trade-offs involved in your solutions.

4. Now read over **Activity Sheet 8.** It will help you to organize your thinking on the questions you just discussed with your group.
5. With your group, complete one **Activity Sheet 8.** Be sure to put your answers in your own words.
6. In the next class you will hold a mini-conference on the Chesapeake Bay. Each group will make a presentation of
   - how their group contributes to the Bay's problems, and
   - the solutions they propose for each solution, the advantages for the Bay and the disadvantages for their group.

Your presentations can be as simple or as elaborate as you want to make them. Here are some basic suggestions:

- Transfer all the information from **Activity Sheet 8** onto a large sheet of newsprint or a space on the chalkboard which your teacher has reserved for you.
- Divide up the presentation into smaller, more manageable tasks. For example, one person states the problem as your group sees it, another tells what your group proposes for solutions, another describes the advantages of each solution to the Bay, and another describes the disadvantages to the group.

7. Those are the minimum requirements. But you might enjoy using a different style of presentation to make it more fun. For example:
   - Hold a panel discussion.
   - Debate the advantages and disadvantages of different solutions to the Bay's problems.
   - Hold a meeting of your special interest group to discuss the Bay problems.
8. Here are a few more ways to make the mini-conference even more interesting:
   - Invite guests. These might be another class, your parents, or the principal.
   - Publicize the mini-conference. Give it a catchy name. Attract attention: notify the school newspaper, hang posters, tell your friends.
   - Use props for your presentation. You might try maps, audiovisual equipment (such as an overhead transparency and projector, a tape recorder and microphone, a video camera), models (of farms, boats, housing developments, crabs, oysters), or "official" identification badges.
   - Wear costumes.

Ideas to Explore

1. Design and write invitations to the mini-conference. Or, write and illustrate a news article for the school paper.
2. Dress up your presentation. Draw pictures or maps, make models, create collages, or design a display to use as part of your presentation.
3. Would you like to be a "reporter" at the mini-conference? You could interview students representing different points of view. Present the interview as if it were on radio or television.

LESSON 16

Holding the Mini-conference: A Look at Trade-offs

Think and Wonder

In this last lesson, you will present your group's point of view on the environmental problems of the Chesapeake Bay. Then you will suggest solutions to the problem, and tell how these solutions would be an advantage to the Bay and perhaps a disadvantage to your group. What will your group do to make the presentation fun and interesting?

Materials

1 sheet of newsprint or chalkboard space on which you have recorded the information from **Activity Sheet 8**

Costumes and props

Find Out for Yourself

1. Listen as your teacher explains what will happen in today's presentations. You will hear about the same problems in the Chesapeake Bay from many different points of view. You will also listen to what different groups judge to be the best solutions to these problems. All this will help you understand how complicated environmental problems are.
2. Make your presentation, and listen while other groups do the same.

Figure 16-1

Making presentations

3. When all groups have finished presenting, look again at all of the class **Point of View Sheets** or the chalkboard space. Share your ideas on:
   - What are the similarities in the way that different groups contribute to the problem? What are the differences?
   - What are the similarities in the solutions that different groups propose? What are the differences?
4. As your final notebook entry, write about one of these topics:
   - When you polluted your ecocolumn with (name of pollutant), it was similar to one of the problems the Chesapeake Bay is experiencing. Describe the similarities between what happened in the ecocolumn and what is happening to the Bay.
   - Healthy plants seem to be the key to a healthy ecosystem, both on land and in the water. Explain why this is true.

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